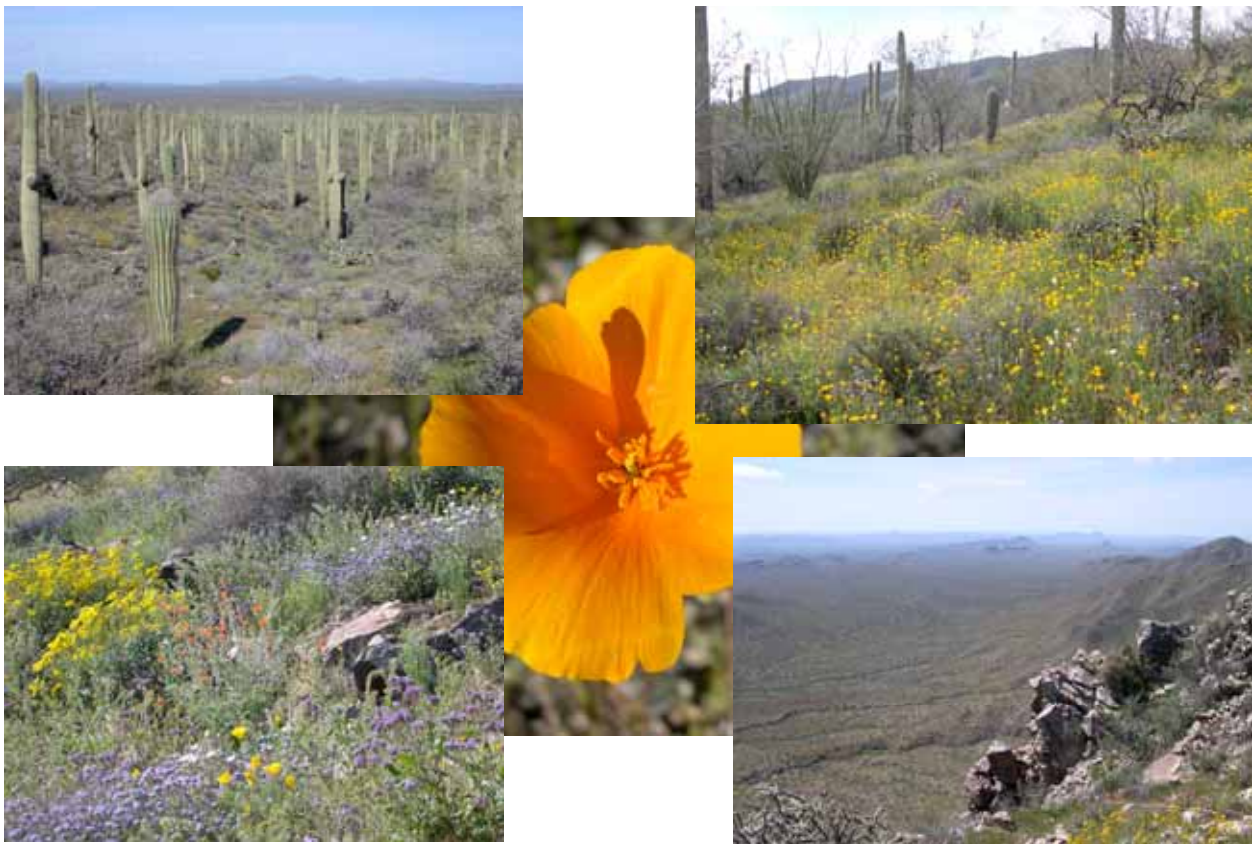


CONSERVATION ELEMENTS OF AND A BIODIVERSITY MANAGEMENT FRAMEWORK FOR THE SONORAN DESERT NATIONAL MONUMENT



June 2005



Photo Credit

Cover photos © Dale Turner. The photos depict various scenes from the Sand Tank Mountains area of the Sonoran Desert National Monument, spring 2005.

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CONSERVATION ELEMENTS OF AND A BIODIVERSITY MANAGEMENT FRAMEWORK FOR THE SONORAN DESERT NATIONAL MONUMENT

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EXECUTIVE SUMMARY

The biological richness and ecological value of the Bureau of Land Management's (BLM) Sonoran Desert National Monument (SDNM) and adjoining lands have been exhorted via ecoregional assessments, focused reports, and most recently through the 2001 Presidential Proclamation that established the monument. This biodiversity management framework document describes the biodiversity of the SDNM and adjoining lands by characterizing a focused set of representative conservation elements—natural communities, species, and various groupings of species—and their associated ecological processes. This information can be used by the BLM and others to guide management of this unique landscape. In addition, the framework provides both a regional ecological and socioeconomic context, the latter of which provides important clues for current and future threats to the SDNM, opportunities for their abatement, and local community perspectives.

The major insight of this framework document—derived from the ecological characteristics of the conservation elements in combination and the socioeconomic factors that may affect their long-term persistence—is that the biodiversity of the SDNM exists and functions within a larger geographic context. The implications of this insight are several. First, the long-term management of the monument's biodiversity requires attention to ecological and not just administrative boundaries. The ecological and socioeconomic data compiled in support of this framework was used to demarcate the appropriate ecological boundary (Figure ES.1). Second, long-term management success will require acceptance of a unified vision and shared sense of responsibility among several land managers, besides the BLM, and other stakeholders for the natural resources contained within this ecologically defined boundary (hereafter referred to as the Sand Tank Mountains Complex). Third, the time to act and implement this vision is now.

The SDNM and adjoining lands are located in proximity to one of the most rapidly urbanizing areas in the Southwest, if not the Nation. The good news is that the landscape of the Sand Tank Mountains Complex, with some notable exceptions such as Interstate 8, is mostly unfragmented and in reasonable ecological condition. At present, land management is mostly a mix of protected areas of various types and working landscapes. The growing recognition of the value of open space, in concert with changing perceptions of the social amenity values offered by public lands, the desire by some area stakeholders to maintain a rural lifestyle, and the presence of socially valued plant communities and species such as saguaro cactus forests and desert bighorn sheep, respectively, also offer a social context in which a comprehensive conservation vision can be pursued. The bad news is that projected growth in the area and its associated impacts threaten this landscape. Species such as desert bighorn sheep are sensitive to continued fragmentation of their habitat. The boundary of the Sand Tank Mountain Complex is defined in part by the habitat and movement needs of this species. Although appropriate management and retention by BLM of existing public lands within the Sand Tank Mountains Complex is key, appropriate management of non-BLM land also is critical for several conservation elements. This document, along with its supporting documents, provides a blueprint and information base that all stakeholders concerned with the ecological and social values of the Sand Tank Mountains Complex can use to help guide the long-term management of the area.

Background and Scope

The Nature Conservancy (Conservancy) and Sonoran Institute (Institute) prepared the SDNM biodiversity management framework as a project under the Sonoran Desert Ecosystem Initiative. The Initiative is a partnership between the Department of Defense, BLM, Conservancy, and Institute. One of its primary

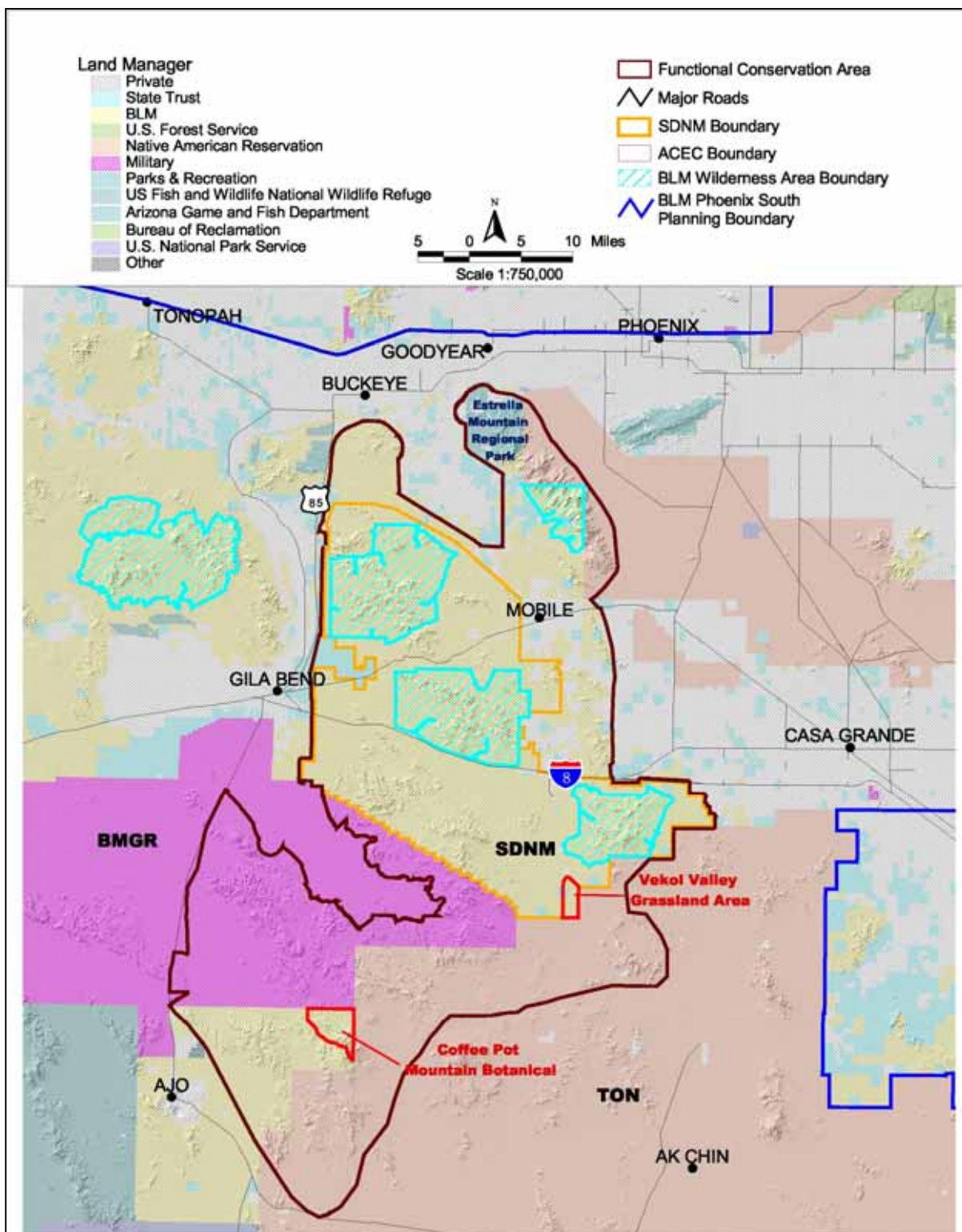


FIGURE ES.1 Sand Tank Mountains Complex Functional Conservation Landscape

thrust areas is to improve the prospects for the management of biodiversity in the Sonoran Desert by assisting federal land managers with conservation planning. With the recent designation of the SDNM and its associated requirement for a resource management plan, as well as its close ecological ties with the eastern portion of the Barry M. Goldwater Range (BMGR), the SDNM was a logical place to partner on conservation planning in the region. Subsequently, the SDNM also became identified as a pilot demonstration area for integrating the Conservancy's approach to conservation planning with the BLM's planning process.

The biological aspects of the framework are based on the Conservancy's approach to site conservation planning that has been adapted to a federal land management context. This approach was applied previously to the BMGR and adheres to contemporary principles of conservation planning. For the SDNM, the focus here is on the selection of conservation elements that can represent the biodiversity of the SDNM and their ecological characterization within regional and monument-scale contexts. Ecological characterization includes an analysis of stresses and their sources by conservation element. In addition, the framework includes, under the direction of the Institute, a significant contribution from the social sciences. In this regard this framework is relatively unique as a biological resource management strategy in its integration of social science considerations. Land managers need to consider both biological and social data, and the linkages between them, when making resource management decisions. To enhance its relevance this document also identifies correspondences between the framework and the (1) principles of ecosystem management and (2) steps in the BLM planning process.

Findings

A total of 26 natural communities/guilds/species are proposed to serve as a focal set of conservation elements for the SDNM. Besides desert bighorn sheep and saguaro, these elements include desert tortoise, Tucson shovel-nosed snake, rufous-winged sparrow, Desert Grassland, and Mountain Upland, the last of which is a natural community that is found only within high-elevation mountain ranges of the Sonoran Desert. The elements selected are the outcome of a coarse filter-fine filter approach meant to capture and represent the biodiversity of the SDNM and adjacent portions of the BMGR and Tohono O'odham Nation for management planning purposes under the BLM's resource management plan for the monument. Detailed ecological characterization information is provided for each element. A fairly broad and strong correspondence exists between the conservation elements recommended for the SDNM as part of the biodiversity management framework and the biological objects identified in the monument proclamation. The areas where overlap does not occur reflect in part situations in which new information since the proclamation was issued has come to light concerning the rarity of certain species and the opportunities afforded by the SDNM for their conservation.

The proposed set of conservation elements is based on our knowledge to date of the natural resources occurring on the SDNM and vicinity. Additional species were suggested by our information gathering or by experts for consideration as conservation elements; however, in many cases we lacked the requisite information needed to determine whether such species qualified as fine-filter conservation elements. As a result, some species can be considered as potential conservation elements. Although we do not discuss them in the context of our selected conservation elements, we do provide information on these species that may prove helpful when assessing at a later date the choice of conservation elements. As a result, we suggest that the selection of conservation elements should be viewed as a dynamic process in which, as new information becomes available, the selection is periodically assessed and updated.

Social science information is integrated throughout the framework. Areas of integration generally focus on using: (1) human valuation of the resources of an area to identify social value species; (2) socioeconomic data to evaluate potential stresses and sources of stress to conservation elements, both today and projected into the future, at local and regional scales; and (3) both of the preceding types of

information to devise possible conservation strategies for multiple or single conservation elements. Primary types of social science information collected and considered include: (1) economic profile information associated with local communities and counties, (2) community values in relation to the SDNM, (3) population growth projection models for areas in the vicinity of the SDNM, and (4) impact assessment of recreational activities on the SDNM. The outcomes of the growth projection models in particular influenced the assessment of how future threats may impact the biodiversity of the SDNM and in part influenced the proposed boundary of the Sand Tank Mountains Complex as a response to such projections.

Sand Tank Mountains Complex Functional Conservation Landscape

To maintain the long-term viability of the SDNM conservation elements within their natural ranges of variability, it is necessary to define a functional conservation landscape that crosses administrative boundaries. Many of these elements do not occur just on the SDNM but have distributions that extend across the monument boundary onto adjoining lands. Based on the biological data layers assembled for the framework, we developed a conceptual boundary for a functional conservation landscape that includes the SDNM and portions of the BMGR at its core (Figure ES.1). The name for this landscape, which encompasses multiple mountain ranges—Sand Tank Mountains Complex, reflects the unique biological resources values that occur near the geographic center of the landscape within the Sand Tank Mountains. These mountains transcend the boundary between the SDNM and BMGR. The boundary encompasses the natural communities that occur on the SDNM and extend, often contiguously, across the monument boundary. Its outer limits include large, contiguous blocks of desert tortoise and desert bighorn sheep habitat and sheep movement corridors, as well as habitat for other species conservation elements.

Current land uses within the Sand Tank Mountains Complex are a mix of protected areas, other special designation areas, buffer areas associated with the BMGR, tribal lands, and working landscapes. All can contribute, if managed appropriately while also meeting their intended uses, to the ecological functionality of the Sand Tank Mountains Complex. As a conceptual boundary, the functional conservation landscape depicted in Figure ES.1 can be modified based on new information. For example, the buffer distance necessary to prevent urban encroachment from adversely impacting SDNM natural resources and the corridor width necessary to prevent fragmentation of the Sierra Estrella, and its associated biological resources, from the rest of the Sand Tank Mountains Complex can be refined with additional data on encroachment impacts and desert bighorn sheep corridor use. Some barriers to wildlife movement, such as Interstate 8, occur internal to the SDNM and are opportunities for potential restoration projects. Their current status, however, makes maintaining currently functional movement corridors within the entirety of the Sand Tank Mountains Complex all the more important to maintain.

The implications for BLM, and adjoining land managers and owners, of the Sand Tank Mountains Complex functional conservation landscape are several. First, it provides a blueprint for identifying those land managers and owners who, if they work together, can maintain the long-term functionality of the Sand Tank Mountains Complex. On the SDNM itself, responsibilities for wildlife management are shared by the BLM and Arizona Game and Fish Department. Across the entirety of the Sand Tank Mountains Complex, other land managers also play a shared vital role in conserving and protecting the resources of the Sand Tank Mountains Complex, including land managers at the BMGR, Tohono O'odham Nation, Estrella Mountain Regional Park, Gila River Indian Community, and Arizona State Land Department, as well as private landowners in Rainbow and Vekol Valleys.

Second, it can assist BLM with land-tenure decisions outside the SDNM. Maintaining under government administration those BLM parcels to the north and east of the SDNM, as well as those parcels that contribute to the connectivity between the SDNM and Sierra Estrella, likely will be important for maintaining the long-term viability of the conservation elements that occur within the SDNM. Third, it

provides local and regional planners, as well as members of the development community, with information that can guide the appropriate placement—or design when placement is otherwise unavoidable—of infrastructure (roads and utilities) and commercial/residential development. Finally, with respect to the BMGR, it provides additional justification, beyond that already articulated in the framework document for the BMGR, for the biological significance of the Saucedo-Sand Tank Mountains and their connection to other portions of a functional conservation landscape.

Coda

The biodiversity management framework, as it was structured for the SDNM, stresses the importance of context and biodiversity representation. As a result, it assesses information from multiple spatial scales. To accomplish representation it uses the concept of a coarse filter-fine filter in which multiple levels of the biological hierarchy also are considered. These approaches, though contemporary, seemingly pose a challenge for federal land management agencies to incorporate into their management plans when (1) the responsibilities for resource management are not necessarily the sole responsibility of the land manager or (2) those responsibilities have to take into account what is happening outside the land management unit. We contend that these challenges are not insurmountable and that management responsibility—which ultimately must be shared and coordinated between those with appropriate authority—and actions are best based on a holistic view of the resource within its appropriate ecological context. That is, an agency's authority may be limited to act but the contexts in which its management decisions should be made should be as inclusive as is necessary to ensure that those with responsibility for shared natural resources, such as desert bighorn sheep and their habitat, understand the dimensions of the conservation challenge and work in a unified way to overcome obstacles to success. With the biological information provided via this framework, and its integration with social science information, we contend we have provided an appropriate baseline blueprint that BLM and others can use to guide biodiversity management within both the SDNM and the Sand Tank Mountains Complex.

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ACKNOWLEDGMENTS

The development of a biodiversity management framework for the Sonoran Desert National Monument (SDNM) would not have been possible without the dedication and support of many individuals working on biodiversity conservation issues within the Sonoran Desert. We identify those individuals below that made significant contributions to framework development. In addition, we especially appreciate the funding support for this project from our partners in the Sonoran Desert Ecosystem Initiative: the Department of Defense, Legacy Resource Management Program, and Bureau of Land Management.

A number of individuals attended the May 13, 2003 experts workshop, held at the Tucson Botanical Garden, at which the conservation elements were discussed and information gathered about stresses and sources of stress. These individuals included: Gene Dahlem, Dave Dalton, Rebecca Davidson, Erik Enderson, Russ Engel, Richard Felger, Pam Foti, Anne Gondor, Karen Kelleher, Megan Kram, Rob Marshall, Elroy Masters, Peter Morrison, Chuck Patterson, Phil Rosen, Sue Rutman, Tim Tibbitts, Dale Turner, Dan Urquidez, Rob Winthrop, and Betsy Wirt. We also thank Dana Backer and Anne Gondor for taking notes at the workshop.

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CHAPTER 1 SCOPE AND STRUCTURE OF THIS FRAMEWORK DOCUMENT

This chapter briefly outlines the scope of the document and its internal structure. In addition to the contents of this particular document, we also identify here those documents that, though they were separately prepared, are an integral part of this biodiversity management framework.

1.1 SCOPE

This framework document provides the results from The Nature Conservancy (Conservancy) and Sonoran Institute's (Institute) development of ecological and socioeconomic information—biodiversity management framework—for the Sonoran Desert National Monument (SDNM) in Arizona. This information can be used by the Bureau of Land Management (BLM) to support its land-use planning process for the SDNM.

The biological aspects of the framework are based on the Conservancy's approach to site conservation planning (TNC 2000) that has been adapted to a federal land management context. This approach was applied previously to the Barry M. Goldwater Range (BMGR; Hall and others 2001) and adheres to contemporary principles of conservation planning. For the SDNM, the focus here is on the selection of conservation elements that can represent the biodiversity of the SDNM and their ecological characterization within regional and monument-scale contexts. Ecological characterization includes an analysis of stresses and their sources by conservation element. In contrast to the BMGR framework (Hall and others 2001), the framework for the SDNM does not identify desired future conditions for the conservation elements nor any monitoring recommendations. It does add, however, under the direction of the Institute, a significant contribution from the social sciences. In this regard this framework is relatively unique as a biological resource management strategy in its integration of social science considerations. To enhance its relevance this document also identifies correspondences between the framework and the (1) principles of ecosystem management and (2) steps in the BLM planning process.

As an administrative unit of the National Landscape Conservation System, the SDNM, and its associated biodiversity, also exists within ecological and social contexts. Threats to the biodiversity of the SDNM and opportunities for its conservation do not stop at the monument's boundary. The combination of ecological and social science data collected and analyzed in support of the framework, especially as it was assessed at multiple spatial scales, also enables placing the management of the SDNM's natural resources into a larger spatial context. As a result, this framework document also provides a description of a spatially explicit, functional conservation landscape centered around the SDNM and the Sand Tank-Sauceda Mountains portion of the BMGR. This conceptual model provides a blueprint for how the BLM can work with other land managers and stakeholders to conserve the natural resources of the SDNM, and its ecologically linked environs, amidst current and projected development and resource use patterns both inside and outside the SDNM.

1.2 DOCUMENT STRUCTURE

This chapter briefly describes the document's scope and how it is structured. It also identifies supporting documents that were separately prepared. The next two chapters identify the administrative contexts for natural resources management planning and biodiversity protection on the SDNM (Chapter 2) and the regional context, both ecological and socioeconomic (Chapter 3). Chapter 4 is the final "scene setting" chapter. It first provides an overview of the biodiversity management framework and then describes the

relationship of the framework to the principles of ecosystem management, BLM's land-use planning process, and SDNM proclamation.

Chapters 5, 6, and 7 provide the methods and findings associated with biodiversity management framework for the SDNM. First, Chapter 5 describes the approach used to select conservation elements and to accomplish their ecological characterization. As part of the methods description, the chapter summarizes the methods used by Morrison and others (2003) to characterize the natural communities of the SDNM and by the document authors to accomplish the additional analyses of natural community data contained herein. Chapter 5 concludes with a section that describes the conceptual basis for defining a functional conservation landscape.

Chapter 6 provides an overview of the conservation elements for the SDNM and their ecological characterization. Again, information from Morrison and others (2003) relative to the natural communities of the SDNM and adjoining areas is summarized. The results of the additional data analyses also are provided. The chapter concludes with a description of the Sand Tank Mountains Complex functional conservation landscape.

Chapter 7 summarizes socioeconomic information collected and analyzed as part of the framework and describes how it was integrated with the biological information. Socioeconomic information that is summarized includes recreational impact data, growth projection model data, and community values.

Chapter 8 identifies the literature cited throughout the document. The document concludes with several appendices. Appendix A defines technical terms used in the document. Appendix B identifies experts consulted and workshop participants during the course of collecting and interpreting the biological information. Appendix C provides detailed ecological characterization information on the species (and guild) conservation elements. Appendix D summarizes information on those species and guilds considered but not selected as conservation elements. And finally, Appendix E summarizes the proceedings of the May 13, 2003 experts workshop on conservation element selection and characterization.

1.3 SUPPORTING DOCUMENTS

Much of the information collected and analyzed in support of the biodiversity management framework for the SDNM was prepared as separate documents. Although much of the information is summarized in this document, these other documents should be consulted for additional detail. These documents include:

- Blueline Consulting Group. 2004. GIS-Based, Three-Dimensional Population Growth Modeling and Cumulative Impact Analysis: Sonoran Desert National Monument and Phoenix South Resource Management Planning Process. Final report to the Sonoran Institute and Bureau of Land Management. Blueline Consulting Group, Sustainability and Global Change Institute, Prescott College, Prescott, Arizona.

Provides information on growth projection modeling, including multiple types of development scenarios.

- Chambers, N. 2004. Wildlife Water Development Workshop: A Review of the Science, Policy, and Human Dimensions. November 2004. Notes from the public participation sessions. Sonoran Institute, Tucson, Arizona.

Summarizes public perceptions about wildlife waters obtained at the November 2004 conference on the topic.

- Foti, P., and C. Patterson. 2003. Sonoran Desert National Monument Recreation Impact Inventory Final Report and associated database. Available <http://gsenm.az.blm.gov/monitoring/>. Northern Arizona University, Flagstaff, Arizona.
- Foti, P., C. Patterson, N. Chambers, and C. McIntyre. 2005. Sonoran Desert National Monument Recreation Impact Inventory Final Report. Northern Arizona University, Flagstaff and Sonoran Institute, Tucson, Arizona. 37 p.

Provides the results of a recreational impact survey conducted on the SDNM.

- Hall, J.A., S. Weinstein, and C.L. McIntyre. 2005. The Impacts of Livestock Grazing in the Sonoran Desert: A Literature Review and Synthesis. The Nature Conservancy in Arizona, Tucson. 284 + xi p.

Provides a review and synthesis of the literature on the impacts of livestock grazing in and management strategies for the Sonoran Desert.

- Morrison, P.H., and S.D. Snetsinger. 2003. Natural Communities of the Sonoran Desert National Monument and Sand Tank Mountains. Report to The Nature Conservancy in Arizona by Pacific Biodiversity Institute, Winthrop, Washington. 67 p.
- Morrison, P.H., H.M. Smith IV, and S.D. Snetsinger. 2003. The Natural Communities and Ecological Condition of the Sonoran Desert National Monument and Adjacent Areas. Report to The Nature Conservancy in Arizona by Pacific Biodiversity Institute, Winthrop, Washington. Vol. 1:113 + xvi p. + Vol. 2 (appendices):395 p.

Provides detailed mapping and ecological assessment of the natural communities of the SDNM and adjoining lands.

- Snetsinger, S.D., and P.H. Morrison. 2004. Native Grass Abundance in the Sonoran Desert National Monument and Adjacent Areas. Report to The Nature Conservancy in Arizona by Pacific Biodiversity Institute, Winthrop, Washington. 63 p.

Provides a model for predicting locations of high abundance of native grasses for certain natural communities on the SDNM.

- Sonoran Institute. 2003. Community Workshops: Sonoran Desert National Monument and Phoenix South Planning Areas. Final report provided to the Bureau of Land Management. Sonoran Institute, Tucson, Arizona.

Provides results of the community workshops related to use of the Economic Profile System and canvassing community values relative to the SDNM.

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CHAPTER 2 ADMINISTRATIVE CONTEXTS FOR NATURAL RESOURCES MANAGEMENT PLANNING AND BIODIVERSITY PROTECTION ON THE SONORAN DESERT NATIONAL MONUMENT

The following sections provide an overview of the legal, regulatory, and partnership contexts that affect natural resources management planning and biodiversity protection on the Sonoran Desert National Monument (SDNM).

2.1 PRESIDENTIAL PROCLAMATION

The SDNM was established by Presidential Proclamation on January 17, 2001 under the authority of the Antiquities Act of 1906 (34 Stat. 225, 16 USC 431) (Clinton 2001). The proclamation identifies objects of biological, scientific, historic, and archaeological significance that occur on the monument and that through the proclamation are afforded protection. Of relevance to this report is the focus in the proclamation on the diverse plant communities, their uniqueness and regional significance, and the accompanying plant and animal diversity that occur on the monument.

The proclamation identifies the Department of the Interior, through the Bureau of Land Management (BLM), as the responsible federal agency for implementing the purposes of the proclamation. The Secretary of Interior is directed to prepare a management plan that addresses the actions necessary to protect the objects identified in the proclamation.

2.2 LEGAL AND REGULATORY REQUIREMENTS FOR BUREAU OF LAND MANAGEMENT LAND-USE PLANNING

Mandates for land use/natural resources planning in the BLM begin with its organic act, the Federal Land Policy and Management Act (FLPMA) of 1976 (43 USC 1701–1785). Other laws provide an authority for planning in the BLM; however, FLPMA provides the primary policy basis and requirements. Section 102 (43 USC 1701) of FLPMA identifies three policy areas that provide BLM not only the appropriate policy context for planning, but also for natural resources inventory, monitoring, protection, and preservation. Meeting the intent of these policies is facilitated through partner engagement and by integration of appropriate biological and socioeconomic information that is obtained and analyzed at the planning and other appropriate geographic scales. The relevant policies, with numbers taken from the Act, are those in which Congress declared that:

(2) the national interest will best be realized if the public lands and their resources are periodically and systematically inventoried and their present and future use is projected through a land use planning process coordinated with other Federal and State planning efforts;

(8) the public lands be managed in a manner that will protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archeological values; that, where appropriate, will preserve and protect certain public lands in their natural condition; that will provide food and habitat for fish and wildlife and domestic animals; and that will provide for outdoor recreation and human occupancy and use;

(11) regulations and plans for the protection of public land areas of critical environmental concern be promptly developed.

Section 201 (43 USC 1711) of the Act further expanded on the inventory provisions of policy by “giving priority to areas of critical environmental concern” as defined in the Act. Section 202 (43 USC 1712) mandates the development of land-use plans for the public lands and also provides broad guidance the Secretary of the Interior on how to approach such planning. Specifically, the Secretary, when developing and revising land-use plans, is mandated to give priority to the designation and protection of areas of critical environmental concern, relying to the extent it is available on the inventory of public lands and their resources, and coordinating the land use inventory, planning, and management activities of or for such lands with those of other federal departments and agencies (as well as state and local governments and Indian tribes).

Planning regulations (43 CFR 1600) to meet the requirements of FLPMA were first promulgated in 1983 (BLM 2000a). Among other requirements, these regulations outline a nine-step planning process (§ 1610.4), which consists of:

- Step 1: Identification of issues.
- Step 2: Development of planning criteria.
- Step 3: Inventory data and information collection.
- Step 4: Analysis of the management situation.
- Step 5: Formulation of alternatives.
- Step 6: Estimation of effects of alternatives.
- Step 7: Selection of preferred alternative.
- Step 8: Selection of resource management plan.
- Step 9: Monitoring and evaluation.

Information in this report can inform to some degree all steps of BLM’s land-use planning process. Chapter 4 describes the relationship of the biodiversity management framework and its associated information content to the BLM planning process. In addition, throughout this report we draw connections between the information provided and its application to BLM’s planning process for the SDNM.

Additional national policy and procedural guidance for planning is provided in BLM Manual 1601 (Land Use Planning; BLM 2000b) and in the BLM Land Use Planning Handbook (BLM 2000c, 2005). Some manual provisions of note regarding BLM policy are: (1) a requirement to consider all available information for making land use plan decisions, including information regarding ecosystem protection and restoration needs (section .06A.3), (2) a requirement to prepare separate resource management plans (RMP) for National Monuments and National Conservation Areas (section .06B.3), and (3) permissive language for conducting planning and regional assessments at multiple scales to set the context for RMPs or multi-jurisdictional plans and subsequent implementation plans (section .06D).

The handbook provides supplemental guidance to BLM employees for implementing the BLM planning requirements established by FLPMA and the planning regulations (BLM 2000c, 2005). Guidance contained within the handbook encourages planning on a variety of scales and is designed to facilitate

multi-jurisdictional planning. The handbook focuses on various aspects of BLM planning, such as types of land-use plan (RMP) decisions, coordination with others, plan implementation, plan monitoring and evaluation, and so on. The latest version of the handbook (BLM 2005) has a section on planning process and products that at least implicitly corresponds to the planning process steps outlined in the planning regulations. The new version also includes additional guidance on how to prepare an analysis of the management situation.

Section I.D of the Appendix C of the handbook specifically addresses special status species. For land-use plan level decisions, the guidance is to identify land-use planning strategies, desired outcomes, and decisions that result in a reasonable conservation strategy for each species (BLM 2000c, 2005). It is BLM's policy (BLM 2001, section .06E) to provide no less protection for BLM sensitive species than it does for federal candidate species; generally, this entails ensuring that BLM actions do not contribute to the need for the species to become listed (BLM 2001, section .06C). Section .22C of BLM's Special Status Species Policy (BLM 2001) encourages BLM managers to consider ecosystem management and the conservation of native biodiversity [as a means] to reduce the likelihood of placing any native species on a special status species list. Appendix D provides guidance on incorporating social science considerations into land-use planning decisions.

2.3 SONORAN DESERT ECOSYSTEM INITIATIVE

The Nature Conservancy and Sonoran Institute have individually had long-standing cooperative relationships with BLM in Arizona involving projects that range from land protection to cooperative management to partnership facilitation. A cooperative relationship also has existed for some time among the Conservancy, Institute, and Department of Defense (DoD). That the four preceding entities would form a working partnership around conservation issues in the Southwest was a logical extension of their individual missions and approaches to working with partners to achieve mission success. To achieve mutual objectives and leverage resources, the four preceding entities established the Sonoran Desert Ecosystem Initiative.

2.3.1 Initiative Origins

The Sonoran Desert Ecosystem Initiative has its roots in a DoD Legacy Resource Management Program funded-effort initiated in the late 1990s that conducted an ecological analysis of conservation opportunities within the 55-million acre Sonoran Desert Ecoregion (see Chapter 3 for a brief description of the ecoregion). The interest of DoD in the analysis—in part fueled by its concern with the potential for an increase in the federal conservation burden and associated mission impacts as human population growth and associated development in the Southwest progressed and continued species endangerment seemed more imminent—was to use its outcomes as a means to identify a shared blueprint for allocating conservation responsibilities throughout the ecoregion.

The analysis outcomes included identification of spatially defined, landscape-scale conservation areas that provided the best remaining on-the-ground opportunities for conserving plant communities and species within the ecoregion and an assessment of some wide-ranging threats to the continued persistence of the preceding communities and species, such as by invasive species. The analysis revealed that federal lands in the US, including a significant amount of BLM-administered lands, accounted for a significant amount in number and acreage of the network of identified conservation areas, yet in general these lands did not receive adequate attention for biodiversity management to ensure community and species persistence. As a follow-up to the analysis, in 2000 the Conservancy and Institute initiated implementation strategies associated with invasive plants and regional approaches to measuring the status of the Sonoran Desert ecosystem. In addition, through a cooperative agreement with Luke Air Force Base, the Conservancy began development of a biodiversity management framework that stepped down the ecoregional data and

analysis outcomes to the scale at which natural resource management decisions would be made for the Barry M. Goldwater Range (BMGR). The framework, completed in October of 2001 (Hall and others 2001), provided regional context and planning-scale information to support development of the BMGR's Integrated Natural Resources Management Plan.

2.3.2 Bureau of Land Management as a Partner

During the early part of federal FY01, DoD natural resource management officials requested the Conservancy and Institute to develop a new Sonoran Desert project vision that could be submitted as a FY02 Legacy Program proposal. With DoD's interest in improving conservation management practices across the Sonoran Desert Ecoregion, the designation of the new BLM Sonoran Desert National Monument in Arizona in January 2001 (Clinton 2001), and the monument's proximity to the BMGR, the Conservancy and Institute made applying the biodiversity management framework to the new monument, and using its analysis outcomes as input to the BLM's land-use planning process for the monument, as the main focal point of its project proposal: the "Sonoran Desert Ecosystem Initiative: Shared Management Framework, Goals, Standards, and Responsibilities." The Institute's role was to assist in integrating social science information with ecological information as part of framework development. The proposal included other conservation activities—such as continued work on invasive species management and regional approaches to ecosystem-based monitoring—that are not addressed further in this document.

Throughout the proposal development and review phases, BLM staff at various levels—Field Office, State Office, and Washington Office—were briefed about the proposal to ensure that staff were comfortable with the proposed work and the associated roles of the Conservancy and Institute. Initially BLM funding support for Year 1 of the projected three-year project was not requested, though the proposal to DoD indicated that the BLM would consider out-year funding. As a result of briefings on the proposal in July 2001 to the Assistant Director for Renewable Resources and Planning and the Director of the then Office of the National Landscape Conservation System, BLM Washington Office staff decided to immediately support funding half of the land-use planning associated work. The BLM subsequently has committed to provide a portion of the funding for all three years of the Initiative. Funding transfers and identification of specific work scope have been addressed through individual Assistance Agreements and Task Orders between BLM and the Conservancy and Institute, respectively.

CHAPTER 3 REGIONAL CONTEXT

The Sonoran Desert National Monument (SDNM) is located in a region characterized by extremes. The Sonoran Desert is the most biologically rich desert in North America and is also one of the fastest growing regions on the continent. The purpose of this chapter is to provide information on how the SDNM fits into a larger ecological and social landscape within the Sonoran Desert. The chapter begins with a general description of the Sonoran Desert Ecoregion, including its biotic communities and current land management. This is followed by an overview of the results of a recent assessment of the conservation priorities and the main threats to biodiversity within the Sonoran Desert Ecoregion. The regional context is rounded out by information on population growth and demographic and economic shifts in the Sonoran Desert Ecoregion, which will undoubtedly affect the use of and impacts to the biodiversity of the SDNM in the years to come. The Sonoran Institute recently collected much of this socioeconomic information. The chapter concludes with a discussion of the relationship between the biodiversity of the SDNM and the findings of the ecoregional assessment.

3.1 SONORAN DESERT ECOREGION

Ecoregions are large units of land and water that share similar climate, topography, and biological communities (Omernick and Bailey 1997). The Sonoran Desert Ecoregion encompasses 22 million hectares (55 million acres) in southern Arizona, southeastern California, northern Baja California, and northwestern Sonora (Figure 3.1).¹

3.1.1 General Description and Biotic Subdivisions

The Sonoran Desert Ecoregion is located within the Basin and Range physiographic province, with numerous northwest-southeast oriented mountain ranges separated by broad, expansive valleys. Most of the ecoregion lies below about 800 meters (2,600 feet) elevation, and the low rugged mountain ranges are generally below about 1,200 meters (4,000 feet). Like other deserts, the Sonoran Desert is characterized by its aridity and extended periods of drought. The Sonoran Desert is the most tropical of North America's warm deserts (Chihuahuan, Mojave, and Sonoran); its winters are mild, with eight to 12 frost-free months depending on location and year (Turner and Brown 1994). Most of the Sonoran Desert has a bimodal pattern of rainfall, with gentle winter rains carried by frontal storms from the Northern Pacific and violent tropical monsoon thunderstorms in the summer. A rainfall gradient exists from west to east across the Sonoran Desert whereby the total annual rainfall is greater in the east than in the west.

The plant life forms that distinguish the Sonoran Desert from other deserts are columnar cacti, such as saguaro (*Carnegiea gigantea*), senita (*Pachycereus schottii*=[*Lophocereus schottii*]), cardón (*Pachycereus pringlei*), or Organ Pipe cactus (*Stenocereus thurberi*) and leguminous trees, including mesquites (*Prosopis spp.*), palo verdes (*Cercidium spp.*), and ironwood (*Olneya tesota*). The plant communities of the Sonoran Desert are thought to have evolved during a drying trend in the late Miocene, approximately eight million years ago (Van Devender 2000). Climatic fluctuations resulted in the expansion and contraction of desert vegetation since that time, until the modern geographic extent and characteristics of vegetation communities became established sometime within the last 4,500 to 9,000 years (Van Devender 2000). The ancestors of many Sonoran Desert species are derived from tropical

¹As defined and delineated by Marshall and others (2000), based largely on Brown and Lowe (1980).

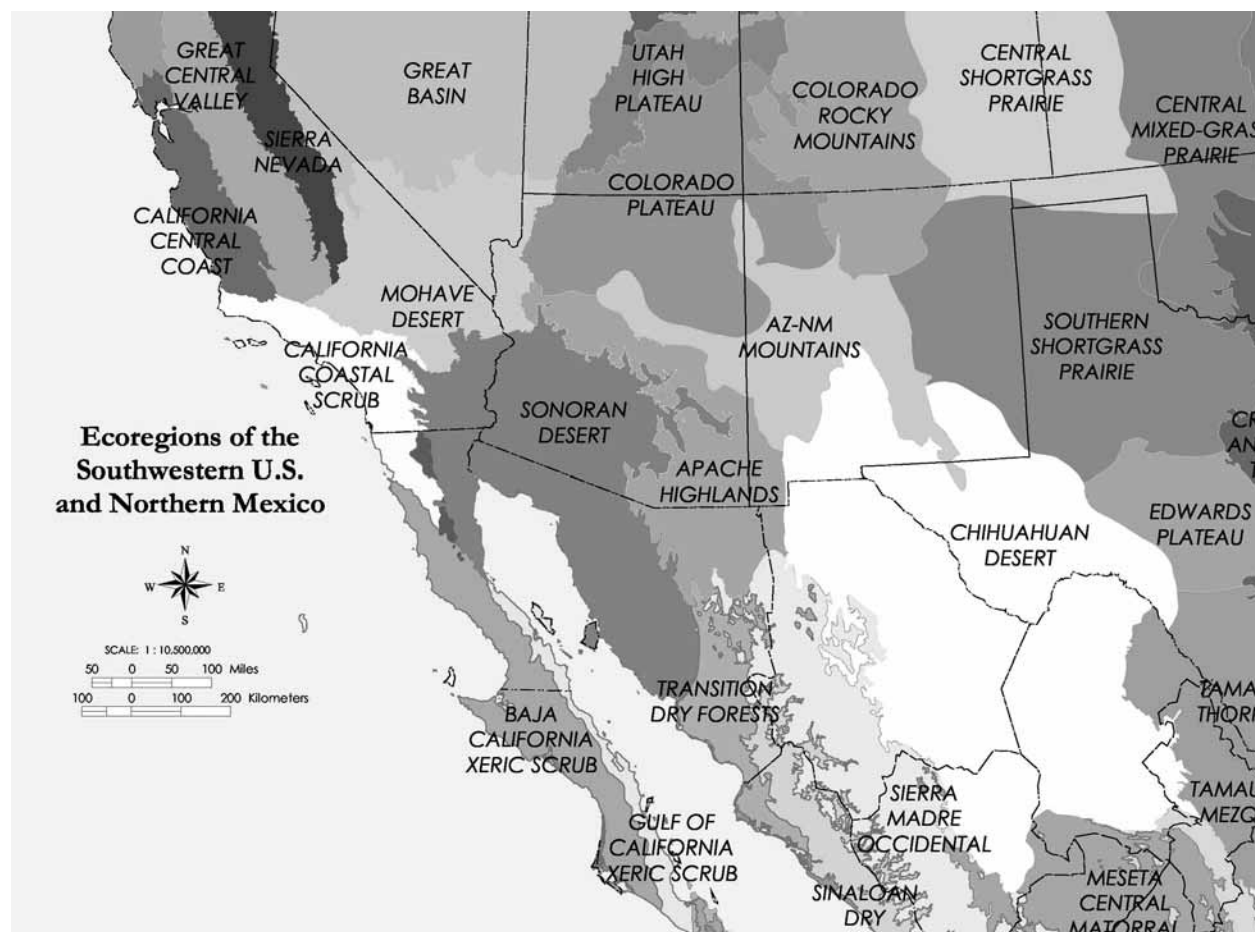


FIGURE 3.1 Sonoran Desert Ecoregion

thornscrub to the south, and the life histories and phenologies of many of these species are attuned to the summer rains.

As originally described by Shreve (1951), the Sonoran Desert Ecoregion has seven major subdivisions based on differences in vegetation. However, there is disagreement on the limits of the Sonoran Desert at its southern end where it grades into thornscrub, and some authors exclude one or more of Shreve's subdivisions based on differences in vegetation, plant and animal distributions, and/or climate (reviewed in Búrquez and others 1999). The delineation of the Sonoran Desert Ecoregion shown in Figure 3.1 is based on Marshall and others' (2000) assessment of the region, which closely conforms to that of Brown and Lowe (1980). As such, the ecoregion includes four biotic subdivisions: the Lower Colorado River Valley, Arizona Uplands, Plains of Sonora, and Central Gulf Coast. The portion of the Sonoran Desert Ecoregion within the United States includes two biotic subdivisions: the Lower Colorado River Valley and the Arizona Uplands.

The Lower Colorado River Valley is the largest and most arid subdivision of the Sonoran Desert. It occurs at low elevations on rolling plains and is dominated by the creosotebush-white bursage (*Larrea tridentata*-*Ambrosia dumosa*) matrix community. The Arizona Uplands Subdivision forms the transition between the plains of the Lower Colorado River Valley and the Apache Highlands Ecoregion to the north and east. It also occurs on mountain ranges surrounded by the lower, drier Lower Colorado River Valley subdivision in southwestern Arizona. The Arizona Uplands Subdivision receives significantly greater

winter rainfall than the other subdivisions and is generally found on slopes and dissected sloping plains (Turner and Brown 1994). The matrix community of the Arizona Uplands is paloverde-mixed cacti desert scrub, characterized by stands of saguaro cactus and numerous leguminous desert trees, particularly along xeroriparian corridors (dry washes or arroyos) (Turner and Brown 1994). Numerous species of cacti are best represented in this subdivision and are intermixed with numerous other species of small trees, shrubs, forbs, and grasses (Turner and Brown 1994). The Sonoran Desert National Monument encompasses portions of both the Lower Colorado River Valley and the Arizona Uplands subdivisions.

3.1.2 Conservation Need and Land Management

Although the Sonoran Desert Ecoregion is one of the most arid regions in North America, it is remarkably rich in biological diversity, including a high proportion of endemic plants, reptiles, and fish (see Nabhan and Holdsworth 1999 for a summary). Over 2,500 pollinator species—representing invertebrates, birds, and bats—have been documented, including the highest known diversity of bee species in the world (Buchmann and Nabhan 1996, Buchmann 2000). More than 500 bird species migrate through, breed, or permanently reside in the ecoregion—nearly two-thirds of all species that occur in northern Mexico, the United States, and Canada combined. Much of the ecoregion still remains as large, unfragmented landscapes. However, the Sonoran Desert has also undergone unprecedented population growth, resulting in habitat loss and the overuse of natural surface water and groundwater resources, which threaten the viability of both terrestrial and aquatic systems alike (Nabhan and Holdsworth 1999).

The pattern of land ownership and management in the Sonoran Desert Ecoregion is remarkably different across the United States-Mexico border. More than a quarter of the entire ecoregion is managed by U.S. federal agencies. The BLM manages the largest portion, almost 17%, of the ecoregion and over 32% of the U.S. portion of the ecoregion (3.7 million hectares [9.2 million acres]). The Department of Defense also manages a significant area of land in the Sonoran Desert (1.3 million hectares [3.2 million acres]). Less than 10% of the ecoregion is composed of private landholdings in the U.S. In contrast, over 86% of Mexico's portion of the Sonoran Desert Ecoregion is private or communally owned (ejido) land (Marshall and others 2000). The pattern of land ownership in the Sonoran Desert Ecoregion indicates that different conservation and protection strategies are required in the United States and Mexico. Sonoran Desert conservation simply cannot be accomplished in the United States without the assistance and support of federal land management agencies, including the BLM. Figure 3.2 depicts the land ownership and management status for the SDNM, Phoenix South Planning Area, and vicinity.

3.2 ASSESSMENT OF CONSERVATION PRIORITIES IN THE SONORAN DESERT ECOREGION

In 1998 a two-year effort was launched to analyze ecological data and identify conservation priorities in the Sonoran Desert Ecoregion. The goal of the assessment was to identify a network of conservation areas—that included species and natural communities representative of Sonoran Desert biodiversity—which, if appropriately managed, would ensure the long-term conservation of the native biodiversity of the Sonoran Desert. A brief account of the effort is outlined here. A full description of the ecoregional analysis can be found in *An Ecological Analysis of Conservation Priorities in the Sonoran Desert Ecoregion* by Marshall and others (2000).

3.2.1 Overview of Assessment Approach

The ecoregional assessment was conducted by a binational technical team, represented by staff from The Nature Conservancy, Sonoran Institute, Instituto del Medio Ambiente y el Desarrollo Sustentable del Estado de Sonora (IMADES), and the Arizona Game and Fish Department. Primary funding for the assessment was provided by the Department of Defense Legacy Resource Management Program. The ecoregional assessment used a science-based approach that integrated information from State Natural

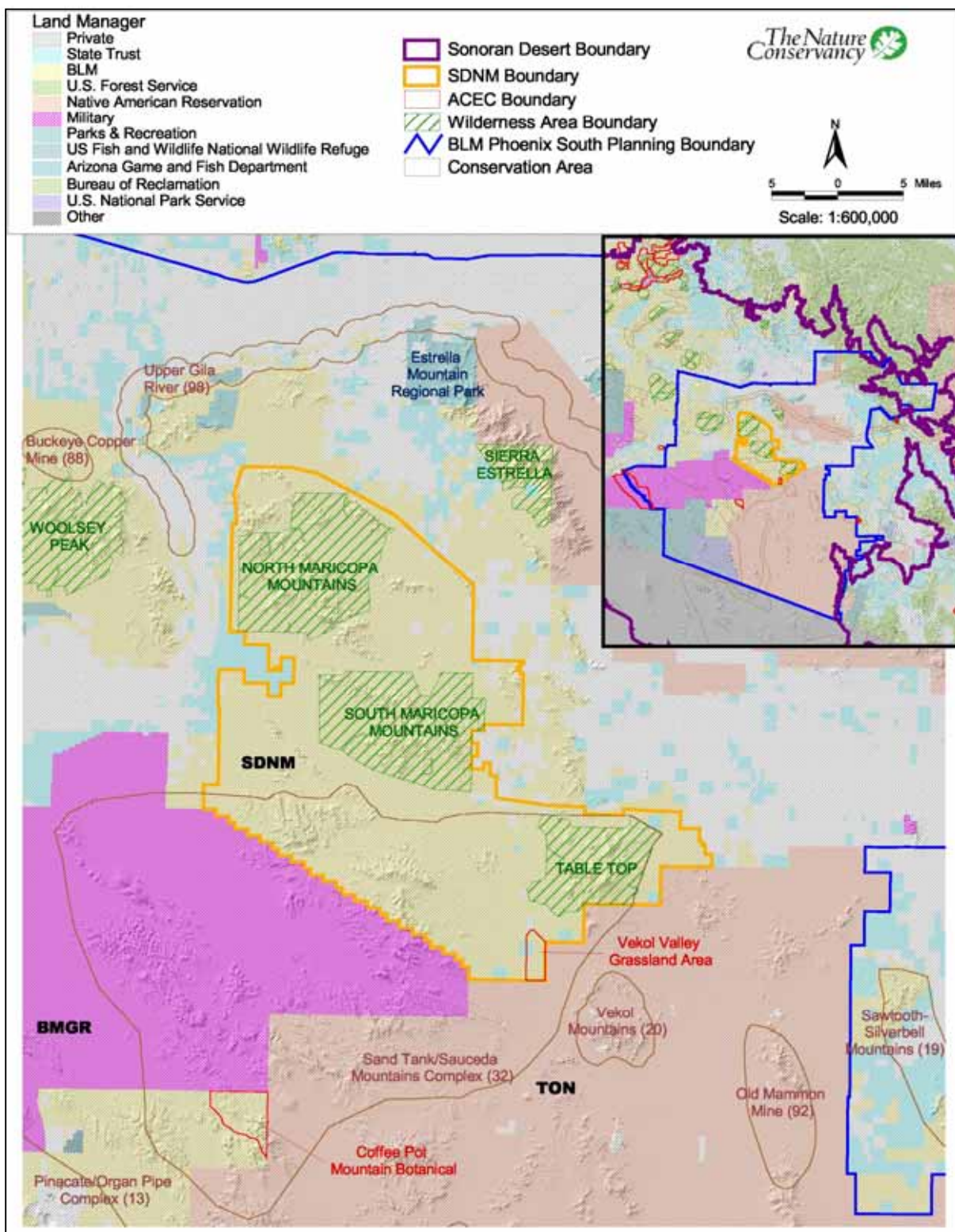


FIGURE 3.2 Land Management in the Vicinity of the Sonoran Desert National Monument and Phoenix South Planning Areas

Heritage Programs, published literature, and workshops with regional scientific experts. More than 100 experts from public agencies, Native American Tribes, conservation organizations, academic institutions, and private resource professions provided input to the analysis.

The basic unit of analysis used to identify a network of conservation areas is the *conservation element* (also termed *conservation target*). Conservation elements are species and natural communities that are representative of Sonoran Desert biodiversity. A total of 353 species from seven higher taxonomic groupings (plants, invertebrates, fish, amphibians, reptiles, birds, and mammals) and 78 natural communities (including terrestrial vegetation communities and aquatic communities) were selected as conservation elements of the Sonoran Desert Ecoregion.

Expert-nominated areas that captured multiple conservation elements from multiple taxa were used as nuclei for identifying conservation areas. Additional information was used to refine each area's size and shape to capture additional elements or to ensure that areas with incompatible land use or non-viable element occurrences were not included. Conservation areas represent focal landscapes for developing public awareness and implementing conservation actions to ensure conservation elements remain viable on the landscape.

3.2.2 Conservation Areas and Threats to Biodiversity in the Sonoran Desert Ecoregion

In total, 100 large landscapes (capturing entire ecosystems and their associated ecological processes) and 79 localized areas (sites of rare plant or animal occurrences) were identified across the ecoregion based on the distribution and aggregations of the selected conservation elements (Figure 3.3; the outlines of the landscape-scale conservation areas in the vicinity of the SDNM also are shown in Figure 3.2, as well as their relationship to land management status). The landscape conservation areas range in size from 163 hectares to 2.5 million hectares (403 acres to 5.7 million acres). Figure 3.3 identifies two conservation areas of particular interest: Sand Tank/Sauceda Mountains Complex (No. 32) and Pinacate/Organ Pipe/Goldwater Complex (No. 13). Conservation area No. 32 overlaps with the southern portion of the SDNM. In addition, the SDNM has close ecological and land management ties with conservation area No. 13. A smaller conservation area to the southeast of the SDNM (Vekol Mountains; unnumbered in Figure 3.3) also has ecological ties to the monument (this is discussed in more detail in section 6.5). Figure 3.2 shows the relationship of the preceding conservation areas to the SDNM.

The network of conservation areas encompasses a total of 9,355,508 hectares (23,108,106 acres) of land in the United States and Mexico. More than 87% of the conservation areas in the U.S. portion of the ecoregion are managed by federal or state public agencies. The Bureau of Land Management manages the greatest area of land within the conservation areas in the U.S.: 1,285,509 hectares (3,176,553 acres), which contribute to portions of 50 different conservation areas.

An analysis of the major threats to biodiversity was also conducted as part of the Sonoran Desert ecoregional assessment. Threats can be separated into a stress and its sources (conversely, a source of stress can exert one or more stress). A stress is the impairment or degradation of the size, condition, or landscape context of a conservation element that results in reduced viability of the element, whereas the source of stress is the human- or biological-related factor that causes the stress. Over 100 experts provided input on the major threats that are affecting the biodiversity of each of the conservation areas. The major sources identified for 100 landscape-scale conservation areas are listed below (with the number of conservation areas affected by each source and one or more of the primary resultant stresses indicated within the parentheses).

- introduction of non-native plants and animals (73; altered composition/structure, extraordinary competition for resources, alteration of natural fire regimes)

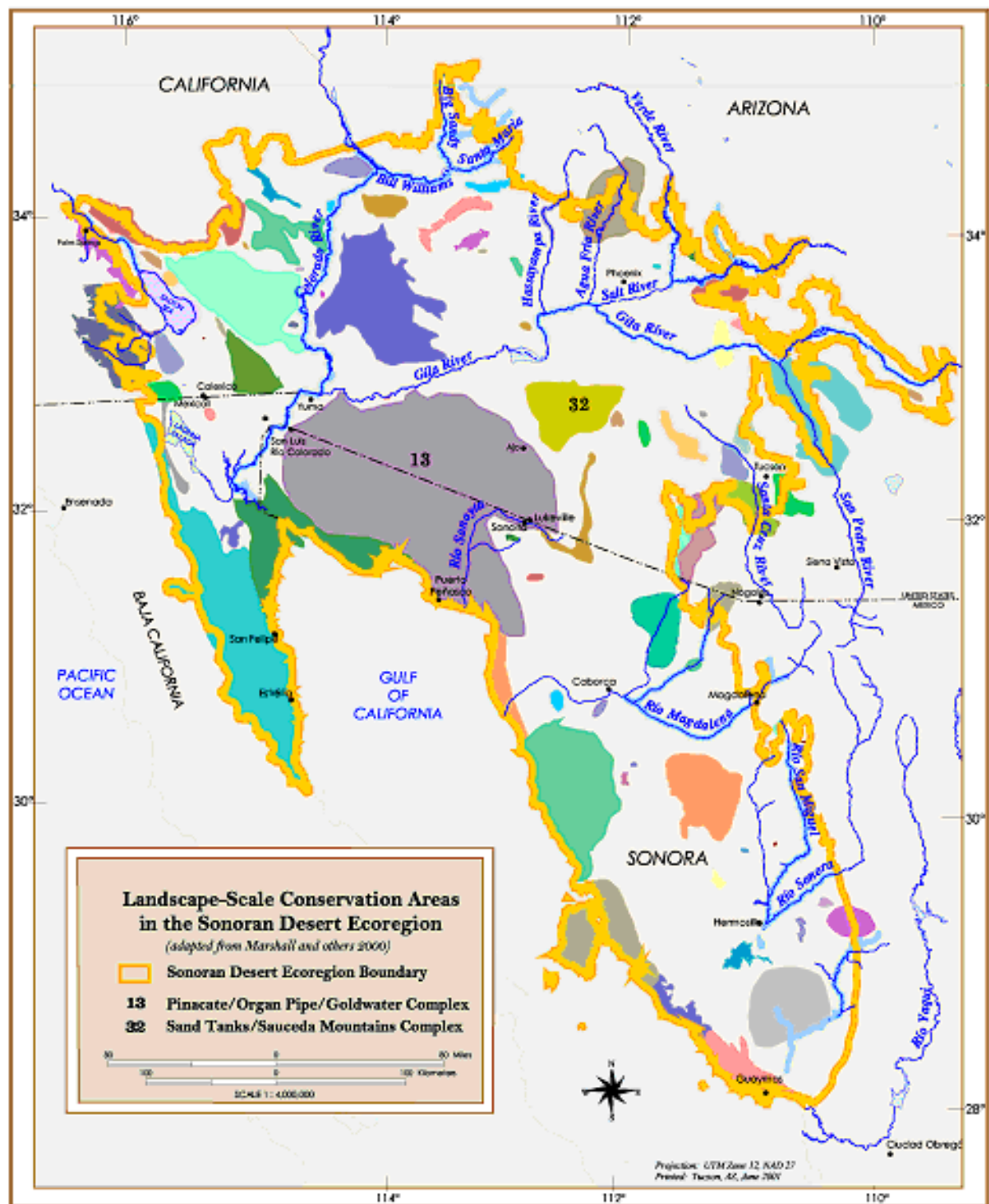


FIGURE 3.3 Landscape-Scale Conservation Areas

- recreation (72; habitat disturbance)
- urban development (56; habitat destruction and fragmentation)
- mining (55; habitat destruction and various other stresses)
- improper livestock management (53; altered composition/structure, excessive herbivory, and in extreme cases habitat conversion)
- extraction of groundwater, diversion, or impoundment of surface water (40; altered of natural hydrologic regimes)
- introduction of fire into non-fire adapted vegetation community (38; alteration of natural fire regimes)
- conversion of desert vegetation to agriculture (35; habitat conversion and fragmentation).

The above activities and land uses represent major, widespread sources of stress to native Sonoran Desert biodiversity. Many of these sources span administrative and political boundaries. The preceding list of sources of stress and accompanying stresses represents a starting point from which we can look more closely at the threats within or among conservation areas and begin to develop comprehensive conservation strategies to limit their impact on Sonoran Desert biodiversity. Human activities are largely responsible for the above-mentioned threats and the Sonoran Desert, as a region with unprecedented population growth (Nabhan and Holdsworth 1999), is likely to witness an increase in at least some of these threats in the coming years. It is critical that we understand the trends in population growth and demographics in the Sonoran Desert Ecoregion, and how they may relate to stresses and their sources, if we are to develop a better understanding of current and predicted future threats to biodiversity.

3.3 SOCIOECONOMIC CONTEXT OF THE SONORAN DESERT NATIONAL MONUMENT

The Sonoran Desert National Monument is located primarily in Maricopa County, with just the far southeastern portion (including Table Top Wilderness) located in Pinal County. Pima County adjoins Maricopa and Pinal Counties and while none of the monument is included in Pima County the “Ajo block” BLM lands are part of the Phoenix South Planning Area (Figure 3.2; Ajo block is located south of the Barry M. Goldwater Range [BMGR]). In addition, the town of Tucson, in Pima County, is a potential source of stakeholders for and users of the monument. Also located within Pima County is the Tohono O’odham Nation, which shares the southeastern border of the monument.

3.3.1 Community Demographics and Economics

The demographics and economics of Maricopa County are dominated by the Phoenix metropolitan area. The total population in Maricopa County in the year 2000 was over 3 million. This is a result of a 217% increase in population between 1970 and 2000, making it one of the fastest growing counties in the nation. Maricopa County has a young median age (33 years), with about a quarter of the population of Hispanic ethnicity. The County has a diverse economy with a median family income of about \$52,000, which is higher than the state average of about \$47,000. The SDNM lies just 60 miles southwest of Phoenix.

Surrounding the monument are several small, rural communities. West of Phoenix along the Interstate 10 corridor are the largest and fastest growing communities whose development activities could impact monument values from the north. Buckeye (2000 population of 6,537) is located near the northwest

corner of the monument. Other communities bordering the monument are much smaller. Gila Bend (2000 population of 1,980) is the only community on the west side of the monument. Maricopa (2000 population of 1,040), Mobile, and Casa Grande (2000 population of 25,244) border on the east. With the exception of Casa Grande, which is a fairly large city with a diverse economy, the smaller communities are distinct in character and are experiencing growth and economic transitions in different ways.

In general, the small towns surrounding the SDNM have been slow growing or even decreasing in population over recent decades. A large Hispanic population is present in these communities (around 45%), and typically high unemployment and poverty rates and low family incomes exist. The economies were dominated previously by agriculture, manufacturing, and construction, but they are in transition to more service-related sectors and, in the case of Maricopa, are becoming bedroom communities for Phoenix. Maricopa, while documented in the 2000 census at just over 1,000 people, is an example of the tremendous change that can happen quickly in these communities. Over the last three years, the character of the area has changed dramatically as new housing developments have sprung up.

As the economy and demographics change around the monument, new issues and pressures (threats) will affect it. As this area develops, additional threats from recreational uses, utility and travel corridors, air quality, invasive species, and other impacts will likely increase. Wildlife corridors and habitat, pristine desert landscapes, and wilderness qualities are likely to decrease unless measures are put in place to protect them from these threats.

3.3.2 Population Growth in the Sonoran Desert and Regions Surrounding the Sonoran Desert National Monument

Gorenflo (2002) used the Sonoran Desert Ecoregion as a case study to show how human population data can be analyzed and mapped to provide input into conservation planning analyses. Gorenflo's (2002) analysis used census data from Mexico and the United States from 1970 to 2000 and population data projected to 2010 to look at spatial and temporal population change in the ecoregion and its relationship to the conservation areas. The most rapid period of population growth in the ecoregion and the most widespread threats to biodiversity began after World War II and continue into the present day. Manufacturing industries have developed on both sides of the border, and tourism activities and retirement populations have expanded primarily on the U.S. side. In 1970 the population in the Sonoran Desert Ecoregion was approximately 2.3 million and by 1990 it had almost doubled to 4.7 million (Gorenflo 2002). The average annual percent change in population in the Sonoran Desert from 1970 to 1980 was 4.1%, and it decreased only slightly to 3.3% from 1980 to 1990 and to 3.1% from 1990 to 2000 (Gorenflo 2002). If the 1990 to 2000 demographic changes are projected to continue at the same pace through the year 2010, then the region will reach 8.8 million people by 2010. This would represent an almost quadrupling of the population over a 40-year period.

Figure 3.4 depicts the relationship between the conservation areas identified by Marshall and others (2000) and the population density in the year 2000 (top map) and the average annual rate of population growth from 1990 to 2000 (bottom map). These maps are adapted from Gorenflo (2002) and are based on census tract data in the United States, which is more fine-scaled than county data. Census data from Mexico were not included in these particular analyses because available census data for these years were lacking at the appropriate scale. The boundaries of Conservation Area No. 32 encompass the Sand Tank Mountains in the southern portion of the Sonoran Desert National Monument (this conservation area will be discussed in detail in section 3.4.1). It is clear from Figure 3.4 that although the conservation area has a low population density, it is located in proximity to areas with a high rate of population growth from 1990 to 2000.

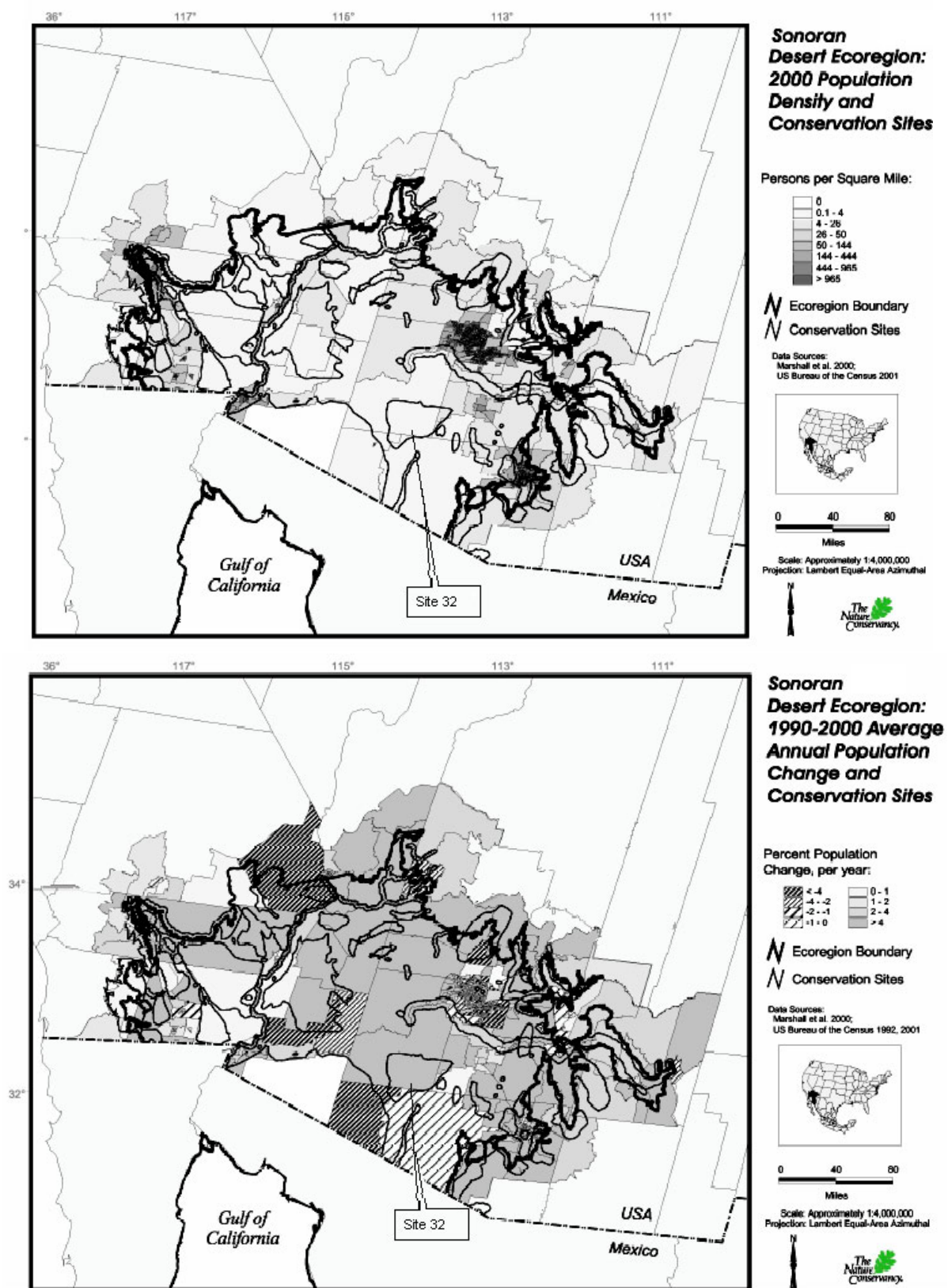


FIGURE 3.4 Population Density (2000; Top) and Average Annual Population Change (1990 to 2000; Bottom) in Relation to Conservation Sites (Areas)

The SDNM is, and will continue to be, affected by growth pressures from the Phoenix Metropolitan Area and the growth of towns near the monument boundary. The Sonoran Institute contracted with Blueline Consulting Group, part of the Sustainability and Global Change Institute at Prescott College, to develop a population growth and land-use allocation model to evaluate the current trends and potential future impacts of growth on the monument as part of the SDNM biodiversity management framework project. The objective of model development was to provide users with a tool to rapidly generate land-use change scenarios and impacts. Users can apply various growth rate and land-use allocation assumptions as part of scenario development.

Blueline Consulting Group developed a number of reasonable scenarios to illustrate a range of potential land-use change patterns (Blueline Consulting Group 2004). The specific population growth projections, and the timeframes over which they occur, that drive these changes are not as important in the discussion here as the expected development patterns that would result. No matter what growth rates are considered BLM will need to factor in the consequences of population growth for its management of the monument, though certainly higher growth rates will result in more near-term consequences. From the standpoint of growth-induced encroachment along the SDNM boundary or growth affecting the monument's connectivity to other natural resource management areas (such as the Sierra Estrella Wilderness northeast of the SDNM), the following patterns are discernible from the scenarios. The southern boundary of the monument is contiguous with the Barry M. Goldwater Range and the Tohono O'odham Nation and is, therefore, somewhat protected from the impacts of growth. The resources along the east boundary; however, could be affected by growth around Maricopa, especially if growth extends into the Vekol Valley south of Mobile. The western boundary would be affected by growth in Gila Bend and Buckeye that also would extend along the Highway 85 corridor. Most of the growth pressure appears to affect the northern boundary of the monument. The Interstate 10 corridor, Tonopah, Buckeye, Goodyear, and the Rainbow Valley areas are predicted to grow the fastest as the Phoenix Metropolitan Area continues to expand. The potential development footprint of Goodyear itself would affect the SDNM's connectivity with other management areas and also directly encroach on a portion of the monument's northern boundary.

3.4 ECOLOGICAL CONTEXT OF THE SONORAN DESERT NATIONAL MONUMENT

The conservation areas identified in Marshall and other's (2000) Sonoran Desert ecoregional assessment serve as a "conservation blueprint" that can guide conservation action towards areas where there is the best chance to successfully protect and conserve the region's biological diversity. Portions of eighteen conservation areas occur within the BLM Phoenix South planning area. The largest conservation area that is wholly contained within the BLM Phoenix South planning area is Conservation Area (CA) 32, the Sand Tank/Sauceda Mountains Complex.

3.4.1 Sand Tank/Sauceda Mountains Complex Conservation Area

The Sand Tank/Sauceda Mountains Complex conservation area overlaps with the boundaries of the Sonoran Desert National Monument (Figure 3.2). Marshall and others (2000) assessment was the first analysis that highlighted the ecological importance of this area, which is now partially incorporated within the boundaries of the Sonoran Desert National Monument. The ecoregional data associated with the Sand Tank/Sauceda Mountains Complex serve as a starting point from which we can evaluate the regional significance of the biological resources within the SDNM. The boundaries of the landscape-scale conservation areas in the Sonoran Desert Ecoregion were based on the available conservation element occurrence data at the time the ecoregional assessment was conducted. Conservation areas were delineated at a coarse geographic scale (approximately 1:500,000), which was appropriate for planning within the 22-million hectares ecoregion. Conservation planning within any one of the conservation areas identified in the ecoregional assessment can be significantly enhanced by the addition of fine-scale

information. In other words, the boundaries of CA 32 are not “hard” and areas within the SDNM and proximity that are excluded from CA 32, such as the Maricopa Mountains, are not necessarily unimportant ecologically. When planning at a finer geographic scale, such as for the Sonoran Desert National Monument, conservation area boundaries identified at the ecoregional scale often need to be adjusted. To make the most ecologically appropriate adjustments, ecoregional data on conservation element occurrence and threats should be supplemented with more detailed and finer scale information (Groves 2003).

3.4.2 Conservation Goals for Conservation Elements in the Sand Tank/Sauceda Mountains Complex

One of the challenges of conservation biology is to determine “how much is enough”; that is, how much area of a natural community or how many populations of a species are needed, and where should they occur on the landscape, to maintain the genetic variation and long-term viability of species and communities. Conservation goals are set for conservation elements to address this question and to determine if the network of conservation areas is adequate to maintain the long-term viability of Sonoran Desert biodiversity. In the Sonoran Desert ecoregional assessment (Marshall and others 2000) conservation goals were set for each conservation element based on their global rarity and/or their historic or current distributions. For matrix communities, such as paloverde-mixed cacti, the conservation goal was based on maintaining a percentage of the community’s historic extent. The goal for rare (global ranks G1 and G2) and/or listed species was to maintain all viable occurrences (by including all occurrences within conservation areas). Conservation goals for other species of management concern consisted of two components to capture viable populations of species and maintain their occurrence across their natural range of variation. These two components were (1) total number of occurrences and (2) distribution among biotic subdivisions within the ecoregion. The network of conservation areas shown in Figure 3.3 is a first attempt to meet the conservation goals set for as many of the 353 species and 78 natural community conservation elements of the Sonoran Desert Ecoregion as possible (Marshall and others 2000).

The boundaries of CA 32 encompass 13 conservation elements that represent a couple of natural communities and all major higher taxonomic groups except fish and invertebrates. Table 3.1 lists the conservation elements that occur within CA 32, identifies their respective conservation goals, and indicates whether or not the goals were met. Table 3.1 also demonstrates the relative significance of CA 32 towards conserving each element by presenting (1) the number of conservation areas in which each conservation element occurs, (2) the number of occurrences of each conservation element within CA 32, (3) the number of occurrences within all conservation areas combined, and (4) the number of occurrences (of species only, not natural communities) within the entire Sonoran Desert.

It is notable that four of the 13 conservation elements (tobosa grassland, gilded flicker, Abert’s towhee, and Sonoran green toad) did not meet their conservation goals (Table 3.1). Furthermore, the tobosa grassland was only identified in one other conservation area. This indicates that based on the available occurrence data, CA 32 may be important in the conservation of these four species/communities and that the network of conservation areas proposed by Marshall and others (2000) and exhibited in Figure 3.3 may be insufficient to ensure their long-term conservation. As the primary land managers associated with CA 32, the BLM, Department of Defense, and the Tohono O’odham Nation have an opportunity to make significant contributions towards the conservation of these species and communities by managing their lands so that viable populations and natural communities are maintained.

Other noteworthy conservation elements in CA 32 are the rare/special status species whose conservation goal is to maintain all viable occurrences (Kofa barberry, acuña cactus, red-backed whiptail, and Sonoran

TABLE 3.1 Conservation Elements in the Sand Tank/Sauceda Mountains Complex and Their Conservation Goals (Derived from Data in Marshall and others 2000)

Common Name	Scientific Name	Global Rank ¹	Conservation Status ²	Conservation Goals ³	No. Conservation Areas (CA) with Element	No. Occurrences in CA 32	No. Occurrences in all Conservation Areas in the Sonoran Desert	Total Species Occurrences in Sonoran Desert ⁴	Numeric Goal	Distribution Goal
Community										
Tobosa grassland ⁵	<i>Pleuraphis mutica</i> ⁵	G2		40 sites	2	1	2	N/A	Not met	Not met
Palo verde-mixed cacti (group)	<i>Parkinsonia-Carnegeia-Opuntia</i> (group)	GU		30% of historic extent	9	2	72	N/A	Met ⁶	Met ⁶
Ecological gradient	Ecological gradient			N/A	14	1	14	N/A	N/A	N/A
Plant										
Kofa barberry	<i>Berberis harrisoniana</i>	G1G2	BLM	Maintain all viable occurrences	3	2	10	10	Met	N/A
Acuña cactus	<i>Echinomastus erectocentrus</i> var. <i>acunensis</i>	G3T1Q	ESA(C), MEX(P), NPL(HS)	Maintain all viable occurrences	6	2	12	12	Met	N/A
Amphibian										
Sonoran green toad	<i>Bufo retiformis</i>	G3G4	MEX(R)	Maintain ≥ 6 viable occurrences in each Subdivision, or ≥ 24 occurrences for all Subdivisions in which the species occurs	5	1	13	13	Not met	Not met

TABLE 3.1 Conservation Elements in the Sand Tank/Sauceda Mountains Complex and Their Conservation Goals (Derived from Data in Marshall and others 2000)—continued

Common Name	Scientific Name	Global Rank ¹	Conservation Status ²	Conservation Goals ³	No. Conservation Areas with Element	No. Occurrences in CA 32	No. Occurrences in all Conservation Areas in the Sonoran Desert	Total Species Occurrences in Sonoran Desert ⁴	Numeric Goal	Distribution Goal
<i>Reptile</i>										
Red-backed whiptail	<i>Cnemidophorus burti xanthonotus</i> ⁷	G4T2	ESA(SC), BLM, USFS	Maintain all viable occurrences	2	2	8	8	Met	N/A
Desert tortoise	<i>Gopherus agassizii</i> (Sonoran population)	G4T?	ESA(SC) MEX(A), WSCA	Maintain ≥ 6 viable occurrences in each Subdivision, or ≥ 24 occurrences for all Subdivisions in which the species occurs	28	20	263	530	Met	Met
<i>Bird</i>										
Gilded flicker	<i>Colaptes chrysoides</i>	G5	BCC, CA(SE)	Maintain ≥ 6 viable occurrences in each Subdivision, or ≥ 24 occurrences for all Subdivisions in which the species occurs, to maintain their status at the rank of G3 or above	8	1	14	14	Not met	Not met

TABLE 3.1 Conservation Elements in the Sand Tank/Sauceda Mountains Complex and Their Conservation Goals (Derived from Data in Marshall and others 2000)—continued

Common Name	Scientific Name	Global Rank ¹	Conservation Status ²	Conservation Goals ³	No. Conservation Areas with Element	No. Occurrences in CA 32	No. Occurrences in all Conservation Areas in the Sonoran Desert	Total Species Occurrences in Sonoran Desert ⁴	Numeric Goal	Distribution Goal
Abert's towhee	<i>Pipilo aberti</i>	G3		Maintain ≥ 6 viable occurrences in each Subdivision, or ≥ 24 occurrences for all Subdivisions in which the species occurs	9	1	12	12	Not met	Not met
Mammal										
Sonoran pronghorn	<i>Antilocapra americana sonoriensis</i>	G5T1	ESA(LE), WSCA, MEX(P)	Maintain all viable occurrences	4	1	23	23	Met	N/A
California leaf-nosed bat	<i>Macrotus californicus</i>	G4	ESA(SC), BLM, WSCA	Maintain ≥ 6 viable occurrences in each Subdivision, or ≥ 24 occurrences for all Subdivisions in which the species occurs	34	5	137	198	Met	Not met ⁸
Cave myotis	<i>Myotis velifer</i>	G5	ESA(SC), BLM	Maintain ≥ 6 viable occurrences in each Subdivision, or ≥ 24 occurrences for all Subdivisions in which the species occurs	26	2	63	95	Met	Not met ⁸

¹Global Ranks indicate the rarity and vulnerability of a taxon or plant community across its distribution. Global Rankings range from G1 (most rare and imperiled) to G5 (common and secure). Definitions for all global ranks are provided in Appendix A, Table A.1.

²Legend: BLM: BLM Sensitive Species; BCC: U.S. Fish and Wildlife Service Bird of Conservation Concern; CA: Listed as Threatened or Endangered in California; ESA: federal protection in the U.S.; MEX: federal protection in Mexico; NPL: Arizona Native Plant Law; WSCA: Wildlife of Special Concern in Arizona; USFS: USFS Sensitive Species. See Appendix A, Table A.2 for conservation status codes and definitions.

³Conservation goals for species are determined based on the global rank of the taxon and degree of endemism. Conservation goals for natural communities are based on distribution and spatial patterns of occurrence within the ecoregion. See Marshall and others (2000) for additional details.

⁴The total number of occurrences in the Sonoran Desert is based on data used in the ecoregional assessment (Marshall and others 2000) and includes National Heritage Program element occurrence data for Arizona, California, and Sonora, expert-delineated polygons of occurrences, and other data sources. This information was available only for species and not natural communities. Subdivision refers to the Arizona Upland, Central Gulf Coast, Lower Colorado River Valley, and Plains of Sonora Subdivisions in the Sonoran Desert Ecoregion.

⁵This community was inaccurately identified as big galleta grassland (*Pleuraphis rigida*) in Marshall and others (2000).

⁶The estimated extent of paloverde-mixed cacti community circa 1800 is 1,616,000 hectares (4,040,000 acres) in the Arizona Upland Subdivision and 536,800 hectares (1,342,000 acres) in the Lower Colorado River Valley Subdivision (Marshall and others 2000). The estimated current extent of this community within the conservation areas in each respective subdivision is 569,630 hectares (1,424,080) and 168,750 hectares (421,870 acres). This translates to 35% of the historic extent of paloverde-mixed cacti community in the Arizona Upland Subdivision and 31% in the Lower Colorado River Valley Subdivision.

⁷Crother (2000) elevated this taxon to a full species (*Cnemidophorus xanthonotus*). Crother and others (2003) recognized a change in the name of the genus to *Aspidoscelis*.

⁸Goals were not met for this species in the Central Gulf Coast and Plains of Sonora Subdivisions, most likely due to a lack of occurrence data for the species in these regions in Mexico.

pronghorn²) and the Sonoran desert tortoise. The Sand Tank Mountains have one of the highest densities of desert tortoise documented in the entire ecoregion. Of the 28 conservation areas where Sonoran desert tortoise were documented, only three conservation areas had more occurrences than CA 32: Kofa Complex (54 occurrences), Pinacate/Organ Pipe/Goldwater Complex (CA 13 on Figure 3.3; 46 occurrences), and San Pedro River/Aravaipa Creek (22 occurrences).

3.4.3 Regional Perspective of the Biodiversity of the Sonoran Desert National Monument

As previously mentioned, Marshall and others (2000) were the first to produce a regional-scale assessment that highlighted the unique and significant biological resources of the region encompassed in Conservation Area 32, including portions of the Saucedo Mountains, Sand Tank Mountains, Coffee Pot Mountain area, Vekol Valley, and Table Top Mountain. Subsequent reports and analyses, such as that produced by Marshall (2000) and Turner and others (2000) provided additional detail and more local-scale information on the biodiversity of the SDNM and vicinity. These assessments not only provide lists of species and natural communities that occur on the monument, but they also offer a regional perspective that emphasizes the significance and uniqueness of the biological resources on the SDNM within their broader ecological context.

Some of the conservation elements that occur within CA 32 represent high quality examples compared with their occurrences within other conservation areas in the ecoregion. For example, although extensive areas of the paloverde-mixed cacti community remain throughout the Sonoran Desert, the examples of this community in the Sand Tank and Saucedo Mountains have been described by Marshall (2000) as one of the most structurally complex examples in the Sonoran Desert. Exceptionally dense stands of saguaro, a high density of leguminous trees and cacti, and abundant native annual and perennial grasses that extend over a largely unfragmented landscape characterize this community on the SDNM and adjoining portions of the BMGR. The SDNM and adjoining portions of the Tohono O'odham Nation also are distinguished within the Sonoran Desert ecoregion by the fine soils in the Upper Vekol Valley that support one of the only—and largest—tobosa grasslands remaining in the Sonoran Desert (see section 3.4.2).

Ecoregional assessments rely heavily on spatial data such as element occurrence datasets such as those available from Natural Heritage Programs. These datasets, however, are never complete, and some species may occur in areas for which there is an absence of data. Species inventories and compilations of finer scale information on the SDNM, such as that provided in Turner and others (2000), were not available at the time of Marshall and others (2000) analysis of conservation priorities in the Sonoran Desert Ecoregion. As a result, although the ecoregional assessment documents 13 conservation elements occurring within CA 32, other sources of data indicate that additional ecoregional conservation elements occur within CA 32 and the remainder of the SDNM. The SDNM likely contributes towards meeting the ecoregional conservation goals for these species and communities as well. In arriving at an appropriate list of conservation elements representative of the biodiversity of the SDNM and its regional significance, we therefore accounted for both the information in Marshall and others (2000) plus additional sources of ecological information (see Chapters 5 and 6 for additional details on SDNM conservation element selection criteria and the results of the selection process).

²Conservation Area 32 was identified primarily as historical and/or potential future habitat for the Sonoran pronghorn. A pronghorn was documented crossing Highway 85 from west to east in the vicinity of the Crater Range on the BMGR, which is a direct connection to the Saucedo Mountains, Vekol Valley, and Sand Tank Mountains (Marshall 2000).

3.5 CONCLUSIONS

The information provided in this chapter sets the regional context for discussing the biological resources of the SDNM and the accompanying socioeconomic issues BLM may face regarding their present and future management. Because the regional information is coarse in its detail, finer scale information, when available, will often be needed to better define the biodiversity of the SDNM and vicinity and the stresses and sources of stress that threaten its long-term viability. The regional-scale information helps to identify the relative significance of SDNM biodiversity and to indicate what the overall trends may be for particular resources and their associated threats so that monument-specific management decisions are crafted within an appropriate context.

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CHAPTER 4 INTEGRATING ECOSYSTEM MANAGEMENT PRINCIPLES INTO THE PLANNING PROCESS FOR THE SONORAN DESERT NATIONAL MONUMENT

This chapter overviews how the Sonoran Desert National Monument (SDNM) biodiversity management framework: (1) incorporates the principles of an ecosystem-based approach to biological resources management (hereafter referred to as ecosystem management), (2) can be integrated with the Bureau of Land Management's (BLM) land-use planning process, and (3) can facilitate meeting the requirements of the SDNM proclamation. The following sections address the preceding purposes by providing a:

- brief overview of the framework's conceptual basis and its relationship to ecosystem management principles
- description of the general relationship of the framework to the BLM planning process and the SDNM proclamation objectives
- description of the more specific relationship between framework-related information and BLM's analysis of the management situation planning step.

4.1 OVERVIEW OF THE BIODIVERSITY MANAGEMENT FRAMEWORK

The biodiversity management framework is based on the premise that it can provide federal land managers with a pro-active, ecosystem-based approach to natural resources management, which can complement compliance-driven management. The Nature Conservancy in Arizona developed the framework by adapting the Conservancy's conservation area planning process (TNC 2000) to reflect the typical scale and planning requirements of a federal land management unit. The framework consists of a sequence of steps that in combination provide federal land managers the information and context they need to enhance the effective and efficient management and protection of biodiversity on federal lands.

To address the human dimensions of biodiversity management and protection, the Conservancy teamed with the Sonoran Institute (Institute) to refine the framework for its application to the SDNM by integrating social science information into the different steps of the framework. This refinement, as well as other enhancements, builds on the lessons learned from the application of the framework to the natural resource management needs of the Barry M. Goldwater Range (BMGR; Hall and others 2001).

4.1.1 Framework Steps

The complete framework includes six steps. The last step may be performed as a separate exercise, as it entails development (and implementation) of an adaptive management strategy that may follow subsequent to a land-use planning process and resultant management plan. The steps described below should each be conducted if the full benefits of the framework are to be realized; however, this may not always be possible. Elsewhere in this document, we describe the steps, or portions thereof, that were accomplished for the SDNM.

Step 1: Identify a Set of Conservation Elements

A set of conservation elements (species and natural communities) must represent—in essence serve as a surrogate for—the native biodiversity of an area. The rationale behind selecting a representative, limited number of conservation elements is extensively discussed in the literature (see Parrish and others [2003] and references cited therein). Element selection includes a consideration of the regional context of an element's occurrence (for example, whether it is endemic to the region) and the relative importance of the area under consideration to that element's conservation. In addition, elements are selected and often defined in association with the ecological processes that sustain them. Because it is impractical to consider and analyze data for all species, communities, ecosystems, and landscapes that may occur within a planning area, and because data are often lacking to guide the management of all but a few species, the framework uses a hierarchical approach, or more specifically a coarse filter-fine filter (Hunter 1991, Haufler and others 1996), to ensure representation and to make sure the set of elements chosen is manageable and relevant. The details of the selection process for the SDNM are provided in Chapter 5.

Step 2: Compile Information about Each Conservation Element

For each conservation element, information is compiled from the literature and other sources (including local resource managers and researchers) that addresses the management-relevant ecological information and conservation status of each element, including its spatial distribution within the planning area and adjoining areas if known. Collected information includes the identification of stresses and their sources, within the planning area and regionally, that threaten the long-term viability of the conservation elements. In addition, if a fine-filter element has specific habitat management needs that are not captured through management of the coarse-filter elements, these are identified as well.

Step 3: Derive Potential Future Ecological Conditions

Potential future ecological conditions are derived for each conservation element. The information can inform the selection of desired conditions and conservation goals by the federal land manager. We distinguish potential from desired conditions here to illustrate that the framework provides achievable options (potential conditions) that the land manager may ultimately adopt in part, completely, or not at all as its desired conditions through the land-use planning process. Quantitatively defined conditions are preferable, but are not always achievable. Ecological models that conceptually describe the interaction between ecological conditions (state) and disturbances (transitions) for natural communities or life history requirements of species can be developed on a case-by-case basis depending on the available information to help guide development of future condition descriptions and provide a road map for the manager for achieving desired conditions.

Step 4: Identify Threat Abatement Strategies

In this step threat abatement strategies are identified that can be either specific to a particular conservation element or applicable to multiple elements. Threat abatement strategies should respond to the specific stresses and sources of stress identified in Step 2 above. In addition, if desired, framework information can be used in this step to identify geographically defined land management categories and associated management standards, as was done for the Barry M. Goldwater Range (Hall and others 2001). Management standards may provide one of the mechanisms for implementing a particular threat abatement strategy.

Step 5: Develop Monitoring Objectives

Monitoring objectives are identified for the conservation elements that focus on relevant management questions and information needs. The desired future ecological conditions for each conservation element inform this process. Monitoring objectives also can be threat-based at least in part and, as a result, may include a focus on assessing the status of major stresses and their sources and the success of associated threat abatement strategies.

Step 6: Develop and Implement an Adaptive Management Strategy

As part of the framework or as part of a separate process, the information collected to this point, especially the objectives identified in Step 5 above, is used to develop an adaptive management strategy. Under such a strategy, data collected during monitoring on resource and threat trends must enable the resource manager to make appropriate management adjustments. As a result, indicators should be selected for monitoring that respond to the objectives, enable the effects of management to be measured, and provide a sufficient warning as to when a management adjustment is needed. Most importantly, monitoring should be hierarchical—for example, by considering landscape, community, species, and genetic levels (Noss 1990, Haufler and others 2002)—in its planning and execution, so that it is efficient, affordable, effective, and easily implemented. The adaptive management strategy also should account for appropriate ecological boundaries and the regional context, as the status of a conservation element is dependent not only on its viability within the land management unit but also within a broader ecologically defined assessment area (analysis area of BLM 2005) and the region. With these considerations in mind, the adaptive management strategy also could be used to identify appropriate opportunities for coordinated management with adjacent land managers. Finally, the strategy is implemented, lessons are learned, and adjustments are made as necessary to both the monitoring aspects of the strategy and management actions.

Additional details on the framework and its application, especially with respect to the SDNM, are provided in subsequent chapters that deal with specific steps. In the next section, however, we first describe much of the conceptual basis underlying the framework by its relationship to the principles of ecosystem management.

4.1.2 Framework Relationship to Ecosystem Management Principles

The biodiversity management framework is rooted in the principles of ecosystem management (see Grumbine [1994] for one example of an articulation of these principles), with many of its precepts based on contemporary conservation biology theory (Noss 1990, Poiani and others 2000). To illustrate the relation of the framework to ecosystem management principles, Table 4.1 identifies several ecosystem management principles stated in broad terms, descriptive elements of each principle that are explanatory of what the principle is intended to address, and how the framework meets each principle. Whenever possible, examples appropriate to the SDNM are used to illustrate the framework's correspondence; however, as the framework is incomplete for the SDNM (for example, it does not include at this time an adaptive management strategy), we describe how the framework may meet the principle in its general application.

All principles outlined in Table 4.1 should be considered if the goal is to fully implement an ecosystem management approach. Additional principles of ecosystem management, such as organizational change (Grumbine 1994), are not addressed here as they are supplemental to the steps of the framework. Still, for effective implementation federal agencies should consider this latter principle as well. Ecosystem management as an approach to federal land management is still a work in progress and many of its finer

TABLE 4.1 Principles of Ecosystem Management and Framework Correspondence

Principle	Descriptive Elements	Framework Correspondence
Regional Context	- Includes consideration of the human and ecological context beyond the planning/management area. - Provides information on the relative significance (biological and use) of the resources that are to be managed. - Addresses broader patterns of landscape change, such as regional patterns of growth, climate change, regional air quality, watershed “health,” nutrient deposition, invasive species, and so on. - Provides contextual information to guide monitoring questions and management priorities.	- SDNM framework relies on the information contained in Marshall and others (2000) for its regional biological context. - For social context, much of the relevant information, such as local demographic and economic profile data, has been gathered as part of this framework. - Regional-scale information is used to help guide selection of conservation elements and to evaluate the relative significance of the SDNM to their conservation, as well as to identify pervasive regional-scale threats.
Hierarchical Context	- Provides for a “systems” perspective that encompasses: - Levels of the biological hierarchy (genes, populations-species, communities-ecosystems, regional landscapes) - Spatial (local, intermediate, coarse, and regional) and temporal (near-term to evolutionary) scales - Connections between all levels and scales (including how they “nest” when considering management strategies). - Forces a shift in focus from the protection and management of individual species to the conservation of higher levels of the biological hierarchy (within which species nest).	- Coarse filter-fine filter approach (Hunter 1991, Haufler and others 1996) encompasses different biological levels and spatial scales of occurrence and ecological function. - Natural communities serve as the coarse filter. - Fine filter consists of species, guilds, and specialized habitats that are selected on the basis of several screening criteria (see Chapter 5). - Intact and functioning coarse filter is presumed to meet the management needs for species not selected as fine-filter elements.
Ecological Boundaries/ Collaborative Management	- Requires working across administrative/ political boundaries and defining ecological boundaries at appropriate scales. - Necessitates coordinated management of natural communities, species, and their associated ecological processes that occur across administrative boundaries, which can lead to developing: - Common objectives for similar/shared resources (shared spatially or in identity).	- Conservation element occurrence and ecological process attributes are assessed as they occur on the ecologically defined landscape and not just within the SDNM boundaries. - Natural communities are mapped and assessed across the SDNM’s boundary with the Barry M. Goldwater Range and Tohono O’odham Nation to capture shared resources.

TABLE 4.1 Principles of Ecosystem Management and Framework Correspondence—continued

Principle	Descriptive Elements	Framework Correspondence
Ecological Boundaries/ Collaborative Management-continued	2. Common tools or metrics for monitoring (to be able to assess management across boundaries) 3. Collaborative management decisions, while retaining individual mission-related decision authority.	• Species information also is prepared with ecological boundaries in mind.
Ecological Integrity	• Emphasizes protection of total native diversity (genes, populations-species, communities-ecosystems) and the ecological patterns and processes that maintain that diversity. • Includes addressing: 1. Conservation (and/or restoration) of viable populations of native species 2. Maintenance of disturbance regimes and ecological patterns and processes 3. Representation of ecosystem types across their natural ranges of variation. • Includes consideration of socioeconomic change and its influence on integrity (human population growth, development encroachment) • Involves considerations relative to each conservation element of: 1. Size (minimum dynamic area, metapopulation size) 2. Condition (composition, structure, function [ecological or demographic processes integral to the biotic element under consideration]). Ecological integrity of a biotic element will be maintained when the factors that contribute to condition are within their natural/historical range of variability. 3. Landscape context (connectivity and fragmentation, ecological gradients, external ecological processes). • Involves distinguishing between ecological integrity and ecosystem health, in which the latter concept implies that the management goal includes some level of sustainable human exploitation of resources.	• Coarse filter-fine filter approach is used both to ensure overall native biodiversity on the SDNM is represented when considering management actions and to make the total number of conservation elements selected efficient for management purposes. • Moreover, conservation element selection under the framework, in addition to its emphasis on addressing different levels of the biological hierarchy and spatial scales, also focuses on separately identifying these elements in part based on their dependency on different ecological processes or responses to different types of threats. • Social science data serve to identify the human influences on the selected conservation elements and also to identify those elements people value. • Each conservation element, or combination of elements when appropriate, is evaluated for its current ecological integrity and potential future ecological condition (see Hall and others [2001] for examples of this application).
Adaptive Management	• Encourages viewing management as a learning process or continuous experiment in which incorporating the results of previous actions enables resource managers to remain flexible and to adapt to uncertainty.	• Management decisions must be made in the presence of uncertainty. • Because framework information is based on the

TABLE 4.1 Principles of Ecosystem Management and Framework Correspondence—continued

Principle	Descriptive Elements	Framework Correspondence
Adaptive Management-continued	- Includes 3 main components: 1. Data collection—historical and contemporary social and biological data sets; contemporary analytical tools 2. Monitoring—should be effective, efficient, and hierarchical in its approach; address management questions; set quantitative benchmarks, when possible, against which the manager can assess the success or failure of management actions. 3. Flexible decision space—allows the manager to institutionalize new learning, be responsive to change, and alter management actions based on new information.	most contemporary information available and is hierarchical and forward-thinking in its approach, the effects of uncertainty are limited to the extent achievable. - Framework also incorporates a thematic approach (see Hall and Marshall [2002] for an early expression of these themes, which are a work in progress) to devise an appropriate monitoring and adaptive management strategy that: 1. Focuses on the most relevant management questions and information gaps associated with the selected conservation elements 2. Approaches monitoring from a hierarchical perspective to gain efficiency 3. Incorporates ecological models 4. Facilitates flexible decision space for the resource manager.
Humans Embedded in Nature	- Humans have profound influences on ecological patterns and processes and are in turn affected by them. - Ecosystem management must meet human needs and address human values. - Human uses of ecosystems must be compatible with long-term maintenance of ecological integrity and ecosystem health.	- Social science information is collected and applied to address: 1. Value people place on particular biological resources and biodiversity in general, as well as non-biological values 2. Threats human activities pose to the long-term viability of biodiversity 3. Opportunities provided by working with human communities to forge solutions that are protective of biodiversity values while meeting compatible human needs on the SDNM.

points of implementation continue to undergo refinement as conservation biology theory advances through experimentation and learning by doing.

4.1.3 Integration of Social Science Information

The Institute's community-based approach to conservation recognizes the linkages between human communities and the biodiversity of western landscapes. Human valuation of these landscapes is the basis for natural resource decisions. By understanding the values, economies, and quality of life in local communities, federal land managers can more effectively engage community members in the public planning process, and they can make more informed decisions that are supported by these communities. Social science information collected and compiled by the Institute can inform not only the framework, but also several other aspects of the BLM planning process for the SDNM. In the context of the framework,

social science information is used to instruct conservation element selection, threat analysis (in terms of both stresses and sources of stress), and threat abatement strategies.

Social science information, collected at the appropriate scale(s), can help federal land managers anticipate and understand those anthropogenic stresses and their sources that may threaten the persistence of a region's biodiversity. For example, by understanding and preparing for changes in recreational use within a land management area that may accompany regional population growth and changing demographics, managers are better positioned to make decisions that anticipate and accommodate such changes while still protecting both the area and region's biodiversity. Social science information and its application can be conservation element specific or it can provide details on regional-scale changes in human demographic and development patterns that may have pervasive effects on the native biodiversity of the SDNM.

Metrics of socioeconomic status, or social indicators, may include aspects of demographics, culture, economics, land and resource use, and environmental quality that are each considered at various geographic scales, including regional, county, and community. Assessment of these indicators can facilitate a better understanding of social conditions, trends, and rates of change. Selection of social indicators involves the federal land manager, social scientists, and civil leaders. Chapter 7 provides detailed information on the types of social information collected as part of the biodiversity management framework for the SDNM.

4.2 FRAMEWORK RELATIONSHIP TO THE BUREAU OF LAND MANAGEMENT'S LAND-USE PLANNING PROCESS AND SONORAN DESERT NATIONAL MONUMENT PROCLAMATION

The previous section outlined the relationship of the biodiversity management framework to the principles of ecosystem management. This section identifies areas of correspondence between the framework and BLM's planning decisions and land-use planning process.

4.2.1 How the Bureau of Land Management Makes Land-Use Planning Decisions

Chapter 2 outlined the regulatory steps BLM follows to prepare and implement a resource management plan. These steps, which in brief address: issue identification; planning criteria; data compilation; management situation analysis; alternative formulation, effects analysis, and selection; and plan monitoring and evaluation, are all integral to the types of decisions BLM can make within a resource management plan. This land-use planning process results in plan decisions that fall into two categories: (1) desired outcomes (expressed as goals and objectives) and (2) allowable uses (including restricted or prohibited) and actions anticipated to achieve desired outcomes (BLM 2000c, 2005). In addition, BLM resource management plans also may incorporate specific management standards and criteria into the planning process.

Desired Outcomes

The BLM Land Use Planning Handbook (BLM 2000c, 2005) defines goals as generally broad statements of desired outcomes, whereas objectives identify specific, usually quantifiable and measurable desired conditions for resources. The goals and objectives serve as the basis for determining allowable uses and actions.

Allowable Uses and Actions

Although site-specific use levels are normally identified during subsequent implementation planning, the resource management plan must set the broad context for identifying site-specific resource use levels

(BLM 2000c, 2005). For example, the resource management plan will identify lands open or closed to specific uses.

Actions can include proactive measures to restore or protect land health or administrative designations such as Areas of Critical Environmental Concern (ACEC). Actions also can include land tenure decisions, in which BLM identifies lands for retention, proposed disposal, or acquisition. Land tenure decisions must be in concert with the desired outcomes articulated in the resource management plan (BLM 2000c). The proclamation establishing the SDNM also can be interpreted as establishing specific desired outcomes and allowable uses that must be incorporated into the resource management plan for the SDNM (see section 4.2.3).

Management Standards

Standards are descriptions of physical and biological conditions or the degree of function required for healthy, sustainable lands. Standards may address both site-specific and landscape- or watershed-scale conditions. In Arizona an important standard that is incorporated into all land-use plans in the state are the Arizona Standards for Rangeland Health and Guidelines for Grazing Administration (approved April 28, 1997 by the Secretary of the Interior).

4.2.2 Framework Relationship to Bureau of Land Management Land-Use Planning

In a February 2000 report to Congress, “Land Use Planning for Sustainable Resource Decisions,” the BLM outlined its strategy for correcting deficiencies associated with its aging and outdated land-use plans (BLM 2000a). The reasons that plans had become outdated included: (1) rapid population growth in the West that has led to urban expansion and encroachment into previously rural areas, (2) changing demographics and values, (3) changing use demands, (4) continued species declines, (5) special designations, and (6) broader scientific understanding of ecological principles and scale considerations, which in combination exceeded BLM’s capacity to resolve existing land use conflicts, much less correct deficiencies in older plans or plan for future demands on the public lands.

The preceding considerations exacerbate the challenges BLM faces in planning for and managing the Nation’s public lands. Given these challenges, it is important for land managers to apply management frameworks that are comprehensive (holistic), contextual, representative, and efficient. The biodiversity management framework is designed to meet these contemporary planning needs insofar as biological resources and their integration for management purposes with social indicators are concerned. Table 4.2 illustrates how framework concepts and information can inform the different steps of the BLM land-use planning process. The analysis of the management situation is discussed in more detail in Section 4.3.

To help provide a spatial frame of reference to the information in Table 4.2 and elsewhere in this chapter, three conceptual areas are introduced here: (1) **planning area**—which encompasses the entirety of the area to be considered in the resource management plan regardless of jurisdiction or ownership, (2) **decision area**—which encompasses the public lands within the planning area for which BLM has authority and can make decisions, and (3) **analysis area**—which encompasses an area used for describing and evaluating resources that occur outside the planning area or across its boundary (BLM 2005). For these resources BLM would need a larger context to gauge the effects of BLM actions. Use of an analysis area concept is consistent with considering cumulative effects and using broader-scale assessment data to help inform more localized decisions.

TABLE 4.2 Generalized Land-Use Planning Steps and Framework Integration

BLM Planning Steps (Generalized)	How the Framework Informs Each Planning Step
I. Scoping and Planning Criteria	Because the framework relies in large measure on the principles of ecosystem management, the process steps that it incorporates can help BLM frame appropriate planning criteria, such as using regional-scale information to help guide planning decisions. In particular, the selection of conservation elements (Step 1 of the framework; section 4.1.1) supports scoping as it helps to focus planning attention on the most relevant biotic elements occurring with the planning and analysis areas. In addition, Step 2 of the framework can be used to identify the most important socioeconomic issues affecting the selected elements. In turn, the scoping process can help inform steps in the framework, such as element selection.
II. Data Collection	The framework is not a data collection protocol per se; however, by focusing attention on those conservation elements of management significance—that is, those elements that are identified through the coarse filter-fine filter approach and are surrogates for capturing the management requirements of the biodiversity of an area, it can help identify critical data gaps that when addressed improve the framework’s conceptualization of the planning area and ultimately enhance BLM’s planning decisions and resulting management effectiveness and efficiency. Such data can include social science data that relate to social values associated with the biodiversity of an area and social trends that either threaten or provide opportunities for biodiversity conservation. Furthermore, the framework helps to focus the data collection—insofar as biodiversity protection and management is concerned—on those items pertinent to planning decisions and, as a result, helps to avoid collection of unnecessary data.
III. Analysis of the Management Situation	This step is described in more detail in section 4.3.
IV. Resource Goals and Land Health Standards	Broad biological resource-related goals are derivable from the principles of ecosystem management and the planning criteria developed in BLM Step I, tailored to the specific context of the planning and analysis areas identified by BLM. Framework information can inform such goals and, when it includes condition assessment information (as was developed for the natural communities on the SDNM), also can complement other BLM information in evaluating adherence to the Land Health Standards and developing strategies for moving toward compliance.
V. Alternative Formulation	The framework emphasizes the importance of scale and ecological processes to biodiversity management planning. As a result, it focuses on providing and analyzing information in a spatial context. Information provided and analyzed in this way is amenable to opportunity/constraint type analyses that can assist in forging appropriate plan alternatives (and assessing impacts; see VI.). For example, a spatial model of conservation element occurrence, condition, and connectivity considerations can be overlaid with a potential use to evaluate areas of overlap and non-overlap.

TABLE 4.2 Generalized Land-Use Planning Steps and Framework Integration—continued

BLM Planning Steps (Generalized)	How the Framework Informs Each Planning Step
A. Resource Objectives and Desired Future Conditions	The framework facilitates development of spatially explicit depictions of resource occurrence and its condition, which can assist BLM in setting relevant and achievable resource objectives and desired future conditions. This is most appropriate with respect to the natural community conservation elements, given BLM’s focus on habitat management. The framework emphasizes an ecological approach to designating potential future conditions, based on descriptions of the element’s composition, structure, function, and landscape context, that BLM can use to set desired conditions. When applicable, identifying potential future conditions for natural communities can be based on ecological models of various degrees of complexity. The assumptions implicit in the framework’s conservation element selection process ensure that those biological resources, ecological processes, and threats of relevance to BLM’s land management mandate and of importance to alternative formulation will be considered. Examples include: • federal listed, federal candidate, and regionally vulnerable (at-risk) species (management needs of some BLM sensitive species may be captured under the natural community coarse filter) • habitats and plant communities (the latter are explicitly identified as objects under the SDNM proclamation) that, as expressed through the delineation and characterization of natural communities occurring within the planning and analysis areas, constitute the coarse filter • ecological processes, both at the community level and species level (for example, dispersal), that must be maintained or restored to sustain the biodiversity of the planning and analysis areas • threats to the long-term viability of the conservation elements at the scales of the planning and analysis areas that must be considered—and when appropriate to BLM’s decision-making authority must be addressed—and that may relate to altered ecological processes, incompatible uses or levels of use, or other factors. To be successful in realizing its objectives and desired conditions, BLM may need to coordinate its actions with others that may have the jurisdiction over or may share the resource.
B. Land Use Allocations	By understanding the spatial distribution of conservation elements and associated ecological processes across the planning and analysis areas, BLM can make informed decisions as to how to allocate uses across the planning area that: • take advantage of biodiversity conservation opportunities where incompatible use constraints are minimal or planned uses are compatible with conservation • place uses where biodiversity values are minimal or conservation opportunities are lacking or expensive to implement • minimize those areas and decisions where conservation opportunities and potential incompatible uses significantly overlap.

TABLE 4.2 Generalized Land-Use Planning Steps and Framework Integration—continued

BLM Planning Steps (Generalized)	How the Framework Informs Each Planning Step
B. Land Use Allocations— continued	Framework information can help BLM decide whether particular biological resources require specific management attention that warrants designation of a special management area, such as an Area of Critical Environmental Concern, to distinguish its management from other areas. Finally, it can help BLM define a functional conservation area, including movement corridors needed to maintain area-dependent species.
C. Management Actions	Potential management actions, based on the identified conservation elements, ecological processes, and threats and their spatial distribution, can be derived as an outcome of the framework's ecological characterization of each element (framework steps 2 through 5), including its conservation status, threats to its persistence, potential desired conditions, and associated management questions. As a result, the framework can inform the full suite of management actions, including threat abatement strategies and restoration needs, needed to maintain currently viable resources in good condition, reverse downward trends for those resources in decline or in need of restoration, or mitigate the effects of proposed actions so that desired conditions can still be achieved.
D. Land Tenure	The framework provides BLM information that can be used as one part of its basis for making specific land tenure decisions by considering the: (1) regional context of biodiversity information, (2) human valuation of biodiversity or its specific components, and (3) spatial occurrence of conservation elements and associated ecological processes across the landscape, including species dispersal patterns that relate to issues of connectivity.
VI. Effects Analysis	The suite of conservation elements and their current and desired future condition can serve as the baseline against which a planning team can evaluate the effects of the alternatives on biodiversity, including at-risk species and habitats identified through the coarse filter-fine filter approach, and overall ecological integrity. Social science information also is considered when it points to likely trends in resource use under different alternatives or across all alternatives in common.
VII. Adaptive Management and Monitoring	For each conservation element, as appropriate, the framework identifies relevant management questions associated with the conservation element itself, any associated ecological processes, or applicable stresses and their sources. In addition, any data gaps, which if not addressed could preclude effective management of the conservation element under consideration, also are identified. This information can inform the development of an adaptive management and monitoring strategy for a planning area that is hierarchical and efficient in its formulation. If an ecological model, especially one in the form of a state-and-transition model, was developed, this information can be used to inform the adaptive management component directly for an element or suite of elements. Applicable social science information also can be considered.

4.2.3 Framework Relationship to the Sonoran Desert National Monument Proclamation

Although BLM attempts to make decisions on a broad scale in land-use plans, sometimes site-specific implementation decisions can be made through a resource management plan when required by regulation (BLM 2000c, 2005). In addition, in the case of a national monument or national conservation area, the enabling Congressional legislation or Presidential Proclamation that established the land management unit also can mandate more specific desired outcomes or allowable uses and actions that are carried through the planning process and reflected in all alternatives.

The Presidential Proclamation that established the SDNM on January 17, 2001 contains a number of planning-related sideboards (Clinton 2001). These sideboards highlight both the important objects (resources) to be considered and the uses that will be constrained as part of any alternative evaluated during the monument's planning process. Chapter 6 provides a cross-walk between those biological objects identified in the proclamation that the SDNM was established to protect and the conservation elements selected herein as part of the framework and its element selection step through the coarse filter-fine filter approach. We will not repeat that detail here, but simply note: (1) the high correspondence between the objects and conservation elements indicates that the framework captures a significant amount of the biological significance of the monument; (2) the proclamation emphasizes protecting plant communities/habitats, which exemplifies system-level thinking and is consistent with the framework's use of natural communities as a coarse filter; and (3) also consistent with the framework, the proclamation considers the importance of intact ecological processes and the regional/national significance of the monument's biological resources. As a result, the framework not only provides BLM an ecosystem-based approach for conserving the overall native biodiversity of the SDNM, it also provides BLM an approach that is generally explicit with respect to addressing for management purposes those biological objects identified in the proclamation.

4.3 FRAMEWORK INFORMATION INTEGRATION INTO THE ANALYSIS OF THE MANAGEMENT SITUATION

To illustrate how framework concepts and information can inform the analysis of the management situation, Table 4.3 identifies in a general way some of the relevant components of the analysis and how the framework can inform each component. Analysis components are taken from Appendix F of the current version of the BLM's Land Use Planning Handbook (BLM 2005). Biological resources are categorized within the analysis of the management situation in part via the manner in which they fall under a certain administrative category that will affect the nature of plan decisions (for example, special status species, wild horse and burros, and so on). The framework on the other hand, insofar as it addresses the totality of biological resources (biodiversity) occurring within the planning and analysis areas, encompasses biological resources from a hierarchical and scale perspective—while still explicitly addressing certain administrative categories such as federal listed and candidate species. Administrative categories may become important later for implementation purposes but may not represent the best organizing principle for planning assessment purposes if BLM desires to get a handle on the current status, trends, risks, and opportunities associated with biodiversity occurring on BLM managed lands. If BLM were to emphasize biodiversity as an overarching resource category, then the appropriate “indicators” for such a category are suggested to be the conservation elements identified through the framework's coarse filter-fine filter approach.

TABLE 4.3 Relevant Components Included in the Analysis of the Management Situation and Framework Integration

BLM Analysis of the Management Situation Components (Generalized)	How the Framework Informs
I. Area Profile (Biological Resources)	Because the framework considers biological resource information within appropriate ecological boundaries, it can provide BLM information applicable to the decision, planning, and analysis areas.
A. Resources 1. Regional context 2. Resource-specific information	For each conservation element the framework provides information on its ecological characteristics and conservation status within a regional context. The use of biologically based organizing principles for describing and characterizing biological resources provides a credible and comprehensive basis for describing the biodiversity of an area. Information is included, as appropriate, for each conservation element that describes its current ecological and management status, historic and current stresses and their sources (threats), and key occurrences where its conservation can be best accomplished.
B. Resource Uses	For each conservation element the framework evaluates local and regional threats to persistence that may be attributable to specific uses.
C. Special Designations	The framework provides biological resource information in a spatial context that can be used to justify new designations or management standards for both existing and new designations.
D. Social and Economic Features	The framework provides required socioeconomic assessment and context information. In addition, social science information that pertains to particular conservation elements can be used to evaluate risks and opportunities regarding their management.
II. Management Opportunities	Because the framework includes information on the ecological condition (best opportunities for conservation) of conservation elements in a spatial context, to the extent that information is available or was collected, it enables analysis of opportunities and constraints related to options for changing resource management and use. Such an analysis can optimize scenarios that minimize resource protection and use conflicts.
III. Consistency/Coordination with Other Plans	Because the framework considers biological resource information within appropriate ecological boundaries, it identifies biological resources that are common to or dependent on other land managers and their associated jurisdictions and actions. Additionally, through the use of ecological boundaries, opportunities for enhancing coordination or gaining expertise or resources through cooperative relationships are identified.

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CHAPTER 5 CONCEPTUAL BASIS FOR CONSERVATION ELEMENT SELECTION AND GENERAL METHODS

Chapter 4 provided an overview of the biodiversity management framework's conceptual basis and its relationship to the principles of ecosystem management. In this chapter we briefly describe some of the conceptual basis behind the specific framework step of conservation element selection, including additional detail about the coarse filter-fine filter approach. This is followed by a description of the specific steps involved in selecting the final suite of conservation elements to represent the biodiversity of the Sonoran Desert National Monument (SDNM) and compiling information about each element. A third main section addresses in detail the selection, description, and assessment of natural community conservation elements, and we conclude with a section on defining a functional conservation area.

5.1 SELECTION OF CONSERVATION ELEMENTS: GENERAL PRINCIPLES

It has only been since the early 1990s that federal environmental policy has recognized native biodiversity protection and management as an end in itself. Up until then the focus of conservation tended to be endangered, threatened, or otherwise rare species. As a result, whereas conservation within the private sector focused on relatively small nature preserves, listed species management and recovery planning dominated on public lands (Poiani and others 2000, Hall and others 2001). If the long-term protection of native biodiversity is the desired outcome of management, then appropriate management frameworks and metrics to assess the status of biodiversity over time are needed (Noss 1990).

Biodiversity viewed expansively includes many levels of biological organization (for example, species, communities, landscape types) that each reflect complex composition, structure, and function (that is, associated ecological processes) (Noss 1990). Such diversity also occurs across different spatial scales. As a result, biodiversity management and protection must address the need to conserve dynamic, multi-scale ecological patterns and processes that sustain the full complement of species and natural communities (see Poiani and others 2000 and references cited therein). But it must also do so in an efficient and effective manner.

The shift from biodiversity conservation based on rare or listed species to conservation based on more inclusive levels of biological organization has been itself problematic. Some attempts have been made to use groups of species or single species to represent the conservation needs of other species; however, such approaches have often drawn sharp criticism for their lack of a biological basis and rigor of application (see Hall and others 2001 and references therein). The conceptual basis underlying the use of species as surrogates continues to evolve, but a full treatment of the status of this work is beyond the scope of this document. To address the preceding concerns about using species alone as surrogates, the use of ecosystems as the unit of biodiversity management has gained favor within the scientific community (Ecological Society of America 1995). Ecosystems, or natural communities as used herein (see section 5.3 below), can be defined as spatially explicit, but scale-independent and dynamic, units that include all ecologically linked components of the biotic and abiotic environment within their boundaries.

5.1.1 Coarse Filter-Fine Filter Approach

The Conservancy has attempted to minimize the disadvantages of focusing either on species or ecosystems by linking species and ecosystem-level concepts to address biodiversity conservation in what has become known as the coarse filter-fine filter approach (Hunter 1991, Haufler and others 1996). This

approach identifies a suite of surrogates, referred to as conservation targets or conservation elements, to represent the key components of biodiversity that require management attention. The coarse filter-fine filter approach can be applied at different scales for accomplishing different purposes. For example, at the regional scale it can be used to identify a regional network of conservation areas important for biodiversity conservation. At finer scales the approach is used to identify a suite of conservation elements that can represent the native biodiversity at a particular conservation area or land management unit.³ The elements in combination are meant to capture the full complement of ecological processes and to help identify the most important threats to biodiversity present within the particular area under consideration. A central and testable hypothesis to this approach is that ***appropriate management of the suite of conservation elements selected for a particular conservation area or land management unit will ensure the long-term persistence of the overall native biodiversity at that site.***

The coarse filter-fine filter approach stresses the importance of conserving viable examples of natural communities—the coarse filter—to protect and meet the management needs of the vast majority of species. Natural communities should be defined and delineated such that they capture the diversity of abiotic components and ecological processes occurring in an area, such as soil types, microclimates, hydrologic regimes, and so on, that support the area’s range of plant community types and habitats. Natural communities identified in the coarse filter should be viable: that is, of sufficient size, condition, and appropriate landscape context to be protective of the vast majority of their associated species.

Conservation elements whose management needs would go unmet under a coarse-level approach are treated individually: the fine filter (Poiani and others 2000). These elements can be single species, guilds,⁴ or specialized habitats that require individual management attention. Guilds are considered as conservation elements when (1) the combination of species considered better captures the range of management issues that may be of management concern and (2) use of the guild concept potentially results in a more efficient management approach versus addressing each species individually. Species elements may already be rare, and deserving of focused management attention (such as a federal listed species), or they may have specialized habitat needs that are overlooked at the community level. Species or guilds that also play a disproportionate role in maintaining key ecological processes that maintain natural communities—keystone species—also are considered. A representative approach is used to select fine-filter conservation elements such that species from all major taxonomic groups and of different degrees of rarity are evaluated for inclusion as fine-filter conservation elements. For example, some relatively abundant or widely distributed species may be particularly vulnerable to a particular threat and, as a result, may be on the horizon for listing if not managed properly now. Specific criteria to help guide selection of fine-filter conservation elements were developed and described by Hall and others (2001) to support conservation element selection on the Barry M. Goldwater Range (BMGR). These criteria have been modified slightly for their application to the SDNM by the addition of a social value criterion and explicit inclusion of certain special status species categories. Table 5.1 contains the full set of criteria.

³Conservation areas identified through a regional assessment, such as those conducted by the Conservancy through its ecoregional assessments, can be upwards of a few million acres in extent and cover multiple landowners and managers. A particular land management unit may encompass, overlap with, or be concordant with a conservation area. In practice, however, the boundary of a conservation area is only roughly defined at the regional scale and should be adjusted at finer scale planning levels to reflect the actual spatial occurrence of conservation elements and ecological processes pertinent to the area under consideration.

⁴A guild represents a group of species that exploit the same class of environmental resources in a similar way (Begon and others 1990).

TABLE 5.1 Fine-Filter Criteria Used to Select Species, Guilds, and Specialized Habitat Conservation Elements

Criteria	Definition
Special status species	Species that are U.S. federal candidate, proposed, threatened, or endangered.
Area-dependent species	Species that require the use of a large minimum area to meet all of their life cycle and demographic requirements and that may be especially vulnerable to habitat fragmentation that isolates various natural community types from each other.
Keystone species	Species that have a disproportionately large effect on other species in a community (Meffe and Carroll 1994) or on the maintenance of critical ecological processes (Poiani and others 2000).
Specialized species	Species that may demonstrate a strong association for a particular natural community or a specific biotic or abiotic component of that community, but whose management needs are not fully met within that community type. Not to be confused with an indicator species, which is a characteristic or surrogate species for a community or ecosystem (Meffe and Carroll 1994).
Regionally vulnerable species	Species that although they may be widely distributed throughout the ecoregion, they may be regionally vulnerable if the current or predicted future threats to their viability are considered. Such species may be subject to intense collection or overharvest pressures, may be especially vulnerable to the effects of fragmentation, or may be particularly sensitive to the impacts of a particular environmental threat (for example, acid rain) that is regional in its scope.
Social value species	Species that have significant social meaning or cultural importance to the human communities associated with an area in which the species occurs.
Specialized habitats	A small-patch community that often is associated with local-scale, habitat-restricted species or large-patch communities that are widely scattered and/or rare throughout the Sonoran Desert Ecoregion.

5.1.2 Additional Comments About Spatial Scale and Levels of Biological Organization as They Apply to the Coarse Filter-Fine Filter Approach

Biodiversity occurs at both different levels of biological organization and at different spatial or geographic scales (Noss 1990, Poiani and others 2000). To efficiently capture the biodiversity of an area both properties of biodiversity need to be considered. The coarse filter-fine filter approach explicitly captures the community-ecosystem and population-species levels of biological organization. If well-crafted in terms of conservation element selection, it also can be used to capture portions of the genetic and regional landscape levels as well.

To address spatial scale considerations, it is important to realize that different components of biodiversity occur and persist on the landscape at different scales. Figure 5.1 displays the relationship between four spatial scale representations and two organizational levels (species and communities) of biodiversity. Linear communities, such as riparian communities, do not fit easily into the spatial scale schema and may require a case-by-case assessment of their spatial properties. Table 5.2 provides a sample of ecological characteristics, applicable to each intersection of scale and organizational level. The intersections should be used as a guide and should not be viewed as non-overlapping or rigid in their application. For example, some coarse-scale, area-dependent (sensitive) species may behave as habitat specialists for most of their life cycle but require the use of other habitats to meet dispersal requirements or other needs.

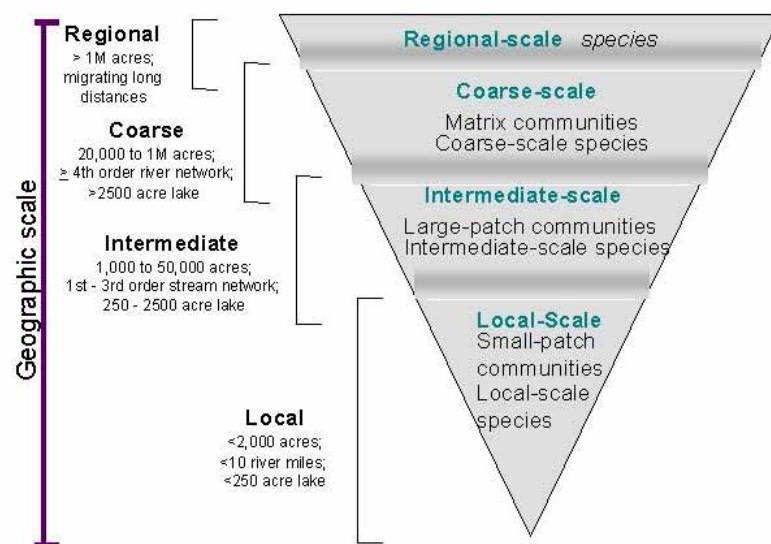


FIGURE 5.1 Biodiversity Expressed at Different Spatial Scales and Levels of Organization (adapted from Poiani and others [2000])

TABLE 5.2 Characteristics of Species and Natural Communities at Different Spatial Scales¹

Level of Biological Organization and Scale	Characteristic	Example
Regional-scale species	Wide-ranging	Caribou
Matrix community	Successional mosaic, large spatial extent, amorphous boundaries	Sagebrush steppe
Coarse-scale species	Area-dependent [sensitive], habitat generalists	Red-cockaded woodpecker
Large-patch community	Defined by physical factors/regimes, internal structure and composition either homogeneous or patchy	Pine barren
Intermediate-scale species	Use large patches or multiple habitats	Timber rattlesnake
Small-patch community	Geomorphically defined, spatially fixed discrete boundaries	Bog
Local-scale species	Habitat restricted or specific	Bay checkerspot butterfly

¹Adapted from Poiani and others (2000).

A more complete description of the spatial pattern associated with each of the natural community types listed in Table 5.2, as well as for linear communities, is provided in Appendix A, Table A.3. A particular conservation area or land management unit will be composed of a mixture of natural communities that

typify these different spatial patterns. Finally, each species and natural community also can be characterized by its distributional characteristics. Distribution patterns are an additional piece of information that can be used to determine the appropriateness of a species or natural community to be used as a conservation element for a particular conservation area or land management unit. Table A.4 in Appendix A provides definitions for each of the distribution categories considered in this report.

5.2 SELECTION AND CHARACTERIZATION OF CONSERVATION ELEMENTS FOR THE SONORAN DESERT NATIONAL MONUMENT

This section first describes the specific steps that were taken to select appropriate conservation elements for the SDNM. Such elements should be: (1) representative of biodiversity within the Sonoran Desert Ecoregion, (2) relevant to natural resources management on the monument, (3) representative of the occurrence of biodiversity at different spatial scales, across taxonomic categories (plants, birds, mammals, and so on), and across different levels of rarity, and (4) inclusive of natural communities and species that have specialized management needs. Moreover, as the previous section outlined in terms of the conceptual basis underlying element selection, the conservation element selection process is conducted in accordance with a coarse filter-fine filter approach. The section concludes with a brief overview of characterization methods.

5.2.1 Steps in the Selection Process

The following steps are not necessarily rigid in their application or progression. Some steps of the selection process may occur concurrently, or they may be repeated in an iterative manner prior to arriving at a final list of conservation elements.

Step 1: Developed an Initial List of Conservation Elements

To develop an initial list of conservation elements applicable to the SDNM, we started by consulting two pieces of information. First, we assessed the list of conservation elements identified for biodiversity management of the BMGR (Hall and others 2001). Hall and others (2001) used the same coarse filter-fine filter approach to choose conservation elements to represent these lands, which are adjacent to the SDNM on their northwestern end. Although the BMGR and SDNM are ecologically different in some regards, they also share some natural communities and species in common. In addition, the assessment of the biodiversity of the BMGR by Hall and others (2001) is directly applicable to the SDNM, because it included an analysis of the Sand Tanks Mountains area. A portion of this area (previously referred to as Area A when administratively part of the BMGR) was turned back over to the Bureau of Land Management (BLM) to administer in 2001 and is now part of the SDNM. Hall and others' (2001) assessment considered information from numerous and extensive expert interviews, workshops, and current scientific literature.

Second, we assessed the regional conservation element information contained in Marshall and others' (2000) ecological analysis of conservation priorities within the Sonoran Desert Ecoregion (see also the discussion in Chapter 3 on this document's findings and its relevance to the SDNM). This document identified conservation elements for the Sonoran Desert Ecoregion and based on their distribution identified priority landscape-scale conservation areas for biodiversity conservation throughout the ecoregion. The boundary of one of these conservation areas (Conservation Area No.32: Sand Tank/Sauceda Mountains Complex) overlaps with a significant portion of the SDNM (Figure 3.2).

Step 2: Refined the Initial List by Considering Additional Sources of Information and by Applying the Fine-Filter Screening Criteria

Because the information considered in Step 1 above was for geographic areas that only partially overlapped with the SDNM, we modified the initial list by considering additional sources of information. Some of the species or natural communities considered in Step 1 do not occur on the SDNM and had to be deleted from consideration. In addition, species and natural communities that do occur on the SDNM (or for certain species, may have suitable habitat on the SDNM even if not confirmed to be present) may not have been considered for the BMGR or Sand Tank/Sauceda Mountains Complex conservation area. This could result either because they did not occur in these locales or because these areas did not contain good representative examples of particular species or natural communities. Similarly, just because certain species or natural communities are present on the SDNM doesn't mean they occur as suitable representations of such elements to warrant identification as a conservation element for the SDNM. Finally, because Hall and others (2001) also considered guilds, we had to consider the possibility that the species composition of such guilds may need to be adjusted to reflect conditions on the SDNM.

Species and natural communities that were added to the initial list of conservation elements on the SDNM, or guilds that were modified, were done so based on the following additional sources of information:

- *Biological Resources of the Proposed Sonoran Desert National Monument, Arizona* (Turner and others 2000) and cited literature therein and Marshall (2000). The first reference provides species lists of all the major taxa known from personal observations or surveys on the SDNM. Marshall (2000) provides additional detail about the conservation elements occurring within the Sand Tank/Sauceda Mountains Complex conservation area and information about additional elements not identified by Marshall and others (2000) as ecoregional conservation elements for this area.
- Arizona Breeding Bird Atlas survey (ABBA 2001). This survey is a geospatial-referenced dataset of all bird species observed in Arizona during surveys conducted from 1993 to 2000 and their breeding status. Nineteen survey blocks included portions of the SDNM.
- Agency documents, such as the BLM Wilderness Management Plan for the Maricopa Complex (BLM 1995).
- Expert interviews. The interviews provided additional information on potential conservation elements, though at least initially expert opinion was not solicited to review the list of conservation elements; instead, experts were asked to provide background information on particular species or natural communities (Appendix B, Table B.1 contains a list of the experts consulted).

We screened all of the potential species conservation elements against the fine-filter criteria in Table 5.1 before concluding whether they should be included or excluded as a SDNM conservation element. For the natural community conservation elements, or the coarse filter, an initial representation of the natural communities present on the SDNM was developed by (1) extending the BMGR model of natural community conservation elements to include the SDNM and (2) using additional geospatial data sources to represent the communities on the SDNM that were not selected as conservation elements on the BMGR. Additional steps in the selection and characterization of the natural community conservation elements are addressed in section 5.3. The information compiled to this point was summarized in a report and submitted to BLM in October 2002 as *Conservation Elements of the Sonoran Desert National Monument: A Preliminary Analysis* (Weinstein and others 2002).

Step 3: Consulted with Partnering Agencies and Held Expert Workshop

The preliminary analysis was distributed to partners at the Arizona Game and Fish Department (AGFD), BLM Phoenix Field Office, BLM National Office, Department of Defense, Luke Air Force Base, and the Sonoran Institute. The preliminary findings served as a starting point to engage agency staff and discuss natural resources and conservation opportunities on the monument. Follow-up meetings with staff at the BLM Phoenix Field Office and AGFD were held to discuss the report and to address comments and questions about element selection. We also accessed AGFD, Heritage Data Management System occurrence data, not available by the time the preliminary analysis was completed, to support the appropriateness of element selection and assist in characterization.

The Conservancy convened an experts workshop on May 13, 2003 in Tucson, Arizona. The twenty-four participants represented eleven different organizations and a great variety of backgrounds and expertise (Appendix B, Table B.2). The primary workshop activities focused on (1) discussing the preliminary list of conservation elements and developing a final list, (2) providing workshop participants with information on current studies relating to the national monument, and (3) discussing regional (Sonoran Desert) and monument-specific stresses and sources of stress to the conservation elements. The Conservancy produced background material on the conservation elements, stresses, and sources of stress, which served as a starting point for vetting the list of conservation elements and discussing their associated threats. Additional presentations given by some of workshop participants provided background information on various topics relating to the SDNM. Nina Chambers (Sonoran Institute) presented information on socioeconomic condition and trends in the human communities adjoining the monument, Pam Foti and Chuck Patterson (Northern Arizona University) described their work evaluating the ecological impacts of recreation activities on the national monument, Peter Morrison (Pacific Biodiversity Institute) discussed preliminary natural community mapping and characterization on the monument, and Anne Gondor (Conservancy) presented initial analyses of road density and potential zone of domestic livestock influence on the monument and surroundings. Appendix E contains a summary of workshop presentations, discussions, and findings.

The workshop did not resolve the selection status of a limited number of species and guilds. We summarized workshop findings and sent to all participants for review and comment. We then conducted follow-up research and interviews with some of the experts to resolve those outstanding questions needed to finalize the conservation element list (Appendix B, Table B.3). We discussed our findings and recommendations with BLM Phoenix Field Office staff to arrive at a final list of conservation elements.

Note.—The natural communities, species, and guilds that are selected through the coarse filter-fine filter approach are designed to become the land manager’s focus for management and monitoring for the foreseeable future. Conservation element selection, however, should be viewed as a dynamic process in that sometimes decisions to include or exclude certain conservation elements are based on incomplete information. The suite of coarse- and fine-filter elements chosen to represent the biodiversity of an area may need to be revisited: for example, to account for new information on pervasive threats to certain species or natural communities. As our knowledge of Sonoran Desert biodiversity grows, so does our ability to develop more informed schema that are efficient and effective in protecting the desert’s unique ecological values.

5.2.2 Characterization

A number of resources, including agency and academic expert opinion or their unpublished data, spatial data on occurrence and movement, and published research, were consulted to obtain relevant ecological and conservation-related information on each of the species conservation elements (see section 5.3 for information gathering relative to the natural community conservation elements). Some of this

information was gathered as part of the conservation elements selection process described in section 5.2.1, but this effort was supplemented by additional information gathering once the list of elements became final. In-person or telephone interviews were conducted with experts for each conservation element, as appropriate (see Appendix B, Table B.4 for the list of experts consulted). Information from each of the sources above was used to characterize each species element regarding its: ecological characteristics; status, threats, and management; and mapping and information needs. Information provided for each species is not necessarily exhaustive, but rather focuses on that information relevant to planning and management considerations. Spatial information is included when available. Table 5.3 provides a description of each category of information compiled for the species elements.

TABLE 5.3 Categories of Information Compiled for the Species Elements

Information Category	Description
<i>Overview</i>	
Taxonomy	Taxonomic status of the taxon under consideration is described. This category is provided if there is some uncertainty as to the taxonomic status of the taxon. Nomenclature issues also may be described.
Rationale for selection as a conservation element	Underlying basis for selecting the taxon, guild, or group as a conservation element, including its relationship to the fine-filter criteria, is identified. The Overview section also may include a discussion on the makeup of a guild: why certain species were included and others not included.
Specific habitat needs on the SDNM	The taxon's relationship to the natural communities and geographic locales of the SDNM is described and any specific habitat needs that may or may not be captured by management of the natural community are identified.
<i>Ecological Characteristics</i>	
Abundance	Characteristic or SDNM-specific estimates of individuals or typical densities of a population are provided. In some cases, ecological factors that affect abundance are described.
Habitat associations	A general description of the plant communities or habitats with which the taxon may be associated with across its range is provided. Relationships to the natural communities on the SDNM are shown spatially when possible. For the native grass group conservation element, habitat association information is captured in terms of the different compositional, structural, and functional characteristics of the native grass group in its different manifestations by natural community.
Food and water requirements	General description of dietary habits and drinking water requirements are provided.
General life history	General information on the taxon's development, reproduction, and seasonal activities is provided.
Biotic interactions	Inter- and intra-specific interactions, such as competition or predator-prey relationships, are described.
Landscape context	Information on metapopulation dynamics, movement/dispersal areas, and impediments to movement is described. This information could be displayed spatially in some cases.
<i>Status, Threats, and Management</i>	
Distribution	The geographic range of each taxon is described. Information includes historic versus current distribution (if known and if they are significantly different). Range maps are provided, if available. Information on known or expected distribution on the SDNM also is included.

TABLE 5.3 Categories of Information Compiled for the Species Elements—continued

Information Category	Description
Conservation status	Status information, such as Global Rank, State Rank in Arizona, special management status in Arizona and/or in the U.S. (such as under the Arizona Native Plant Law, as a BLM Sensitive Species, Wildlife of Special Concern in Arizona, listed or proposed Threatened or Endangered, candidate for listing, etc.), is provided. In addition, other groups that are tracking the taxon because of a conservation concern (such as Arizona Partners in Flight, USFWS Birds of Conservation Concern, or the Western Bat Working Group) are identified. Information also is included on the status of the species where it occurs on the SDNM. Some conservation status data maybe provided in a spatial format (such as Breeding Bird Atlas data or where a species occurs/where the best examples are known from on the SDNM).
Stresses and sources of stress	Threat information, by type of stress and by source, is provided. When possible, distinctions are made between regional and localized (on the SDNM) stresses and sources of stress. This information is provided in tabular format rather than as text to facilitate linking stresses with their corresponding sources of stress.
<i>Mapping and Information Needs</i>	
Mapping comments	Information is provided that describes how to model the occurrence of the species, if actual occurrence data are not available. Details on data limitations for existing occurrence data/maps also are provided.
Information needs	Any outstanding data needs, on any topic that is particularly relevant to management of the species, are identified.

Some of the plant species richness and cover data collected as part of the natural community characterization (see section 5.3) proved useful for characterizing the SDNM status of the saguaro (*Carnegiea gigantea*) and native grass group conservation elements. For the former we calculated size class (< 1 meter, 1 meter to 5 meters, and > 5 meters) summary statistics for stem counts, constancy, and percent cover across all size classes for each of the natural communities and ecological condition classes (see section 5.3.3 for a description of the condition classes and how they were assigned to natural community condition assessment plots). We also compared stem counts and percent cover data between the BMGR-former Area A (previously withdrawn portion of the SDNM prior to 2001) portion of the SDNM and the remainder of the SDNM by applying the non-parametric Mann-Whitney test. Statistical significance was set for all tests at $p < 0.05$. For the native grass group, we calculated species richness and the mean percent cover by individual species within the group by natural community.

5.3 SELECTION, DESCRIPTION, AND ASSESSMENT OF NATURAL COMMUNITY CONSERVATION ELEMENTS

Natural communities, as they are characterized in this report, represent an integration of both traditionally defined plant communities as well as habitats based in part or primarily on abiotic features. As a result, they can be based on plant communities that are defined at different hierarchical levels of organization (for example, association, alliance, or higher levels), on strictly abiotic features of the environment that account for hydrological and/or geomorphological characteristics of the community, or on a combination of abiotic and biotic features. In combination, selected natural communities for an area of interest are meant to capture the range of community-level elements that occur at different scales, are maintained by different ecological processes, or are subjected to different primary threats. If selected and mapped

carefully, these natural communities also should enable capturing the full range of environmental gradients that may occur in an area. As described in Chapter 4, the biodiversity management framework for the SDNM uses natural communities to represent the coarse filter: community-level conservation elements that encompass the habitat needs, if managed appropriately, for the majority of species within an area.

5.3.1 Background

Selection and description of the natural communities occurring on the SDNM built on earlier efforts to describe plant communities and wildlife habitats within the Sonoran Desert. Two recent efforts had a significant influence on the approach taken herein toward selection and description. First, the ecological analysis of conservation priorities in the Sonoran Desert Ecoregion (Marshall and others 2000) identified a number of plant communities of regional significance occurring in the Sand Tank Mountains and vicinity. Available mapping information for these communities, however, was coarse in scale and accuracy (the Arizona Gap map [Arizona Gap Program 1998] was used as the original source data).

Second, Hall and others (2001) defined natural communities for the adjoining BMGR based on (1) an assessment of available vegetation mapping information at different scales for the BMGR and (2) the findings of a workshop involving regional scientific experts and natural resource managers familiar with the natural communities of the BMGR and/or plant community ecology within the Sonoran Desert. Based on the available information, including relative ecological significance of the natural communities of the BMGR within a regional context, workshop attendees reached a consensus on what natural communities should be considered for the range. Many of these communities were defined based on biophysical descriptions. Because on-the-ground mapping data for some natural communities were not available, Hall and others (2001) used the biophysical descriptions as surrogates to create geospatial models for mapping those communities across the BMGR. In combination the natural communities identified and described by the workshop attendees resulted in community-level conservation elements that were practical and logical units for conservation and management purposes on the BMGR.

The Conservancy contracted with Pacific Biodiversity Institute (PBI) for the purpose of mapping, characterizing, and assessing the condition of the natural communities of the SDNM. The intent was to enhance the spatial accuracy and community descriptions of the natural communities as they occurred on the SDNM compared to the coarse-scale and modeled information currently available. The contractor was requested to build on and improve the natural community information collected, synthesized, and mapped for the BMGR that had been extrapolated through modeling and other data sources by the Conservancy to reflect monument-specific natural communities. Pacific Biodiversity Institute conducted its work in two phases. Morrison and Snetsinger (2003; Phase 1) and Morrison and others (2003; Phase 2 plus information from Phase 1) contain the complete details of PBI's methods. What follows in the next two sections is a synopsis of those methods by project phase.

5.3.2 Phase 1: Mapping and Initial Description

The goals of Phase 1 were to map and describe the natural communities occurring on the SDNM and key extensions of Desert Grassland and Mountain Upland communities on adjacent lands. The contractor approached these tasks in an integrative manner by using existing vegetation maps, a wide variety of existing geospatial data, Landsat Enhanced Thematic Mapper 7 (TM7) satellite imagery, digital orthophotography, literature review, and reconnaissance-level fieldwork that focused on the collection of ecological data on composition, structure, and function of the natural communities.

After reviewing the draft natural community map and geospatial models developed by the Conservancy for the SDNM, PBI processed and examined Landsat TM7 imagery from March 2002 and earlier dates,

1996 color infrared (CIR) digital orthophoto quarter quads (DOQQ) for nearly the entire study area, and 1996 panchromatic digital orthophotography provided by BLM for the entire study area. The latter imagery was compressed and of poorer quality, so when available the CIR DOQQs were used preferentially to assist with mapping the natural communities. Geospatial layers, such as soils, topography, and hydrography, were reviewed and evaluated, with the Natural Resource Conservation Service's (NRCS) soil map proving the most useful for improving the accuracy of the natural community map. Literature considered included NRCS's Ecological Site Descriptions (ESD) applicable to the area of the SDNM.

Pacific Biodiversity Institute conducted its fieldwork from November 27 to December 23, 2002. Ecological data and photographs were recorded that could supplement the geospatial data for improving boundary delineation of the natural communities and to assist in preparing community descriptions. The percent canopy cover of all plant species within 30-meter radius sample plots was recorded, as well as various physical data. Plot data were collected at 123 sites stratified across significant ecological gradients within each community type. Because fieldwork occurred during the period of maximum plant dormancy, the data collected contributed to an initial, but incomplete, description of the natural communities.

Besides the direct use of imagery and field data to refine the mapping and description of the natural communities of the SDNM, PBI also developed two geospatial models to assist in boundary delineation between community types. The first model helped separate the Creosotebush-Bursage Desert Scrub community from the Paloverde-Mixed Cacti-Mixed Scrub on Bajadas community. The second model enabled predicting the spatial distribution of the Mountain Upland community. Both models constituted enhancements to earlier Conservancy-generated models for these communities. Integration of the preceding models and the other data were used ultimately to construct a natural community map of the SDNM and adjacent areas that was further modified and improved by the more detailed fieldwork and analysis accomplished during Phase 2.

Finally, PBI compared the natural communities mapped in Phase 1, which are based on a combination of vegetation and physical factors, to the ecological site classes of NRCS, which are based primarily on soil differences. The SDNM falls within three different state soil survey areas. In addition, the southwest portion of the SDNM (the area formerly withdrawn before 2001 as part of the BMGR) is not mapped. Because the existing surveys are based on different data and coding structures, PBI first cross-walked the data to arrive at a common list of 15 ecological site classes. Many of these classes when mapped actually represent a complex of subclasses. For example, the limy fan ecological site class included four subclasses in which limy fan occurred alone or as a complex with other ecological site classes in which it still was the predominant class. The mapped ecological site classes were then intersected with the natural community map to ascertain the degree of overlap between the classes and communities.

5.3.3 Phase 2: Description Refinement and Condition Assessment

The primary goal of Phase 2 was to conduct both coarse- and fine-scale analyses of the ecological condition of the natural communities on the SDNM and adjacent areas of the BMGR and Tohono O'odham Nation (study area); however, the extensive field data collected during this phase also contributed to updating the natural community descriptions and map developed during Phase 1. As part of the condition assessment, PBI collected information on the distribution and abundance of non-native (exotic) plants. Species inventoried likely include a subset of non-native plants, invasive plants, that cause adverse ecological impacts to natural communities and species.

Data Compilation and Collection

The coarse (landscape-level) assessment incorporated current and historic aerial photography, satellite imagery, and other geospatial data to assist in determining the spatial relationship between the natural communities and potential disturbance features. Evaluation of aerial photo chronosequences from 1958 to 1996 helped to focus on areas within each natural community that were observably altered by human activities. A number of geospatial disturbance layers were developed to aid analyses, including potential livestock congregation areas (based largely on BLM's range improvement data layer), roads, and disturbed areas (polygon features of unspecified disturbance type) and linear features (for example, off-road vehicle paths). For subsequent spatial modeling of condition, two derivative geospatial layers were constructed: distance from potential livestock congregation areas and distance from roads.

Pacific Biodiversity Institute conducted its Phase 2 fieldwork from March 27 to May 21, 2003. Two types of sample plots were used: (1) non-native plant plots and (2) natural community condition assessment plots. The sample design for the non-native plant plots focused on the relationship of non-native plant distribution with distance from roads and other travel corridors. Plots consisted of three meter radius plots located three and 10-meters distant from road edges on either side of the road at half mile intervals. The percent canopy cover of each non-native plant was recorded in a total of 836 plots; for some plots frequency data also were recorded. Road classification information (for example, paved or unpaved) was recorded to enable analysis of type of road effects on non-native plant distribution. Data collected were compatible with submittal to the Southwest Exotic Plant Mapping Program (SWEMP).

Natural community condition assessment plots consisted of 12.5-meter radius circular plots. Three hundred and thirteen plots, permanently marked with rebar, were distributed according to two types of stratification. First, plots were distributed within and across natural communities in a manner that captured potential ecological gradients (as evidenced by such features as soil, geology, elevation, and aspect) that could contribute to within-community natural variation (see Table 5.4 for plot allocation by community type). Second, plots were located along disturbance-gradient transects that extended out from selected disturbed areas such as a livestock congregation areas at intervals of 500 meters or less and out to five kilometers. Plot locations along the disturbance gradient were determined in consultation with BLM to mimic expected intensity patterns of livestock use. Vegetation sampling within plots consisted of ocular estimates of total percent canopy cover of all species present. In selected plots, point-intercept transects along four cardinal direction radii of the plot were used to help calibrate field crew ocular cover estimates. Figure 5.2 shows the location of all Phase 1 and 2 data collection points within the study area.

During field sampling, PBI collected disturbance-related data, such as numbers of livestock prints and dung and number of individual vehicle tracks. Based on a subset of this collected information, a livestock impact index and a vehicle use index were calculated. While traversing natural communities between plot locations, PBI made and noted opportunistic observations of rare and non-native plants. In addition, PBI conducted unique assessments for three of the natural communities. For the Desert Grasslands community, PBI used field surveys and a chronosequence of aerial photos to assess this community on both the SDNM and Tohono O'odham Nation. Mesquite Woodlands were assessed using a combination of three different methods: (1) a variation of the natural community condition assessment plots in which data on tree height and diameter also were collected, (2) imagery analysis, and (3) mesquite condition and extent plots. Because of the unique spatial pattern associated with the Braided Channel Floodplains community, PBI applied a community-specific sample design to assess this community. This design involved placing sample plots along a transect that captured the various habitat types that contributed to the community's horizontal structure: for example, active wash, floodplain island, floodplain terrace, and mesquite terrace.

TABLE 5.4 Primary Factors Influencing Variation in Species Composition for Each Major Natural Community in the Study Area¹

Primary Factors Influencing Variation in Composition within Each Natural Community	Creosotebush-Bursage Desert Scrub (87 plots)	Paloverde-Mixed Cacti-Mixed Scrub on Bajadas (34 plots)²	Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes (64 plots)	Mesquite Woodland (13 plots)	Mountain Upland (36 plots)	Braided Channel Floodplain (21 plots)	Mountain Xeroriparian Scrub (16 plots)	Valley Xeroriparian Scrub (25 plots)
Elevation	X				X	X	X	X
Slope steepness			X		X			
Aspect			X		X		X	
Soil texture		X						
Geology			X				X	
Distance from potential livestock congregation area	X	X		X				
Distance from roads				X				
Livestock impact index	X					X		

¹Number of natural community condition assessment plots located within a community type is indicated within the parentheses following each community's name. In addition, assessment plots were located in Rock Outcrop (7 plots), Desert Grassland (6 plots on the SDNM), and Desert Spring (3 plots) natural communities. These latter communities were not assessed for compositional variation.

²One additional plot was not used to analyze variation, as it occurred in a significantly disturbed area at a transition zone between this community and Creosotebush-Bursage Desert Scrub.

Analyses

Pacific Biodiversity Institute used the data collected during Phase 2 to refine the mapping and descriptions of the natural communities on the SDNM and adjacent portions of the BMGR and Tohono O'odham Nation. In addition, to detect whether any major cover type discontinuities occurred along the monument boundary, PBI extended the natural community map to include a quarter-mile buffer outside the remaining portions of the SDNM's boundary.

Non-native plant occurrence and cover data contributed to a number of analyses. First, these data, from both the (1) non-native plant plots and (2) natural community condition assessment plots were used to examine the relationship of non-native plant occurrence with various human-related disturbance, such as distance from roads, and environmental factors. Second, natural community condition assessment plot data were used to evaluate differences in percent canopy cover of non-native plants between natural communities. Third, these latter data also were used as condition variables for the ecological condition analyses (see below).

To assess the ecological condition of the natural communities, PBI's analytical approach had to address two key Phase 2 tasks: (1) identify the environmental and anthropogenic factors, and their relative significance, that contribute to variation within the natural communities occurring on the SDNM and (2) develop a spatially explicit model of ecological condition for each of the natural communities. The

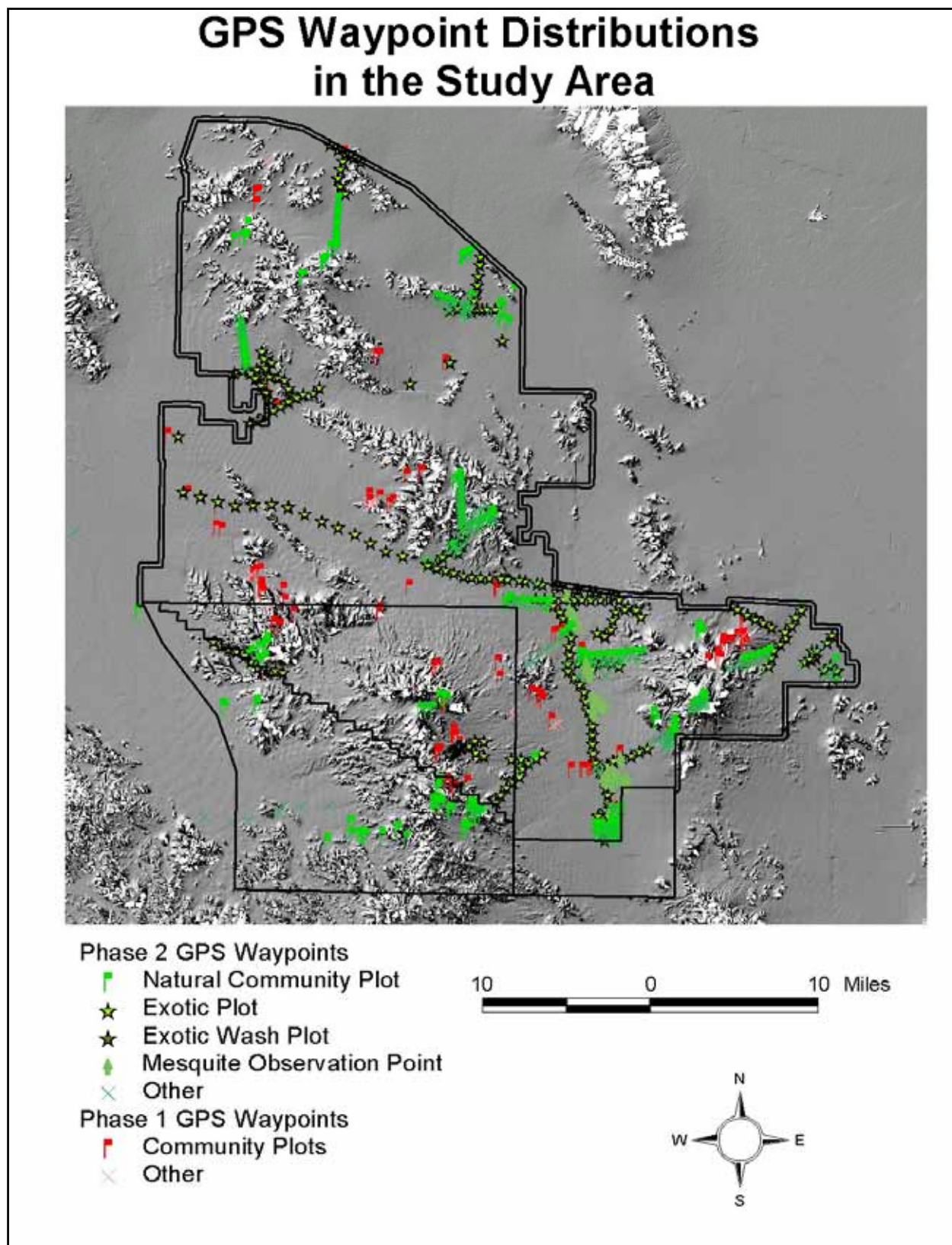


FIGURE 5.2 Distribution of all Phase 1 and 2 Data Collection Locations

relationship between these two tasks and the analytical methods used to address them is complex; as a result, in the following overview of PBI's analytical methods, we describe their approach as a series of steps.

Step 1. Examine variation within natural communities.—Pacific Biodiversity Institute used two analytical techniques to examine the variability of species composition within the natural communities and to determine its potential casual factors: Detrended Correspondence Analysis (DECORANA), an ordination technique commonly used in community ecology (Hill and Gauch 1980), and hierarchical cluster analysis. Both analyses used the species data (richness and abundance) from the natural community condition assessment plots. “Rare” species (those occurring in less than 5 of the 320 plots) were not included in the analysis data sets (Gauch 1989).

Detrended Correspondence Analysis creates a continuous ordering (ordination) of the plots based on their similarity. Detrended Correspondence Analysis is suited to analyze species compositional shifts that are gradient dependent. As an indirect gradient analysis technique, DECORANA is useful in representing the actual underlying gradients in community data, whether or not those gradients relate to secondary variables measured in the study (for example, elevation, aspect, and so on). The results from DECORANA were used primarily to evaluate the relationship between various environmental and anthropogenic factors and the general patterns of compositional variation within a natural community. To simplify and clarify DECORANA results for each natural community, PBI used its field observations as a basis to include only those factors that appeared influential in affecting variation for a particular community. Table 5.4 identifies the primary factors influencing variation in species composition in each natural community.

In contrast to DECORANA, cluster analysis is a classification technique that divides or classifies the data into as many discrete groups as the data analyst specifies. Based on the amount of variation present within the natural communities observed during fieldwork and the number of natural community condition assessment plots located within each community, PBI determined the number of groups or clusters into which the data should be divided (group number ranged from four to 10). Once the data are grouped, it is up to the analyst to interpret the clusters and identify which factors appear to be influencing subdivision and grouping of the data. As a result, some clusters are more interpretable than others. When used in conjunction with DECORANA, cluster groups can be used to identify either significant compositional variants or anthropogenic disturbance-induced differences in ecological condition within a community.

Step 2. Identify field-based measures of condition and condition classes.—To evaluate the ecological condition of the natural communities, PBI first identified field-based measures that are strongly indicative of changes in ecological condition. These measures included number and percent canopy cover of native plants, number and percent cover of non-native plants, number and percent cover of native grasses, and percent cover of sand and soil (index of the amount of bare ground). In addition, PBI also considered two anthropogenic disturbance indices: a livestock impact index and a vehicle use index. These latter measures can be considered in two ways: (1) as part of the condition-related variables for assessment purposes or (2) separately from the condition-related variables if desired to segregate out direct measures of anthropogenic disturbance from their presumed effects.

Next, the preceding field-based measures were used to define three levels of ecological condition or condition classes. These classes can be applied uniquely to each natural community to reflect its individual ecological characteristics. First, however, PBI used qualitative descriptions of biotic and disturbance characteristics to describe each condition class in general terms that were appropriate to all natural communities. The resultant condition classes can be briefly summarized as follows (Appendix B contains the full original PBI class descriptions):

- **Condition Class 1.** This class typifies areas that have been altered in terms of composition, structure, and function from what is expected based on natural ranges of variation attributable to environmental (non-anthropogenic) factors.⁵ Rare plants are generally absent and native grasses are usually absent or in low abundance (commensurate with characteristics of the individual community). Native species composition is skewed to those plants that are tolerant of regular disturbance. Non-native plants contribute significantly to total vegetation cover and species richness. One or more vegetation structural layers may be modified or even missing. Bare ground is widespread. Evidence of accelerated erosion and soil compaction is often widespread and, where applicable, hydrologic alterations are often present. Direct evidence of various anthropogenic stressors is usually abundant.
- **Condition Class 2.** This class typifies areas showing characteristics intermediate between Condition Classes 1 and 3. Rare plants may be present, but typically are those species that can tolerate some degree of disturbance. Overall native species diversity may be lower than expected and non-native plants are present and at moderate abundance. Although native grasses are often present, they are usually lower in richness and abundance than is typical for the community type. Usually all vegetation structural layers are present, though some deviations in form and stature from reference conditions may occur. Evidence of accelerated erosion and soil compaction is present, but localized. Hydrologic alteration is absent. Direct evidence of various anthropogenic stressors may be present, but is not widespread or abundant.
- **Condition Class 3.** This class typifies areas that are close to representing reference conditions for the natural community in question: that is, composition, structure, and functional attributes of the area are within the expected natural range of variation for the community as influenced only by environmental factors in the absence of anthropogenic disturbance factors.⁶ Certain rare plants may only exist within these areas and native grasses are usually present and often relatively abundant commensurate with natural community type. Some level of non-native plant infestation may be present; however, there is no noticeable adverse effect on native species composition, community structure, and ecological process functioning. Vegetation structure is unaltered from reference conditions. Accelerated erosion, soil compaction, and hydrologic alteration are absent. Direct evidence of various anthropogenic stressors is usually absent.

Based on the field-based measures and other sources of information (for example, DECORANA and cluster analysis results and field observations of accelerated erosion and soil compaction), PBI assigned

⁵Natural ranges of variation are used here to refer to expected values of natural community composition, structure, and function in the absence of anthropogenic influence (for North America generally determined to be most reasonably applied in reference to the period immediately prior to major European influence [Haufler and others 2000]). Anthropogenic influences may cause natural communities to exist outside their natural ranges of variation by: (1) adding or removing structural layers of vegetation, or significantly altering their proportional relationship; (2) removing species or adding species not previously associated with the community or changing the relative abundance of species in the community, or (3) altering the frequency, timing, or intensity of natural disturbance regimes or other ecological processes. Alterations “outside” the pre-European ranges often can result through human-induced reductions in a range (ecosystem simplification): for example, through conversion of natural, multi-species, variable-aged forests into monoculture, single-aged plantations (Holling and Meffe 1996).

⁶Although information for determining natural ranges of variation based on historical evidence is often lacking, it does not reduce the scientific relevance of the approach nor preclude its use (Haufler and others 2002). Contemporary reference sites may not exist, but if they do they should be areas with evidence of minimal anthropogenic influences that are large enough and sufficiently buffered that historically dominant ecological processes are still operating (Andreasen and others 2001, Haufler and others 2002). The approach taken by PBI is to use the criterion of minimal evidence of anthropogenic influence to indicate a reference site or reference conditions.

each natural community condition assessment plot to one of the three condition classes. To ascertain how well the condition classes, as assigned to the plots, could be differentiated based on the field measures, PBI used multivariate analysis of variance (MANOVA) to test data and plot assignments associated with the Creosotebush-Bursage Desert Scrub community. Six of nine condition/disturbance factors differed significantly between condition classes. This analysis was accomplished only for Creosotebush-Bursage Desert Scrub as an illustrative example.

Step 3. Test relationship between field-based measures of ecological condition and geospatial data layers.—The DECORANA and cluster analyses identified several disturbance-related measures that influenced variation in natural community species composition (Table 5.4). These factors potentially affect variation by altering the composition, structure, or function of a natural community outside its natural range of variation. These deviations outside the natural range of variation, or changes in ecological condition, can be directly measured by changes in species composition variables or indirectly inferred by disturbance measures, as indicated above. To test whether ecological condition on the SDNM could be spatially modeled, PBI first used linear regression to analyze the relationship between the field-based measures of condition and disturbance and two geospatial layers: distance from potential livestock congregation areas (mostly based on BLM’s range improvement geospatial layer as modified by field observations) and distance from roads. Analyses of within-community variation also supported the appropriate use of these two geospatial layers to spatially model condition. Most regressions were significant, with the relationship between field variables and distance from potential livestock congregation areas showing the stronger set of relationships.

Step 4. Develop spatial models of ecological condition.—Pacific Biodiversity Institute used (1) the results of the regressions described above, (2) the summary statistics for the plot-based condition measures by condition class for each natural community, and (3) their field observations to establish criteria for spatially modeling condition for a given community. The models differed by community and typically were based on differing thresholds (breaks between condition classes) applied to the distance from roads and distance from potential livestock congregation areas geospatial layers. The final condition map integrated the condition class maps for each natural community, plus some additional disturbance data overlays that included: (1) buffered roads, linear disturbance features, and developed/disturbed sites geospatial layers and (2) a BMGR surface disturbance layer generally corresponding to live ordnance target areas and one-year Explosive Ordnance Disposal (EOD) sweep areas associated with the East Tactical Range. Factors used in modeling and mapping ecological condition, by natural community, are provided in Table 5.5.

5.3.4 Additional Analyses of Natural Community Condition Assessment Plot Data

As described in section 5.3.3, PBI conducted some limited analyses to ascertain how well the assigned natural community condition classes could be differentiated based on natural community condition assessment plot data for the Creosotebush-Bursage Desert Scrub community (Morrison and others 2003:76–78). The plot variables considered in these analyses related to the field-based factors PBI hypothesized were related to condition: number and percent cover of native species, number and percent cover of non-native species, number and percent cover of native grasses, percent cover of sand and soil, livestock index, and vehicle index.

We expanded on these analyses by analyzing a broader suite of composition variables for all natural community types that had data for at least two condition classes with sample sizes of two or more plots per condition class. Natural communities that met these conditions included:

Table 5.5 Inputs to the Community Condition Models and Final Condition Map

Factors Used in Modeling and Mapping Ecological Condition Class	Creosotebush-Bursage Desert Scrub	Paloverde-Mixed Cacti - Mixed Scrub on Bajada	Paloverde -Mixed Cacti-Mixed Scrub on Rocky Slope	Mountain Upland	Mesquite Woodland	Braided Channel Floodplain	Valley Xeroriparian Scrub	Mountain Xeroriparian Scrub	Desert Grassland	Rock Outcrop	Desert Springs
Distance from potential livestock congregation area	X	X			X	X	X				
Natural community boundary (that is, community was assigned to a single condition class)			X	X				X		X	X
Natural community boundary divided between SDNM and Tohono O'odham Nation lands									X		
Roads	X	X	X	X	X	X	X	X	X	X	X
Linear disturbances	X	X	X	X	X	X	X	X	X	X	X
Developed/disturbed sites	X	X	X	X	X	X	X	X	X	X	X
Live ordnance target areas and one-year EOD sweep operations (relevant only to communities occurring on the BMGR)	X	X	X				X	X		X	

- Creosotebush-Bursage Desert Scrub (Condition Class 1, N = 18; Condition Class 2, N = 66, Condition Class 3, N = 3)
- Paloverde-Mixed Cacti-Mixed Scrub on Bajadas (Condition Class 2, N = 20; Condition Class 3, N = 14)
- Mesquite Woodland (Condition Class 1, N = 10; Condition Class 2, N = 3)
- Valley Xeroriparian Scrub (Condition Class 1, N = 10; Condition Class 2, N = 14).

We tested the ability to differentiate assigned condition classes based on: (1) total number and percent cover of all species, native species, and non-native species; (2) number and percent cover of native and non-native grasses; (3) number and percent cover of native and non-native forbs; (4) and number and percent cover of six other life form groups tested separately (shrubs, trees, cacti, vines, ferns and club mosses, and parasitic species). Percent cover data were first transformed using an arcsine transformation prior to parametric analysis. Cover values greater than 100% were assigned a value of 100% prior to transformation. All data, including transformed cover data, were checked for normality. For cover data that were still non-normal even after transformation, we analyzed the untransformed data using non-parametric statistics.

For the normally distributed Creosotebush-Bursage Desert Scrub plot data we first conducted a one-way analysis of variation (ANOVA) for each of the dependent variables. To conduct post-hoc pairwise comparisons, we applied the Bonforoni adjustment to Fisher's least significant difference test in which the probabilities are adjusted by multiplying by the number of pairwise tests performed. For all other normally distributed natural community plot data, we conducted unpaired *t*-tests.

For the non-normally distributed Creosotebush-Bursage Desert Scrub plot data we conducted a Kruskal-Wallis *k*-sample test (nonparametric ANOVA). For post-hoc pairwise comparisons, along with tests of other non-normally distributed natural community plot data, we applied the Mann-Whitney test. This test can address unequal-sized samples. We again applied the Bonforoni adjustment to the probabilities obtained in the pairwise test comparisons.

Statistical significance was set for all tests at $p < 0.05$. All analyses were performed using either Systat Version 10 or 11 software.

5.4 DEFINING A FUNCTIONAL CONSERVATION AREA

Although the selection of conservation elements was accomplished with the spatial extent of the SDNM in mind, many of the conservation elements and their associated ecological processes occur across the monument boundary. The SDNM boundary is an administrative boundary that at least for some conservation elements and ecological processes may not by itself encompass sufficient area or the appropriate spatial configuration of the different natural communities to maintain the long-term viability of included conservation elements. When determining how big and in what spatial configuration a conservation area needs to be, it is important to consider the natural communities and species that are the focus of management attention and the spatial scales at which they and their supporting ecological processes occur. That is, how big needs to be defined on the basis of what area and spatial pattern is needed to maintain the biological resources contained within.

To help frame the above discussion we can make use of the concept of a functional conservation area. Poiani and others (2000) define a functional conservation area as "a geographic domain that maintains focal natural communities, species, and supporting ecological processes within their natural ranges of variability." The definition readily leads to two characteristics of functional conservation areas: (1) size, configuration, and other design features are determined by the focal biological elements and supporting ecological processes and (2) the area is functional if it maintains focal biotic and abiotic patterns and processes within their natural ranges of variability over time frames relevant to conservation planning and management (for example, 100 to 500 years; Poiani and others [2000]). In addition, functional conservation areas do not necessarily preclude compatible human activities (for example, working landscapes) and ecological management (for example, prescribed burning) or restoration (for example, invasive plant removal and replacement with native species) may be necessary to maintain functionality.

Poiani and others (2000) define three types of functional conservation areas: sites, landscapes, and networks. Each of these types is generally associated with a particular spatial scale or scales. The different spatial scales, which are defined in Figure 5.1, are: local, intermediate, coarse, and regional. As mentioned above, size is determined by the biotic elements that occur within the conservation area of interest and that are intended to be the focus of management attention. Each element is associated with its own particular spatial scale. Functional sites conserve a small number of natural communities and/or species within their natural ranges of variability at one or two scales below the regional scale. Functional landscapes conserve many natural communities and species within their natural ranges of variability at all scales below the regional scale. Functional networks are integrated sets of sites and landscapes designed to conserve regional-scale species, such as migrating ungulate species or top predators, within their natural ranges of variability. Any particular conservation area can include a mix of species and

ecosystems that in combination occur at multiple scales and that nest together in complex configurations (Poiani and others 2000). Functional conservation areas that attempt to conserve matrix communities or area dependent species such as desert bighorn sheep (*Ovis canadensis mexicana*) will need to encompass sufficient size to address the coarse-scale requirements of these elements.

As we will see in Chapter 6, based on the conservation elements identified for the SDNM, their associated ecological processes, and the spatial scales at which they occur, the appropriate functional conservation area to define that will maintain the biological resources of the SDNM is a functional conservation landscape. In section 6.5 we define the appropriate boundary of this functional conservation landscape.

CHAPTER 6 OVERVIEW OF CONSERVATION ELEMENTS RELEVANT TO THE SONORAN DESERT NATIONAL MONUMENT

This chapter summarizes information relative to the conservation elements selected to represent the biodiversity of the Sonoran Desert National Monument (SDNM) and also provides brief descriptions of each individual element. Additional details about each selected conservation element, and some additional elements that were considered but not selected, are provided in appendices to this report or in other cited documentation. The chapter also provides a comparison between the objects identified in the proclamation for the SDNM (Clinton 2001) and the conservation elements to identify their degree of overlap. The chapter concludes with a description of the Sand Tank Mountains Complex Functional Conservation Landscape, which includes the SDNM at its core.

6.1 SUMMARY INFORMATION ACROSS ALL ELEMENTS

A total of 26 natural communities/guilds/species are proposed to serve as a focal set of conservation elements for the SDNM. These elements represent the outcome of a coarse filter-fine filter approach meant to capture and represent the biodiversity of the SDNM and adjacent portions of the Barry M. Goldwater Range (BMGR) and Tohono O’odham Nation for management planning purposes under the Bureau of Land Management’s resource management plan for the monument.

The proposed set of conservation elements is based on our knowledge to date of the natural resources occurring on the SDNM and vicinity. Additional species were suggested by our information gathering or by experts for consideration as conservation elements; however, in many cases we lacked the requisite information needed to determine whether such species qualified as fine-filter conservation elements. As a result, some species can be considered as potential conservation elements. Although we do not discuss them in the context of our selected conservation elements, we do provide information later in this report on these species that may prove helpful when assessing at a later date the choice of conservation elements. As a result, we suggest that the selection of conservation elements should be viewed as a dynamic process in which, as new information becomes available, the selection is periodically assessed and updated.

The proposed conservation elements for the SDNM are identified in Table 6.1. They are arranged within a matrix that shows their alignment with geographic scale and level of biological organization. Linear communities do not necessarily align with a particular geographic scale, but they are included for completeness. The table also identifies the basis for including a fine-filter element (see Table 5.1 for descriptions of the fine-filter criteria used to select species, guilds, and specialized habitat conservation elements). Table 6.2 summarizes information on global and state ranks, distribution, whether the element was considered as a Sonoran Desert ecoregional target (Marshall and others 2000), and conservation status.

6.2 NATURAL COMMUNITY CONSERVATION ELEMENTS

With the exception of the specialized habitats identified in Table 6.1, the natural community conservation elements represent the coarse filter for capturing the biological diversity of the SDNM and adjacent portions of the BMGR and Tohono O’odham Nation. As a coarse filter, the combination of natural communities, when appropriately managed to ensure the long-term persistence of each community type, should provide a reasonable assurance that the majority of species associated with these communities will remain viable as well.

TABLE 6.1 Conservation Elements of the Sonoran Desert National Monument¹

Geographic Scale	Level of Biological Organization		
	Species/Guild	Terrestrial Natural Community	Aquatic Natural Community
Regional	None identified to date	N/A	N/A
Coarse	Native grass group (RV) Bat guild (S, SS [includes one federal endangered species]) Desert bighorn sheep (AD, RV) Primary excavator (cavity) guild (K, S)	Creosotebush-Bursage Desert Scrub Paloverde-Mixed Cacti-Mixed Scrub on Bajadas Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes	None identified to date
Intermediate	Saguaro (SV) Desert tortoise (RV) Le Conte's thrasher (S, RV) Cactus ferruginous pygmy-owl (RV, SS [federal endangered]) Rufous-winged sparrow (S, RV)	Mountain Upland Desert Grassland Braided Channel Floodplain	None identified to date
Local	Maricopa leaf-nosed snake (RV) Tucson shovel-nosed snake (RV) Red-backed whiptail (RV) Ephemeral water-breeding amphibian guild (S) Acuña cactus (RV, SS [federal candidate])	Rock Outcrop (SH) Mesquite Woodland	Tinaja (SH) Desert Spring (SH)
Linear	N/A	Valley Xeroriparian Scrub Mountain Xeroriparian Scrub	N/A

¹Elements in **bold text** are specific to the SDNM (that is, they were not selected as elements on the BMGR by Hall and others 2001) or, for guilds, are modified in composition from the similar guild defined for the BMGR. Legend: AD = area-dependent species; K = keystone species; RV = regionally vulnerable species; S = specialized species; SH = specialized habitat, SS = special status species; SV = social value species. Complete definitions for these fine-filter criteria are provided in Table 5.1. Figure 5.1 describes the geographic scales considered.

6.2.1 Identification, Mapping, and Description of Natural Communities

Pacific Biodiversity Institute identified, mapped, and described 12 natural communities within the study area, which includes the SDNM, adjacent portions of the BMGR in the Sand Tank Mountains area, adjacent portions of the Tohono O'odham Nation containing Desert Grassland community occurrences, and a quarter mile area around other portions of the monument (Morrison and Snetsinger 2003, Morrison and others 2003). Figure 6.1 depicts the spatial distribution pattern of the natural communities within this boundary. Their spatial scale of occurrence is identified in Table 6.1 and extent in hectares in Table 6.3.

TABLE 6.2 Summary Information for Sonoran Desert National Monument Conservation Elements

Taxon Common Name or Natural Community	Scientific Name	G Rank ¹	Combined G Rank ¹	S Rank ¹	Distribution ²	Ecoregion Target ³	Status ⁴	Comments
Natural Community (Coarse Filter)								
Creosotebush-Bursage Desert Scrub		GU	GU		L	Yes		
Paloverde-Mixed Cacti-Mixed Scrub on Bajadas		GU	GU		L	In part		Ecoregion target was paloverde-mixed cacti.
Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes		GU	GU		L	In part		Ecoregion target was paloverde-mixed cacti.
Valley Xeroriparian Scrub		GU	GU		L	No		
Mountain Xeroriparian Scrub		GU	GU		L	No		
Braided Channel Floodplain		GU	GU		L	No		
Mountain Upland		GU	GU		E	No		
Desert Grassland		G5	G5		P	Yes		
Mesquite Woodland		G3	G3		L	Yes		
Natural Community (Specialized Habitat)								
Tinaja		GU	GU		L	No		
Desert Spring		GU	GU		L	Yes		
Rock Outcrop		GU	GU		L	Yes		
Plants								
Acuña cactus	<i>Echinomastus erectocentrus</i> var. <i>acunensis</i>	G3T1Q	G1	S1	E	No	C	
Saguaro	<i>Carnegiea gigantea</i>	G5	G5		L	Yes		Crested (cristate) forms are Highly Safeguarded and all other forms are Salvage Restricted under the Arizona Native Plant Law.
Native grass group	Numerous included taxa					No		
Amphibians								
Sonoran Desert toad	<i>Bufo alvarius</i>	G5	G5	S5	E	Yes		Included in ephemeral water-breeding amphibian guild.

TABLE 6.2 Summary Information for Sonoran Desert National Monument Conservation Elements—continued

Taxon Common Name or Natural Community	Scientific Name	G Rank ¹	Combined G Rank ¹	S Rank ¹	Distribution ²	Ecoregion Target ³	Status ⁴	Comments
Great Plains toad	<i>Bufo cognatus</i>	G5	G5	S5	W	No		Included in ephemeral water-breeding amphibian guild.
Red-spotted toad	<i>Bufo punctatus</i>	G5	G5	S5	W	No		Included in ephemeral water-breeding amphibian guild.
Sonoran Green toad	<i>Bufo retiformis</i>	G3G4	G3	S3	E	Yes		Included in ephemeral water-breeding amphibian guild.
Couch's spadefoot	<i>Scaphiopus couchii</i>	G5	G5	S5	W	No		Included in ephemeral water-breeding amphibian guild.
Western narrowmouth toad	<i>Gastrophryne olivacea</i>	G5	G5	S3	L	No		Included in ephemeral water-breeding amphibian guild.
Lowland burrowing tree frog	<i>Pterohyla fodiens</i>	G4	G4	S1S2	L	No		Included in ephemeral water-breeding amphibian guild.
Reptiles								
Desert tortoise (Sonoran Desert population)	<i>Gopherus agassizii</i>	G4	G4	S4	L	Yes		
Red-backed whiptail	<i>Aspidozelis xanthonotus</i>	G4T2	G2	S2	E	Yes		
Maricopa leaf-nosed snake	<i>Phyllorhynchus browni lucidus</i>	G5T2	G2	S2	E	Yes		
Tucson shovel-nosed snake	<i>Chionactis occipitalis klauberi</i>	G5T2T3Q	G3	S?	E	No		
Birds								
Cactus ferruginous pygmy-owl	<i>Glaucidium brasilianum cactorum</i>	G5T3	G3	S1	E	Yes	LE	
Gilded flicker	<i>Colaptes chrysoides</i>	G5	G5	S5	E	Yes	BCC	Included in the primary excavator (cavity) guild.
Gila woodpecker	<i>Melanerpes uropygialis</i>	G5	G5	S5	L	No	BCC	Included in the primary excavator (cavity) guild.

TABLE 6.2 Summary Information for Sonoran Desert National Monument Conservation Elements—continued

Taxon Common Name or Natural Community	Scientific Name	G Rank ¹	Combined G Rank ¹	S Rank ¹	Distribution ²	Ecoregion Target ³	Status ⁴	Comments
Ladder-backed woodpecker	<i>Picoides scalaris</i>	G5	G5	S5	W	No		Included in the primary excavator (cavity) guild.
Le Conte's thrasher	<i>Toxostoma lecontei</i>	G3	G3	S3	L	Yes	BCC	
Rufous-winged sparrow	<i>Aimophila carpalis</i>	G4	G4	S3	E	Yes	BCC	
Mammals								
California leaf-nosed bat	<i>Macrotus californicus</i>	G4	G4	S3S4	L	Yes	S	Included in the bat guild.
Cave myotis	<i>Myotis velifer</i>	G5	G4	S4	W	Yes	S	Included in the bat guild.
Lesser long-nosed bat	<i>Leptonycteris curasoae yerbabuenae</i>	G4T3T4	G4	S2	L	Yes	LE	Included in the bat guild.
Desert bighorn sheep	<i>Ovis canadensis mexicana</i>	G4T3T4Q	G4	S3S4	L	Yes		

¹Global (G) and state (S) rank codes are defined in Appendix A, Table A.1.

²Distribution codes are defined in Appendix A, Table A.4.

³Based on Sonoran Desert Ecoregion conservation target information contained in Marshall and others (2000).

⁴C = federal Candidate; LE = listed federal Endangered; BCC = U.S. Fish and Wildlife Service bird of conservation concern; S = Bureau of Land Management Sensitive Species.

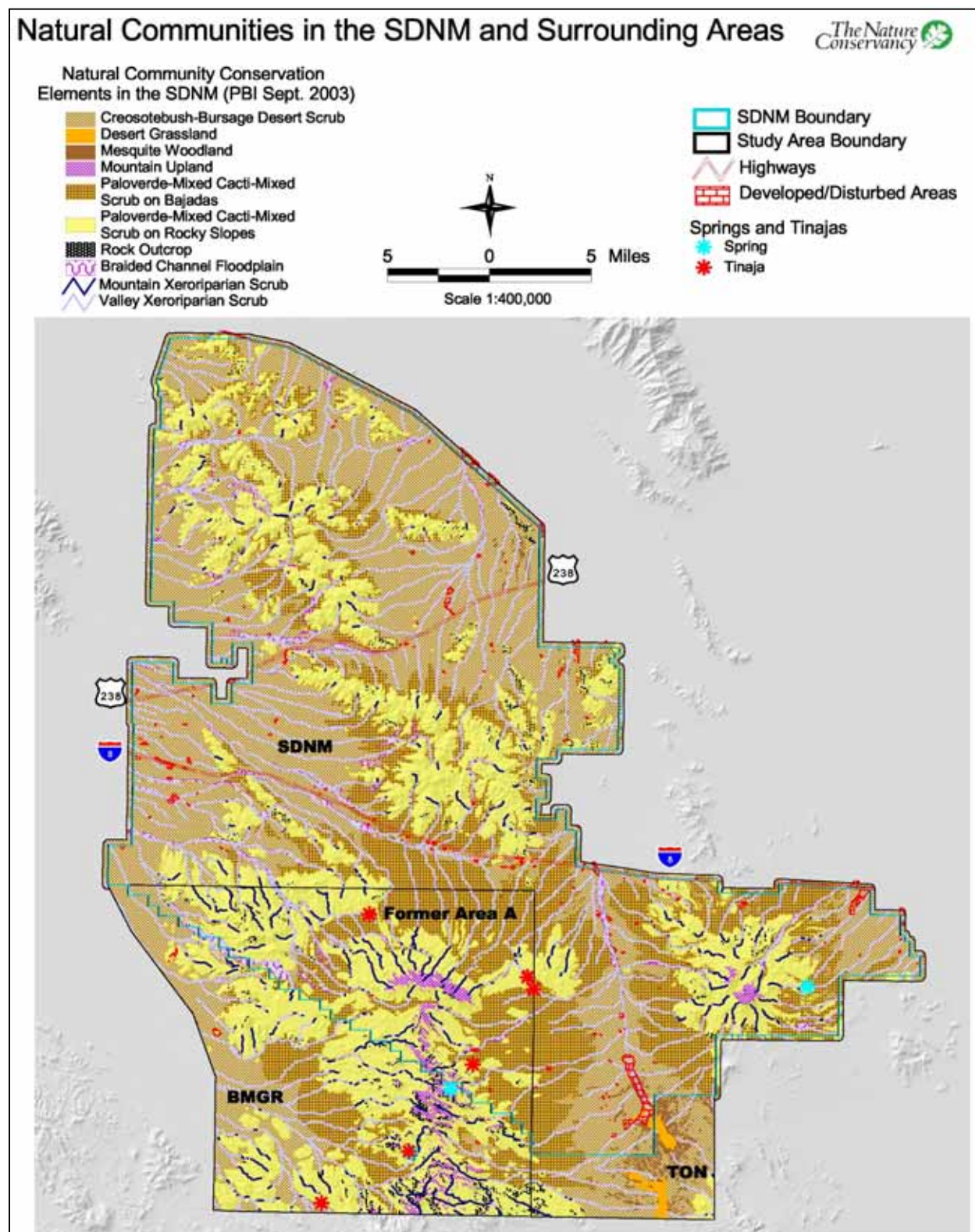


Figure 6.1 Natural Communities of the Sonoran Desert National Monument and Adjacent Areas

Table 6.3 Area Covered by Major Natural Communities

Natural Community		SDNM (ha)	SDNM Buffer (ha)	BMGR and TON ¹ Extension (ha)	Study Area (ha)
Non-Riparian Communities	<i>Creosotebush-Bursage Desert Scrub</i>	82,909	6,566	15,436	104,911
	<i>Paloverde-Mixed Cacti-Mixed Scrub on Bajadas</i>	50,895	1,215	7,787	59,897
	<i>Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes</i>	59,190	660	21,749	81,599
	<i>Mountain Upland</i>	1,283	0	1,019	2,302
	<i>Desert Grassland</i>	102	0	679	781
	<i>Mesquite Woodland</i>	676	49	957	1,681
	<i>Rock Outcrop</i>	627	2	998	1,627
	Total Area of Non-Riparian Communities	195,683	8,491	48,625	252,799
Riparian Communities	<i>Braided Channel Floodplain</i>	5,186	157	176	5,519
	<i>Valley Xeroriparian Scrub</i> ²	2,790	158	544	3,492
	<i>Mountain Xeroriparian Scrub</i> ²	348	1	177	526
	Total Area of Riparian Communities				9,537

¹TON = Tohono O'odham Nation.

²These two communities were mapped as overlays to the rest of the natural communities and, as a result, their area values were not subtracted when calculating the other community area amounts.

Eleven of the 12 communities occurred on the SDNM. Desert Springs were mapped only within the BMGR portion of the Sand Tank Mountains; however, it's possible this community type may occur or occurred in the past on the monument. A few discontinuities of the natural communities occurred within the quarter mile area outside the SDNM boundary (depicted in Figure 6.1 as a thin strip along the northern, northwestern, and northeastern boundaries of the SDNM). Two of these discontinuities are represented by agricultural strips of land oriented generally north-south that abut the monument on its northern boundary in the Rainbow Valley area.

Pacific Biodiversity Institute's comparison of the relationship of the natural community types as mapped on the SDNM to Natural Resources Conservation Service (NRCS) ecological site classes based on soil survey information demonstrated a moderate to strong correspondence, depending on community type. The lack of perfect overlap is not surprising given the different criteria involved for classifying natural communities versus ecological sites. Still, some of the correspondences are of interest. For example, the basalt hills, granitic hills, and schist hills tended to spatially overlap with the higher elevation natural communities, with most of the spatial extent of these three preceding site classes corresponding to the Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes community. The Mountain Upland and Rock Outcrop communities accounted for most of the remaining overlap, with Mountain Uplands found mostly on basalt hills and Rock Outcrops mostly corresponding to the granitic hills.

Similarly, the limy fan, the most extensive ecological site class on the SDNM in terms of areal extent, was dominated by the Creosotebush-Bursage Desert Scrub community (85% of the class occurs in association with this community), whereas an additional 14% occurred in association with the Paloverde-

Mixed Cacti-Mixed Scrub on Bajadas community. The imperfect correspondence reflects in part the additional physical factors, such as elevation, besides soil characteristics that govern plant compositional transitions across natural communities. These latter two natural communities, which are matrix communities, also occurred on a number of other ecological sites. As such, they illustrate that the natural communities are a coarser classification than ecological site classes, especially for those natural communities that occur over large spatial areas and experience a range of environmental conditions that could influence community composition. The more localized natural communities on the other hand, such as the Desert Grassland community, tended to correspond primarily with just two or three ecological site classes each.

Pacific Biodiversity Institute identified a total of 325 native plants and 21 non-native plants during the course of their Phase 1 and Phase 2 fieldwork. These numbers likely underestimate the size of the flora of the area as the long-term regional drought and restricted window of the survey period probably caused a number of species present in the area to be missed. Of the 325 native plants identified, three taxa were considered very rare or rare (1 or 2 rank, respectively) at the global or state scale: shrubby falsemallow (*Malvastrum bicuspidatum*; G4; S2), Arizona pholistoma (*Pholistoma auritum* var. *arizonicum*; G5T2T3; no Arizona state rank; however, it is an S1 plant in California); and Sonoran mountain rosewood (*Vauquelinia californica* ssp. *sonorensis*; G4T1; S1) (rank definitions can be found in Appendix A, Table A.1). The Sonoran mountain rosewood also is a Bureau of Land Management (BLM) Sensitive Species (BLM 2001). Shrubby falsemallow and Sonoran mountain rosewood are endemic to Arizona. Sonoran mountain rosewood was evaluated but not selected as a fine-filter conservation element (see Appendix D, Table D.3); however, neither the shrubby falsemallow nor the Arizona pholistoma were evaluated as part of this study as their identification as rare species came late in the process. Their conservation status needs to be confirmed.

Brief descriptions of each natural community are provided in following paragraphs. Detailed descriptions and field data associated with each community, including species composition data organized by growth-form category, are provided in Morrison and Snetsinger (2003) and Morrison and others (2003).

Creosotebush-Bursage Desert Scrub

Creosotebush-Bursage Desert Scrub is the primary matrix community that occupies the lowest elevations on the SDNM and covers desert flats, valley bottoms, and lower portions of bajadas. The community is dominated by creosotebush (*Larrea tridentata* [= *L. divaricata tridentata*]) and has a relatively small leguminous tree component compared to the Paloverde-Mixed Cacti-Mixed Scrub on Bajadas and Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes communities. Compositional variants that form recognizable subdivisions within this community likely occur, but were not fully described during this study. Elevation and livestock-associated disturbance gradients seem to be the primary contributors to environmental- and anthropogenic-related variation, respectively (Table 5.4).

Paloverde-Mixed Cacti-Mixed Scrub on Bajadas

Paloverde-Mixed Cacti-Mixed Scrub on Bajadas is the secondary matrix community that is characterized by greater leguminous tree and cacti cover than the Creosotebush-Bursage Desert Scrub community. This community is typically spatially "sandwiched" in between the Creosotebush-Bursage Desert Scrub and the Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes communities. This community occurs on the gentle slopes of desert bajadas. It is much more extensively expressed on the bajadas associated with the Sand Tank and Table Top Mountains than on the bajadas surrounding the Maricopa Mountains to the north of Interstate 8 (Figure 6.1). This is the community in which saguaro (*Carnegiea gigantea*) "cactus forests" are found. The lower elevations of this community and the upper elevations of the Creosotebush-Bursage Desert Scrub community form a relatively broad ecotone, as community composition and structure transition from characteristics of one community into the other. In addition to using elevation

and slope break parameters to help model the separation between this community and Cresotebush-Bursage Desert Scrub, PBI also applied a vegetative cover criterion. Paloverde-Mixed Cacti-Mixed Scrub on Bajadas characteristically contains at least five percent cover of leguminous trees as determined through interpretation of DOQQ imagery. Considerable variation in composition characterizes this community. Soil texture and livestock-associated disturbance gradients seem to be the primary contributors to environmental- and anthropogenic-related variation, respectively (Table 5.4).

Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes

Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes is the tertiary matrix community that occupies the mountainous slopes in the study area. A higher leguminous tree component, as well as a more frequent occurrence of brittlebush (*Encelia farinosa* var. *farinosa*) and wolfberries (*Lycium* spp.), distinguish this community from the Paloverde-Mixed Cacti-Mixed Scrub on Bajadas community. The transition between the bajada and rocky slope communities occurs at a slope break of about five to six degrees. Slope, aspect, and geology seem to be the primary contributors to environmental-related variation (Table 5.4). Anthropogenic disturbance factors do not correlate strongly with compositional variation for this community. Some species associates have strong associations with particular substrates, moisture regimes, or temperature regimes. For example, Arizona spike-moss (*Selaginella arizonica*) occurs in high abundance primarily on north aspects of granitic mountains.

Mountain Upland

Mountain Upland is a large patch community limited to the highest elevations (and mostly northern aspects) occurring in the study area. This botanically diverse community is primarily distinguished by the occurrence of crucifixion thorn (*Canotia holacantha*), desert agave (*Agave deserti simplex*), banana yucca (*Yucca baccata*), and other high elevation shrub and tree associates. Perennial plant cover is high (mean from plots of about 60%), with about 10% cover attributable to native perennial grasses. Because the community is associated with the Table Top Mountains as well as the Sand Tank Mountains, its distribution is more extensive than was described in Hall and others (2001; though PBI's updated spatial model for mapping this community reduced its presumed areal coverage in the Sand Tank Mountains considerably). Hall and others (2001) assumed a similar combination of plants may occur only at the upper elevations of the Ajo Mountains. Elevation, slope, and aspect seem to be the primary contributors to environmental-related variation (Table 5.4). Anthropogenic disturbance factors likely do not strongly influence compositional variation for this community. Mountain Upland is one of the few natural communities within the study area that experiences regular freezing temperatures in the winter and frequent cloud cover that may help to maintain relatively high moisture levels.

Desert Grassland

Desert Grassland is a large patch community that is limited in occurrence within the study area to the upper Vekol Valley flats. A portion of the community occurs within the Vekol Valley Area of Critical Environmental Concern within the southeast corner of the SDNM. More extensive occurrences of this community are present on the adjacent portions of the Tohono O'odham Nation. This community is identifiable by its dominant bunch grass component, tobosa grass (*Pleuraphis mutica*), and a single vegetative layer structure. The community occurs on poorly drained desert valley bottoms with significant hydrologic flow accumulation from the surrounding uplands. Livestock grazing, periodic flooding, and hydrologic alterations caused by spreader dikes present in the area potentially influence the composition and structure of this community. In some places, velvet mesquite (*Prosopis velutina*) has recently invaded portions of the Desert Grassland community. To better understand the compositional and structural variation characteristic of this community would require surveys of Tohono O'odham Nation occurrences, as well as additional seasonally relevant surveys on the SDNM.

Mesquite Woodland

Mesquite Woodland is a small patch, or at times linear, community that occurs in lowland flats. Within the study area, mesquite stands are closely associated with water impoundments, xeroriparian communities, and areas that had experienced substantial grazing pressure or periodic flooding. This community is characterized by its woodland structure and the dominance of velvet mesquite. Mesquite Woodland is a community that is limited in its distribution compared to its historic range. It provides important wildlife habitat. Pacific Biodiversity Institute stratified the Mesquite Woodland community within the study area into three sub-community types:

1. Mesquite-dominated woodlands established before the 1960s.
2. Mesquite stands found on or near spreader dikes or water tanks.
3. Mesquite stands invading other natural communities after 1968.

Sub-community 1 is likely the only type that corresponds to what were originally naturally occurring Mesquite Woodlands, as natural stands are typically associated with riparian areas or areas where the water table is close to the surface. Most mesquite stands within the study area show evidence of anthropogenic disturbance. Some sub-community 1 stands are associated with the Braided Channel Floodplain community in the lower Vekol Valley and additional stands of this type also can be found in the North Tank area near Mobile. Distance from roads and potential livestock congregation areas seem to be the primary contributors to anthropogenic related variation (Table 5.4).

Rock Outcrop

Rock Outcrop is a small patch community that typically occurs as a mosaic with the Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes or Mountain Upland communities. This community has low vegetative cover compared to the surrounding communities. The substrate is bedrock without soil accumulation. Anthropogenic disturbance factors likely do not strongly influence compositional variation for this community. Desert rock outcrops provide microhabitats important to the survival of many species of plants and animals.

Valley Xeroriparian Scrub

Valley Xeroriparian Scrub is a linear community that occurs around and encompasses the seasonal wash beds on the bajadas and lowland flats within the study area. This community has a high leguminous tree component, abundant vines, and a multi-layered canopy structure. It is distinguished from the Mountain Xeroriparian Scrub community by having a wash channel that is not confined to a bedrock substrate. This community's spatial occurrence is sensitive to peak flood-flow events. Elevation seems to be the primary contributor to environmental-related variation (Table 5.4); however, vegetation patterns within this community also may be affected by broader-scale patterns. Frequency, volume, and duration of flow along wash channels of different size are a function of the associated watershed area and regional rainfall regime (Warren and Anderson 1985). These factors can contribute to compositional and structural variation within Valley Xeroriparian Scrub communities. This community is particularly important to wildlife, especially migratory birds (Morrison and others 1997; see also Johnson and Haight 1985).

Mountain Xeroriparian Scrub

Mountain Xeroriparian Scrub is a linear community that occurs around and encompasses the seasonal wash beds on the steeper mountain slopes of the study area. This community has a high leguminous tree component and a multi-layered canopy structure. It is distinguished from the Valley Xeroriparian Scrub

community by having a wash channel that is confined to a bedrock substrate. This community's spatial occurrence is not sensitive to peak flood-flow events. Elevation, aspect, and geologic substrate seem to be the primary contributors to environmental-related variation (Table 5.4).

Braided Channel Floodplain

Braided Channel Floodplain is a large patch community that has many similarities to the Valley Xeroriparian Scrub community but differs in regard to its width, dominant geomorphic/hydrologic processes, and vegetation composition. This community occupies relatively broad floodplain areas within the mountain valleys and along major washes on the bajadas. Multiple, cross-braiding channels characterize this community. Vegetated island areas and adjacent floodplain zones often are present that are inundated by floodwaters during high flow events. This community is much wider in cross-section than the typical xeroriparian communities. Because the floodplains are complexes of many sub-communities, which occupy a variety of surfaces with different disturbance histories (for example, flooding, erosion, and deposition), compositional and structural variation is high. Despite this variation, floodplain indicator plants desert broom (*Baccharis sarothroides*) and cheesebush (*Hymenoclea salsoa*) generally are a consistent part of the flora. Some of the best examples of this community within the study area occur in the Sand Tank Mountains along Sand Tank Wash and within Vekol Valley along Vekol Wash. Elevation and the livestock-associated disturbance index seem to be the primary contributors to environmental- and anthropogenic-related variation, respectively (Table 5.4).

Desert Spring

Desert Spring is a small patch community that surrounds and encompasses a naturally occurring spring. This community has a unique plant species composition compared to the surrounding matrix community in which it occurs. The presence of plants typically sensitive to dry soil conditions is a good indicator of this community. Both springs PBI visited within the study area, which were both located on the BMGR, likely were developed at some point in the past. Subsequent to PBI's study, Gene Dahlem of BLM (pers. comm.) identified the existence of a spring, Kate's Spring, on the east side of Table Top Mountain, the location of which is identified in Figure 6.1.

Tinaja

Tinaja is a small patch community that encompasses a naturally occurring tinaja. Tinajas are typically small aquatic ecosystems formed through water accumulation in bedrock depressions. This community does not usually contain much terrestrial vegetation. Tinajas can be an important source of water for desert wildlife. Water duration depends on a number of factors, including tinaja dimensions, local rainfall patterns, and catchment area. Many of the tinajas within the study have been developed to create more extensive water catchments for wildlife or livestock use. A good example of an undeveloped tinaja can be found near Bender Spring in Bender Canyon.

The locations (Figure 6.1) of tinajas (and springs) on the BMGR-former Area A portion of the study area is based on point data obtained from Luke Air Force Base's Special Aquatic Sites data layer and selecting from the data what was identified as natural tinajas and springs. The actual extent of natural tinajas is probably underrepresented by the available data.

6.2.2 Condition Assessment

Figure 6.2 shows PBI's aggregate spatial model of ecological condition within the study area using the three condition classes defined in Chapter 5. To the original PBI condition map (Morrison and others 2003) we added grazing allotment boundaries and the locations of the natural community condition assessment plots, color-coded by condition class. We also added a short descriptive name to each

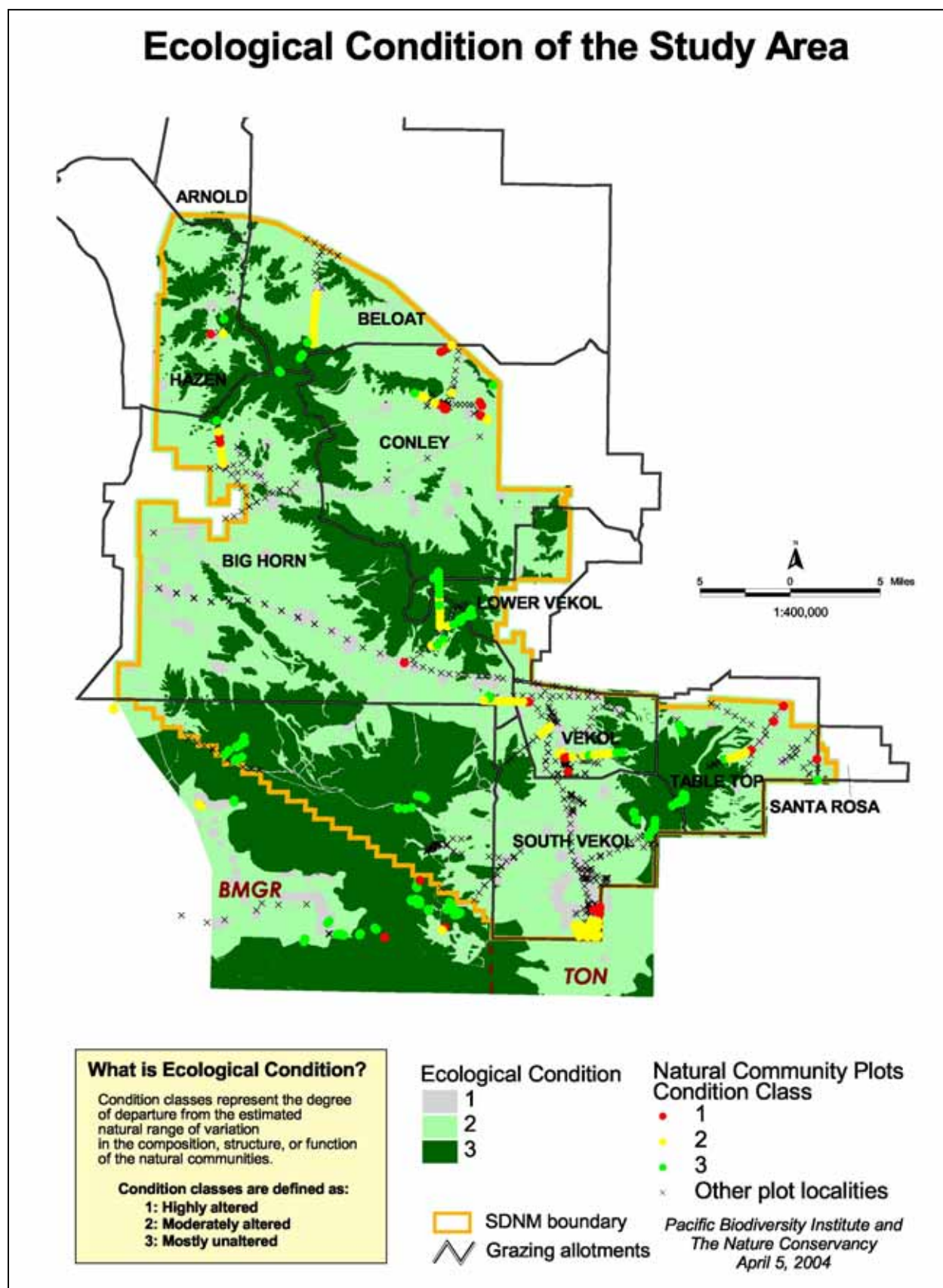


FIGURE 6.2 Spatial Model of Ecological Condition Classes within the Study Area

condition class to facilitate identification. Ecological condition across the study area differs considerably between natural communities and often from one location to another within a community. Based on the field-based measures of condition and anthropogenic disturbance indices identified in Chapter 5, some communities appear to be experiencing high levels of human-related stress, whereas other communities are experiencing little such stress. Of the three matrix communities, which cover 97.5% of the study area, Paloverde-Mixed Scrub-Mixed Cacti on Rocky Slopes is in the best overall condition (mostly in Condition Class 3), followed by Paloverde-Mixed Scrub-Mixed Cacti on Bajadas, and finally by Creosotebush-Bursage Desert Scrub, which contains a fair amount of highly disturbed areas (Condition Class 1; see Figure 6.3, which provides a breakdown by area of the amount of each natural community within each condition class). The higher elevation communities—Mountain Upland and Rock Outcrop—demonstrated little anthropogenic related stress and thus were modeled exclusively as Condition Class 3.

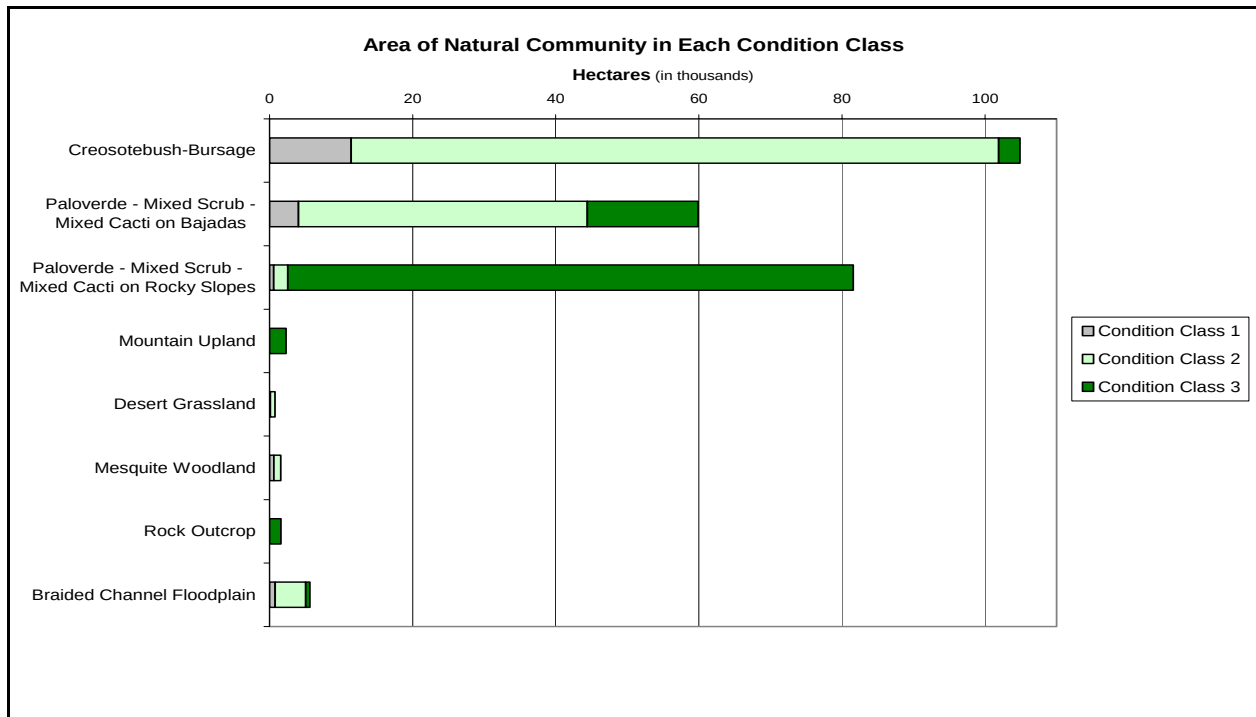


FIGURE 6.3 Area (in Hectares) of Natural Communities by Ecological Condition Class

Notwithstanding the within-community variation and inherent simplicity of this type of analysis, for illustrative purposes the ecological condition of natural communities within the study area can be ranked from least altered condition to most altered condition. In the list that follows the least altered community is listed first and the most altered community is listed last.

1. Rock Outcrop
2. Mountain Upland
3. Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes
4. Mountain Xeroriparian Scrub
5. Tinaja
6. Paloverde-Mixed Cacti-Mixed Scrub on Bajadas
7. Valley Xeroriparian Scrub
8. Braided Channel Floodplain
9. Creosotebush-Bursage Desert Scrub
10. Desert Grassland

11. Desert Spring
12. Mesquite Woodland

Over 95% of the area constituting the first five natural communities in the list are mapped as Condition Class 3. The next four natural communities have significantly lower areas mapped as Condition Class 3 than the first five communities, but these communities still retain over 10% of their areas in Condition Class 3. The last three natural communities in the list do not contain any areas mapped as Condition Class 3 and are considerably degraded from reference conditions.

Pacific Biodiversity Institute based the above rankings not only on the modeled proportion of each natural community in each condition class but also on field observations (for example, observations of accelerated soil erosion and soil compaction) and the abundance of non-native plants characteristic of each natural community within the study area. Figure 6.4 provides a breakdown of the mean percent cover of non-native plants by natural community type (based only on data from the natural community condition assessment plots). The characteristic percent cover of non-native plants differs between the natural communities. Three different subgroups are statistically discernible based on cover differences:

1. Rock Outcrop, Mountain Upland, Mountain Xeroriparian Scrub, and Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes are included in the first subgroup (relatively low percent cover of non-native plants)
2. Paloverde-Mixed Cacti-Mixed Scrub on Bajadas, Desert Grassland, Desert Spring, Valley Xeroriparian Scrub, Creosotebush-Bursage Desert Scrub, and Braided Channel Floodplain are included in the second subgroup (with the exception of Braided Channel Floodplain, other subgroup members also are included in subgroup 1)
3. Mesquite Woodland, which is the sole member of subgroup 3 (relatively high percent cover of non-native plants).

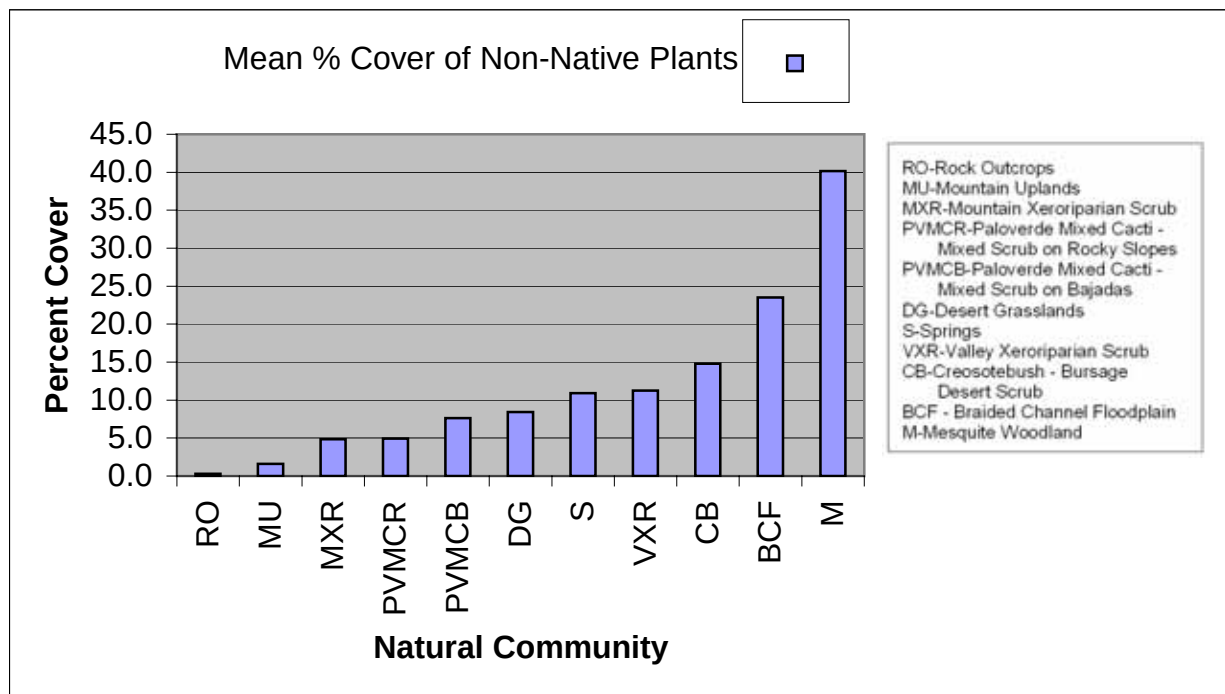


FIGURE 6.4 Mean Percent Cover of Non-Native Plants by Natural Community Type

Based on the combination of non-native plant abundance data from both the natural community condition assessment and non-native plant plots, PBI used linear regression to analyze the relationship of the five most common species based on percent cover to environmental- (elevation, slope, and aspect) and anthropogenic-related disturbance factors (distance from roads and distance from potential livestock congregation areas). The five species were Sahara mustard (*Brassica tournefortii*), red brome (*Bromus rubens*), filaree (*Erodium cicutarium*), Arabian grass (*Schismus arabicus*; although PBI recorded all specimens of *Schismus* as *S. arabicus*, it is likely that some specimens were Mediterranean grass [*S. barbatus*]), and London rocket (*Sisymbrium irio*). Seven hundred and fifty-two plots contained at least one of these five species. Filaree could not be significantly related to any of the factors. Elevation explained 18.6% of the variation in percent cover of Arabian grass. For all other species and factors, even when significant relationships were present, all of the *r*-squared values (which represent the amount of variation in percent cover explained by the factor) were low. Distance from roads did not significantly explain any of the variation in any of the species, and distance from potential livestock congregation areas was only weakly related to percent cover of Arabian grass and red brome. Despite the lack of correlation with distance from roads, PBI did observe that the Interstate 8 corridor contained a high abundance of non-native plants in contrast to many of the smaller and unpaved roads on the SDNM. This finding is consistent with other studies (for example, Gelbard and Belnap 2003) that identify a correlation between non-native plant abundance and species richness with road type in semi-arid environments.

In summary, the spatial model of ecological condition (Figure 6.2) provides relevant, landscape-scale information to BLM on the ecological condition of natural communities on the SDNM. As a heuristic model, it can serve as a baseline for trend analysis and, with appropriate refinement or combination with other spatial data layers, as a basis for making land-use allocation decisions. The model, or more accurately the collection of models, and resultant map could be improved in several ways. First, spatial accuracy could be enhanced by: (1) completely and accurately attributing the BLM's range improvement data layer; (2) developing a spatial impact model that relates to livestock use of xeroriparian communities for foraging, resting and movement; (3) incorporating the effects of road type and the down-gradient effects of range improvements; and (4) collecting additional field data at sample points near the supposed boundary between condition classes to refine model assumptions. Second, incorporation of other types of data that correlate with alterations in natural community condition, such as impacts of undocumented alien traffic, also would be of benefit in building a more heuristic model that links cause and effect. Third, because the area has experienced a long-term regional drought that may affect apparent vegetative composition and relative abundance, fully quantifying the condition classes for each natural community would be aided by collecting data under a representative wet period. Finally, an evaluation of the degree of fragmentation of each natural community would add an additional assessment component of ecological condition that would address patch size, edge, distribution pattern, and connectivity considerations.

6.2.3 Additional Analyses of Natural Community Condition Assessment Plot Data

To evaluate how well the assigned ecological condition classes could be segregated when the underlying plot data were quantitatively analyzed, we statistically tested the natural community condition assessment plot data for differences between condition classes. The results of the additional plot data analyses are presented below by natural community type for those communities that met the conditions for analysis articulated in section 5.3.4.

Creosotebush-Bursage Desert Scrub

Sample sizes, though in some cases limited, permitted statistical tests associated with all three ecological condition classes for the Creosotebush-Bursage Desert Scrub natural community. Tables 6.4 and 6.5 present the results of the analysis of variance tests and the pairwise tests, respectively. A number of the parametric and non-parametric analysis of variance statistical tests were significant (14 of 24 possible

TABLE 6.4 One-Way Analysis of Variances and Kruskal-Wallis *k*-Sample Tests for Differences in Condition Classes: Creosotebush-Bursage Desert Scrub

Dependent Variable	Sum of Squares	df	Mean Square	F-ratio	Kruskal-Wallis Test Statistic	p-value ¹
Total # Species		2			6.871	0.032
Total Cover		2			12.717	0.002
Total # Native Species		2			5.463	0.065
Total Native Transformed Cover ($C > 100 = 100$) ²	2718.045	2	1359.023	7.323		0.001
Total # Non-Native Species		2			11.097	0.004
Total Non-Native Cover		2			12.069	0.002
# Native Grass Species		2			7.258	0.027
Native Grass Species Transformed Cover	49.250	2	24.625	1.623		0.203
# Non-Native Grass Species		2			8.912	0.012
Non-Native Grass Species Cover		2			6.682	0.035
# Native Forb Species		2			4.896	0.086
Native Forb Species Cover		2			13.642	0.001
# Non-Native Forb Species		2			10.192	0.006
Non-Native Forb Cover		2			8.230	0.016
# Shrub Species		2			3.058	0.217
Shrub Species Transformed Cover	194.472	2	94.236	2.812		0.066
# Tree Species		2			8.702	0.013
Tree Species Cover		2			8.950	0.011
# Cacti Species	6.387	2	3.193	3.045		0.053
Cacti Species Cover		2			13.445	0.001
# Vine Species	0.004	2	0.002	0.156		0.856
Vine Species Transformed Cover	0.030	2	0.015	0.156		0.856
# Ferns and Club Mosses ³	N/A	N/A	N/A	N/A		N/A
Fern and Club Moss Cover ³	N/A	N/A	N/A	N/A		N/A
# Parasitic Species	0.099	2	0.049	1.118		0.332
Parasitic Species Transformed Cover	0.360	2	0.180	0.126		0.881

¹Bolded values are significant at $p < 0.05$.

²For plots in which cover exceeded 100%, the value was set at 100% cover prior to transformation.

³Species representing this life form were not recorded with the Creosotebush-Bursage Desert Scrub natural community.

analyses; Table 6.4). Based on the pairwise comparisons (Table 6.5), most of the statistically significant results were attributable to differences between Condition Classes 1 and 2. Moreover, in the two cases in which the differences between Condition Classes 2 and 3 also were significant (total native species cover and native forb species cover), the direction of the differences were reversed. Where the directionality of differences was consistent between the different combinations of condition classes (11 of the dependent variables), none, one, or, in one case (cover of cacti species), two of the pairwise comparisons were significant. The small sample size associated with Condition Class 3 ($n = 3$) likely contributes to low statistical power for pairwise tests that include Condition Class 3. The most consistency, in regard to

TABLE 6.5 Descriptive Statistics and Condition Class Pairwise Comparisons: Creosotebush-Bursage Desert Scrub

Dependent Variable	Condition Classes			Comparisons (p-values) ¹		
	CB 1 (mean ± SD) ² n = 18	CB 2 (mean ± SD) ² n = 66	CB 3 (mean ± SD) ² n = 3	CB 1–2	CB 2–3	CB 1–3
Total # Species	18.9 ± 13.0	12.7 ± 5.7	22.0 ± 4.4	0.297	0.072	0.339
Total Cover	74.26 ± 34.18	43.45 ± 26.47	67.33 ± 10.54	0.003	0.306	1.000
Total # Native Species	15.8 ± 11.7	11.3 ± 5.8	20.7 ± 4.6	0.816	0.084	0.522
Total Native Transformed Cover (C > 100 = 100) ³	47.31 ± 26.48	31.31 ± 17.82	63.25 ± 11.72	0.007	0.048	0.984
Total # Non-Native Species	3.1 ± 2.2	1.5 ± 0.6	1.3 ± 0.6	0.003	1.000	0.435
Total Non-Native Cover	26.18 ± 19.70	12.52 ± 13.05	4.08 ± 3.57	0.003	0.726	0.081
# Native Grass Species	0.6 ± 0.9	0.3 ± 0.6	1.7 ± 1.5	0.258	0.060	0.480
Native Grass Species Transformed Cover	0.22 ± 0.35	0.56 ± 2.21	1.83 ± 2.75	1.000	0.226	0.300
# Non-Native Grass Species	1.3 ± 0.8	0.9 ± 0.3	1.0 ± 0.0	0.009	1.000	1.000
Non-Native Grass Species Cover	17.04 ± 13.99	10.02 ± 11.01	4.00 ± 3.61	0.048	1.000	0.168
# Native Forb Species	11.0 ± 9.1	8.0 ± 3.7	14.0 ± 3.0	1.000	0.069	0.621
Native Forb Species Cover	33.47 ± 20.44	19.28 ± 15.52	46.17 ± 10.93	0.012	0.033	0.684
# Non-Native Forb Species	1.8 ± 1.6	0.5 ± 0.7	0.3 ± 0.6	0.006	1.000	0.435
Non-Native Forb Cover	9.08 ± 15.98	2.12 ± 7.15	0.08 ± 0.14	0.018	1.452	0.402
# Shrub Species	2.8 ± 2.0	2.0 ± 1.1	3.0 ± 1.7	0.453	0.747	1.000
Shrub Species Transformed Cover	6.83 ± 5.10	9.97 ± 6.88	10.42 ± 2.18	0.071	1.000	0.602
# Tree Species	1.2 ± 1.1	0.4 ± 0.6	0.3 ± 0.6	0.012	1.000	0.663
Tree Species Cover	7.53 ± 10.59	1.14 ± 3.45	0.08 ± 0.14	0.009	1.000	0.519
# Cacti Species	0.2 ± 0.5	0.7 ± 1.1	1.7 ± 0.6	0.286	0.321	0.079
Cacti Species Cover	0.06 ± 0.14	0.32 ± 0.76	4.75 ± 3.73	0.327	0.006	0.003
# Vine Species	0.0 ± 0.0	0.0 ± 0.1	0.0 ± 0.0	1.000	1.000	1.000
Vine Species Cover	0.00 ± 0.00	0.00 ± 0.03	0.00 ± 0.00	1.000	1.000	1.000
# Parasitic Species	0.1 ± 0.3	0.0 ± 0.2	0.0 ± 0.0	0.457	1.000	1.000
Parasitic Species Cover	0.03 ± 0.08	0.05 ± 0.37	0.00 ± 0.00	1.000	1.000	1.000

¹Bolded values are significant at $p < 0.05$. Shaded cells represent p-values obtained via the parametric Fisher's least significant difference test with the probabilities adjusted by the Bonforoni adjustment to account for the number of pairwise tests conducted. Unshaded cells represent p-values obtained via non-parametric Mann-Whitney tests adjusted by the Bonforoni adjustment.

²Cover values are untransformed values.

³For plots in which cover exceeded 100%, the value was set at 100% cover prior to transformation.

directional trends, is seen in the responses of non-native species. In almost all cases—with the species richness of non-native grasses the only marginal exception, non-native species richness and cover decreased progressively in the direction of Condition Class 1 to 3. Besides total native species cover and native forb species cover, the direction of change between Condition Classes 1 and 2 and between 2 and 3 also was reversed for nine additional dependent variables. The higher species richness and cover of native forbs in particular in Condition Class 1 plots versus Condition Class 2 plots seemed to contribute to the reversal in expected directional trends.

Morrison and others' (2003:table 26) similarly analyzed a subset of the Creosotebush-Bursage Desert Scrub condition class data. Their multivariate analysis results were essentially the same for the same variables tested, except for total number of native species. They obtained a significant result for this variable based on a parametric ANOVA test, whereas, because we found the data non-normal, we obtained a marginal, but still non-significant, non-parametric test result (Table 6.4). Morrison and others (2003) also noted that though some variables followed expected trends (their Table 25), some did not (these authors did not statistically analyze any pairwise tests). They attributed the latter cases in part to the relatively high standard deviations associated with Condition Class 1 means and the possibility that "outlier" plots may be present that skew the response patterns (see below for further discussion of this topic).

A number of factors may affect the perceived response patterns of the dependent variables as interpreted from the data in Table 6.5. First, in most cases when mean values were similar between condition classes or in some cases even when Condition Class 1 had smaller mean values, the standard deviations associated with Condition Class 1 were relatively large compared to the other classes. This indicates that Condition Class 1 plots, relative to other plots, are in combination highly variable and could be amenable to further subdivision and analysis—that is, plot variability within Condition Class 1 may not necessarily be attributable to outlier plots per se but may reflect actual but more complicated response patterns. Two types of plot subdivision are possible.

Morrison and others' (2003) sample design for locating plots, in particular in Creosotebush-Bursage Desert Scrub, involved establishing plot locations along a gradient of distance from what they defined as livestock congregation areas (either a livestock water development or corral). Some of the Condition Class 1 plots were located in the denuded area or "sacrifice zone" located at the center of a congregation area (typically surrounding a water development; Morrison and others [2003]) and, as a result, likely show different responses in the dependent variables compared to plots outside the sacrifice zone. In addition to further plot subdivision by distance, a second manner of segregating plots also may be of interest. Corrals may exhibit different patterns of surrounding livestock usage than water developments, and the same may be true for in-service water developments versus those that have been out of service for a period of time. Of course, the latter segregation of plots requires accurate knowledge of the service history of individual livestock water developments.

Second, the response patterns may not follow simple spatial relationships. Andrew (1988) adopted the use of a sigmoid logistic curve to describe the behavior of ecological variables meant to measure livestock impacts as a function of distance from water. Close to the water response variables show little variation—the area of no change represents the sacrifice zone. From the edge of the sacrifice zone to a point at which livestock impacts are presumably no longer discernible, the response in the ecological variable is predicted to be essentially linear with distance. Although the above general response pattern may apply to each ecological variable considered, the distance to which the response is constant, then linear, and then indiscernible may differ for each variable. Moreover, the response patterns can be affected by the stocking rate, topographic features, plant community differences, and the pattern of animal activity in response to environmental conditions. Although Brooks and others (In Press) found that plant responses to livestock impacts with distance from water in the Mojave Desert generally followed expected trends—native species richness and cover decreased with proximity to the watering site,

whereas non-native species generally tended to follow an opposite pattern—red brome decreased with proximity to the watering sites. Brooks and others' (In Press) hypothesized the response of red brome may have been because of competitive interactions with the other non-native species whose abundance increased with proximity to the watering sites. The implications of Brooks and other' (In Press) study is that response patterns may be complex.

In summary, although all variables analyzed in Table 6.5 did not follow expected trends in a consistent manner across all condition classes, such results may not necessarily be attributable to outlier plots. Senft (1983) noted that livestock may alter nitrogen cycle rates and intensities in the vicinity of watering sites. Such alterations may not only favor non-native plants (Senft 1983), but also may affect the fine-scale response patterns of native plants in the vicinity of watering sites. Such an effect could explain the response patterns of native forbs in Morrison and others' (2003) study. Still, it should be noted that Morrison and others (2003) did not have an opportunity to validate their assignment of condition classes to each condition assessment plot, so the possibility remains that further refinement of their condition class model and its underlying assumptions could alter plot assignments and the subsequent interpretation of the condition class data.

Paloverde-Mixed Cacti-Mixed Scrub on Bajadas

Data were available to compare only Condition Class 2 with Condition Class 3 data. Eight different comparisons were significantly different (Table 6.6). Species richness and abundance were significantly greater in Condition Class 3 plots compared to Condition Class 2 plots and the differences were attributable to a greater number and cover of native species. Across life form groups, native forb and cacti species richness and cover were significantly greater in Condition Class 3 plots compared to Condition Class 2 plots. Native grass species richness and cover both tended to be greater in Condition Class 3 plots; however, the results were non-significant. Distance from livestock congregation areas and soil texture both significantly contributed to compositional differences within the Paloverde-Mixed Cacti-Mixed Scrub on Bajadas natural community (Morrison and others 2003); as a result, the statistically significant differences identified in Table 6.6 may be attributable to both abiotic and anthropogenic factors and not solely to either one.

Mesquite Woodland

Data were available to compare only Condition Class 1 with Condition Class 2 data, though the sample size for Condition Class 2 was small. Of all the comparisons analyzed, only non-native grass species cover, non-native forb species cover, and shrub species cover were significantly different between the two condition classes (Table 6.7). Non-native grass and shrub cover were significantly greater in Condition Class 1 plots compared to Condition Class 2 plots, whereas the reverse was true for non-native forb cover. Although the results were non-significant, tree species cover followed the same trend as shrub cover, whereas native grass species richness and cover followed a trend opposite to that of non-native grass cover. Non-native species were a significant component of the Mesquite Woodland natural community (Figure 6.5). Moreover, the occurrence of filaree within the Mesquite Woodland natural community showed a strong positive relationship with distance from potential livestock congregation areas and distance from road (Morrison and others 2003). Livestock will eat filaree and, as a result, the increase in non-native forb cover in Condition Class 2 plots as compared to Condition Class 1 plots may be correlated with reduced grazing pressure. All of the Condition Class 2 plots were at least 1420 meters (about 0.9 miles) from a potential livestock congregation area (Morrison and others 2003).

Valley Xeroriparian Scrub

Data were available to compare only Condition Class 1 with Condition Class 2 data. Of all the comparisons analyzed, only the number of vine species and vine species cover were significantly different

TABLE 6.6 Descriptive Statistics and Condition Class Comparisons: Paloverde-Mixed Cacti-Mixed Scrub on Bajadas

Dependent Variables	Condition Classes		Statistical Values			
	PVMCB 2 (mean $\pm$ SD) ¹ n = 20	PVMCB 3 (mean $\pm$ SD) ¹ n = 14	Mann-Whitney U Test Statistic	t-value	df	p-value ²
Total # Species	19.6 $\pm$ 6.5	26.6 $\pm$ 4.8		-3.457	32	0.002
Total Cover (C > 100 = 100) ³	42.49 $\pm$ 15.69	57.48 $\pm$ 17.95		-2.684	32	0.011
Total # Native Species	18.6 $\pm$ 6.4	25.5 $\pm$ 4.8		-3.439	32	0.002
Total Native Cover (C > 100 = 100) ³	37.71 $\pm$ 13.77	49.57 $\pm$ 15.15		-2.375	32	0.024
Total # Non-Native Species	1.1 $\pm$ 0.2	1.1 $\pm$ 0.5		-0.698	32	0.490
Total Non-Native Cover (C > 100 = 100) ³	4.78 $\pm$ 5.31	7.91 $\pm$ 9.87		-1.120	32	0.271
# Native Grass Species	0.4 $\pm$ 0.7	1.1 $\pm$ 1.3		-1.935	32	0.062
Native Grass Species Cover	0.14 $\pm$ 0.26	0.79 $\pm$ 1.23	100.0			0.109
# Non-Native Grass Species	1.0 $\pm$ 0.0	1.0 $\pm$ 0.0		N/A	N/A	N/A
Non-Native Grass Species Cover	4.76 $\pm$ 5.30	7.88 $\pm$ 9.78		-1.120	32	0.271
# Native Forb Species	10.5 $\pm$ 4.1	14.4 $\pm$ 3.0	62.0			0.006
Native Forb Species Cover	15.90 $\pm$ 9.71	27.50 $\pm$ 11.77		-3.267	32	0.003
# Non-Native Forb Species	0.1 $\pm$ 0.2	0.1 $\pm$ 0.5		-0.698	32	0.490
Non-Native Forb Species Cover	0.01 $\pm$ 0.06	0.04 $\pm$ 0.13		-0.493	32	0.625
# Shrub Species	4.2 $\pm$ 1.7	5.1 $\pm$ 1.8		-1.329	32	0.193
Shrub Species Cover	15.06 $\pm$ 6.80	11.68 $\pm$ 6.13		1.540	32	0.133
# Tree Species	1.2 $\pm$ 0.8	1.1 $\pm$ 0.5		0.442	32	0.661
Tree Species Cover	5.38 $\pm$ 8.12	5.98 $\pm$ 7.38		-0.536	32	0.596
# Cacti Species	2.0 $\pm$ 1.5	3.6 $\pm$ 1.5	65.0			0.006
Cacti Species Cover	1.20 $\pm$ 1.63	3.52 $\pm$ 3.03		-3.554	32	0.001
# Vine Species	0.1 $\pm$ 0.2	0.1 $\pm$ 0.3		-0.254	32	0.801
Vine Species Cover	0.01 $\pm$ 0.06	0.07 $\pm$ 0.27		-0.698	32	0.490
# Ferns and Club Mosses	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0		N/A	N/A	N/A
Fern and Club Moss Cover	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00		N/A	N/A	N/A
# Parasitic Species	0.1 $\pm$ 0.3	0.1 $\pm$ 0.6		-0.371	32	0.713
Parasitic Species Cover	0.02 $\pm$ 0.08	0.04 $\pm$ 0.09		-0.371	32	0.713

¹Cover values are untransformed values.²Bolded values are significant at $p < 0.05$.³For plots in which cover exceeded 100%, the value was set at 100% cover prior to transformation.

TABLE 6.7 Descriptive Statistics and Condition Class Comparisons: Valley Xeroriparian Scrub

Dependent Variables	Condition Classes		Statistical Values			
	VXR 1 (mean $\pm$ SD) ¹ n = 10	VXR 2 (mean $\pm$ SD) ¹ n = 14	Mann- Whitney U Test Statistic	t-value	df	p-value ²
Total # Species	34.2 $\pm$ 10.6	34.3 $\pm$ 9.5		-0.021	22	0.984
Total Cover (C > 100 = 100) ³	65.50 $\pm$ 14.19	85.50 $\pm$ 34.98		-0.654	22	0.520
Total # Native Species	32.3 $\pm$ 10.5	32.2 $\pm$ 9.4		0.021	22	0.983
Total Native Cover (C > 100 = 100) ³	55.55 $\pm$ 15.51	70.55 $\pm$ 25.93		-1.642	22	0.115
Total # Non-Native Species	1.9 $\pm$ 1.0	2.1 $\pm$ 1.0		-0.416	22	0.682
Total Non-Native Cover (C > 100 = 100) ³	9.95 $\pm$ 8.02	11.95 $\pm$ 15.90		-0.022	22	0.983
# Native Grass Species	1.2 $\pm$ 1.5	1.7 $\pm$ 0.8		-1.056	22	0.303
Native Grass Species Cover	1.32 $\pm$ 2.56	1.39 $\pm$ 1.12		-1.140	22	0.267
# Non-Native Grass Species	1.2 $\pm$ 0.4	1.1 $\pm$ 0.3		0.916	22	0.370
Non-Native Grass Species Cover	7.52 $\pm$ 7.57	10.41 $\pm$ 13.48		-0.294	22	0.772
# Native Forb Species	20.3 $\pm$ 5.7	19.7 $\pm$ 6.5		0.229	22	0.821
Native Forb Species Cover	19.38 $\pm$ 6.63	24.43 $\pm$ 14.99		-0.888	22	0.384
# Non-Native Forb Species	0.7 $\pm$ 0.7	1.0 $\pm$ 0.9		-0.905	22	0.375
Non-Native Forb Species Cover	19.38 $\pm$ 6.63	24.43 $\pm$ 14.99		0.556	22	0.584
# Shrub Species	7.1 $\pm$ 4.3	6.8 $\pm$ 2.2		0.236	22	0.815
Shrub Species Cover	11.80 $\pm$ 11.31	19.86 $\pm$ 11.62		-2.039	22	0.054
# Tree Species	2.2 $\pm$ 0.6	2.2 $\pm$ 0.4		-0.066	22	0.948
Tree Species Cover	22.32 $\pm$ 15.93	22.09 $\pm$ 16.01		-0.132	22	0.896
# Cacti Species	0.8 $\pm$ 1.0	0.9 $\pm$ 1.2		-0.124	22	0.903
Cacti Species Cover	0.20 $\pm$ 0.26	0.32 $\pm$ 0.50		-0.254	22	0.802
# Vine Species	0.1 $\pm$ 0.3	0.6 $\pm$ 0.6	41.5			0.043
Vine Species Cover	0.02 $\pm$ 0.08	0.43 $\pm$ 0.63	40.0			0.036
# Ferns and Club Mosses	0.2 $\pm$ 0.6	0.0 $\pm$ 0.0	77.0			0.237
Fern and Club Moss Cover	0.05 $\pm$ 0.16	0.00 $\pm$ 0.00	77.0			0.237
# Parasitic Species	0.4 $\pm$ 0.5	0.4 $\pm$ 0.5		0.205	22	0.840
Parasitic Species Cover	0.45 $\pm$ 0.95	1.03 $\pm$ 2.40		-0.403	22	0.691

¹Cover values are untransformed values.²Bolded values are significant at p < 0.05.³For plots in which cover exceeded 100%, the value was set at 100% cover prior to transformation.

between the two condition classes (Table 6.8). Condition Class 2 plots contained a significantly greater number of vine species and larger percent cover of vines than Condition Class 1 plots. Woody perennial vines are considered a conspicuous component of this community type (Hall and others 2001); as a result, a reduction in vine species richness and abundance may indicate signs of community degradation. Shrub species cover also tended to be greater in Condition Class 2 plots, though the result was non-significant.

TABLE 6.8 Descriptive Statistics and Condition Class Comparisons: Mesquite Woodland

Dependent Variables	Condition Classes		Statistical Values			
	M 1 (mean $\pm$ SD) ¹ n = 10	M 2 (mean $\pm$ SD) ¹ n = 3	Mann-Whitney U Test Statistic	t-value	df	p-value ²
Total # Species	17.3 $\pm$ 6.3	18.0 $\pm$ 9.5		-0.152	11	0.882
Total Cover (C > 100 = 100) ³	135.25 $\pm$ 55.90	174.58 $\pm$ 75.06	11.0			0.498
Total # Native Species	14.4 $\pm$ 5.9	16.0 $\pm$ 8.7		-0.374	11	0.715
Total Native Cover (C > 100 = 100) ³	100.60 $\pm$ 41.81	116.25 $\pm$ 59.69		-0.145	11	0.887
Total # Non-Native Species	2.9 $\pm$ 0.9	2.0 $\pm$ 1.0		1.520	11	0.157
Total Non-Native Cover (C > 100 = 100) ³	35.65 $\pm$ 19.62	58.33 $\pm$ 20.21		-1.447	11	0.104
# Native Grass Species	0.5 $\pm$ 1.0	1.7 $\pm$ 0.6		-1.941	11	0.078
Native Grass Species Cover	4.95 $\pm$ 14.96	29.17 $\pm$ 44.26		-1.940	11	0.078
# Non-Native Grass Species	1.2 $\pm$ 0.4	0.7 $\pm$ 0.6		1.785	11	0.102
Non-Native Grass Species Cover	21.02 $\pm$ 11.29	4.33 $\pm$ 5.13		2.877	11	0.015
# Native Forb Species	9.4 $\pm$ 4.7	10.0 $\pm$ 7.8		-0.169	11	0.869
Native Forb Species Cover	19.42 $\pm$ 12.26	14.42 $\pm$ 2.50		0.432	11	0.674
# Non-Native Forb Species	1.7 $\pm$ 0.7	1.3 $\pm$ 0.6		0.846	11	0.415
Non-Native Forb Species Cover	13.62 $\pm$ 22.66	54.00 $\pm$ 19.70	3.0			0.043
# Shrub Species	2.6 $\pm$ 1.0	3.3 $\pm$ 0.6		-1.227	11	0.245
Shrub Species Cover	49.67 $\pm$ 16.15	16.32 $\pm$ 16.97		-2.677	11	0.022
# Tree Species	1.5 $\pm$ 0.7	1.0 $\pm$ 0.0	21.0			0.212
Tree Species Cover	59.45 $\pm$ 27.42	23.00 $\pm$ 28.00		2.169	11	0.053
# Cacti Species	0.2 $\pm$ 0.4	0.0 $\pm$ 0.0	18.0			0.418
Cacti Species Cover	0.05 $\pm$ 0.01	0.00 $\pm$ 0.00	18.0			0.418
# Vine Species	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0		N/A	N/A	N/A
Vine Species Cover	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00		N/A	N/A	N/A
# Ferns and Club Mosses	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0		N/A	N/A	N/A
Fern and Club Moss Cover	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00		N/A	N/A	N/A
# Parasitic Species	0.2 $\pm$ 0.4	0.0 $\pm$ 0.0	18.0			0.418
Parasitic Species Cover	0.40 $\pm$ 0.97	0.00 $\pm$ 0.00	18.0			0.420

¹Cover values are untransformed values.

²Bolded values are significant at $p < 0.05$.

³For plots in which cover exceeded 100%, the value was set at 100% cover prior to transformation.

Summary

Non-parametric tests tend to have less statistical power than parametric tests. Instead of testing for normality for all data associated with a particular dependent variable, we tested the data for each condition class separately. In addition, probabilities associated with pairwise tests, when appropriate, were adjusted upward using the Bonforoni adjustment. As a result, the statistical analyses presented above are fairly conservative.

Overall analytical results indicate some degree of condition class segregation for each natural community analyzed, but not necessarily based strictly on the condition variables used by Morrison and others (2003). The responses of the variables were complex for Creosotebush-Bursage Desert Scrub and not always consistent in direction across condition classes. Relatively small sample sizes may have obscured discerning response patterns for all natural communities analyzed. Key response variables that may be the best indicators of change likely differ between natural communities. A finer spatial-scale analysis of plot data surrounding water developments and a better characterization of the service status of a water development may be prerequisite for understanding the complex response patterns of vegetation in the immediate vicinity of watering sites.

6.2.4 Applications to Bureau of Land Management Land-Use Decisions

The SDNM proclamation highlights community-level biological resources as objects of significance (Clinton 2001). In its focus on such objects and their associated ecological processes, the proclamation embodies system-level thinking. To ensure the appropriate protection and management of such objects, BLM needs baseline data and analyses on the types of plant communities and habitats (natural communities) that occur on the monument and that can be delineated in part on the basis of their different management issues. Such information should include an ecological characterization of each community and its natural range of variation, the spatial distribution of each community, and the status of each community's ecological condition across the SDNM. In addition, to the extent that BLM desires to use natural communities as a coarse filter, information that can inform the appropriate management of these communities by BLM also can be used indirectly to protect species objects and other elements of biodiversity that are not separately addressed as fine-filter conservation elements.

The natural community descriptions and ecological condition assessment information contained in this report and in Morrison and others (2003) provides BLM with contemporary information applicable to the natural communities that occur on the SDNM and their current ecological condition. Such information, especially as it is spatially based, will enable BLM to make more informed decisions regarding spatial allocations of use and management strategies for natural community objects (and their associated species diversity) on the SDNM. Community-level information that is gathered and analyzed at a geographic scale that corresponds to the size of the monument (or BLM resource management areas in general) often is not available to land managers. Available information is often coarse in relation to the information needed for spatially allocating resource management decisions at scales used by BLM for land-use planning (for example, Gap vegetation data) or, it is collected at a project/implementation scale (for example, by grazing allotment) in a manner that doesn't afford an opportunity to discern more pervasive trends in resource condition at the land-use planning scale. The natural community information provided here is intermediate in scale to the two previous examples and, as a result, is commensurate with the data needs of a BLM resource management plan. In the next few subsections, we describe some specific applications of the natural community information.

Comparison to Information Collected at Other Scales

The natural community information described here can complement information gathered and used by BLM at other scales to inform decision-making. For example, the relative rarity (for example, Desert

Grassland), uniqueness (for example, Mountain Upland), quality (for example, Paloverde-Mixed Cacti-Mixed Scrub communities), and wildlife significance (for example, xeroriparian communities) of the natural communities of the SDNM are apparent primarily when considered within a regional context. As a result, regional-scale data is important in providing a basis for comparison and in establishing the relative significance of a natural community occurrence and its ecological condition; however, as mentioned above, the type of information needed to adequately describe natural communities at the scale of the SDNM can not easily be gleaned from regional-scale vegetation data such as Gap. Comparisons between regional-scale data and the intermediate-scale data as represented by the natural community information provided here for the SDNM may still need to be qualitative because of current classification differences and accuracy issues attributable to the differences in scale and methods used for mapping.

The natural community mapping and condition assessment information provides BLM an overview of the spatial pattern and extent of community-level objects and their relative ecological condition across the SDNM. Such information can serve as a first cut opportunity and constraint map for allocating land-use decisions that are then implemented at the project/implementation scale. Enhancements to this type of spatial information can be made by combining the natural community spatial data with spatially explicit species (fine-filter) and threat information. To the extent that the preceding information is provided within the context of the surrounding landscape (that is, outside the SDNM boundaries), it can assist BLM with land tenure decisions within the Phoenix South Planning Area that affect SDNM resources and for designing cooperative management strategies with the BMGR, Tohono O'odham Nation, and other land managers/owners (see section 6.5).

Grazing Administration

The ecological condition map provides a monument-wide perspective on the potential status of livestock grazing impacts on natural community composition, structure, and function as distinguished from variation attributable to environmental factors such as elevation and soil. As such, it provides a coarse assessment (spatially and temporally) of how well rangelands on the monument meet Arizona BLM land health standards. For example, analysis of data collected for the Creosotebush-Bursage Desert Scrub community reveals that compositional variation and ecological condition are most strongly determined by gradients in distance from livestock water source, a livestock influence index, and an elevation gradient. Areas in close proximity to water sources or other substantial range improvements often have highly altered vegetative compositions and structures and altered soil surface conditions. The influence (stress) of livestock extends throughout most of the Creosotebush-Bursage Desert Scrub community, as few of the locations PBI visited within the study area were without some indication of livestock influence; however, livestock also exhibit a gradient of influence related to distance from water sources. Areas classified as Condition Class 2 should be carefully evaluated for adherence to the land health standards, as such areas often are characterized by their relative abundance of non-native plants and relatively low abundance and diversity of native grasses. Condition Class 1 areas, to the extent they reflect model assumptions, likely do not meet land health standards. Such areas are limited in extent compared to the Class 2 modeled areas (Figures 6.2 and 6.3). The preceding conclusions are somewhat tempered by the complicated response patterns exhibited by the variables used to measure and discriminate condition classes for Creosotebush-Bursage Desert Scrub (see section 6.2.3).

Because the condition assessment is a generalized model and is subject to the accuracy limitations described in section 6.2.2, it is not necessarily sensitive to the individual vagaries of management prescriptions and local conditions within each grazing allotment and, as a result, to enable allotment-specific management decisions it should be supplemented by additional data collection and analysis that stratifies land health determinations at the scale of the allotment. The BLM collects such information through its land health assessment methodology, the plant composition data from which is compared to ecological site class information generated by the NRCS. The PBI and BLM approaches likely represent to some degree different perspectives on how to evaluate ecological condition/land health. At the very

least the results from the PBI condition assessment can be used to inform additional allotment-based sampling conducted by the BLM and to provide the broader-scale context for assessing deviations from the land health standards.

More importantly, the information collected by PBI's sampling and analytical approach and BLM's land health assessment approach may both be important to BLM's ability to make informed decisions relative to grazing administration on the SDNM. The SDNM proclamation (Clinton 2001) requires BLM to balance grazing with protection of monument objects north of Interstate 8. Many of the management questions that arise from this compatibility standard may require new data and analytical tools that go beyond the original design and purposes of the methods BLM currently uses to assess land health. This situation suggests it would benefit BLM to take a step back and consider a broader suite of available data and methods to inform their decision-making. Within this context the BLM recently requested that the Conservancy conduct a literature review of livestock grazing impacts and management strategies applicable to the Sonoran Desert. The final literature review, synthesis, and conclusions (Hall and others 2005) provides BLM another source of information upon which to base its grazing administration decisions.

6.2.5 Future Data Collection and Analysis Needs

Pacific Biodiversity Institute collected and analyzed an extensive amount of data on the natural communities of the SDNM and adjoining portions of the BMGR. The utility of the data collected to date could be enhanced by conducting additional analyses. In addition, new questions arose during the investigations that additional data collection and analysis could address. Based on the information received to date, BLM may identify its own set of additional analysis or data collection needs. Future data collection and analysis needs can be subdivided into a number of broad categories to facilitate organization and prioritization. These are:

- fine-filter element assessments (we discuss this topic here as a matter of convenience because future work would build on the data collected by Morrison and others 2003)
- natural community assessments
- enhancements to the spatial accuracy of map products
- refinements to natural community subdivisions and characterizations
- desired future conditions and landscape/community-level trend analysis and monitoring protocols
- expansion of mapped/assessed areas to encompass full extent of the Sand Tank Mountains Complex.

Fine-Filter Element Assessments

Potential fine-filter element assessments include (1) characterization and distribution of the native grass group conservation element on the SDNM and adjoining portions of the BMGR and (2) a saguaro demographic study. Analyses of existing PBI data (Morrison and others 2003) and recent information contained in Snetsinger and Morrison (2004) have provided some preliminary information relevant to the preceding assessments (see section 6.3 and Appendix C) and also could be used to guide further studies. The degree of additional data collection that may be required is dependent on the type of management questions asked and the level of confidence needed in the answer. Regional experts at a May 2003 workshop expressed the view that the SDNM provides an opportunity to conserve what is becoming a more limited occurrence of native grass diversity and abundance across the Sonoran Desert. In addition,

saguaro is an expressed object of interest to be protected under the SDNM proclamation. We can enhance prospects for conserving these two elements by improving our understanding of their ecology and status on the SDNM.

Natural Community Assessments

Potential additional natural community specific assessments include (1) a more extensive Desert Grassland characterization within the Vekol Valley of the SDNM and Tohono O’odham Nation and (2) a focused Mesquite Woodland distribution, characterization, and condition assessment. At least within the upper Vekol Valley, an overlap would occur between these two assessments, as local conditions there (both natural and artificial) lead to an interaction between these two natural communities. To better understand the interactions and how they may have been affected by hydrologic regime alterations in the valley, the assessments could include evaluations of historic aerial photography. This would include an analysis of historic aerial imagery from 1953 that was not previously available.

Enhancements to the Spatial Accuracy of Map Products

The mapping of natural communities on the SDNM and adjoining areas did not include a post-hoc accuracy assessment in which randomly selected sample locations are used to confirm the spatial accuracy of the final map. This is a traditional step in mapping plant communities that was not budgeted for as part of PBI’s work to date. Despite this limitation, it is reasonable to assume the map is still the most accurate information available. Enhancements to the mapping of xeroriparian communities (depending on the availability of finer-scale hydrography data) and to the predictive models used to assist in mapping some of the natural communities also are possible. Section 6.2.2 already discussed potential accuracy improvements associated with the ecological condition map and models.

Refinements to Natural Community Subdivisions and Characterizations

Although Morrison and others (2003) identified potentially recognizable variants within some of the natural communities based on cluster analysis, these variants were not further distinguished spatially. As a result, additional analyses of community compositional and structural variation are possible, such as: (1) analysis of variation across all natural communities versus within community variation to verify that the currently identified natural communities represent reasonable natural groupings, (2) identification of management-relevant subdivisions (variants) within the existing natural communities, and (3) additional analysis of environmental and anthropogenic factors that contribute to variation (and altered ecological condition) within natural communities.

Desired Future Conditions and Landscape/Community-Level Trend Analysis and Monitoring Protocols

The results from PBI’s work to date include analyses that reflect some historical data. Most of the data collection and analysis, however, provides a snapshot in time of the SDNM’s (and adjoining areas) community-level resources. Some degree of repeat sampling may be advisable to ascertain seasonal and year-to-year variation that may be important to incorporate. The available data; however, are sufficient to enable developing a first iteration of heuristic numeric indicators based on measures of composition and abundance. These indicators can be used to guide development of potential state and transition models and desired future ecological conditions for the natural communities. As additional data are collected, the condition classes and models can be modified as needed to update management decisions and strategies. In addition to vegetation sampling that improves our understanding of environmental- and anthropogenic-related variation of the natural communities on the SDNM, it also will be necessary to periodically survey the status of the natural communities and potential stresses and their sources. This includes surveying for changes in the diversity, distribution, and abundance of non-native plants. Appropriate monitoring

protocols need to be developed that are cost effective, relatively easy to implement, and provide land managers relevant information for decision-making. Such protocols should enable trend analysis at the landscape (monument-wide) and community biological levels and also facilitate management coordination with adjoining land managers for ecologically linked areas. Additionally, protocols should be compatible with being used to inform regional-scale monitoring assessments of ecological status.

Expansion of Mapped/Assessed Areas to Encompass Full Extent of the Sand Tank Mountains Complex

Natural community mapping and modeling could be extended to those unmapped areas adjacent to the SDNM that may be important for maintaining connectivity with other managed areas (for example, BLM lands adjacent to the SDNM that form a corridor to the Estrella Mountains). Section 6.5 describes the concept of a functional conservation landscape in which the SDNM forms a significant portion of the core area of the landscape. Ideally, natural community mapping, modeling, and assessment of this entire landscape would be beneficial for decision-making.

6.3 SPECIES AND GUILD CONSERVATION ELEMENTS

The species and guilds are included as part of the fine filter. They are identified for individual management attention based on the assumption that management of the natural communities alone may not be sufficient to ensure their long-term persistence. They may already be rare, and deserving of focused management attention (such as a federal listed or Candidate species), or they may have specialized habitat needs that are overlooked at the community level. Keystone species also are included in the fine filter because of the unique role they play in structuring communities. Guilds are identified as conservation elements when they can represent a range of management considerations better than individual species within the guild can represent alone, especially when management needs may conflict. In addition, we have aggregated a suite of species, native grasses, as a conservation element. Although not necessarily rare as individual species, their occurrence as part of diverse and abundant aggregations within multiple natural communities, as supposedly found on the SDNM, was considered rare and regionally vulnerable by participants at the May 13, 2003 experts workshop. As a result, the SDNM may be an important area for their conservation.

In this section we first provide an overview of the species and guild conservation elements. The information provided is a distilled version of the detailed information contained in Appendix C for each species and guild. Next, we provide some summary data on the distribution of species and guild conservation elements by taxonomic group and global rank.

Although a number of species and potential guilds were considered as conservation elements for the SDNM, not all were eventually selected. Appendix D briefly describes the species and guilds considered but not selected as conservation elements. In addition, in Appendix D we also compare species on BLM's sensitive species list and U.S. Fish and Wildlife Service's birds of conservation concern list that are applicable to the SDNM with the final list of conservation elements. We check to see whether such species were selected as conservation elements and if not whether they are expected to be captured for management purposes by a coarse-filter conservation element. Finally, Appendix E provides documentation relative to the expert input obtained at and subsequent to the May 13, 2003 workshop that assisted in finalizing the selection of conservation elements for the SDNM.

6.3.1 Overview of Species and Guild Conservation Elements

In the paragraphs that follow, a brief rationale is provided that identifies the basis for including a particular species or guild as a conservation element for the SDNM. We also provide some information related to the specific habitat needs of the species on the SDNM. Appropriate sources for cited

information, when needed, are provided in Appendix C and are not repeated here. Elements are presented by taxonomic group. Tables 6.1 and 6.2 provide additional summary information regarding the fine-filter elements (see section 6.1 for details).

Plants

Acuña cactus (*Echinomastus erectocentrus* var. *acunensis*).—The acuña cactus is a regionally vulnerable species that is also a federal Candidate species. It is a rare, Sonoran Desert endemic species that is found only in a few localities in the United States, all of which are in Arizona. Acuña cactus may be rare and patchily distributed because it has specialized habitat needs that are not yet understood. Alternatively, its presumed rarity may be because only a small portion of its potential habitat has been surveyed. Within its restricted range, the cactus is threatened by habitat destruction and illegal collection.

The SDNM may represent an important conservation opportunity for this species because of the absence of the preceding regional threats; however, the acuña cactus is known from only one locality on the SDNM in association with the Mountain Upland natural community. It is difficult to find (especially when it is not flowering), so there are likely additional occurrences on the SDNM (possibly within the Mountain Upland or the Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes natural communities). Although specific habitat needs of acuña cactus within these natural communities are not known, the species may be impacted by activities that result in excessive soil disturbance. The area where acuña cactus is known from on the SDNM is sufficiently remote and removed from anthropogenic disturbances such that most of the threats present elsewhere in its range are likely absent on the monument. Because only one individual has been found on the monument, it is not known if a viable population of acuña cactus exists on the SDNM.

Saguaro cactus (*Carnegiea gigantea*).—The saguaro has significant social value and as such is a species that resonates with the public. On this basis, saguaro cactus was selected as a conservation element for the SDNM. Moreover, the saguaro, in part because it is an endemic species, is emblematic of the Sonoran Desert and it is highlighted as an “object” in the Sonoran Desert National Monument proclamation.

Numerous abiotic and biotic factors potentially influence saguaro distribution and abundance on the SDNM. Within appropriate saguaro habitat (determined in part by temperature, elevation, and aspect), saguaros require protective seedling germination and development sites, pollinators, and seed dispersers. A critical habitat component for saguaro development is the availability of nurse plants, which provide suitable microclimate and protection from herbivory during germination, seedling development, and juvenile growth. Saguaros are widely distributed across the SDNM and occur in every natural community except Desert Grassland and Mesquite Woodland. It achieves its highest mean percent cover in the Paloverde-Mixed Cacti-Mixed Scrub on Bajadas (0.40%) and the highest stem count in the Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes (3.46) natural communities (see Appendix C, Table C.2). Saguaro occurs at 50% or higher constancy (percent of natural community condition assessment plots for the community containing saguaro) in Mountain Xeroriparian Scrub, Paloverde-Mixed Cacti-Mixed Scrub on Bajadas, Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes, and Rock Outcrop natural communities (Table C.2); however, for the Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes natural community it is mostly absent or at lower densities on north-facing slopes. Saguaros are more closely associated with Mountain Xeroriparian Scrub than with the other xeroriparian natural community types.

The ecological condition class data (Table C.2; see section 5.3.3 for class definitions) show some trend in increased constancy, stem counts, and cover with condition class (in the direction of 1 to 3); however, because of small sample sizes for some classes and small absolute numbers for the preceding three metrics we did not analyze the data statistically. Based on PBI’s coarse size class data (< 1 meter, 1 meter to 5 meters, and > 5 meters), saguaro recruitment does not seem to be an immediate issue on the

SDNM, though again some tendency exists for stem counts of short saguaro to be lower within the lower ecological condition classes (Table C.2).

Appendix C, Table C.3 compares saguaro stem counts and percent cover data between the former Area A and adjoining portions of the BMGR compared with the remainder of the SDNM. The analysis of the geographic data indicates limited differences in saguaro stem counts and percent cover values between the two geographic areas analyzed (Table C.3). Across all natural communities, the mean number of short stems, tall stems, and total stems and percent cover are significantly different ($p < 0.05$) between the two geographic areas with the higher number of stem counts and cover values occurring within the former Area A and the adjoining portions of the BMGR. Medium stem counts are not significantly different. When tested by natural community type, significant differences occur between the two geographic areas only for number of short and total stems and percent cover (Mountain Xeroriparian Scrub, with Area A/BMGR stem counts and cover values lower) and percent cover (Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes, with Area A/BMGR having the larger percent cover).

Native grass group (multiple species).—The native grass group was selected as a conservation element because several of the natural communities occurring on the SDNM include an atypically high abundance and species richness of native grasses relative to other areas in the Sonoran Desert. Although the native annual and perennial grass taxa found within the monument are not individually rare, their occurrence as diverse assemblages with high cover values is regionally rare and on this basis the group is considered a regionally vulnerable conservation element.

Native grasses present on the SDNM were determined by compiling species lists from recent botanical work. Thirty-nine native grass taxa are currently documented from the SDNM, including 16 annuals and 23 perennials. Additional native grass taxa, particularly annuals, are likely to be discovered with future plant surveys of the monument. At present, all native grasses known to occur on the SDNM are included in the native grass group. Additionally, although tobosa grass (*Pleuraphis mutica*) is included as part of the group, it also is the dominant grass component of the Desert Grassland natural community. Tobosa grass is included as a component of the native grass group because of isolated occurrences in natural communities outside the Desert Grassland, including on the summit of Table Top and in the Sand Tank Mountains. Additional information is needed to determine the relative ecological and conservation significance of each species in the group and which areas of the SDNM have the best representation of native grasses (and within these areas, which species are present).

Based on PBI's natural community condition assessment plots, which recorded 20 individual native grass species or varieties, species richness varied from three (Mesquite Woodland and Braided Channel Floodplain; Desert Grassland contained two native grass species) to 13 (Mountain Upland) species and total cover varied from 0.40% (Paloverde-Mixed Cacti-Mixed Scrub on Bajadas) to 13.94% (Mountain Upland; native grass cover was 15.25% in the Desert Grassland). Each species may have its own specific habitat needs that enable it to maintain viable populations on the SDNM.

Amphibians

Ephemeral water-breeding amphibian guild.—This guild is composed of seven native frogs (anurans) that are documented to occur on the SDNM: the Sonoran Desert toad (*Bufo alvarius*), red-spotted toad (*Bufo punctatus*), Sonoran green toad (*Bufo retiformis*), Great Plains toad (*Bufo cognatus*), western narrow-mouthed toad (*Gastrophryne olivacea*), lowland burrowing treefrog (*Pternohyla fodiens*), and Couch's spadefoot (*Scaphiopus couchii*). The Sonoran Desert toad and Sonoran green toad are both endemic to the Sonoran Desert. The Vekol Valley portion of the SDNM is near the northern edge of the range of three of the species: Sonoran green toad, lowland burrowing treefrog, and western narrow-mouthed toad, each of whom have a limited distribution in the United States and are known to co-occur elsewhere only on the Tohono O'odham Nation. The seven amphibians in the ephemeral water-breeding

guild are specialized species that rely on scarce surface waters. The natural communities that serve as the coarse filter do not capture the management needs of the guild because (1) some species use artificial aquatic habitats not included as part of the coarse filter or captured as a fine-filter specialized habitat and (2) the habitat needs of each species are not just restricted to aquatic habitats but also include adjacent terrestrial habitats.

Each of the species in the guild has certain terrestrial and aquatic habitat associations. Potential differences likely exist between the species in the types of surface water used on the SDNM (natural or modified tinajas, temporary pools, or artificial water developments). Some species in the guild may have a competitive advantage relative to the others in natural (generally ephemeral) versus human-altered water sources (that may retain water at least seasonally). As a result, these species are best managed as a guild because though they have some similar habitat needs, a management decision based on the needs of one species may not meet the needs of or could have potentially adverse results for other species in the guild. Permanent and/or ephemeral water sources are important for reproduction and completing the larval stage of development. Rodent burrows or those dug by the frogs themselves are important shelter sites used during periods of inactivity. Desert amphibians typically migrate between aquatic breeding habitat and terrestrial habitats, but little is known about their terrestrial habitat needs and the requirements for maintaining connectivity between their aquatic and terrestrial habitats. The Vekol Valley may be a disproportionately important area for several species in the ephemeral water-breeding amphibian guild for several reasons: (1) its clay soils are suitable for winter aestivation and hold moisture during summer rains, (2) it includes areas of Mesquite Woodland and Desert Grassland, which are the typical terrestrial habitat for the western narrow-mouthed toad and lowland burrowing treefrog, and (3) its water availability has been enhanced by the construction of spreader dikes, which may benefit some species in the guild.

Reptiles

Desert tortoise (*Gopherus agassizii*).—The desert tortoise is federal listed as a Threatened species in California, Nevada, Utah and in Arizona north and west of the Colorado River (essentially the Mojave Desert population). Although desert tortoise populations in the Sonoran Desert of Arizona have no legal federal protection, the species is thought to be regionally vulnerable and declining over much of its range because of habitat loss and degradation, habitat fragmentation, and genetic contamination. The BLM manages the majority of desert tortoise habitat and therefore has the opportunity to significantly influence long-term conservation of desert tortoise and their habitats.

The SDNM is a regionally significant area for desert tortoise conservation in Arizona. The monument boundaries encompass more than a fifth of the most essential desert tortoise habitat (Category 1) in the state, as well as a portion of Arizona's largest contiguous area of Category 1 tortoise habitat in the Sand Tank and Saucedo Mountains. Desert tortoise in the Sonoran Desert are typically associated with the Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes natural community; however, they also can be found on lower bajadas, particularly in association with caliche soils in xeroriparian channels. Desert tortoise have relatively large home ranges and make periodic long-distance movements between mountain ranges, which may be essential to maintain genetic diversity and population viability. Roads and urban or agricultural lands may impede desert tortoise movements and fragment habitat.

Red-backed whiptail (*Aspidoscelis xanthonota* = *C. xanthonotus* = *Cnemidophorus burti xanthonotus*).—The red-backed whiptail has a restricted distribution, is endemic to the Sonoran Desert, and is known from only a limited number of isolated mountaintops and canyons in the Sonoran Desert in south-central Arizona. The red-backed whiptail has been documented on the SDNM on Table Top and Javelina Mountains. Although recent work has documented this taxon's occurrence in new localities and in a greater range of habitats than was previously known, it remains one of the most isolated, restricted distribution reptiles in the Sonoran Desert in Arizona. It occupies only a small minority of the habitat

within its range and populations are relatively small and geographically isolated (and possibly genetically differentiated). These populations may be particularly sensitive to drought and climate change. The red-backed whiptail is a regionally vulnerable species based on the broad-scale threats that are present across its limited range.

On the SDNM the red-backed whiptail is associated with the Mountain Upland, Mountain Xeroriparian Scrub, and Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes natural communities in the Sand Tank and Table Top Mountains. The specific habitat needs within these natural communities are not well understood; however, a perceived threat to this taxon across its known range is habitat degradation or loss due to wildfire, overgrazing, or global climate change.

Maricopa leaf-nosed snake (*Phyllorhynchus browni lucidus*).—The taxonomy of the Maricopa leaf-nosed snake is unsettled, as some authors recognize the subspecies and others do not. Recent studies on leaf-nosed snakes at Organ Pipe Cactus National Monument (OPCNM) found that color variation in *P. browni* subspecies show abrupt transitions rather than clinal variation, which suggests that *P. browni lucidus* and *P. browni browni* deserve distinct taxonomic status as subspecies or even full species. Additional research is needed to clarify these taxonomic uncertainties. Few records for the Maricopa leaf-nosed snake exist in museum collections or in the Arizona Heritage Data Management System. The presence of the Maricopa leaf-nosed snake has not been confirmed within the boundaries of the SDNM, but a focused search has not yet been conducted. It is expected to occur in appropriate habitat on the monument, as the SDNM is situated in the center of the Maricopa leaf-nosed snake’s distribution. The SDNM is an important area to conserve the taxon because the monument is free of many of the threats that occur elsewhere within the taxon’s range.

The Maricopa leaf-nosed snake is a Sonoran Desert endemic taxon that is regionally vulnerable because it has a restricted range in southern Arizona and some populations have been observed to be declining, likely because areas of former habitat have been lost to urban and agricultural development in the Phoenix area. As a result, the principle cause of population declines of the Maricopa leaf-nosed snake is thought to be attributable to habitat loss.

Where its habitat is intact, the specific habitat needs of leaf-nosed snakes (including the Maricopa leaf-nosed snake subspecies) are not well known or defined. Because they are specialized as substrate burrowers, leaf-nosed snakes presumably require intact soils that have not been affected by anthropogenic activities that can cause soil compaction. Based on research conducted at OPCNM, the Maricopa leaf-nosed snake occurs on upper and middle bajadas and extends onto lower bajadas on sandy loam soils. Relative to the natural communities on the SDNM, the Maricopa leaf-nosed snake is most likely to be found associated with two of the three matrix communities on the monument: Creosotebush-Bursage Desert Scrub and Paloverde-Mixed Cacti-Mixed Scrub on Bajadas. The transition zone between these two matrix communities is likely to be the main habitat for the Maricopa leaf-nosed snake, and it is expected to occur on the friable sandy or gravelly soils associated with the bajadas of Javelina Mountain and Maricopa Mountains. This taxon may be patchily distributed and rare across the SDNM.

Tucson shovel-nosed snake (*Chionactis occipitalis klauberi*).—Four subspecies of the western shovel-nosed snake (*Chionactis occipitalis*) are currently recognized, though the taxonomy is not well resolved. In the vicinity of the SDNM, populations of *C. occipitalis* have a phenotype that is considered intermediate between the Colorado Desert (*C. o. annulata*) and Tucson shovel-nosed subspecies (*C. o. klauberi*). With additional genetic work some of the subspecies may be elevated to full species status. In addition, local variation (such as the phenotype that has characteristics of both the Colorado Desert and Tucson subspecies described above) may be significant and, as a result, these local populations may represent unique genetic units. The taxonomic unit selected as a conservation element on the SDNM is *C. o. klauberi* and the population that is considered intermediate between *C. o. klauberi* and *C. o. annulata*. To simplify the language in this report, both of these taxa—the Tucson subspecies and the intermediate

phenotype described above—will be referred to as the “Tucson shovel-nosed snake,” except where otherwise noted.

The Tucson shovel-nosed snake is a Sonoran Desert endemic taxon with a restricted distribution, as it is known only from a small area in Arizona in portions of Pinal, Maricopa, and Pima Counties. This taxon is considered regionally vulnerable because much of its formerly occupied lowland valley floor habitat within an already restricted range has been cleared or severely impacted by agricultural and urban development. This altered habitat no longer seems occupied. The greatest abundance of the Tucson shovel-nosed snake is estimated to occur west of Mobile on the SDNM. The monument largely lacks the main threats to this subspecies (habitat loss and degradation) and may therefore represent the best opportunity to protect the taxon. As a result, the population that is currently characterized as intermediate between *C. o. klauberi* and *C. o. annulata* may represent one of the only opportunities to protect the Tucson shovel-nosed snake.

Little is known about the specific habitat needs of this subspecies. Because of its burrowing habits, however, the shovel-nosed snake is associated with areas characterized by soft sandy loams, loose soil, fine, wind-blown sands (such as in washes), or occasionally on rocky hillsides with pockets of sand among rocks. The snake requires these deep valley fill soils for burrowing and nesting. Creosotebush (*Larrea tridentata*) serves as foraging and escape habitat. The snake spends the day underneath the soil substrate around creosotebush and forages nocturnally generally within a 0.9 to 1.4 m² (10 to 15 ft²) area surrounding the shrub.

The Tucson shovel-nosed snake has been observed on the SDNM near Mobile, where it has been recorded at various localities along the Maricopa-Mobile Road (Route 238). The snake’s presence in these locales was associated with sites whose soils had a high percentage (ranging from 49 to 85%) of fine sand, silt, and clay (classified as sandy loams, loamy sands, gravelly-sandy loams, and silty-sandy loams). The vegetation in these areas corresponded to Creosotebush-Bursage Desert Scrub and Valley Xeroriparian Scrub natural communities. Although the specific habitat needs of the Tucson shovel-nosed snake on the monument are not well understood, it is known that this is one of the few areas in its range where individuals are found reliably.

Birds

Cactus ferruginous pygmy-owl (*Glaucidium brasilianum cactorum*).—The cactus ferruginous pygmy-owl is a Sonoran Desert endemic, regionally vulnerable taxon, whose population in Arizona is federal listed as Endangered. The pygmy-owl was historically common in mesquite bosques and riparian cottonwood-willow forests in Arizona. Habitat destruction and modification have resulted in dramatic population declines to the point that the pygmy-owl has almost been extirpated from Arizona. Remaining cactus ferruginous pygmy-owl populations in Arizona occur primarily in Sonoran desertscrub habitat and are threatened by continued habitat loss and habitat alteration.

Although the pygmy-owl’s presence has not been confirmed on the SDNM, the monument has extensive areas of suitable habitat, including Paloverde-Mixed Cacti-Mixed Scrub and xeroriparian scrub natural communities where structurally complex and dense vegetation is found. Because the SDNM lacks many of the threats that are present in other parts of the pygmy-owl’s range in Arizona, the monument could potentially play a role in the recovery of this subspecies in the Sonoran Desert. A portion of the monument is included as part of one of the proposed recovery areas in the Draft Recovery Plan for the cactus ferruginous pygmy-owl.

Primary excavator (cavity) guild.—This guild is composed of the gilded flicker (*Colaptes chrysoides*), which is a species endemic to the Sonoran Desert, Gila woodpecker (*Melanerpes uropygialis*), and ladder-backed woodpecker (*Picoides scalaris*). The primary excavator (cavity) guild was selected as a

conservation element because the woodpecker species in the guild have specialized needs for nesting sites, and they serve as keystone species by creating cavities in saguaro and desert trees that are used as nest sites by numerous other cavity-nesting birds. Excavated cavities in saguaros also provide roost sites for solitary bats, small mammals, and reptiles. Furthermore, Gila woodpeckers are important as pollinators of saguaro and disseminators of their seed. As such, they may play an important role in the maintenance of saguaros as a component of the Paloverde-Mixed Cacti-Mixed Scrub natural communities. The woodpeckers are best treated as a guild because each species has a preferred nest excavation substrate and constructs cavities that differ in their dimensions; in turn, the characteristics of the cavity affect which species of secondary cavity nesters use the excavation. Although these species may not require specific habitat management different than that necessary to maintain the natural communities on the SDNM, a decline in the abundance of any of the woodpeckers would be a concern because so many other species rely on them for nest site excavation.

Even though each species in the guild has slightly different habitat needs, xeroriparian areas (Braided Channel Floodplain, Valley Xeroriparian Scrub, and Mountain Xeroriparian Scrub natural communities) provide important foraging habitat for all three woodpeckers. In addition, ladder-backed woodpeckers also nest in these xeroriparian habitats. The Paloverde-Mixed Cacti-Mixed Scrub natural communities provide nesting and foraging habitat for the woodpeckers, particularly the Gila woodpecker and gilded flicker. Mature and dense saguaro stands, such as that found on the bajadas and rocky slopes of the Sand Tank Mountains, may be disproportionately important breeding areas for the Gila woodpecker and gilded flicker populations on the SDNM.

Le Conte's thrasher (*Toxostoma lecontei*).—Le Conte's thrasher has a limited distribution, occurring primarily within the Mojave and Sonoran Deserts. It is one of the few birds that is closely associated with the sparsely vegetated, arid desert valley bottoms characteristic of the Lower Colorado River Valley Subdivision of the Sonoran Desert. Le Conte's thrasher has specific habitat needs such that it is not found uniformly throughout its valley bottom habitat, and it has a relatively large home range requirement that makes populations vulnerable to habitat fragmentation and local extirpation. Le Conte's thrasher is identified as regionally vulnerable in numerous evaluations, because populations are declining throughout the range of the species. Much of the species' primary habitat association, saltbush desert scrub, has been lost to agricultural conversion. Other valley bottom habitat used by Le Conte's thrasher, including Creosotebush-Bursage Desert Scrub, has also been lost because of agricultural and urban development or has been degraded by numerous uses, including off-road vehicle use and improper livestock management.

Although the status of Le Conte's thrasher on the SDNM is not well-known, the species is expected to breed there as suitable habitat exists on the monument. This offers an opportunity to protect this species in an area free from many of the threats present elsewhere in its range. On the SDNM, Le Conte's thrasher is associated with the Creosotebush-Bursage Desert Scrub and Valley Xeroriparian Scrub natural communities. Le Conte's thrasher is likely to be patchily distributed within these natural communities based on its need for scattered shrubs, trees, and/or cacti as nest sites and leaf litter under shrubs as foraging sites.

Rufous-winged sparrow (*Aimophila carpalis*).—The rufous-winged sparrow is a narrowly distributed endemic that is found in few localities in suitable habitats (Sonoran Desert grasslands or desert scrub with a grass component) within the Sonoran Desert. This species also is regionally vulnerable, as much of its former habitat has been lost or degraded by historic overgrazing and agricultural and urban development. Although the SDNM is not identified as a core area for rufous-winged sparrow conservation, the species' range is considerably limited and any habitats that support viable populations—including areas on the SDNM—represent a conservation opportunity for this species.

Rufous-winged sparrows breed in the tobosa grasslands in the Vekol Valley and probably also breed in xeroriparian washes in the Sand Tanks Mountains. Rufous-winged sparrow habitat on the SDNM

corresponds to the following natural communities: Desert Grassland (in the Vekol Valley), Valley Xeroriparian Scrub, and Braided Channel Floodplains (in the Sand Tank Mountains area). The birds also may breed and/or forage in the Paloverde-Mixed Cacti-Mixed Scrub on Bajadas natural community in the Sand Tank Mountains where native grasses are present in adequate amounts. Grass is an essential habitat component for rufous-winged sparrows; as a result, the sparrows are particularly sensitive to historic or current grazing pressures that reduce the abundance of native grasses.

Mammals

Bat guild.—This guild is composed of the lesser long-nosed bat (*Leptonycteris curasoae yerbabuenae*), California leaf-nosed bat (*Macrotus californicus*), and cave myotis (*Myotis velifer*). The lesser long-nosed bat is a federal Endangered species, and the California leaf-nosed bat and cave myotis are BLM Sensitive Species. Each of these species relies on the availability of caves and/or mines to roost in. These landform features are not captured by the natural community conservation elements. Additionally, each species uses other community types, such as xeroriparian areas, high-density saguaro stands, and tinajas, to meet their food and water requirements. Roosting colonies of bats, particularly maternal colonies during the birthing season, are vulnerable to disturbance. Controlled light and temperature conditions are important for each species. Recreational use of caves and mines is a threat to roosting bats because of the effects of direct disturbance and the potential to affect cave and mine microclimates. Lesser long-nosed bats are not presently known to roost on the SDNM, though a few individuals have been observed foraging in the Sand Tank Mountains. These bats differ from most other bat species in that the traditional means of protecting roost sites by installing “bat-friendly” gates across cave and mine entrances may inhibit the movement of this species. To the extent that the SDNM provides potential roost sites for this species, the actions taken to protect bat roost sites in general need to account for the needs of the lesser long-nosed bat.

The Maricopa Mountains have not been surveyed for bats. This region of the SDNM likely provides foraging habitat for cave myotis and California leaf-nosed bats, and it also may contain roost sites that have not yet been discovered. Although the Maricopa Mountains do not have many mines or large caves, even small caves and shelter sites that are likely present in the Maricopas could serve as significant roost sites and potentially harbor several hundred bats. The primary need of all species within the guild on the SDNM is roost sites that are protected from disturbance. In relation to the natural communities present on the SDNM, the bat guild is most closely associated with the Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes and Bajadas natural communities and embedded xeroriparian natural communities (Valley and Mountain Xeroriparian Scrub and Braided Channel Floodplains).

Desert bighorn sheep (*Ovis canadensis mexicana*).—Numerous subspecies of bighorn sheep (*Ovis canadensis*) are recognized throughout their range in western North America. In the southwestern U.S. and northern Baja California, four subspecies are traditionally recognized: *Ovis canadensis nelsoni*, *O. c. cremnobates*, *O. c. mexicana*, and *O. c. weemsi*. Some experts recognize two subspecies in Arizona: *O. c. mexicana* and *O. c. nelsoni*; however, it is difficult to differentiate the subspecies based on morphology. The taxonomy is not well resolved and based on mitochondrial DNA (*mtDNA*) and morphology some authors suggest only one subspecies of bighorn sheep is present in Arizona: *O. c. nelsoni*. Genetic and/or morphological differentiation may be expected to increase as bighorn sheep populations become progressively more fragmented and isolated. Additional research is needed to resolve taxonomic uncertainties. Regardless of whether it is considered a distinct subspecies, the population of desert bighorn centered in the desert southwest, which is identified by some as *Ovis c. mexicana*, is the taxonomic unit selected as a conservation element for the SDNM.

Bighorn sheep populations have declined dramatically throughout their range from historic levels. In the desert southwest populations have become fragmented and isolated by roads and fences. As a result, the desert bighorn sheep can be considered a regionally vulnerable subspecies. Desert bighorn sheep have

been documented from all the mountain ranges on the SDNM with herds that were once considered one of the few robust and viable populations left in Arizona. In recent years, however, bighorn numbers have dropped on the SDNM and concern exists for their long-term viability. As an area-dependent species, desert bighorn sheep require large, unfragmented landscapes to maintain population viability. A landscape approach to their management is needed, as the alluvial flats between mountain ranges may act as important corridors for sheep to gain access to other ranges for foraging and lambing.

Important features of desert bighorn habitat are cliffs, rock outcrops, and talus slopes, which are used as escape terrain. In relation to the natural communities on the SDNM, desert bighorn sheep are most closely associated with Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes, Mountain Upland, and Rock Outcrop natural communities. Desert bighorn sheep, however, move seasonally between the uplands and bajadas and also travel across desert valleys between mountain ranges. Desert bighorn habitat, as mapped by the BLM, encompasses 117,522 hectares (290,401 acres) or 58.5% of the SDNM and includes representations of all natural communities except Mesquite Woodland and Desert Grassland. The SDNM is important for the conservation of desert bighorn sheep as it encompasses a functional landscape of interconnected mountain ranges and valleys, as well as portions of movement corridors to adjoining sheep-occupied landscapes such as the Sierra Estrella. The most critical habitat need of desert bighorn sheep on the SDNM is to maintain movement corridors between mountain ranges located within the monument and on adjoining lands. Some important areas for sheep movement on the SDNM already present movement obstacles for bighorn, such as Interstate 8 and Route 238. It is essential that impediments to movement are minimized by enforcing appropriate speed limits on paved roads, limiting the use of fencing, or using “sheep-friendly” fencing where fencing is necessary, and avoiding, or at least mitigating, the effects of new utility corridor or road development, on existing movement corridors.

6.3.2 Distribution of Rarity Ranks and Taxonomic Breadth and Comparison with Other Special Status Lists

Table 6.9 provides the distribution of species elements, including species within guilds, by combined global ranks and taxonomic groups as a check to see whether the selection of conservation elements is skewed to rare elements or a particular taxonomic group or groups.

Of the 23 total species included in Table 6.9, 13 species are included within three different guilds. The remaining 10 species are stand-alone conservation elements. With the exception of amphibians, at least one of these stand-alone species is included within each taxonomic group. The three guilds are spread among different taxonomic groups. We did not treat the native grass as a guild, nor did we include its individual species in the table totals. Depending on the natural community under consideration, the composition of the group will differ.

Relatively few rare species (G1 and G2) are included. All federal listed species, whose status generally corresponds to the preceding global ranks, are by default included as conservation elements. For a large landscape, the SDNM seems to contain a relatively low number of currently listed species. Global ranks G3 through G5, on the other hand, contain relatively high numbers of conservation elements that are fairly evenly split between the three rank categories (especially the G4 and G5 categories). With appropriate management of these latter conservation elements now, the BLM can better position itself to anticipate future trends in resource viability and to make the necessary management adjustments that can hopefully avoid future listings.

6.4 COMPARISON BETWEEN PROCLAMATION OBJECTS AND CONSERVATION ELEMENTS PROPOSED HEREIN

The proclamation for the SDNM (Clinton 2001) identified numerous natural communities and species as objects that occur within the boundaries of the monument. Objects identified in a proclamation of this

type reflect the important features of an area that justify the designation. As a result, management prescriptions for the SDNM presumably should ensure that those biological objects identified in the proclamation remain viable over the long term. One measure then of the efficacy of the biodiversity management framework to support such a goal is to assess how well the recommended conservation

TABLE 6.9 Species (and Species within Guilds) Conservation Elements for the Sonoran Desert National Monument by Taxonomic Group and Combined Global Rank

Taxon	Total ¹	Combined Global Rank ²					
		G1 (rarest)	G2	G3	G4	G5 (most common)	GU (unranked)
Plants	2	1	0	0	0	1	0
Amphibians	7	0	0	1	1	5	0
Reptiles	4	0	2	1	1	0	0
Birds	6	0	0	2	1	3	0
Mammals	4	0	0	0	4	0	0
Total	23	1	2	4	7	9	0

¹Total includes individual species within a guild; however the total does not include the members of the native grass group, which as currently defined includes at least 39 species or varieties and likely includes additional species.

²Global ranks are defined in Appendix A, Table A.1. Criteria for converting global ranks to combined global ranks also are provided as part of Table A.1.

elements for the SDNM, which themselves are surrogates for the overall native biodiversity that occurs on the SDNM, encompass the biological objects identified in the proclamation. Table 6.10 compares the correspondence between elements and objects.

TABLE 6.10 Correspondence between Conservation Elements and Biological Objects Identified in the Sonoran Desert National Monument Proclamation (Clinton 2001)

Common Name	Recognition in Proclamation
<i>Plant Communities and Specialized Habitats</i>	
Creosotebush-Bursage Desert Scrub	“The lower elevations and flatter areas of the monument contain the creosote-bursage plant community. This plant community thrives in the open expanses between the mountain ranges, and connects the other plant communities together.”
Paloverde-Mixed Cacti-Mixed Scrub on Bajadas	• “...one of the most structurally complex examples of palo verde/mixed cacti associations in the Sonoran Desert. The dense stands of leguminous trees and cacti are dominated by saguaros, palo-verde trees, ironwood, prickly pear, and cholla.” • “Individual saguaro plants are indeed magnificent, but a forest of these plants that make up the forest community, is an impressive site to behold.” • “...includes large saguaro cactus forest communities that provide excellent habitat for a wide range of wildlife species.”
Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes	As above, for Paloverde-Mixed Cacti-Mixed Scrub on Bajadas.

TABLE 6.10 Correspondence between Conservation Elements and Biological Objects Identified in the Sonoran Desert National Monument Proclamation (Clinton 2001)—continued

Common Name	Recognition in Proclamation
Valley Xeroriparian Scrub	“The washes in the area support a much denser vegetation community than the surrounding desert, including mesquite, ironwood, paloverde, desert honeysuckle, chuperosa, and desert willow, as well as a variety of herbaceous plants. This vegetation offers the dense cover bird species need for successful nesting, foraging, and escape, and birds heavily use the washes during migration.”
Mountain Xeroriparian Scrub	As above, for Valley Xeroriparian Scrub.
Braided Channel Floodplain	As above, for Valley Xeroriparian Scrub.
Mountain Upland	• “The higher peaks include unique woodland assemblages...” • “...although a few plants from the more mesic period, including the Kofa Mountain barberry, Arizona rosewood, and junipers, remain on higher elevations of north-facing slopes.”
Desert Grassland	“Rare patches of desert grassland can also be found throughout the monument, especially in the Sand Tank Mountains area.” ¹
Mesquite Woodland	
Tinaja	“Important natural water holes, known as tinajas, exist throughout the monument.”
Spring	
Rock Outcrop	
<i>Plants</i>	
Acuña cactus	“...the endangered acuña pineapple cactus is also found in the monument.” ²
Saguaro	• “The most striking aspect of the plant communities within the monument are the abundant saguaro cactus forests.” • “The saguaro cactus forests within the monument are a national treasure, rivaling those within the Saguaro National Park”. • “The saguaro is a signature plant of the Sonoran Desert.”
Native grass group	“Rare patches of desert grassland can also be found throughout the monument, especially in the Sand Tank Mountains area.” ¹
<i>Amphibians</i>	
Ephemeral water-breeding amphibian guild	“The Vekol Valley and Sand Tank Mountain areas contain especially diverse and robust populations of amphibians.”
Sonoran Desert toad	
Great Plains toad	
Red spotted toad	
Sonoran green toad	“During summer rainfall events, thousands of Sonoran green toads in the Vekol Valley can be heard moving around and calling out.”
Couch’s spadefoot	
Great Plains narrowmouth toad	
Lowland burrowing tree frog	
<i>Reptiles</i>	
Maricopa leaf-nosed snake	
Tucson shovel-nosed snake	
Red-backed whiptail	“The monument also supports a diverse array of reptiles and amphibians, including the Sonoran desert tortoise and the red-backed whiptail.”

TABLE 6.10 Correspondence between Conservation Elements and Biological Objects Identified in the Sonoran Desert National Monument Proclamation (Clinton 2001)—continued

Common Name	Recognition in Proclamation
Desert tortoise	“The monument also supports a diverse array of reptiles and amphibians, including the Sonoran desert tortoise and the red-backed whiptail. The Bureau of Land Management has designated approximately 25,000 acres of land in the Maricopa Mountains area as critical habitat for the desert tortoise.”
Birds	
Le Conte's thrasher	
Rufous-winged sparrow	
Cactus ferruginous pygmy-owl	“Numerous species of raptors and owls inhabit the monument...”
Primary excavator (cavity) guild	
Gilded flicker	
Gila woodpecker	
Ladder-backed woodpecker	
Mammals	
Desert bighorn sheep	“The diverse plant communities present in the monument support a wide variety of wildlife, including...a robust population of desert bighorn sheep, especially in the Maricopa Mountains area...”
Bat guild	“Bat species within the monument include the endangered lesser long-nosed bat, the California leaf-nosed bat, and the cave myotis.”
California leaf-nosed bat	
Cave myotis	
Lesser long-nosed bat	

¹This quote may refer to either the desert grassland community (such as the tobosa grassland in the Vekol Valley) or the abundant native grasses that are notably present in the Sand Tank Mountains.

²The acuña cactus is actually a candidate for listing under the Endangered Species Act. It is not an endangered species, as described here.

The information in Table 6.10 demonstrates a fairly broad and strong correspondence between the conservation elements recommended for the SDNM as part of the biodiversity management framework and the biological objects identified in the monument proclamation. The areas where overlap does not occur reflect in part situations in which new information since the proclamation was issued has come to light concerning the rarity of certain species and the opportunities afforded by the SDNM for their conservation. The Maricopa leaf-nosed and Tucson shovel-nosed snakes, for example, fall into this category. In addition, a number of the guilds we identified included several species not identified in the proclamation (and a few that were), because part of our purpose was to highlight the differences in management requirements between different members of a guild. Finally, we were more inclusive of the range of natural communities that occurred on the SDNM than the proclamation. In summary, the conservation elements recommended to serve as biodiversity surrogates for the SDNM effectively capture for management purposes the biological objects identified in the SDNM proclamation.

6.5 SAND TANK MOUNTAINS COMPLEX FUNCTIONAL CONSERVATION LANDSCAPE

In section 5.4 we provided an overview of the definition of and the conceptual basis underlying functional conservation areas. We indicated that the type, size, and spatial configuration of a functional conservation area is dictated by the natural communities, species, and associated ecological processes it is intended to encompass. In combination the conservation elements identified for the SDNM and their associated ecological processes cover three different spatial scales: local, intermediate, and coarse (Table

6.1). To maintain the long-term viability of these elements within their natural ranges of variability, it is necessary to define a functional conservation landscape that crosses administrative boundaries. Many of these elements do not occur just on the SDNM but have distributions that extend across the monument boundary onto adjoining lands. For example, several of the natural communities, such as Mountain Upland and the coarse-scale matrix Paloverde-Mixed Cacti-Mixed Scrub communities, are continuous across the boundary between the SDNM and BMGR. Intact, relatively unfragmented blocks of these natural communities, especially of the size and ecological condition existing on the SDNM and BMGR, are rare in the Sonoran Desert. In addition, a number of species, such as desert tortoise and desert bighorn sheep, have habitat that is continuous across the SDNM boundary. The desert bighorn sheep in particular, as an area-dependent species, also requires movement corridors of appropriate ecological condition to move between its mountainous habitat areas.

To define the boundary of the functional conservation landscape that includes the SDNM, we first assessed the mapping information for the natural communities of the SDNM and where these communities were mapped on adjoining lands (Figure 6.1). In addition, we considered the occurrence and potential habitat information for all the fine-filter species and guild conservation elements, in particular the habitat and movement corridors associated with the desert tortoise and desert bighorn sheep (Figures 6.5 and 6.6).

Besides Mountain Upland and the Paloverde-Mixed Cacti-Mixed Scrub communities, other natural communities also are continuous across or occur outside but near the SDNM boundary: for example, Desert Grassland on the Tohono O’odham Nation. In addition, linear communities, such as Braided Channel Floodplain and Valley Xeroriparian Scrub, extend across the SDNM boundary. A number of these linear communities, such as those associated with the Vekol Wash, potentially are important movement corridors and provide thermal refugia, nest sites, and forage for many species of wildlife. An important extension of the Vekol Wash north of Interstate 8 is located outside the SDNM boundary.

The SDNM and adjoining portions of the BMGR contain regionally significant occurrences of desert tortoise habitat (see section C.3.1). Relatively large blocks of Category 1 habitat—considered the most essential habitat to maintain populations with the highest densities, stable or increasing populations, and fewest conflicts—are located north of Interstate 8 on the SDNM and mostly southwest of the former Area A on the BMGR (Figure 6.5). Category 2 habitat—of intermediate value, but still important—occurs south of Interstate 8 on the SDNM, but it also extends along the low hills north of the Table Top Mountains to the east of the Vekol Wash and occurs in the Sierra Estrella northeast of the SDNM. Although desert tortoises primarily occur in mountain ranges on rocky slopes and bajadas associated with the Paloverde-Mixed Cacti-Mixed Scrub natural communities, they occasionally will move between these habitats across the valley bottoms.

Figure 6.6 not only shows the extent of desert bighorn sheep habitat on the SDNM and adjoining lands, but also depicts their potential movement corridors (see section C.5.2 for additional detail on how these features were delineated). Desert bighorn sheep habitat in the area is associated with multiple mountain ranges, including the Sierra Estrella to the northeast of the SDNM, North and South Maricopa Mountains, Table Top Mountains, Sand Tank Mountains, Saucedo Mountains to the southwest of the SDNM, Vekol Mountains to the southeast of the SDNM, and to the south of the SDNM/BMGR the Batamote, Sikort Chuapo, and Pozo Redondo Mountains. These latter mountains, along with the Saucedo and Sand Tank Mountains, occur as relatively contiguous habitat. Connectivity with the other mountain ranges is via movement corridors that differ according to the degree to which they may include impediments to movement, such as roads, and their importance for preventing population fragmentation (Figure 6.6).

In addition to the habitat and movement corridor data for the preceding two species, we also note that a portion of the recovery area for the cactus ferruginous pygmy-owl extends onto portions of the SDNM

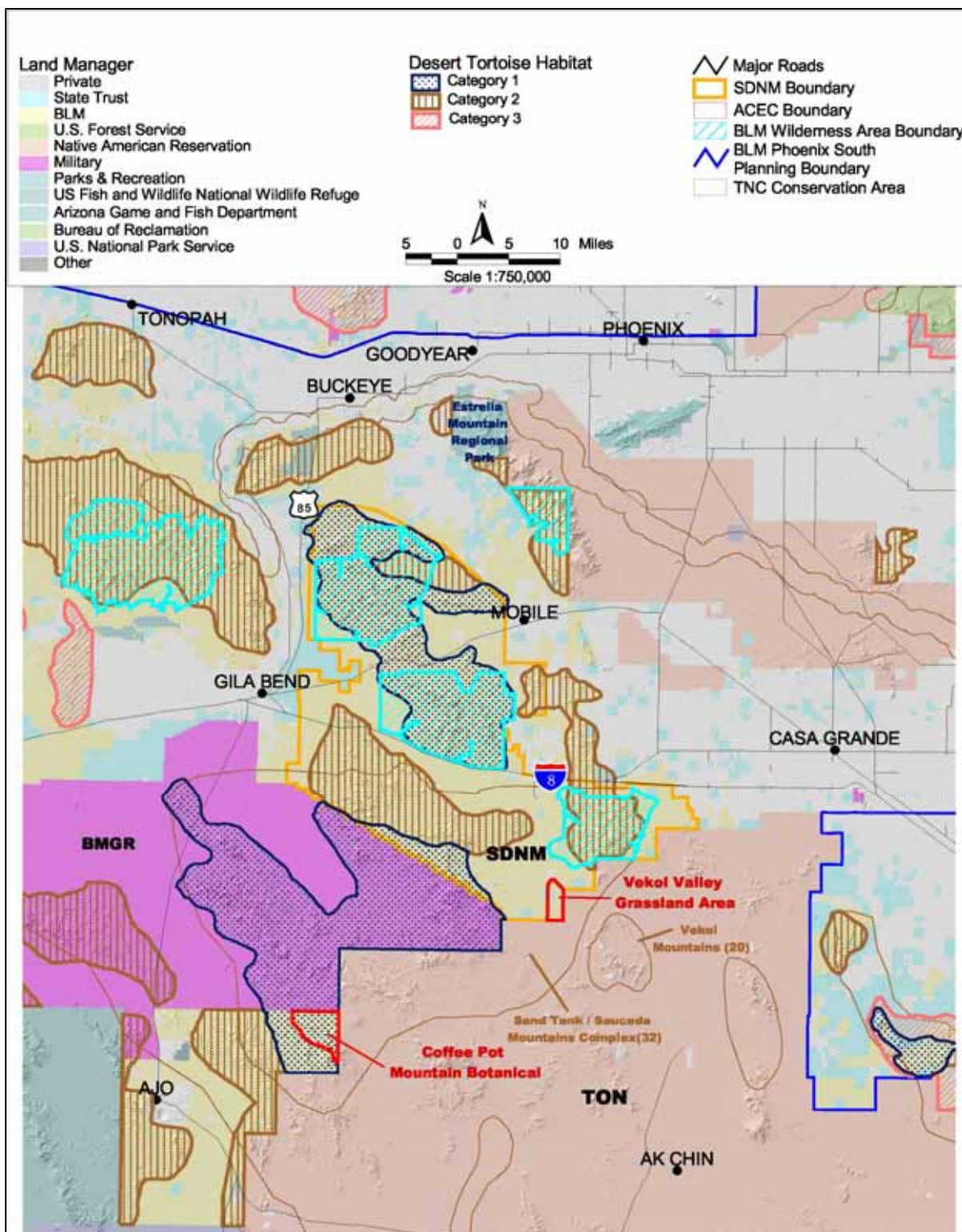


FIGURE 6.5 Desert Tortoise Habitat on the Sonoran Desert National Monument and Adjoining Areas

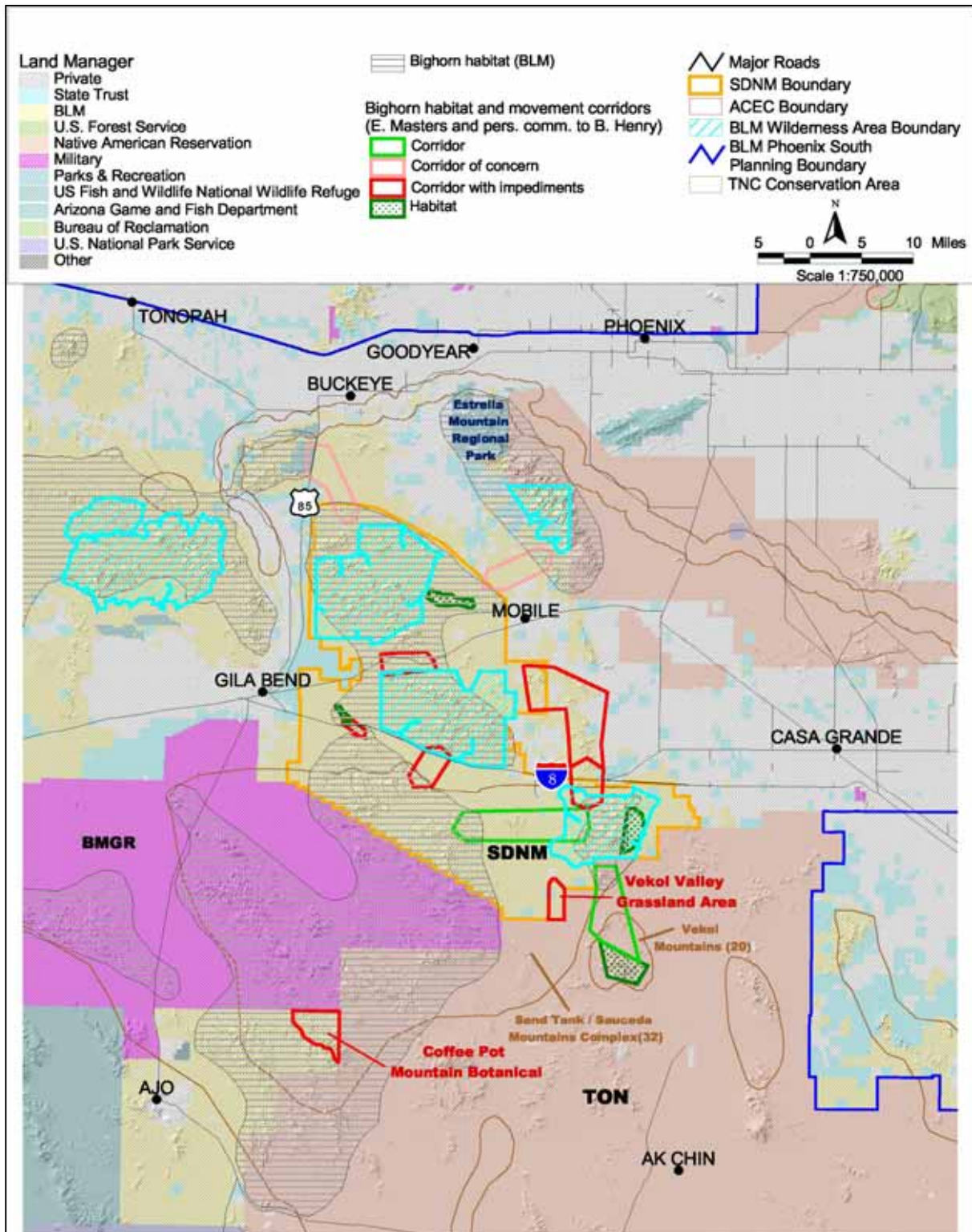


FIGURE 6.6 Desert Bighorn Sheep Habitat and Movement Corridors on the Sonoran Desert National Monument and Adjoining Areas

(see section C.4.1). Connectivity between this portion of the owl's recovery area and other recovery habitat is with habitat on the eastern portion of the BMGR. Similarly, important habitat for the conservation of the Tucson shovel-nosed snake extends across the SDNM boundary in the vicinity of Mobile (see section C.3.4).

Based on the biological data layers briefly described above, we developed a conceptual boundary for a functional conservation landscape that includes the SDNM and portions of the BMGR at its core (Figure 6.7). The name for this landscape, which encompasses multiple mountain ranges—Sand Tank Mountains Complex, reflects the unique biological resources values that occur near the geographic center of the landscape within the Sand Tank Mountains. These mountains transcend the boundary between the SDNM and BMGR. The name also provides a connection to the ecoregional conservation area that primarily overlaps with the functional conservation landscape boundary: the Sand Tank/Sauceda Mountains Complex conservation area (Marshall and others 2000; Figures 6.5 and 6.6). The boundary also encompasses a second conservation area: Vekol Mountains (Marshall and others 2000; Figures 6.5 and 6.6). Besides providing habitat for desert bighorn sheep, California leaf-nosed bats, and cave myotis, this conservation area also contains a population of Nichol turk's head cactus (*Echinocactus horizonthalonius* var. *nicholii*), which is an endemic, G4T2, and federal listed Endangered plant. This species was not identified as a conservation element for the SDNM.

The boundary encompasses the natural communities that occur on the SDNM and extend, often contiguously, across the monument boundary. Its outer limits include large, contiguous blocks of desert tortoise and desert bighorn sheep habitat and sheep movement corridors. To the west and south, we did not extend the boundary beyond Highways 85 and 86, respectively, even though small portions of tortoise and sheep habitat extend across these roads. Besides internal connectivity, a functional conservation landscape may have connectivity with other landscapes, so the choice of boundary is in part dependent on determining how viable the movement corridors are and delineating a landscape that is mostly contiguous and manageable in size (with due consideration for the number of land owners and the different types of land uses that may need to be considered). We considered Highway 85 to be significant barrier to movement for many wildlife species, especially as upgrades occur to convert it to a four-lane highway. Although Interstate 8 and Route 238 (along with the parallel rail line) are currently significant internal barriers to some wildlife movement, they are internal to the SDNM boundary and potential candidates for management actions that restore some degree of connectivity. A critical movement corridor to maintain is the one between the SDNM and Sierra Estrella that extends across BLM land through Rainbow Valley (Figure 6.6).

Other bases for the landscape boundary include the following. First, the BMGR portion of the boundary was taken from Hall and others (2001). This boundary is roughly similar to the desert tortoise and desert bighorn sheep habitat boundaries and is the boundary recommended by Hall and others (2001) to designate the Sand Tank-Sauceda Mountains Special Natural Area on the BMGR. The boundary excludes the East Tactical Range Manned Range No. 3 on the BMGR, so conflicts with the military mission are minimized. Hall and others (2001) can be consulted for additional detail about this boundary and the biological resources contained within. Second, we extended the boundary to the northeast of the SDNM within mostly BLM land to create a buffer zone against projected urbanizing development emanating from the Buckeye area. This area is currently a working landscape (ranching) and is assumed to remain so at least for a certain distance from the SDNM. Similarly, the area east of the SDNM within the southeastern portion of Rainbow Valley and the lower part of Vekol Valley north of Interstate 8 are generally working landscapes with some agriculture also present. Third, the boundary encompasses protected areas, such as the four BLM wilderness areas and other special designation areas, such two BLM Areas of Critical Environmental Concern and the Estrella Mountain Regional Park (Figure 6.7).

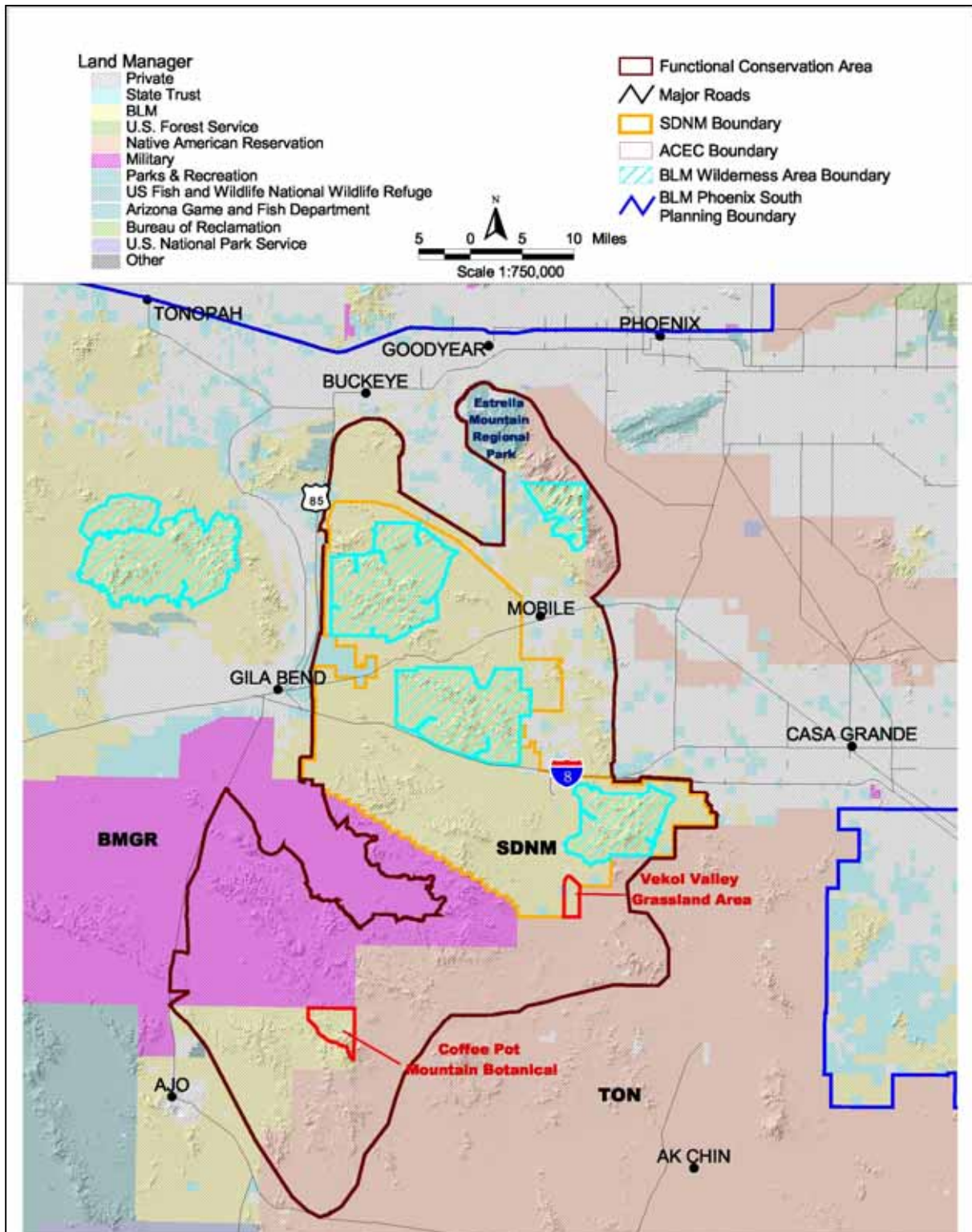


FIGURE 6.7 Sand Tank Mountains Complex Functional Conservation Landscape

As a result, land uses within the Sand Tank Mountains Complex are a mix of protected areas, other special designation areas, buffer areas associated with the BMGR, tribal lands, and working landscapes. All can contribute, if managed appropriately while also meeting their intended uses, to the ecological functionality of the Sand Tank Mountains Complex. As a conceptual boundary, the functional conservation landscape depicted in Figure 6.7 can be modified based on new information. For example, the buffer distance necessary to prevent urban encroachment from adversely impacting SDNM natural resources and the corridor width necessary to prevent fragmentation of the Sierra Estrella, and its associated biological resources, from the rest of the Sand Tank Mountains Complex can be refined with additional data on encroachment impacts and desert bighorn sheep corridor use.

The implications for BLM, and adjoining land managers and owners, of the Sand Tank Mountains Complex functional conservation area are several. First, it provides a blueprint for identifying those land managers and owners who, if they work together, can maintain the long-term functionality of the Sand Tank Mountains Complex. Second, it can assist BLM with land-tenure decisions outside the SDNM. Maintaining under government administration those BLM parcels to the north and east of the SDNM, as well as those parcels that contribute to the connectivity between the SDNM and Sierra Estrella, may be important for maintaining the long-term viability of the conservation elements that occur within the SDNM. Third, it provides local and regional planners, as well as members of the development community, with information that can guide the appropriate placement—or design when placement is otherwise unavoidable—of infrastructure (roads and utilities) and commercial/residential development. Finally, with respect to the BMGR, it provides additional justification, beyond that already articulated in Hall and others (2001), for the biological significance of the Saucedo-Sand Tank Mountains and their connection to other portions of a functional conservation landscape.

CHAPTER 7 INTEGRATING SOCIOECONOMICS AND PUBLIC INVOLVEMENT INTO THE BIODIVERSITY MANAGEMENT FRAMEWORK AND THE BUREAU OF LAND MANAGEMENT'S PLANNING PROCESS FOR THE SONORAN DESERT NATIONAL MONUMENT

This chapter summarizes a number of socioeconomic and public involvement activities conducted by the Sonoran Institute (Institute) and The Nature Conservancy (Conservancy) that have contributed to the planning process for the Sonoran Desert National Monument (SDNM). These activities are in addition to the public involvement implemented by the Bureau of Land Management (BLM) and their contractors in accordance with BLM planning guidelines and the National Environmental Protection Act (NEPA).

The American public is increasingly aware of the importance of public lands in regard to quality-of-life issues and readily voices its opinion about resource management decisions. Within the context of the BLM's multiple-use mandate, the planning process is a balance of competing needs, interests, and values. Socioeconomic information and public involvement can help to inform how to achieve this balance. Social science information in land-use planning can include: (1) the economic, political, and social structure of communities, regions, and the nation as a whole; (2) social values, beliefs, and attitudes; (3) how people interact with the landscape; and (4) sense-of-place issues.

For the Sonoran Desert National Monument and the Phoenix South Planning Area, public involvement included obtaining information from socioeconomic profiles (status and trends); community workshops; population growth modeling; an assessment of recreation use impacts; and public opinion and perceptions about wildlife water developments.

The Institute worked in collaboration with the BLM and Conservancy to integrate the social and ecological information provided. The last section of this chapter discusses how this integration provides a broader context for understanding management issues.

7.1 BUREAU OF LAND MANAGEMENT GUIDANCE FOR SOCIOECONOMIC INPUT INTO THE PLANNING PROCESS

For a number of years, the BLM has provided guidance on how to incorporate socioeconomic information into its planning process (BLM 2000c, 2005). In addition, it has recently drafted more specific and updated guidance (see http://www.blm.gov/planning/tools_social.html). By statute, regulation, and executive order, the BLM must use social science in the preparation of informed, sustainable land-use planning decisions. Section 202(c)(2) of the Federal Land Planning and Management Act (FLPMA) of 1976 (43 USC 1701–1785) requires the BLM to integrate physical, biological, economic, and other sciences in developing land-use plans (43 USC 1712(c)(2)). Planning regulations (43 CFR 1600) 10.4–3 and 1610.4–6 also require BLM to analyze social, economic, and institutional information (§ 1610.4–3 and 1610.4–6). Section 102(2)(A) of the National Environmental Protection Act (NEPA) of 1969 (42 USC 4321–4347) requires federal agencies to “insure the integrated use of the natural and social sciences...in planning and decision making” (42 USC 4332(2)(A)). In addition, a recent Instruction Memorandum (No. 2003–169) requires the use of the Economic Profile System (EPS), developed by the Sonoran Institute in collaboration with the BLM, in public involvement for resource management planning. Federal agencies also are required to “identify and address...disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States” in accordance with Executive Order 12898 on Environmental Justice.

To be effective, social science data and methods should be integrated into the entire planning process, from preparing the pre-plan to implementation, monitoring, and adaptive management. Table 7.1 describes examples of social science activities for each step of the planning process.

TABLE 7.1 Social Science Activities for Each Step in the Planning Process

Planning Steps	Social Science Activities
Steps 1 and 2—Identify Issues and Develop Planning Criteria	- Identify publics and strategies to reach them. - Identify social and economic issues. - Identify social and economic planning criteria.
Step 3—Inventory Data	- Identify inventory methods. - Collect necessary social and economic data.
Steps 4—Analyze Management Situation	- Conduct social and economic assessment, including existing conditions and trends and the impacts of continuing current management. - Document assessment methods in an appendix or technical supplement.
Step 5—Formulate Alternatives	Identify social and economic opportunities and constraints to help formulate alternatives.
Step 6—Estimate Effects of Alternatives	- Identify analysis methods. - Analyze the social and economic effects of the alternatives. - Document impact analysis methods in an appendix or technical supplement. - Assess mitigation opportunities to enhance alternatives' positive effects and minimize their negative effects.
Steps 7 and 8—Identify Preferred Alternative and Finalize Plan	Identify potential social and economic factors to help select the Preferred Alternative.
Step 9—Monitor and Evaluate	Track social and economic indicators.

No standard scope of work exists for socioeconomic analysis. Many different sources and methods are used to collect socioeconomic data and incorporate them into planning and resource management. Topics and methods should be shaped by the social context and potential resource allocation decisions under consideration for each plan. The purpose of the social and economic assessment (affected environment) and impact analysis (environmental consequences) should be to inform BLM decision-makers and the public about the human context of the planning effort and to identify the potential effects, constraints, and opportunities associated with planning alternatives.

Table 7.2 provides a proposed list of socioeconomic priorities for use in resource management plans. Each topic is prioritized in one of three groups:

1. **Basic** are those topics that should be addressed
2. **Optional** are to be addressed as warranted by local context and issues
3. **Not currently indicated** are those topics to address if indicated by new information.

With these priorities taken together, this list provides a comprehensive approach to data collection and application that remains flexible to management needs while presenting a robust analysis of the socioeconomic context. These priorities also form the basis by which plans and the analysis of the management situation may be evaluated.

TABLE 7.2 Social Science Topics and Analysis¹

Category	Topic	Planning Relevance	Examples	Priority
Demography and social indicators	Population	Potential demand on BLM lands and resources	Population trends; distribution by age and gender	1
	Inequality	Differences in visibility and influence; identify vulnerable populations (environmental justice)	Income distribution; percent of households in poverty;	1
	Social difference	Barriers to public involvement; different user needs and values; identify distinctive populations (environmental justice)	Ethnicity; languages spoken in household; tribal affiliation	2
	Social indicators	Can indicate community strengths and weaknesses that may have implications for planning issues	Crime rates, divorce rates, unemployment, education, length of residence	2
Social organization and institutions	Government	Potential cooperating agencies; contacts for plan coordination	Municipal and county governments in/near planning area; special districts; tribal governments	1
	Non-governmental institutions	Potential partners for plan implementation; sources of economic and social resilience	Grange; Chamber of Commerce; church groups; ethnic advocacy organizations	2
	Communities of place	Local and regional population centers relative to planning area	Gateway communities; natural resource-dependent communities	1
	Social groups and networks	Opportunities for informal contacts in seeking public comment and communicating plans and proposals	Networks linking ranchers or retirees	2
	Occupational and interest groups	Provide range of perspectives on potential land use decisions	Wilderness advocates; oil and gas producers	1
Attitudes and values	Values and beliefs regarding local environment and its use	Local understandings may shape acceptability of proposed land use decisions [formal techniques: surveys, interviews, focus groups]	Survey to clarify local understanding of effects of coal bed methane technology on ground-water conditions	3

TABLE 7.2 Social Science Topics and Analysis¹—continued

Category	Topic	Planning Relevance	Examples	Priority
Attitudes and values—continued	Attitudes regarding proposed land management actions	While public attitudes are elicited in scoping, formal data collection can identify important differences between groups, providing further information to help identify impacts and mitigation strategies [formal techniques: surveys, interviews, focus groups]	Interviews to assess social impacts of prescribed burning	3
	Quality of life	Can indicate community perceptions that may have implications for planning issues	Perceived access to community resources; satisfaction with community conditions, such as opportunities for employment	2
Human geography	Distribution of communities, roads, and resources	Clarify geo-spatial context; can predict potential conflicts and impacts over proposed land use allocations	Wildland-urban interface, recreational demand from nearby cities	1
	Land ownership and access	Can predict potential conflicts and impacts over proposed land use allocations	Split estate ownership of sub-surface minerals	2
	Culturally significant places and areas	Identify constraints on site-specific activities (may be developed in cultural resource analysis)	Locally valued buildings, sites, and landscapes; sense of place	2
Economic value	Products and uses of the assessment (study) area	Regional economic sectors and their interrelation	Annual receipts from manufacturing, agriculture, mining, tourism	1
	Non-market values of resources and activities	More complete description of economic and cultural benefit of BLM lands and resources	Area of Critical Environmental Concern's (ACEC) value to visitors: qualitative (description) or quantitative (willingness to pay)	3
	Dependence on BLM lands and resources	Understand the potential local and regional impacts of land use decisions	Value of BLM timber sales, visitor-day expenditures	1
Employment, income, and subsistence	Employment	Change in relative significance of various economic sectors	Jobs from government, construction, agriculture	1
	Income	Change in relative significance of various economic sectors	Non-labor income (dividends, transfer payments)	1
	Economic diversity and resilience	Ability of stakeholder communities to respond to external change	Level of dependence on single economic sector	2

TABLE 7.2 Social Science Topics and Analysis¹—continued

Category	Topic	Planning Relevance	Examples	Priority
Employment, income, and subsistence—continued	Regional economic organization	Identify amount and geographic distribution of new indirect and induced employment resulting from additional local investment	New local jobs resulting from proposed increase in oil and gas production on public lands	1
	Subsistence activities	Non-market production from BLM lands for local use	Amount and value of subsistence hunting by local residents	2
Public finance and government services	Government revenues and expenditures	Fiscal capacity and resilience under change	County payment in lieu of taxes (PILT) receipts	2
	Public infrastructure and services	Community services may be impacted by resource or recreational development of public lands	Expenditures on schools, roads	2
Environmental Justice	Characterize Environmental Justice populations in planning area	Demography and social Indicators: inequality, social difference	Much of the commercial harvesting of non-timber forest products in Pacific Northwest is organized through ethnic networks	1
	Assess potential for disproportionate impacts to Environmental Justice populations	Identify whether Environmental Justice issues require further modification of alternatives, or further mitigation of impacts	Positive correlation between areas with high levels of proposed oil and gas development and American Indian populations	1

¹Source: Checklist for BLM Socio-Economic Analysis: Resource Management Plan/Environmental Impact Statement. Rob Winthrop, Senior Social Scientist, November 8, 2004.

7.2 SOCIOECONOMIC INFORMATION PROVIDED THROUGH THE ECONOMIC PROFILE SYSTEM AND OTHER METHODS

Basic socioeconomic information was provided to the planning process for the SDNM during the early scoping phases. This information was compiled using the Economic Profile System (EPS) for counties and communities, and additional information was collected for some areas by a graduate student intern working for the Institute. Figure 7.1 shows a map of the planning area and the communities directly surrounding the SDNM.

7.2.1 Methods

The EPS is a data archive and retrieval system that runs in the spreadsheet program Microsoft Excel. It was developed by the Institute with assistance from the BLM as a tool for communities to gain a better understanding of their local and regional economies and changing economic and demographic trends. In addition, it provides the BLM with a simple and efficient way to compile socioeconomic information for its plans. The EPS consists of a series of templates and macros contained in an Excel workbook. The user simply selects a geography of interest (region, county, or community), presses “go,” and a 45-page

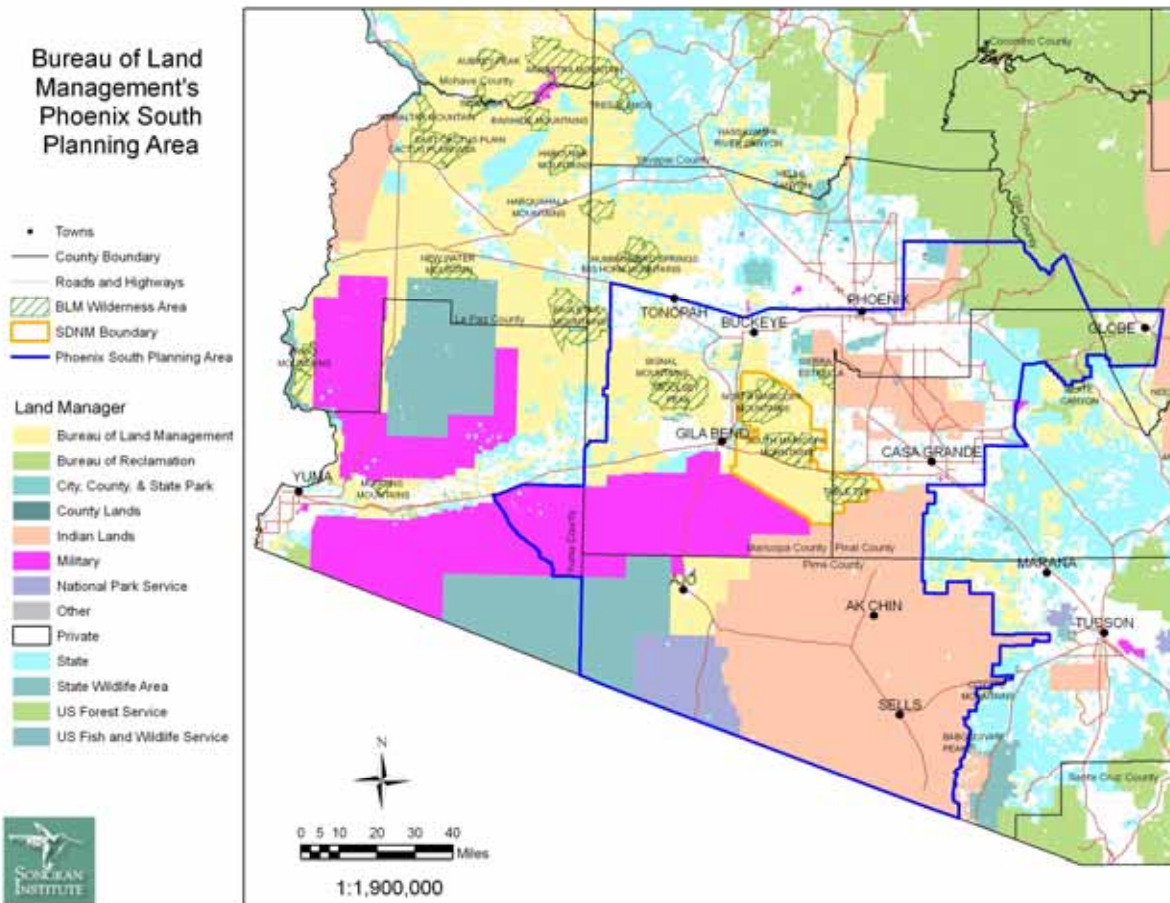


FIGURE 7.1 Map of the BLM Phoenix South Planning Area and Some Surrounding Communities

economic profile for that area is produced. The data sets used in creating the profile are linked to it. Data used in the EPS come from primary government sources and include: the U.S. Department of Commerce, Bureau of Economic Analysis and Bureau of the Census, and U.S. Department of Labor, Bureau of Labor Statistics.

Table 7.3 indicates the kinds of socioeconomic information collected for each area (county or community). The EPS county profiles illustrate trends from 1970 to 2000, whereas the EPS community profiles provide a snapshot of local conditions from the 2000 census but with greater breakdown of information according to gender. A graduate student intern, from the University of Arizona Planning Department, assisted in the collection of additional socioeconomic information, such as voting statistics, school enrollment and spending, and other data. Trend reports (1970 to 2000) were prepared for these additional indicators, and four-page summaries were produced for easy access to the range of information. The summaries and EPS profiles (county and communities) were used in community meetings, were made available during the scoping meetings and open houses (held in February 2003), and were used by the BLM staff to become familiar with the communities in the planning area.

A variety of information is provided in these profiles and reports, all of which were provided to the BLM as printed reports and electronic databases. Table 7.4 provides a list of the information measures. For specific data sources, the individual reports are the best source of this information. Copies of the

TABLE 7.3 Kinds of Community- and County-Level Information Provided

Community/ County	Socioeconomic Summary	Trend Report 1970 to 2000	EPS 1970 to 2000	EPS-C 2000 Snapshot	Other ¹
Ajo	X	X		X	
Ak-Chin				X	
Buckeye	X	X		X	
Casa Grande	X	X		X	
Gila Bend	X	X		X	
Globe				X	
Marana	X			X	
Phoenix	X	X		X	
Sells	X	X		X	
Tonopah					X
Tucson	X	X		X	
Yuma				X	
Maricopa County	X		X		
Pima County	X		X		
Pinal County	X		X		
3-County Area		X			
Yuma County			X		

¹No Census information was available for Tonopah. A brief summary prepared by the Arizona Department of Commerce was provided to the BLM.

TABLE 7.4 Socioeconomic Measures

Category	Measure
Population	Total number of people, population change
	Number of people by age and gender
	Median age, age distribution
	Race
	Ethnicity
	Place of birth
	Migration
	Language
	Urban versus rural population
Housing	Number of housing units, change in housing units
	Vacant housing units for seasonal use
	Age of housing stock (year built)
	Home rental affordability, median rent
	Home ownership affordability, median value
	Homeownership by ethnicity
Employment	Employment by industry
	Employment by occupation
	Seasonal employment
	Business size and ownership
	Minority-owned businesses
	Workers per family

TABLE 7.4 Socioeconomic Measures

Category	Measure
Employment—continued	Workers by hours per week
	Unemployment
	Place of work (in or outside the area)
	Commute method and time
	Military versus civilian employment
Economics	Income distribution
	Per capita income
	Income distribution
	Median family income
	Income by work status (full-time versus part-time) and gender
	Sources of income
	Net farm income
	Gross farm income versus production expenses (profit)
	Poverty by age and gender
	Poverty by race and ethnicity
	Families under the poverty level by household type
Education	Educational attainment
	School enrollment
	Drop out rate for public schools grades 9 to 12
	Educational spending
Civics	Voter turnout for presidential and non-presidential election years
	Registered voters
Health and safety	Crime rates
	Infant mortality rates
	Cardiovascular disease mortality rates
	Motor vehicle accident mortality rates
	Lung cancer mortality rates
	Per capita hospital beds and physicians per capita
Agriculture	Change in acres of farmland
	Average size of farms
	Change in market value of agricultural products
Transportation	Means of transportation
	Mean travel time
	Daily vehicle miles traveled, per capita daily vehicle miles

summaries and the EPS profiles are available to download from the following web site:
<http://www.sonoran.org>.

7.2.2 Results

Findings from this information are specific to the geographic area but some general trends can be discussed. The Phoenix Metropolitan Area, located just 97 kilometers (60 miles) north and east of the SDNM, dominates the economic trends in Maricopa County and exerts significant population and development growth pressure on the northern boundary of the monument. The total population in Maricopa County in the year 2000 was over three million. This is a result of a 217% increase in population between 1970 and 2000, making it one of the fastest growing counties in the nation. West of

Phoenix along the Interstate 10 corridor are the largest and fastest growing communities, whose development activities could impact SDNM values from the north. The north and northeast sides of the monument show the most recent growth with the most diverse economies.

In general, the remaining small towns surrounding the SDNM have been slow growing or even decreasing in population over recent decades—this is particularly true of towns along the western and southern boundaries. A large Hispanic population is present in these communities (around 45% of the population), and typically high unemployment and poverty rates and low family incomes exist. The economies were previously dominated by agriculture, manufacturing, and construction, but they are now in transition to more service-related sectors and, in the case of some small towns near the edge of the monument, are becoming bedroom communities for Phoenix. Just over the last three years tremendous changes in growth around the SDNM have become evident.

As the economy and demographics change around the SDNM, new issues and pressures will affect it. As this area develops, additional threats from recreational uses, utility and travel corridors, air quality, invasive species, and other impacts are likely to increase. Wildlife corridors and habitat, pristine desert landscapes, and wilderness qualities are likely to decrease unless measures are put in place to protect them.

7.3 POPULATION GROWTH PROJECTION MODEL

Part of what the socioeconomic profiles illustrated was the growth in communities around the SDNM. The monument is affected, and will continue to be affected, by growth pressures from the Phoenix Metropolitan Area and the growth of towns near the SDNM boundary. The Institute contracted with Blueline Consulting Group, part of the Sustainability and Global Change Program at Prescott College, to develop a population growth model to evaluate the current trends and potential impacts of growth on the SDNM.

7.3.1 Methods

With core funding from the National Aeronautical and Space Administration (NASA), the Blueline Consulting Group developed a model-based approach to planning. The objective of these models is to provide users with a tool to rapidly generate land-use change scenarios and impacts based on population growth numbers. The scenarios are generated using PC-based ESRI ArcView and Spatial Analyst extensions and three-dimensional representation using Terra Vista or 3D Analyst. The spatial growth model is intended to complement local planning efforts and be integrated into the impact analysis for the Environmental Impact Statement supporting the BLM resource management plans. It is designed to analyze the effects of BLM management activities and long-term cumulative impacts and be capable of generating multiple scenarios.

The population growth model is based on recent or historic population growth rates. For the Phoenix South Planning Area the growth rates of specific communities, including Buckeye, Casa Grande, Gila Bend, Goodyear, Maricopa, Tonopah, and many others in Maricopa, Pinal, and Pima Counties between 1990 and 2000, were used as a basis for the scenario projections. The model used the best information available. Data were provided by the BLM (spatial overlays, planning boundaries), Maricopa Association of Governments and local governments (growth planning policies, zoning), and the U.S. Bureau of the Census (population data). The quality and availability of data can be a limitation of the model. Scenarios used both a flat (constant) growth rate (what most planners use for projection estimates) and a compounded growth rate (what has been shown in this region to be more realistic for recent growth). Spatial allocation rules were applied to reflect various patterns of growth, including single-family, multi-

family/mixed development, and dispersed development. Rules also were applied to spatially locate the growth according to current average lot size, in areas with established services, and along roadways.

7.3.2 Results

Several scenarios were developed to illustrate the range of potential development patterns and project out to 2030. As a projection, these scenarios should be interpreted as the potential range of growth patterns, rather than one scenario being “correct” or exactly what will occur (BlueLine Consulting Group 2004). The following are a few example scenarios, but the possibilities are endless. The BLM and the U.S. Air Force, Luke Air Force Base received training on how to use the model, and they can update data and manipulate rules to have the model more accurately respond to their specific planning needs.

Scenario 1

The first scenario is based on the growth rate of each metropolitan planning area and the land base available in each for development. This scenario was run once with a flat growth rate and again with a compounded growth rate of growth (see Table 7.5 for a summary). This scenario also provides the basis for the following scenarios.

TABLE 7.5 Population Growth Model Scenarios for 2030 Based on Compounded and Flat Rates of Change

Variable	Flat Rate	Compounded Rate
Population	5,183,897	13,005,901
Average percent change	189.7%	706.3%
New housing units	984,622	3,846,201
New acres developed	180,094	1,452,561

Scenario 2

Scenario 2 builds on Scenario 1 by allocating the growth spatially toward areas defined as multi-family/mixed development areas.

Scenario 3

The third scenario also builds on Scenario 1, but it draws growth toward areas defined as single-family development areas.

The real power of modeling comes in the ability to run as many scenarios as needed to understand the issues and possibilities for current or future actions. Spatial representation of the growth patterns clearly shows the SDNM in the context of population growth and the developed landscape (see Figure 7.2). The southern boundary of the monument is contiguous with the Barry M. Goldwater Range (BMGR) and the Tohono O’odham Nation and is, therefore, somewhat protected from growth. The east boundary is affected by growth around Maricopa and farther away communities such as Casa Grande. The western boundary is affected by growth in Gila Bend and Buckeye along the expanding Highway 85 corridor. Most of the population pressure appears to affect the northern boundary of the SDNM. The Interstate 10 corridor—including Buckeye, Goodyear, and the Rainbow Valley area—is predicted to grow fastest as the Phoenix Metropolitan Area continues to expand. Once this information is understood, the real issue is how to anticipate, guide, and prepare BLM lands to cope with future growth that seems likely to be steady and increasing in rate at least for the immediate future. As communities continue to re-shape their general

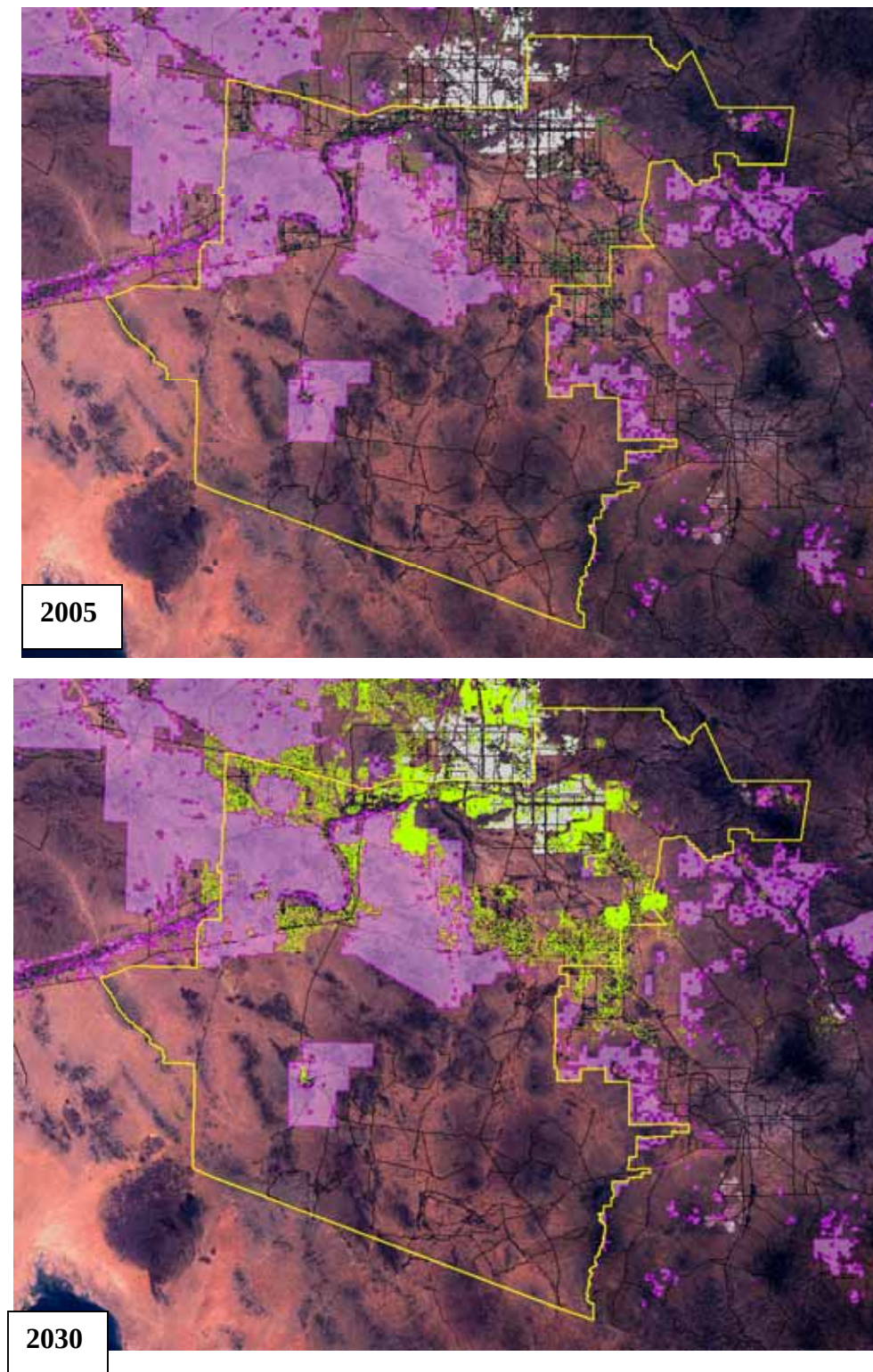


FIGURE 7.2 Maps Resulting from the Growth Model Projections. The yellow line represents the boundary of the Phoenix South Planning Area. The BLM lands are shaded purple. Population growth is shown in green. These images compare expected population in the years 2005 and 2030 based on current (compounded) population growth rates and the spatial distribution of development from Scenario 3.

plans, these changes can be incorporated into the model and used to assess the potential effect on BLM lands. An inherent limitation in this process is the unavailability of data, or the inability of jurisdictions to share data (whether by policy or because of lack of capacity). As more jurisdictions overcome these limitations the model can be improved with better data.

7.4 COMMUNITY WORKSHOPS, VALUES, AND QUALITY OF LIFE

Community participation in BLM's planning process for the SDNM and Phoenix South Planning Areas began with a series of open houses in February 2003. The purpose of these open houses was to initiate a dialogue between the public and BLM, in which BLM could explain the structure and process for the plan and assist the communities in helping to identify planning issues. The Institute participated in all of the public open houses by providing a Spanish language translation of BLM informational handouts, and it also made a bilingual staff member available at the events in case any non-English speakers had questions for the BLM staff. The Institute also provided informational handouts on socioeconomics, and the Conservancy contributed informational handouts on the biodiversity of the SDNM. After this initial contact with communities was made, more in-depth community workshops were conducted. The following is a discussion of the workshops conducted by the Institute. Although additional community workshops were conducted by URS Corporation (the contractors hired by BLM to assist with preparation of planning documents), they will not be discussed here.

7.4.1 Methods

In November and December 2003 the Institute facilitated a series of five community workshops in partnership with the BLM as part of public participation for the SDNM and Phoenix South planning efforts. The workshops were held in Ajo, Buckeye, Gila Bend, Mobile, and Tonopah. The purpose of the workshops was to discuss values and quality-of-life issues people associate with their community and the SDNM and how they, in partnership with the BLM, can protect these values based on current and predicted trends in population growth. Economic Profile System reports and information from the growth model projections were presented. The workshops generally lasted two to three hours and included:

- a values exercise in which participants wrote down three things they value most about their community and the surrounding landscape (including BLM lands)
- presentations by Karen Kelleher on where BLM is in the planning process, Nina Chambers (Sonoran Institute) on social and economic trends in the region, and Hoyt Johnson (Blueline Consulting/NASA) on the results of population growth modeling out to the year 2030
- a discussion of five questions that explore what communities and the BLM can do, independently and together, to manage public lands, accommodate growth, and maintain local values.

7.4.2 Results

The vision the communities described for themselves was consistent: they all expressed wanting to maintain their current quality of life and general rural character while gaining additional amenities in their communities (such as better jobs, restaurants and movie theatres, and community services).

Participation

In general, participation in the community workshops was good. The best levels of participation were in Ajo, Tonopah, and Mobile. These three communities are more rural than Gila Bend and Buckeye, seem to have more people that live near the border with BLM lands (or perhaps have more connection to the

BLM lands), and have specific issues or interests related to the BLM lands or the planning process. For example, current issues in Ajo involve access, in Tonopah it's the protection of Saddle Mountain, and in Mobile it's the siting of a proposed utility corridor. It is also worth noting that Ajo had the largest number of participants attend the meeting, and it had a number of people expressed distrust for the BLM. All the other community workshops had a more relaxed atmosphere and no such distrust was expressed. All the workshops showed that people are willing to collaborate with the BLM. The following sections provide a summary of findings from the workshops. Refer to the final report (Sonoran Institute 2003) for more detailed information.

Community Values

Many similarities were present among the communities in the values they expressed. They all included some values about the natural environment, their communities, and the role of public lands for recreation and open space. Some of the commonly expressed values among all the communities included: wildlife, flora and fauna, rural character, solitude/peacefulness/quiet/ remoteness, "small town" character, and open space. Many expressed the value of accessing public lands—for a wide range of uses.

At the same time, pronounced differences occurred across the communities in the way they expressed what they valued. These differences are interesting because they reflect the character of the communities and perhaps the different levels of growth they have experienced. Below are short descriptions for each community.

Ajo.—Two values distinguished Ajo from the other communities. First, "freedom" was repeated often in the values. This related mostly to access to BLM lands and being able to enjoy a range of activities from walking and solitude to family excursions to the use of off-highway vehicles (OHVs). The second striking difference was the emphasis and specificity of value toward the Sonoran Desert and the emphasis on its "pristine" nature and beauty. Ajo residents also expressed values about their small community in regard to its solitude and quietness. Many concerns were expressed about access and damage to the resources, as well as the value of the BLM maintaining management authority of the lands around the community to help control/limit growth.

Mobile.—Mobile was striking in its "leave us alone" sentiment. The most commonly expressed values in Mobile were about privacy, remoteness, peacefulness, and the role of public lands to protect and maintain these qualities.

Tonopah.—Tonopah is unique in its rural character. People in Tonopah expressed similar values as other communities, such as privacy, quiet, solitude, and freedom, but had less emphasis and less specific value placed on the desert environment and more values related to rural ranching communities. These included "open range," "no close neighbors," references to scenery and vistas, rural and ranch environment, and equestrian recreation. A concern was voiced here, as in other communities, about damage to the area from inappropriate OHV use and other recreation.

Gila Bend.—The values expressed in Gila Bend were evenly split between values of the natural Sonoran Desert, small town community, and rural character. Similar to Ajo, people have specific values related to the Sonoran Desert. Similar to Ajo and Buckeye, they value their community and neighbors. And similar to Tonopah, they expressed values related to rural character, scenery, and open space.

Buckeye.—The values expressed in Buckeye were the most dissimilar to the other communities. This may be a reflection of the difference in the make up of the participants (who were primarily professionals involved in some way in community planning and development), or it could simply be the difference between Buckeye and the other communities. Values were expressed about the natural environment, but

they were much less specific. Rather than “pristine Sonoran Desert” or “native flora and fauna,” community members expressed values about “sense of place,” views, and open space. In fact, “open space” and “mountain views” were the most repeated values. In addition, values about people, jobs, and growth were often expressed that were not commonly heard from the other communities.

Overall, the communities perceived that the SDNM and the proximity of other BLM lands to their communities would have a positive impact. The most common perceptions were that the BLM lands would help insulate their communities from growth and would provide open space. In addition, the BLM lands were perceived to provide some modest economic growth due to recreation and tourism. A few concerns were expressed about the negative impacts of recreation and tourism use (expressed by Ajo, Mobile, and Tonopah), such as increased traffic, lack of access control, and resource damage.

Bureau of Land Management Priorities and Issues

Participants had an opportunity to express what they thought should be BLM’s priorities for land management. These were quite similar across all the communities and included:

Maintain and improve resource protection.—People understood BLM’s multiple-use mission and while they were concerned about access, they also supported the protection of resources and the maintenance of areas in pristine condition. Residents of Tonopah also mentioned specific resource priorities such as providing and protecting wildlife corridors and making more opportunities available for ecological and cultural research on the SDNM.

Provide access.—A wide range of access and use concerns was expressed. Mobile was least interested in additional access provided around their community. Ajo expressed their desire for (nearly unlimited) local access through more control and limitations on others visiting the area (specifically limiting long-term stays of recreational vehicles). Participants recognized, however, the need to accommodate all kinds of uses and that some inappropriate uses occur that are damaging to the resources.

Increase public outreach.—A common desire expressed by all communities was for more information that clearly explains policies and the reasons for these policies, a list of acceptable and unacceptable activities, clear access and road markings (maps and signage), and educational materials and programs that help inform the public about appropriate recreational behaviors.

Volunteer programs.—An interest was expressed in all the communities in volunteer programs and continued cooperation and collaboration in planning and management.

Safety and law enforcement.—Safety was a concern expressed particularly in connection with illegal traffic from the U.S.-Mexico border (in Ajo, primarily). Law enforcement also was expressed as a way to better control recreation conflicts and prevent resource damage.

Community Interests and Priorities

Participants were asked what they thought their role could be in support of BLM land management. An easy acceptance of the role local communities can have and their impact on the surrounding lands was apparent. Again, commonalities and agreement existed among the communities about what they can do to support the BLM. These included:

Local planning and policies.—Particularly after the presentations on growth and regional trends, rich discussion ensued about the kinds of planning and policy decisions communities can make that may help them deal with growth. The participants also supported the concept that these planning and policy

decisions are made in collaboration with the BLM and within the broader context of neighboring communities and the county. Strong sentiment was expressed in the communities to maintain BLM management authority of the lands to limit growth and provide open space.

Public outreach.—To go along with the expressed priority that BLM focus on public outreach, residents also said that they could help get the message out to their neighbors. In particular, participants expressed an interest in education (especially for the youth) in appropriate use of OHVs.

Local law enforcement.—Because the BLM cannot provide the law enforcement coverage each community desires with the amount of acreage and number of staff available, significant interest among the communities was expressed in somehow coordinating with local law enforcement, establishing a hotline to report incidents on BLM land, and instituting other kinds of “neighborhood watch” models to report and monitor disturbances.

Volunteerism.—An interest was present in all the communities to help with volunteer projects—including clean-up activities, research and stewardship, monitoring, or education and outreach.

The information above is extremely valuable to the BLM in the early stages of the planning process to anticipate the kinds of relevant management issues that will be brought up in the public process and that will need to be addressed in alternative development. Caution should be used, however, in interpreting this information. The results listed here are only from those residents who volunteered to participate in these public workshops. As a result, these findings are not from a sample statistically representative of all residents from these communities.

7.5 RECREATION IMPACT ASSESSMENT

Recreational impacts are one of the main sources of stress on both the natural and cultural resources of the SDNM. To better understand the level and kinds of impacts currently affecting monument resources, the Institute contracted Northern Arizona University (NAU) to conduct a rapid site assessment of recreational impacts. The Conservancy collaborated on this effort by providing natural community descriptions. Community types were noted on the survey forms, which enabled subsequent analyses that correlated recreation data with community type. The rapid assessment was intended to provide a baseline inventory that could be used to guide future monitoring by BLM. As changes are detected through monitoring, the BLM can decide what actions are necessary to maintain their management goals.

7.5.1 Methods

The methodology used by NAU was based on the limits-of-acceptable change approach, which applies the premise of inventory and monitoring linked with adaptive management responses (Foti and Patterson 2003). Data collection occurred between January and May of 2003. Nearly 500 miles of roads were surveyed to identify recreational sites and assess their impacts. If NAU detected indications from the road that a recreation site was nearby, the site was recorded. A total of 410 recreation impact sites were recorded. At each site NAU recorded information on a rapid assessment form that described the biophysical features of the area (including a classification by general type of vegetation community), the extent and type(s) of impacts, and an annotated overall impact rating (that is, extreme, heavy, moderate, slight, or unimpacted). More detail about the methodology and survey form can be found at: <http://www.sonoran.org/pdfs/Sonoranreport.pdf>. In addition, NAU recorded each site’s location with a Global Positioning System unit and took digital photos in all four cardinal directions. Data were entered into an Access database, which is available on the Internet at: <http://gsenm.az.blm.gov/monitoring>.

7.5.2 Results

Overall, recreational impact on the SDNM could be considered moderate. Only 28% of all sites were recorded as extremely or heavily impacted and 36% were assessed as slightly impacted. A wide variety of activities were recorded on the monument. The most common uses of extremely and heavily impacted sites were camping, OHV use, and social trails. The BLM considers four distinct management areas within the monument (see Figure 7.3), and additional analysis of recreation impacts was conducted using these management areas. Not all areas of the SDNM are affected equally.

The northern portion of the SDNM, north of Route 238, has the greatest number and density of sites. Although a majority (69%) of these sites are only moderately or slightly impacted, this area gets most of the activity and variety of uses. The northern area has the greatest OHV use with 76% of the sites having moderate to extreme impacts. In addition, 82% of sites in this area had moderate to extreme impacts from recreational shooting. Trash is also a major impact with 83% of the sites showing evidence of trash or dumping. The southwest portion, formerly known as Area A on the BMGR, has the fewest sites, with 80% of them moderate to slightly impacted. The southeast portion, including Vekol Valley, has 65% of its sites only moderate to slightly impacted, but 30% of the sites are extremely impacted. This area also has the greatest amount of illegal migrant impacts, which cause moderate to extreme impacts on 84% of the sites. The following is a more specific discussion of impacts based on primary activities.

Camping

Nearly 90% of the recreation sites assessed on the SDNM were used for camping; and camping created some of the most serious impacts on the monument. As previously mentioned, the northern portion of the SDNM had the greatest number of campsites (61%). About 86% of the sites assessed were next to the road or within about 15 meters (50 feet). Most sites (56%) were single party sites. In cases where biological soil crust or desert pavement were present near the site, it was often impacted (49% of sites having biological soil crust and 58% of sites having desert pavement). Fuelwood collection was found to be a problem, with damage to trees and shrubs in 44% of the sites. The good news, however, is that the extent of damage is relatively low. Seventy percent of the sites were assessed as having slight or moderate impacts, whereas only 14% were assessed as extremely impacted.

Incompatible Off-Road Vehicle Use

The study found that off-road use along roads and washes was a problem. Over 95% of the roads surveyed had associated off-road use. In 40% of the cases, off-road use appeared to be frequent. In addition, a total of 222 sites indicated washes were impacted with off-road use or about 40% of the sites surveyed. Of all campsites, 56% showed OHV use, with the majority (55%) of impacts in the northern portion of the monument. The central portion of the SDNM, the area between Route 238 and Interstate 8, showed the least amount of impact with just 15% of sites impacted and most of those (79%) moderate to slightly impacted.

Target and Recreational Shooting

Shooting impacts were found in 20% of the sites surveyed. Often, these sites also were associated with damage to saguaros (*Carnegiea gigantea*) (12% of total sites surveyed) and other cacti (10% of total sites surveyed). Again, the northern portion of the monument was most heavily impacted with 81% of the total occurrences and 82% of those causing moderate to extreme impacts.

Recreation Impacts on the Sonoran Desert National Monument

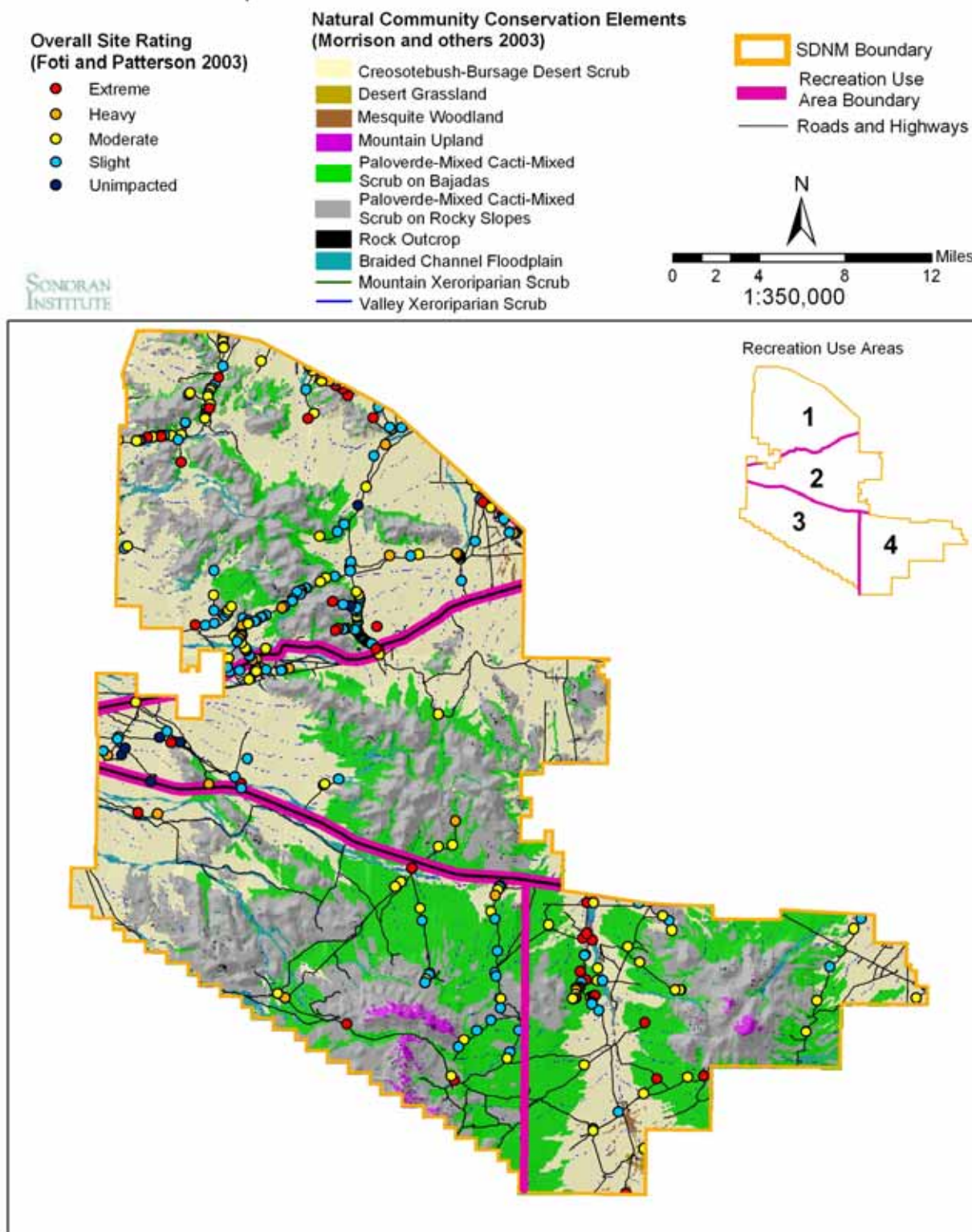


FIGURE 7.3 Recreation Site Distribution and Impact Rating on the Sonoran Desert National Monument

Litter and Trash

Litter was a major impact on the monument with 68% of all sites having litter and 15% showing evidence of trash dumping. Of the extremely impacted sites, 89% had litter and 40% had trash dumping.

Illegal Immigrant Impacts

Illegal immigrant impacts are not always possible to discern from other impacts, but 20% of all sites were discernable as illegal immigrant impacts. Not surprisingly, 97% of the impacts were found south of Interstate 8, with the majority (62%) found in the southeast area including Vekol Valley. This area also had more intense impacts with 84% rated as moderate to extreme, whereas in the southwest area (former Area A) 83% of the impacts were moderate to slight.

Northern Arizona University also found that the majority (61%) of the recreational sites are located in the flat areas of Creosotebush-Bursage Desert Scrub and 21% in the Paloverde-Mixed Cacti-Mixed Scrub on Bajadas. Less than 4% of recreation sites were located in Mesquite Woodlands and within washes (Valley Xeroriparian Scrub and Braided Channel Floodplain).

7.6 WILDLIFE WATERS DEVELOPMENT WORKSHOP

Many specific issues are considered in BLM management planning that have complex and divided public interest and perceptions. One issue that has particular importance in southwestern deserts is wildlife water developments. Wildlife waters seem to combine a number of issues including: wildlife management, consumptive versus non-consumptive recreation, wilderness, and access. The BLM invited the Institute to help facilitate and compile public opinion resulting from a recent workshop (Chambers 2004). The purpose was to solicit public input that could help the BLM, and other federal and state agencies, in understanding public perceptions of the issue.

7.6.1 Methods

Public involvement and opinion was solicited at the workshop in several ways. As part of the workshop program, speakers representing a range of philosophies regarding wildlife waters were invited to present their views at the beginning of the workshop. Although the presentations focused on results from recent scientific studies, presenting the philosophical perceptions up-front was a great way to sensitize the audience about the complexity of the issue and how the same scientific information could be interpreted or perceived in different ways. Everyone had the opportunity to comment throughout the workshop. A “listening post” was established at the back of the meeting room where people could post their comments about what they thought are “positive” or “negative” aspects of wildlife waters. Posting these comments gave everyone an opportunity to read and learn about “both sides” of the issue. A comment box was available as well for people who either had comments that went beyond what they thought was good or bad about waters, or who did not want their comment to be posted and read by others. And, lastly, a facilitated session near the end of the workshop allowed for the generation of comments and suggestions, based on common values generated by the group, for what the federal and state agencies should consider when making decisions about wildlife waters. The last session of public involvement then identified further areas for research and prioritized them.

7.6.2 Results

Resulting public opinion from the workshop should be understood within its limitations. The opinions compiled are those only from the self-selected group of people who attended the workshop and do not represent all of the opinions potentially held by the public. In addition, it is useful to understand who the

workshop participants were: approximately 74% of the participants were federal (52%) and state (22%) employees. The remaining 26% included university researchers (6%), tribal representatives (4%), environmental and sportsmen's groups (6%), and others (including consulting groups) or people who didn't list an affiliation (10%).

The perceptions can be categorized in several ways. Distinctions were drawn regarding where waters are appropriate and where they are not, the appropriate and inappropriate design of waters, whether wildlife should be actively managed or not, and whether waters are needed at all. Several themes emerged that dominated the different philosophical opinions. First, a lot of discussion occurred about whether or not natural waters had become insufficient for wildlife to survive and if artificial waters produced artificially high numbers of wildlife. Second, a debate ensued about where the burden of proof lies: some believe that waters should be provided unless proven to be either not needed or actually detrimental for some reason, whereas others believe just as strongly that before waters are provided the need and benefit must be proven.

These themes were reflected in the rest of the comments, and it did not seem that a "majority" of one opinion or another could be distinguished. A fairly even split among the "pro" and "con" arguments was present. The group did generate an extensive list of considerations for land managers that demonstrates some of the public's perceptions along with expressed feelings of ignorance and distrust. Many people expressed feelings that decisions were "unfair" or that some interests had more sway than others. Comments about simply not understanding how decisions are made and what information is used in those decisions were also expressed.

And finally the priorities identified for research were also consistent with comments heard throughout the workshop. The top two priorities were to better understand the:

- difference between use, benefit, and need—just because wildlife use waters, it doesn't necessarily mean they are benefiting from them or actually need them
- long-term effects of climate change and how changes may affect habitat and population distribution.

The issue of wildlife waters is just one example of a complex issue that will not likely be "solved" through research or education. It is likely that differing philosophies and opinions always will surround this issue. Agencies such as the BLM are put in a position of balancing these opinions, considering the points of view as well as the scientific findings, and making decisions to the best of their ability and in such a way that is understood by the public.

7.7 INTEGRATION OF BIOLOGICAL AND SOCIOECONOMIC INFORMATION

On an ongoing basis, staff at the Conservancy and Institute assess ways to better integrate socioeconomic information into the biodiversity management framework. Areas of integration generally focus on using: (1) human valuation of the resources of an area to identify social value species; (2) socioeconomic data to evaluate potential stresses and sources of stress to conservation elements, both today and projected into the future, at local and regional scales; and (3) both of the preceding types of information to devise possible conservation strategies for multiple or single conservation elements.

Together with the BLM, educational materials (handouts and a display) were developed to engage the public in the biodiversity and natural resource values on the monument as part of the February 2003 public scoping meetings. Social and economic information was integrated at the May 13, 2003 experts workshop that began to define the final suite of conservation elements for the SDNM and associated

ecological characteristics, including threats. Social scientists, including Rob Winthrop (BLM Washington, DC Office), as well as agency and academic biologists participated in the workshop. Presentations by the social scientists (described in section 5.2.1 and Appendix E) provided the other workshop participants with a social and economic context for conservation issues on the SDNM. The presentations on the conservation elements provided all participants an appreciation of the biodiversity of the monument and how the coarse filter-fine filter approach attempts to capture it. For example, part of the workshop discussion led to the identification of saguaro as a fine-filter conservation element under the criterion of a social value species (see Table 5.1).

The series of community workshops highlighted the different ways communities value the SDNM and its resources. Resource management issues differed among the communities according to their socioeconomic conditions and the ways people interacted with the resources. For example, smaller communities that were closer to the SDNM seemed to use the resources of the monument for recreation more and care more about issues of access and resource damage compared to larger communities with more diverse economies that expressed values monument-associated values related to the protection of open space and scenic vistas.

The growth model illustrated areas around the SDNM that will potentially experience high rates of growth. One example of how this social information can be integrated into natural resource decisions is in regard to protecting habitat for desert bighorn sheep (*Ovis canadensis mexicana*). If the area of Rainbow Valley continues to develop as predicted, it could potentially fragment bighorn sheep habitat and the connection between the monument and the Sierra Estrella (see section 6.5 for additional discussion). Growth surrounding the SDNM also will impact recreational use of the monument's resources. As the recreation impact study showed, the northern portion of the SDNM, near where population growth is occurring most rapidly, experiences the greatest amount of use and impacts by far in comparison with the rest of the monument.

The recreation impact study also illustrated how different human uses of the SDNM have different effects on the resource. Although most of the recreation sites recorded on the monument were only slightly or moderately impacted overall, the activities that caused the most resource damage had to do with the inappropriate use of OHVs. Impacts at these sites also were correlated with recreational shooting, which in 10% of the cases included direct impacts to saguaro. The recreation impact data also showed that the Creosotebush-Bursage Desert Scrub natural community was most impacted by recreation (likely because most of the recreation sites are located within this community). Sensitive higher elevation natural communities, xeroriparian habitats (washes), and Mesquite Woodlands generally were not affected at this time by recreation.

Public perceptions about management issues demonstrate that people care about wildlife and the natural Sonoran Desert ecosystems. They also highly value public lands for a number of reasons including access and recreation as well as open space and scenic vistas. As BLM makes management decisions for the SDNM, it is hoped that the biodiversity and socioeconomic information presented during this process will be useful.

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APPENDIX A TECHNICAL DEFINITIONS

TABLE A.1 Natural Heritage Program Global Ranking Definitions^{1,2}

Global Rank	State Rank	Definition
G1	S1	Very Rare: 1 to 5 occurrences or very few individuals or acres
G2	S2	Rare: 6 to 20 occurrences or few individuals or acres
G3	S3	Uncommon or Restricted: 21 to 100 occurrences, rather rare throughout a fairly wide range, or fairly common in a rather restricted range.
—	S3S4	Fairly Common: 51 to 100 occurrences and found over a rather wide range within the State.
G4	S4	Apparently Secure: more than 100 occurrences, though it could be quite rare in some parts of its range.
G5	S5	Demonstrably Secure: more than 100 occurrences.
GU	—	Unranked.

¹Priority ranking (1 to 5) based on the number of occurrences throughout the entire range of the element (from Arizona Game and Fish Department, Heritage Data Management System, 1/12/1994).

²Combined global ranks were determined from the following global rank designations:

G1 = G1, G1Q, G1T1, G4T1, G3T1Q, G5T1Q, G4G5T1, G5T1 (G_T1Qs need case by case review), G1G2
 G2 = G2, G2?, G3T2, G1G3, G2G3, G3T2, G3G4T2, G2G4T1T2Q, G4T1T2, G4T2, G4?T2?, G5T2, G5T1T2, G5T1T2Q (again, G_T2Qs need case by case review)
 G3 = G3, G3?, G3Q, G3?Q, G2G3Q, G2G4, G2G4T?, G3G4T3, G3G4, G3QT2T3, G3T3Q, G4T2T3, G4T3, G4T3?, G4?T3, G4?T3, G5T2T3, G5T3, G5T3?, G5T2T3Q
 G4 = G4, G4?, G?, G4T4, G3G5, G4T3T4, G5T4, G5T3T4, G4G5T3T4, G4G5T4, G4G5
 G5 = G5, G5?, G5T, G5T?;

where G#T# indicates a rank assigned to a subspecies (or variety), G#Q# indicates a taxon whose taxonomic status is questionable and whose rank may change once the taxonomic question is settled, and G#? indicates insufficient information to give a definitive ranking (confidence of numeric rank is plus or minus one rank).

TABLE A.2 Conservation Status Codes and Definitions

Code	Definition
<i>Endangered Species Act Status Definitions¹</i>	
LE	Listed Endangered: imminent jeopardy of extinction.
LT	Listed Threatened: imminent jeopardy of becoming Endangered.
XN	Experimental nonessential population.
PE	Proposed Endangered.
PT	Proposed Threatened.
C	Candidate: species for which the US Fish and Wildlife Service has sufficient information on biological vulnerability and threats to support proposals to list as Endangered or Threatened under the Endangered Species Act; however, proposed rules have not been issued because such actions are precluded at present by other listing activities.

TABLE A.2 Conservation Status Codes and Definitions—continued

Code	Definition
SC	Species of Concern: the terms “Species of Concern” or Species at Risk” should be considered as terms-of-art that describe the entire realm of taxa whose conservation status may be of concern to the US Fish and Wildlife Service, but neither term has official status (former C2 species).
<i>Mexican Status Definitions²</i>	
P	Determined Endangered in Mexico: in danger of extinction.
A	Determined Threatened in Mexico: could become endangered if factors causing habitat deterioration or population decline continue.
R	Determined Rare in Mexico: populations viable but naturally scarce or restricted to an area of reduced distribution or very specific habitats
Pr	Determined Subject to Special Protection in Mexico: utilization limited due to reduced populations, restricted distribution, or to favor recovery and conservation of the taxon or associated taxa.
<i>State Status: Arizona Native Plant Law (1993)³</i>	
HS	Highly Safeguarded: no collection allowed.
SR	Salvage Restricted: collection only with permit.
ER	Export Restricted: transport out of state prohibited.
SA	Salvage Assessed: permits required to move live trees.
HR	Harvest Restricted: permits required to move plant by-products.
<i>State Status: Wildlife of Special Concern⁴</i>	
WSCA(WC)	Wildlife of Special Concern in Arizona: species whose occurrence in Arizona is or may be in jeopardy or with known or perceived threats or population declines.
<i>Bureau of Land Management Status⁵</i>	
Sensitive	Sensitive species [which are in addition to species designated as federal listed, proposed, or candidate] are those designated by a [BLM] State Director, usually in cooperation with the state agency responsible for managing the species and State Natural Heritage Programs, as sensitive. They are those [native] species that: (1) could become endangered in or extirpated from a state, or within a significant portion of its distribution; (2) are under status review by the Fish and Wildlife Service and/or National Marine Fisheries Service; (3) are undergoing significant current or predicted downward trends in habitat capability that would reduce a species’ existing distribution; (4) are undergoing significant current or predicted downward trends in population or density such that federal listed, proposed, candidate, or state listed status may become necessary; (5) typically have small and widely dispersed populations; (6) inhabit ecological refugia or other specialized or unique habitats; or (7) are state listed but which may be better conserved through application of BLM sensitive species status.
<i>US Fish and Wildlife Service: Birds of Conservation Concern⁶</i>	
BCC	Covers migratory birds of conservation concern across the entire US, including Alaska, Pacific islands, and Caribbean islands and territories, identified at three geographic scales: North American Bird Conservation Initiative Bird Conservation Regions, US Fish and Wildlife Service Region, and national.

¹Endangered Species Act of 1973 (as amended) and Federal Notice of Review (1996), US Department of Interior, Fish and Wildlife Service (from Arizona Game and Fish Department Heritage Data Management System, 4/4/1997).

²Secretaría de Desarrollo Social, NORMA Oficial Mexicana NOM-059-ECOL-1994 Service (from Arizona Game and Fish Department Heritage Data Management System, 4/4/1997).

³From Arizona Game and Fish Department Heritage Data Management System, 4/4/1997.

⁴As described by the Arizona Game and Fish Department's listing of Wildlife of Special Concern in Arizona, October 1996 draft (from Arizona Game and Fish Department Heritage Data Management System, 4/4/1997).

⁵BLM. 2001. BLM Manual 6840 – Special Status Species Management. U.S. Department of the Interior, Bureau of Land Management. January 2001.

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TABLE A.3 Typical Spatial Patterns for Natural Communities in the Sonoran Desert Ecoregion¹

Spatial Pattern	Characteristics
Matrix	Natural communities form extensive and contiguous cover 2,000 to 500,000 ha in size. Occur on ecoregion's most extensive landforms and typically have wide ecological tolerances; aggregate of all matrix communities covers 70 to 80% of ecoregion; often influenced by large-scale processes (for example, climate patterns).
Large patch	Natural communities with interrupted cover ranging in size from 50 to 2,000 ha. Aggregate of all large-patch communities may cover as much as 20% of the ecoregion.
Small patch	Natural communities that form small, discrete areas of cover one to 50 ha in size. Occur in very specific ecological settings, such as on specialized landform types or in unusual microhabitats. May contain disproportionately large percentage of ecoregion's total flora and also support a specific and restricted set of specialized fauna.
Linear	Natural communities occur as linear strips. Often represent ecotone between terrestrial and aquatic ecosystems. Aggregate of all linear communities covers only a small percentage of the natural vegetation of the ecoregion. Local-scale processes, such as river flow regimes, strongly influence community structure and function, leaving communities highly vulnerable to alterations in the surrounding land and water-scape.

¹Spatial pattern characteristics adapted from Anderson and others (1999).

TABLE A.4 Global Distribution Characteristics for Conservation Elements in the Sonoran Desert Ecoregion¹

Distribution	Characteristics
Restricted/Endemic	Species or natural community occurs primarily in one ecoregion: it is either entirely endemic to the ecoregion or has more than 80% of its range within ecoregion.
Limited	Species or natural community occurs in the ecoregion, but also within a few other adjacent ecoregions (that is, its core range is in one or two ecoregions, yet it may be found in several other ecoregions).
Widespread	Species or natural community is distributed widely in several to many ecoregions and is distributed relatively equally among ecoregions. Widespread does not necessarily mean "common." For example, some wetland types are distributed widely, though total acreage is small and the occurrences are widely separated.

TABLE A.4 Global Distribution Characteristics for Conservation Elements in the Sonoran Desert Ecoregion¹—continued

Distribution	Characteristics
Disjunct	Species or natural community occurs in the ecoregion as a disjunct from the core of its distribution (less than 10% of its total distribution is in the ecoregion) and is more commonly found in other ecoregions. Disjunct occurrences of communities reflect similarly disjunct occurrences of key environmental factors or ecological processes, and these occurrences may represent variation in composition, structure, and potential for evolutionary divergence.
Peripheral	Species or natural community is more commonly found in other adjacent ecoregions (less than 10% of its total distribution is in the ecoregion of interest). Peripheral occurrences may or may not represent significant variation relative to occurrences in adjacent ecoregions. Goals for peripheral communities should account for the fact that most of their conservation will take place in other ecoregions. Opportunistic capture of these types often may be sufficient. Selection of examples for conservation should be informed by consideration of how they compare in size, quality, and variation with those in the adjacent or other ecoregions.

¹Distribution characteristics adapted from Anderson and others (1999).

APPENDIX B EXPERTS CONSULTED AND WORKSHOP PARTICIPANTS

TABLE B.1 Experts Providing Input on Conservation Elements

Name	Affiliation	Expertise
Lin Peist	Arizona Game and Fish Dept.	Mesquite mouse, small mammals
Tim Snow	Arizona Game and Fish Dept.	Bats
Dale Turner	The Nature Conservancy	Vekol Valley, reptiles
Peter Warren	The Nature Conservancy	Plant species and vegetation communities
Kathryn Mauz	University of Arizona	Tobosa grasslands
Matthew Goode	University of Arizona	Rock outcrops, reptiles
Phil Rosen	University of Arizona	Reptiles, amphibians

TABLE B.2 Participants at Experts Workshop (May 13, 2003)

Name	Affiliation
Nina Chambers	Sonoran Institute
Gene Dahlem	BLM (Phoenix Field Office)
Dave Dalton	Roper Scientific
Rebecca Davidson	Arizona Game and Fish Department
Erik Enderson	Drylands Institute
Russ Engle	Arizona Game and Fish Department
Richard Felger	Drylands Institute
Pam Foti	Northern Arizona University
Anne Gondor	The Nature Conservancy
John Hall	The Nature Conservancy
Karen Kelleher	BLM (Phoenix Field Office)
Megan Kram	BLM (National)
Rob Marshall	The Nature Conservancy
Elroy Masters	BLM (Phoenix Field Office)
Peter Morrison	Pacific Biodiversity Institute
Chuck Patterson	Northern Arizona University
Phil Rosen	University of Arizona
Sue Rutman	Organ Pipe Cactus National Monument
Tim Tibbitts	Organ Pipe Cactus National Monument
Dale Turner	The Nature Conservancy
Dan Urquidez	Arizona Game and Fish Department
Stephanie Weinstein	The Nature Conservancy
Rob Winthrop	BLM (National)
Betsy Wirt	Luke Air Force Base

TABLE B.3 Experts Consulted to Resolve Final Conservation Element List

Name	Affiliation	Conservation Elements
Sherry Barrett	Fish and Wildlife Service	Kit fox
Richard Felger	Drylands Institute	California snakewood, crucifixion thorn, Thornber's fishhook cactus, varied fishhook cactus, Tumamoc globeberry
Bob Henry	Arizona Game and Fish Department	White-tailed deer
Peter Morrison	Pacific Biodiversity Institute	Native grass group, night-blooming cereus
Sue Rutman	Organ Pipe Cactus National Monument	California snakewood, crucifixion thorn, Thornber's fishhook cactus, varied fishhook cactus, Tumamoc globeberry
Dale Steele	California Department of Fish and Game	Kit fox
David Tibor	California Native Plant Society	California snakewood
Dan Urquidez	Arizona Game and Fish Department	White-tailed deer
Peter Warren	The Nature Conservancy	California snakewood, crucifixion thorn, Thornber's fishhook cactus, varied fishhook cactus, Tumamoc globeberry, night-blooming cereus

TABLE B.4 Experts Consulted for Species-Specific Characterization Information

Name	Affiliation
Sherry Barrett	USFWS
Mark Cochran	CH2M Hill
Troy Corman	Arizona Game and Fish Department, Non-game branch
David Dalton	Roper Scientific
Grant Drennen	BLM Tucson Field Office
Erik Enderson	Drylands Institute
Mima Falk	U.S. Fish and Wildlife Service
Richard Felger	Drylands Institute
David Griffin	Griffin Biological Services
John Gunn	Southwest Natural Resource Management Consultants
Bob Henry	Arizona Game and Fish Department
Andrew Holycross	Arizona State University
Rob Marshall	The Nature Conservancy
Elroy Masters	BLM
Peter Morrison	Pacific Biodiversity Institute
Scott Richardson	USFWS
Philip Rosen	University of Arizona
Sue Rutman	Organ Pipe Cactus National Monument
Susan Rutman	Organ Pipe Cactus National Monument
Jay Sheppard	American Ornithologists' Union

TABLE B.4 Experts Consulted for Species-Specific Characterization Information—continued

Name	Affiliation
Linwood Smith	Environmental Planning Group
Dale Steele	California Department of Fish and Game, Species Conservation and Recovery Program
Dennis Suhre	University of Arizona
Tim Tibbitts	Organ Pipe Cactus National Monument
David Tibor	California Native Plant Society
Dale Turner	The Nature Conservancy
Peter Warren	The Nature Conservancy
Betsy Wirt	Luke Air Force Base

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APPENDIX C SPECIES CONSERVATION ELEMENTS: ECOLOGICAL CHARACTERIZATION

This appendix contains detailed ecological characterization information on the species, as well as the more inclusive guilds and groups, that were selected as fine-filter conservation elements for the Sonoran Desert National Monument (SDNM) and immediate vicinity. The elements are arranged in taxonomic order beginning with plants.

C.1 PLANTS

Two individual species and one group were selected as conservation elements.

C.1.1 Acuña Cactus (*Echinomastus erectocentrus* var. *acunensis*)

Overview

Rationale for selection as a conservation element.—*Regionally vulnerable, federal candidate.* The acuña cactus was selected as a conservation element because it is a rare species with a restricted distribution that is found only in a few localities in the United States, all of which are in Arizona. Within its restricted range, the cactus is threatened by habitat destruction and illegal collection (Falk 2002). The SDNM may represent an important conservation opportunity for this species because of the absence of these regional threats. The acuña cactus is a candidate species for federal listing under the Endangered Species Act. As a result, it is considered a special status species by the BLM and subject to management as outlined in the Bureau of Land Management's (BLM) manual on Special Status Species Management (BLM 2001).

Specific habitat needs on the SDNM.—The acuña cactus is known from only one locality on the SDNM, associated with the Mountain Upland natural community (as mapped and described by Morrison and others 2003). Acuña cactus is difficult to find (especially when it is not flowering) so likely additional occurrences are present on the SDNM than what is currently known (May 2003 experts workshop), possibly within the Mountain Upland or the Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes natural community. Acuña cactus may be impacted by activities that result in excessive soil disturbance (Backer and Warren 1998). Other specific habitat needs of acuña cactus within these natural communities are not known. This species may be rare and patchily distributed because it has specialized needs that are not yet understood or because only a small portion of its potential habitat has been surveyed (Pima County 2001). The area where acuña cactus occurs on the SDNM is sufficiently remote and removed from anthropogenic disturbances such that most of the threats present elsewhere in its range are likely absent on the monument. It is probable that habitat for this species will persist on the SDNM if these areas meet BLM land health standards and maintain their existing ecological condition, as described by Morrison and others (2003). Because only one individual has been found on the monument, it is not known if a viable population of acuña cactus exists on the SDNM.

Ecological Characteristics

Abundance.—Known populations have abundances that range from 40 to 300 individuals. The cactus is difficult to find and may be more abundant and widespread than current assessments indicate (Pima County 2001).

Habitat associations.—The acuña cactus is found between 365 and 850 meters elevation (1,200 to 2,600 feet) on the upper half of top of broad dissected hills (Arizona Rare Plant Committee 2000) in the Arizona Upland subdivision of the Sonoran Desert (Geraghty and Miller and SWCA 1997). Populations also occur in well-drained knolls and gravel ridges between major washes. Slopes range from 0 to 30% in known sites (Geraghty and Miller and SWCA 1997). Substrates include bright red to white andesite, granite and limestone (Pima County 2001). Other plants found in sites occupied by acuña cactus include creosotebush (*Larrea tridentata*), ocotillo (*Fouquieria splendens*), triangle-leaf bursage (*Ambrosia deltoidea*), brittlebush (*Encelia farinosa*), ironwood (*Olneya tesota*), buckhorn cholla (*Opuntia acanthocarpa*), littleleaf paloverde (*Parkinsonia microphylla*), and Mormon tea (*Ephedra* spp.). (NatureServe 2003).

General life history.—Red-purple flowers, approximately five centimeters (two inches) in diameter are produced between early March to early April, with a peak of flowering in mid March. The probability of flowering depends on both the height of the plant, plant volume (representing water storage), and rainfall. The smallest individual observed with flowers was 24 millimeters (about one inch) tall, whereas greater than 90% of plants taller than 90 millimeters (3.5 inches) produce flowers. Plants are largely self-incompatible and require insect pollination to achieve fruit set (94% produce fruits with insect visitation; Johnson 1992).

Biotic interactions.—The following information is from Johnson's (1992) study of the pollination and reproductive ecology of acuña cactus at Organ Pipe Cactus National Monument (ORPI). Insect visitors are mostly solitary bees from the families Andrenidae, Anthophoridae, Halictidae and Megachilidae. The most abundant visitors to flowers at a population of acuña cactus in ORPI were *Megachile palmensis* (Family Megachilidae) and *Diadasia rinconis* (Family Anthophoridae). Large individuals (greater than 90 to 100 mm in height) may be infested and even killed by the larvae of the Opuntia borer, *Moneilema gigas* LeConte (Family Cerambycidae), which also commonly infests *Opuntia fulgida* and *O. engelmannii*. The larvae of *M. gigas* kill plants by consuming the interior of the cactus flesh and severing the root and stem. A common fruit and seed predator of the acuña cactus at ORPI is the moth larva *Yosemitia graciella* (Hulst) (Family Pyralidae). *Yosemitia graciella* attacked 30 out of 50 monitored plants in a single year and reduced seed set by 35%. This larva also feeds on other cacti, including hedgehog cactus (*Echinocereus* species). The flowers of the acuña cactus are similar to hedgehog cacti (*Echinocereus* sp.) and the two species overlap in flowering time and exploit the same guild of pollinators, however there does not appear to be competition between these species for pollinators.

Landscape context.—Movement corridor or dispersal requirements for this species are unknown (Pima County 2001). For example, how acuña cactus seeds disperse is fairly unknown. Seeds fall to ground and may germinate next to the parent plant and wind, rain, and small insects possibly disperse some seeds. Ants may carry seeds to unsuitable areas, resulting in the loss of the seeds (NatureServe 2003). There is no known density estimate or minimum patch size estimates for a population (Pima County 2001).

Status, Threats, and Management

Distribution.—The distribution of the acuña cactus stretches from western Pima County east to the Sand Tank Mountains of Maricopa County north to Pinal County and south to northern Sonora, Mexico (Pima County 2001; Figure C.1). There are four documented populations within the U.S. located at Coffee Pot Mountain, Organ Pipe Cactus National Monument, and near Ajo and Florence, Arizona (NatureServe 2003; Figure C.2). Potential habitat exists on the Tohono O'odham Nation and in the Sand

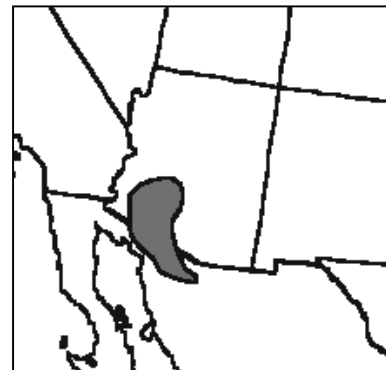


FIGURE C.1 Distribution of the Acuña Cactus. From Pima County (2001).

Tanks Mountains (NatureServe 2003). A population also exists near Sonoita, Mexico (NatureServe 2003). An additional site was located in the Sand Tank Mountains in 2000 but to date only a single live individual has been located (Falk 2002, Turner and others 2000, May 2003 experts workshop). One historic location has not been located recently (Falk 2002). Additional populations may be present but have not been found because only a small portion of the possible range has been surveyed (Pima County 2001)

Conservation status.—The acuña cactus has a global heritage status rank of G3T1Q (NatureServe 2003; also see Appendix A, Table A.1). A G3 rank indicates that the species can be fairly common but occurs within a restricted range or is rare throughout a fairly wide range. A T rank of 1 indicates that the status of this taxon (variety *acunensis*) is critically imperiled globally because of extreme rarity or because of some factor(s) making it especially vulnerable to extinction. The “Q” in the global rank code refers to the unresolved taxonomy of the subspecies/variety. Although this variety has not been recognized by some taxonomists (NatureServe 2003), it is tracked by numerous agencies.

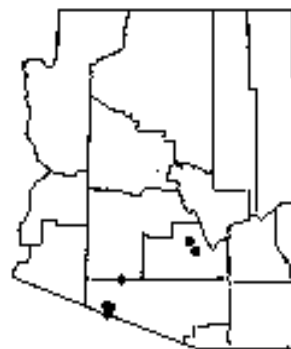


FIGURE C.2. Known Localities of Acuña Cactus in Arizona. From Arizona Rare Plant Field Guide (2000).

The acuña cactus is a candidate species for federal listing under the U.S. Endangered Species Act and is listed endangered in Mexico (En Peligro de Extinción). It is also protected under the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) where it is listed in Appendix 1 (most critical endangered; NatureServe 2003). Acuña cactus is protected from collection (classified as highly safeguarded) by the Arizona Native Plant Law. The species is also a priority vulnerable species in Pima County’s Sonoran Desert Conservation Plan (Pima County 2001).

Stresses and sources of stress.—Few known threats to the acuña cactus occur on the SDNM. Table C.1 identifies potential stresses and sources of stress confronting acuña cactus across the species’ range. At present, individuals are known only from remote parts of the Sand Tanks Mountains that have been free from livestock grazing for decades and where illegal off-road vehicle use is extremely unlikely to occur. Morrison and others (2003) found that the ecological condition of natural communities in areas occupied by acuña cactus to be close to baseline conditions, with few stresses (Condition Class 3). Acuña cactus is not grown in the cactus trade and a potential threat to the population on the SDNM is illegal collection, particularly during the flowering season when individuals are more conspicuous (May 2003 experts workshop). Because only one live individual has been found on the SDNM, it is not known if viable populations of the acuña cactus occur on the monument.

Mapping and Information Needs

Mapping comments.—Geraghty and Miller and SWCA (1997) generated a habitat similarity map of the eastern portion of the Barry M. Goldwater Range (including “Area A”, now included within the SDNM) based upon characteristics of habitat occupied by acuña cactus. Areas were given a rank score between 0 and 2 for geologic formations and plant communities, 0 being the least similar and 2 the most similar. A combined score of 4 represents an area that is most similar to known habitat for the acuña cactus. The ranking does not take elevation into account (Geraghty and Miller and SWCA 1997). Some areas on the SDNM are ranked as 4, most similar to known acuña cactus habitat (Geraghty and Miller and SWCA 1997).

TABLE C.1 Acuña Cactus: Stresses and Sources of Stress

Stress	Source of Stress	Geographic Scope of Potential Impacts	Comments or Source of Information
Altered composition	Mortality of adults, due to unknown causes	Regional and SDNM	Dead plants and uprooted individuals (possibly from animals) have been found on Organ Pipe Cactus National Monument due to unknown causes. Mortality in monitoring plots was associated with very dry winters (Falk 2002). A dead individual also was found on the SDNM (B. Wirt, pers. comm.).
	Historic and current illegal collection of plant	Regional and SDNM	Pima County (2001), NatureServe (2003). Theft is suspected to occur on Organ Pipe Cactus National Monument (S. Rutman, pers. comm.).
Habitat loss and degradation	Off-road vehicle use	Regional	NatureServe (2003).
	Road development and maintenance (existing and future)	Regional	NatureServe (2003).
	Grazing of livestock and burros	Regional	Pima County (2001).
	Historic mining	Regional	Pima County (2001). Historic mining heavily impacted the Ajo population.

Pima County (2001) modeled potential habitat for the acuña cactus based on vegetation community, slope, and elevation. Elevation ranged from 400 to 600 meters (1,310 to 1,970 feet), and critical habitat included creosotebush-bursage and paloverde-mixed cacti communities. This model did not consider geology. Because the cactus is difficult to detect, habitat modeling is an important tool to prioritize survey areas, but the modeling does not determine presence of the cactus due to the limited number of known populations and the coarse spatial scale considered in models (Geraghty and Miller and SWCA 1997).

Information needs.—Additional information is needed on the occurrence and population viability of acuña cactus on the SDNM. Existing or modified habitat models for the Sand Tank Mountains and/or other parts of the SDNM would help identify priority areas of survey for acuña cactus. This species appears to be sensitive to habitat disturbances such as mining and grazing (Pima County 2001) necessitating the inclusion of current and historic land use, in addition to vegetation, slope, elevation, and geology in habitat modeling.

C.1.2 Saguaro Cactus (*Carnegiea gigantea*)

Overview

Rationale for selection as a conservation element.—*Social value.* Saguaro cactus was selected as a conservation element on the Sonoran Desert National Monument (SDNM) based on input at an experts workshop held in May 2003. Saguaro has significant social value and is a species that resonates with the public. The saguaro is emblematic of the Sonoran Desert and it is highlighted as an “object” in the SDNM Proclamation (Clinton 2001), as shown in these quotes from the proclamation: “The most striking aspect of the plant communities within the monument are the abundant saguaro cactus forests.” and “The saguaro cactus forests within the monument are a national treasure, rivaling those within the Saguaro National Park.”

Saguaro also may meet the conservation element selection criteria as a keystone species, defined as a species that has a disproportionately large effect on other species in a community (Meffe and Carroll 1994). A keystone species, however, has other attributes that have not specifically been evaluated for saguaro.¹

Specific habitat needs on the SDNM.—Many abiotic and biotic factors influence saguaro distribution and abundance on the SDNM. Plot data collected by Morrison and others (2003) provide some baseline information on saguaro presence and dominance within natural communities and by geographic area and ecological condition class on the SDNM. In general, the saguaro is widely distributed on the SDNM and occurs in every natural community except Desert Grassland and Mesquite Woodland. It does differ, however, in various measures of abundance by natural community type and to a more limited extent by ecological condition class and geographic area (see **Habitat associations** below).

Within appropriate saguaro habitat (determined in part by temperature, elevation, and aspect), saguaros require protective seedling germination and development sites, pollinators, and seed dispersers. A critical habitat component for saguaro development is the availability of nurse plants, which provide suitable microclimate and protection from herbivory during germination, seedling development, and juvenile growth.

Ecological Characteristics

We do not attempt to provide an extensive account of the ecology, management, and conservation of saguaro cactus in this report. Unless noted otherwise, the information below comes from Steenbergh and Lowe (1976, 1977, 1983), Pavek (1993), and Turner and others (1995). More detailed, comprehensive accounts on saguaro are available from these sources.

Abundance.—Saguaro abundance is influenced primarily by abiotic factors including soils, rainfall, temperature, elevation, and aspect. Saguaros are generally less abundant on north-facing slopes and the densest stands in Arizona are roughly east of 112.8° W. The saguaro is dependent upon warm season rains for its survival, so saguaro abundance and survival is low in the western portion of its range near the Colorado River where the majority of rain falls in the winter. Low temperatures and frost limit saguaro persistence along the northern, northeastern, and upper elevations of its range. Saguaro death will occur after prolonged exposure to freezing temperatures, and variations in saguaro abundance are often due to

¹Recent studies to advance and refine the keystone species concept have defined a keystone species as one that has a large effect on community structure and function that is disproportionate to its relative abundance (for example, it is not important simply because it is dominant) and that has a unique function in the community, which may differ at some temporal and/or spatial scales (Kotliar 2002).

recurring catastrophic freezes. In the southern part of its range, saguaro is restricted to lower elevations and may be limited by competition with more tropical vegetation. Because saguaros are long-lived and slow growing, local differences in abundance may reflect land-use history and climatic events. Recruitment events usually occur during several consecutive years of mild and wet weather. On the SDNM, the highest densities of saguaro are generally found on the upper bajadas (P. Morrison, pers. comm.).

Habitat associations.—The saguaro has the broadest habitat associations of all the Sonoran Desert columnar cacti. It occurs at elevations from 500 to 1,525 meters (1,640 to 5,000 feet) and depends largely on warm-season rains. The saguaro is most closely associated with the Arizona Upland subdivision of the Sonoran Desert, where it is found on rocky slopes, bajadas, and, at lower densities, in Arizona Upland valley bottoms. Saguaro occurs on shallow soils that are light, coarse-textured, and rocky and often underlain by an impervious caliche soil layer. In the more arid portions of the Sonoran Desert, saguaros are primarily restricted to xeroriparian channels in valley bottoms and on gently sloping bajadas.

Table C.2 provides summary statistics on saguaro constancy, percent cover, and stem count by natural community and ecological condition class on the SDNM. Stem count data are subdivided into three size classes: short (< 1 meter), medium (1 to 5 meters), and tall (> 5 meters). Table C.3 subdivides the percent cover and stem count data by two geographic areas: (1) the portion of the SDNM that was formerly know as Area A when it was previously withdrawn from the pblic domain for military purposes and adjoining portions of the Barry M. Goldwater Range (BMGR) and (2) the rest of the SDNM exclusive of the former Area A. Table C.3 also provides results of statistical tests of the geographic data by natural community type and across all communities. Data on which the analyses in Tables C.2 and C.3 are based originally were collected by Morrison and others (2003).

Saguaro has its highest mean percent cover in the Paloverde-Mixed Cacti-Mixed Scrub on Bajadas natural community (0.40%; Table C.2). Saguaro also is present with relatively high mean cover and high constancy in plots in the Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes natural community, but is mostly absent or at lower densities on north-facing slopes. The more limited presence of saguaro on such slopes may reflect limiting temperature conditions. Total number of stems is highest in the Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes and Rock Outcrop communities. Saguaro is sometimes a component of Creosotebush-Bursage Desert Scrub, particularly in the variant of the natural community that represents the ecotone with Paloverde-Mixed Cacti-Mixed Scrub on Bajadas. Based on Morrison and others' (2003) plot data, saguaros are more closely associated with the Mountain Xeroriparian Scrub in comparison to other xeroriparian natural community types (Table C.2).

The ecological condition class data (Table C.2; see section 5.3.3 for class definitions) show some trend in increased constancy, stem counts, and cover with condition class (in the direction of 1 to 3); however, because of small sample sizes for some classes and small absolute numbers for the preceding three metrics we did not analyze the data statistically. Even with the rough estimates of size class distribution, saguaro recruitment does not seem to be an immediate issue on the SDNM, though again some tendency exists for stem counts of short saguaro to be lower within the lower condition classes.

The geographic data analysis indicates limited differences in saguaro stem counts and percent cover values between the two geographic areas analyzed (Table C.3). Across all natural communities, the mean number of short stems, tall stems, and total stems and percent cover are significantly different ($p < 0.05$) between the two geographic areas with the higher number of stem counts and cover values occurring within the former Area A and the adjoining portions of the BMGR. Medium stem counts are not significantly different. When tested by natural community type, significant differences occur between the two geographic areas only for number of short and total stems and percent cover (Mountain Xeroriparian

TABLE C.2 Saguaro Constancy, Cover, and Stem Count Information by Natural Community and Condition Class

Natural Community ¹	Plots	Total Saguaro			Short Saguaro	Medium Saguaro	Tall Saguaro	Other Vegetation
		Constancy ²	No. Stems (mean $\pm$ SD)	% Cover ³ (mean $\pm$ SD)	No. Stems (mean $\pm$ SD)	No. Stems (mean $\pm$ SD)	No. Stems (mean $\pm$ SD)	% Cover ³ (mean $\pm$ SD)
All	313	39.0%	1.25 $\pm$ 2.69	0.17 $\pm$ 0.36	0.39 $\pm$ 1.02	0.54 $\pm$ 1.43	0.32 $\pm$ 0.86	65.19 $\pm$ 36.45
<i>Natural Community</i>								
CB	87	18.4%	0.18 $\pm$ 0.50	0.04 $\pm$ 0.09	0.05 $\pm$ 0.22	0.11 $\pm$ 0.35	0.02 $\pm$ 0.15	50.73 $\pm$ 30.57
DG	6	0.0%	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	46.08 $\pm$ 27.56
MW	13	0.0%	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	144.56 $\pm$ 59.89
MU	36	22.2%	0.69 $\pm$ 2.14	0.10 $\pm$ 0.24	0.26 $\pm$ 0.85	0.31 $\pm$ 1.16	0.11 $\pm$ 0.40	81.28 $\pm$ 24.50
MXR	16	50.0%	0.69 $\pm$ 2.14	0.22 $\pm$ 0.33	0.26 $\pm$ 0.85	0.31 $\pm$ 1.16	0.11 $\pm$ 0.40	81.47 $\pm$ 29.05
PVMCB	35	65.7%	2.38 $\pm$ 3.12	0.40 $\pm$ 0.63	0.81 $\pm$ 1.69	0.69 $\pm$ 1.20	0.88 $\pm$ 1.38	63.30 $\pm$ 24.28
PVMCRS	64	76.6%	3.46 $\pm$ 4.18	0.36 $\pm$ 0.43	1.04 $\pm$ 1.43	1.70 $\pm$ 2.54	0.72 $\pm$ 1.08	49.39 $\pm$ 18.20
RO	7	85.7%	3.33 $\pm$ 3.39	0.39 $\pm$ 0.43	0.83 $\pm$ 1.17	1.00 $\pm$ 1.10	1.50 $\pm$ 1.76	18.61 $\pm$ 11.17
BCF	21	9.5%	0.05 $\pm$ 0.23	0.02 $\pm$ 0.08	0.00 $\pm$ 0.00	0.05 $\pm$ 0.23	0.00 $\pm$ 0.00	65.86 $\pm$ 44.57
VXR	25	28.0%	0.58 $\pm$ 1.25	0.07 $\pm$ 0.11	0.21 $\pm$ 0.59	0.21 $\pm$ 0.51	0.17 $\pm$ 0.64	76.50 $\pm$ 28.83
<i>Natural Community Subdivided by Condition Class</i>								
CB-1	18	0.0%	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	74.57 $\pm$ 34.30
CB-2	66	22.7%	0.23 $\pm$ 0.56	0.06 $\pm$ 0.11	0.06 $\pm$ 0.25	0.14 $\pm$ 0.40	0.02 $\pm$ 0.13	43.48 $\pm$ 26.50
CB-3	3	33.3%	0.33 $\pm$ 0.58	0.08 $\pm$ 0.14 ⁴	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.33 $\pm$ 0.58	67.33 $\pm$ 10.54
MU-3	36	22.2%	0.69 $\pm$ 2.14	0.10 $\pm$ 0.24	0.26 $\pm$ 0.85	0.31 $\pm$ 1.16	0.11 $\pm$ 0.40	81.28 $\pm$ 24.50
MXR-3	16	50.0%	0.69 $\pm$ 2.14	0.22 $\pm$ 0.33	0.26 $\pm$ 0.85	0.31 $\pm$ 1.16	0.11 $\pm$ 0.40	81.47 $\pm$ 29.05
PVMCB-1	1	0.0%	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	72.25 $\pm$ 0.00
PVMCB-2	20	45.0%	1.21 $\pm$ 1.82	0.38 $\pm$ 0.78	0.42 $\pm$ 0.69	0.26 $\pm$ 0.65	0.53 $\pm$ 1.26	42.56 $\pm$ 15.71
PVMCB-3	14	100.0%	4.42 $\pm$ 3.82	0.46 $\pm$ 0.35	1.50 $\pm$ 2.54	1.42 $\pm$ 1.56	1.50 $\pm$ 1.45	57.50 $\pm$ 17.96
PVMCRS-3	64	76.6%	3.46 $\pm$ 4.18	0.36 $\pm$ 0.43	1.04 $\pm$ 1.43	1.70 $\pm$ 2.54	0.72 $\pm$ 1.08	63.30 $\pm$ 24.28
RO-3	7	85.7%	3.33 $\pm$ 3.39	0.39 $\pm$ 0.43	0.83 $\pm$ 1.17	1.00 $\pm$ 1.10	1.50 $\pm$ 1.76	18.61 $\pm$ 11.17
BCF-1	1	0.0%	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	92.75 $\pm$ 0.00
BCF-2	20	10.0%	0.05 $\pm$ 0.23	0.03 $\pm$ 0.08	0.00 $\pm$ 0.00	0.05 $\pm$ 0.23	0.00 $\pm$ 0.00	64.52 $\pm$ 45.29
VXR-1	10	30.0%	0.33 $\pm$ 0.71	0.08 $\pm$ 0.12	0.22 $\pm$ 0.67	0.11 $\pm$ 0.33	0.00 $\pm$ 0.00	65.62 $\pm$ 14.21
VXR-2	14	21.4%	0.64 $\pm$ 1.50	0.05 $\pm$ 0.11	0.07 $\pm$ 0.27	0.29 $\pm$ 0.61	0.29 $\pm$ 0.82	82.75 $\pm$ 35.03
VXR-3	1	100.0%	2.00 $\pm$ 0.00	0.25 $\pm$ 0.00	2.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	97.75 $\pm$ 0.00

¹CB = Creosotebush-Bursage Desert Scrub; DG = Desert Grassland; MW = Mesquite Woodland; MU = Mountain Upland; MXR = Mountain Xeroriparian Scrub; PVMCB = Paloverde-Mixed Cacti-Mixed Scrub on Bajadas; PVMCRS = Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes; RO = Rock Outcrop; S = Desert Spring; BCF = Braided Channel Floodplain; VXR = Valley Xeroriparian Scrub. Condition classes are defined in section 5.3.3.

²Constancy was calculated using percent cover data.

³Untransformed mean was used to calculate summary statistics.

⁴The plot within which a saguaro was recorded did not include a cover estimate. We assumed the percent cover value was equivalent to trace or 0.25%.

TABLE C.3 Area Comparison of Saguaro Percent Cover and Stem Count Information: Descriptive Statistics and Statistical Tests by Natural Community Type and All Communities

Dependent Variable	Location		Comparisons		
	Former Area A and BMGR (mean $\pm$ SD)	Remainder SDNM (mean $\pm$ SD)	Mann-Whitney U Test Statistic	df	p-value
<i>Creosotebush-Bursage Desert Scrub</i>					
Sample Size (n)	11	76			
No. Total Stems	0.30 $\pm$ 0.48	0.16 $\pm$ 0.50	426.5	1	0.159
No. Short Stems	0.10 $\pm$ 0.32	0.04 $\pm$ 0.20	386.5	1	0.418
No. Medium Stems	0.10 $\pm$ 0.32	0.11 $\pm$ 0.36	366.0	1	0.978
No. Tall Stems	0.10 $\pm$ 0.32	0.01 $\pm$ 0.12	396.5	1	0.097
Percent Cover ¹	0.07 $\pm$ 0.12	0.04 $\pm$ 0.09	466.0	1	0.349
<i>Mountain Upland</i>					
Sample Size (n)	22	14			
No. Total Stems	0.52 $\pm$ 1.75	0.93 $\pm$ 2.67	141.0	1	0.772
No. Short Stems	0.19 $\pm$ 0.68	0.36 $\pm$ 1.08	139.5	1	0.209
No. Medium Stems	0.14 $\pm$ 0.66	0.57 $\pm$ 1.65	133.0	1	0.332
No. Tall Stems	0.19 $\pm$ 0.51	0.00 $\pm$ 0.00	168.0	1	0.145
Percent Cover ¹	0.09 $\pm$ 0.23	0.11 $\pm$ 0.27	155.0	1	0.964
<i>Mountain Xeroriparian Scrub</i>					
Sample Size (n)	9	7			
No. Total Stems	0.12 $\pm$ 0.35	2.60 $\pm$ 1.95	5.0	1	0.012
No. Short Stems	0.00 $\pm$ 0.00	0.60 $\pm$ 0.55	8.0	1	0.016
No. Medium Stems	0.00 $\pm$ 0.00	1.00 $\pm$ 1.41	12.0	1	0.063
No. Tall Stems	0.12 $\pm$ 0.35	1.00 $\pm$ 1.73	14.0	1	0.243
Percent Cover ¹	0.14 $\pm$ 0.33	0.32 $\pm$ 0.31	13.5	1	0.036
<i>Paloverde-Mixed Cacti-Mixed Scrub on Bajadas</i>					
Sample Size (n)	5	30			
No. Total Stems	2.00 $\pm$ 1.00	2.44 $\pm$ 3.38	78.5	1	0.555
No. Short Stems	0.00 $\pm$ 0.00	0.96 $\pm$ 1.81	40.0	1	0.091
No. Medium Stems	0.60 $\pm$ 0.89	0.70 $\pm$ 1.26	71.0	1	0.825
No. Tall Stems	1.40 $\pm$ 1.14	0.78 $\pm$ 1.42	95.0	1	0.094
Percent Cover ¹	0.40 $\pm$ 0.34	0.40 $\pm$ 0.67	98.0	1	0.243
<i>Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes</i>					
Sample Size (n)	28	36			
No. Total Stems	4.33 $\pm$ 4.35	2.67 $\pm$ 3.92	78.5	1	0.555
No. Short Stems	1.26 $\pm$ 1.43	0.83 $\pm$ 1.42	40.0	1	0.091
No. Medium Stems	2.11 $\pm$ 2.78	1.33 $\pm$ 2.28	71.0	1	0.825
No. Tall Stems	0.96 $\pm$ 1.22	0.50 $\pm$ 0.90	95.5	1	0.094
Percent Cover ¹	0.53 $\pm$ 0.55	0.24 $\pm$ 0.26	665.5	1	0.014
<i>Rock Outcrop</i>					
Sample Size (n)	2	5			
No. Total Stems	0.50 $\pm$ 0.71	4.75 $\pm$ 3.30	0.5	1	0.100
No. Short Stems	0.50 $\pm$ 0.71	1.00 $\pm$ 1.41	3.5	1	0.803
No. Medium Stems	0.00 $\pm$ 0.00	1.50 $\pm$ 1.00	1.0	1	0.114
No. Tall Stems	0.00 $\pm$ 0.00	2.25 $\pm$ 1.71	1.0	1	0.140
Percent Cover ¹	0.12 $\pm$ 0.18	0.55 $\pm$ 0.41	1.5	1	0.130

TABLE C.3 Area Comparison of Saguaro Percent Cover and Stem Count Information: Descriptive Statistics and Statistical Tests by Natural Community Type and All Communities—continued

Dependent Variable	Location		Comparisons		
	Former Area A and BMGR (mean $\pm$ SD)	Remainder SDNM (mean $\pm$ SD)	Mann-Whitney U Test Statistic	df	p-value
Valley Xeroriparian Scrub					
Sample Size (n)	6	19			
No. Total Stems	0.40 $\pm$ 0.89	0.63 $\pm$ 1.34	44.5	1	0.779
No. Short Stems	0.40 $\pm$ 0.89	0.16 $\pm$ 0.50	52.5	1	0.536
No. Medium Stems	0.00 $\pm$ 0.00	0.24 $\pm$ 0.56	37.5	1	0.237
No. Tall Stems	0.00 $\pm$ 0.00	0.22 $\pm$ 0.71	42.5	1	0.459
Percent Cover ¹	0.08 $\pm$ 0.13	0.07 $\pm$ 0.11	61.0	1	0.744
All Natural Communities					
Sample Size (n)	86	227			
No. Total Stems	1.85 $\pm$ 3.24	1.02 $\pm$ 2.42	10,217.0	1	0.001
No. Short Stems	0.56 $\pm$ 1.08	0.33 $\pm$ 0.99	9,697.5	1	0.005
No. Medium Stems	0.80 $\pm$ 1.90	0.44 $\pm$ 1.20	9,071.1	1	0.169
No. Tall Stems	0.49 $\pm$ 0.93	0.26 $\pm$ 0.26	9,687.0	1	0.003
Percent Cover ¹	0.26 $\pm$ 0.42	0.14 $\pm$ 0.32	11,694.0	1	0.002

¹Untransformed mean was used to calculate summary statistics and for Mann-Whitney tests.

Scrub, with Area A/BMGR stem counts and cover values lower) and percent cover (Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes, with Area A/BMGR having the larger percent cover).

General life history.—Saguaro reach sexual maturity at 30 to 35 years of age. Peak flowering occurs from mid-May to mid-June before the onset of summer monsoons. Each flower is open for less than 24 hours and requires cross-pollination to produce fruit. Pollinators include nectivorous bats, including the lesser long-nosed bat (*Leptonycteris curasoae*) and the Mexican long-tongued bat (*Choeronycteris mexicana*), white-winged dove (*Zenaida asiatica*), honeybees (*Apis mellifera*), and a native bee (*Diadasia opuntiae*) (Phillips and Wentworth Comus 2000). Fruit matures in June and early July and the primary seed dispersers are birds, including white-winged doves, Gila woodpeckers (*Melanerpes uropygialis*), and house finches (*Carduelis psaltria*). Saguaro seeds are short-lived and seedbanks are not maintained in the soil. Successful seedling establishment is almost always under protective nurse plants, which provide suitable microclimates and protection from herbivores. Most saguaro seedlings die in their first year from drought, frost, or animal activity. Larger seedlings, up to 20 years old and 30 centimeters (12 inches) tall have high mortality rates from herbivory by small mammals. Much higher survival rates until old age are achieved by plants that reach about one meter height (three feet) (approximately 40 years of age). Saguaro growth rates are controlled mainly by rainfall, soil characteristics, and plant size (growth rates increase as the plant gets larger and has more water storage capability). Most growth occurs during the summer monsoons in July to September. Near Tucson, a saguaro takes about 10 years to reach 3.8 centimeters (1.5 inches) in height, and 30 years to reach 61 centimeters (two feet). The height and approximate age of first flowering is about 2.4 meters (eight feet) and 55 years near Tucson (Phillips and Wentworth Comus 2000). Saguaro begin to grow arms when the plant is between 50 to 75 years of age.

Biotic interactions.—Saguaro require nurse plants, such as paloverde (*Parkinsonia microphylla*), to provide suitable microclimate and protection for germination and during the seedling and juvenile growth

stages. Saguaros provide numerous resources for countless species. Flowers offer nectar and pollen for numerous insects, birds such as the migratory white-winged dove, and the federally endangered lesser long-nosed bat. Saguaro fruit has been a traditional food source and a ceremonial food for the Tohono O'odham people for generations and is a source of building materials. Saguaro fruit is one of the only moist foods available during the foresummer drought and is an important food source for numerous species including Gila woodpeckers, white-winged doves, and house finches (which are also effective seed dispersers) as well as numerous other species of birds, insects, and mammals. Woodpeckers excavate cavities in saguaro, which in turn are used as nest sites by woodpeckers and many species of migratory birds as well as bats and occasionally by small mammals. Cavities excavated by the gilded flicker (*Colaptes chrysoides*) sometimes kill the saguaro. Fallen saguaros provide habitat for many small animals including snakes, lizards, rodents, and invertebrates, including species of flies that are specialized to breed only in rotten columnar cacti. Areas with high densities of saguaros provide habitat for numerous other species, including other conservation elements selected on the SDNM, including the cactus ferruginous pygmy-owl, the bat guild, and the woodpecker guild (see reports on those species for additional information on their association with saguaro and habitat needs).

Landscape context.—Saguaro seeds are dispersed by frugivores including white-winged doves and Gila woodpeckers. Seed banks are not maintained in the soil, so adult, sexually mature saguaros are necessary for regeneration. Large-scale mortality events are a concern because of the low rates of seedling recruitment and survival.

Status, Threats, and Management

Distribution.—The saguaro is endemic to the Sonoran Desert. Within the Sonoran Desert, the saguaro is almost completely restricted to Arizona and western Sonoran. Few saguaros are found in Sinaloa and on the west side of the Colorado River in California. The distribution of saguaro within the Sonoran Desert is limited by the amount of summer rainfall in the west and by low temperatures along the northern, northeastern, and upper elevation margins of its range.

Conservation status.—The global heritage status rank of saguaro is G5, which indicates that the species is secure across its range (NatureServe 2003; see also Appendix A, Table A.1). International trade in saguaro is restricted and the cactus is listed in CITES Appendix II: species that are not necessarily threatened with extinction but that may become so unless trade is closely controlled. The saguaro also is protected under the Arizona Native Plant Law. Crested (cristate) forms of the saguaro are Highly Safeguarded and all other forms are Salvage Restricted.

Some areas on the SDNM that qualitatively stand out as having high densities of mature saguaros and saguaros of numerous age classes include portions of the Sand Tank Mountains, such as the north bajada of Javelina Mountain, heavily dissected bajadas east of the Blue Plateau and the eastern bajada between Johnson Well and Javelina Mountain (R. Marshall and P. Morrison, pers. comm.), and the bajada north and east of Bighorn Peak in the South Maricopa Mountains Wilderness (P. Morrison, pers. comm.). The section on habitat associations above, as well as Tables C.2 and C.3, provides an analysis of some quantitative data associated with saguaro stems counts and percent cover on the SDNM and adjoining portions of the BMGR

An unusually high number of downed and standing dead adult saguaros were observed in the North Maricopa Mountain Wilderness near Margie's Cove East trailhead in 2003 (D. Turner, pers. comm.). Additional information is needed to evaluate the extent and cause of adult mortality in this area and to determine if adequate recruitment is present to replace these individuals in the long-term. Saguaro in other areas of the Maricopas have abundant scar tissue that at first glance looks as though it was caused

by shooting damage, when in fact it was due to a severe hailstorm. Effects on growth rates and mortality caused by this event have not yet been documented.

Stresses and sources of stress.—Human-caused damage to saguaros has occurred in numerous localities on the SDNM and is discussed in the following section. First, Table C.4 identifies potential stresses and sources of stress confronting saguaro across the species' range.

TABLE C.4 Saguaro Cactus: Stresses and Sources of Stress

Stress	Source of Stress	Geographic Scope of Potential Impacts	Comments or Source of Information
Altered composition/excessive mortality of adults	Mortality of adults from vandalism, including shooting.	Regional and SDNM	Foti and Patterson (2003) and Foti and others (2005); Table C.5 and Figure C.3 herein.
Altered composition/insufficient recruitment	Insufficient germination and/or survival of seedlings and juveniles due to inappropriate livestock grazing management practices.	Regional	Insufficient information exists to determine whether livestock grazing on the SDNM is a significant stress, though the analysis of plot data collected by Morrison and others (2003) suggests continued observation of livestock-saguaro interactions would be prudent (see the section on Habitat associations). Hall and others (2005) provide a review of the literature regarding livestock impacts to saguaro recruitment and survival.
Habitat loss/excessive mortality	Fire, which may be carried by fine-fuels resulting from non-native invasive plants, can kill all age classes of saguaro and can eliminate protective growth and germination sites under nurse plants.	Regional	Pavek (1993) reviews fire effects and post-fire recovery of saguaro (also see Hall and others 2005). Morrison and others (2003) provide data on the distribution of non-native plants on the SDNM. No evidence exists to date of fire-induced saguaro mortality on the SDNM.
Habitat loss	Urban development, especially in mountain foothills in the Tucson Basin and near Phoenix.	Regional	

The effects of livestock grazing on saguaro abundance and demographics on the SDNM have yet to be examined in detail. Saguaro are slow growing and require many decades for populations to recover from poor recruitment events (Turner and Funicelli 2000) that may be caused by both unfavorable climatic periods and anthropogenic factors. Hall and others (2005) recently conducted a literature review of livestock grazing impacts in the Sonoran Desert that included the impacts to saguaro recruitment and survival. These authors concluded that although climate variability is the primary factor affecting trends in saguaro populations, livestock grazing can have localized impacts. Such impacts potentially are

greatest on saguaro germination and seedling and juvenile survival and can include indirect impacts such as damage to saguaro nurse plants. Impacts to adult saguaro or at larger spatial scales may occur through grazing-induced spread of non-native plants capable of carrying fire. The degree of impact is more likely dependent on grazing intensity rather than season of use as seedling and juvenile saguaro are vulnerable to trampling, herbivory, and adverse impacts to nurse plants during the first five years of life.

Morrison and others' (2003) data on non-native plant occurrence on the SDNM provide baseline information on this potential threat to saguaros and their habitat. Currently, non-native plants are patchily distributed throughout the SDNM and the distribution of most species is not clearly associated with anthropogenic disturbance variables or environmental factors (Morrison and others 2003). The natural communities with the highest mean cover of non-native invasive plants are Mesquite Woodland, Braided Channel Floodplain, and Creosotebush-Bursage Desert Scrub. Some of the plot data, however, indicates that localized areas within Paloverde-Mixed Cacti-Mixed Scrub natural communities on Bajadas and Rocky Slopes have high mean cover of non-native plants (Morrison and others 2003:Appendix E). The high percent cover of red brome (*Bromus rubens*) at some locations in the Sand Tank Mountains is a concern because this species can grow in dense stands and can readily carry fire.

One threat to saguaro that has been documented on the SDNM is vandalism, including shooting of adult saguaro (Foti and Patterson 2003). This type of damage to saguaros can impact their ability to provide needed resources (such as cavities used as nest sites) to other species and can cause the death of mature individuals, many of which are likely over a hundred years old. Foti and Patterson (2003) surveyed 410 sites along roads on the SDNM for recreational impacts, including damage to saguaros. Fifty-one of the sites surveyed (over 12%) had damage to saguaros. Figure C.3 shows 351 recreation sites on the SDNM (59 recreation sites were removed from the analysis because they were outside the SDNM boundaries).

Fifty of the sites in Figure C.3 (over 14%) had damage to saguaro (Table C.5). Furthermore, Figure C.3 and data in Table C.5 indicate a strong correlation existed between sites with saguaro damage and sites with target practice and/or other evidence of shooting activities. Of the 50 recreation sites with saguaro damage, 43 sites (86%) had either shooting impacts or were used for target practice. Of all the recreation sites surveyed on the SDNM, about 12% had damage to saguaros and were used for target practice or had evidence of shooting impacts. An additional 72 recreation sites had shooting impacts, but did not have damage to saguaros. In a subsequent analysis of the recreational impact data, Foti and others (2005) found that of 69 recreation sites used for target practice 29 of these sites (42%) also had damage to saguaros.

Table C.5 also shows the breakdown of recreation sites with saguaro damage by natural community (as mapped and described by Morrison and others 2003). The Braided Channel Floodplain had the highest percentage of sites with damaged saguaro within a natural community (31%), whereas the Creosotebush-Bursage Desert Scrub community had the highest percentage of sites with damaged saguaro when considered across all natural communities (10%).

Mapping and Information Needs

Mapping comments.—Recreation sites shown in Figure C.3 were obtained from a database associated with the study of Foti and Patterson (2003). Recreation site UTM coordinates were projected into GIS, but 59 of the 410 sites were removed because they were outside the boundaries of the SDNM, in some cases because of apparent errors in the UTM coordinates reported in the database (that is, when projected these points were located well beyond the survey area). As a result, the sample size was reduced to a total of 351 recreation sites, but this did not change the relative percentage of sites within a natural community. All percentages reported in Table C.5 are based on a total of 351 recreation sites.

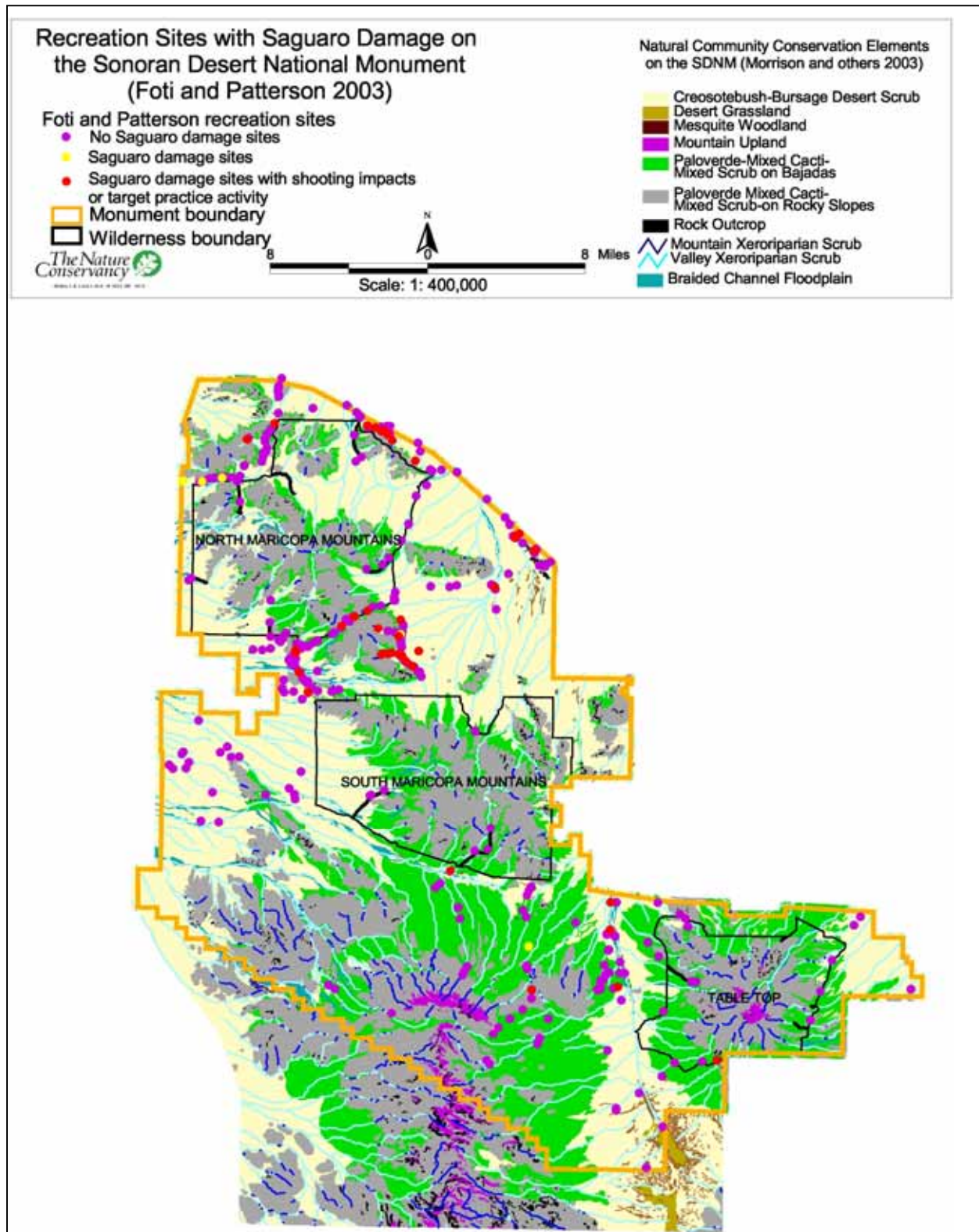


FIGURE C.3 Recreational Sites on the Sonoran Desert National Monument and their Relationship to Saguaro Damage

TABLE C.5 Saguaro Damage by Natural Community

Natural Community	No. of Sites per Community	No. of Sites with Damaged Saguaro	% of Damaged Saguaro Sites with Shooting Impacts or Used for Target Practice	Sites with Saguaro Damage by Community (%)	% Damaged of Total Recreational Sites
Braided Channel Floodplain	16	5	4	31%	1%
Creosotebush-Bursage Desert Scrub	224	34	30	15%	10%
Desert Grassland	1	0	0	0%	0%
Mesquite Woodland	3	0	0	0%	0%
Paloverde-Mixed Cacti-Mixed Scrub on Bajadas	67	4	3	6%	1%
Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes	38	7	6	18%	2%
Rock Outcrop	2	0	0	0%	0%
Total	351	50	43	14%	14%

The location of the recreation site in each natural community is based on the classification of natural communities by Morrison and others (2003), which itself is based on spatial information that considers the Braided Channel Floodplain community as part of the main spatial coverage and not as a separate overlay. Previously, Morrison and Snetsinger (2003) considered this community as a separate overlay. The classification of natural communities existing at recreation sites differed between Foti and Patterson (2003) and Morrison and others (2003) with 136 of 351 sites classified differently (see Table C.6 for the complete comparison). The most common misclassifications between Foti and Patterson's (2003) classification compared to that of Morrison and others' (2003) were to classify a site as occurring within Creosotebush-Bursage Desert Scrub instead of Paloverde-Mixed Cacti-Mixed Scrub on Bajadas (52 sites) and the reverse situation (24 sites). All analyses in Table C.5 were based on Morrison and others' (2003) natural community classification, because this was a more thorough assessment of natural communities than that done by Foti and Patterson (2003). Saguaro occurrence data in regard to natural community and geographic area on the SDNM are based on plot data associated with the study of Morrison and others (2003).

Information needs.—Saguaro demographic data collected by Morrison and others (2003) provide baseline information on current saguaro population demographics and its relationship with natural communities, environmental gradients, and disturbance gradients. Although some evidence exists that livestock grazing may impact saguaro recruitment, additional studies are needed to understand this relationship, especially on the SDNM. With livestock grazing soon to be eliminated south of Interstate 8 on the SDNM, an opportunity exists to monitor changes to saguaro populations with this change in land management. Because saguaros are such long-lived plants, few long-term studies of saguaro population demographics have been conducted within different natural communities. Additional demographic studies of saguaro on the SDNM would complement other long-term saguaro studies, such as that conducted at Saguaro National Park (Turner and Funicelli 2000), and provide a more complete picture of the long-term health of saguaro populations in Arizona.

TABLE C.6 Comparison of Vegetation/Natural Community Classifications at Recreation Sites on the Sonoran Desert National Monument

Foti and Patterson (2003) Dominant Vegetation	Morrison and others' (2003) Natural Community Spatial Coverage	Morrison and Snetsinger's (2003) Natural Community Spatial Coverage (Braided Channel Floodplain excluded)	Number of Classification Differences¹
Creosotebush-Bursage Desert Scrub	Braided Channel Floodplain	Creosotebush-Bursage Desert Scrub	8
Creosotebush-Bursage Desert Scrub	Braided Channel Floodplain	Paloverde-Mixed Cacti-Mixed Scrub on Bajadas	2
Creosotebush-Bursage Desert Scrub	Desert Grassland	Desert Grassland	1
Creosotebush-Bursage Desert Scrub	Mesquite Woodland	Mesquite Woodland	3
Creosotebush-Bursage Desert Scrub	Paloverde-Mixed Cacti-Mixed Scrub on Bajadas	Paloverde-Mixed Cacti-Mixed Scrub on Bajadas	52
Creosotebush-Bursage Desert Scrub	Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes	Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes	15
Mesquite Bosque	Creosotebush-Bursage Desert Scrub	Creosotebush-Bursage Desert Scrub	1
Paloverde-Mixed Cacti-Mixed Scrub on Bajadas	Creosotebush-Bursage Desert Scrub	Creosotebush-Bursage Desert Scrub	24
Paloverde-Mixed Cacti-Mixed Scrub on Bajadas	Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes	Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes	15
Paloverde-Mixed Cacti-Mixed Scrub on Bajadas	Rock Outcrop	Rock Outcrop	2
Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes	Braided Channel Floodplain	Paloverde-Mixed Cacti-Mixed Scrub on Bajadas	6
Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes	Creosotebush-Bursage Desert Scrub	Creosotebush-Bursage Desert Scrub	4
Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes	Paloverde-Mixed Cacti-Mixed Scrub on Bajadas	Paloverde-Mixed Cacti-Mixed Scrub on Bajadas	2
Unknown	Creosotebush-Bursage Desert Scrub	Creosotebush-Bursage Desert Scrub	1
Total			136

¹Number of classification differences refers to the number of recreation sites that have natural communities classified differently by Foti and Patterson (2003) and Morrison and others (2003).

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C.1.3 Native Grass Group

Overview

Rationale for selection as a conservation element.—*Regionally vulnerable.* The native grass group was selected as a conservation element because several of the natural communities occurring on the Sonoran Desert National Monument (SDNM) include an atypically high abundance of native grasses relative to other areas in the Sonoran Desert. Although the native annual and perennial grass species found within the monument are not individually rare, their occurrence as diverse assemblages with high cover values is regionally rare. The native grass group was suggested as a conservation element at an experts workshop held in May 2003. Botanists and other experts present at the workshop stated that the SDNM has the best expressions of intact Sonoran Desert perennial grass assemblages in southern Arizona and that this assemblage has been lost throughout much of the Sonoran Desert.

Species included in the native grass group.—Native grasses present on the SDNM were determined by compiling species lists from recent botanical work by Turner and others (2000), Morrison and others (2003), and Snetsinger and Morrison (2004). Thirty-nine native grass taxa are currently documented from the SDNM, including 16 annuals and 23 perennials (Table C.7). Additional native grass taxa, particularly annuals, are likely to be discovered with future plant surveys of the monument. At present, all native grasses known to occur on the SDNM are included in the native grass group. Additionally, although tobosa grass (*Pleuraphis mutica*) is included as part of the group, it also is the dominant component of the Desert Grassland natural community (as described by Morrison and others [2003]). Tobosa grass is included as a component of the native grass group because of isolated occurrences in natural communities outside the Desert Grassland, including on the summit of Table Top and in the Sand Tank Mountains (Morrison and others 2003, Snetsinger and Morrison 2004). Additional information is needed to determine the relative ecological and conservation significance of each species in the group and which areas of the monument have the best representation of native grasses (and within these areas, which species are present).

Specific habitat needs on the SDNM.—Mean percent cover of native grass species by natural community on the SDNM (and adjoining portions of the Barry M. Goldwater Range [BMGR]) are displayed in Table C.8. The data were compiled from plot data collected by Morrison and others (2003). Based on percent cover data from these field plots, the native grass group seems particularly well-represented in portions of the Mesquite Woodland, Mountain Upland, Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes, and Mountain Xeroriparian Scrub natural communities (Table C.8). The Mountain Upland community had the greatest taxonomic richness (13 taxa) followed closely by the Mountain Xeroriparian Scrub and Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes communities (11 taxa each, respectively). The Desert Grassland natural community also has a high native grass cover due to the dominance of tobosa grass, but as described above, this area is treated as a natural community conservation element separate from the native grass group. Each species of grass may have its own specific habitat requirements that enable it to maintain viable populations on the SDNM. As a group, the grasses will persist as components of the natural communities provided disturbance is below threshold values that preclude periodic recruitment. Native grasses are susceptible to excessive herbivory, particularly by domestic livestock, and to invasion by shrubs and non-native plants.

Ecological Characteristics

Composition and Abundance.—With the exception of tobosa grasslands, which typically occur as monospecific stands on fine-textured soils in areas where surface run-off accumulates, native grasses are interspersed among other vegetation on the SDNM. The occurrence of any particular grass species on the SDNM is controlled mainly by soil characteristics and climate. The relative abundance of the different

TABLE C.7 Species included in the Native Grass Group on the Sonoran Desert National Monument¹

Scientific Name ²	Common Name	Life Span	Plot Data Available from the Study of Morrison and others (2003)
<i>Aristida adscensionis</i>	Six-weeks three-awn	Annual	X
<i>Aristida purpurea</i> var. <i>nealleyi</i>	Purple three-awn	Perennial	
<i>Aristida purpurea</i> var. <i>parishii</i>	Purple three-awn	Perennial	X
<i>Aristida purpurea</i> var. <i>purpurea</i>	Purple three-awn	Perennial	X
<i>Aristida ternipes</i> var. <i>gentilis</i>	Poverty three-awn	Perennial	
<i>Aristida ternipes</i> var. <i>ternipes</i>	Spidergrass	Perennial	X
<i>Bothriochloa barbinodis</i>	Cane bluestem	Perennial	
<i>Bouteloua aristidoides</i>	Six-weeks needle grama	Annual	
<i>Bouteloua barbata</i>	Six-weeks grama	Annual	
<i>Bouteloua curtipendula</i>	Sideoats grama	Perennial	X
<i>Bouteloua repens</i>	Slender grama	Perennial	X
<i>Bouteloua rothrockii</i>	Rothrock grama	Perennial	
<i>Bouteloua trifida</i>	Red grama	Perennial	
<i>Brachiaria arizonica</i>	Arizona signalgrass	Annual	
<i>Bromus carinatus</i>	California brome	Annual	X
<i>Digitaria californica</i>	Arizona cottontop	Perennial	X
<i>Elymus elymoides</i>	Bottlebrush squirreltail	Annual	X
<i>Enneapogon desvauxii</i>	Spike pappusgrass	Perennial	
<i>Eragrostis pectinacea</i>	Purple lovegrass	Annual	
<i>Dasyochloa pulchella</i> (= <i>Erioneuron pulchellum</i>)	low woollygrass or fluff-grass	Perennial	X
<i>Heteropogon contortus</i>	Tanglehead	Perennial	X
<i>Hilaria belangeri</i>	Curly mesquite	Perennial	
<i>Hordeum pusillum</i>	Little barley	Annual	
<i>Leptochloa dubia</i>	Green sprangletop	Perennial	
<i>Leptochloa fusca</i>	Mexican sprangletop	Annual	
<i>Leptochloa panicea</i>	Red sprangletop	Annual	X
<i>Leptochloa viscida</i>	Sticky sprangletop	Annual	
<i>Muhlenbergia microsperma</i>	Littleseed muhly	Annual	X
<i>Muhlenbergia porteri</i>	Bush muhly	Perennial	X
<i>Panicum hirticaule</i>	Mexican panicgrass	Annual	
<i>Pleuraphis mutica</i>	Tobosa grass	Perennial	X
<i>Pleuraphis rigida</i>	Big galleta	Perennial	X
<i>Poa bigelovii</i>	Bigelow bluegrass	Annual	X
<i>Setaria leucopila</i>	White-haired bristlegrass	Perennial	
<i>Setaria vulpiseta</i> (= <i>S. macrostachya</i>)	Plains bristlegrass	Perennial	
<i>Sporobolus cryptandrus</i>	Sand dropseed	Perennial	
<i>Tridens muticus</i>	Slim tridens	Perennial	X
<i>Trisetum interruptum</i>	Southern oats	Annual	X
<i>Vulpia octoflora</i>	Sixweeks fescue	Annual	X

¹Occurrence data from Turner and others (2000), Morrison and others (2003), and Snetsinger and Morrison (2004).²Nomenclature is concordant with the Integrated Taxonomic Information System (ITIS 2002).

TABLE C.8 Mean Percent Cover and Taxonomic Richness of Native Grasses by Natural Community¹

Species	Mean Percent Cover by Natural Community ²										
	CB n = 87	DG n = 6	MW n = 13	MU n = 36	MXS n = 16	PVMCB n = 35	PVMCRS n = 64	RO n = 7	S n = 3	BCF n = 21	VXS n = 25
<i>Aristida</i> sp.	0 ⁵				0.03	0.04	0.11				0.03
<i>Aristida adsensionis</i>					0.02	0.01	0.01	0.04			
<i>Aristida purpurea</i> var. <i>parishii</i> ³								0.04			
<i>Aristida purpurea</i> var. <i>purpurea</i> ⁴				0.07	0.09	0.01	0.06	0.14	0.08		0.13
<i>Aristida ternipes</i> var. <i>ternipes</i>									0.08		
<i>Bouteloua</i> sp.				0.17				0.07			
<i>Bouteloua curtipendula</i>					0.02						
<i>Bouteloua repens</i>				0.03					0.67		
<i>Bromus carinatus</i>									0.08		
<i>Digitaria californica</i>				0.01							
<i>Elymus elymoides</i>				0.50							
<i>Dasyochloa pulchella</i> (= <i>Erioneuron pulchellum</i>)	0.04				0.02	0.05	0.17			0.01	0.01
<i>Heteropogon contortus</i>	0 ⁵			0.01	0.05				0.08		
<i>Leptochloa panicea</i>				0.01							
<i>Muhlenbergia</i> sp.							0.05				
<i>Muhlenbergia microsperma</i>			10.33	0.03			0.04	0.04			0.09
<i>Muhlenbergia porteri</i>	0.03			6.45	1.86	0.01	1.17	0.32	0.33		0.02
<i>Pleuraphis</i> sp.					0.33						
<i>Pleuraphis mutica</i>	0.34	15.23		3.94	0.06		0.01	0.14	0.08		0.01
<i>Pleuraphis rigida</i>	0 ⁵	0.02		0.62	0.14		0.02		0.67		
<i>Poa bigelovii</i>	0.04		0.02	1.32	2.53	0.04	0.09	0.11	3.00	0.27	0.57
<i>Tridens muticus</i>				0.07			0.32				
<i>Trisetum interruptum</i>					0.02		0 ⁵				
<i>Vulpia octoflora</i>	0.07		0.19	0.71	1.30	0.24	1.01	0.18	0.42	0.17	0.46
Total % Cover by Community	0.52	15.25	10.54	13.94	6.47	0.40	3.06	1.08	5.49	0.45	1.32
Species Richness by Community	8	2	3	13	11	6	11	9	10	3	7

¹Percent cover data based on plot data from the study of Morrison and others (2003).

²Natural community codes are as follows: CB = Creosotebush-Bursage Desert Scrub; DG = Desert Grassland; MW = Mesquite Woodland; MU = Mountain Upland; MXS = Mountain Xeroriparian Scrub; PVMCB = Paloverde-Mixed Cacti-Mixed Scrub on Bajadas; PVMCRS = Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes; RO = Rock Outcrop; S: Springs (outside the SDNM boundary on the BMGR); BCF: Braided Channel Floodplain; VXS: Valley Xeroriparian Scrub.

³Referred to as *Aristida parishii* in Morrison and others (2003). We follow nomenclature supported by the Integrated Taxonomic Information System (ITIS 2002).

⁴Referred to as *Aristida purpurea* in Morrison and others (2003). We follow nomenclature supported by the Integrated Taxonomic Information System (ITIS 2002).

⁵Zero cover values indicate that the taxa was present in one or more sample plots, but mean cover was trace.

grass species can change substantially over time and is highly dependent on land-use history and recent weather patterns. The variation in landforms, geology, soils, and timing and amount of rainfall likely provides niche diversity and may explain some of the grass diversity present on portions of the SDNM.

Different assemblages of grass species are represented in all eleven natural communities on the SDNM (Morrison and others 2003; Table C.8). The distribution of native grasses within each natural community is a result of interacting abiotic and biotic factors. Table C.8 reveals some patterns in relative abundance of some native grasses on the monument and their affinity with particular natural communities. Littleseed muhly (*Muhlenbergia microsperma*) had a relatively high mean percent cover within the Mesquite Woodland natural community, whereas bush muhly (*Muhlenbergia porteri*) had relatively high mean percent cover within the Mountain Uplands. In contrast, the annual grasses Bigelow bluegrass (*Poa bigelovii*) and sixweeks fescue (*Vulpia octoflora*) had relatively low mean percent cover (except in Mountain Xeroriparian Scrub) but each occurred in all natural communities except the Desert Grassland. Bush muhly and tobosa grass had the widest ecological amplitude among the perennial grasses, each occurring in eight different natural communities. The grass composition of the Desert Grassland natural community was dominated by tobosa grass. Tobosa grass also had relatively high mean percent cover in the Mountain Upland natural community but otherwise occurred at much lower percent cover values. Extensive grass cover in the Mesquite Woodland may have been due to suitable microhabitats under tree canopies (Tiedemann and Klemmedson 1973). The absence of big galleta (*Pleuraphis rigida*) from the Braided Channel Floodplain and Valley Xeroriparian Scrub natural communities is perhaps noteworthy.

Portions of the Sand Tank Mountains have an abundance of annual and perennial grasses that is significant when compared to other Sonoran desertscrub communities in Arizona (Turner and others 2000). An outstanding feature noted by Turner and others (2000) was the prominence of grasses, including six-weeks grama (*Bouteloua barbata*), curly mesquite (*Hilaria belangeri*), bush muhly, and tobosa grass in the Paloverde-Mixed Cacti-Mixed Scrub communities of the Sand Tank Mountains.

In addition to Table C.8, Figures C.4 and C.5 depict taxonomic richness and cover class information based on the plot data collected by Morrison and others (2003) overlaid on the natural community map. These figures provide some indication of the spatial distribution of grass taxonomic richness and abundance on the SDNM and adjoining portions of the BMGR. Snetsinger and Morrison (2004) used the plot cover data, along with field reconnaissance and abiotic information, to develop a preliminary predictive model of native grass abundance on the SDNM. This model can be used to help guide future investigations of native grass diversity on the SDNM and adjoining portions of the BMGR.

Structure.—The native grass group includes both annuals and perennials. The perennial grasses are suffrutescent, caespitose, or sod-forming. Although the occurrence of most of the grasses can be described as patchy, tobosa will form almost monospecific stands and bush muhly will tend to aggregate at the base of woody shrubs and trees. Under grazing pressure, perennial grasses, including bush muhly, Arizona

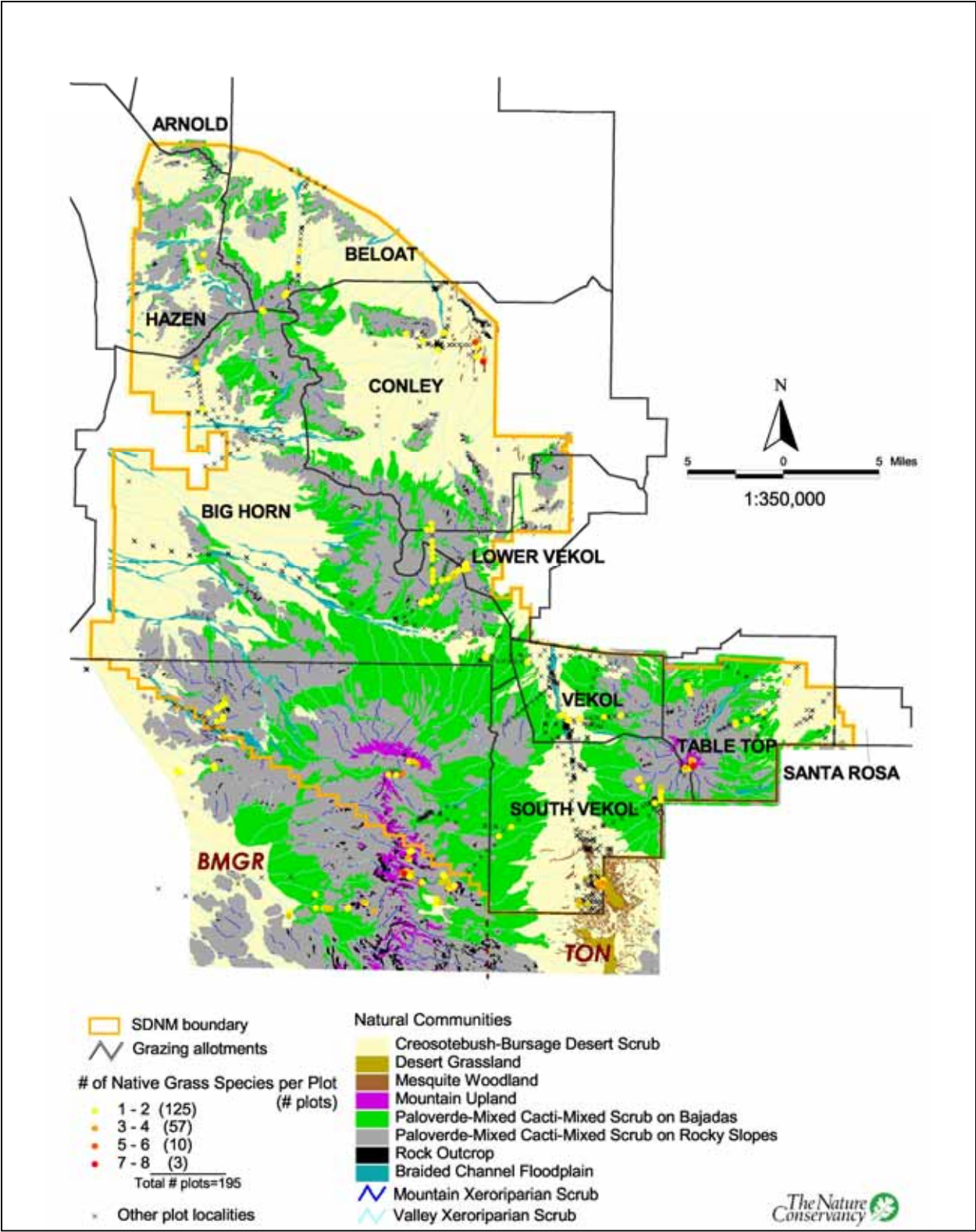


FIGURE C.4 Species Richness of Native Grasses on the Sonoran Desert National Monument and Adjoining Areas

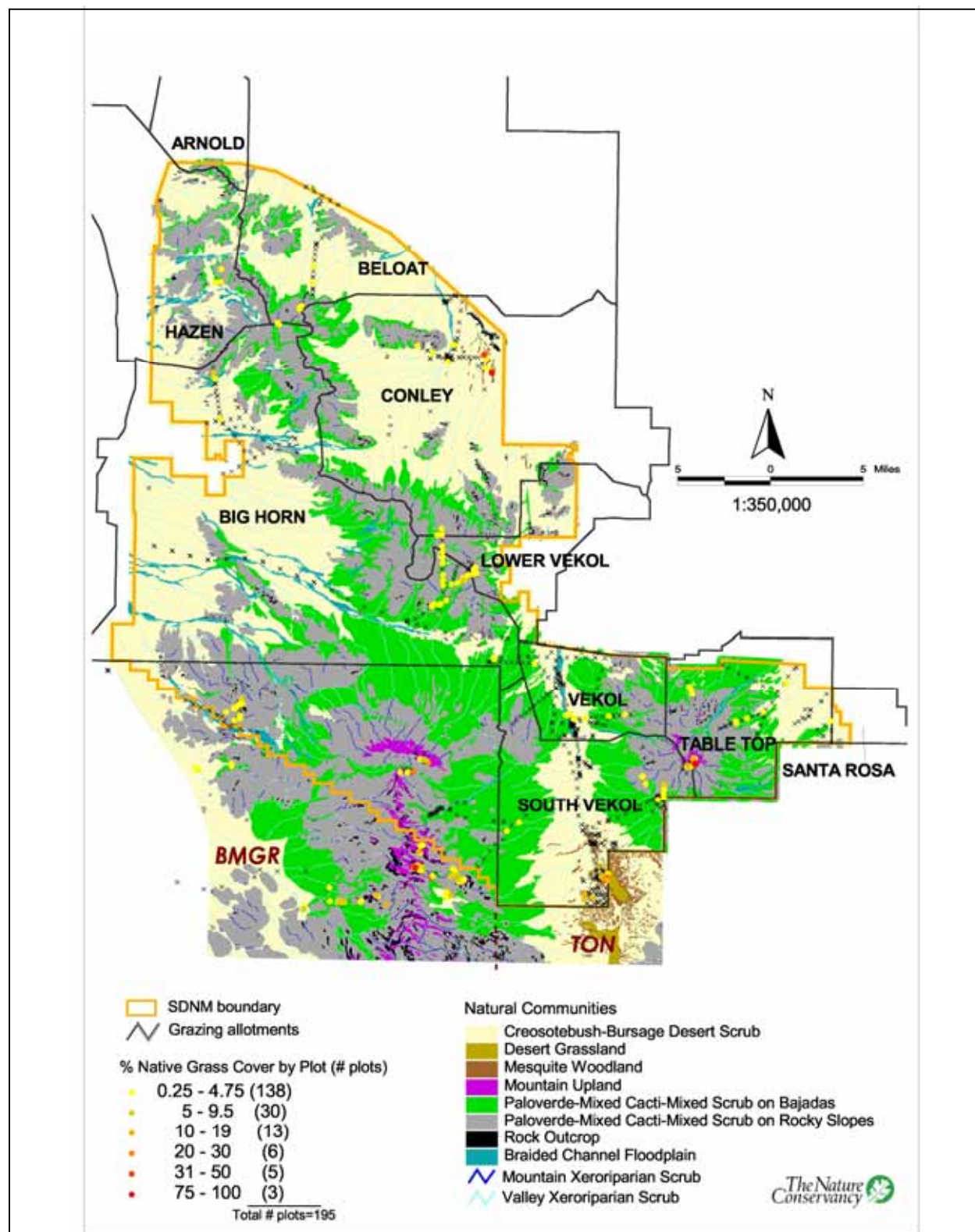


FIGURE C.5 Percent Cover of Native Grasses on the Sonoran Desert National Monument and Adjoining Areas. No plots contained 50 to 75% cover of native grasses. “x” = other plot localities.

cottontop (*Digitaria californica*), and bristlegrass (*Setaria* spp.), will aggregate under mesquite trees. These microsites provide suitable soil conditions for perennial grass growth, including increased nitrogen concentrations and higher soil moisture content (Tiedemann and Klemmedson 1973).

Function.—Grasses of the native grass group are typical intensive exploiters, having a shallow root network that enables them to extract a large proportion of their moisture from shallow soil horizons (Burgess 1995). This root structure plays a critical role in reducing soil erosion and enhancing infiltration. Desert annuals (including annual grasses as well as forbs) spend most of their lives as seeds and only during favorable precipitation regimes do they germinate and become conspicuous. Many of the desert annuals compete for limited nutrients and are sensitive to invasions by opportunistic non-native annuals (Inouye 1980, Pake and Venable 1995, Pake and Venable 1996). Desert annuals are a primary food source for ants and rodents and influence the population dynamics and species composition of these consumers (Venable and Pake 1999). Many of the species in the native grass group provide forage to other conservation elements such as desert tortoise and desert bighorn sheep.

Landscape context.—Native grass seed dispersal mechanisms are specific to each species. Some species use birds as carriers to accomplish long-distance dispersal, others have windborne seeds, and some have seeds that are dispersed shorter distances by rodents or insects. Habitat fragmentation, especially that caused by roads, may serve as corridors for introduction and movement of non-native invasive species, which can outcompete native grasses and thereby impact native grass abundance and distribution (Gelbard and Belnap 2003).

Status, Threats, and Management

Distribution.—None of the taxa considered to be part of the native grass group are necessarily rare when considered as individual taxa. A number of species have mostly Southwest distributions such as tanglehead (*Heteropogon contortus*), big galleta, bush muly, curly mesquite, tobosa grass, and Arizona cottontop, whereas a few, such as sideoats gramma (*Bouteloua curtipendula*) and sand dropseed (*Sporobolus cryptandrus*) sixweeks fescue, and little barley (*Hordeum pusillum*), are widely distributed outside the Southwest.

The current distribution of native grasses on the SDNM likely reflects both land-use history and abiotic conditions, such as elevation, soils, and climate. It is beyond the scope of this report to determine the specific causes of the current distribution pattern of native grasses on the SDNM; however, Snetsinger and Morrison (2004) found that elevation, aspect (as expressed by northness), and a Landsat TM 7 tasseled cap image band that corresponded to canopy and soil moisture best predicted high native grass abundance on the SDNM and adjoining portions of the BMGR. Abundance does not necessarily equate with distribution, but it does at least indicate the likelihood whether various components of the native grass group may be found in a particular area. The predictive model of Snetsinger and Morrison (2004) only applies to the Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes and Mountain Uplands natural communities as plot samples collected by Morrison and others (2003) indicated these two communities contained most of the occurrences of high native grass abundance that were amenable to modeling.

Conservation status.—The SDNM has some of the best remaining examples of native grass assemblages in southern Arizona (S. Rutman, pers. comm.). The extent of native grasses throughout the Sonoran Desert has been declining over the last century in part because of inappropriate grazing management practices, unfavorable climatic conditions, land-use change, and competition by non-native invasive plants. These factors continue to threaten to reduce native grass abundance and diversity throughout much of the Sonoran Desert (S. Rutman, R. Felger, and P. Morrison, pers. comm.). The predictive model developed by Snetsinger and Morrison (2004) provides baseline information for identifying where the best examples of the native grass group may occur within the higher elevation communities of the SDNM

and adjoining portions of the BMGR. Other than climate change, these areas also likely have the least exposure to stresses that threaten their long-term persistence. Much of the Sand Tank Mountains area has been free from mining, livestock grazing, and extensive vehicular traffic for the past 60 years or so.

Stresses and sources of stress.—Table C.9 identifies potential stresses and sources of stress to the native grass group. Inappropriate livestock grazing management (both historic and current) reportedly is the single largest activity that has impacted the abundance of native grasses in the Sonoran Desert (Turner and Brown 1994). Despite the apparent certainty of the preceding observation, the actual literature on livestock grazing-native grass interactions is relatively sparse. Hall and others (2005) recently reviewed the literature on livestock grazing impacts in the Sonoran Desert. They found examples that high stocking rates associated with overgrazing adversely impacted native perennial grasses, but the literature did not provide any indication of stocking rates that had been tested for their ability to maintain native perennial grasses in the Sonoran Desert. McAuliffe (1998) hypothesized that suffrutescent grasses (that is, grasses that store carbohydrates in dormant aboveground biomass during drought and winter), such as tobosa grass, big galleta, and bush muly, are especially susceptible to adverse impacts from grazing during the dormant season because grazing during this time reduces their capacity for future regrowth and survivability during drought.

TABLE C.9 Native Grass Group: Stresses and Sources of Stress

Stress	Source of Stress	Geographic Scope of Potential Impacts	Comments or Source of Information
Habitat degradation/ direct mortality	Inappropriate livestock grazing management practices (historic and current)	Regional and SDNM	McAuliffe (1998), Morrison and others (2003), Hall and others (2005). The latter reference provides a review of the literature regarding livestock impacts to native perennial grasses
	Off-road/off-trail use	Regional and SDNM	S. Rutman and R. Felger (pers. comm.).
	Fire	Regional and SDNM	Brooks (1999).
Resource competition	Non-native invasive plant species	Regional and SDNM	Morrison and others (2003), Pake and Venable (1995).

Livestock and associated management practices also may have indirect effects on native grass abundance by assisting in the spread of non-native invasive plants, especially those that are capable of carrying and increasing under fire (Hall and others 2005). Although not typically a direct impact, activities such as off-road and off-trail usage also provide a means for spreading non-native invasive plants, which can in turn have adverse impacts on native plant abundance and diversity.

Some non-native invasive species, such as Schismus (*Schismus* spp.) and filaree (*Erodium cicutarium*), are common and widespread on the SDNM and may have already spread to their fullest extent (Morrison and others 2003). These invasive plants may limit the potential expression of the native grass group in some areas by competing for scarce resources (Pake and Venable 1995). Even areas where the native grass group is currently best represented and seems secure on the SDNM may be threatened in the future by non-native invasive plant species that are not yet widespread on the monument, such as red brome (*Bromus rubens*), buffelgrass (*Pennisetum ciliare*), and Sahara mustard (*Brassica tournefortii*) (Morrison and others 2003). Schismus, filaree, and red brome can be a threat to native grasses through not only resource competition. These species also have been linked to a positive grass/fire cycle in the Mojave Desert whereby these non-native plants (1) reach densities and cover amounts that provide sufficient fuel

and connectivity to carry fire and (2) their abundance increases as a result of fire (Brooks 1999). These and other non-native invasive species that are currently present in localized areas on the SDNM also may have the potential to carry fire in Sonoran Desert plant communities. As a result, their presence could have significant adverse consequences for the persistence of the native grass group.

Mapping and Information Needs

Mapping comments.—In addition to the Desert Grassland community mapped by Morrison and others (2003), other areas of high native grass abundance need to be identified spatially. Sentsinger and Morrison (2004) used the plot data of Morrison and others (2003) as input to a model that predicted areas of high abundance of native grasses within the Mountain Upland and Paloverde-Mixed acti-Mixed Scrub natural communities. Figures C.4 and C.5 also used the Morrison and others (2003) plot data to depict taxonomic richness and percent cover class values overlayed on the natural community map of Morrison and others (2003).

Information needs.—Additional information is needed to validate the species that are included within the native grass group and to determine the relative significance of the species richness and abundance patterns found on the SDNM and adjoining portions of the BMGR as compared with other locales in the Sonoran Desert. In addition, additional characterization of abiotic and land-use factors is necessary to understand why certain areas maintain high richness and abundance of native grasses and others do not and if it is possible to restore native grass diversity to areas that previously may expressed such diversity. Climate change models might be useful to predict changes in native grass abundance and distribution and to identify areas where native grass conservation is most likely to be successful over the long-term on the SDNM and BMGR.

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C.2 AMPHIBIANS: EPHEMERAL WATER-BREEDING AMPHIBIAN GUILD

Instead of addressing individual species, amphibians are captured as a guild whose members share a mutual need for ephemeral waters to complete their life cycles.

Overview

Species included in the ephemeral water-breeding amphibian guild.—This guild is composed of seven native frogs (anurans) that are documented to occur on the Sonoran Desert National Monument (SDNM): the Sonoran Desert toad (*Bufo alvarius*), red-spotted toad (*Bufo punctatus*), Sonoran green toad (*Bufo retiformis*), Great Plains toad (*Bufo cognatus*), western narrow-mouthed toad (*Gastrophryne olivacea*), lowland burrowing treefrog (*Pternohyla fodiens*), and Couch's spadefoot (*Scaphiopus couchii*).

Species excluded from the ephemeral water-breeding amphibian guild.—In addition to the seven species named above, three other anurans have been documented to occur on the SDNM but were excluded from the guild: Woodhouse's toad (*Bufo woodhousii*), the green toad (*Bufo debilis*), and the Rio Grand leopard frog (*Rana berlandieri*) (Turner and others 2000).

Woodhouse's toad is common and widespread west of the Mississippi River. This species is most commonly associated with perennial streams or agriculture near streams (P. Rosen, pers. comm.). Woodhouse's toad was excluded from the ephemeral water-breeding amphibian guild because it is a widespread, common species that is tolerant of various kinds of habitat disturbance and has no evidence of significant regional declines (NatureServe 2003).

The green toad is typically found in grasslands in southeastern Arizona. One record exists of a green toad collected from the Vekol Valley on the SDNM, which represents a significant range extension for the species and the first verified coexistence of the green toad with the related Sonoran green toad (Jones and others 1983). The specimen has since been confirmed to indeed be that of the green toad (Sullivan and others 1996); however, no recent reports of this species in Vekol Valley exist. As a result, the green toad is currently excluded from the guild until its current presence on the SDNM can be confirmed.

The Rio Grande leopard frog is native to New Mexico, Texas, and south through Mexico (Stebbins 1985). It was first documented as an introduced species in Arizona in 1981 on the Colorado River and has since spread throughout Arizona's rivers, wetlands, cattle tanks, and agricultural areas, where it is often found with native Woodhouse's toad (Rorabaugh and Sredl 2002). The Rio Grande leopard frog is a large predator, competitor, and potential disease vector and is considered a threat to native ranid frogs and garter snakes (Rorabaugh and Sredl 2002).

Taxonomy and nomenclature.—The common name of *Bufo alvarius* is the Sonoran Desert toad or the Colorado River toad. *Gastrophryne olivacea* is commonly called either the western or Great Plains narrow-mouthed (or narrowmouth) toad. The common name of *Pternohyla fodiens* is the lowland burrowing treefrog or the northern casque-headed frog.

The taxonomy of *Gastrophryne olivacea* is not well resolved (reviewed by Nelson 1972). Lowe (1964) reported two species of *Gastrophryne* in Arizona, *G. carolinensis*, found in few localities in oak woodland in the Pajarito and Patagonia mountains, and *G. olivacea* in the Sonoran Desert. Today only one species is recognized in Arizona: *G. olivacea*. Some authors, however, recognize subspecies of *Gastrophryne olivacea*, including the Plains narrow-mouthed toad (*Gastrophryne olivacea olivacea*) in the central and eastern portion of its distribution and the Sinaloan narrow-mouthed toad (*G. o. mazatlensis*) in Sinaloa, Sonora, and southern Arizona (Stebbins 1985). Currently, the Society for the

Study of Amphibians and Reptiles recognizes only the full species but suggests that cryptic species are possible given the extensive distribution of the species (Crother 2000).

Rationale for selection as a conservation element.—*Specialized species.* The seven amphibians in the ephemeral water-breeding guild were selected as conservation elements because they are specialized species that rely on scarce surface waters to reproduce and complete the larval stage of development. The coarse filter alone does not capture the guild because each species uses not only aquatic habitats but also adjacent natural communities during other parts of its life cycle. Each of the species in the guild has certain terrestrial and aquatic habitat preferences. There are potential differences in the types of surface water that each species may use on the SDNM (natural or modified tinajas, temporary pools, or artificial water developments) and some species in the guild may have a competitive advantage relative to others in natural versus human-altered water sources. These species are best managed as a guild because although they have some similar habitat needs, a management decision based on the needs of one species may not meet the needs of the others or could have potentially adverse results for other species in the guild. Furthermore, amphibians are declining globally and the status of desert amphibians is not well known. Although the status of most of the species in the guild is considered globally secure, some are considered sensitive species in Arizona or have regional threats in the Sonoran Desert (discussed in the **Conservation status** section). The Vekol Valley on the SDNM is also notable as occurring near the northern edge of the range of three amphibians—the Sonoran green toad, lowland burrowing treefrog, and the western narrow-mouthed toad—that have a limited distribution in the United States and also are known to co-occur elsewhere only on the Tohono O’odham Nation (Turner and others 2000).

Specific habitat needs on the SDNM.—The habitat needs on the SDNM differ for each species in the ephemeral water-breeding amphibian guild. Permanent and/or ephemeral water sources are important for reproduction and the larval (tadpole) lifestage. Rodent burrows or those dug by the toads themselves are important shelter sites used by the amphibians during periods of inactivity. Desert amphibians typically migrate between aquatic breeding habitat and terrestrial habitats, but little is known about their terrestrial habitat needs, including needs to maintain connectivity and prevent fragmentation (see also the *Landscape context* section). Predicted associations with natural communities on the SDNM, as described by Morrison and others (2003), are suggested for each species below.

The Vekol Valley deserves special mention for its importance to the ephemeral water-breeding amphibian guild. This area has a combination of characteristics that make it the most important place on the SDNM for at least three of the species in the guild—the Sonoran green toad, western narrow-mouthed toad, and the lowland burrowing treefrog—that are at the northern edge of their distribution in the Vekol Valley and are not likely to be found elsewhere in great numbers on the SDNM. The Vekol Valley may be a disproportionately important area for these and other species in the ephemeral water-breeding amphibian guild on the SDNM for several reasons: (1) its clay soils are suitable for winter aestivation and hold moisture during summer rains, (2) it includes areas of mesquite woodland and desert grassland natural communities, which are the preferred habitat of the western narrow-mouthed toad and lowland burrowing treefrog, and (3) water availability has been enhanced by the construction of spreader dikes, which may have benefited some species in the guild.

Only three species in the guild are tracked by the Heritage Data Management System (HDMS): the Sonoran green toad, western narrow-mouthed toad, and lowland burrowing treefrog. Occurrence data for these species on the SDNM and within ten miles of the monument boundary are shown in Figure C.6. The occurrence data in Figure C.6 include actual and “fuzzed” locations, which are displayed at a coarse scale that does not reveal specific sites. Additional information on the habitat associations of each species is provided below, as well as in the **Habitat associations** section.

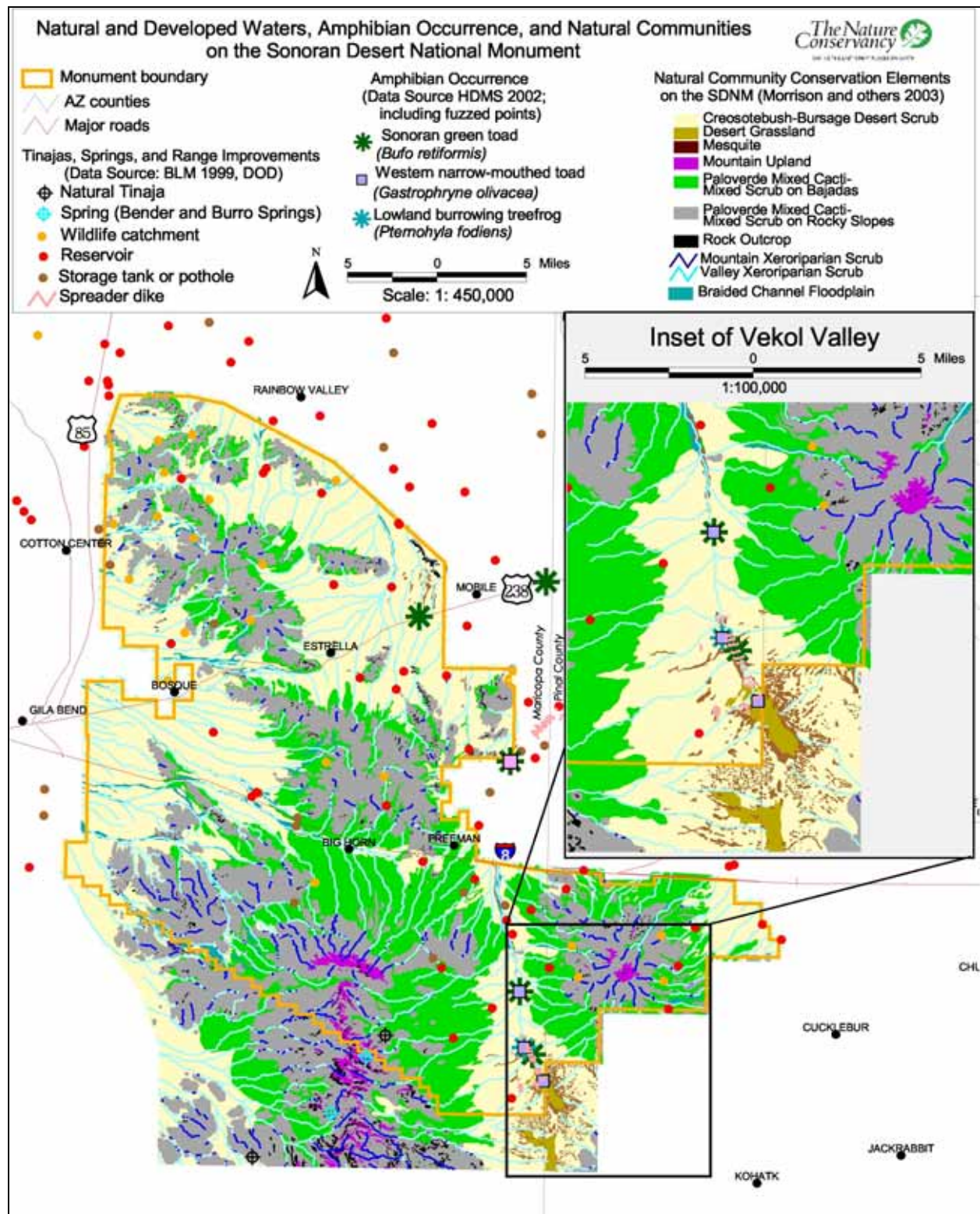


FIGURE C.6 Occurrence and Potential Habitat Data for Members of the Ephemeral Water-Breeding Guild

- **Sonoran Desert toad.** This species is most likely to be associated with permanent or long duration water sources in valley bottoms on the SDNM. It also uses adjoining natural communities and will move relatively long distances (several kilometers) from water sources. The Sonoran Desert toad uses rodent burrows as shelters during the day and in winter. This species has likely benefited on the monument from artificial water development. On Organ Pipe Cactus National Monument (ORPI), the Sonoran Desert toad was the most widely distributed anuran (compared to the red-spotted toad, Great Plains toad, and the Sonoran green toad), found in mountain canyons, on bajadas, and valley-bottom floodplains (Rosen and Lowe 1996). On the SDNM, the Sonoran Desert toad could be found in any of the natural communities described by Morrison and others (2003), but is least likely to be found in the steep, sparsely vegetated Rock Outcrop natural community.
- **Red-spotted toad.** On the SDNM the red-spotted toad is likely to be most closely associated with temporary pools and natural tinajas in bedrock bajadas and mountains (P. Rosen, pers. comm.). Where this species occurs away from canyons and rock slopes, it is more dependent upon summer rains for breeding and may be found in loamy (not clay) soils in the creosotebush flats (E. Enderson, pers. comm.). Red-spotted toads are more restricted to natural (unimproved) desert water sources than is the Sonoran Desert toad. Rocky areas may be important habitat components as red-spotted toads hide in rock crevices or under rocks when inactive; however, they will also take shelter underground (NatureServe 2003). This species could be associated with most of the natural communities described by Morrison and others (2003), but is least likely to be found in the Desert Grassland, Mesquite Woodland, or Creosotebush-Bursage Desert Scrub natural communities in the Vekol Valley where the soils are probably too heavy and clayey for this species. Springs and tinajas in the Sand Tank Mountains on the SDNM and Barry M. Goldwater Range (BMGR) are breeding sites for this species.
- **Sonoran green toad.** The Sonoran green toad has a restricted distribution in the United States, known from the Tohono O'odham Nation north to near Mobile. Hulse (1978) describes the Sonoran green toad habitat as open, rolling mesquite-grassland between 152 to 457 meters (500 to 1,500 feet) elevation. In the vicinity of the SDNM, the Sonoran green toad is known from the Mesquite Woodland natural community in the upper Vekol Valley and in Creosotebush-Bursage Desert Scrub in the Mobile Valley (Figure C.6). It breeds in temporary pools in Vekol Valley (Turner and others 2000), as well as in the pools behind spreader dikes located in the valley. The Sonoran green toad is not found in abundance in permanent waters or stock tanks (E. Enderson, pers. comm.) and its breeding cycle is strictly tied to summer monsoon rains (Sullivan and others 1996). Although the Sonoran green toad is usually found in association with other anurans (Sullivan and others 1996), it seems to be less abundant in permanent pools where the Great Plains toad and Sonoran Desert toad are at high numbers. This may be because its calls are drowned out by the much louder calls of the Great Plains toad (E. Enderson, pers. comm.). The Sonoran green toad migrates between breeding and non-breeding habitats (NatureServe 2003), but the habitat connectivity needs for this species are not known.
- **Great Plains toad.** The Great Plains toad is a generalist species found in a variety of arid terrestrial habitats including mesquite grasslands, desert riparian associations, and desert scrub at elevations up to 1,800 meters (5,906 feet) (Krupa 1990). In relation to natural communities on the SDNM, the Great Plains toad may be most closely associated with the Mesquite Woodland, Desert Grassland, Valley Xeroriparian Scrub, Braided Channel Floodplain, Creosotebush-Bursage Desert Scrub, and Paloverde-Mixed Cacti-Mixed Scrub on Bajadas natural communities. The Great Plains toad breeds in clear waters of temporary pools, shallow ponds, reservoirs (NatureServe 2003), as well as irrigation ditches and flooded fields (Stebbins 1985). This species may initiate breeding prior to the onset of the summer monsoons (E. Enderson, pers. comm.) and requires water sources that do not dry quickly

as metamorphosis takes longer in this species (18 to 49 days in Oklahoma) than in some of the other desert anurans (Bragg 1940, NatureServe 2003). As a result, the Great Plains toad has likely benefited from water developments on the SDNM and, along with the Sonoran Desert toad, is the most abundant toad breeding in pooled water behind spreader dikes in the Vekol Valley (E. Enderson, pers. comm.). This species migrates up to several hundred meters between terrestrial habitat and breeding pools (NatureServe 2003).

- **Western narrow-mouthed toad.** The western narrow-mouthed toad is known primarily from the Mesquite Woodland and Desert Grassland natural communities on the SDNM in the Vekol Valley (Jones and others 1983, E. Enderson, pers. comm.; Figure C.6). It is also associated with Creosotebush-Bursage Desert Scrub in the Vekol Valley, including at the Lower Vekol Wash (Figure C.6). The most numerous and dense population of western narrow-mouthed toads reported in Arizona was on the SDNM in 2002, from the “hog house” south to the mesquite bosque in the Vekol Valley (E. Enderson, pers. comm.). The series of spreader dikes constructed in the Vekol Valley have contributed to increased flooding and water impoundments and may have contributed to the high abundance of this species in the upper Vekol Valley. The occurrence of the western narrow-mouthed toad in the lower Vekol Valley is also associated with the presence of spreader dikes (Figure C.6). Abundant detritus found in the Mesquite Woodland of the Vekol Valley provide cover to adults during the breeding season (E. Enderson, pers. comm.), and the deep clay soils that retain water in the Vekol Valley are likely important for aestivation (Jones and others 1983). The Arizona Game and Fish Department (AGFD 2003a) describes this species as “more terrestrial than aquatic in habits,” found near streams, seeps, and ephemeral pools under large flat rocks or dead wood, and in moist crevices or burrows, often with rodents, lizards, and tarantulas (Nelson 1972, AGFD 2003a). Site fidelity may be high for this species (Sredl and Field In Press).
- **Lowland burrowing treefrog.** The lowland burrowing treefrog was only recently discovered in August 2000 on the SDNM in the Vekol Valley (Enderson and Bezy 2000). This species is known primarily from tropical deciduous forest and thornscrub in Mexico. The Vekol Valley represents the northernmost portion of this species range and the only area on the SDNM from which it is known. The lowland burrowing treefrog is closely associated with the Mesquite Woodland natural community in Arizona, including on the SDNM (Figure C.6). Lowland burrowing treefrogs climb trees as high as 5 feet (AGFD 2003b) and have been found in mesquite in the Vekol Valley (E. Enderson, pers. comm.). The lowland burrowing treefrog also may be associated with Valley Xeroriparian Scrub natural community in the Vekol Valley, particularly if mesquite (*Prosopis* spp.) is an associate.
- **Couch’s spadefoot.** Couch’s spadefoot is known from the Vekol Valley, Table Top, and Sand Tank Mountains on the SDNM (Turner and others 2000; E. Enderson, pers. comm.). During periods of inactivity, Couch’s spadefoot uses burial sites located in the soil beneath dense vegetation in valley bottoms. This species may be found associated with temporary pools or modified waters in valley bottoms throughout the SDNM where it is most likely associated with Creosotebush-Bursage Desert Scrub, Paloverde-Mixed Cacti-Mixed Scrub on Bajadas, Desert Grassland, and Mesquite Woodland natural communities.

Ecological Characteristics

For each of the following topics, general information that is relevant to all species is provided first and more detailed information specific to each species follows, when available. Some of the information below is taken from Hall and others (2001).

Abundance.—The species in the ephemeral water-breeding amphibian guild are dependent, to differing degrees, on summer rainfall, and their relative abundance on the SDNM is expected to be greater than in the more winter-rain dominated desert regions to the west. The relative abundance of each species in the guild also may depend on the characteristics of the habitat, including the type of water source (tinaja, spring, tank, reservoir, or other source) and if the source is natural or modified, the ecological attributes of the surrounding habitat, and the composition of the other amphibian species present at the water source. Interspecific interactions and competitive displacement between species in the guild can potentially alter the population structure of these species. Couch's spadefoot has a brief larval stage and may outcompete other species at ephemeral water sources, but may be subject to increased predation rates at permanent pools (Woodward 1983). In contrast, the Great Plains toad and Sonoran Desert toads have longer larval development times, so they do well in longer-lived water sources and have likely benefited from artificial water developments in the desert (P. Rosen, pers. comm.).

Habitat associations.—Habitat associations are described below by species.

- **Sonoran Desert toad.** The Sonoran Desert toad is found in a wide variety of habitats from mesquite-creosotebush lowlands to bajadas, oak-sycamore-walnut association in mountain canyons, and tropical deciduous thornscrub in Mexico. On Organ Pipe Cactus National Monument it is the most widespread anuran and its occurrence has been documented in mountain canyons, on bajadas, and on valley bottom floodplains (Rosen and Lowe 1996). It is found near permanent water associated with springs, reservoirs, and streams, but more typically it is seen at ephemeral, intermittent, or semi-permanent waters (P. Rosen, pers. comm.) in temporary, or more commonly, permanent water sources (Fouquette 1970). The Sonoran Desert toad can venture several miles from water (Stebbins 1985, Phillips and Wentworth Comus 2000). It breeds in most any water source, including stock ponds, tinajas, sewage overflows, and other human-influenced water sources (P. Rosen, pers. comm.). For successful reproduction, however, this species requires water sources that persist for longer durations than some other desert anurans. The Sonoran Desert toad is found primarily in the Lower Colorado River subdivision of the Sonoran Desert, but they also can occur in the Arizona Uplands subdivision. Within these subdivisions, they range from sea level to approximately 1,610 meters (5,300 feet) above sea level (Fouquette 1970). It may also be associated with grasslands and oak woodlands (Lowe 1964). The Sonoran Desert toad commonly takes refuge in rodent burrows, where it also hibernates (Lowe 1964).
- **Red-spotted toad.** The red-spotted toad is widely distributed in the western United States and Mexico and is found in a variety of habitats and elevations. Red-spotted toads are found in rocky canyons and arroyos in deserts, grasslands, and thornscrub, and montane woodlands up to about 1,980 meters (6,500 feet) (NatureServe 2003, P. Rosen, pers. comm.). This species breeds in springs and temporary pools of seasonal streams and seeks shelter in rocky areas alongside these water sources (Stebbins 1985).
- **Sonoran green toad.** Across its range in the United States and Mexico, the Sonoran Green toad is most common in open, rolling mesquite grasslands between 152 to 457 meters (500 to 1,500 feet) elevation (Hulse 1978). In southern Arizona the Sonoran green toad occurs in a variety of habitats, including Creosotebush-Bursage Desert Scrub and Paloverde-Mixed Cacti-Mixed Scrub natural communities and desert grasslands over 914 meters (3,000 feet) elevation (Sullivan and others 1996). The Sonoran green toad breeds in a variety of ephemeral and permanent water sources including cattle tanks and roadside pools along washes (Sullivan and others 1996). Aquatic habitats used for breeding are bordered by grass and scattered shrubs (Stebbins 1985).
- **Great Plains toad.** The Great Plains toad has a wide distribution in the United States, occupying grasslands and plains in the eastern and central portion of its range (Bragg 1940) and deserts,

semidesert shrublands, stream valleys, and agricultural areas in the arid western portion of its range (NatureServe 2003). It breeds in shallow waters, temporary pools, ponds, and reservoirs (NatureServe 2003). In Oklahoma the Great Plains toad was associated with clear water especially in flooded fields and buffalo wallows, but rarely in tanks, ditches, or permanent ponds (Bragg and Smith 1943). The Great Plains toad burrows underground and remains there during cold winter months and periods of summer drought (NatureServe 2003).

- **Western narrow-mouthed toad.** This species is found in a wide variety of habitats in Arizona, from creosote flats, semi-desert grasslands, oak-woodland communities greater than 1,200 meters (3,937 feet) above sea level (Sullivan and others 1996). In other parts of its range, the western-narrow-mouthed toad occurs in prairies, deciduous forests, and open woodlands (Sredl and Field In Press). Western narrow-mouthed toads are nocturnal secretive species that require shelter and moisture, finding it in varied places usually near water, including in rodent or spider burrows, under rocks, in mud cracks, under plant debris or logs, or under tree bark or roots (Sredl and Field In Press).
- **Lowland burrowing treefrog.** This species is found in temporary waters in washes and rain-formed pools (Sullivan and others 1996) from sea level to 1,500 meters elevation (4,921 feet) in the southern portion of its range in Mexico (Trueb 1969). A large population has been regularly observed on the Tohono O'odham Nation near Hickiwan and the San Simon Wash (Sullivan and others 1996). The lowland burrowing treefrog is found in open mesquite grassland habitat, associated with large washes with well-formed mesquite bosques (AGFD 2003b). This species breeds in temporary pools in washes, in depressions, along roads, or in earthen cattle tanks (Sredl In Press).
- **Couch's spadefoot.** Couch's spadefoot is seasonally found in arid conditions in areas of sandy soils, creosotebush, mesquite, and desert grasslands and prairies. Throughout its range it is associated with shortgrass plains, mesquite savanna, creosotebush scrub, cultivated areas, and thornscrub (NatureServe 2003). Couch's spadefoot burrow underground or occupy rodent burrows when they are inactive (NatureServe 2003). Its associated (more successful) breeding areas are in ephemeral waters such as playas, but individuals may be found breeding in any desert water source including those modified by humans (tanks, charcos, sewage ponds) (P. Rosen, pers. comm.; Rosen and Lowe 1996). The species breeding behavior is more closely tied to major rainfall events and ephemeral water sources than the Sonoran Desert toad.

Food and water requirements.—Generally, the species in the ephemeral water-breeding amphibian guild are herbivores as larvae and prey on invertebrates as adults. Larvae eat algae, suspended matter, plant tissue, and organic debris. Adult amphibians eat small terrestrial insects and spiders. Exceptions to these food preferences or more specific information is provided below for some species in the guild.

- **Sonoran Desert toad.** The principal food source of adult Sonoran Desert toad is beetles (Phillips and Wentworth Comus 2000), but adults are relatively large and can eat mice, other amphibians, including Couch's spadefoot and Great Plains toad, small lizards, and a variety of invertebrates including tarantulas and snails (P. Rosen, pers. comm., Fouquette 1970). It is not known if they are predatory on red-spotted toads (P. Rosen, pers. comm.).
- **Western narrow-mouthed toad.** Adult western narrow-mouthed toads are ant specialists (Nelson 1972).

General life history.—The species in the ephemeral water-breeding amphibian guild spend long periods of their adult lives inactive underground during periods of drought and during the winter. Emergence from underground shelters is initiated in most species by the summer monsoon rains, although some species, including the Sonoran Desert toad and the Great Plains toad, become active earlier in warm,

moist spring weather. Desert anurans congregate en masse at water sources where females lay eggs which are externally fertilized by males. Each species has different development times from egg to the end of the tadpole stage, which affects reproductive success at ephemeral waters with different durations. Juvenile toads disperse from aquatic breeding habitat but little is known about dispersal distances or terrestrial habitat associations for most species. Additional information is provided below on the life history of each species in the guild.

- **Sonoran Desert toad.** Sonoran Desert toads spend the winter underground in kangaroo rat burrows and may even be found in a hole still occupied by a kangaroo rat (D. Suhre, pers. comm.). They typically emerge from their shallow burrows earlier than other anurans (before the summer rains) (P. Rosen, pers. comm.) and seek waters in which to breed. Individuals are active mostly during the summer rainy season, from May to September. Because of water development and human activity in the desert, the species' breeding season is not necessarily tied directly to rainfall (Fouquette 1970, P. Rosen, pers. comm), though it is, as for all other Sonoran Desert anurans, a summer rainy-season breeder. Adults are nocturnal during the hot summer months. They have greater reproductive success if they get a head-start on breeding before the Mexican spadefoot (*Scaphiopus multiplicatus*), whose larvae are predatory and cannibalistic (D. Suhre, pers. comm.). (Mexican spadefoot are not present on the SDNM.) Adult Sonoran Desert toads travel between water sources at night using creosotebush areas, but inter-waterway routes are not well known. Individuals can live between 10 to 20 years and development from the larval stage to the adult takes six to 10 weeks (Phillips and Wentworth Comus 2000).
- **Red-spotted toad.** This species is nocturnal in the summer, but it may be active during the day in cooler weather. It breeds mainly after summer rains and its larvae metamorphose in six to eight weeks (Phillips and Wentworth Comus 2000). Breeding choruses may last a few weeks (NatureServe 2003).
- **Sonoran green toad.** Males typically call from beneath vegetation such as small shrubs or grasses one to five meters from the waters' edge. Mating amplexus is initiated on land, but females then carry the male to the water for oviposition (Sullivan and others 1996). Satellite males—those employing an alternative reproductive strategy of “sneaking” in which they do not vocalize, but rather remain near calling males and try to intercept females for mating—may be common in high density congregations (Sullivan and others 1996). Sonoran green toads dig burrows which are used during periods of inactivity (NatureServe 2003).
- **Great Plains toad.** The Great Plains toad breeds during warm rains in spring or summer. Although usually nocturnal, the Great Plains toad may be diurnal during wet and humid weather (NatureServe 2003). The Great Plains toad has a 28 to 45 day larval period (Bragg and Smith 1943) and reaches adult size and sexual maturity in two to four years depending on food availability (Bragg 1940). The Great Plains toad digs underground shelters which it uses during dry periods, and it may also seek shelter under rocks or in burrows (Bragg 1940).
- **Western narrow-mouthed toad.** This is a small species that is often difficult to detect in the field owing to its habit of ceasing its call when humans are nearby, so many details and observations on its life history are lacking. The western narrow-mouthed toad is an explosive breeder that has been observed calling and breeding one to four nights following a rainfall (Sullivan and others 1996). Males generally call from next to water or from emergent vegetation, and non-calling, satellite males have not been observed (Sullivan and others 1996). They have been found in large monotypic aggregations as well as with other species associates (Sullivan and others 1996). In Texas breeding occurs from mid-March to September (Sredl and Field In Press). Development from larval to adult

stage takes 28 to 50 days (Sredl and Field In Press). Little is known about aestivation in this species, but adults spend periods of inactivity underground and under rocks (Sredl and Field In Press).

- **Lowland burrowing treefrog.** The lowland burrowing treefrog is a secretive amphibian that is difficult to find when not in a chorus aggregation, and is a species that is rarely encountered on road-side surveys (Sullivan and others 1996). It is an explosive breeder that is dependent on the summer monsoons to initiate breeding, more so than other desert amphibians including the western narrow-mouthed toad or the Sonoran green toad (Sullivan and others 1996). Breeding generally occurs between June to September in temporary pools filled by summer rains (Sredl In Press). Male lowland burrowing treefrogs chorus in or near water, and they cease calling less than 36 hours after a rain (Sullivan and others 1996). Adults burrow into mud at the end of the monsoon and secrete a transparent epidermal cocoon, consisting of layers of skin and mucus, that prevents desiccation until the next rains (Ruibal and Hillman 1981). The lowland burrowing treefrog is the only hylid frog and the only North American anuran known to secrete a cocoon (Ruibal and Hillman 1981).
- **Couch's spadefoot.** These toads have extremely rapid metamorphosis, with eggs hatching within a day and larvae maturing into terrestrial juveniles in less than two weeks on average (Phillips and Wentworth Comus 2000). Juveniles and adults bury themselves using their "spade foot" into sandy soil to avoid heat and dessication, and they spend the dry season underground in deep burrows made by gophers, kangaroo rats, or themselves (Stebbins 1985). They are mostly active at night during summer rains in the Sonoran Desert. If insufficient rain occurs, adults apparently can remain underground for over a year (P. Rosen, pers. comm.). Their emergence is triggered by low frequency vibration from thunder and heavy rains (Phillips and Wentworth Comus 2000). Upon emergence, they undertake a frenzied breeding and feeding cycle that is adapted to the infrequent desert rains. The extremely rapid development of spadefoot larvae is presumably an adaptation to ephemeral waters in which aquatic predators generally are lacking.

Biotic interactions.—The duration of breeding water sources is a factor that influences some biotic interactions, including predation of amphibian larvae and interspecific larval competition between the ephemeral water-breeding amphibian guild species. A study in the Chihuahuan Desert in New Mexico found that permanent ponds have a significantly greater number (individuals and species) of terrestrial predators than temporary pools, and more individual aquatic predators per cubic meter (Woodward 1983). Moreover, through choice experiments this author found that aquatic predators of amphibian larvae (Belostomatids, Notonectids, Aeshnid species and Tiger salamander [*Ambystoma tigrinum*] larvae), consumed more larvae of temporary water-breeding amphibians (*Scaphiopus couchi*, *S. multiplicatus*, *S. bombifrons*, and *Bufo cognatus*) than permanent water-breeders (*Rana catesbeiana* and *R. pipiens*) (Woodward 1983). Woodward (1983) observed that temporary-pond larvae were almost continually in motion, whereas permanent-pond larvae were almost always stationary. Apparently, the behavior of permanent water-breeding amphibian larvae has been selected for escaping predation, whereas temporary water-breeding amphibian larvae are selected to move constantly to feed and metamorphose quickly to the adult stage before their temporary pools evaporate. As a result, ephemeral water-breeders are at a disadvantage in permanent water bodies and are easier targets for predators in comparison to permanent water-breeding amphibian larvae that remain immobile during the day (Woodward 1983).

Dayton and Fitzgerald (2001) conducted similar research at Big Bend National Park in Texas to try to understand factors that may limit co-occurrence of desert anurans, including Couch's spadefoot, western narrow-mouthed toad, red-spotted toad, and the Texas toad (*Bufo speciosus*). The amphibians studied had a significantly non-random pattern of occurrence such that they were mostly found in single species groups at breeding sites in ephemeral waters. The authors' results also provide support for Woodward's (1983) findings. At ephemeral sites Couch's spadefoot larvae outcompeted the other species, whereas the spadefoot larvae were subject to greater predation rates in longer duration water sources (Dayton and

Fitzgerald 2001). Predators of amphibian larvae in longer-lasting ephemeral pools include: water scavenger beetle larvae (Hydrophilidae), diving beetles and larvae (Dysticidae), giant waterbugs (Belostomatidae), back swimmers (Notonectidae), water scorpions (Nepidae), dragonfly larvae (Anisoptera), damselfly larvae (Zygoptera), black neck garter snakes (*Thamnophis cryptospsis*), and yellow mud turtles (*Kinosternon flavescens*) (Dayton and Fitzgerald 2001).

In some waters on the SDNM, numerous species of amphibians co-occur. All species in the ephemeral water-breeding amphibian guild, except for the red-spotted toad, have been found in pools in the Vekol Valley (E. Enderson, pers. comm.). The situation on the SDNM offers unique research opportunities that could provide clues into the competitive dynamics and factors that may limit or promote coexistence of these amphibians under different hydrological regimes, which are important considerations for conservation and management of the individual species.

Additional information on biotic interactions are provided below for some individual species.

- **Sonoran Desert toad.** Larval Sonoran Desert toads face competition (for food) with other larval anurans, including spadefoots, if they choose a breeding site in an ephemeral pool. In some areas with extreme resource competition and ephemeral waters, Sonoran Desert toad larvae and eggs fall victim to the predatory larvae of other species (D. Suhre, pers. comm.) and are certainly preyed on by aquatic invertebrates as well. This species has granular glands located behind the tympanum in the parotid glands, in the femorals, tibiae, and forearms. In these locations, potent alkaloids are produced that may protect the Sonoran Desert toad from predators. The alkaloids produced by the Sonoran Desert toad have psychoactive properties and are collected by some people (without harming the toad) and smoked for hallucinogenic effects (Most 1984).
- **Red-spotted toad.** Larval red-spotted toads may face competition (for food) with other larval anurans if they choose a breeding site in which artificial water development results in a semi-permanent to permanent water source. Local hybridization with Woodhouse's toad occurs near Grand Junction, Colorado (NatureServe 2003). Hybridization also occurs with the Sonoran green toad (Hulse 1978).
- **Sonoran green toad.** The Sonoran green toad has been found to form hybrids with closely related species including *Bufo kelloggi* (Sapo mexicano-menor), green toad, and red-spotted toad (Hulse 1978). Hybridization between the Sonoran green toad and red-spotted toad rarely occurs because of differences in calls and the preferred habitats of each, however co-occurrence and interbreeding of the species may be facilitated by habitat modification, such as roads and cattle tanks (Sullivan and others 1996). The Sonoran green toad's calls are nearly indistinguishable from those of the western narrow-mouthed toad. Sullivan and others (1996) never found this species breeding in monospecific groups in southern Arizona. Instead, it was found in the same pools as many other desert amphibian species including Sonoran desert toad, Great Plains toad, red-spotted toad, western narrow-mouthed toad, lowland burrowing treefrog, Couch's spadefoot, and the southern spadefoot (*Scaphiopus multiplicatus* [= *Spea multiplicata*]). Erik Enderson has observed that the Sonoran green toad is absent or not as numerous in pools where the Great Plains toad and Sonoran Desert toad are located (E. Enderson, pers. comm.).
- **Western narrow-mouthed toad.** The western narrow-mouthed toad eats only ants and occurs near ant colonies. This species has been found in burrows with eastern moles (*Scalopus aquaticus*), lizards, skinks, and tarantulas (Sredl and Field In Press). It may have a symbiosis with tarantulas whereby the toads receive protection from predators by the tarantulas in exchange for keeping tarantula burrows free of stinging and biting ants (Sredl and Field In Press). Western narrow-mouthed toads are found in pools with many other species of anurans throughout their range (Sredl and Field In Press), but

populations that co-occurred with Couch's spadefoot had slightly lower abundance (Dayton and Fitzgerald 2001).

- **Lowland burrowing treefrog.** The lowland burrowing treefrog has been reported to occur in temporary pools with all other amphibian species in the guild (Sredl In Press). The lowland burrowing treefrog has specialized anti-predator behaviors including the "unken reflex" (in which the adult stiffens its body, arches its back, and raises its limbs) and using its head to seal itself into a burrow (Sredl In Press).
- **Couch's spadefoot.** Couch's spadefoot larvae feed voraciously and can outcompete species adapted to more permanent water (Woodward 1983), though this species is at a disadvantage in more permanent waters in which predators are more abundant and other species (such as the Sonoran Desert toad and Great Plains toad) likely have a competitive advantage (Woodward 1983, Dayton and Fitzgerald 2001). In some situations Couch's spadefoot larvae are found at such high densities that density-dependent intraspecific competition likely occurs (Dayton and Fitzgerald 2001).

Landscape context.—All species in the ephemeral water-breeding amphibian guild move between aquatic and terrestrial habitats; however, little is known of movement distances or corridors. Amphibian movement near water sources close to paved roads can be disastrous for amphibians, where in a single night collisions with vehicles can severely impact local amphibian populations. Metapopulation dynamics are also not well understood for desert amphibians, where larger pools may serve as population sources and smaller pools with unpredictable or insufficient water duration might act as population sinks in some years. A permanent pool behind a spreader dike near the Vekol Valley Road is possibly a population source for some of the amphibian species that breed there (E. Enderson, pers. comm.). The duration of surface water in the Mesquite Woodland in the Vekol Valley is variable and may not allow for recruitment of some species in some years (E. Enderson, pers. comm.).

Figure C.7 shows natural and artificial water sources (tinajas, springs, spreader dikes, tanks, wildlife catchments, reservoirs, and potholes) with a 500 meter (0.3 miles) and one kilometer (0.6 miles) buffer around each water. The buffered areas represent potential areas of movement for amphibians, if present at the water sources. This is a coarse representation of movement areas because: (1) as previously noted, more information is needed on dispersal movements and home ranges of desert amphibians; (2) amphibians are not necessarily present at each of these points; and (3) the water layer is likely missing some points, especially natural tinajas where amphibians may be present. Nonetheless, Figure C.7 serves as a hypothesis and a starting point from which to evaluate amphibian movement areas around water sources and to identify potential problem areas (such as where the buffered points overlap with paved roads).

Additional information on the landscape context of individual species is provided below.

- **Sonoran Desert toad.** Sonoran Desert toads disperse between water sources at night and are capable of travelling long distances (over a mile) in a night (D. Suhre, pers. comm.). The characteristics of their preferred inter-waterway dispersal corridors are not known.
- **Red-spotted toad.** The red-spotted toad disperses along intermittent streams after breeding (NatureServe 2003).
- **Sonoran green toad.** Sonoran green toad adults have been found far from water (roughly estimated as at least a kilometer) in creosote flats on loamy soils where there is rarely standing water (E. Enderson pers. comm.).

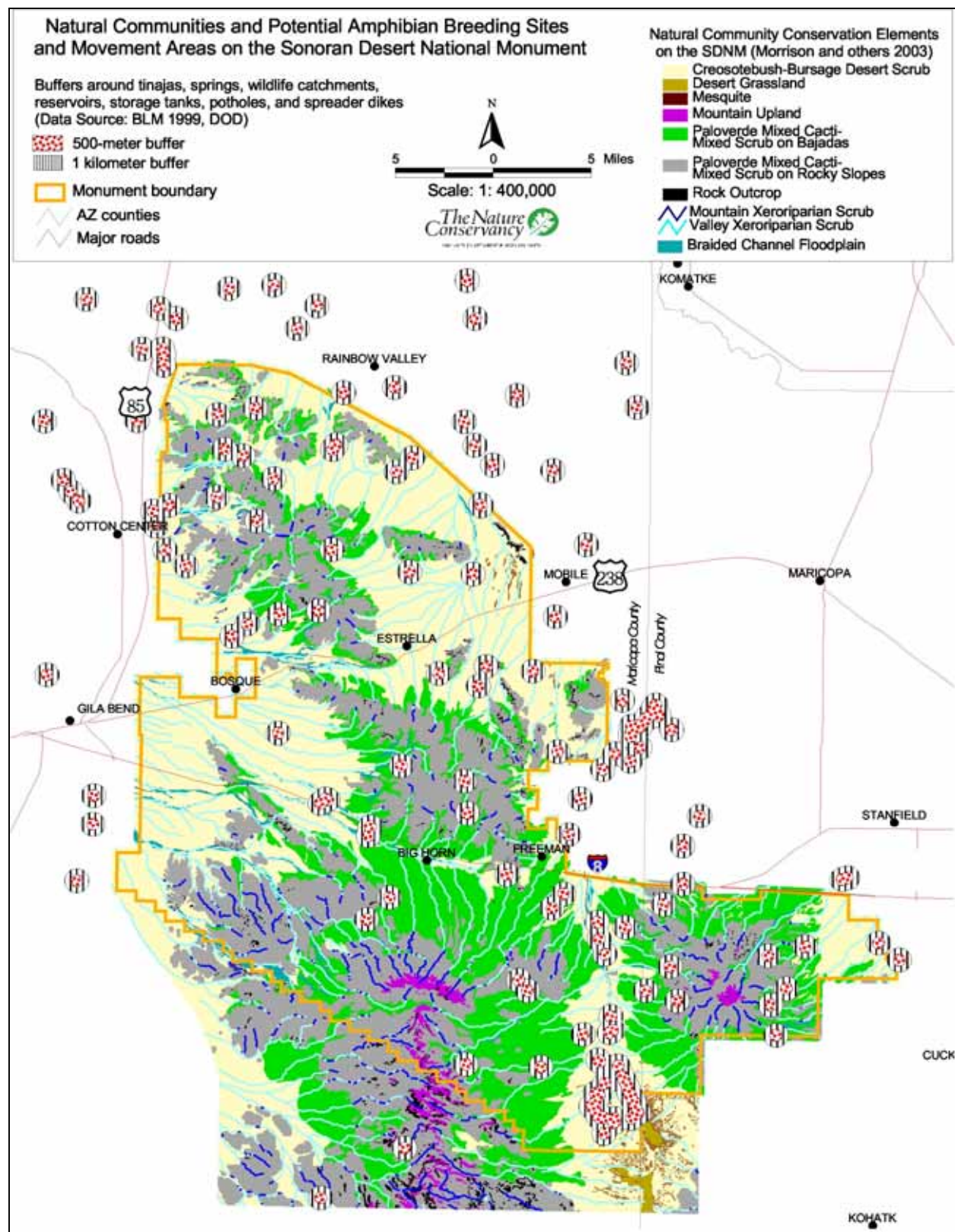


FIGURE C.7 Potential Amphibian Breeding Sites and Movement Areas on the Sonoran Desert National Monument

- **Great Plains toad.** Great Plains toads migrate several hundred meters between terrestrial habitat and breeding pools (NatureServe 2003).
- **Western narrow-mouthed toad.** This species may travel relatively long distances from water, as indicated by observations of adults in the creosote flats in 2002, when individuals were found in large numbers in the Vekol Valley (E. Enderson, pers. comm.). Yearlings and juveniles have been observed in dried mud in the winter, but seasonal movements of adults are poorly known (E. Enderson, pers. comm.). Juveniles disperse widely from breeding ponds and, in years when juveniles are unable to disperse because of drought, they face high rates of mortality from predation (Sredl and Field In Press). A population of western narrow-mouthed toads in Kansas had a home range of approximately 22 meters (72 feet) in radius, and males tended to travel longer distances than females (Sredl and Field In Press). Other authors have suggested that this species does not have a well-defined home range and wanders in any direction within suitable habitat (reviewed by Sredl and Field [In Press]). Migrations to breeding ponds were stimulated by rains greater than five centimeters (two inches), which fills ponds and moistens the earth for overland migrations (Sredl and Field In Press).
- **Lowland burrowing treefrog.** The characteristic movements of this species are not known (Sredl In Press).
- **Couch's spadefoot.** Couch's spadefoot migrates several hundred meters between breeding pools and non-breeding terrestrial habitat (NatureServe 2003).

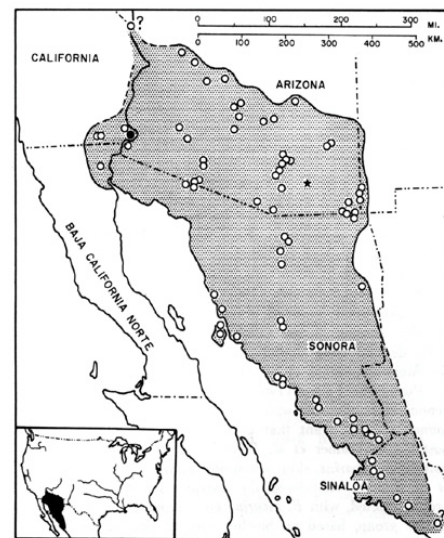
Status, Threats, and Management

Distribution.—Distribution maps for each species are provided in Figures C.8 to 14.

- **Sonoran Desert toad.** This toad is endemic to the Sonoran Desert Ecoregion. Its range extends from the Lower Colorado and Gila Rivers of Arizona and extreme southwestern New Mexico south to northwestern Sinaloa and extreme southeastern California. It occurs from sea level to above 1,219 meters (4,000 feet) (Stebbins 1985; Figure C.8).



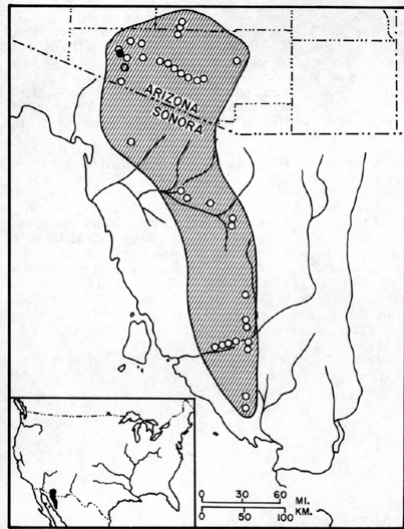
FIGURE C.9 Distribution of the Red-Spotted Toad (*Bufo punctatus*) in the United States. From AmphibiaWeb (2003).



MAP. The solid circle marks the type-locality; open circles indicate other records. The star marks a fossil locality.

FIGURE C.8 Distribution of the Sonoran Desert Toad (*Bufo alvarius*). From Fouquette (1970).

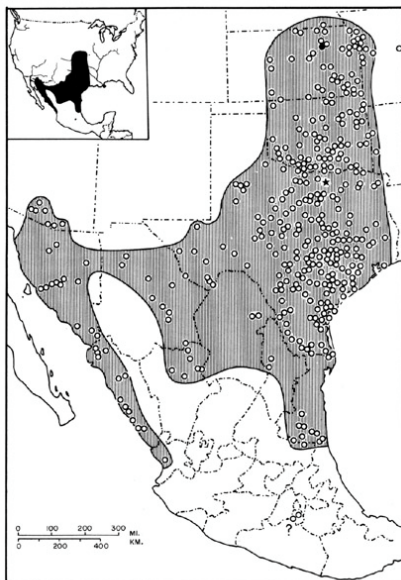
- **Red-spotted toad.** This species' range extends from southeastern California to southern Nevada, southern Kansas, central Texas, and south through Mexico to Hidalgo and southern Baja California (Stebbins 1985). It is found at elevations below sea level up to 2,134 meters (7,000 feet) (Phillips and Wentworth Comus 2000; Figure C.9).



MAP. The solid circle marks the type-locality; open circles indicate other records.

FIGURE C.10 Distribution of the Sonoran Green Toad (*Bufo retiformis*). From Hulse (1978).

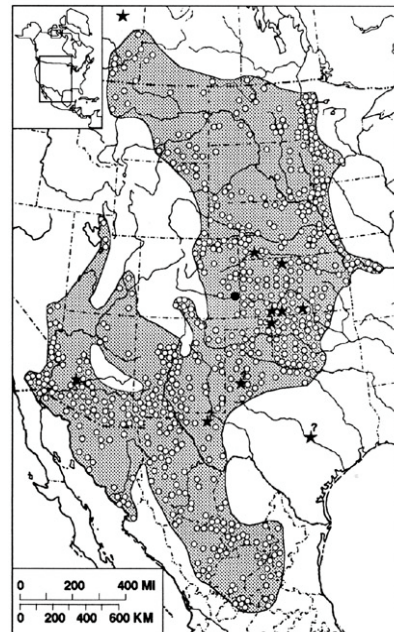
- **Great Plains toad.** This species is found up to 1,800 meters elevation throughout its range and up to 2,440 meters in Colorado (8,005 feet). It occurs from southern Manitoba and southeastern Alberta, east to Minnesota, through the Great Plains, west to Montana, Wyoming, the southwest and southeastern California, and south to Northern Sinaloa and San Luis Potosí, Mexico (Figure C.11).



MAP. The solid circle marks the restricted type-locality; open circles indicate other records. The star marks a fossil locality.

FIGURE C.12 Distribution of the Western Narrow-Mouthed Toad (*Gastrophryne olivacea*). From Nelson (1972).

- **Sonoran green toad.** This species is endemic to southern Arizona and Sonora in the Sonoran Desert Ecoregion (Figure C.10). Hulse (1978) suggested that the range of this species might expand into Southern Pinal county northward to Santa Rosa and Gila Valleys in association with irrigation and agricultural activity; however, Sullivan and others (1996) did not find evidence to support this hypothesis. Sullivan and others (1996) found this species in all historic localities in southern Arizona except for near San Xavier Mission near Tucson.



MAP. Distribution of *Bufo cognatus*. Solid circle indicates the type-locality, open circles represent localities from literature and museum records. Stars represent fossils; those with question marks indicate fossils that could be of *B. cognatus*, *B. speciosus*, or a recent ancestor.

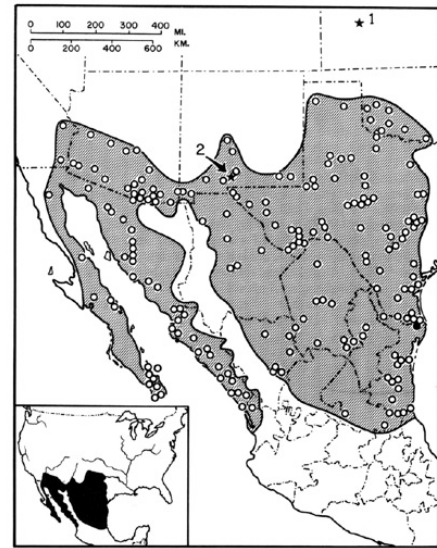
FIGURE C.11 Distribution of the Great Plains Toad (*Bufo cognatus*). From Krupa (1990).

- **Western narrow-mouthed toad.** This species is found from extreme southern Nebraska and western Missouri, south through most of Kansas, Oklahoma, and Texas to the Mexican Plateau, Southern Arizona, San Luis Potosí, the Pacific Lowlands of Mexico south to Nayarit (Nelson 1972; Figure C.12). It is found from sea level to 1,251 meters (4,100 feet) throughout most of its range and from 427 to 1,434 meters (1,400 to 4,700 feet) in Arizona (AGFD 2003). Sullivan and others (1996) compared current and historic populations in southern Arizona and did not relocate this species near Peña Blanca Lake in Santa Cruz County nor near the San Xavier Mission. A new locale was found for this species by Sullivan and others (1996) at Lukeville, close to the international boundary.

- Lowland burrowing treefrog.** This species is found in south-central Arizona to western Sonora, coastal Sinaloa, the foothills of the Pacific slopes of the Sierra Madre Occidental, Nayarit, and the Mexican Plateau in Jalisco (Trueb 1969; Figure C.13). The lowland burrowing treefrog was discovered in the United States in 1957 and in the Vekol Valley on the SDNM in 2000 (Enderson and Bezy 2000; Sredl In Press). It is found at elevations ranging from sea level to 1,500 meters (4,921 feet) and its distribution may be restricted to areas where soil temperatures do not drop below freezing (Sredl In Press). Sullivan and others (1996) compare known historic and current distributions of this species in Arizona and relocated treefrogs at most sites. They also found additional localities at Sells Wash (a tributary of San Simon Wash). The species' distribution in the United States is limited and is known only from washes in the Quijota, Gu Oidak, Santa Rosa, and Vekol Valleys in Pima, Pinal, and Maricopa Counties, Arizona (Sredl In Press).



FIGURE C.13 Distribution of the Lowland Burrowing Treefrog (*Pterohyla fodiens*) in the United States. From AmphibiaWeb (2003).



MAP. The solid circle marks the type-locality; open circles indicate other records. Stars indicate fossil records.

FIGURE C.14 Distribution of Couch's Spadefoot (*Scaphiopus couchii*). From Wasserman (1970).

- Couch's spadefoot.** This species is distributed from southeastern California through southern Arizona and southern New Mexico into central Texas and southwestern Oklahoma (Figure C.14). In Mexico it is found along eastern Baja California and on western and eastern mainland Mexico south to southern San Luis Potosi (Stebbins 1985, Phillips and Wentworth Comus 2000). Relict populations occur in the Colorado Desert in California on dry washes at the edge of sand dunes (Mayhew 1965).

Conservation status.—All species in the ephemeral water-breeding amphibian guild may be collected in Arizona, as per regulations of the Arizona Game and Fish Department.

- Sonoran Desert toad.** The Global Rank of the Sonoran Desert toad is G5: many and/or large occurrences of the species occur throughout most of its range (NatureServe 2003). The trend in population size, area of occurrence, and number of occurrences is unknown (NatureServe 2003). The Sonoran Desert toad is a generalist amphibian that has probably expanded its range in the desert because of human activity and has most likely benefited from human-induced water developments in the desert (P. Rosen, pers. comm.).

- **Red-spotted toad.** The Global Rank of the red-spotted toad is G5: many and/or large occurrences of the species occur throughout most of its range (NatureServe 2003). Its population trend is unknown but is probably stable to slightly declining (NatureServe 2003).
- **Sonoran green toad.** The Global Rank of the Sonoran green toad is G3 indicating that it is vulnerable due to a restricted range (NatureServe 2003). As of 1997, this species was known from 40 sites in the United States, all of which are in Arizona (NatureServe 2003). Its status in Mexico is not known and its status on the Tohono O’odham Nation is not well known because surveys were limited because of some restrictions in property access (NatureServe 2003). This species is on the International Union for Conservation of Nature and Natural Resources (IUCN) Red List in which it is classified as Lower Risk Near Threatened. It is also listed in CITES Appendix 1 most endangered list, with trade prohibited except under special circumstances or with permit. Currently over-collection is the primary threat to this species (NatureServe 2003). The Sonoran green toad is tracked by Heritage Data Management System (HMDS) in Arizona.
- **Great Plains toad.** The Global Rank of the Great Plains toad is G5: many and/or large occurrences of the species occur throughout most of its range (NatureServe 2003). It is a Species of Concern in Canada (NatureServe 2003).
- **Western narrow-mouthed toad.** The Global Rank of the western narrow-mouthed toad is G5, and it has a state rank in Arizona of S3, indicating that it is vulnerable in the state (NatureServe 2003). This species is classified as Wildlife of Special Concern in Arizona (AGFD 1996) and Rare by the Mexico Endangered Species Act. Trend in the abundance of this species is not well known but historic localities on the eastern edge of its range in Arizona were no longer occupied in resurvey efforts (Sredl and Field In Press).
- **Lowland burrowing treefrog.** The Global Rank of the lowland burrowing treefrog is G4, indicating that it is uncommon but not rare and apparently secure in most of its range (NatureServe 2003). Its state rank in Arizona is S1S2, meaning that it imperiled or critically imperiled because of extreme rarity. This indicates that it is vulnerable to extirpation in Arizona, the only state where the species occurs in the United States (NatureServe 2003). This species is a Wildlife of Special Concern in Arizona (AGFD 1996) and its trend in abundance is unknown (NatureServe 2003). Within its range in the United States, this species is specialized on mesquite bosques in xeroriparian scrub, a habitat that has largely been lost due to historic woodcutting and lowering of water tables. Within its range in the United States, all known occurrences are found on the Tohono O’odham Nation and BLM land. Occurrences of this species are tracked by HDMS in Arizona.
- **Couch’s spadefoot.** The Global Rank of Couch’s spadefoot is G5: many and/or large occurrences of the species occur throughout most of its range (NatureServe 2003).

Stresses and sources of stress.—Table C.10 identifies potential stresses and sources of stress to the ephemeral water-breeding amphibian guild. As discussed in the **Biotic interactions** section, characteristics of breeding waters, specifically water duration, have been found to affect interspecific competition between the amphibians in the guild and may influence species composition and population dynamics at breeding sites. The Sonoran Desert toad and Great Plains toad have likely benefited from water development on the SDNM, whereas some of the other species may be at a competitive disadvantage and subject to increased predation rates in permanent water sources. All species in the amphibian guild, except the red-spotted toad, have been recorded from temporary rain pools or from behind the spreader dikes in the Vekol Valley on the SDNM (E. Enderson, pers. comm.) implying that at present, excessive competitive interactions resulting in exclusion of one or more species from the pools is

TABLE C.10 Ephemeral Water-Breeding Amphibian Guild: Stresses and Sources of Stress

Stress	Source of Stress	Geographic Scope of Potential Impacts	Comments or Source of Information
Adult mortality (altered population composition and/or structure)	Collisions with vehicles on paved roads during breeding season.	SDNM and regional	See Figure C.7 for areas where mortality on roads may be most likely to occur.
Excessive competition or predation (altered composition of guild species)	Introduction and spread of non-native Rio Grande leopard frog.	Regional	E. Enderson (pers. comm.).
	Altered hydroperiod from water development.	SDNM and regional	Woodward (1983), Dayton and Fitzgerald (2001).
Habitat loss or degradation	Intensive agricultural development, urban development.	Regional	NatureServe (2003).
Sonoran green toad: altered population composition	Collection for pet trade or research.	Regional	NatureServe (2003).
Couch's spadefoot: mortality and/or reduced reproductive success	Monogenean parasitic infection.	Regional	NatureServe (2003).

not occurring. Prior to making any management decision on the future of the spreader dikes on the SDNM, it is important to evaluate potential effects on the relative abundance of the species in the amphibian guild. In particular this consideration applies to any potentially adverse effects on the three species with restricted distributions in Arizona: the Sonoran green toad, western narrow-mouthed toad, and lowland burrowing treefrog.

A potential future stress to the ephemeral water-breeding amphibian guild on the SDNM is displacement of guild members by other, more effective amphibian competitors, such as the Rio Grande leopard frog (E. Enderson, pers. comm.). The Rio Grande leopard frog is primarily associated with agriculture or developed waters and has been found on the SDNM (Turner and others 2000). This species could potentially enter the Vekol Valley with a large flood event. If populations of the Rio Grande leopard frog were to become established, they would likely outcompete the smaller anuran species of the ephemeral water-breeding amphibian guild (by eating adults or via larval competition).

Vehicular collisions can be a major source of adult mortality, especially along high-speed, paved roads. Traffic on Interstate 8, Route 238 (Maricopa Road), and Route 85 could potentially impact amphibian populations on the SDNM. Water source distribution on the SDNM suggest that potential impacts due to traffic mortality are along Interstate 8 and Route 85, in both Creosotebush-Bursage Desert Scrub and Paloverde-Mixed Cacti-Mixed Scrub on Bajadas natural communities (Figure C.7). The species most likely to be impacted by traffic mortality along roads in these areas are the Sonoran Desert toad, Great Plains toad, Couch's spadefoot, and red-spotted toad.

A threat specific to the Sonoran green toad is over-collection of adults for the pet trade or scientific purposes. This species is brilliantly colored and is highly valued by collectors. Population declines have occurred at sites on the Tohono O'odham Reservation due to heavy collection pressures (E. Enderson,

pers. comm.). Collection of this species does occur in the Vekol Valley, but is not presently considered a threat because of the inaccessibility of the breeding habitat during the summer monsoons (E. Enderson, pers. comm.).

Mapping and Information Needs

Mapping comments.—Figure C.6 shows the distribution of the amphibians tracked by HDMS in relation to water sources and natural communities. Figure C.7 includes all of the same water sources mapped in Figure C.6, with a spatial buffer of 500 and 1,000 meters around each water to show potential movement areas for amphibians. These waters represent potential breeding habitat but are not necessarily occupied by the amphibians. Because HDMS tracks only the western narrow-mouthed toad, the Sonoran green toad, and the lowland burrowing treefrog, we were unable to confirm the presence of the other amphibians throughout the SDNM.

Some water sources found on the SDNM may not be shown in Figures C.6 and C.7 because of a lack of spatial information. Additional tinajas are likely to be present (but are yet unmapped) in the rocky and inaccessible areas of the Sand Tanks Mountains and may harbor small populations of amphibians. A new location for a tinaja in the Sand Tanks was described by Morrison and others (2003), but was not included in Figures C.6 and C.7. Moreover, a spring, Kate's Spring, is present on the east side of Table Top Mountain (G. Dahlem, pers. comm.), but is not shown on Figure C.6. Information on the water duration or volume of water held was not available and some waters shown in Figures C.6 and C.7 may not be maintained. In sum, Figures C.6 and C.7 are a starting point for considering amphibian distribution, habitat, and movement areas on the SDNM. Furthermore, movement areas shown in Figure C.6 are rough estimates based on information from NatureServe (2003) and personal communications with herpetologists. Little quantitative information is available on individual species movement. Some species, such as the Sonoran Desert toad, may occur up to three miles (4.8 kilometers) from the water source (P. Rosen, pers. comm.), whereas other species might not move as far from water as shown in Figure C.6.

The Arizona Gap Analysis Project (2001) has mapped the distributions of the amphibians in the ephemeral water-breeding guild based on vegetation communities, slope, elevation, and their distributions in Arizona. These models could also be applied to map species distributions and habitat on the SDNM. Modeled habitat for each species, as described in the Arizona Gap Project Amphibian Metadata (Arizona Gap Analysis Project 2001, Appendix 3–2a), are as follows:

- **Sonoran Desert toad.** Below 1,610 meters (5,300 feet) in desert habitats (primary habitat) and less commonly in grasslands (secondary habitat).
- **Red-spotted toad.** Predicted to associate preferentially with natural tinajas and springs. Mapped as areas within three kilometers (1.9 miles) of slopes >30% below 1,980 m (6,550 feet).
- **Sonoran green toad.** Within its range found between 150 to 730 meters elevation (500 to 2,400 feet) outside a three kilometer (1.9 miles) buffer around 50% or greater slopes.
- **Great Plains toad.** Up to elevations of 2,440 meters (8,000 feet) in grasslands, desert, and agriculture.
- **Western narrow-mouthed toad.** Within its range in Arizona it is mapped based on mesquite grassland and oak woodland habitat with refinement based on occurrence information and expert input.

- **Lowland burrowing treefrog.** Within its range in Arizona it is mapped up to elevations of 1,490 meters (4,900 feet) in desert and desert grassland habitat within the Sonoran Desert.

Information on distribution models for Couch's spadefoot was unavailable.

Information needs.—Information is needed to quantify the relative usage and co-usage of different water sources on the SDNM by members of the ephemeral water-breeding amphibian guild. This could help elucidate dynamic species interactions in different aquatic habitat types and different water durations. Such information could be used to ensure that management accounts for each species' needs without negatively affecting conservation of the other species. Additional information on the specific terrestrial and aquatic habitat needs of amphibians in the Vekol Valley is needed to understand how spreader dikes and resultant hydrological modifications may have impacted the preferred terrestrial habitats (Mesquite Woodland versus Desert Grassland natural communities) of the species and how the altered hydrology (pooled water behind berms) affects species abundance and interspecific competition. More information is needed on species movements between aquatic and terrestrial habitats. Little is known about long-term trends in population status of most desert anurans, but is least known for the Sonoran green toad, lowland burrowing treefrog, and western narrow-mouthed toad.

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C.3 Reptiles

Four different reptile species, one tortoise, one lizard, and two snakes, are included as conservation elements.

C.3.1 Desert Tortoise (*Gopherus agassizii*)

Overview

Taxonomy.—The Sonoran Desert and Mojave Desert populations of the desert tortoise are not considered separate subspecies at present, but the populations are distinct based on genetics, morphology, behavior, and ecology (NatureServe 2003). Whenever possible, information specific to the Sonoran Desert population of desert tortoise is provided.

Rationale for selection as a conservation element.—*Regionally vulnerable.* The desert tortoise is federal listed as a threatened species in the Mojave Desert and in Arizona north and west of the Colorado River. Although desert tortoise populations in the Sonoran Desert have no legal federal protection, the species is thought to be vulnerable and declining over much of its range because of habitat loss and degradation, habitat fragmentation, and genetic contamination (AGFD 1996). The BLM manages the majority of desert tortoise habitat and therefore has the opportunity to significantly influence long-term conservation of desert tortoise and their habitats. The BLM recognizes its disproportionate responsibility for the conservation of desert tortoise habitat and has developed a management plan for desert tortoise habitat across the species' range (BLM 1988a) and a strategy for implementing this plan in Arizona (BLM 1990). The Sonoran Desert National Monument (SDNM) is a regionally significant area for desert tortoise conservation in Arizona. The monument boundaries encompass more than a fifth of the most essential desert tortoise habitat (Category 1) in the state, as well as a portion of Arizona's largest contiguous area of Category 1 tortoise habitat in the Sand Tank and Sauceda Mountains.

Specific habitat needs on the SDNM.—Desert tortoise in the Sonoran Desert are typically found on rocky slopes in Paloverde-Mixed Cacti-Mixed Scrub natural community. They also can be found, however, on lower bajadas, particularly in association with caliche soils in xeroriparian channels. Figure C.15 displays desert tortoise habitat as classified by the BLM (1988a) in relation to natural communities on the SDNM (as mapped and described by Morrison and others 2003) and in the immediate vicinity of the SDNM. It is apparent in Figure C.15 that even Category 1 desert tortoise habitat encompasses numerous natural communities, including Rock Outcrops, Mountain Upland (primarily at lower elevations of this natural community), Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes and on Bajadas, some areas of Creosotebush-Bursage Desert Scrub, and embedded xeroriparian natural communities (Braided Channel Floodplain, Mountain and Valley Xeroriparian Scrub). Because they make long-distance movements within and between mountain ranges, desert tortoise will use virtually all natural communities on the SDNM. Occurrence data for desert tortoise indicate that numerous individuals have been found outside BLM-designated habitat on the SDNM, including in the Vekol Valley on Paloverde-Mixed Cactus-Mixed Scrub on Bajadas, Creosotebush-Bursage Desert Scrub, Desert Grassland, and Mesquite Woodland natural communities (Figure C.15).

The BLM (1990) provides numerous objectives and management actions to maintain desert tortoise habitat and population viability across the species' range. Some important habitat components that desert tortoise require to maintain viable populations include shelter sites, unfragmented habitat for movements and to maintain metapopulations, and adequate quantity and quality of forage. Shelter sites are critical as thermal refugia during periods of activity in the spring and summer and as hibernacula in the winter. Shelters may be burrows dug by the tortoise itself, white-throated woodrat (*Neotoma albigula*) burrows, or may be found under shrubs, in large crevices in rock outcrops, in the shade of boulders, or on lower

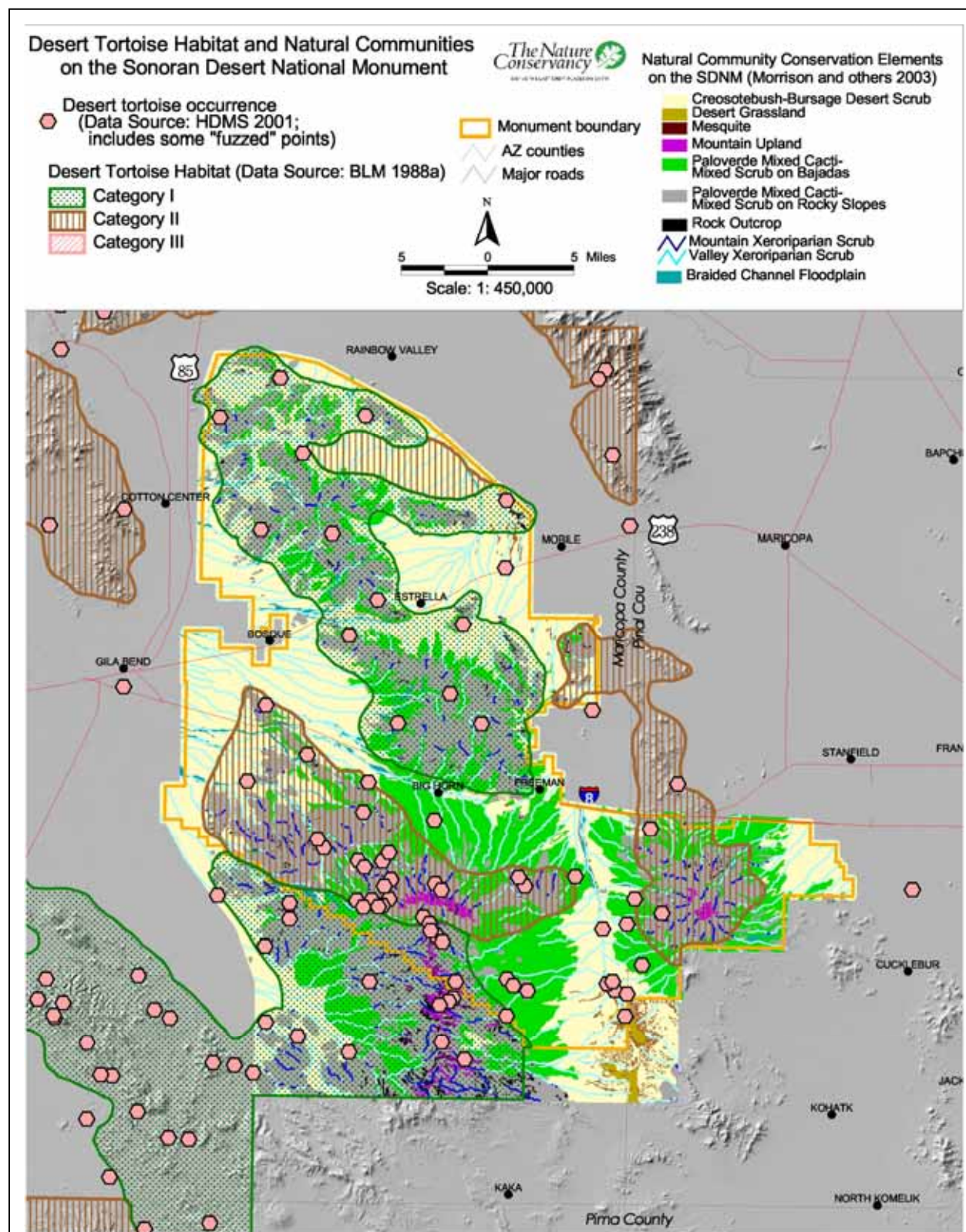


FIGURE C.15 Desert Tortoise Habitat, as Delineated by the Bureau of Land Management, and Heritage Program Occurrence Data for the Sonoran Desert National Monument and Vicinity and Their Relationship to the Natural Communities of the Monument

bajadas in caliche soils along incised xeroriparian washes (Averill-Murray and others 2002a, b). Attributes of shelter sites (including elevation and/or aspect) may influence survival during periods of extended drought and high temperatures (Wirt and Holm 1997a).

Desert tortoises are generalist herbivores, but they also have physiological limitations such that forage quality and quantity may affect survival, especially during extreme climatic events (see also the **Food and water requirements** section). Objective 10 of the BLM Strategy for Desert Tortoise Habitat Management on Public Lands in Arizona (BLM 1990) offers guidance to manage livestock such that adequate forage and cover is available for desert tortoise in designated habitat.

Desert tortoises have relatively large home ranges and make periodic long-distance movements between mountain ranges (see **Landscape context** section), which may be essential to maintain genetic diversity and population viability. Roads and urban or agricultural lands may impede desert tortoise movements and fragment habitat. Unfragmented dispersal areas are especially important to permit natural recolonization of suitable habitat after large mortality events (Wirt and Holm 1997a). Paved roads on the SDNM dissect desert tortoise habitat (Figure C.15) and may represent a mortality risk or an impediment to movement across otherwise suitable habitat.

Comprehensive reviews that address most aspects of desert tortoise biology, ecology, and conservation have been compiled by Arizona Interagency Desert Tortoise Team (AIDTT 1996, 2000), Grover and DeFalco (1995), Johnson and others (1990), NatureServe (2003), and Van Devender (2002a). Below we provide a brief summary of some of the literature as it relates to conservation and management of the desert tortoise in the Sonoran Desert. Some of the information below also is taken from Hall and others (2001).

Ecological Characteristics

Abundance.—The abundance of desert tortoise populations in the Sonoran Desert covaries with rainfall along the west to east gradient, in which tortoises are more abundant in areas of higher rainfall (for example, Saguaro National Park). Local population sizes are highly correlated with shelter availability (Averill-Murray and others 2002a, b). The greatest documented decline in a desert tortoise population in Arizona was in the Maricopa Mountains, where the population dropped from over 140 to approximately 20 from 1987 to 1994 (Wirt and Holm 1997a). The cause of this dramatic population decline was thought to be in part due to prolonged drought and high temperatures, which results in physiological stress, dietary stress (lack of nutritious forage including ephemeral plants), and/or overheating (Wirt and Holm 1997a). Burrow depth and aspect may influence abundance and provide climatic buffering (Wirt and Holm 1997b). Within a geographic area, elevation and physiography also may influence abundance. For example, although located close to the Maricopa Mountains, the Espanto Mountains did not suffer such a dramatic decline in tortoise abundance, possibly because they are a lower, smaller mountain range that rapidly cools at night (Wirt and Holm 1997a).

Population viability may be better evaluated by age and sex distributions than by absolute density. For populations listed as threatened, no specific density is required for delisting but a stable population is confirmed by age class proportions that approach the following: hatchlings 22%, small juveniles 22%, larger juveniles 6%, subadults 8%, adults 42% (NatureServe 2003).

Habitat associations.—In the Sonoran Desert desert tortoises occur primarily in the Arizona Upland subdivision in mountain ranges on rocky slopes and bajadas within Paloverde-Mixed Cacti-Mixed Scrub natural communities. The largest populations are found at the base of mountains within boulder-strewn areas. Rocky outcrops provide important habitat by blocking the sun and heat, providing a cooler, wetter environment, displacing water, and providing growing areas for mesic vegetation. Desert tortoises also

have been found as much as 4.8 kilometers (three miles) away from the mountains on middle bajadas in association with caliche caves along major arroyos (B. Wirt, pers. comm.). Outside the SDNM, populations rarely occur in semidesert grassland habitat (Tortolita Mountains) and in oak woodland at 1,520 meters (4,987 feet) elevation (Chimineá Canyon in the Rincon Mountains; Van Devender 2002b). Desert tortoises are absent or found in low densities in fine-grained silt and clay soils of valley bottoms, thereby avoiding mortality risk to eggs and young in monsoonal flooding events (Van Devender 2002b). Tortoises are found in thornscrub and extend into the transition of tropical deciduous forest in northern Sinaloa, Mexico (Bury and others 2002).

Burrows and caliche caves are important for maintaining constant temperature and relative humidity, which influence tortoise viability. Desert tortoises use packrat burrows and caliche caves on lower bajadas and major washes (Van Devender 2002b). Aspect is important, particularly in the western parts of the Sonoran Desert. Eastern and northern aspects are used during the summer months (Wirt and Holm 1997 a, b). Because these aspects are exposed during summer to the direct sun for shorter periods compared with other aspects, they provide relatively cool and mesic conditions. Tortoises hibernate on southern and western slopes because these exposures provide relatively warm conditions during the winter (B. Wirt, pers. comm.).

Food and water requirements.—Desert tortoises are generalist herbivores that eat a mixture of dried and fresh vegetation consisting of forbs, grasses, and perennial plant leaf litter, depending on what is available. Forage composition and the mixture of fresh and dried vegetation are important for maintaining blood hydration, salt, and mineral levels (Oftedal 2002, B. Wirt, pers. comm.). Desert tortoise reproduction and growth rates may depend on adequate forage and nutrition (Grover and DeFalco 1995). Forage quality and quantity can potentially impact tortoise survival, particularly during periods of drought and in the western portions of the Sonoran Desert where rainfall is low (Oftedal 2002). Tortoises can go for many months without drinking, but they must drink sufficient water at least once a year to maintain blood hydration (B. Wirt, pers. comm.).

Desert tortoise has been documented to eat 199 plant species in the Arizona Upland subdivision of the Sonoran Desert (Van Devender and others 2002). Major forage species includes grasses, desert vine (*Janusia gracilis*), and mallows, including desert rose mallow (*Hibiscus coulteri*), globe mallow (*Sphaeralcea ambigua*), and Indian mallow (*Albutilon* sp.). Non-native plants, including filaree (*Erodium cicutarium*), Malta star thistle (*Centaruea melitensis*), Mediterranean grass (*Schismus* spp.), red brome (*Bromus rubens*), Sahara mustard (*Brassica tournefortii*), and Russian thistle (*Salsola tragus*) have been documented as a minor part of the diet and may be of inferior nutritional quality than native forage species (Oftedal 2002, Van Devender and others 2002). Extended summer drought and high temperatures can be particularly stressful to tortoises in the Sonoran Desert and cause dehydration, starvation, and liver and kidney disease (Dickinson and others 2002).

General life history.—The following information is summarized from Averill-Murray and others' (2002a, b) description of the activity, behavior, and population ecology of the desert tortoise in the Sonoran Desert, unless noted otherwise.

Desert tortoises are active in the spring and summer months. They retreat to underground hibernacula in late October. Onset is highly variable, from late September to mid-December, depending on temperature. Winter rains determine the availability of spring annuals and, as a result, dictate when tortoises emerge from hibernation (B. Wirt, pers. comm.). Females become active in the spring, generally in March, basking and moving within their home range and foraging on spring annuals, if available. Males become active after the summer rains in July when they forage and visit females found within their home range. Summer rains affect the availability of food and water resources and determine the timing of reproductive activity (B. Wirt, pers. comm.). Females mate with multiple males and store sperm for up to three years

(B. Wirt, pers. comm.). Ovulation and mating occurs in the April and May. Some fertilization takes place at this time from sperm from spring matings and/or sperm stored from prior seasons or years (NatureServe 2003). Approximately six eggs are laid in nests that have been dug into the soil, usually in late June. One clutch of eggs is produced per year in the Sonoran Desert. Eggs have a 90-day development period and hatch in late September or early October. Desert tortoises characteristically have low hatchling survival and juvenile recruitment. Adults are long-lived. Based on growth rates they are estimated to live up to 64 years (Germano and others 2002).

Females reach sexual maturity at 220 millimeters (8.7 inches) carapace length or between approximately 19 and 21 years of age (Germano and others 2002). As a result of their low annual reproduction, relatively late age of sexual maturity, and long life span, adult longevity is necessary to maintain desert tortoise populations and populations can be threatened by large adult mortality events. Because female tortoises store sperm, populations can remain viable even when population densities are relatively low (B. Wirt, pers. comm.). In drought years, tortoises sustain a reduced metabolic rate and rarely emerge from burrows to feed. When rains arrive, desert tortoise emerge from shelter sites to drink and feed off dried plant material (Ofstedal 2002).

Biotic interactions.—Available food and water is dependent on winter and summer rains. Predation of juveniles may be severe in some areas, particularly by ravens (*Corvus corax*) in the Mojave Desert (Kristan and Boarman 2003). Many other animals, including snakes, insects, lizards, rodents, javelina, and birds, will seek shade in abandoned or occupied shelters also used by desert tortoise (Averill-Murray and others 2002b).

Landscape context.—Some mixing of populations occurs because of dispersal by young males across valleys where suitable habitat exists. Large populations in good habitat are the population source for the poorer habitat (sink) areas (B. Wirt, pers. comm.). A two-year study of radioed tortoises in the Sonoran Desert revealed the following: desert tortoises have overlapping home ranges, the mean home range of females was marginally smaller than those of males, and home range sizes significantly differed between sites (Averill-Murray and others 2002b). Male home ranges ranged from 9.2 to 25.8 hectares (22.7 to 63.8 acres), and female home ranges ranged from 2.6 to 23.3 hectares (6.4 to 57.6 acres) (Averill-Murray and others 2002b). Desert tortoises can make long-distance movements across valleys between mountain ranges. One radioed female was tracked moving from Saguaro National Park, Rincon Mountain District to the foothills of the Santa Rita Mountains, approximately 32 kilometers (20 miles) (Stitt and others 2002). The tortoise spent the winter in the Santa Ritas and returned backed to Saguaro East (with some assistance from researchers), which equals a round trip of over 80 kilometers (50 miles).

Figures C.15 and C.16 provide information on desert tortoise occurrences on the SDNM and vicinity and potential movement areas across ownerships and natural communities. Desert tortoise habitat mapped by the Arizona Gap Program (1999a) shows tortoise habitat in areas where BLM did not categorized it, such as on Native American lands. Tortoise habitat and occurrence data in Figure C.16 reveal that desert tortoises move between the SDNM and Barry M. Goldwater Range (BMGR) in the area of the Sand Tank and Saucedas Mountains. This area also is continuous with desert tortoise habitat on the Tohono O'odham Reservation (as mapped by Arizona Gap Program 1999a). It also seems likely that tortoises may move between the SDNM and the Tohono O'odham Reservation via the Vekol Valley and Table Top Mountains (Figure C.16). Several tortoise occurrences along or near Route 238, Interstate 8, Route 85, and Interstate 10 indicate that these roads are potential barriers to dispersal.

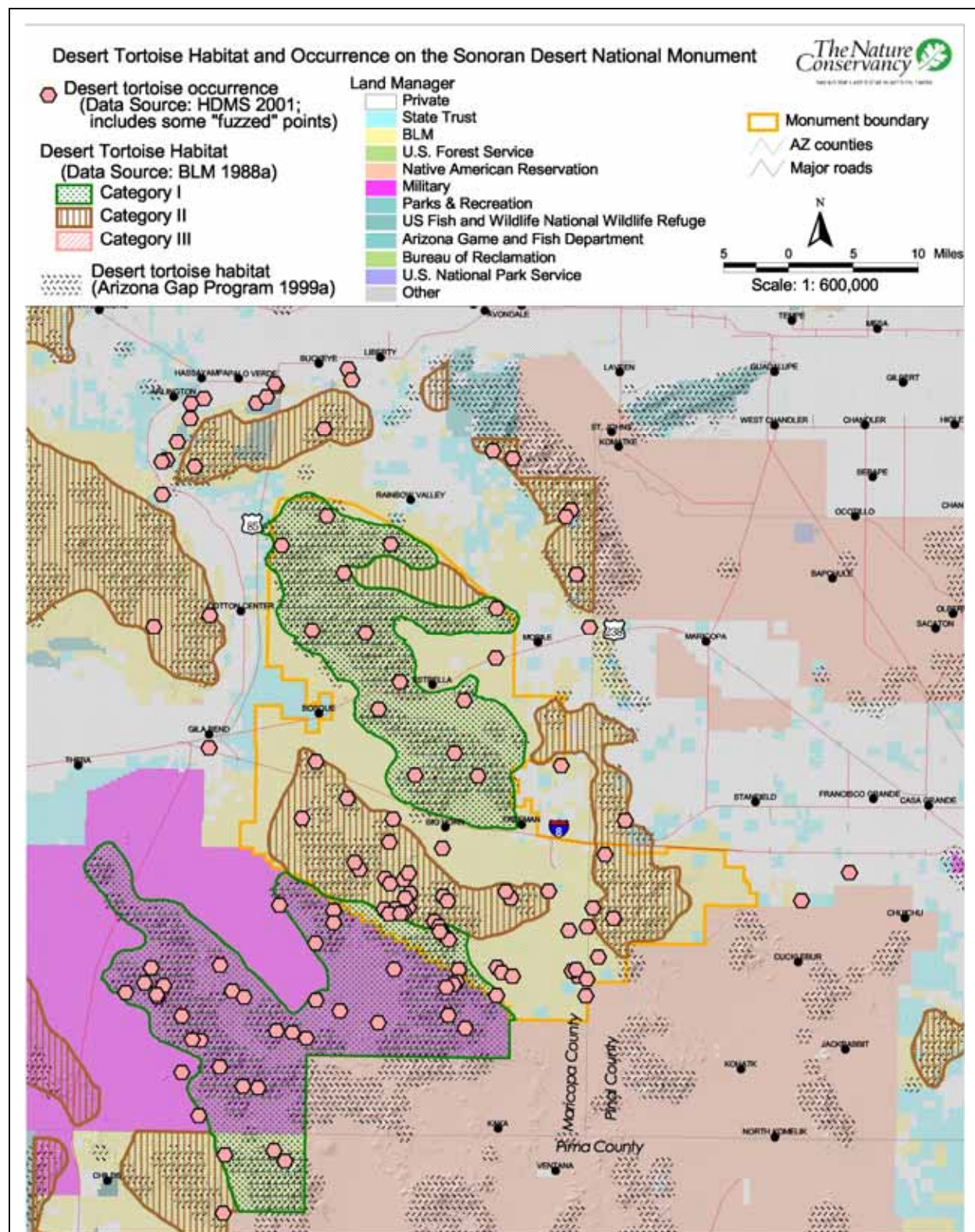


FIGURE C.16 Desert Tortoise Habitat, as Delineated by the Bureau of Land Management and Arizona Gap Program, and Heritage Program Occurrence Data for the Sonoran Desert National Monument and Vicinity and Their Relationship to Land Administration

Status, Threats, and Management

Distribution.—Desert tortoises occur in the Mojave and Sonoran Deserts of southeastern California, southern Nevada, extreme southwestern Utah, Arizona, and northern Sonora, Mexico, generally at elevations below 1,200 meters (4,000 feet). Desert tortoises also occur in tropical deciduous forests in southern Sonora and the northern edge of Sinaloa, Mexico. A range-wide distribution map of desert tortoise is presented in Figure C.17.

Conservation status.—The desert tortoise has a global rank of G4, which indicates that the species is widespread and apparently secure; however, a cause for long-term concern may exist for the species in parts of its range because of current population trends and threats (NatureServe 2003). The IUCN lists the desert tortoise as vulnerable, and populations in California, Nevada, Utah, and Arizona (north and west of the Colorado River) are listed as Threatened under the Endangered Species Act (NatureServe 2003; Figure C.17). The Arizona Game and Fish Department classifies the desert tortoise as a Wildlife of Special Concern in Arizona (AGFD 1996) and NatureServe (2003) identifies the species as S4, apparently secure, in Arizona. Many groups and individuals are active in desert tortoise conservation and research in Arizona. A consortium of biologists and government agencies, the Arizona Interagency Desert Tortoise Team (AIDTT), conducts and coordinates research and management efforts to conserve the species and prevent habitat loss and degradation (AIDTT 1996).

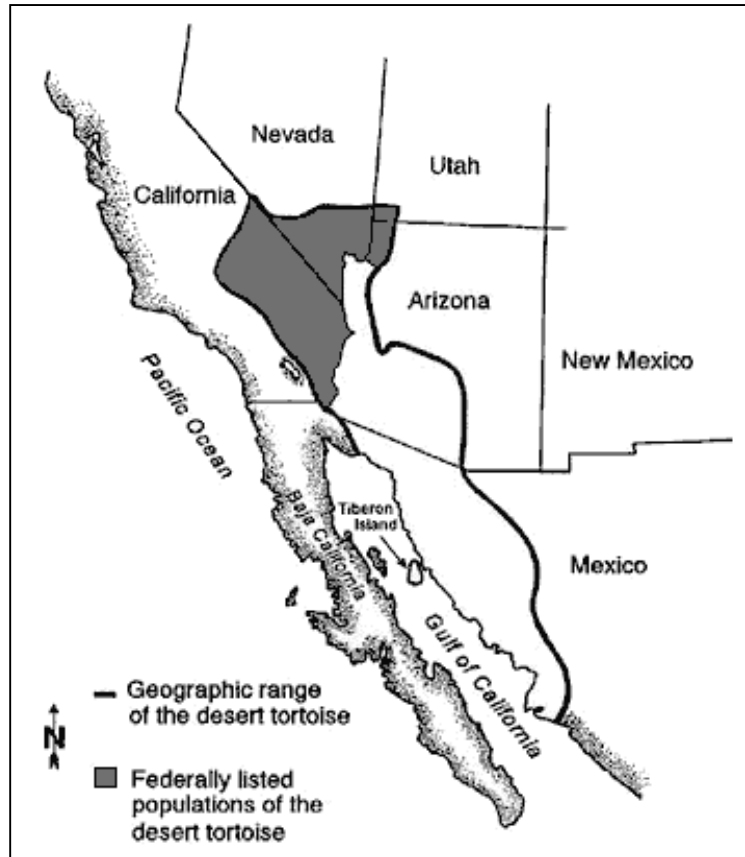


FIGURE C.17 The Geographic Range of the Desert Tortoise (*Gopherus agassizii*). The portion of the geographic range where populations are federally listed is shaded. Graphic from Berry (1997) and range from Stebbins (1985).

The BLM has a disproportionate responsibility for the conservation of desert tortoise, because the agency manages the majority of desert tortoise habitat across the species' entire range (BLM 1988a). To address their management responsibilities, the BLM has developed a management plan for desert tortoise on public lands (BLM 1988a) and a strategy for carrying out the plan in Arizona (BLM 1990). The BLM characterizes tortoise habitat on their managed lands into three categories according to the following criteria:

- importance of the habitat to maintaining viable populations
- resolvability of management conflicts
- desert tortoise density

- population status (increasing, stable or decreasing) (BLM 1988a, BLM 1990).

Based on these criteria, Category 1 desert tortoise habitat includes the most essential habitat to maintain populations with the highest densities, stable or increasing populations, and fewest conflicts, whereas Category 3 habitats are the least essential and Category 2 are intermediate (BLM 1988a). The goal of the BLM is to maintain stable, viable desert tortoise populations in Category 1 and 2 habitats and to limit population declines to the extent possible in Category 3 habitats by mitigating impacts.

Figure C.18 depicts desert tortoise habitat within the Sonoran Desert, BLM's Phoenix South Planning Area, and SDNM, as categorized by BLM (1988a) and the Arizona Gap Program (1999a). The SDNM is a regionally significant area for desert tortoise conservation, as it includes a large portion of the total Category 1 habitat in Arizona and a portion of the largest contiguous Category 1 habitat (95,516 hectares [238,790 acres]) in the Sand Tank and Saucedas Mountains (Figure C.18). Sixty percent of the SDNM is classified as either Category 1 or 2 tortoise habitat (Table C.11). Table C.11 compares the area of each category of desert tortoise habitat within the SDNM, within the Phoenix South Planning Area, and across the species' range in Arizona. The Category 1 desert tortoise habitat on the SDNM represents 22% of all Category 1 habitat in Arizona.

TABLE C.11 Area of Desert Tortoise Habitat in Arizona, Bureau of Land Management Phoenix South Planning Area, and on the Sonoran Desert National Monument¹

Category	Sonoran Desert National Monument			Phoenix South Planning Area		Arizona	
	Hectares (acres)	Percent of Each Category in SDNM	Area in SDNM/ Area in Arizona, Expressed as a Percentage	Hectares (acres)	Percent of Each Category in Phoenix South Planning Area	Hectares (acres)	Percent of each Category in Arizona
1	67,288 (166,272)	34	22	159,062 (393,048)	4	308,709 (762,834)	10
2	52,637 (130,067)	26	5	270,162 (667,583)	8	1,084,394 (2,679,584)	36
3	0	0	0	65,894 (162,827)	2	1,622,030 (4,008,109)	54
Not classified	80,936 (199,998)	40	—	3,237,441 (7,653,914)	86	—	—
Total Area ²	200,861 (496,337)	100	—	3,592,559 (8,877,372)	100	3,015,133 (7,450,527)	100

¹Calculated based on a geospatial analysis.

²For the Sonoran Desert National Monument and Phoenix South Planning Areas, "Total Area" refers to the total area of land within the boundary. For Arizona, "Total Area" refers to the total area of land that is classified as desert tortoise habitat within Arizona.

As delineated by BLM, the majority of desert tortoise habitat on the SDNM occurs on somewhat inaccessible rocky slopes where the habitat is free of most human impacts and disturbance. An analysis of the ecological condition of the natural communities within desert tortoise habitat indicates that, at present, the majority of desert tortoise habitat on the SDNM is in the highest ecological condition class

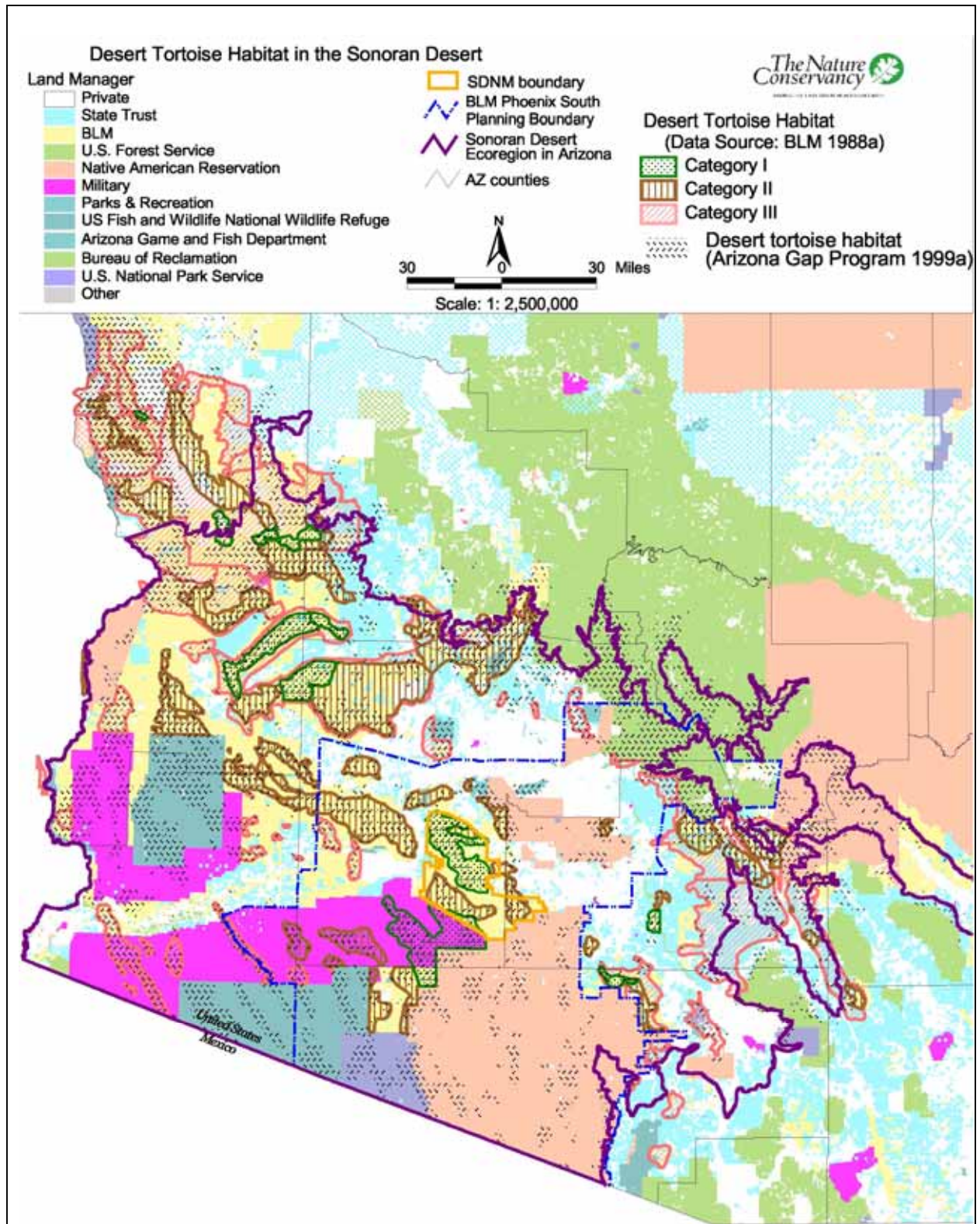


Figure C.18 Desert Tortoise Habitat, as Delineated by the Bureau of Land Management and Arizona Gap Program, in Arizona and Their Relationship to Land Management

(Table C.12). The assessed ecological condition of the natural communities present on the SDNM is based on Morrison and others (2003). These authors evaluated ecological condition based on plot-level and landscape-level assessments (see also Chapters 5 and 6 for additional details on the methods and results of Morrison and others [2003]). According to Morrison and others' (2003) analysis, areas in Condition Class 3 are those that show the least signs of anthropogenic stress within the study area and are closest to representing baseline conditions, whereas those in Condition Class 1 have been anthropogenically altered to the point that ecological condition often deviates dramatically from baseline conditions. Areas in Condition Class 2 are in intermediate in condition. Desert tortoise habitat that is in Condition Class 1 occurs mostly as small patches along roads or is surrounded by habitat of higher condition.

TABLE C.12 Area of Desert Tortoise Habitat on the Sonoran Desert National Monument in each Ecological Condition Class

Desert Tortoise Habitat Category ¹	Ecological Condition Class (Hectares [Acres]) ²			
	1	2	3	Total
1	2201 (5,440)	27,719 (68,493)	37,368 (92,339)	67,288 (166,272)
2	1,754 (4,335)	21,530 (53,202)	29,352 (72,530)	52,636 (130,067)
Total	3,955 (9,775)	49,249 (121,695)	66,720 (164,869)	119,924 (296,339)
Total (%)	3.3	41.1	55.6	100

¹Desert tortoise habitat as defined and mapped by BLM (1988a, 1990).

²Ecological condition as defined and mapped by Morrison and others (2003).

Stresses and sources of stress.—The SDNM is a significant area for the conservation of desert tortoise, because many of the threats that the species faces in other parts of its range, such as habitat loss, are absent on the SDNM. As previously mentioned, the largest population die-off noted in Arizona was on the SDNM in the Maricopa Mountains on Category 1 tortoise habitat. Climate change—if it is associated with extended periods of drought and higher temperatures—may pose a threat to populations on the SDNM and cause additional large-scale mortality events. Habitat fragmentation both within the SDNM (caused by paved roads) and across adjoining lands causes genetic isolation and may inhibit movement (or cause mortality/roadkill) and repopulation of suitable habitat after die-offs.

Potential future threats to desert tortoise on the SDNM include fire carried by invasive non-native grasses and excessive predation caused by ravens. Currently, invasive non-native plants are patchily distributed on the SDNM and do not occur at high densities within desert tortoise habitat (Morrison and others 2003). In the Mojave Desert, raven abundance is high around landfills and is associated with increased mortality of desert tortoise (Kristan and Boarman 2003). A possible concern is that the numerous landfills surrounding the SDNM within Rainbow Valley and near the Gila River Indian Reservation may increase raven abundance and represent a threat to the long-term viability of desert tortoise populations on the SDNM (May 2003 experts workshop); however, this remains to be studied.

Table C.13 identifies potential stresses and sources of stress confronting the desert tortoise across the species' range. Most of these threats are not known to impact desert tortoise populations on the SDNM. It is possible that some activities that occur on the SDNM, such as livestock grazing and illegal off-road vehicle use (including where it occurs in washes), may threaten desert tortoises; however, the relative impact of these activities has not been documented.

TABLE C.13 Desert Tortoise: Stresses and Sources of Stress

Stress	Source of Stress	Geographic Scope of Potential Impacts	Comments or Source of Information
Altered/ disturbed habitat	Invasive non-native grasses	Regional	Invasive non-native grasses, including red brome, buffelgrass, and fountain grass, can provide sufficient fuels to carry fire through desert habitats. Fire can alter tortoise habitat by eliminating thermal refugia (shrubs, packrat middens) and increasing grass cover and density such that they pose formidable barriers to tortoise movement (Esque and others 2002). Fire can also cause injury or mortality to tortoise. The effect of invasive non-native species on tortoise nutrition and diet is inconclusive.
	Boulder collection (legal and illegal)	Regional and SDNM	Illegal boulder collection has occurred in the past on the SDNM in the Espanto and Maricopa Mountains, but in general has a low probability of occurrence on the SDNM (May 2003 expert workshop)
	Inappropriate livestock grazing management practices	Regional	Studies have reported that excessive grazing may increase soil compaction and erosion and cause changes to vegetation, which in some cases is detrimental to tortoises. Livestock also have been found to trample young tortoise and damage tortoise burrows and vegetation used as shelters (reviewed by Grover and DeFalco 1995); however a review of the literature by Hall and others (2005) concluded that impacts to desert tortoise by cattle may be mostly limited in the Sonoran Desert because of habitat segregation.
	Excessive off-road vehicle use	Regional	Excessive off-road vehicle (ORV) use can cause similar impacts to soil and vegetation in tortoise habitat (reviewed by Grover and DeFalco 1995).
Excessive competition for resources	Competition with livestock (including wild horses and burros) for forage	Regional	Ephemeral grazing systems may be particularly detrimental to desert tortoise because their growth and reproduction depends on years of above average annual forage (reviewed by Grover and DeFalco 1995); however, see the above comment regarding the conclusions of Hall and others (2005), as the preceding findings may be applicable only to the Mojave Desert.
Habitat loss and fragmentation	Urban and agricultural development (historic and current)	Regional	Urban development has led to the loss of large areas of important tortoise habitat in the foothills around Tucson and Phoenix. Development of lands surrounding the SDNM, such as in the Rainbow Valley, could fragment tortoise populations by impeding movements.
Altered composition, excessive mortality	Illegal collection of individuals from wild populations	Regional	NatureServe (2003).

TABLE C.13 Desert Tortoise: Stresses and Sources of Stress—continued

Stress	Source of Stress	Geographic Scope of Potential Impacts	Comments or Source of Information
Altered composition, excessive mortality—continued	Vandalism/illegal shooting	Regional	NatureServe 2003
	Roadkills. Mortality of tortoises occur both on paved and unpaved roads and also may occur from off-road vehicle use.	Regional and SDNM	On the SDNM, Route 238 and Interstate 8 represent the greatest threats to tortoises because of high-speed traffic (May 2003 expert workshop). Grover and DeFalco (1995) reviewed the literature on mortality from ORV use. Studies have shown that fencing is effective in reducing tortoise mortality along roads and that they enter underground culverts to move safely across fenced roads (NatureServe 2003).
	Excessive predation	Regional and SDNM	In the Mojave Desert increased risk of desert tortoise predation by ravens was found in areas with: (1) high raven abundance at landfills and (2) breeding pairs in low raven density areas (where pairs spend less time in nest defense/territorial behavior) (Kristan and Boarman 2003). Raven abundance increases around landfills and in areas with increased trash on trails and campsites (including from illegal immigration traffic; May 2003 expert workshop). Coyote, feral cat, and domestic dogs also are predators of tortoises, particularly in the wildland/urban interface (NatureServe 2003).
	Disease, including upper respiratory tract (URT) disease and shell disease	Regional	Upper respiratory tract disease is caused by an infection of <i>Mycoplasma agassizii</i> and is associated with release of captive tortoises into wild populations. It has been a cause of death of thousands of wild tortoises in the Mojave Desert in recent years (Berry 1995); however, Sonoran Desert populations seem to maintain low levels of infection without developing the disease (Dickinson and others 2002). Shell disease may be caused by toxins or a nutritional deficiency. Tortoises with shell disease have been found in the Mojave and Sonoran Deserts; however, the disease has only been implicated in high rates of mortality in the Mojave Desert population (Dickinson and others 2002).

TABLE C.13 Desert Tortoise: Stresses and Sources of Stress—continued

Stress	Source of Stress	Geographic Scope of Potential Impacts	Comments or Source of Information
Altered composition, excessive mortality—continued	Climate change	Regional and SDNM	Severe climate conditions can cause high rates of adult mortality (Wirt and Holm 1997a). Populations can be slow in recovering from such die-offs, with a population growth rate of 0.5% to 1% per year (NatureServe 2003). It is also possible that sex ratios could be affected by climate change (temperatures between 26.1 and 30.6 °C [79 to 87 °F] produce all males; temperatures between 31.1 and 32.8 °C [88 to 91 °F] produce all females).

Mapping and Information Needs

Mapping comments.—Desert tortoise habitat categories are mapped and described by BLM (BLM 1988a, 1990; associated *aztort_p* ArcView shapefiles of tortoise habitat received from the BLM Phoenix Field Office). The Arizona Gap Project mapped desert tortoise habitat based on granitic geology (substrates that permit burrowing) and areas within one kilometer (0.6 miles) of slopes 30% or greater (Arizona Gap Analysis Project 2001, reptile metadata Appendix 3–2; HO35RS shapefile received from the Sonoran Desert Field Station (Arizona Gap Program 1999a)). Desert tortoise occurrence data were acquired in 2001 from the Heritage Data Management System of the Arizona Game and Fish Department. Occurrence data include actual and “fuzzed” points and all are displayed (Figures C.15 and C.16) at a scale that does not reveal sensitive site information (a point is approximately 1.6 kilometer [one mile] across). The natural communities on the SDNM and their ecological condition were described and mapped by Morrison and others (2003). It is difficult to predict tortoise presence within caliche caves in xeroriparian areas as these are not mapped physical features.

Information needs.—More information is needed to evaluate the following topics:

- relative importance of the Vekol Valley as tortoise habitat or a movement corridor between mountain ranges (note numerous occurrences of tortoise in this area in Figures C.15 and C.16)
- relative importance and use of caliche caves
- frequency that tortoise cross Interstate 8 and Route 238, the areas where they cross, and mortality rates along these roads
- potential effects of global climate change on desert tortoise (including effects on rainfall, spring and summer forage availability, and invasive non-native species distributions)
- effect of livestock grazing on desert tortoise (direct effects and indirect effects on forage quantity/quality) in the Sonoran Desert (most research on this topic has been done in the Mojave Desert; see Hall and others 2005)
- effect of raven predation on desert tortoise in the Sonoran Desert (research on this topic has been done in the Mojave Desert).

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C.3.2 Red-backed whiptail (*Aspidoscelis xanthonota* = *Cnemidophorus xanthonotus* = *Cnemidophorus burti xanthonotus*)

Overview

Taxonomy.—A number of authors have considered the red-backed whiptail to be a subspecies of the canyon or giant spotted whiptail (*Cnemidophorus burti*): *C. burti xanthonotus*. The other subspecies of *C. burti* found in the United States is the giant spotted whiptail (*Cnemidophorus burti stictogrammus*) (Stebbins 1985). Some authors consider the red-backed whiptail to have full species status (*Cnemidophorus xanthonotus*), because it is geographically isolated and morphologically distinguished from *C. burti* (Crother 2000). More recently, Crother and others (2003) revised the genus name of *Cnemidophorus* to *Aspidoscelis* for North American whiptails. We recognize *Aspidoscelis xanthonota* here.

Rationale for selection as a conservation element.—*Regionally vulnerable.* The red-backed whiptail has a restricted distribution and is known from a limited number of isolated mountaintops and canyons in the Sonoran Desert in south-central Arizona. The red-backed whiptail is mentioned in the Sonoran Desert National Monument (SDNM) Proclamation (Clinton 2001). Two known localities of the red-backed whiptail occur on the SDNM: on Table Top and Javelina Mountains (BLM 1995, Turner and others 2000, HDMS 2002). Up until recently, the red-backed whiptail was recorded from only four mountain ranges: the Ajo and Puerto Blanco Mountains on Organ Pipe Cactus National Monument, Table Top Mountains, and Sierra Estrella Mountains (Stebbins 1985). Recent work has located the whiptail in 12 additional localities and in a greater range of habitats than was previously known; however, the red-backed whiptail remains one of the most isolated, distributionally restricted reptiles in the Sonoran Desert in Arizona and occupies a small minority of the habitat within its range (Rosen and others 2002). Additionally, populations are relatively small, geographically isolated (and possibly genetically differentiated), and particularly sensitive to drought and climate change (Rosen and Lowe 1996, Rosen and others 2002), which makes this taxon regionally vulnerable.

Specific habitat needs on the SDNM.—The species is known from rocky areas in juniper-oak woodlands, productive Arizona Upland Sonoran desertscrub, upper elevation Sonoran Desert montane grassland, and xeroriparian areas or canyons with dense scrub (Lowe 1964, Stebbins 1985, Pima County 2001, Rosen and others 2002). The red-backed whiptail requires a mosaic of open areas and vegetative cover where it forages (BISON-M 2002). On the SDNM the species is associated with the Mountain Upland, Mountain Xeroriparian Scrub, and Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes natural communities in the Sand Tank and Table Top Mountains. The specific habitat needs within these natural communities are not well understood; however, a perceived threat to this species across its known range is habitat degradation or loss due to wildfire, overgrazing, or global climate change (see **Stresses and sources of stress**). It is likely that red-backed whiptail habitat will persist if the areas occupied by the whiptail on the SDNM meet BLM land health standards and maintain their existing ecological condition as described by Morrison and others (2003).

Ecological Characteristics

Abundance.—Red-backed whiptail survival and reproductive rates have been linked to weather conditions, revealing declines in abundance during drought years (Rosen and Lowe 1996). Rosen and others (2002) estimate a density of 12 red-backed whiptails per hectare (30 per acre) based on transect monitoring in Alamo Canyon at Organ Pipe Cactus National Monument.

Habitat associations.—The red-backed whiptail has been located across an elevation gradient ranging from approximately 400 meters (1,300 feet) elevation in the Quitobaquito Hills to 1,400 meters (4,600

feet) near Mount Ajo (Organ Pipe Cactus National Monument) with the majority of observations ranging from 730 to 1,097 meters (2,400 to 3,600 feet; Rosen and others 2002). Our knowledge of the habitat associations of the red-backed whiptail has been greatly enhanced by recent work by Rosen and others (2002). Rosen and others (2002) describe these habitats as ranging from lower elevation (700 to 975 meters [2,300 to 3,200 feet]) canyon bottoms, xeroriparian scrub, and productive Arizona Upland rocky slopes to higher elevation (generally above 1,070 meters [3,500 feet]) montane Sonoran Desert grasslands. Rosen and others (2002) found that the red-backed whiptail did not show a particularly strong affinity for xeroriparian areas, as had been previously thought. Telemetried individuals were observed a mean distance of 22 meters (+/- 5 meters) (72 +/- 16 feet) from the closest wash edge in 49 observations (Rosen and others 2002).

The Arizona Upland rocky slope habitat described by Rosen and others (2002) is characterized by relatively high species diversity and cover and arid subtropical scrub plants including *Coursetia* (*Coursetia* sp.), Mexican jumping bean (*Sebastiania biloculare*), and croton (*Croton* sp.). These areas most closely correspond to the Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes natural community and Mountain Xeroriparian Scrub as described by Morrison and others (2003). Rosen and others (2002) noted red-backed whiptails on the north-facing slopes of the Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes natural community (a variant of the community described by Morrison and others [2003]) in areas with high cover of spike moss (*Selaginella* sp.). The habitat that Rosen and others (2002) describe as “montane Sonoran Desert grasslands” are equivalent to the Mountain Upland natural community as described by Morrison and others (2003) and Brown (1978), with species such as jojoba (*Simmondsia chinensis*), Arizona yucca (*Yucca arizonica*), crucifixion thorn (*Canotia holacantha*), and perennial grasses including tobosa (*Pleuraphis mutica*). Whiptails also were found scattered throughout rock outcrops in the Ajo Mountains in areas with boulders and juniper as well as open grass and shrub (Rosen and others 2002).

Food and water requirements.—Canyon spotted whiptails (*Aspidoscelis burti*) eat spiders, scorpions, and a variety of insects (BISON-M 2002). They feed by digging and nosing into leaf litter, soil, and among dense vegetation (BISON-M 2002). Specific information on food and water requirements of the red-backed whiptail is not available.

General life history.—Many species of whiptails are parthenogenetic: that is, their populations consist only of females who reproduce asexually by laying unfertilized eggs that hatch into females (Stebbins 1985). The red-backed whiptail, however, has both males and females and reproduces sexually. Individuals breed from May through August and females produce between one and four eggs per clutch (Stebbins 1985, Pima County 2001), which they lay in burrows that they dig themselves (BISON-M). The giant spotted whiptail (*Aspidoscelis burti stictogramma*) produces more than one clutch per year, but this has not been shown for *A. xanthonota* (Pima County 2001). Red-backed whiptails are active during the day from mid-spring through early fall (Pima County 2001) and hibernate in the winter (BISON-M 2002).

Biotic interactions.—The range of the tiger whiptail (*Aspidoscelis tigris*) overlaps with that of the red-backed whiptail, but the tiger whiptail is often found in the valleys and lower slopes. Where the two species co-occur on the slopes they may be competitors (Rosen and others 2002). In Alamo Canyon (on Organ Pipe Cactus National Monument), the primary predator of adult red-backed whiptail lizards is probably the Sonoran whipsnake (*Masticophis bilineatus*) (Rosen and others 2002). Another closely related species, the Sonoran spotted whiptail (*A. sonorae*), is speculated to be a potential competitor with the red-backed whiptail (Rosen and others 2002). At present the two species distributions do not overlap; however, Rosen and others (2002) caution biologists and other collectors against accidental releases of the Sonoran spotted whiptail.

Landscape context.—According to the Pima County Sonoran Desert Conservation Plan (2001), the red-backed whiptail requires 809 square meters (about 0.2 acres) for a home range. As a result, a minimum patch size of 20 hectares (50 acres) is required to support a viable population of 250 pairs. The species is not migratory. Populations occur in disjunct locales and corridors may be required for connectivity and gene flow between populations, however, corridor needs and potential barriers to dispersal are unknown (Pima County 2001). A connectivity goal for this species in Pima County is to maintain over/underpasses for dispersal across highways and major roads (Pima County 2001). Four adult red-backed whiptails with surgically implanted radios were successfully tracked with telemetry over two to eight weeks and were found to move within an area of 60 to 188 meters (200 to 620 feet) by 40 to 223 meters 130 to 730 feet) (Rosen and others 2002). This translates to approximately 2,400 to 41,924 m² (0.6 to 10.4 acres) which is significantly larger than the home range estimated by Pima County (2001). In any case, habitat fragmentation is not likely to be a threat in red-backed whiptail habitat on the SDNM, because they are found primarily in relatively rugged and remote areas in the Table Top Wilderness and at higher elevations in the Sand Tank Mountains on the SDNM and BMGR.

Status, Threats, and Management

Distribution.—The distribution pattern of the red-backed whiptail suggests that this species may have once been more widely distributed but has retreated to suitable habitat in relatively mesic Sonoran Desert mountains as the climate has become hotter and drier. The red-backed whiptail is known from scattered Sonoran Desert mountain ranges in south-central Arizona. The SDNM is near the northern edge of the red-backed whiptail's range (Figures C.19 and C.20). A population is also known from north of the monument in the Sierra Estrella Mountains. The distribution and status of red-backed whiptails is not known in Sonora, Mexico. The red-backed whiptail has not been located in the Saucedo Mountains on the BMGR, but is expected to occur there (Rosen and others 2002). It is not expected to occur in the Maricopa Mountains (Rosen and others 2002).

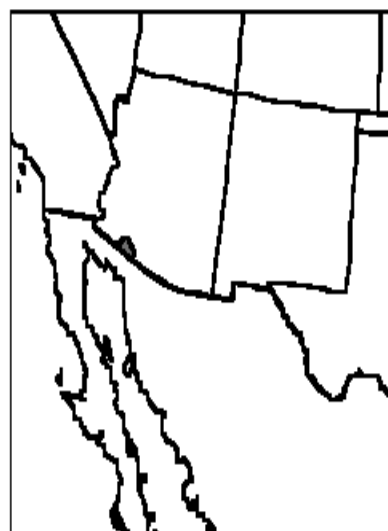


FIGURE C.19 Range of the Red-Backed Whiptail (*Aspidoscelis xanthonota*). From Pima County (2001).

Conservation status.—Status ranks are based on identifying the red-backed whiptail taxon as a subspecies (NatureServe 2003). The red-backed whiptail has a global rank of G4T2, which indicates that the species (*Aspidoscelis burti*) is apparently secure but that the subspecies (*A. burti xanthonota*) is globally imperiled because of rarity (NatureServe 2003). This makes it vulnerable to extinction or elimination. In Arizona it has an S2 ranking (NatureServe 2003). *Aspidoscelis burti* is classified as a sensitive species by the BLM (2000d) and the USFS (2000) and was a former Category 2 candidate for protection under the Endangered Species Act; however, the BLM status likely does not extend to *A. xanthonota* (T. Cordery, pers. comm.). The red-backed whiptail is a priority vulnerable species under Pima County's Sonoran Desert Conservation Plan (Pima County 2001), and the Heritage Data Management System of the Arizona Game and Fish Department tracks the occurrence of the taxon.

Stresses and sources of stress.—Table C.14 identifies potential stresses and sources of stress confronting the red-backed whiptail across the species' range. At present the primary threat to this species on the SDNM is climate change. The red-backed whiptail is particularly sensitive to drought (Rosen and Lowe 1996, Rosen and others 2002), which climate change may exacerbate. Areas occupied by the red-backed whiptail on the SDNM are classified by Morrison and others (2003) as Condition Class 3, which is assigned to areas that show the least signs of anthropogenic stress within the study area and are closest to

Distribution of the red-backed whiptail

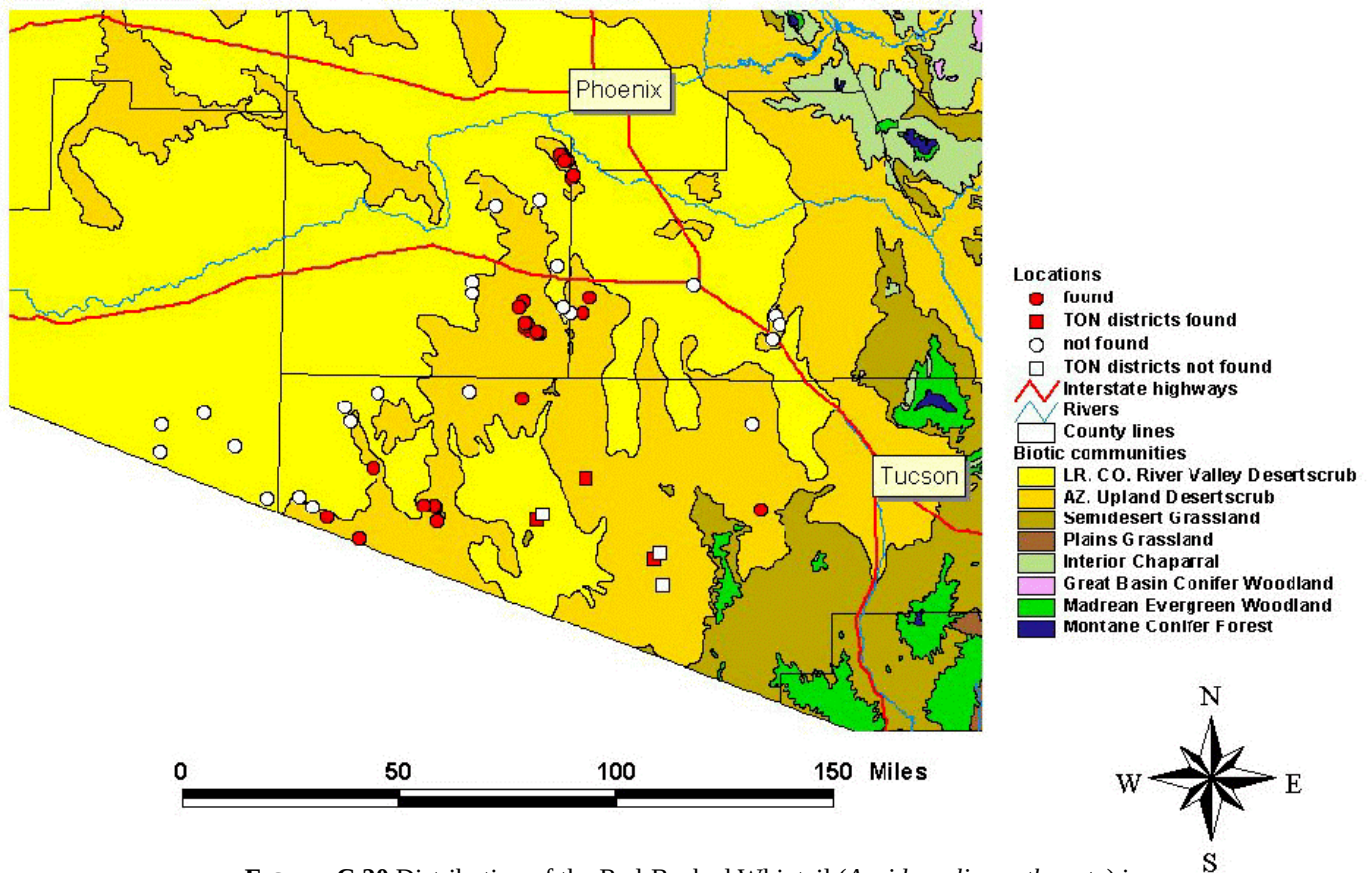


FIGURE C.20 Distribution of the Red-Backed Whiptail (*Aspidoscelis xanthonota*) in Arizona (from Rosen and others 2002). Biotic communities are based on Arizona Gap Program (1998). Occupied locations include the Sand Tank and Table Top Mountains. Locations in the Sand Tank Mountains include Javelina Mountain on the SDNM and Bender Spring on the BMGR.

representing baseline condition. Invasive non-natives plants, including red brome and Arabian grass (*Schismus arabicus*), were found, however, with low percent cover at localized sites in the Sand Tank and Table Top Mountains (Morrison and others 2003). If these plants spread throughout these areas or increase in cover, they could represent a threat to the red-backed whiptail in the future by providing a fuel source for fires.

Mapping and Information Needs

Mapping comments.—Potential habitat of the red-backed whiptail has been modeled in Pima County as part of the Sonoran Desert Conservation Plan. The model is based on vegetation (oak, paloverde mixed cacti, and mesquite), elevation (primarily between 800 to 1,200 meters [2,625 to 3,935 feet], but ranging from 600 to 1,600 meters [1,970 to 5,250 feet]), slope, and landform (rocky canyons and tertiary volcanic landforms) (Pima County 2001). A similar model could be developed for the potential habitat of red-backed whiptail on the SDNM, however, existing occurrence data for the red-backed whiptail in the Sand Tank and Table Top Mountains is the best source of information on where the species should be found.

TABLE C.14 Red-Backed Whiptail: Stresses and Sources of Stress

Stress	Source of Stress	Geographic Scope of Potential Impacts	Comments or Source of Information
Habitat degradation	Improper livestock management	Regional	Pima County (2001). Heavy grazing may impact whiptail food availability or cause increased predation by raptors along fencelines (Rosen and others 2002).
	Climate change	Regional and SDNM	Considered to be the primary threat to the species (Rosen and others 2002)
Habitat loss	Wildfire (caused by invasive non-native species)	Regional	Invasive non-native grasses, such as red brome (<i>Bromus rubens</i>) and buffelgrass (<i>Pennisetum ciliare</i>), may increase the frequency and intensity of fires in the limited area of occupied habitat (Pima County 2001).
Altered composition (population declines)	Drought	Regional and SDNM	Drought can decrease reproductive success and population density (Rosen and Lowe 1996).
	Collection	Regional	The species is expected to become increasingly valued in the pet trade in the future. Collection (including by scientists) could have impacts at sites with low whiptail densities, particularly on the Tohono O’odham Nation (Rosen and others 2002).

The general localities of red-backed whiptails on and in the vicinity of the SDNM are displayed in Figure C.21 in relationship to natural community distributions. Red-backed whiptail occurrence data are a mixture of “fuzzed” and actual points in the Sand Tank Mountains (HDMS 2002) and are based on a coarse locality (based on Township/Range/Section information) for a specimen collected in 1981 from Table Top Mountain (Rosen and others 2002). These points are depicted to enable a comparison of the occurrence of whiptails in relation to the natural communities of the SDNM, but are displayed at a coarse scale that does not reveal sensitive site localities.

Information needs.—The most comprehensive study on red-backed whiptails to date is by Rosen and others (2002). Some of their recommendations for further research include: (1) further examine local differentiation and uniqueness between populations; (2) monitor this taxon as an indicator of the ecological effects of climate change, which is likely to significantly affect this taxon, and (3) determine the distribution and variation of the red-backed whiptail in Sonora. Other general questions include: What are the specific habitat needs of the red-backed whiptail on the SDNM or in other locations? What are the home range and dispersal requirements of red-backed whiptails?

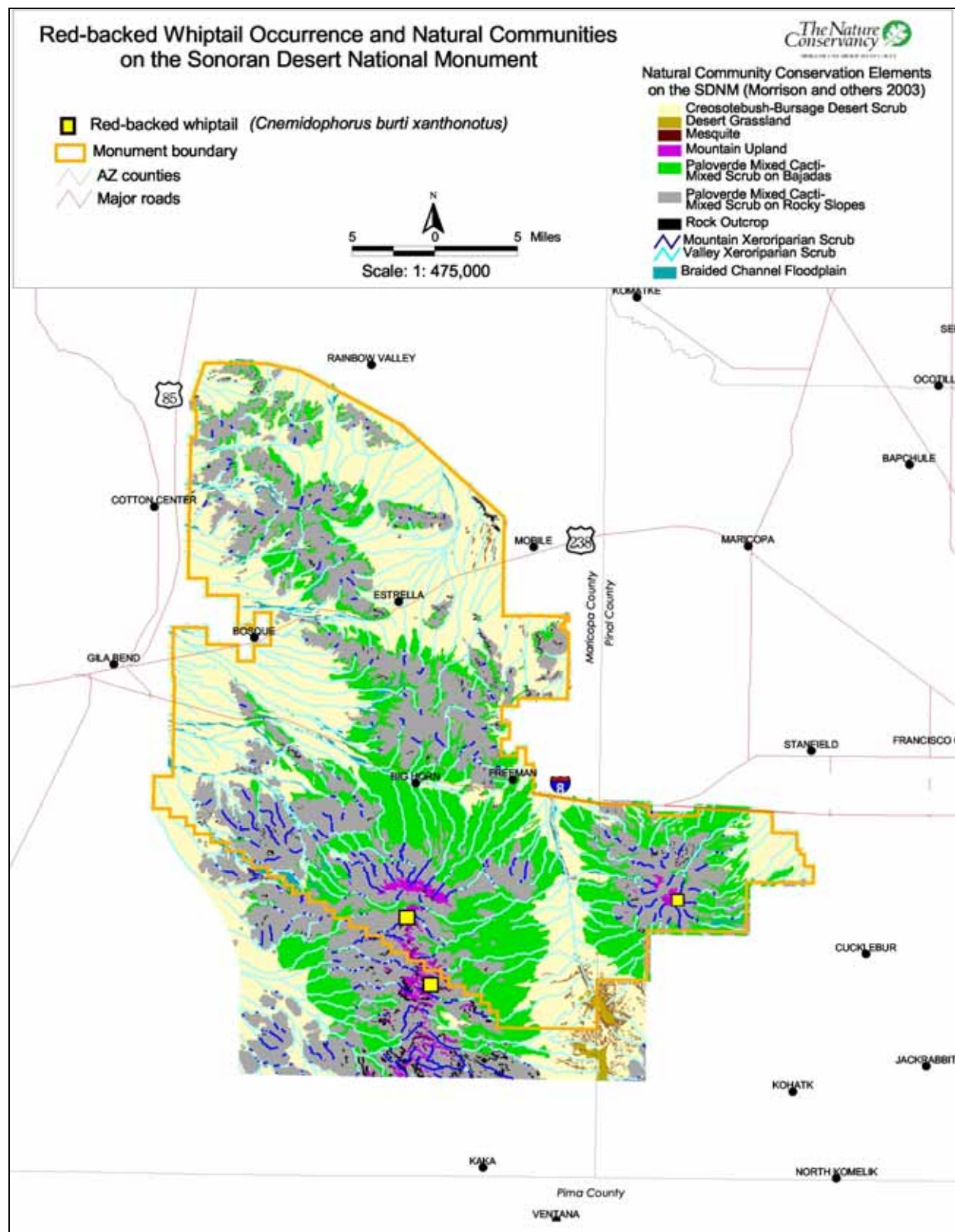


FIGURE C.21 Red-Backed Whiptail Occurrences on the Sonoran Desert National Monument in Relation to Natural Community Distributions

C.3.3 Maricopa leaf-nosed snake (*Phyllorhynchus browni lucidus*)

Overview

Taxonomy.—The leaf-nosed snakes, genus *Phyllorhynchus*, are represented by two species: the saddled leaf-nosed snake (*Phyllorhynchus browni*) and the spotted leaf-nosed snake (*Phyllorhynchus decurtatus*). The taxonomy of these snakes is not well resolved. Some authors recognize five subspecies of the spotted leaf-nosed snake (*P. decurtatus decurtatus*, *P. d. arenicola*, *P. d. norrisi*, *P. d. nubilus*, and *P. d. perkinsi*) and four subspecies of the saddled leaf-nosed snake (*P. browni browni*, *P. b. fortitus*, *P. b. klauberi*, and *P. b. lucidus*) (reviewed by McDiarimid and McCleary 1993). Two of the saddled leaf-nosed snake subspecies are found in Arizona: the Maricopa leaf-nosed snake (*P. browni lucidus*) and the Pima leaf-nosed snake (*P. browni browni*) (Stebbins 1985); however, the taxonomy of the nominal subspecies are not well-studied and may represent local ecological adaptations rather than the evolutionary history of the taxa (McDiarimid and McCleary 1993, Crother 2000). Recent studies on leaf-nosed snakes at Organ Pipe Cactus National Monument found that color variation in *P. browni* subspecies show abrupt transitions rather than clinal variation, which suggests that *P. browni lucidus* and *P. browni browni* deserve distinct taxonomic status as subspecies or even full species (Rosen and others 1996; P. Rosen, pers. comm.). Additional research is needed to clarify these taxonomic uncertainties.

Both the saddled and spotted leaf-nosed snakes are known from within or near the boundary of the Sonoran Desert National Monument (SDNM) (Turner and others 2000; P. Rosen, pers. comm.). The taxonomic unit selected as a conservation element on the SDNM is the Maricopa leaf-nosed snake (*Phyllorhynchus browni lucidus*), because the SDNM includes habitat for this subspecies and the monument represents an important conservation opportunity for this narrowly distributed taxon. The Maricopa leaf-nosed snake, and all leaf-nosed snakes in general, are poorly known biologically and few data exist regarding their occurrences. Much of the available scientific information is applicable to the saddled leaf-nosed snake (*P. browni*) or to leaf-nosed snakes in general (*Phyllorhynchus* species). Probably the most detailed information on leaf-nosed snakes comes from Rosen and others' (1996) intensive study of the two species from 1987 to 1995 on Organ Pipe Cactus National Monument (ORPI). Whenever possible, information related specifically to the Maricopa leaf-nosed snake subspecies is presented in this report; however, in some cases the only information available is on closely related taxa.

Rationale for selection as a conservation element.—*Regionally vulnerable.* The Maricopa leaf-nosed snake is considered regionally vulnerable because it has a restricted range in southern Arizona, and some populations have been observed to be declining. Declines are likely due to losses of former habitat areas that have undergone urban and agricultural development in the Phoenix area (Rosen and others 1996). Few records for the Maricopa leaf-nosed snake exist in museum collections or in the Heritage Data Management System (HDMS) of the Arizona Game and Fish Department. The presence of the Maricopa leaf-nosed snake has not been confirmed within the boundaries of the Sonoran Desert National Monument, but a focused search has not yet been conducted. It is expected to occur in appropriate habitat on the monument, as the SDNM is situated in the center of the Maricopa leaf-nosed snake's distribution. The SDNM is an important area to conserve the taxon because the monument is free of many of the threats that occur elsewhere with the taxon's range (P. Rosen, pers. comm.).

Specific habitat needs on the SDNM.—The principle cause of population declines of the Maricopa leaf-nosed snake is thought to be attributable to habitat loss (Rosen and others 1996). Where its habitat is intact, the specific habitat needs of leaf-nosed snakes (including the Maricopa leaf-nosed snake subspecies) are not well known or defined. Because they are specialized as substrate burrowers, leaf-nosed snakes presumably require intact soils that have not been affected by anthropogenic uses that can cause soil compaction. Based on research conducted at ORPI, the Maricopa leaf-nosed snake occurs on the upper and middle bajadas and extends onto lower bajadas on sandy loam soils (Rosen and others

1996). Relative to the natural communities on the SDNM described and mapped by Morrison and others (2003), the Maricopa leaf-nosed snake is most likely to be found associated with two of the three matrix communities on the monument: Creosotebush-Bursage Desert Scrub and Paloverde-Mixed Cacti-Mixed Scrub on Bajadas. Variants of these two natural communities that represent a transition zone between them are likely to be the main habitat for the Maricopa leaf-nosed snake (P. Rosen, pers. comm.). This subspecies may be patchily distributed and rare in portions of the SDNM. It is not expected to occur on Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes, nor on the clay soils in the Vekol Valley (Desert Grassland natural community) where soil burrowing would be difficult (P. Rosen, pers. comm.). The Maricopa leaf-nosed snake is expected to occur on friable sandy or gravelly soils on the upper bajadas of Javelina Mountain and in the Maricopa Mountains. Additional information is needed to determine the most important areas for this taxon on the SDNM and its specific habitat needs. Some additional comments on the habitat needs of leaf-nosed snakes can be found in the **Habitat associations** section.

Ecological Characteristics

Abundance.—Little is known of the factors that affect abundance of leaf-nosed snakes. Rosen and others (1996) found that abundance of the spotted leaf-nosed snake declined during and after a period of drought, but saddled leaf-nosed snakes did not show this trend. On ORPI the population density of the two species of leaf-nosed snakes (*P. browni* and *P. decurtatus*) in productive habitat was estimated as 0.52 individuals per hectare (0.21 individuals per acre) (Rosen and others 1996), and densities of the spotted leaf-nosed snake subspecies ranged from one individual per hectare (0.40 individuals per acre) to one individual per ten hectares (0.04 individuals per acre) (Rosen and others 1996). The Maricopa leaf-nosed snake may be expected to occur at higher densities in occupied habitat on the SDNM because the monument includes habitat that is relatively mesic compared with habitat found in other parts of the subspecies' distribution (P. Rosen, pers. comm.).

Habitat associations.—The saddled leaf-nosed snake inhabits areas with rocky or sandy soils from 300 to 900 meters (1,000 to 3,000 feet) above sea level (Stebbins 1985). In Arizona it is found in desertscrub with a variety of associated plants, including with mesquite (*Prosopis* spp.), saltbush (*Atriplex* spp.), creosotebush (*Larrea tridentata*), paloverde (*Cercidium* spp.), and saguaro (*Carnegiea gigantea*) (Rosen and others 1996). On ORPI the Maricopa leaf-nosed snake seems to prefer brushy areas, primarily mesquite and secondarily saltbush (Rosen and others 1996). It burrows into sandy or rocky soils or under fallen logs or debris (NatureServe 2003). A multivariate analysis of habitat characteristics of both species of leaf-nosed snake on OPRI found that they co-occur broadly in non-rocky habitat throughout the study area (Rosen and others 1996). Rosen and others (1996) also found a slight tendency for the saddled leaf-nosed snake to occupy the upper bajadas and to be more associated with upland (rather than xeroriparian) habitat in comparison to the spotted leaf-nosed snake. The Arizona Gap Analysis Project's (2001) model (Arizona Gap Program 1999b) of saddled leaf-nosed snake habitat shows that the snake could occur throughout the SDNM outside of the Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slope and Mountain Upland natural communities (Figure C.22).

Food and water requirements.—Saddled leaf-nosed snakes are highly specialized feeders, subsisting almost entirely on lizard eggs (with one record of consumption of a small lizard) (Stebbins 1985, Rosen and others 1996). They can sustain a low metabolic rate and survive long periods of time without food (Rosen and others 1996).

General life history.—The leaf-nosed snakes are soil burrowers. They are strictly nocturnal and are most active above ground on humid, rainy nights in June (NatureServe 2003). They are inactive in cold temperatures or extreme heat. Sexual maturity is delayed in these snakes to two years of age for males and two to three years for females (Rosen and others 1996). Females lay two to five eggs in an underground burrow or den (dug by the snakes themselves) in mid June (BISON-M 2002, NatureServe

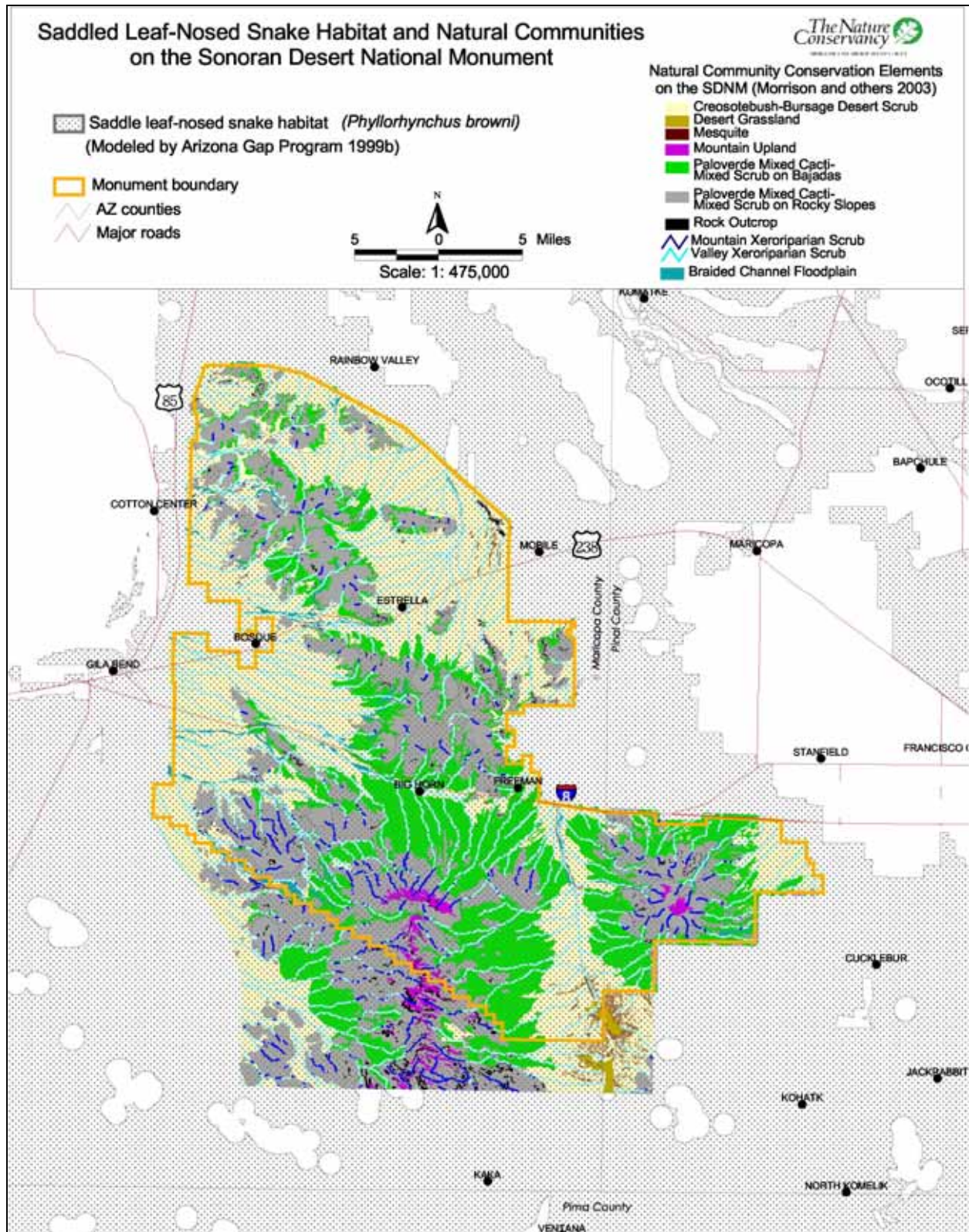


FIGURE C.22 Saddled Leaf-Nosed Snake Habitat in Relation to Natural Communities on the Sonoran Desert National Monument

2003). Because the snakes are relatively long-lived and have delayed reproduction, they may be more vulnerable to anthropogenic influences than other snakes (Rosen and others 1996).

Biotic interactions.—The saddled leaf-nosed snake occupies the same habitat as the spotted leaf-nosed snake and they may compete for food and other resources (Rosen and others 1996).

Landscape context.—Mark-recapture studies of the closely related spotted leaf-nosed snake in Arizona showed that their density ranged from one individual per hectare (0.40 individuals per acre) to one individual per ten hectares (0.04 individuals per acre) (Rosen and others 1996). Based on these data, a relatively viable population of 250 pairs would require between 500 to 5,000 hectares (1,235 to 12,355 acres). Similar to other species of snakes, the Maricopa leaf-nosed snake is attracted to warm paved surfaces at night and may therefore be subject to high rates of mortality from vehicular traffic (Rosen and others 1995). Although snakes can cross roads, roads may present a barrier to dispersal because high mortality rates can cause local population declines in some species (Rosen and Lowe 1994).

Status, Threats, and Management

Distribution.—The saddled leaf-nosed snake is known from south-central Arizona in Maricopa, Pinal, and Pima Counties (Figure C.23) to the southern base of the Mogollon Rim and south through Sonora to south-central Sinaloa (Stebbins 1985). The distribution of the saddled leaf-nosed snake (habitat as modeled by the Arizona Gap Program 1999b) in relation to land management is displayed in Figure C.24. The Maricopa leaf-nosed snake occurs in a narrow band in appropriate habitat on the western portion of the distribution shown in Figures C.23 and C.24, in extreme western Pinal county, southeastern Maricopa county, and western Pima county near Ajo, Why, and at OPRI. The Maricopa leaf-nosed snake also was documented in the Tucson Mountains, west of Tucson (Marshall and others 2000).

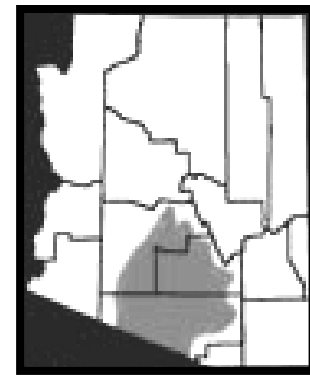


Figure C.23 Distribution of the Saddled Leaf-Nosed Snake (*Phyllorhynchus browni*) in Arizona.

Conservation status.—The saddled leaf-nosed snake is endemic to the Sonoran Desert Ecoregion. Its status and biology are poorly known, few studies have been conducted on the species, and only a paucity of collection records exist. The Maricopa leaf-nosed subspecies is ranked as G5T2, which indicates that the species is demonstrably secure but that the subspecies taxon is imperiled (NatureServe 2003). Imperilment is due to rarity and habitat loss occurring within its restricted range. The Maricopa leaf-nosed snake is designated a Sensitive Species by the US Forest Service (2000) and its occurrence is tracked by the Arizona Game and Fish Department Heritage Data Management System (HDMS).

The Maricopa leaf-nosed snake was a conservation target (or conservation element) in the multi-agency, international conservation assessment of the Sonoran Desert Ecoregion (Marshall and others 2000). The occurrence of this taxon, along with the occurrence of many other species and natural communities, was used to identify priority conservation areas important for protecting and maintaining the ecoregion's biodiversity. At the time of the Sonoran Desert ecoregional assessment, the majority of the 19 occurrences in the HDMS database for this subspecies were from ORPI and on BLM land north of ORPI in the Ajo Block. No occurrence information for the Maricopa leaf-nosed snake existed on the SDNM in the HDMS. Five conservation areas were identified in the ecoregional assessment that included the Maricopa leaf-nosed snake: (1) Pinacate/Organ Pipe/Goldwater Complex, (2) Arnett Creek, (3) Tonto Creek/Salt and Verde/Meddler Wash, (4) San Simon/Sonoyta Valley, and (5) Tucson Mountains (Marshall and others 2000). The first conservation area listed overlaps with BLM land in the Phoenix South Planning area in the Ajo Block. Because the global rank of the subspecies is a G5T2 (treated as a

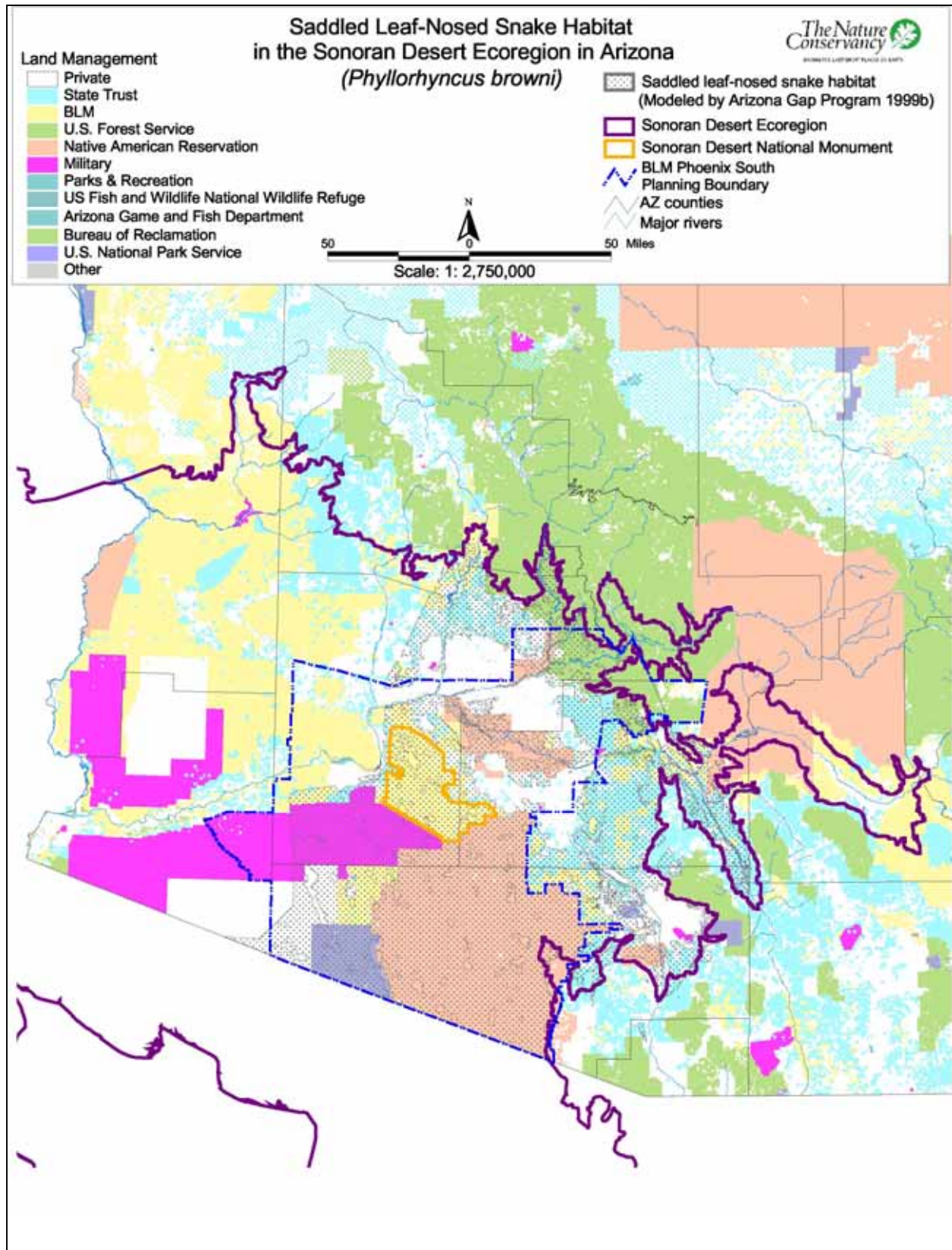


FIGURE C.24 Saddled Leaf-Nosed Snake Habitat in Arizona in Relation to Land Management

G2 in the Sonoran Desert ecoregional assessment), the conservation goal set forth in Marshall and others (2000) was to maintain all viable occurrences of the subspecies. At the time of the ecoregional assessment, 20 occurrences of the Maricopa leaf-nosed snake had been documented but only six of these were included in conservation sites (Marshall and others 2000). In other words, the conservation goals for the Maricopa leaf-nosed snake will not be met by focusing solely on the sites delineated in the ecoregional assessment and additional areas are required to secure the long-term viability of this taxon. With appropriate management for this subspecies' needs, the SDNM could contribute to this goal.

Healthy populations seem to occur on OPRI where habitat is intact (Rosen and others 1996). The status of the subspecies on BLM land north of OPRI has not been reported; however, according to data associated with the Sonoran Desert Ecoregion assessment (Marshall and others 2000), the Maricopa leaf-nosed snake was recorded there as early as 1952 and as recently as 1994. Occurrence and status of the Maricopa leaf-nosed snake on the Tohono O'odham Nation are not known.

Stresses and sources of stress.—Table C.15 identifies potential stresses and sources of stress confronting the Maricopa leaf-nosed snake across the subspecies' range. The main threat to the leaf-nosed snakes is habitat loss. The saddled leaf-nosed snake has suffered habitat loss to urban development and sprawl around Phoenix and Tucson, and to agriculture in the Avra Valley. The Maricopa leaf-nosed snake has lost habitat in the northeastern portion of its range around Phoenix and will continue to lose habitat as the communities around the SDNM grow in the future, particularly Maricopa and Buckeye, which are expecting great increases in population in the coming decades. The Maricopa leaf-nosed snake has a very restricted distribution with populations found in localized areas. As a result, a potential threat is that small, isolated populations may be more vulnerable to population fragmentation and declines.

TABLE C.15 Maricopa Leaf-Nosed Snake: Stresses and Sources of Stress

Stress	Source of Stress	Geographic Scope of Potential Impacts	Comments or Source of Information
Habitat loss	Historic and current conversion of native habitat to agriculture and urban development	Regional	Especially from growth of Phoenix and its suburbs (Rosen and others 1996).
Habitat degradation (soil compaction)	Soil compaction can be caused by inappropriate livestock grazing management practices or off-road vehicle use	Regional and SDNM	Soil compaction prohibits leaf-nosed snakes from burrowing. Off-road vehicle use on the SDNM is not permitted (but occurs illegally in some areas).
Excessive mortality	Mortality from vehicular traffic on roads	Regional and SDNM	Rosen and others (1996).

The potential threats to the Maricopa leaf-nosed snake on the SDNM include soil compaction, which may be caused by historic or current, illegal off-road vehicle uses or inappropriate livestock management and road mortality along paved roads (Interstate 8 and Route 238). Because the Maricopa leaf-nosed snake has a specialized diet, a potential secondary threat on the SDNM and elsewhere is any activity or use that causes a decline in lizard abundance or lizard reproductive success. In the Mojave Desert, off-road vehicle use and sheep grazing reduced ground cover and caused declines in lizard abundance and biomass (Busack and Bury 1974). The effects of pesticide drift on lizard abundance or reproductive success is not known, but could have important implications for the conservation of leaf-nosed snakes.

Mapping and Information Needs

Mapping comments.—The saddled leaf-nosed snake habitat displayed in Figures C.23 and C.24 was modeled by the Arizona Gap Program (1999b). The Arizona Gap Analysis Project final report (Arizona Gap Analysis Project 2001) states that vertebrate habitat distribution coverages were modeled, in part, on their association with vegetation types and by applying masks based on geographic range, elevation, expert opinion, or other variables, as appropriate. As modeled by the Gap Program, saddled leaf-nosed snake habitat was absent on rocky slopes and is found outside one kilometer (0.6 miles) of slopes 50% or greater up to an elevation of 1070 meters (3,500 feet) (Arizona Gap Analysis Project 2001, reptile metadata Appendix 3–2). Based on Arizona Gap vegetation classes, saddled leaf-nosed snake habitat was primarily associated with Sonoran desertscrub, including both creosotebush-bursage and paloverde-mixed cacti (Arizona Gap Analysis Project 2001, Appendix 5–3b).

Information needs.—Focused surveys may be required to confirm the presence of the Maricopa leaf-nosed snake on the SDNM and to evaluate its relative abundance within the monument and in comparison to other parts of its range. Additional information is needed on many aspects of the biology and conservation of the Maricopa leaf-nosed snake, including the factors that influence its habitat associations (such as plant communities or soil types) and more quantitative and spatially explicit information on threats to the subspecies on the SDNM and elsewhere.

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C.3.4 Tucson shovel-nosed snake (*Chionactis occipitalis klauberi*)

Overview

Taxonomy.—Four subspecies of the western shovel-nosed snake (*Chionactis occipitalis*) currently are recognized: the Mojave shovel-nosed snake (*C. o. occipitalis*), the Nevada shovel-nosed snake (*C. o. talpina*), the Colorado Desert shovel-nosed snake (*C. o. annulata*), and the Tucson shovel-nosed snake (*C. o. klauberi*) (Crother 2000, Mahrtdt and others 2001). In the vicinity of the Sonoran Desert National Monument (SDNM), populations of *C. occipitalis* have a phenotype that is considered intermediate between the Colorado Desert and Tucson shovel-nosed subspecies characterized by a unique coloration (darkened scale edges on secondary cross bands; Klauber 1951, Stebbins 1985). Although it is generally agreed that there are four subspecies of the western shovel-nosed snake, the taxonomy is not well resolved and some suggest that with genetic work some of these populations may be elevated to full species status (Pima County 2001, Rosen 2003). In addition, local variation (such as the phenotype that has characteristics of both the Colorado Desert and Tucson subspecies described above) may be significant and, as a result, these local populations may represent unique genetic units (P. Rosen, pers. comm.).

The taxonomic unit selected as a conservation element on the SDNM is *C. o. klauberi* and the population that is considered intermediate between *C. o. klauberi* and *C. o. annulata*. To simplify the language in this report, both of these taxa—the Tucson subspecies and the intermediate phenotype described above—will be referred to as the “Tucson shovel-nosed snake,” except where otherwise noted.

Rationale for selection as a conservation element.—*Regionally vulnerable.* The Tucson shovel-nosed snake has a restricted distribution, as it is known only from a small area in Arizona in portions of Pinal, Maricopa, and Pima Counties. This taxon is considered regionally vulnerable because much of its formerly occupied lowland valley floor habitat within an already restricted range has been cleared or severely impacted by agricultural and urban development. This altered habitat no longer seems to be occupied. The greatest abundance of the Tucson shovel-nosed snake is estimated to occur west of Mobile on the SDNM (P. Rosen, pers. comm.). The monument largely lacks the main threats to this subspecies (habitat loss and degradation) and may therefore represent the best opportunity to protect the taxon (P. Rosen, pers. comm.). As a result, the population that is currently characterized as intermediate between *C. o. klauberi* and *C. o. annulata* may represent one of the only opportunities to protect the Tucson shovel-nosed snake (P. Rosen, pers. comm.).

Specific habitat needs on the SDNM.—The Tucson shovel-nosed snake is a nocturnal animal that burrows in loose sand by “sand swimming” (wriggling through sand rather than tunneling; Stebbins 1985). Little is known about the specific habitat needs of this subspecies. Because of its burrowing habits, however, the shovel-nosed snake is found in areas with soft sandy loams, loose soil, fine, wind-blown sands (such as in washes), or occasionally on rocky hillsides with pockets of sand among rocks (Stebbins 1985, Pima County 2001). The snake requires these deep valley fill soils for burrowing and nesting. The western shovel-nosed snake (and associated subspecies) often spends the day underneath the soil substrate around creosotebush (*Larrea tridentata*), and nocturnal foraging generally occurs within 0.9 to 1.4 m² (10 to 15 ft²) surrounding the bush (Pima County 2001). Creosotebush also serves as foraging and escape habitat (Stebbins 1985, Pima County 2001). Aside from these uses of creosotebush, little is known about the specific needs of the species in terms of other vegetation characteristics or plant communities.

The Tucson shovel-nosed snake has been observed on the SDNM near Mobile, where it has been recorded at various localities along the Maricopa-Mobile Road (Route 238) (P. Rosen, pers. comm.). In the vicinity of Mobile, the Tucson shovel-nosed snake was found at sites with soils that had a high

percentage (ranging from 49 to 85%) of fine sand, silt, and clay (classified as sandy loams, loamy sands, gravelly-sandy loams, and silty-sandy loams; P. Rosen, pers. comm.). The Tucson shovel-nosed snake was found in areas on the SDNM that correspond to Creosotebush-Bursage Desert Scrub and Valley Xeroriparian Scrub natural communities as described and mapped by Morrison and others (2003). Although the specific habitat needs of the Tucson shovel-nosed snake on the monument are not well understood, it is known that this is one of the few areas in its range where individuals are found reliably. Existing descriptions of the occupied habitat, including natural community and ecological condition characterizations (Morrison and others 2003), and recreation impact assessments (Foti and Patterson 2003) may provide baseline conditions that can help to set the desired future conditions needed to maintain viable shovel-nosed snake habitat into the future.

Figure C.25 depicts the habitat of the western shovel-nosed snake (as modeled by the Arizona Gap Program 1999c) in relation to the natural communities on the SDNM (as mapped by Morrison and others 2003). It appears that the majority of the potential habitat for the shovel-nosed snake on the monument is in Creosotebush-Bursage Desert Scrub and embedded Valley Xeroriparian Scrub and Braided Channel Floodplain natural communities, with some possible extensions into Paloverde-Mixed Cacti-Mixed Scrub communities south of Interstate 8. Along with additional information on soils, this map could facilitate identifying other potential habitat areas for the Tucson shovel-nosed snake on the monument.

Ecological Characteristics

Abundance.—The western shovel-nosed snake is most abundant within the Gran Desierto dunes, Mojave Desert, and Lower Colorado River Valley (P. Rosen, pers. comm.). Information on abundance and density of the Tucson shovel-nosed snake subspecies is quite limited and factors that affect density are unknown (Pima County 2001). Road cruising and pitfall trapping are effective methods to monitor the subspecies. The tracks of shovel-nosed snakes are distinctive in the sand and might also be useful to evaluate relative density (Pima County 2001).

Habitat associations.—The western shovel-nosed snake occurs from below sea level to close to 1,500 meters elevation (4,920 feet). The species is found in desert washes, valleys, sand dunes, and bajadas on sparsely vegetated, sandy to gravelly habitats (Mahrdrdt and others 2001). Habitat associations for the species include creosotebush, mesquite bosque, xeroriparian scrub, areas with desert grasses, and Sonoran desertscrub (BISON-M 2002, NatureServe 2003).

The Tucson shovel-nosed snake is found at the arid edge of the Arizona Upland subdivision of the Sonoran Desert. In this region, the shovel-nosed snake is found in productive creosote-mesquite floodplains, creosotebush-bursage desert scrub, and in xeroriparian washes (P. Rosen, pers. comm.). Soils are primarily sandy loams with sparse gravel. At 11 sites where the subspecies was observed (eight of which were in the vicinity of Mobile, Arizona), soil characterizations had a mean percent composition of 10.4% gravel, 31.0% coarse sand, and 58.6% fine sand, silt, and clay (P. Rosen, pers. comm.).

Food and water requirements.—Food preferences of the Tucson shovel-nosed snake are likely similar to that recorded for the species (western shovel-nosed snake). The western shovel-nosed snake eats adult and larval stages of insects, spiders, centipedes, and buried moth pupae (Stebbins 1985). The Tucson shovel-nosed snake, however, may be somewhat unique in its food habits compared with other subspecies because it seems to be resistant to scorpion (*Vejovis spinigeris*) venom, and scorpions may constitute a significant portion of the Tucson shovel-nosed snake's diet (Pima County 2001).

General life history.—The western shovel-nosed snake lays two to four eggs in summer (Stebbins 1985). It lays its eggs in an underground burrow or den that the snake creates itself (BISON-M 2002). Based on

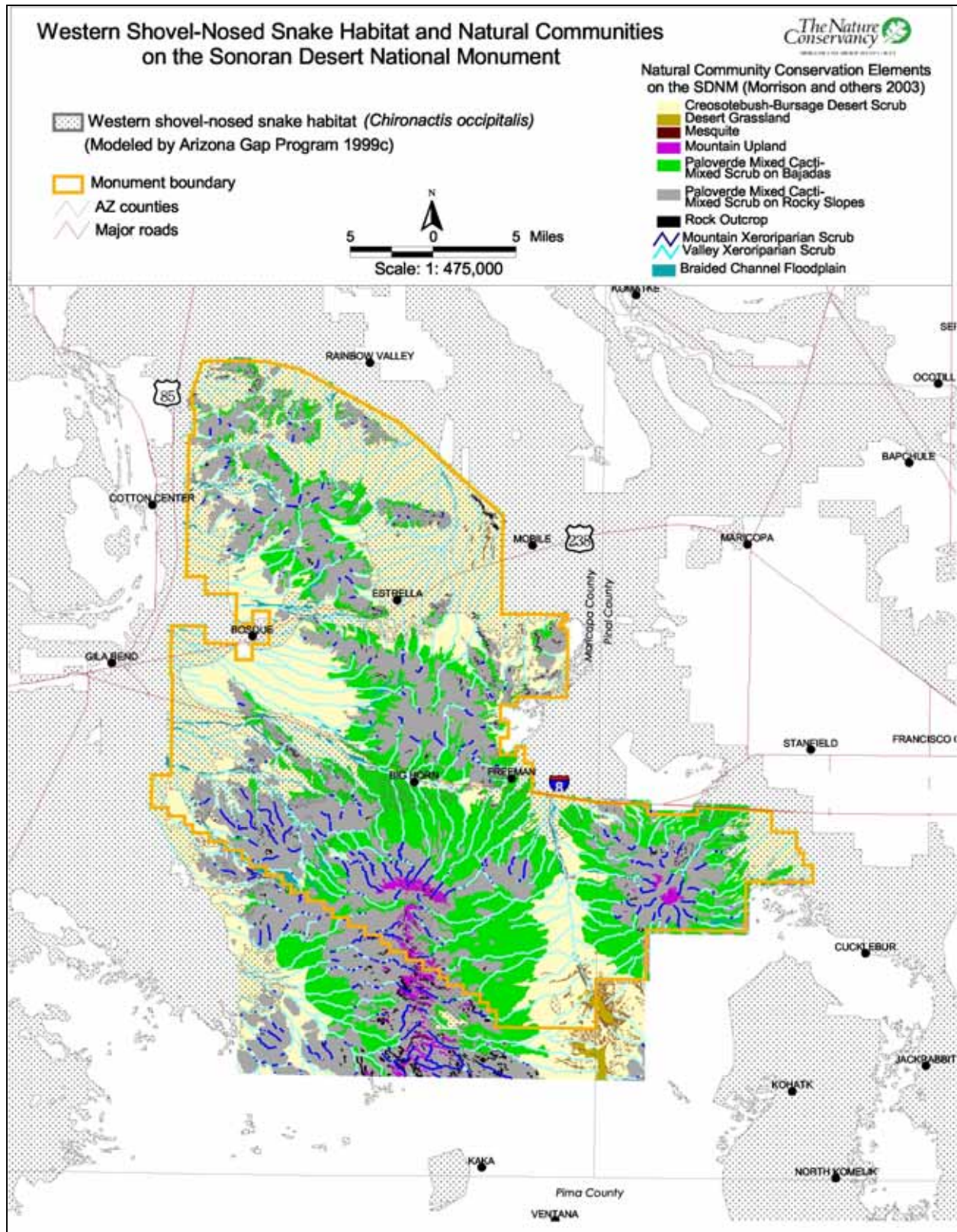


FIGURE C.25 Western Shovel-Nosed Snake Habitat in Relation to Natural Communities on the Sonoran Desert National Monument

dates of collection in museum records (collected primarily on roadside surveys), the Tucson shovel-nosed snake is most active in May with a decrease in observed activity until July and almost no observations after early/mid-July (P. Rosen, pers. comm.). This is in contrast to findings for other subspecies of the shovel-nosed snake that have high activity levels in late summer and in contrast to other species of snakes that show increased activity during and after the summer monsoons (P. Rosen, pers. comm.).

Landscape context.—The Tucson shovel-nosed snake requires approximately two hectares (five acres) for a home range (Pima County 2001). As a result, the minimum patch size for a viable population of 250 pairs is estimated at 506 hectares (1,250 acres) (Pima County 2001). Corridor or migratory needs have not been identified for this species, however, highways, major roads, and streams are potential barriers for movement across habitat (Pima County 2001). The connectivity goals for this subspecies in Pima County may offer some guidance for habitat protection elsewhere, including on the SDNM. These goals are to: (1) conserve 95% of vegetation cover within two kilometers (1.2 miles) of barriers, with 75% vegetation cover in other habitat areas, and (2) create and maintain over/underpasses for highways and major roads for dispersal (Pima County 2001). Route 238 bisects known habitat for the Tucson shovel-nosed snake on the SDNM. It is not known if or how this road impacts the movement of the shovel-nosed snake, but increased traffic volume at high speeds would likely cause higher mortality rates. Studies have shown that mortality of snakes on roads (including that of the closely related Organ Pipe shovel-nosed snake, *Chionactis paratrostris*) can cause local population declines and localized extinctions (Rosen and Lowe 1994). Roadless or otherwise unfragmented habitat may be important for this subspecies (Pima County 2001).

Status, Threats, and Management

Distribution.—The range map displayed in Figure C.26 includes the distribution of both the Tucson shovel-nosed snake subspecies and the population with characteristics intermediate between the Tucson and Colorado Desert subspecies.

- Historic.** The Tucson shovel-nosed snake was known from the margin of the Arizona Upland subdivision of the Sonoran Desert Ecoregion in the regions near Ajo, Cave Creek, Florence, Picacho, Casa Grande, Scottsdale, Marana, and the north-central portion of the Tohono O’odham Nation (Pima County 2001, P. Rosen, pers. comm.). The distribution of the phenotype intermediate between *C. o. annulata* and *C. o. klauberi* was noted from Casa Grande, as far west as Gila Bend, north to Aguila, and south to Ajo (Klauber 1951).
- Current.** Many of the historic localities of the Tucson shovel-nosed snake are no longer occupied. The Tucson shovel-nosed snake is thought to be extirpated from the Scottsdale region because of habitat loss from urban sprawl and agricultural conversion and to be severely impacted in the Casa Grande region and in the Avra and Santa Cruz Valleys near Marana because of conversion of desert habitat to agriculture (P. Rosen, pers. comm.). Most of the current range of the Tucson shovel-nosed snake is thought to be in southern Pinal County (Pima County 2001). More information is needed on the current distribution of this subspecies on the Tohono O’odham Nation.

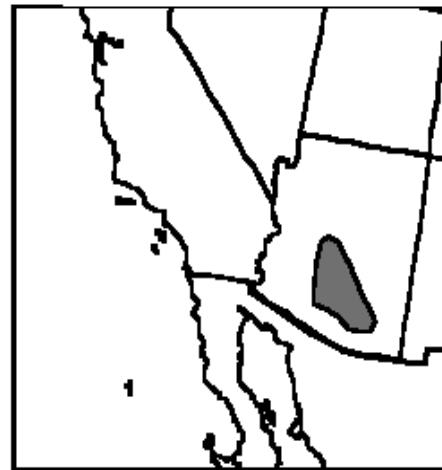


FIGURE C.26 Range of the Tucson Shovel-Nosed Snake (*Chionactis occipitalis klauberi*). From Pima County (2001).

Conservation status.—The western shovel-nosed snake has a global rank of G5, which indicates that the species is secure (common, widespread, and abundant) throughout most of its range (NatureServe 2003). The Tucson shovel-nosed snake subspecies has a global rank of G5T2T3Q (NatureServe 2003). The T rank indicates that the status of this taxon is thought to range between 2 (imperiled and vulnerable to extinction or elimination) to 3 (vulnerable because it is rare and local throughout its range or because other factors make it vulnerable to elimination). The “Q” in the global rank code refers to the unresolved taxonomy of the subspecies.

The Tucson shovel-nosed snake is a priority vulnerable species in Pima County’s Sonoran Desert Conservation Plan (Pima County 2001). The Town of Marana is currently considering preparing a multi-species Habitat Conservation Plan (HCP) for lands under its jurisdiction. The Tucson shovel-nosed snake is currently one of the focal species that may be considered for inclusion in the HCP. The Heritage Data Management System (HDMS) of the Arizona Game and Fish Department does not track the western shovel-nosed snake, nor any of the subspecies. As a result, the majority of information on the current status of the Tucson shovel-nosed snake has been reviewed and compiled recently for the above-mentioned conservation efforts/evaluations in Pima County and Marana (such as Pima County 2001, Rosen 2003, P. Rosen, pers. comm.).

The Tucson shovel-nosed snake was first described in 1941 based on a type-locality in Tucson (Klauber 1951). It was best represented by specimens collected from the Marana area in northern Pima and southern Pinal Counties, particularly in the Avra Valley, where it had been collected along the Avra Valley Road. Recent field surveys (May through June 2003) of historic localities in this region failed to relocate a single individual, with one exception of an individual found near Pichaco Peak in Pinal County, and provides further evidence that the subspecies has severely declined in the Avra Valley since 1979 (the year of the last verified museum record) and that it may already be extirpated from this portion of its former range (P. Rosen, pers. comm.). The subspecies has also been extirpated from most areas it formerly occupied in Pima County and has not been recorded in the county since 1982 (Pima County 2001). The subspecies is found in habitats that have been and will likely continue to be threatened by development. The leading expert on this taxon, Dr. Philip Rosen, has stated that when the genetics of the Tucson shovel-nosed snake is clarified “there is a good chance it will have to be listed as an endangered or threatened species, absent a conservation plan” (Rosen 2003).

The population that is intermediate in morphology between *C. o. klauberi* and *C. o. annulata* has been found in relative abundance in road surveys on Route 238 west of Mobile on the SDNM. As a result, this may be the most important area remaining for the conservation of the unique genes of *C. o. klauberi* (P. Rosen, pers. comm.). The status of this taxon in other parts of its range, including the northeast fringe of the Tohono O’odham Nation and in the vicinity of Ajo, is not well known.

Stresses and sources of stress.—Table C.16 identifies potential stresses and sources of stress confronting Tucson shovel-nosed snakes across the taxon’s range. The greatest threat to the Tucson shovel-nosed snake is habitat loss. Because the subspecies is found in few localities, it becomes more critical to address the other potential threats listed in Table C.16 to maintain viable populations in remaining habitat, particularly on the SDNM near Mobile.

Mapping and Information Needs

Mapping comments.—Because little is known about specific habitat needs that influence the distribution of the shovel-nosed snake, field survey efforts may be the most effective way to determine the subspecies’ distribution. In regions where the current distribution of the shovel-nosed snake is not known, potential habitat can be modeled. Pima County modeled Tucson shovel-nosed snake potential habitat based on vegetation (particularly creosotebush-bursage), slope (low angles), elevation (400 to 800

TABLE C.16 Tucson Shovel-Nosed Snake: Stresses and Sources of Stress

Stress	Source of Stress	Geographic Scope of Potential Impacts	Comments or Source of Information
Habitat loss	Historic and current conversion of habitat to agriculture and urban development	Regional	Pima County (2001), P. Rosen (pers. comm.).
Habitat fragmentation	Road development (existing and future)	Regional and SDNM	Existing roads on SDNM, such as the Mobile-Maricopa road (Route 238) may fragment populations. (Pima County 2001).
Habitat degradation	Off-road vehicle use	Regional and SDNM	Effects of off-road vehicles includes soil compaction and/or occasional crushing of buried snakes (Pima County 2001).
	Spread of invasive non-native plants	Regional and SDNM	Although no research exists on the effects of non-native plants on this species, it is speculated that certain non-native invasive plants, such as red brome (<i>Bromus rubens</i>), buffelgrass (<i>Pennisetum ciliare</i>), or Sahara mustard (<i>Brassica tournefortii</i>), could reduce open ground and/or reduce biomass of shovel-nosed snake prey species (Pima County 2001). Moreover, these species provide fine fuels that can carry fire.
Altered population composition/ direct mortality	Traffic on paved roads, particularly in the evening and at night from mid-April through late June	Regional and SDNM	Pima County (2001), P. Rosen (pers. comm.).

meters), and landform for areas within the subspecies' range in Pima County (excluding western and central Pima County where the subspecies does not occur; Pima County 2001). Actual localities for the Tucson shovel-nosed snake on the monument were not available, but it may be useful to acquire these points—from herpetologists that have locality information on the subspecies (such as Philip Rosen, Robert Bezy, and Erik Enderson)—and overlay them on soil maps to identify areas on the SDNM with similar soil characteristics that may be additional occupied or potential shovel-nosed snake habitat. The habitat for the species as modeled by the Arizona Gap Program(1999c; Figure C.25) could also be used to identify other potential habitat for the snake. Because it has been suggested that the Tucson shovel-nosed snake is sensitive to road development or may require roadless areas (Pima County 2001), an analysis of road density (and/or road surface types or use intensity) in currently occupied Tucson shovel-nosed snake habitat would provide baseline data on the distribution of the shovel-nosed snakes in relation to roads. A similar analysis of road density/surface type/use intensity in the Creosotebush-Bursage Desert Scrub natural community on other areas of the SDNM could offer information on other potential habitat areas on the monument.

Information needs.—Because occurrences of the Tucson shovel-nosed snake are based primarily on road-cruise data—the method of searching for snakes by driving slowly along paved roads on warm nights, the subspecies is known only from Route 238 on the SDNM. It is possible that viable populations of the Tucson shovel-nosed snake are found in other portions of the SDNM, possibly north of Route 238 in Creosotebush-Bursage Desert Scrub on the northeast portion of the monument. Any additional localities on the monument would be significant because of the severe population declines of the subspecies in other parts of its range. Additional information needs for the population of the subspecies on the SDNM (and for the subspecies across its entire range) include: What is the abundance and density of Tucson shovel-nosed snakes on the SDNM? Are there specific habitat needs for this taxon? Does traffic on Route 238 impact Tucson shovel-nosed snake habitat connectivity and/or cause excessive mortality? Are invasive non-native plants having an effect on Tucson shovel-nosed snake habitat quality and resultant population densities on the SDNM?

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C.4 BIRDS

Three individual species and one guild were selected as conservation elements.

C.4.1 Cactus Ferruginous Pygmy-Owl (*Glaucidium brasilianum cactorum*)

The purpose of this section is not to provide a full ecological characterization of the cactus ferruginous pygmy-owl, as its management on the Sonoran Desert National Monument (SDNM) would defer to US Fish and Wildlife Service guidelines. Numerous other sources review the ecology, conservation, and management of the cactus ferruginous pygmy-owl in Arizona and throughout its range, including USFWS (1997, 2003), Cartron and Finch (2000), AGFD (2001a), Pima County (2001), and NatureServe (2003).

Rationale for selection as a conservation element.—*Regionally vulnerable, Endangered.* The population of cactus ferruginous pygmy-owl in Arizona is federal listed as Endangered. The pygmy-owl was historically common in mesquite bosques and riparian cottonwood-willow forests in Arizona (AGFD 2001, NatureServe 2003). Habitat destruction and modification have resulted in dramatic population declines to the point that the pygmy-owl has almost been extirpated from Arizona (USFWS 1997, Cartron and Finch 2000). Remaining cactus ferruginous pygmy-owl populations in Arizona occur primarily in Sonoran desertscrub habitat and are threatened by continued habitat loss and habitat alteration (Cartron and Finch 2000).

Although the pygmy-owl's presence has not been confirmed on the SDNM, the monument has extensive areas of suitable habitat, including Paloverde-Mixed Cacti-Mixed Scrub and xeroriparian scrub natural communities where structurally complex and dense vegetation is found. Because the SDNM lacks many of the threats that are present in other parts of the pygmy-owl's range in Arizona, the monument could potentially play a role in the recovery of this subspecies in the Sonoran Desert. A portion of the monument is included as part of one of the proposed recovery areas in the Draft Recovery Plan for the cactus ferruginous pygmy-owl (USFWS 2003).

Cactus ferruginous pygmy-owl occurrence on/in the vicinity of the SDNM.—Numerous surveys for the cactus ferruginous pygmy-owl have been conducted on the SDNM; however, the owl has not yet been confirmed to be present. Routes associated with pygmy-owl surveys conducted by the BLM on the SDNM are displayed in Figure C.27 (route information provided by E. Masters of the BLM). Four possible ("unconfirmed") sightings for the owl occur on or in the vicinity of the SDNM: two in the Sand Tanks Mountains (near Johnson Well; Tim Tibbitts, pers. comm.), one in the East Tactical Range on the Barry M. Goldwater Range (BMGR), and one in the South Maricopa Mountains (SWNRMC 2000). Johnson Well and the location where the individual was sighted in the South Maricopa Mountains (J. Gunn, pers. comm.) are shown in Figure C.27

Surveys for the cactus ferruginous pygmy-owl were initiated on the Barry M. Goldwater Range (BMGR) in 1994, including within areas adjoining the SDNM and in the Sand Tank Mountains within the former "Area A" (which is now located within the monument boundaries). Despite numerous surveys, no cactus ferruginous pygmy-owls have been located on the BMGR. Extensively surveyed areas on the BMGR include Child's Mountain (southern boundary of the BMGR west of Interstate 85), South Boundary (southern boundary of BMGR at Area B), Deadman Gap (east of the Crater Range), and Ten-Mile Wash (south of the Crater Range) (Geo-Marine and Environmental Planning Group 2002). Additional intensively surveyed areas include the East Tactical Range (E-TAC; along roads, the Saucedo and Quilotosa washes, and on 16 transects in roadless areas) (Barry 2001). Additional surveys for nocturnal owls and the cactus ferruginous pygmy-owl were conducted on E-TAC, the Saucedo Mountains, and in the Sand Tanks Mountains (at transects near Johnson Well, Papago Indian Chief Mine, and Sand Tank

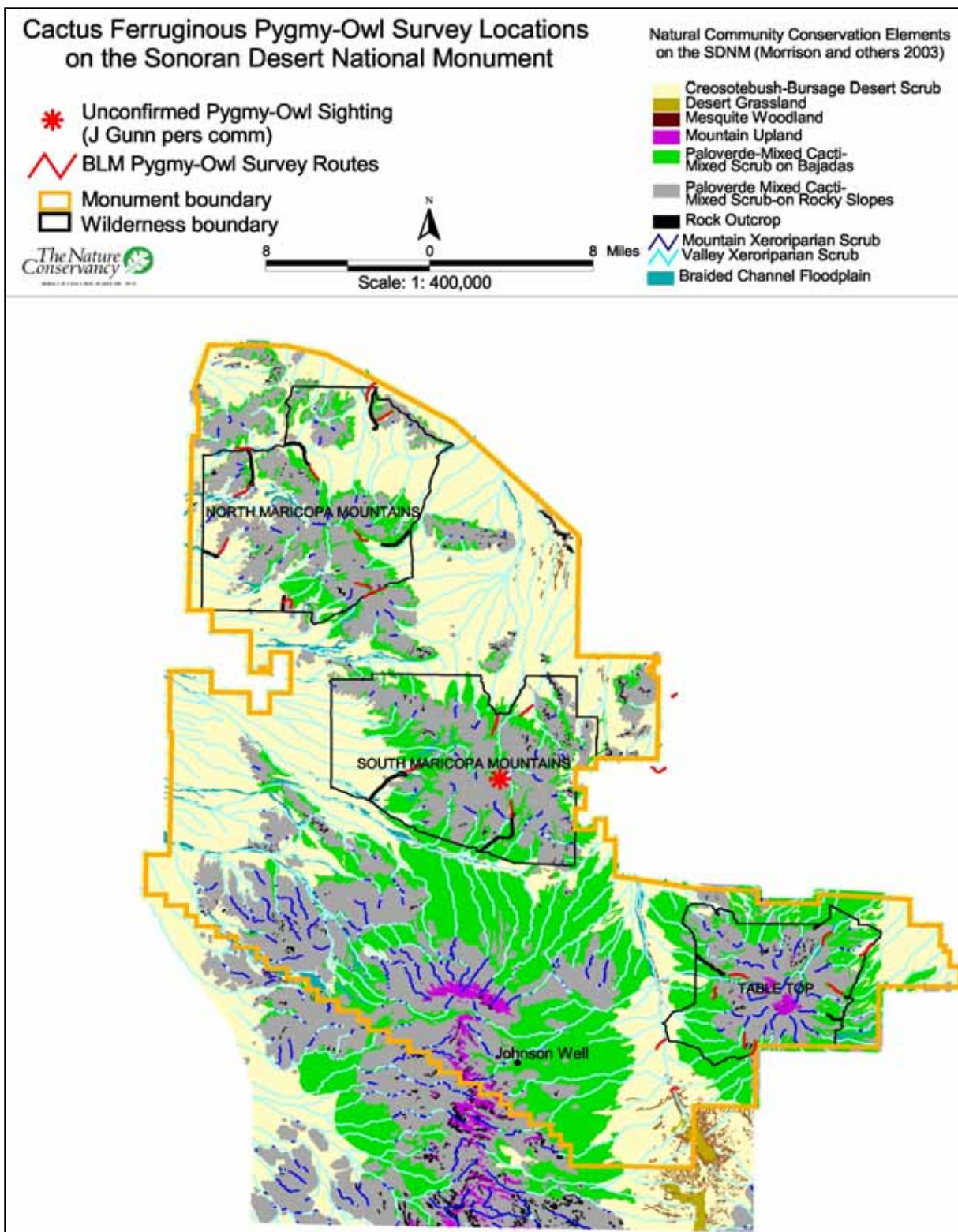


FIGURE C.27 Cactus Ferruginous Pygmy-Owl Survey Routes and Sighting Locations in Relation to Natural Communities on the Sonoran Desert National Monument

Well) (Morrison and Hardy 1996); however, to sample nocturnal owls these surveys were conducted at night, which is not the maximum period of detectability for the diurnal pygmy-owl (SWNRM 2000).

In eight years of data collection, the Arizona Breeding Bird Atlas Project has documented cactus ferruginous pygmy-owls in 13 priority survey blocks and in 7 blocks as casual observations (Figure C.28; ABBA 2001). One pygmy-owl was detected near the boundary of the SDNM on the Tohono O'odham Reservation, in "possible" breeding status (indicating that the species was observed in suitable nesting habitat during its breeding season; Figure C.28).

Specific habitat needs on the SDNM.—In Arizona the cactus ferruginous pygmy-owl is mainly associated with Sonoran desertscrub below 1,220 meters (4,000 feet) elevation, especially along xeroriparian washes with a high density of trees that include mesquite (*Prosopis* spp.), palo verde (*Cercidium* spp.), ironwood (*Olneya tesota*), desert hackberry (*Celtis pallida*), acacia (*Acacia* spp.), bursage (*Ambrosia* spp.), and saguaro (*Carnegiea gigantea*) (USFWS 1997, NatureServe 2003). Cactus ferruginous pygmy-owls require two main habitat components: dense woody thickets or woodlands for foraging and protection of juveniles and cavities in large trees or saguaro cacti for nesting (Wilcox and others 2000). More specific habitat requirements for the pygmy-owl are not well understood. Wilcox and others (2000) compared habitat characteristics of cactus ferruginous pygmy-owl nest sites and perch trees with random sites within the Tucson Basin, Altar Valley, and Organ Pipe Cactus National Monument. Although the results are considered preliminary because of small sample sizes, the authors identified a trend in which stem densities at upper canopy levels (above three meters [10 feet]) and the mean number of plant species was greater at nest sites than at random sites. Mid-story vegetation density is also important in providing thermal cover and increasing available prey. Wilcox and others (2000) also found that fewer total cacti were present at nest sites and perch trees than at random sites, possibly because higher rates of juvenile mortality (impalement) occur in areas of high-density cholla and prickly pear cactus.

If present on the SDNM, the cactus ferruginous pygmy-owl would nest in saguaro cacti in cavities constructed by the gilded flicker and/or the Gila woodpecker (see section C.4.2). In relation to the natural communities described and mapped by Morrison and others (2003), the cactus ferruginous pygmy-owl would most likely be associated with Paloverde-Mixed Cacti-Mixed Scrub on Bajadas, Valley Xeroriparian Scrub, and Braided Channel Floodplains on the SDNM. Northwest of Tucson, cactus ferruginous pygmy-owls were most closely associated with the sandy loam upland and sandy bottom ecological sites in the Upper Sonoran Desert Shrub (Major Land Resource Area 40–1) (G. Drennen, pers. comm.)

Areas on the SDNM that are most likely to have cactus ferruginous pygmy-owls have high densities of mature saguaros and xeroriparian vegetation. Notable areas of saguaro forest on the SDNM include the north bajada of Javelina Mountain (P. Morrison, T. Tibbitts, pers. comm.), the bajadas in the South Maricopa Mountains Wilderness north and east of Bighorn Peak (P. Morrison, pers. comm.), and the eastern bajada of the Sand Tank Mountains between Johnson Well and Javelina Mountain (R. Marshall, pers. comm.). This latter area also has good examples of ironwood forest, a habitat favored by pygmy-owls (T. Tibbitts, pers. comm.). Portions of the Sand Tank Mountains, South Maricopa Mountains Wilderness, and Table Top Mountains Wilderness are proposed as recovery areas for the pygmy-owl (Figure C.29; USFWS 2003). These areas were proposed as recovery areas because they capture a large percentage of the historical range of the pygmy-owl, they include potentially suitable nesting habitat, and because they improve connectivity with potential populations within the Tohono O'odham Nation (USFWS 2003).

Many of these areas of potential pygmy-owl habitat have not been extensively surveyed. In addition, the pygmy-owl may be present but unresponsive to tapes of their calls in areas where surveys have been

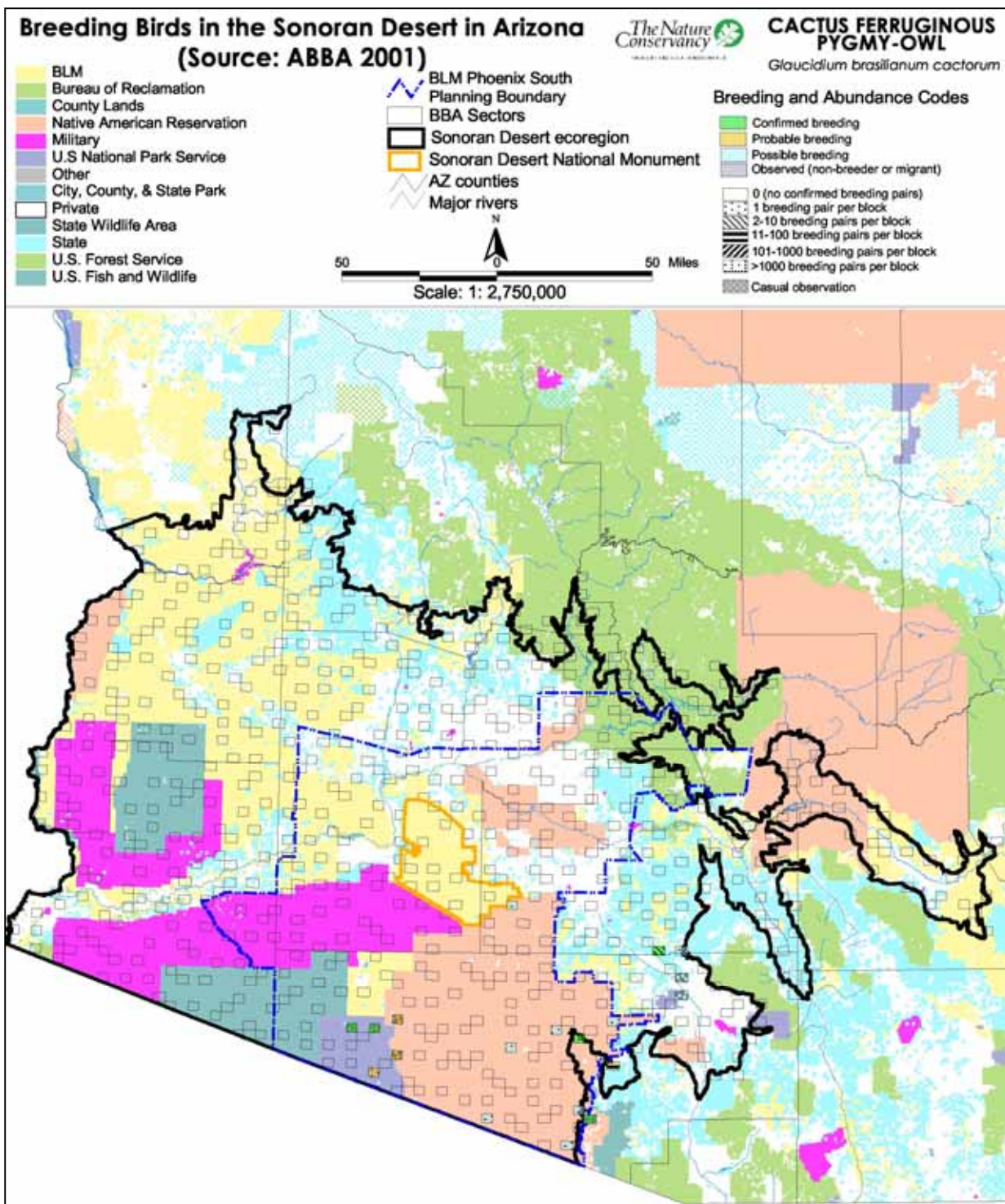


FIGURE C.28 Arizona Breeding Bird Atlas Survey Block Information for the Cactus Ferruginous Pygmy-Owl within the Sonoran Desert

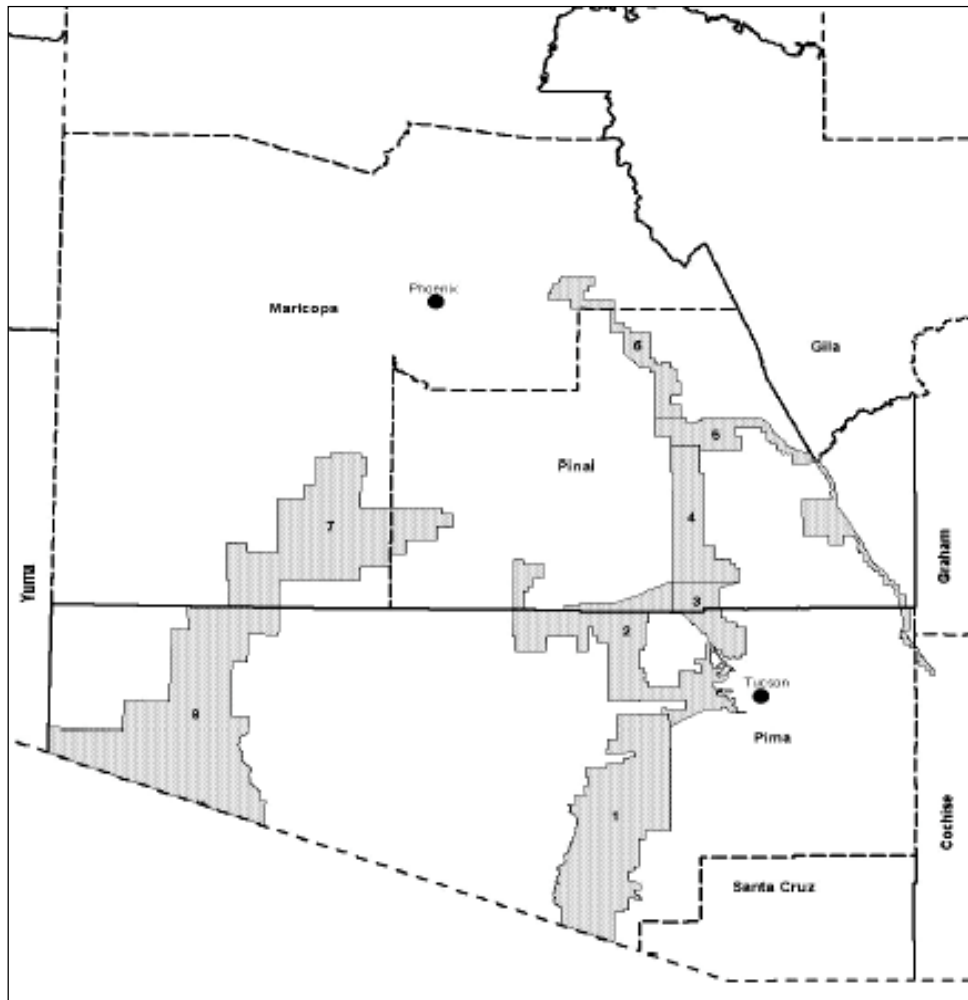


FIGURE C.29 Proposed Recovery Areas for the Cactus Ferruginous Pygmy-Owl (USFWS 2003). Recovery Area-7 includes the eastern portion of the Barry M. Goldwater Range, the Sand Tanks Mountains on the Sonoran Desert National Monument, and the South Maricopa and Table Top Wilderness Areas on the SDNM.

conducted on or near the SDNM. In areas on the northern edge of the pygmy-owl's range where densities of the owl are less and the owls are less territorial, it has been observed that owls do not readily respond to playbacks of their call (T. Tibbitts, pers. comm.).

Conservation status.—The cactus ferruginous pygmy-owl has a global heritage status rank of G5T3, which indicates that the species (*Glaucidium brasilianum*) is secure and the subspecies (*G. b. cactorum*) is globally vulnerable because it is rare and local throughout its range, found in a restricted range, or because of other factors making it vulnerable to extinction or elimination (NatureServe 2003). The subspecies' state rank in Arizona is S1, which signifies that it is critically imperiled in the state (NatureServe 2003). The cactus ferruginous pygmy-owl is listed as a threatened species in Mexico. In the United States, the cactus ferruginous pygmy-owl occurs only in Arizona and Texas. The population in Texas is not protected under the Endangered Species Act, but the population in Arizona is considered unique and has been listed Endangered since 1997 (USFWS 1997). The pygmy-owl is also considered a

Wildlife of Special Concern in Arizona (AGFD 1996) and is designated a Priority Vulnerable Species in the Sonoran Desert Conservation Plan (Pima County 2001).

Only 41 adult cactus ferruginous pygmy-owls were known to exist in Arizona in 1999. Thirty-four adults were detected in 2000 and 36 in 2001 (USFWS 2003). Much of the owl's potential habitat, however, has not been surveyed and its total abundance and distribution in the state are unknown. The pygmy-owl is documented from five general regions:

1. Northwest Tucson and southern Pinal county on the bajadas of the Tortolita Mountains in low-density urban areas and in Sonoran desert scrub
2. Tucson Mountains (one owl in 1998) and just east of this range in Sonoran desert scrub
3. Organ Pipe Cactus National Monument, where they nest in Sonoran Desert scrub. Pygmy-owls have been documented on the monument since the 1940s and almost every year since 1993.
4. Tohono O'odham Nation in Sonoran desert scrub
5. Altar Valley in microphyll or broadleaf woodlands associated with washes and often associated with patches of desert scrub, saguaros, or other cavity-bearing trees (Pima County 2001).

The pygmy-owl was proposed to be listed as federal Endangered in 1993 and was listed as Endangered in March 1997. In July 1999, 295,775 hectares (730,565 acres) of critical habitat were designated. In 2001 a lawsuit was filed with the District Court of Arizona challenging the validity of the US Fish and Wildlife Service's listing of the Arizona population of the pygmy-owl as an endangered species and the designation of its critical habitat. The Court upheld the listing of the pygmy-owl in Arizona but required a new analysis of critical habitat including analysis of the economic and other effects of the designation. Proposed critical habitat was re-designated in November 2002 and was expanded to include 488,863 hectares (1,208,001 acres) in portions of Pima and Pinal Counties (Figure C.30), including approximately 9 percent of the recognized historical range of the pygmy-owl in Arizona (USFWS 2002b). A draft recovery plan for the pygmy-owl in Arizona was issued in January 2003 (USFWS 2003). The ruling on the listing decision of the pygmy-owl is still pending. In August 2003 the 9th Circuit Court of Appeals ruled that the USFWS did not have sufficient evidence that the population of cactus ferruginous pygmy-owl in Arizona was unique and required listing, but it did not remove the listing. The Service was required to file a status report with the Arizona District Court by January 31, 2005, in which it would discuss its review of the pygmy-owl listing rule and its decision whether to administratively revoke the listing rule or take other action to correct the defects identified by the 9th Circuit. A final decision by the Service and Court is expected in the spring of 2005. In the interim the cactus ferruginous pygmy-owl remains a federal listed Endangered species with proposed critical habitat, as shown in Figure C.30.

Mapping and Information Needs

Mapping comments.—The cactus ferruginous pygmy-owl is tracked by the Heritage Data Management System (HDMS); however, no occurrences have been reported on or in the vicinity of the SDNM. Bureau of Land Management survey transects shown in Figure C.27 were received from BLM Wildlife Biologist Elroy Masters in 2003. The possible pygmy-owl sighting in the South Maricopa Mountains shown in Figure C.27 was digitized from information received from the observer, John Gunn. The point is displayed at a coarse scale so as to not reveal sensitive site-specific information.

Pima County (2001) mapped potential habitat for the pygmy-owl in Pima County based on an intensive study by John Regan and his group as part of the Decision Support System modeling process. The habitat

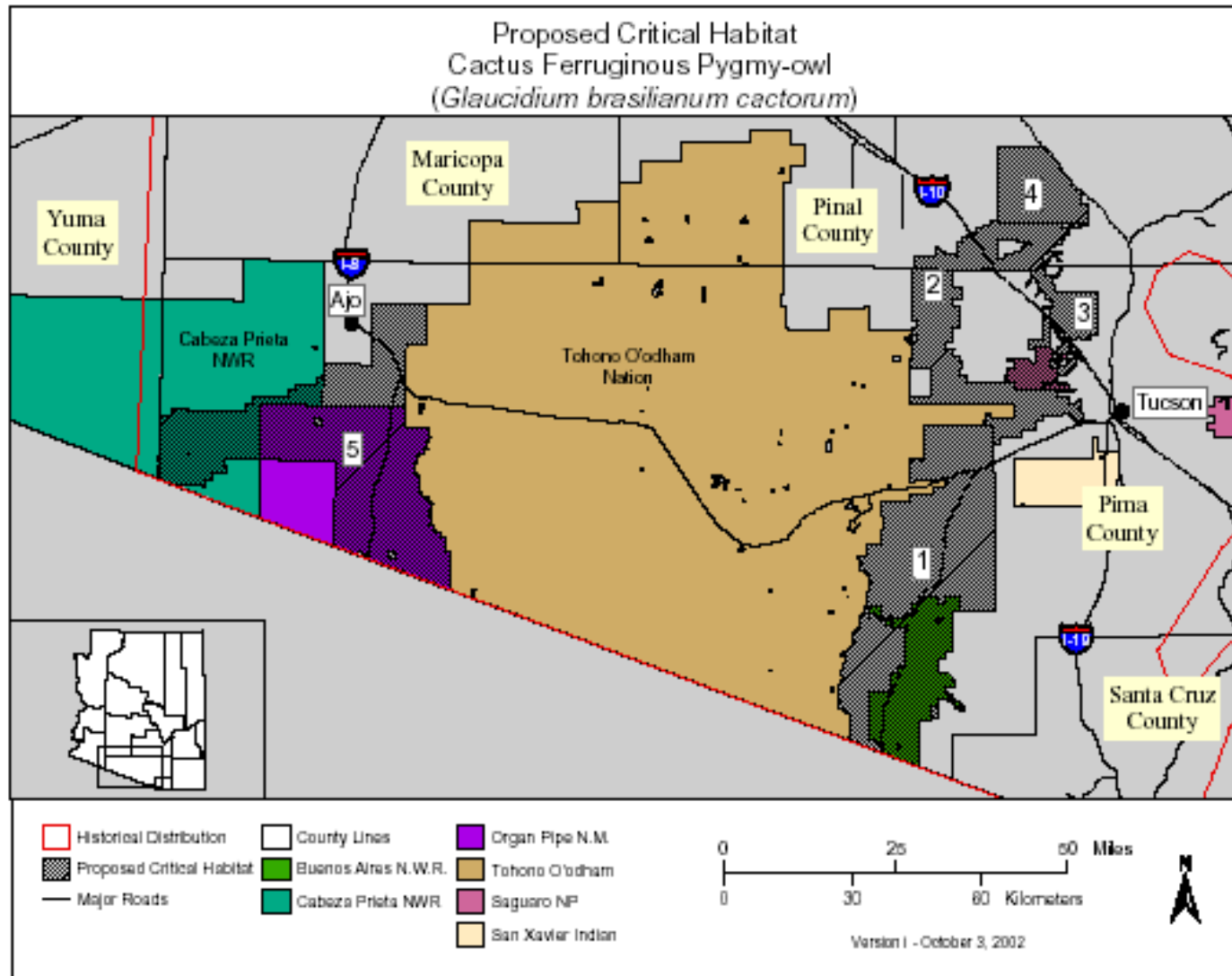


FIGURE C.30 Proposed Critical Habitat for the Cactus Ferruginous Pygmy-Owl (USFWS 2002b).

characteristics are based primarily on known occurrences, elevation (0 to 1200 meters), vegetation, and landform. Land cover types include cottonwood-willow, mesquite, mixed grass-scrub, and paloverde-mixed cacti. Washes and areas with little to no slope are also included in the model.

Information needs.—Additional surveys on the SDNM are needed in priority and proposed recovery areas. A model similar to that described by Pima County (2001) might be useful to identify priority survey areas on the monument. Morrison and others' (2003) data on natural community composition and structure also could be used to identify potential pygmy-owl habitat as more refined information on the habitat needs of the species becomes available. Additional information is also needed on the potential threats to pygmy-owl on the SDNM (which, if the pygmy-owl is not already breeding on the monument, might preclude successful introduction/colonization on the SDNM). Increased recreational use (and/or illegal migrant uses) and invasion of non-native grasses increase the risk of pygmy-owl habitat loss by wildfire, which was considered a threat on Organ Pipe Cactus National Monument (Latta and others 1999). Data on the ecological condition of the natural communities and invasive non-native plant abundance and distribution collected by Morrison and others (2003) could be used to help identify the degree of threat to pygmy-owl habitat on the SDNM.

The Arizona Game and Fish Department (2001a) offers the following recommendations for cactus ferruginous pygmy-owl management:

- refine breeding survey protocols
- conduct surveys
- determine habitat needs
- manage grazing and other land uses to maintain and enhance important occupied or potentially occupied habitats.

Some additional conservation and research recommendations by Arizona Partners in Flight (Latta and others 1999) include:

- reduce fuel loads (of invasive non-native plants) along roadways to lower risk of fire
- investigate juvenile dispersal, home breeding range, wintering range, and habitat use by banding and telemetry
- continue to collect natural history information.

C.4.2 Primary Excavator (Cavity) Guild

Overview

Species included in the primary excavator (cavity) guild.—This guild is composed of three native species of woodpecker that are documented to occur on the Sonoran Desert National Monument (SDNM): Gila woodpecker (*Melanerpes uropygialis*), Gilded flicker (*Colaptes chrysoides*), and Ladder-backed woodpecker (*Picoides scalaris*).

Species excluded from the primary excavator (cavity) guild.—A fourth species of woodpecker, the northern flicker (*Colaptes auratus*), is also a primary excavator of tree cavities that is found throughout much of North America. This species was not selected as part of the primary excavator (cavity) guild because it does not appear that it is breeding on the monument. The red-shafted flicker (*C. auratus cafer*) (a subspecies of the northern flicker in western North America) has a range that overlaps with the gilded flicker in central and southern Arizona (Moore 1995). The red-shafted flicker normally occurs in upland pine-oak woodlands, but extends into lower elevations in riparian woodlands along streams that connect the mountain uplands with the Sonoran Desert—areas where hybrid populations of gilded and red-shafted flickers occur (Moore 1995). The northern (red-shafted) flicker has been sighted on or in the vicinity of the SDNM (for example, see Turner and others 2000), however it is not likely breeding in this region. Based on data from the Arizona Breeding Bird Atlas survey (2001), it appears that the majority of the red-shafted flickers recorded on survey blocks in the Sonoran Desert Ecoregion in Arizona (54 out of 59 survey blocks) were non-breeders or migrants and that the zone of hybridization is likely north and east of the ecoregion. (Figure C.31).

Rationale for selection as a conservation element.—*Keystone Species, Specialized Species.* The primary excavator (cavity) guild was selected as a conservation element because the woodpeckers in the guild have specialized needs for nesting sites, and they serve as keystone species by creating cavities in saguaro (*Carnegiea gigantea*) and desert trees that are used as nest sites by numerous other cavity-nesting birds, including some neotropical migrants (Table C.17). Excavated cavities in saguaros also provide roost sites for solitary bats (Tibbitts and others 2002), small mammals, and reptiles (TNC 2001). Furthermore, Gila woodpeckers are important as pollinators of saguaro and disseminators of their seed (Edwards and Schnell 2000, Kerpez and Smith 1990b). As such, they may play a role in the maintenance of saguaros as a component of the Paloverde-Mixed Cacti-Mixed Scrub natural communities. The woodpeckers are best treated as a guild because each species has a preferred nest excavation substrate and constructs cavities that differ in their dimensions; in turn, the characteristics of the cavity affect which species of secondary cavity nesters use the nest site (Kerpez and Smith 1990a, McAuliffe and Hendricks 1988). Although these species may not require specific habitat management different than that necessary to maintain the natural communities on the SDNM, a decline in the abundance of any of the woodpeckers would be a concern because so many other species rely on them for nest site excavation.

Specific habitat needs on the SDNM.—Each species in the primary excavator (cavity) guild has slightly different habitat needs; however, xeroriparian areas (Braided Channel Floodplain, Valley Xeroriparian Scrub, and Mountain Xeroriparian Scrub natural communities) provide important foraging habitat for all three woodpeckers. Ladder-backed woodpeckers also nest in these xeroriparian habitats in the Sonoran Desert, and they require large mature desert trees in relatively densely vegetated washes for breeding habitat. The Paloverde-Mixed Cacti-Mixed Scrub on Bajadas natural community provides nesting and foraging habitat for the woodpeckers, particularly the Gila woodpecker and gilded flicker. Mature and dense saguaro stands, such as that found on the bajada of the Sand Tank Mountains, may be disproportionately important breeding areas for the Gila woodpecker and gilded flicker populations on the SDNM. Habitat for the woodpeckers will likely be maintained on the SDNM if the above-mentioned natural communities meet BLM land health standards and if saguaro populations include mature

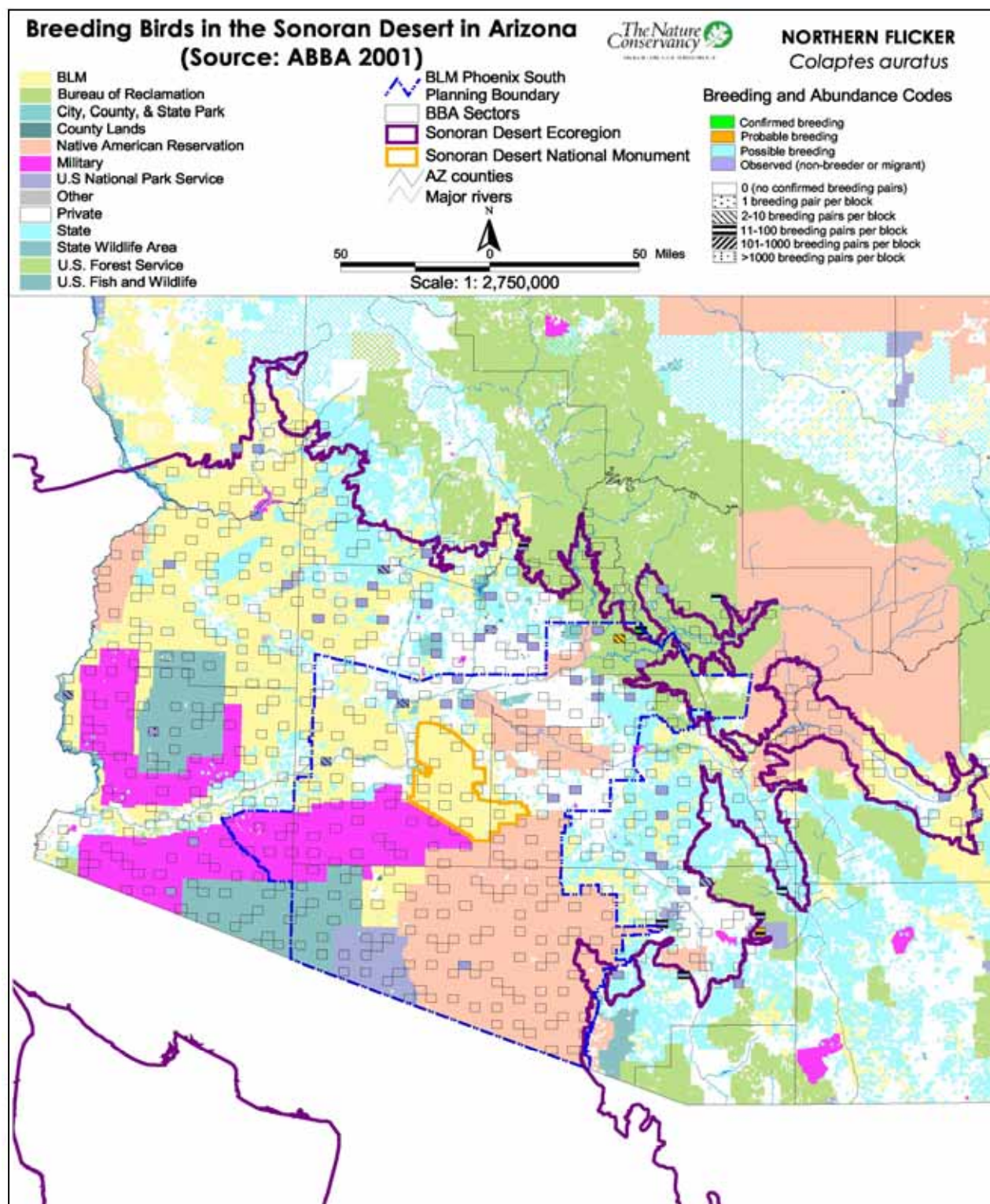


FIGURE C.31 Northern (Red-Shafted Flicker) Arizona Breeding Bird Atlas Survey Information for the Sonoran Desert

TABLE C.17 Secondary Cavity Nesters in the Sonoran Desert¹

Common Name	Scientific Name	Habitat Associations	Status on the Sonoran Desert National Monument ²
American kestrel	<i>Falco sparverius</i>	Nests in saguaro	A common, year-round resident that is found throughout the SDNM (in 14 BBA blocks) and has been confirmed to be breeding in four blocks.
Ash-throated flycatcher	<i>Myiarchus cinerascens</i>	Frequently nests along xeroriparian washes in tree cavities constructed by ladder-backed woodpeckers. May also nest in saguaro.	A neotropical migrant that is commonly found in the spring and summer throughout the Sonoran Desert and has been confirmed to be breeding in 11 BBA blocks in the SDNM.
Brown-crested flycatcher	<i>Myiarchus tyrannulus</i>	Uses saguaros almost exclusively where it breeds in the Sonoran Desert, except where riparian habitats containing cottonwood and willow occur	A neotropical migrant that is a spring/summer resident in the Arizona Upland subdivision of the Sonoran Desert. It was found in 12 BBA blocks in the SDNM and confirmed to be breeding in three blocks.
Cactus ferruginous pygmy-owl	<i>Glaucidium brasilianum cactorum</i>	Nests in saguaro.	Federal Endangered. It was observed in the Arizona BBA survey in 1999 on one survey block that overlaps with the SDNM, however the sighting was on the Tohono O'odham Reservation. The pygmy owl has not been located in other surveys in the SDNM but is expected to be present.
Cactus wren	<i>Campylorhynchus brunneicapillus</i>	Often nests in cholla cactus or desert trees or shrubs, but will occasionally use cavities in saguaro.	A common year-round resident in the Sonoran Desert. It was sighted in all BBA blocks on the SDNM and confirmed to be breeding in 12 blocks
Elf owl	<i>Micrathene whitneyi</i>	Nests in saguaro; hunts in xeroriparian areas and on hillsides where it eats insects.	A neotropical migrant. It was found in 10 BBA blocks on the SDNM. Confirmed to be breeding in three blocks.
House finch	<i>Carpodacus mexicanus</i>	Nests in shrubs, on tree branches, and cavities in trees or saguaro.	A common year-round resident found throughout the SDNM and confirmed to be breeding in nine BBA survey blocks.
Lucy's warbler	<i>Vermivora luciae</i>	May nest along xeroriparian washes in tree cavities constructed by ladder-backed woodpeckers.	A neotropical migrant. Found in 12 BBA blocks in the SDNM and confirmed to be breeding in xeroriparian habitat in six blocks, at densities of 11 to 100 breeding pairs per block.
Purple Martin	<i>Progne subis</i>	In the Sonoran Desert the species nests exclusively in saguaro.	Neotropical migrant. Found in two BBA blocks on the SDNM (Mobile NW and Johnson Well quads). Confirmed to be breeding in the Johnson Well block in Arizona Upland habitat at densities of 2 to 10 breeding pairs per block.
Western screech-owl	<i>Otus kennicottii</i>	Nests in saguaro; hunts in xeroriparian areas and on hillsides where it eats small rodents.	A year-round resident found throughout the SDNM. Confirmed to be breeding in one BBA block (Johnson Well).

¹Adapted from Hall and others (2001), with additional information from ABBA (2001).

²A total of 20 Breeding Bird Atlas (BBA) Blocks within or overlapping with the boundaries of the SDNM were surveyed between 1993 and 2000 (ABBA 2001).

individuals and have appropriate levels of recruitment. Additional information on each woodpecker's habitat needs can be found in the **Habitat associations** section.

Ecological Characteristics

Some of the information below is taken from Hall and others (2001).

Abundance.—The abundance of Gila woodpeckers and gilded flickers closely correlates with the abundance of saguaros. Saguaro density and abundance increases along a west to east rainfall gradient in the Sonoran Desert (see Hall and others [2005] for an analysis of the rainfall gradient). Within the arid Lower Colorado River Valley subdivision of the Sonoran Desert, saguaros are primarily found associated with xeroriparian areas. As a result, the abundance of Gila woodpeckers and gilded flickers is expected to differ along the rainfall gradient, with fewer individuals in the western portions of the Sonoran Desert than in the relatively mesic portions of the Arizona Upland subdivision to the east. Additionally, Gila woodpeckers are fairly dependent on saguaros for food, so where saguaros exist in lower densities or in smaller size/age classes fewer birds are present (Kerpez and Smith 1990b). The Gila woodpecker is expected to be found in lower densities than the gilded flicker in these areas because of its greater dependency on saguaro densities for foraging opportunities (L. Smith, pers. comm.). Ladder-backed woodpeckers, as they are not dependent on the presence of saguaro for nest sites, potentially can occur wherever large mesquite, (*Prosopis* spp.), palo verde (*Cercidium* spp.), or ironwood (*Olneya tesota*) are present (T. Corman, pers. comm.). The relative abundance of each member of the guild will differ as each species' response differs to other components of the habitat beyond the presence of saguaro. For example, the number of Gila woodpecker nests is negatively related to slope, whereas the number of gilded flicker nests is positively related to the volume of ironwood trees (Kerpez 1986, Kerpez and Smith 1990b).²

Most Arizona Breeding Bird Atlas (ABBA) survey blocks on or adjoining the SDNM found Gila woodpeckers at densities ranging from 11 to 100 breeding pairs per block, in which a survey block is 1/6th of a 7.5 minute topographic quadrant or approximately 10 square miles (26 km²; Figure C.32). Gilded flickers were found at intermediate densities across the SDNM, with some survey blocks in the 2 to 10 breeding pairs per block category and other blocks, such as those on the bajadas of the Sand Tank Mountains, at a higher breeding density category (11 to 100 pairs per block; Figure C.33). The ladder-backed woodpecker was found at lower densities on ABBA survey blocks in the vicinity of the SDNM than the other two woodpeckers, with 2 to 10 pairs per block in most survey areas. Most survey block results did not confirm that ladder-backed woodpeckers were breeding (Figure C.34).

The variability in woodpecker density and abundance across the SDNM likely reflects the variation in climate and habitat present on the monument that is notable in part because it is situated at the interface of the Arizona Upland and Lower Colorado River Valley subdivisions of the Sonoran Desert. Arizona Breeding Bird Atlas surveys generally support the expected pattern of woodpecker abundance across a rainfall and vegetation gradient in the Sonoran Desert, with higher abundance of the Gila woodpecker and Gilded flicker in the relatively mesic, eastern portions of the desert, including on the SDNM (Figures C.35 and C.36). Ladder-backed woodpeckers do not seem to follow the same pattern as the other two

²Data for the gilded flicker (*Colaptes chrysoides*) assigned by these authors to the northern flicker (*Colaptes auratus*); however, *C. chrysoides* subsequently was separated from *C. auratus* (American Ornithologists' Union 1995) and based on the respective ranges of the two species the data are likely attributable to *C. chrysoides*.

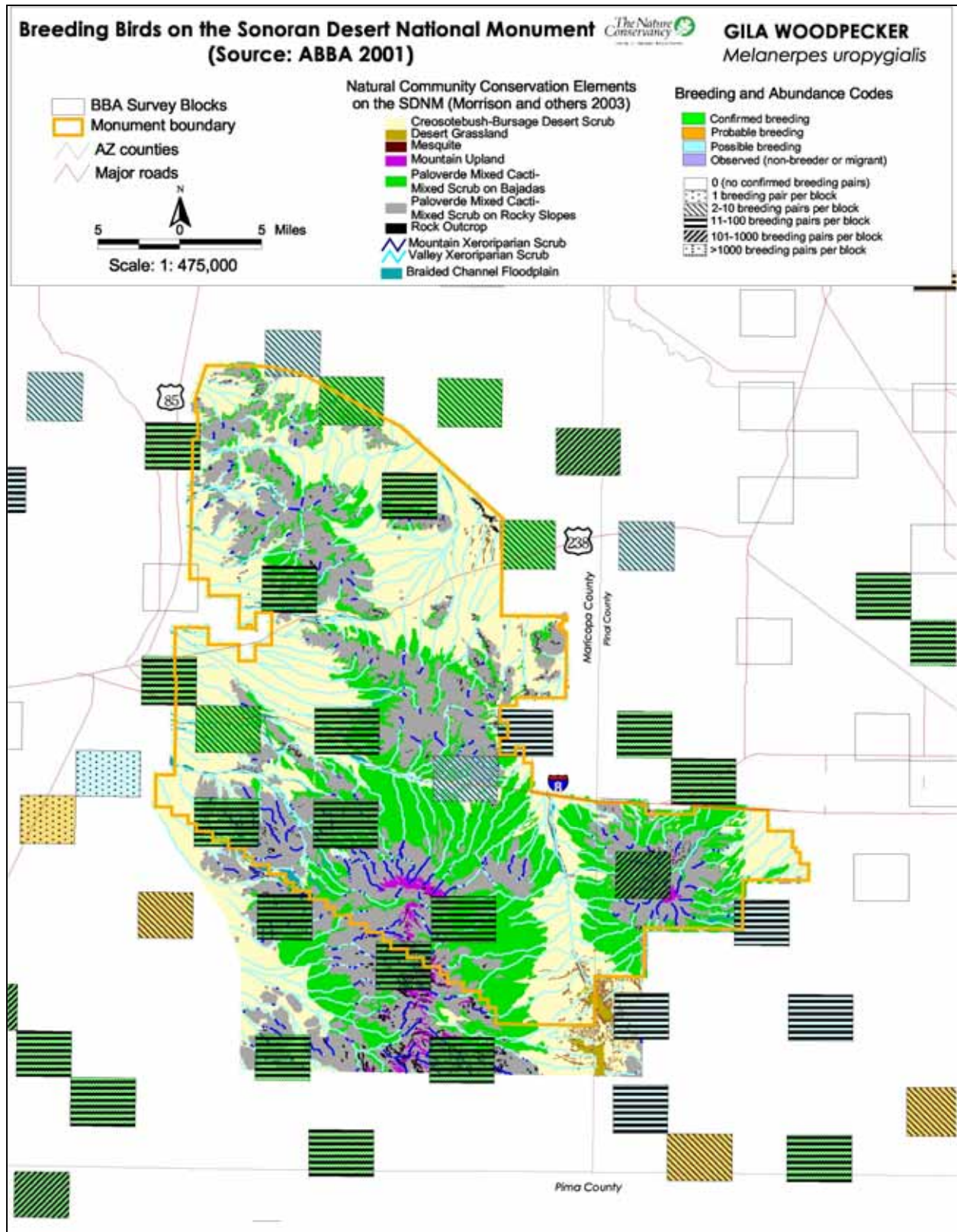


FIGURE C.32 Arizona Breeding Bird Atlas Survey Data for the Gila Woodpecker on the Sonoran Desert National Monument and Vicinity

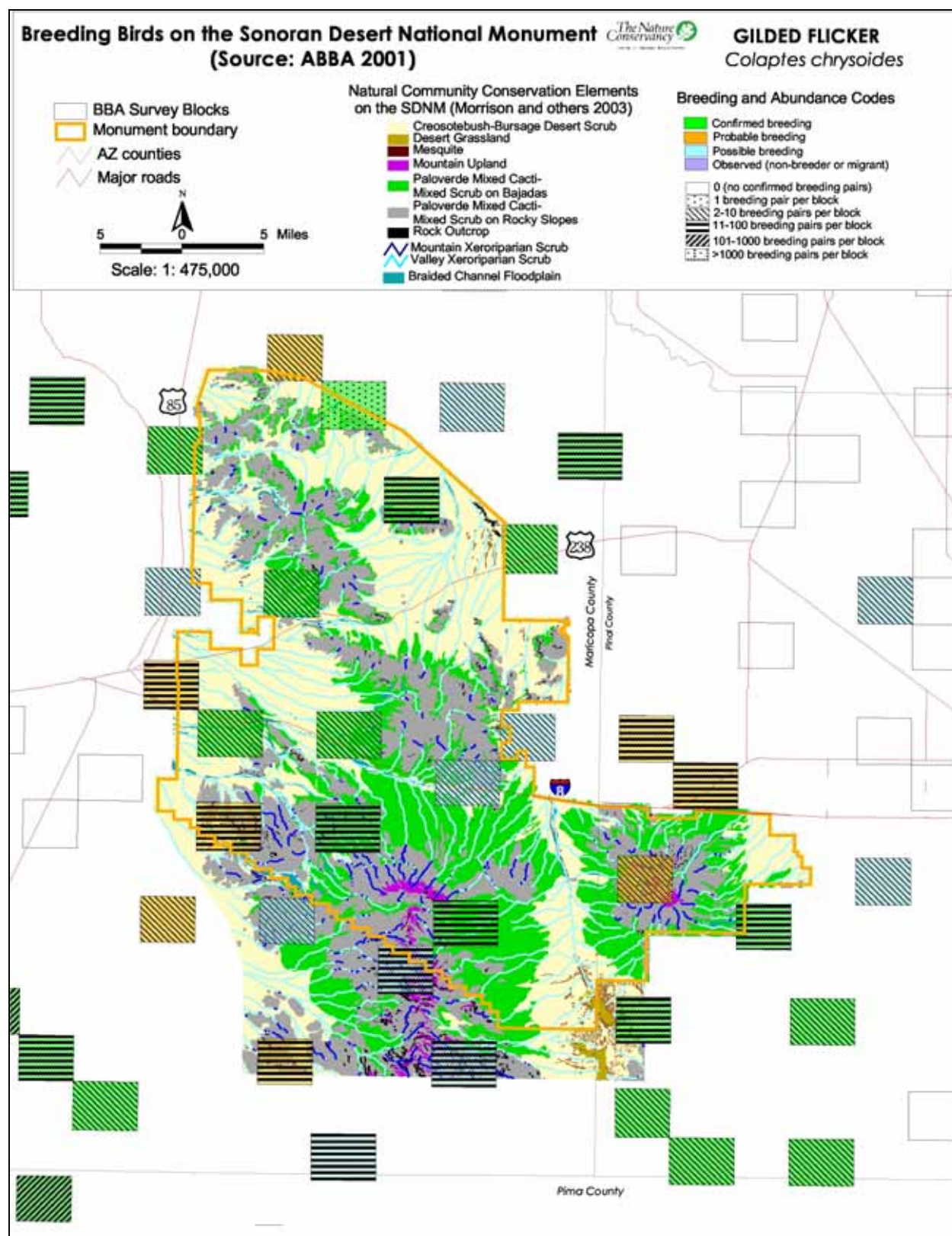


FIGURE C.33 Arizona Breeding Bird Atlas Survey Data for the Gilded Flicker on the Sonoran Desert National Monument and Vicinity

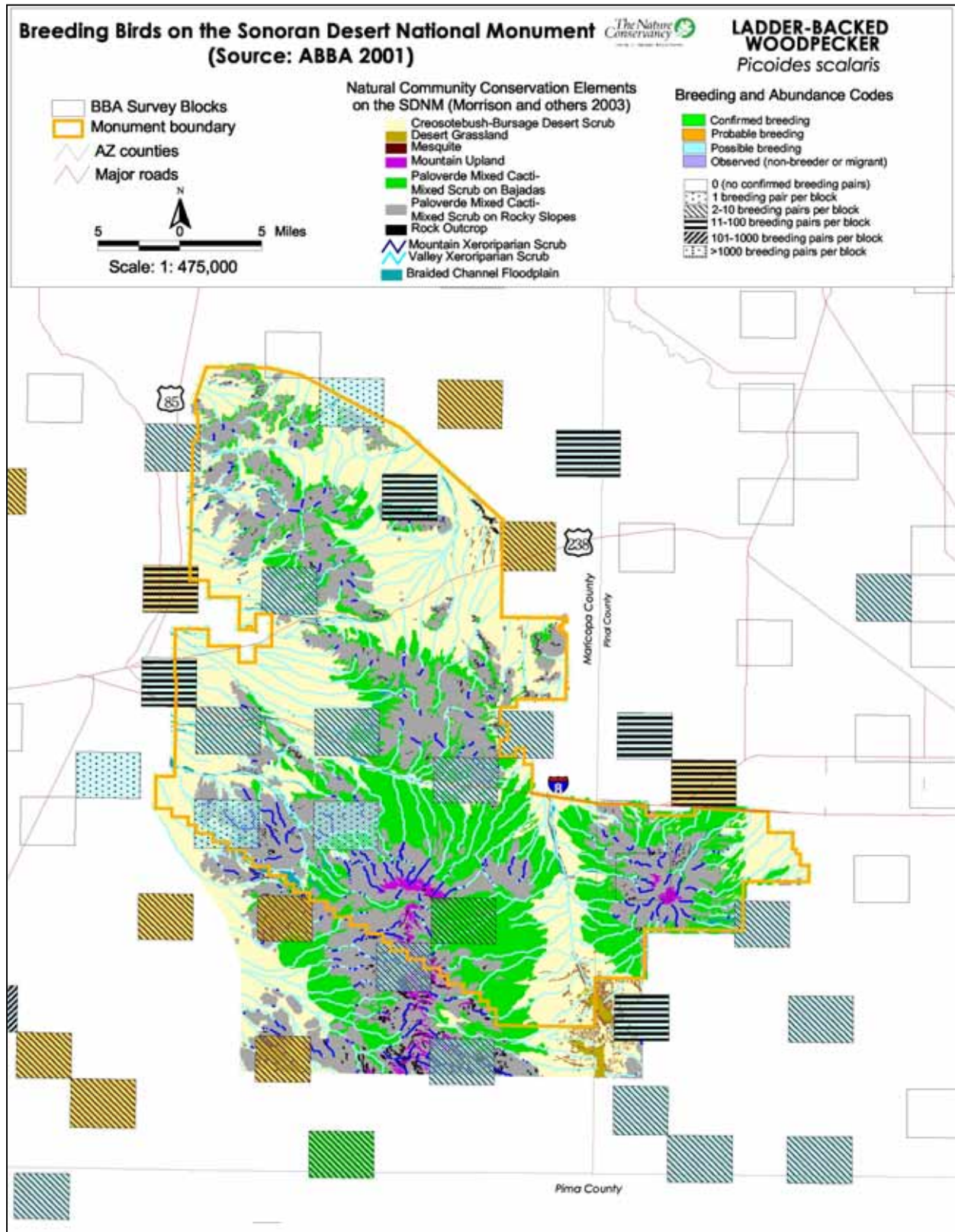


FIGURE C.34 Arizona Breeding Bird Atlas Survey Data for the Ladder-Backed Woodpecker on the Sonoran Desert National Monument and Vicinity

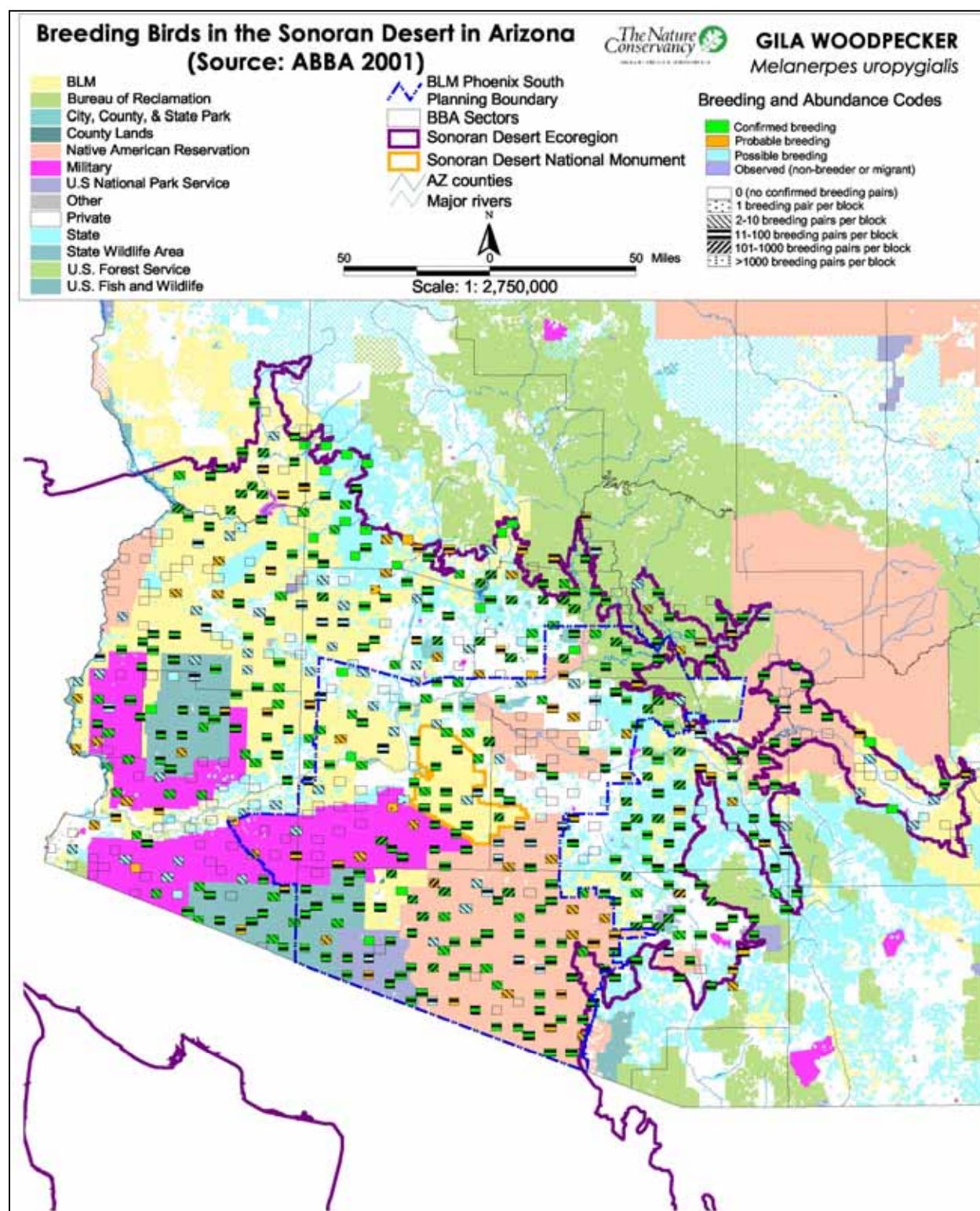


FIGURE C.35 Arizona Breeding Bird Atlas Survey Data for the Gila Woodpecker within the Sonoran Desert in Arizona

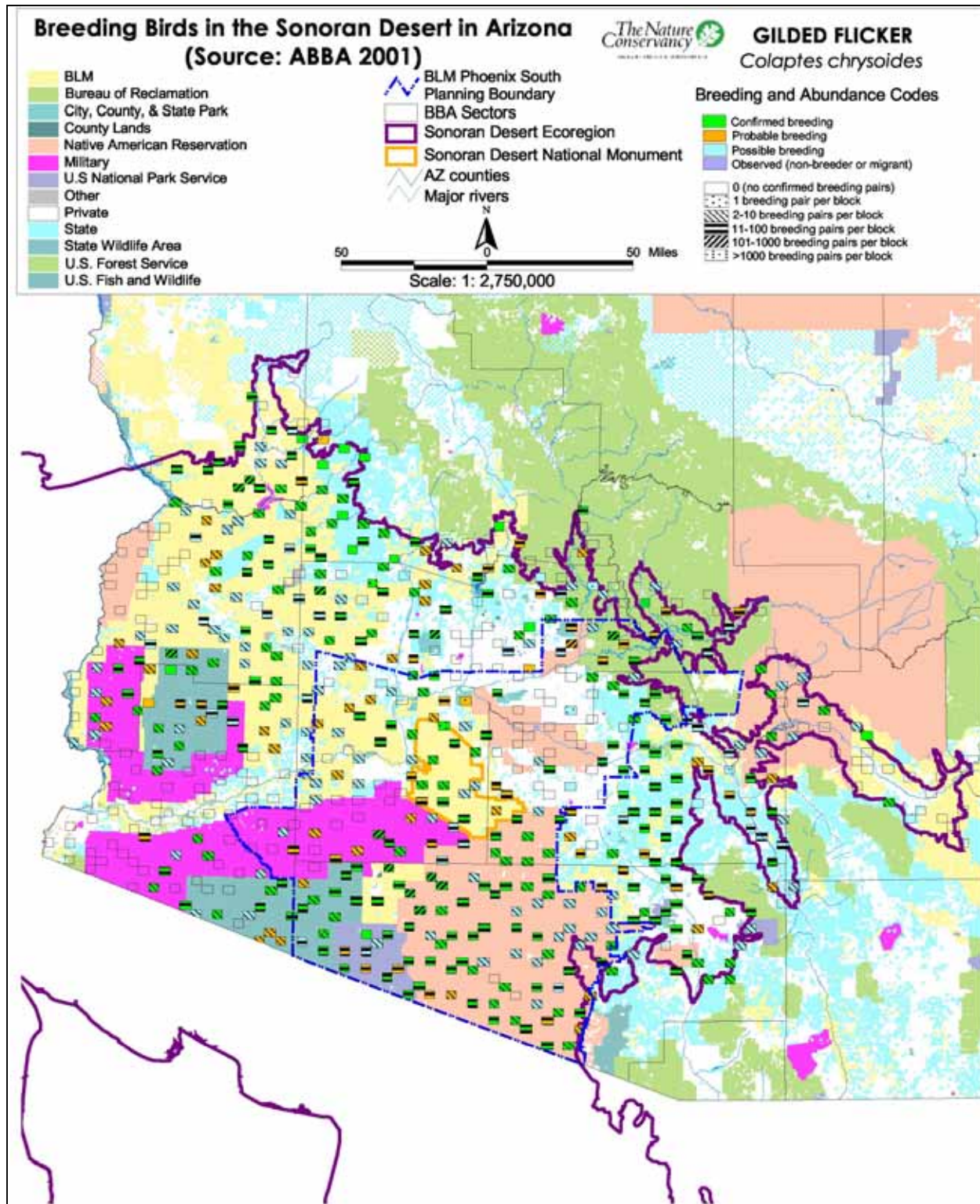


FIGURE C.36 Arizona Breeding Bird Atlas Survey Data for the Gilded Flicker within the Sonoran Desert in Arizona

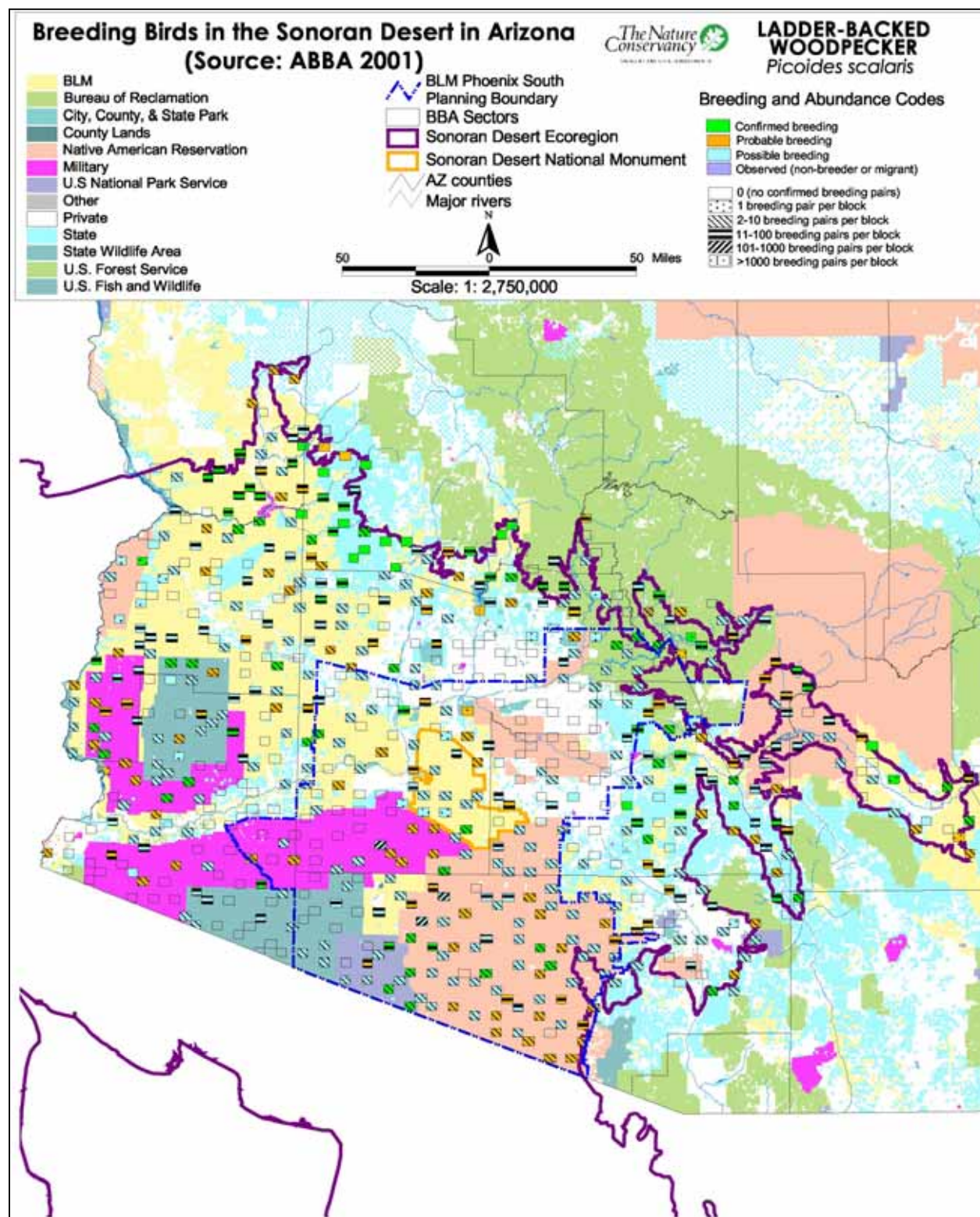


FIGURE C.37 Arizona Breeding Bird Atlas Survey Data for the Ladder-Backed Woodpecker within the Sonoran Desert in Arizona

species from west to east across the Sonoran Desert (Figure C.37), in which higher densities are likely found in association with riparian or dense xeroriparian scrub habitat availability.

Habitat associations and food and water requirements.—Xeroriparian areas are important foraging areas for all of the primary cavity excavators (T. Tibbitts, pers. comm.). Neither Gila woodpeckers nor gilded flickers require standing water as they acquire all their water from food, especially cactus fruits and nectar. Ladder-backed woodpeckers drink water from crevices on trees or other plants (Lowther 2001). Desert trees are often small, with gnarled branches unsuitable for cavity construction and nesting. They also have few naturally occurring holes suitable for a nest (T. Tibbitts, pers. comm.). As a result, saguaros provide one of the main nesting site locations for cavity-nesting birds in the desert. On the SDNM, gilded flickers and Gila woodpeckers will use predominantly saguaros for nest sites (these two species are the only common excavators of cavities in saguaros (Kerpez and Smith 1990a, b). Ladder-backed woodpeckers typically excavate nest cavities in trees, in xeroriparian or riparian areas, or in agave stalks (Russell and Monson 1998). As a result, they provide nest sites for secondary cavity nesters different than those dependent on the other woodpeckers for nest cavities.

Additional information on the habitat associations and food and water requirements specific to each woodpecker species in the guild is found below.

- **Gila woodpecker.** Gila woodpeckers are associated with deserts containing large cacti or trees suitable for nesting, dry subtropical forests, and riparian woodlands (Edwards and Schnell 2000). In non-riparian areas of the Sonoran Desert, Gila woodpeckers rely almost exclusively on saguaro for nest sites (T. Corman, pers. comm.). Moreover, Gila woodpeckers generally nest in areas with and preferentially use saguaros seven meters or larger in height or with six or more arms; however, nesting density also shows a negative relationship with habitats of increased slope (Kerpez 1986, Kerpez and Smith 1990b). Slope as a habitat attribute may correlate with changes in the components of the vegetation that woodpeckers respond to, availability of insects that serve as prey, or woodpecker energetic requirements. The actual relationships are unknown (Kerpez and Smith 1990b). Gila woodpeckers will excavate nest cavities in a paloverde or mesquite tree in the desert infrequently and will use cottonwoods or willows within riparian areas (Edwards and Schnell 2000, L. Smith, pers. comm.). In contrast to the other members of the guild, Gila woodpeckers will use urbanized landscapes, particularly those with mature saguaros in landscaping, and also will nest in non-native shade trees and palm trees (Edwards and Schnell 2000, TNC 2001).

Gila woodpeckers are omnivorous. They eat and capture insects by probing within or gleaning from the bark of trees and cacti. They also will go to the ground to capture visible food items (Edwards and Schnell 2000). Besides insects, they eat cactus fruit, mistletoe berries, and bird eggs (Ehrlich and others 1988). Martindale (1983) examined foraging patterns of Gila woodpeckers within the Tucson Mountain Unit of Saguaro National Park. Ninety three percent of the visits to a foraging substrate by woodpeckers involved paloverde, ironwood, or saguaro. Both sexes spent over half of their total foraging time on saguaros, though paloverde and ironwood trees yielded higher prey capture rates. In addition to foraging needs, saguaro use by Gila woodpeckers is also determined by behavioral/physiological needs, including nest defense (males use saguaro tops as perches) and avoidance of heat stress (both sexes spent time on the shady side of a saguaro that was correlated with temperature).

- **Gilded flicker.** Gilded flickers are common residents wherever large cacti grow and within drainages up to about 1,200 meters elevation (3,937 feet) (Russell and Monson 1998). These flickers use large saguaro, generally at least five meters in height, for nest sites (Kerpez and Smith 1990a, b). Gilded flickers are almost completely dependent upon saguaros for nest sites in the Sonoran Desert (L. Smith, pers. comm.). In riparian areas large deciduous trees, usually cottonwoods, are used (Russell

and Monson 1998). Besides the association with saguaro, Kerpez and Smith (1990b) also observed a positive relationship between the abundance of nesting flickers and the volume of ironwood trees present in the habitat. These authors speculated that the amount of ironwood, and its correlation with the occurrence of other floristic components, may be indicative of plant communities with superior insect foraging opportunities (also see Kerpez 1986). Gilded flickers rarely use saguaros for foraging; instead, they forage primarily for insects, especially ants, on the ground and in annual foliage <10 centimeters (four inches) high (Ehrlich and others 1988, Kerpez and Smith 1990b). Consequently, they are less dependent on an arborescent desert for foraging opportunities (T. Tibbitts, pers. comm.). They also will eat cactus fruit (Phillips and Wentworth Comus 2000).

- **Ladder-backed woodpecker.** Ladder-backed woodpeckers are characteristic of desert scrub, thornscrub, and tropical deciduous forest. Their range extends to higher elevations in riparian corridors where cottonwoods dominate (Russell and Monson 1998). Within the broader vegetation categories just mentioned, the species is typically found amidst dense wash and riparian vegetation (T. Corman, pers. comm.). These woodpeckers typically excavate nest cavities in rotted, dead, or dying branches of trees including mesquite, paloverde, ironwood, willow (*Salix* spp.), and cottonwood (*Populus* spp.) (Ehrlich and others 1988, Russell and Monson 1998, NatureServe 2003, T. Corman, pers. comm.). They also will excavate cavities in agave and yucca stalks (*Agave* spp. and *Yucca* spp.) and occasionally in columnar cacti including cardón cacti (*Cereus pringlei*) and saguaro (Lowther 2001). Nest cavities are usually three to eight meters (10 to 26 feet) above ground (NatureServe 2003). Because ladder-backed woodpeckers do not rely on saguaro in the same way that Gila woodpeckers and gilded flickers do, in desert areas they may be more dependent on the density of leguminous trees as a needed habitat component than the other woodpeckers. Ladder-backed woodpeckers are primarily insectivorous bark probers and gleaners (Russell and Monson 1998). They also will eat cactus fruit (Ehrlich and others 1988). Ladder-backed woodpeckers were located throughout the SDNM in ABBA surveys (Figure C.34), but were confirmed breeding only in one survey block: Johnson Well in the Sand Tank Mountains. This region of the monument presumably includes Xeroriparian Scrub habitat with leguminous trees at sufficient densities and sizes to support Ladder-backed woodpeckers.

Biotic interactions.—Three types of biotic interactions are discussed below: (1) characteristics of nest cavities excavated by the woodpeckers (including potential competition between the Gila woodpecker and gilded flicker and how cavity characteristics may influence secondary cavity nesters), (2) interactions between the guild and bats, and (3) interactions between European starlings and native cavity-nesting species.

- **Cavity characteristics.** In the Sonoran Desert, naturally-occurring nest holes are very rare and cavities created by the woodpeckers are critical as nest sites for some birds that would otherwise not breed in this habitat (Table C.17). The type of substrates used and manner in which each member of the guild constructs its nest cavities will determine (1) the nature of competitive interactions within and outside the guild and (2) which species of secondary cavity nesters will be affected by changes in the abundance of a particular woodpeckers. Within the non-riparian portions of the Sonoran Desert, Gila woodpeckers and gilded flickers almost exclusively use saguaros for nest sites, whereas ladder-backed woodpeckers use leguminous trees. As a result, a competitive interaction may be expected to occur between the Gila woodpecker and gilded flicker.

The selection criteria for use of individual saguaros may differ between the Gila woodpecker and gilded flicker, though they both tend to use large saguaro at least five meters (16.4 feet) tall (Kerpez and Smith 1990a). Both species, however, often will locate nest cavities within the same saguaro (McAuliffe and Hendricks 1988). Each species may select a different location to excavate its nest site within a saguaro. Although Kerpez and Smith (1990a) did not detect any difference in mean height

of the nest cavity between the two species, McAuliffe and Hendricks (1988) found differences in the vertical distributions of the nest cavities excavated by the two species. These latter authors concluded that competitive preemption of potential excavation sites could not fully explain the differential usage of vertical space and that cactus anatomy, and the differences in the capabilities of each species to excavate cavities within a saguaro, also may play a role. Still, some nest-hole competition may occur (Edwards and Schnell 2000, Kerpez and Smith 1990a, b) and each species may use cavities originally excavated by the other species (Kerpez and Smith 1990a). Because the two species do differ in their usage of saguaros as a foraging substrate and in the manner in which they forage, their niche overlap in regard to saguaros, if any, is probably limited to nest-site competition.

Besides the difference in substrate usage, most notably demonstrated by the substrate preferences of the ladder-backed woodpecker in contrast with the other members of the guild, characteristics of the cavity itself can affect which species of secondary cavity-nesting bird may use the nest site once a woodpecker vacates a cavity (Kerpez 1986, Kerpez and Smith 1990a). Gilded flicker cavities as compared with Gila woodpecker cavities are larger in the entrance dimensions and in the vertical extent of the nest cavity chamber (Kerpez 1986, McAuliffe and Hendricks 1988, Kerpez and Smith 1990a); however, the studies upon which the preceding information is based also contained contrasting results for the horizontal depth of the cavity. Overall, however, the larger size of the gilded flicker tends to result in the excavation of larger cavities as compared with the Gila woodpecker. Gila woodpecker cavities may be too small for use by larger species such as the American kestrel (*Falco sparverius*), whereas gilded flicker cavities may be too large for smaller species such as the elf owl (*Micrathene whitneyi*) (Kerpez and Smith 1990a).

Holes excavated in saguaros by Gila woodpeckers usually are not used in the year in which they are excavated, because the sap surrounding the excavation must harden first (Ehrlich and others 1988). Additionally, because Gila woodpeckers nest in the same cavity for several years (Kerpez 1986, Kerpez and Smith 1990b), the number of cavities they make available to secondary nesters may accrue at a relatively slow rate. Despite this limitation, cavities excavated by Gila woodpeckers in saguaro do not kill the cactus and are preserved over time; in contrast, an excavation by a gilded flicker (as it occurs near the stem apex) often results in the relatively quick demise (less than 10 to 20 years) of the saguaro (McAuliffe and Hendricks 1988). Finally, Gila woodpeckers may be important as pollinators of saguaro and disseminators of their seed (Edwards and Schnell 2000, Kerpez and Smith 1990b). As such they may play an important role in the maintenance of saguaros as a component of the Paloverde-Mixed Cacti-Mixed Scrub natural communities.

- **Cavities as Bat Roost Sites.** The primary excavator (cavity) guild not only provides nest sites to the many secondary cavity nesting birds described above and in Table C.17. Excavated cavities in saguaros are also used as roost sites for solitary bats (Tibbitts and others 2002), including the big brown bat (*Eptesicus fuscus*), pallid bat (*Antrozous pallida*), and the Underwood's mastiff bat (*Eumops underwoodi*). The Underwood's mastiff bat is a BLM Sensitive Species and is found in few localities in the United States (only in Pima County, Arizona; NatureServe 2003). The first documented use of a saguaro roost by Underwood's mastiff bat was on Organ Pipe Cactus National Monument in 2001 (Tibbitts and others 2002).
- **Competition with European Starlings.** The European starling (*Sturnus vulgaris*) was introduced to New York City in 1890 and by the late 1940s it had spread across much of North America (Koenig 2003). The European starling is a cavity-nesting species and because of its rapid range extension and dramatic increase in abundance since introduction, considerable concern exists over the effects of this non-native species on the reproductive success of native cavity-nesting birds (Kerpez and Smith 1990b, Koenig 2003, NatureServe 2003). Within the Sonoran Desert European starlings commonly nest in cavities in saguaro (Kerpez and Smith 1990b). European starlings have been found to

compete with Gila woodpeckers and secondary cavity nesters for available nest sites (Hunter 1984, Kerpez 1986, Kerpez and Smith 1990b). The number of Gila woodpeckers nesting in an area is negatively correlated with the number of European starling nests and the number of European starling nests is negatively correlated with the distance to agriculture and lawns (Kerpez and Smith 1990b). Starlings were unable to displace gilded flickers from cavities because the latter were larger and aggressive (Kerpez and Smith 1990b); however, numerous reports exist of starlings usurping nest cavities from closely related Northern flickers (Moore 1995). The Birds of North America species account for ladder-backed woodpecker does not mention competition with European starlings for nest sites (Lowther 2001). Competition between European starlings and ladder-backed woodpeckers may be unlikely in the Sonoran Desert because each species will generally use cavities in different species of plants.

Despite the evidence of competition between European starlings and Gila woodpeckers, as described above, the first comprehensive study of European starlings and its effects on all cavity nesting birds in North America had mixed results (Koenig 2003). Koenig used almost 100 years of data (Breeding Bird Survey [BBS] data from 1966 to 1996 and Christmas Bird Count [CBC] data from 1900 to 1996) for bird observations across North America to compare the relative densities of the cavity nesting species before and after European starlings were first observed at each survey site. The author found no significant effect of European starling presence on the mean density of Gila woodpecker, gilded flicker, or ladder-backed woodpecker across their ranges in North America. The starlings had mostly non-significant effects on the mean density of other species. In some cases, however, significant differences occurred in mean density, but with a lack of correspondence between BBS and CBC datasets. For example, one dataset would show a significant decrease in mean density after starling arrival, whereas analysis of the other dataset would show a significant increase (or no significant change) in mean density after starlings arrived in the survey area (Koenig 2003). Only sapsuckers (*Sphyrapicus* spp.) demonstrated declines in density that are potentially attributed to starlings. Otherwise, despite the abundance and apparent aggressiveness of European starlings, their impact on other cavity-nesting birds is ambiguous. Some species aggressively fight off starlings or some, such as the Northern flicker, have adapted to starlings by nesting later in the season when competition for nest sites declines (Koenig 2003). Because some of the results are ambiguous, the author recommends additional studies to verify the conclusions, at both the continental and population levels (Koenig 2003).

Status, Threats, and Management

Distribution.—Gilded flickers are residents of southeastern California, northeastern Baja California, and central Arizona south to southern Baja California and through Sonora, Mexico to northern Sinaloa (American Ornithologists' Union 1983). Gila woodpeckers are mostly permanent residents in southeastern California (Imperial and Lower Colorado River Valleys), extreme southern Nevada, extreme southwestern New Mexico, southern half of Arizona, most of Baja California except for the northwest corner, and south into central Mexico in a band along the eastern shore of the Gulf of California (Edwards and Schnell 2000). Ladder-backed woodpeckers are residents from the southwestern United States to northeastern Nicaragua (American Ornithologists' Union 1983). The guild is distributed across much of the Sonoran Desert in Arizona (Figures C.35, C.36, and C.37).

Conservation status.—The three woodpeckers that form the guild have Global Ranks of G5, which indicates that their global populations are demonstrably secure (NatureServe 2003). Local declines of some species have occurred, however, in some regions. Gila woodpeckers seem to be declining in southeastern California, which has been attributed to the clearing of woodlots and nest-site competition with European starlings (Hunter 1984, CDFG 2003). Population counts of Gila woodpeckers associated with riparian habitats in Arizona have declined from an estimated 650 birds in 1976 to 561 birds in 1986

(Edwards and Schnell 2000). The North American Breeding Bird Survey data from 1966 to 2001 show a significant decrease in Gila woodpecker abundance of -2.6% per year in the Sonoran Desert ($p=0.01$) (Sauer and others 2001). The Gila woodpecker also shows declines throughout Arizona and the species' entire range, but these decreases in abundance were not significant (-2.5% per year in Arizona [$p = 0.22$] and -2.1% per year survey-wide [$p = 0.36$] from 1980 to 1999; NatureServe 2003). Breeding Bird Survey data from 1966 to 2001 do not show a significant change in the abundance of the ladder-backed woodpecker or the gilded flicker in the Sonoran Desert and in Arizona; however, insufficient data (low abundance of birds and/or low sample sizes of routes) do not enable a reliable estimate of trends for these species (Sauer and others 2001). NatureServe (2003), however, reports declines of ladder-backed woodpeckers near densely populated areas in Arizona and Texas based on Christmas Bird Count survey data.

Both the Gila woodpecker and gilded flicker have been listed as Endangered by California since 1988 (CDFG 2003). Saguaro are scarce in California and, as a result, the Gila woodpecker and gilded flicker are primarily found along the Colorado River, where they excavate cavities primarily in snags and mature trees in cottonwood-willow riparian forests (Hunter 1984). The gilded flicker is endemic to the Sonoran Desert Ecoregion and is designated a priority species in the Arizona Partners in Flight Bird Conservation Plan (Latta and others 1999). Both the gilded flicker and the Gila woodpecker are thought to require management attention and are considered Birds of Conservation Concern by the U.S. Fish and Wildlife Service (USFWS 2002a).

Gilded flickers and Gila woodpeckers were located in every survey block on the SDNM and were confirmed breeding in most blocks (Figures C.32 and C.33). According to habitat data collected and categorized in the Arizona Breeding Bird Atlas surveys (2001), gilded flickers were found in the Arizona Upland subdivision of Sonoran desertscrub habitats on the SDNM and Gila woodpeckers were breeding in Arizona Upland in some survey blocks and Sonoran riparian scrubland (xeroriparian scrub) in others (ABBA 2001). Ladder-backed woodpeckers were found in all survey blocks on the SDNM except on Table Top Mountain (Figure C.34). Ladder-backed woodpeckers were confirmed breeding only in the Johnson Well survey block where they were nesting in Arizona Upland and xeroriparian habitats (ABBA 2001).

Stresses and sources of stress.—Table C.18 identifies potential stresses and sources of stress confronting the members of the primary excavator (cavity) guild. The primary threat to these woodpeckers across their range is habitat loss and degradation, which is not a threat to these species where they occur on the SDNM. The composition and abundance of invasive non-native plants is variable on the SDNM (Morrison and others 2003). Invasive plants could become a threat to the guild on the SDNM in the future if such plants contribute to atypical fuel loads and continue to spread from current localities and increase in cover such that they could carry fire through woodpecker habitat. Desert vegetation is not adapted to fire. If fire were to kill mature saguaros with cavities (usually over 70 years old), it could have long-term repercussions for local Gila woodpecker and gilded flicker populations because of the extremely slow rate of growth of saguaro.

Competition for nest sites with European starlings has been implicated as a threat to Gila woodpecker and Gilded flicker (Kerpez and Smith 1986, Moore 1995, Edwards and Schnell 2000). As previously discussed, however, in the **Biotic interactions** section, the evidence is inconclusive that starlings have caused significant declines in cavity-nesting species (Koenig 2003). Koenig's study focused on declines across the entire range of each species, so it is possible that effects of starling competition on the abundance of woodpeckers or other cavity-nesting species still occur in portions of their range, such as in the Sonoran Desert or at localized sites. Furthermore, although a negative effect of European starlings on native cavity-nesting species abundance is not apparent today, the possibility remains that impacts may be seen in the future as starling populations continue to grow (Koenig 2003). Starlings are not as adapted

TABLE C.18 Primary Excavator (Cavity) Guild: Stresses and Sources of Stress

Stress	Source of Stress	Geographic Scope of Potential Impacts	Comments (Source of Information)
Habitat loss	Historic and current urban and agricultural development.	Regional	Edwards and Schnell (2000), NatureServe (2003).
	Loss of desert vegetation caused by fire carried by invasive non-native plants, such as red brome (<i>Bromus rubens</i>).	Regional	Morrison and others (2003) found relatively low overall percent cover (~7.5%) of invasive non-native plants in the Paloverde-Mixed Cacti-Mixed Scrub on Bajadas natural community; however, some plots in the Sand Tank Mountains (on the BMGR and SDNM) had a high (15 to 30%) cover of red brome.
	Elimination of mesquites and other desert trees (by chaining, herbiciding, and bulldozing for brush control).	Regional	Implicated as a potential cause of the apparent decline of ladder-backed woodpeckers in some parts of its range (NatureServe 2003).
Habitat degradation	Illegal shooting and vandalism of mature saguaros.	Regional and SDNM	Saguaro shooting and vandalism has occurred in some areas on the SDNM and could cause localize impacts to Gila woodpeckers, gilded flickers, and secondary cavity-nesters (Foti and Patterson, Foti and others 2005).
	Decrease in saguaro abundance and/or recruitment caused by inappropriate livestock grazing management practices.	Regional	Hall and others (2005). The majority of impacts to vegetation attributed to livestock grazing on the SDNM were primarily centered in the Creosotebush-Bursage Desert Scrub natural community, according to work conducted by Morrison and others (2003).
	Decrease in the quality and quantity of habitat caused by livestock browsing on trees and shrubs in xeroriparian scrub.	Regional	This threat would primarily impact ladder-backed woodpeckers (Lowther 2001). This is probably not a widespread threat on the SDNM, because ladder-backed woodpeckers were confirmed breeding only in the Sand Tank Mountains where grazing is absent.
Excessive competition for nest sites	Competition with European starlings	Regional and SDNM	See Biotic interactions section and additional comments in this section.

to desert conditions as are the species in the woodpecker guild, and they are generally found in altered landscapes in or on the fringe of agricultural, urban, and residential areas. The association of European starlings with developed areas is apparent based on ABBA (2001) data for the Sonoran Desert and on the SDNM (Figures C.38 and C.39). It is of some concern, however, that starlings were found in the

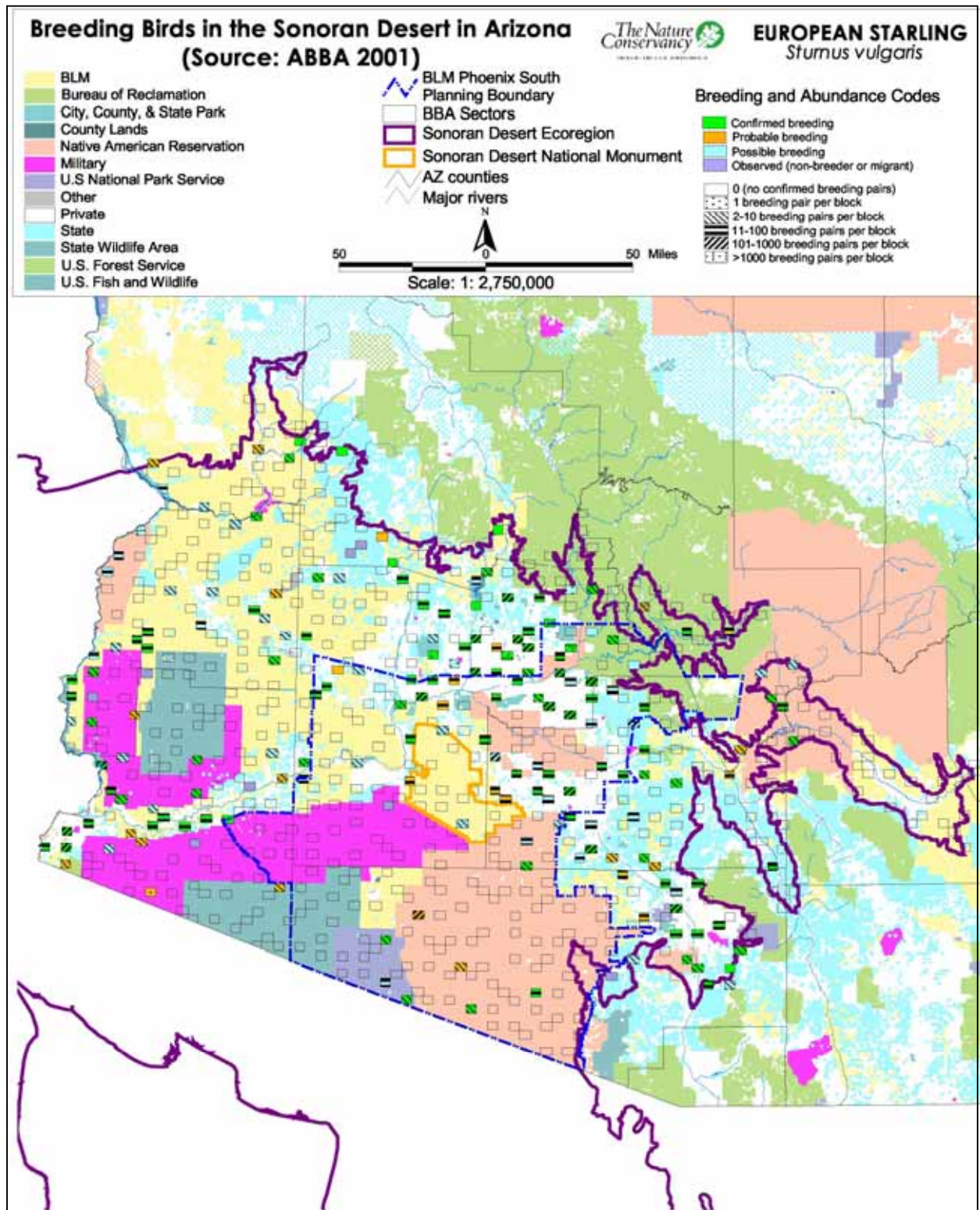


FIGURE C.38 Arizona Breeding Bird Atlas Survey Data for the European Starling within the Sonoran Desert in Arizona

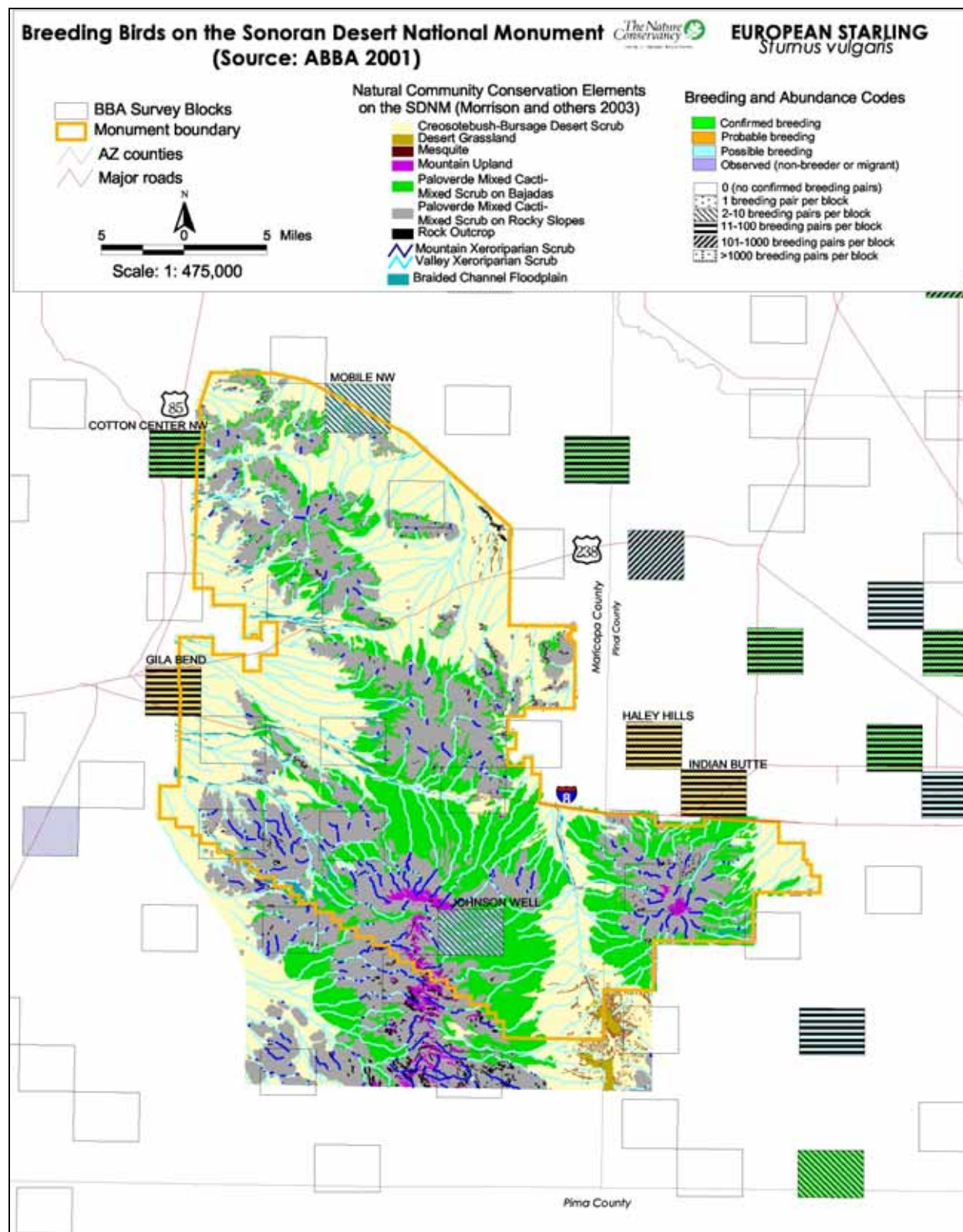


FIGURE C.39 Arizona Breeding Bird Atlas Survey Data for the European Starling on the Sonoran Desert National Monument and Vicinity

heart of native desert habitat in the Sand Tank Mountains at Johnson Well (Figure C.39; ABBA 2001). Although starlings were not confirmed breeding in this survey block, their behavior indicates that they were possibly breeding and not just passing through the area (ABBA 2001). The presence of European starlings in the Sand Tank Mountains could be cause for concern if the starlings are confirmed breeding and/or if they increase in abundance in the area. This is a relatively lush area of the Sonoran Desert with habitat that is considered to be in good condition (Condition Class 3; Morrison and others 2003), and it is an area where all three woodpeckers in the guild have been confirmed breeding along with many secondary cavity-nesting species.

Mapping and Information Needs

Mapping comments.—Distribution, breeding status, and breeding pair abundance information displayed in Figures C.31 to C.39 are based on data collected from 1993 to 2000 as part of the Arizona Breeding Bird Atlas surveys (ABBA 2001). The underlying natural community coverage was produced by Morrison and others (2003).

Information needs.—As the areas surrounding the SDNM continue to grow and become developed, European starlings are likely to increase in abundance and may make inroads into native desert habitats. More information is needed to evaluate whether European starlings could negatively impact the breeding abundance of woodpeckers and secondary cavity-nesting species in the Sonoran Desert and particularly on the SDNM. The effects of pesticide drift from agriculture on woodpeckers and/or the quality or quantity of their food sources is unknown and represents an information need, particularly in desert habitats close to agricultural lands such as that on the SDNM. Pacific Biodiversity Institute (Morrison and others 2003) collected preliminary baseline data on saguaro demographics (for example, size-class distributions) that can be used to evaluate areas where mature saguaros are present and abundant (which may represent important breeding habitat for Gila woodpeckers and Gilded flickers) and where recruitment is occurring. Section C.1.2 provides an analysis of these data. Additional and more detailed saguaro demographic data would be beneficial to collect in a repeated manner so that the availability of cavity substrates can be tracked over time.

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C.4.3 Le Conte's Thrasher (*Toxostoma lecontei*)

Overview

Rationale for selection as a conservation element.—*Specialized Species, Regionally Vulnerable.* Le Conte's thrasher is a species with a limited distribution and one of the few birds that is closely associated with the sparsely vegetated, arid desert valley bottoms characteristic of the Lower Colorado River Valley subdivision of the Sonoran Desert. Le Conte's thrasher has specific habitat needs. It is not found uniformly throughout its valley bottom habitat, and it has a relatively large home range requirement. This makes populations vulnerable to habitat fragmentation and local extirpation (Sheppard 1996, NatureServe 2003). Le Conte's thrasher is considered regionally vulnerable in numerous evaluations (see **Conservation status**) because populations are declining throughout the range of the species. Much of the species' primary habitat, saltbush desert scrub, has been lost to agricultural conversion. Other valley bottom habitats used by Le Conte's thrasher, including Creosotebush-Bursage Desert Scrub, also have been lost because of agricultural and urban development or have been degraded by numerous uses, including off-road vehicle use and improper livestock management practices. Although the status of Le Conte's thrasher on the Sonoran Desert National Monument (SDNM) is not well-known, the species is expected to breed there (T. Corman, L. Smith, and T. Tibbitts, pers. comm.) and suitable habitat exists on the monument. This offers an opportunity to protect this species in an area free from many of the threats present elsewhere across its range.

Specific habitat needs on the SDNM.—Most of the research on Le Conte's thrashers has been conducted in the Mojave and Colorado Deserts in California. Although some of the habitat needs of Le Conte's thrasher may be different in Arizona and/or on the SDNM, many of the species' needs are likely to apply in both regions. On the SDNM, Le Conte's thrasher is associated with Creosotebush-Bursage Desert Scrub and Valley Xeroriparian Scrub natural communities (Morrison and others 2003). Le Conte's thrasher is likely to be patchily distributed within these natural communities based on their need for scattered shrubs, trees, and/or cacti as nest sites and for leaf litter under shrubs as foraging sites (discussed below). Analysis of plot data collected by Morrison and others (2003) could provide information on vegetation composition and structure and guidance on where to look for Le Conte's thrasher; however, validation of this species' occurrence on the monument will be possible only with field surveys.

Below is an overview of some of the habitat needs of Le Conte's thrashers, particularly within the Sonoran Desert in Arizona. Some additional/more general information on Le Conte's thrasher habitat is found in the **Habitat associations** and **Landscape context** sections.

- **Vegetation composition and structure.** Le Conte's thrasher is found in areas with creosotebush (*Larrea tridentata*) and saltbush (*Atriplex* spp.) and sparsely scattered trees or large shrubs, most of which rarely exceed 2.5 meters (8.2 feet) in height. Le Conte's thrasher commonly forages in and/or nests in trees in small washes that traverse low valley bottom habitat (Sheppard 1996). Le Conte's thrashers are rarely found in habitats consisting almost exclusively of creosotebush (Sheppard 1996). Isolated trees and shrubs are essential habitat components that serve as nest sites and night roosts. Tree/shrub densities in Le Conte's thrasher habitat are estimated at approximately 0.4 to 2.8 per hectare (one to 7 per acre; T. Corman, pers. comm.). Although thrashers frequently build their nests in cholla cactus (*Opuntia* spp.) in the Colorado and Mojave Deserts, in Arizona only one out of 21 nests found in the Arizona Breeding Bird Atlas (ABBA) survey was in cholla (T. Corman, pers. comm.). Based on ABBA survey data, Le Conte's thrasher most frequently nest in isolated trees and shrubs, such as mesquite (*Prosopis* spp.), paloverde (*Cercidium* spp.), ironwood (*Olneya tesota*), ocotillo (*Fouquieria splendens*), and wolfberry (*Lycium* spp.) (T. Corman, pers. comm.). Morrison and others (2003) describe 10 variants of the Creosotebush-Bursage Desert Scrub natural community

on the SDNM. Le Conte's thrasher is likely associated with the variants that contain relatively high species diversity or high native tree, cacti, and/or shrub cover. The thrasher is unlikely to be found in the variants of this natural community that are almost exclusively composed of creosotebush.

- **Ground cover.** Le Conte's thrasher is found in areas with a high percentage of bare ground, typically on sandy substrates. Le Conte's thrasher requires undisturbed ground surfaces, including undisturbed areas beneath plants, in their territories as foraging sites. Accumulated leaf litter under plants attracts the arthropod prey consumed by the species. Le Conte's thrasher does not occupy areas with dense or tall ground vegetation, such as grasses (J. Sheppard, pers. comm.), because this vegetation structure reduces foraging habitat and hinders movement by individuals within their territories. Morrison and others (2003) did not collect data on leaf litter in survey plots on the SDNM. The condition assessment and plot data collected by these investigators could be used, however, to identify potential areas occupied by Le Conte's thrasher. For example, areas with a high percentage of bare ground could be identified in plot data. Areas within Creosote-Bursage Desert Scrub and Valley Xeroriparian Scrub natural communities with intact ground surfaces and accumulated leaf litter likely are located away from range developments and/or disturbed areas.
- **Habitat area needs.** In saltbush-cholla scrub habitat in California, Le Conte's thrasher home ranges averaged 40 hectares (99 acres), whereas actively defended breeding territories averaged 6 hectares (15 acres) (Sheppard 1996). This breeding territory size is expected to be approximately the same in the Sonoran Desert (L. Smith, pers. com.). Juvenile dispersal from natal territory can range from several hundred meters to 3.7 kilometers (2.3 miles) (Sheppard 1996). An area of 1000 hectares (2,471 acres) of suitable habitat is thought to be the minimum size needed to support a reasonably viable population of 250 birds (NatureServe 2003).

Ecological Characteristics

Most of the information below is taken from Hall and others (2001).

Abundance.—Le Conte's thrashers are an uncommon resident of the desert Southwest (Sheppard 1996). They have a spotty distribution within creosotebush-dominated habitats, and the valley floors are not uniformly occupied by this species (NatureServe 2003). The factors that affect the abundance and distribution of this species within its range are poorly understood. Population density can approach four to five breeding pairs per square kilometer (with floaters, densities can approach over 10 birds/km² [3.9 birds/mi²]). Overall density within the species' U.S. range, however, averages less than 0.2 pairs/km² [0.08 pairs/mi²] (Sheppard 1996). Population estimates may be underestimates if species phenology is not taken into account. For example, counts of Le Conte's thrashers in the United States are more likely to be accurate from late December through early February, when birds are breeding and actively defending territories. Some survey protocols, however, such as those used in the North American Breeding Bird Survey, tend to rely on data collected in the late spring (long after most Le Conte's thrasher pairs have fledged broods and singing is reduced; Sheppard 1996).

Habitat associations.—Le Conte's thrasher habitat is found at elevations between sea level and 1,150 meters (0 to 3,773 feet). Typical habitat throughout their range consists of sparsely vegetated desert flats, vegetated margins of sand dunes, alluvial fans, or gently rolling hills containing one or more species of saltbush or shadscale (*Atriplex* spp.) and/or cylindrical cholla cactus (*Opuntia* spp.) 0.9 to 1.9 meters (three to 6.2 feet) high (Sheppard 1996). Other desert habitats lacking the above species composition but with similar structural profiles—shrubs are well scattered, most rarely exceeding 2.5 meters (8.2 feet) in height, and ground cover is sparse—may be used; however, the Le Conte's thrasher is rarely found in habitats consisting nearly exclusively of creosotebush (Sheppard 1996). Even in the preceding habitats, and especially in Arizona, isolated trees or tall, thin shrubs that can serve as nest sites may be a necessary

habitat component (T. Corman, pers. comm.). Substrates are typically sandy and territories generally lack surface water and possess little topographical relief (Sheppard 1996). In California, nests were found within 100 meters (330 feet) of stock tanks and wildlife waters (guzzlers), however, these nests were located in areas that were inaccessible to cattle because of fencing or topography (such as deep washes) (J. Sheppard, pers. comm.). Almost all food consumed by this species is found under the litter of desert vegetation or on the substrate; as a result, Le Conte's thrasher requires accumulated leaf litter under most plants within its territory to provide diurnal cover for its arthropod prey (Sheppard 1996). One study of nest site locations (n = 289) across the range of the species identified 85% of the nests as occurring in cholla cactus or saltbush (Sheppard 1996); however, in Arizona the species most frequently nests in shrubby trees and shrubs, such as mesquite, paloverde, ironwood, ocotillo, and wolfberry (T. Corman, pers. comm.). In saltbush/shadscale habitat Le Conte's thrasher pairs generally use less than 20 hectares (50 acres) at any given time (Sheppard 1996).

Food and water requirements.—This bird feeds on the ground using its bill to dig in the soil for food. It is mostly insectivorous, feeding on soil larvae, but it also may eat spiders, centipedes, small lizards, berries, and seeds (Phillips and Comus 2000). Feeding usually takes place in the early morning and at dusk, when insects are most active (Phillips and Comus 2000). Le Conte's thrashers do not drink water and derive all needed moisture from their food.

General life history.—These birds are non-migratory. Pairs mate for life and remain together year-round (Phillips and Comus 2000). Singing starts in mid-fall and peaks in late December and January, when nest building commences (USFWS 1998). Nests are built in thick, dense, thorny shrubs or cactus. Breeding and egg laying occurs between February and June. Mean clutch size is about 3.3 eggs, pairs produce two to three clutches per breeding season average, and about two-thirds of all nesting attempts produce at least one fledged young (Sheppard 1996). Both sexes incubate eggs and tend the altricial young. Juveniles leave their parents' territory at approximately one month of age (Sheppard 1996).

Biotic interactions.—Predation rates in the San Joaquin Valley of Kern County, California were documented at about 10% for both eggs and nestlings (Sheppard 1996). Potential predators of eggs and young include desert spiny lizards (*Sceloporous magister*), round-tailed ground squirrels (*Spermophilus tereticaudus*), gopher snakes (*Pituophis catenifer* [= *P. melanoleucus*]), king snakes (*Lampropeltis* spp.), whipsnakes (*Masticophis* spp.), and coyotes (*Canis latrans*). Domestic dogs and cats are predators of nestlings and can disturb adults (Sheppard 1996, NatureServe 2003). A pair may renest after nest depredation.

Landscape context.—Le Conte's thrashers are non-migratory and spend their lives in the arid deserts of the southwestern U.S. and northwestern Mexico. They have relatively large home ranges and breeding territories, as described above, and are therefore vulnerable to habitat fragmentation. Juveniles have been found to disperse a mean distance of 395 meters (about 0.25 miles) from the nest site when they leave their natal territory, and they continue to disperse in the fall when adults are territorial. A study of the dispersal of 30 juveniles had a range in dispersal distance of 350 to 3,700 meters (1,148 feet to 2.3 miles), with a mean dispersal distance of 1,720 meters (over 1 mile) (Sheppard 1996). Based on dispersal of young, it is estimated that habitat fragments must be closer than 10 to 15 kilometers (6 to 9 miles) apart in order for colonization or recolonization to be possible (Sheppard 1996). Corridors that maintain gene flow between populations are likely to be at least one-kilometer (0.62 mile) wide of appropriate habitat (not pure stands of creosotebush); however, on occasion, some birds may be able to disperse across small areas (one to two kilometers or up to 1.25 miles) of agricultural lands (J. Sheppard, pers. comm.). The ecological characteristics of dispersal areas and the surrounding matrix represent an information need, particularly in fragmented areas. It is not known if roads are barriers to dispersal or if road size, surface characteristics, and/or use intensity are important features that determine fragmentation effects.

It is difficult to determine what areas on and adjoining the SDNM are important for maintaining connectivity because of a lack of information on where Le Conte's thrasher populations occur on the monument. The heart of Le Conte's thrasher distribution in Arizona is found on the Barry M. Goldwater Range (BMGR) and other low desert areas to the southwest of the SDNM (Figure C.40). As a result, it is probably important to maintain connectivity and suitable Le Conte's thrasher habitat in the Creosotebush-Bursage Desert Scrub natural community in the southwestern portion of the monument (Figure C.41), particularly in areas adjoining the BMGR. The Gila River Indian Reservation includes some areas with saltbush desert scrub and is likely to have higher breeding densities of Le Conte's thrasher than that found on the SDNM (J. Sheppard, pers. comm.; note that portions of the reservation were not surveyed by ABBA [Wise and others 2001]). Part of the Gila River Indian Reservation is separated from the SDNM by the Sierra Estrella Mountains and agricultural lands. If areas of contiguous Creosotebush-Bursage Desert Scrub occur between the Gila River Indian Reservation and the monument, these areas should be evaluated for their potential to support Le Conte's thrashers and connectivity should be maintained where possible to permit Le Conte's thrasher dispersal and gene flow.

Status, Threat, and Management

Distribution.—The distribution of Le Conte's thrasher is limited mostly to low desert areas in the Sonoran and Mojave Deserts in western, south-central, and southwestern Arizona, southern Nevada, southeastern California, extreme southwestern Utah, northwestern Sonora, and northeastern Baja California, Mexico. Disjunct populations are found in the San Joaquin Valley, California and central and coastal Baja California (Sheppard 1996). The occurrence of Le Conte's thrasher within its range has been restricted since early accounts of its status in the 1890s because of habitat loss. Approximately 15% of historical localities were lost by 1975, and this loss is expected to have reached 20 to 30% (NatureServe 2003). The SDNM represents the eastern edge of the range of this species.

Conservation status.—Le Conte's thrasher has a Global Rank of G3, which indicates that it is globally vulnerable because it is rare and local throughout its range or is found only in a restricted range (even if abundant in some locations) (NatureServe 2003). Le Conte's thrasher is tracked by numerous organizations and agencies that are concerned about its status. Le Conte's thrasher is a priority species in the Arizona Partners in Flight Bird Conservation Plan (Latta and others 1999) and is designated a Bird of Conservation Concern in the Sonoran and Mojave Deserts by the U.S. Fish and Wildlife Service (USFWS 2002a). Le Conte's thrasher is listed as a Species of Special Concern by the California Department of Fish and Game (Remsen 1978) and is a focal species in the Recovery Plan for Upland Species of the San Joaquin Valley, California (USFWS 1998). Le Conte's thrasher also is protected by the Migratory Bird Treaty Act.

Le Conte's thrashers seem to be persisting where their habitat is intact, but they are intolerant of habitat disturbance associated with human activity (Ehrlich and others 1988). Agriculture and urbanization have eliminated considerable former habitat resulting in large reductions in population numbers in areas affected (for example, south and west of Phoenix and the lower Gila and Salt River Valleys) (Sheppard 1996). Based on satellite imagery, by 1993 at least 26% of 243 historic sites in the United States no longer had suitable habitat within three kilometers (1.9 miles) of the site (Sheppard 1996).

An important center of Le Conte's thrasher distribution in Arizona is on the BMGR (Figure C.40; ABBA 2001, Hall and others 2001). Moreover, the BMGR is an important area for conservation of this bird because it includes relatively large, intact expanses of low desert and, along with Cabeza Prieta National Wildlife Refuge, it contains the largest population of this species across its range in Arizona (T. Corman, pers. comm.). The Gila River Indian Reservation was not surveyed by the Arizona Breeding Bird Atlas Project (Wise and others 2001), but Le Conte's thrashers are known from this region (J. Sheppard, pers. comm.). Some areas in Mexico also are important to Le Conte's thrashers, such as the Gran Desierto,

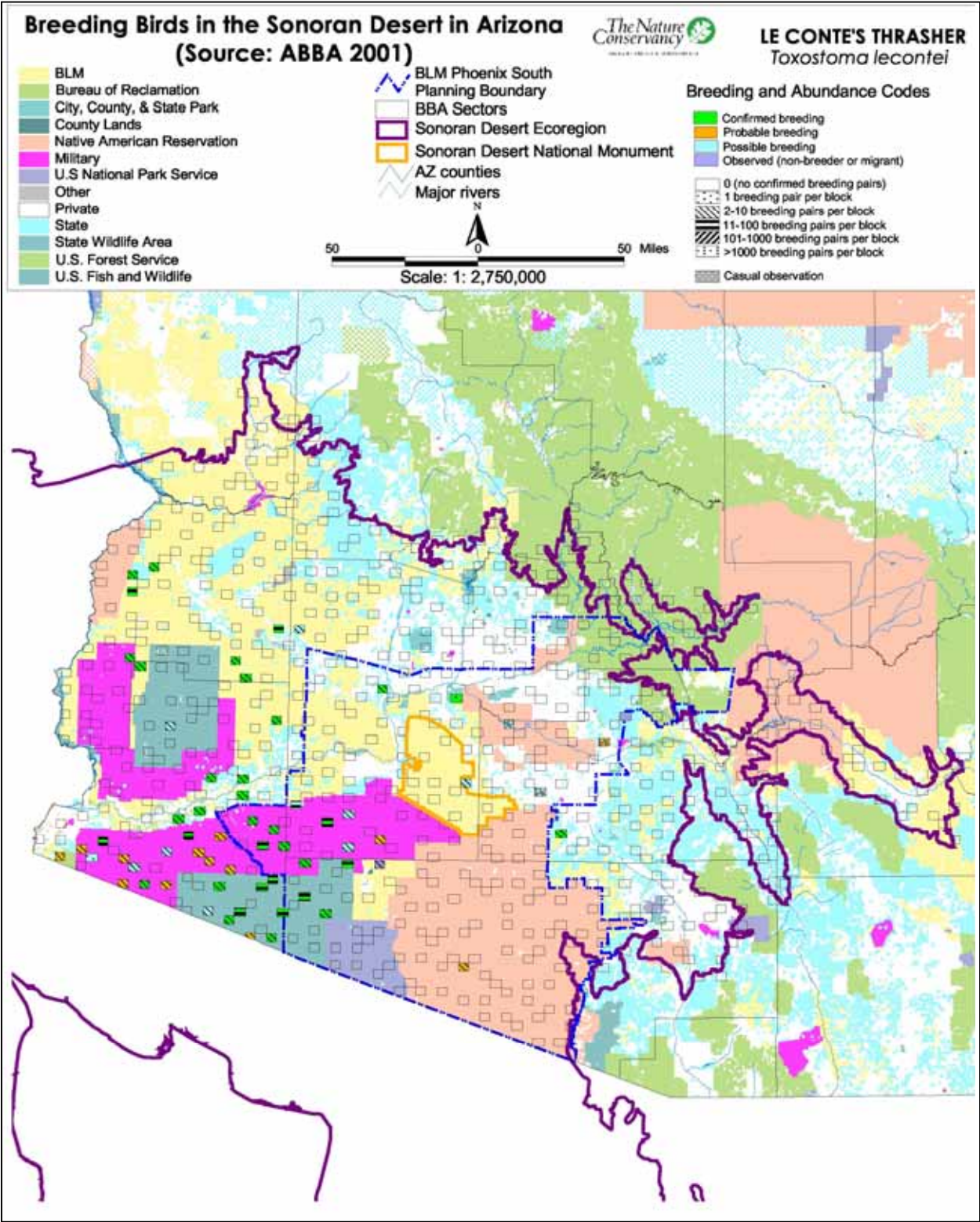


FIGURE C.40 Arizona Breeding Bird Atlas Survey Data for the Le Conte's Thrasher within the Sonoran Desert in Arizona

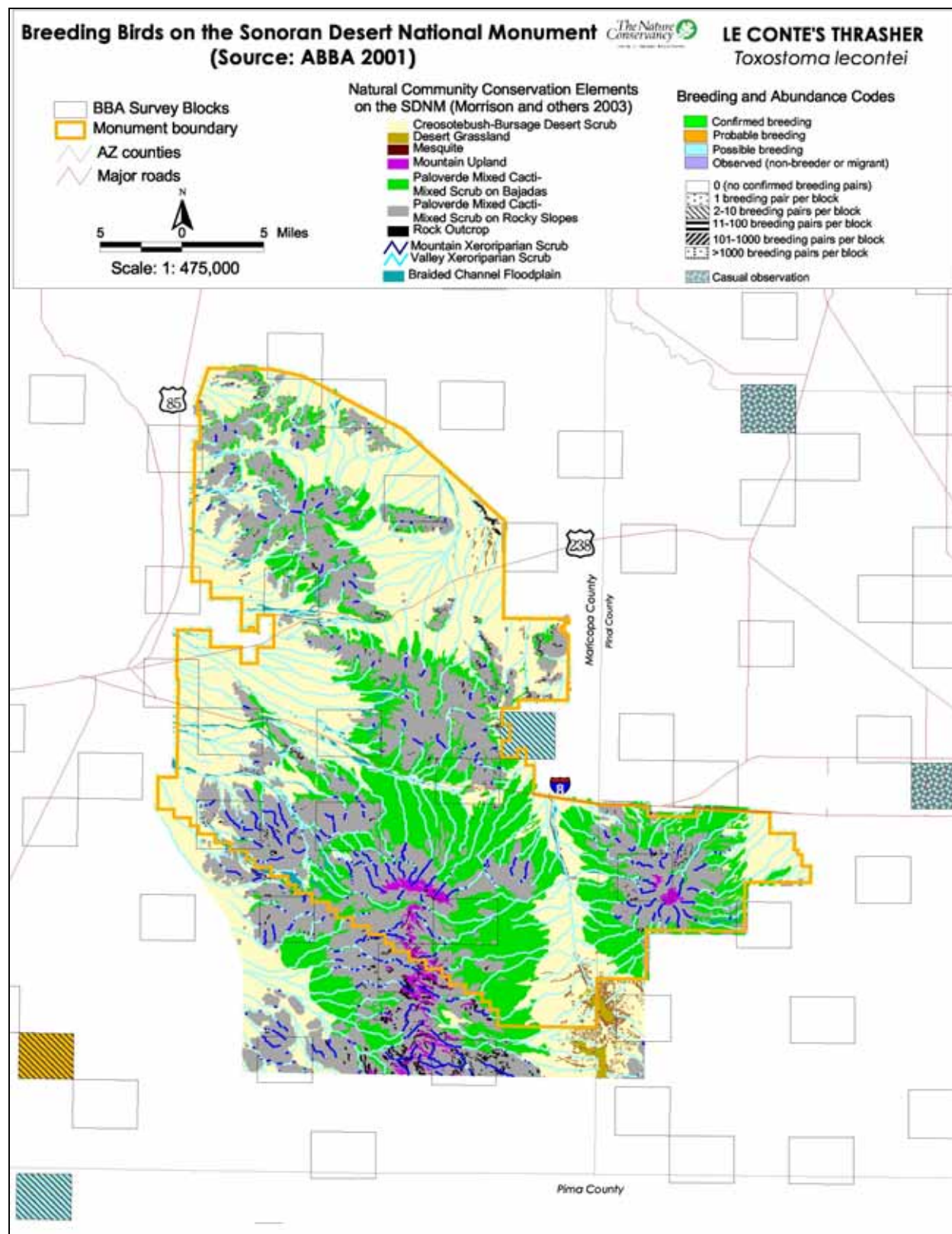


FIGURE C.41 Arizona Breeding Bird Atlas Survey Data for the Le Conte's Thrasher on the Sonoran Desert National Monument and Vicinity

Pinacate Biosphere Reserve, and some local patches; however, much of the species' territory in Mexico is not formally protected.

The status of Le Conte's thrasher on the SDNM is not well documented. The best source of occurrence information on this species is the Arizona Breeding Bird Atlas; however, Le Conte's thrashers are wary of humans and are difficult to find or to confirm breeding using standard ABBA survey methods (Wise and others 2001; T. Corman, pers. comm.). Regional experts on this species have suggested, however, that they expect the monument to support breeding populations of Le Conte's thrashers (T. Corman, J. Sheppard, L. Smith, and T. Tibbitts, pers. comm.). The SDNM includes expanses of low desert that are expected to provide suitable habitat for Le Conte's thrasher, though they are likely patchily distributed across these low desert areas (T. Corman, pers. comm.). Le Conte's thrashers were detected in one Breeding Bird Atlas survey block on the edge of the SDNM (Figure C.41), at a density of two to 10 breeding birds per survey block (one sixth of a 1:24,000 topographic quadrangle, or approximately 26 km² [10 miles²]). This translates to roughly 0.08 to 0.38 breeding pairs per square kilometer (0.03 to 0.15 pairs/mi²). This range of densities is lower than that reported on the BMGR (Hall and others 2001) and other areas (as described in the **Abundance** section), but it is comparable to overall densities across the species' range and overlaps the minimum density of 0.25 pairs/km² (0.10 pairs/mi²) (Sheppard 1996). The birds located in this survey block were in "possible" breeding status, which indicates that the species was observed in suitable nesting habitat during its breeding season but behaviors that indicate breeding—such as territorial behavior, nest building, or courtship—were not observed. It is likely that Le Conte's thrasher breeds in other areas of the SDNM and within additional Breeding Bird Atlas survey blocks where they were not documented (T. Corman, pers. comm.), with densities approximating 1 to 1.5 pairs/km² (0.4 to 0.6 pairs/mi²) (J. Sheppard, pers. comm.). Surveys that specifically target Le Conte's thrashers are needed to identify areas occupied by the birds on the SDNM.

The Arizona Partners in Flight conservation recommendations for Le Conte's thrasher are the following:

- protect known at-risk breeding territories
- avoid off-road recreational vehicle use on BLM land during Le Conte's thrasher breeding season
- protect large tracts of optimal Le Conte's thrasher desert habitat (Latta and others 1999).

The first step in addressing these recommendations on the SDNM is to identify the locations of breeding territories.

Stresses and sources of stress.—Table C.19 identifies potential stresses and sources of stress confronting the Le Conte's thrasher. Le Conte's thrashers are intolerant of many types of habitat disturbance caused by human activities. Heavy livestock grazing can alter the structure of preferred plants used as nest sites, can reduce leaf litter and ground cover that provides foraging habitat, and can prevent seedling establishment of essential habitat components. Livestock grazing is not incompatible with maintaining Le Conte's thrasher habitat, but grazing needs to be at levels that permit seedling establishment and maintains structure of scattered shrubs with heights greater than 1.5 meters (4.9 feet) (USFWS 1998). Heavy off-road vehicle use can eliminate or seriously degrade habitat by altering soil surfaces, eliminating soil surface litter, and altering vegetation structure (by crushing vegetation) (Sheppard 1996). Invasive non-native plants that increase vegetation cover, such as filaree (*Erodium cicutarium*) and annual grasses, reduce available foraging habitat and increase the risk of wildfire (USFWS 1998). As the areas surrounding the SDNM continue to develop, intrusion of domestic dogs and cats from housing developments onto the monument could potentially cause problems for Le Conte's thrashers. Domestic cats can be predators of Le Conte's thrasher chicks and eggs (Sheppard 1996), and domestic dogs and cats are considered a threat to adult thrashers (NatureServe 2003). Another stress of secondary importance to

TABLE C.19 Le Conte's Thrasher: Stresses and Sources of Stress

Stress	Source of Stress	Geographic Scope of Potential Impacts	Comments or Source of Information
Habitat degradation (change in vegetation composition and structure)	Inappropriate livestock grazing management practices	SDNM and regional	NatureServe (2003).
	Off-road vehicle use	SDNM (historic and current/illegal impacts) and regional	NatureServe (2003).
	Addition of surface water to habitat (irrigation, lawns, golf courses)	Regional	NatureServe (2003).
	Spread of invasive non-native plants, particularly annual grasses and those with dense ground cover (for example, filaree)	SDNM and regional	USFWS (1998).
Habitat loss	Historic conversion of saltbush desert scrub to agriculture; current conversion of Creosotebush-Bursage Desert Scrub to urban/exurban development	Regional	Sheppard (1996).
	Fires fueled by invasive non-native plants	SDNM and regional	USFWS (1998).

Le Conte's thrasher are mortality and/or disturbance of juveniles and adults caused by collisions with vehicles (NatureServe 2003). A historic source of stress is pesticide spraying (DDT and DDE), which caused nesting failure (Sheppard 1996). The effects of current pesticide drift from nearby agricultural areas on nesting success and/or the abundance of Le Conte's thrasher's arthropod prey has not been studied.

Mapping and Information Needs

Mapping comments.—The distribution, breeding status, and breeding pair abundance data (Figures C.40 and 41) were obtained from the Arizona Breeding Bird Atlas (ABBA 2001) surveys. These surveys were based on data collected over an eight-year period (1993 to 2000; Wise and others 2001). Areas on the SDNM that are used preferentially by this species are not yet known. Potential habitat could be mapped using Creosotebush-Bursage Desert Scrub polygons (Morrison and others 2003). Plot data (such as species composition and/or percent cover data) from Morrison and others's (2003) recent natural community assessment on the SDNM may also help identify potential habitat within the Creosotebush-Bursage natural community.

Information needs.—The primary data need on the SDNM is to identify potential Le Conte's thrasher habitat and areas that are currently occupied by thrashers. Other important questions to answer on the SDNM and surrounding lands include: what features on the monument and/or adjoining areas result in fragmentation of Le Conte's thrasher populations? For example, what road size or road surface is a barrier to thrashers? Is there a threshold of road densities that thrashers will tolerate in their habitat? What size patch of agricultural land causes habitat fragmentation? One of the recommendations for this

species proposed by Arizona Partners in Flight (Latta and others 1999) was to avoid off-road vehicle use on BLM land during the breeding season. Why? What are the effects of off-road vehicle use on the thrasher and at what level of use intensity does this negatively impact the thrasher? Are there similar impacts/recommendations for other types of vehicles or group camping activities?

Additional research questions that would enhance our knowledge of this species and provide the BLM with useful insights into Le Conte's thrasher management include the following (some of which are suggested by Sheppard [1996] and Latta and others [1999]): what areas do Le Conte's thrashers use preferentially within creosotebush-bursage natural communities and why? Is occupancy due to differences in soils or prey abundance/types? Do invasive non-native plant species or pesticide usage affect the prey base of the Le Conte's thrasher? What determines Le Conte's thrasher territory or home-range size? What are the effects of drought on Le Conte's thrasher prey base and thrasher populations? What are Le Conte's thrasher habitat restoration requirements? Will the species respond positively to rehabilitated farmland? Will Le Conte's thrasher use artificial nest trees in areas where suitable sites are limiting?

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C.4.4 Rufous-Winged Sparrow (*Aimophila carpalis*)

Overview

Rationale for selection as a conservation element.—*Specialized Species, Regionally Vulnerable.* The rufous-winged sparrow was selected as a conservation element because it is a narrowly distributed endemic species that is found in few localities in suitable habitats (Sonoran Desert grasslands or desert scrub with a grass component) within the Sonoran Desert Ecoregion. This species also was selected because it is regionally vulnerable, as much of its former habitat has been lost or degraded by historic overgrazing and agricultural and/or urban development (Brown 1994, Latta and others 1999). Arizona Partners in Flight did not identify the Sonoran Desert National Monument (SDNM) as a core area for rufous-winged sparrow conservation (Latta and others 1999); however, because the range of rufous-winged sparrows is considerably limited, any habitats that support viable populations—including areas on the SDNM—represent a conservation opportunity for this species.

Specific habitat needs on the SDNM.—Rufous-winged sparrows breed in the tobosa grasslands in the Vekol Valley (Turner and others 2000) and probably breed in xeroriparian washes in the Sand Tanks Mountains, as indicated by the presence of a male singing on his territory (ABBA 2001). As described by Morrison and others (2003), rufous-winged sparrow habitat on the SDNM corresponds to the following natural communities: Desert Grassland (in the Vekol Valley), Valley Xeroriparian Scrub, and Braided Channel Floodplains (in the Sand Tank Mountains). The birds also may breed and/or forage in the Paloverde-Mixed Cacti-Mixed Scrub on Bajadas natural community in the Sand Tank Mountains where native grasses are present (T. Corman, pers. comm.). Grass is an essential habitat component for rufous-winged sparrows (see **Habitat associations**); as a result, the sparrows are particularly sensitive to historic or current grazing intensities that reduce the abundance of native grasses (Lowther and others 1999, T. Corman, pers. comm.).

Appropriate management of the Native Grass Group and the Desert Grassland conservation elements will likely benefit rufous-winged sparrows on the SDNM. Based on Morrison and other's (2003) natural community condition assessment, the Desert Grassland natural community in the Vekol Valley is in close proximity to disturbed areas and is significantly altered from baseline ecological conditions (Condition Class 1) due to hydrological modifications and livestock grazing. The condition assessment of this natural community is considered preliminary because quantitative comparisons between the Desert Grassland on the SDNM and the adjoining Tohono O'odham Nation, where the occurrence of Desert Grassland is more extensive, have not yet been done. The effects of the apparently degraded Desert Grassland natural community reported by Morrison and others (2003) on rufous-winged sparrow population density or breeding status are unknown. Viable populations of rufous-winged sparrows will likely be maintained if breeding habitat on the SDNM meets BLM land health standards, including maintaining or restoring desired conditions of native grass composition and structure.

Ecological Characteristics

Abundance.—The breeding density of rufous-winged sparrows is extremely variable from year to year depending on the timing and amount of rainfall (Lowther and others 1999). After years of high rainfall on productive shrub-grassland habitat on the Santa Rita Experimental Range, rufous-winged sparrow densities reached a high of 20 pairs on a 20-hectare (50 acres) plot, but crashed to 2 pairs per plot after a severe decline in precipitation (from 580 mm to 158 mm [22.8 to 6.2 inches]) (Lowther and others 1999). In some dry years pairs may fail to successfully rear offspring or breeding pairs may be absent from appropriate habitat (Lowther and others 1999). The highest density of rufous-winged sparrows on Arizona Breeding Bird Atlas (ABBA) survey blocks (ABBA 2001) was 11 to 100 breeding pairs per block (a survey block is one sixth of a 1:24,000 topographic quadrangle or approximately 26 km² [10

miles²]) or 0.4 to 3.8 pairs/km² (0.2 to 1.5 pairs/mile²). This density was found in the Vekol Valley on the Tohono O’odham Nation (Figure C.42).

Habitat associations.—Rufous-winged sparrows are endemic to the Sonoran Desert Ecoregion where they are found on flat land or gentle hills in desert grasslands, Sonoran desertscrub, and xeroriparian scrub (Phillips and others 1964, Lowther and others 1999). In Sonora, Mexico the sparrows are associated with thornscrub with various grasses, including tobosa (*Pleuraphis mutica*) and false grama (*Cathestecum brevifolium*) and in Sinaloa they are found along the coast near mangroves (Lowther and others 1999). Grasses, including tobosa grass, are an essential habitat component (Lowther and others 1999). Other native grass species known from rufous-winged sparrow habitat in Pima County that are also known from the SDNM include spider grass (*Aristida ternipes*), bristlegrass (*Setaria* spp.), and annual grama grasses (*Bouteloua* spp.) (Lowther and others 1999, Turner and others 2000).

In addition to grasses, rufous-winged sparrow breeding habitat also typically includes xeroriparian washes (Valley Xeroriparian Scrub and/or Braided Channel Floodplain natural communities) and scattered trees or shrubs that are used as nest sites, including chollas (*Opuntia* spp.), foothill paloverde (*Cercidium microphyllum*), desert hackberry (*Celtis pallida*), and mesquite (*Prosopis* spp.) (Lowther and others 1999, Latta and others 1999). Nests are usually located in the fork of a thorny shrub or cactus ranging from 0.5 to 3 meters (1.6 to 9.8 feet) above ground, within grassy swales or xeroriparian washes (Lowther and others 1999, NatureServe 2003). Rufous-winged sparrows also will use former cropland and riparian bottomland if grass is a major habitat component (Latta and others 1999).

Arizona Breeding Bird Atlas surveys reveal that rufous-winged sparrows may occasionally nest (or exhibit some level of breeding behavior) in residential, rural, and park areas (in 6 out of 66 survey blocks in the Sonoran Desert; ABBA 2001). This indicates that individuals may tolerate some level of human alteration of the landscape. Most ABBA records, however, are from native habitat and some areas where the birds were previously known to breed in Pima county, including riparian areas with mesquite, farmland, and deep soil sites with mesquite trees and sacaton grass, have been altered to the point that the birds no longer exist in these areas (Phillips 1968, as cited in Lowther and others 1999).

Food and water requirements.—During the breeding season in Arizona, rufous-winged sparrows feed mainly on arthropods, including caterpillars, ants, and grasshoppers. At other times of the year, they are known to eat small seeds (Lowther and others 1999). Rufous-winged sparrows are able to survive without free water because of their feeding habits (they move into the shade during the hottest time of day) and efficient kidneys (Lowther and others 1999).

General life history.—The following information on rufous-winged sparrow life history is compiled in the species account by Lowther and others (1999). Rufous-winged sparrows are considered monogamous and pairs mate for life. The onset of nesting is closely tied to the first summer rains, usually late June in Arizona, but as early as late March in years of wet winters. Early spring nest construction ceases if vegetation dries, but resumes with the onset of summer rains. Pairs make two or three nest attempts if summer rains are sufficient. Nests are constructed by females and are built from grasses. Usually four to five eggs are laid within a week of the rains, but fewer (two to four eggs) are laid in early (spring) nest attempts or summer renesting attempts. Females incubate the eggs for 11 days and young fledge in eight to nine days. Nestling and egg mortality is frequently high (67% and 27%, respectively). Predators include spiny lizards (*Sceloporous clarki*), coachwhip snake (*Masticophis flagellum*), roadrunner (*Geococcyx californianus*), loggerhead shrike (*Lanius ludovicianus*), curve-billed thrasher (*Toxostoma curvirostre*), and northern mockingbird (*Mimus polyglottus*). Young stay with adults for about three weeks or until second brood is hatched, and they remain on parental territories through the fall and winter. In Arizona rufous-winged sparrows have initiated breeding as early as March 29 and nests with eggs were found as late as September 11 (T. Corman, pers. comm., based on unpublished ABBA data).

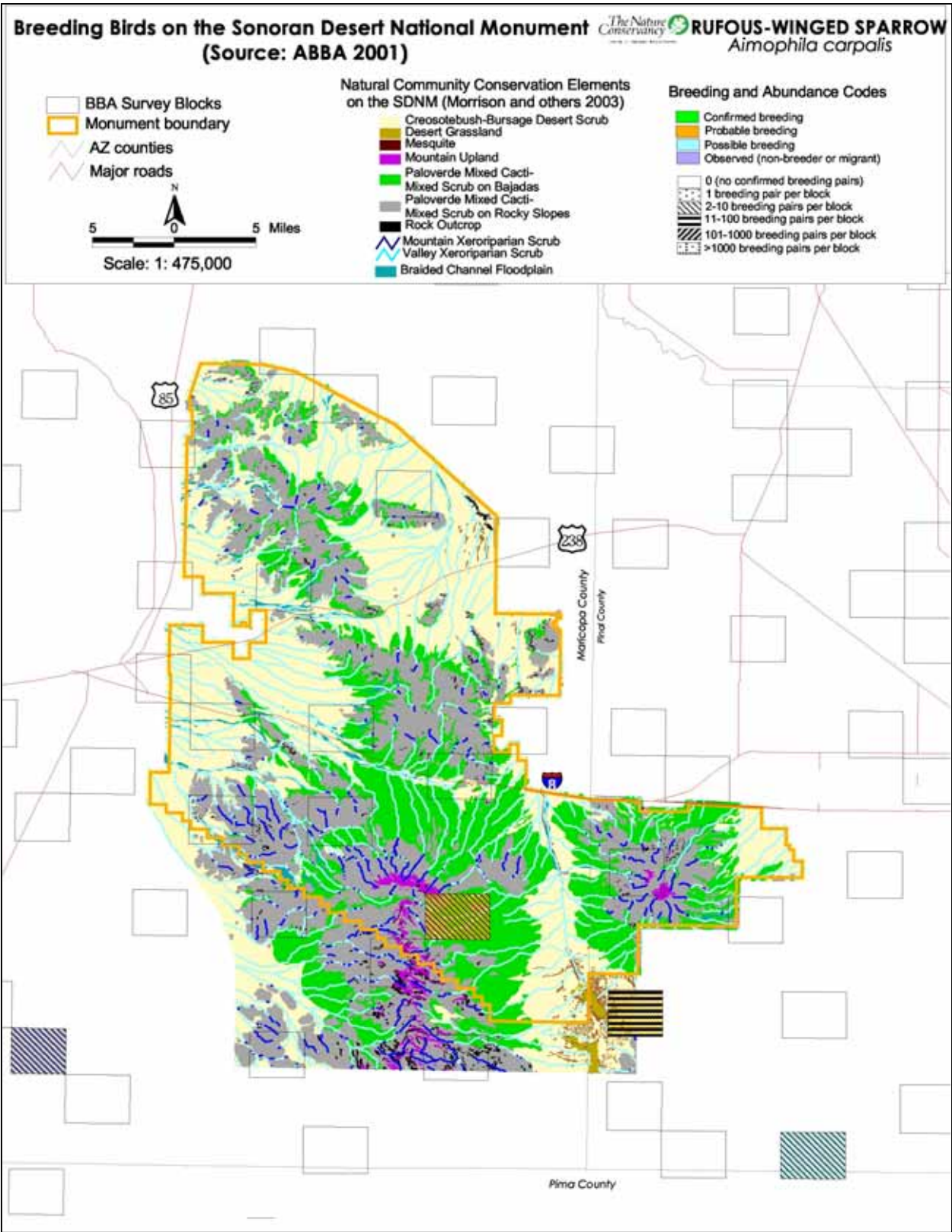


FIGURE C.42 Arizona Breeding Bird Atlas Survey Data for the Rufous-Winged Sparrow on the Sonoran Desert National Monument and Vicinity

Biotic interactions.—Rufous-winged sparrows are gregarious and often join mixed flocks with Brewer’s (*Spizella breweri*), black throated (*Amphispiza bilineata*), and chipping sparrows (*S. passerina*) on their territories (Lowther and others 1999). Brood parasitism by brown-headed cowbirds (*Molothrus ater*) was noted in about one-half of rufous-winged sparrow nests around the time of the species’ discovery (1882), but has rarely been reported since (Lowther and others 1999). Predators of adult sparrows have not been reported.

Landscape context.—Rufous-winged sparrows are non-migratory, though individuals may disperse in winter to search for food (Pima County 2001). Dispersal needs and home range requirements are not known. Breeding territory size depends on resource availability and, near Tucson, ranges from 0.5 to 1.8 hectares per pair (one to 3.5 acres) (Latta and others 1999, NatureServe 2003). Pima County (2001) has developed conservation goals for this species in the proposed Sonoran Desert Conservation Plan based on a 1.2-hectare (three acres) home range. As such, a minimum patch size of 293 hectares (725 acres) is needed to maintain a viable population of 250 pairs (Pima County 2001). Highways and major roads do not likely represent barriers to this species (Pima County 2001).

Status, Threats, and Management

Distribution.—Rufous-winged sparrows are non-migratory residents of south-central Arizona in the United States and extend south along the Pacific slope of Mexico through central Sonoran to central Sinaloa (Figure C.43). The presence of rufous-winged sparrows at known breeding localities in Arizona varies from year to year (Lowther and others 1999). The SDNM represents the northwestern edge of the range of this species.

Historic. Rufous-winged sparrows were first discovered in 1872 by Bendire near old Fort Lowell in Tucson. Soon after discovery they were not seen for over 50 years and were considered extirpated (due to habitat loss caused by overgrazing). The species was rediscovered in the Tucson area in 1936 (Lowther and others 1999). Portions of the historic range of rufous-winged sparrows in the Tucson Basin and Avra and Santa Cruz Valleys are no longer occupied by this species because of habitat loss (Lowther and others 1999).

Present. In Arizona the rufous-winged sparrow is a resident of southern Pinal County, eastern Pima County, western Santa Cruz County, and the northern portion of the San Pedro River in Pinal County (Pima County 2001). This sparrow also breeds in Maricopa County in the Saucedo and Sand Tank Mountains (Latta and others 1999, ABBA 2001). During population eruptions (after wet years), the species has bred as far east as the San Pedro River at Sierra Vista, Tombstone, Saint David, Elgin, and Gardner Canyon wash east of the Santa Rita Mountains and west to Quitobaquito (Latta and others 1999). Figure C.44 shows the abundance and breeding status of rufous-winged sparrows in ABBA survey blocks in the Sonoran Desert.

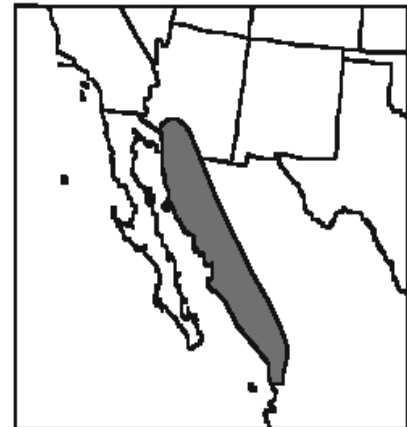


FIGURE C.43 Rufous-Winged Sparrow Distribution. From Pima County 2001)

Conservation status.—Rufous-winged sparrow has a Global Rank of G4, which indicates that it is uncommon but not rare in most of its range and global populations are apparently secure, though a cause for long-term concern may exist (NatureServe 2003). In the United States, the rufous-winged sparrow is only found in Arizona, where it has a National Heritage Status Rank of N3 and State Rank of S3. This signifies that the species is vulnerable because of its restricted range (even if abundant at some locations) (NatureServe 2003). Because of this potential vulnerability, the rufous-winged sparrow is a focal species

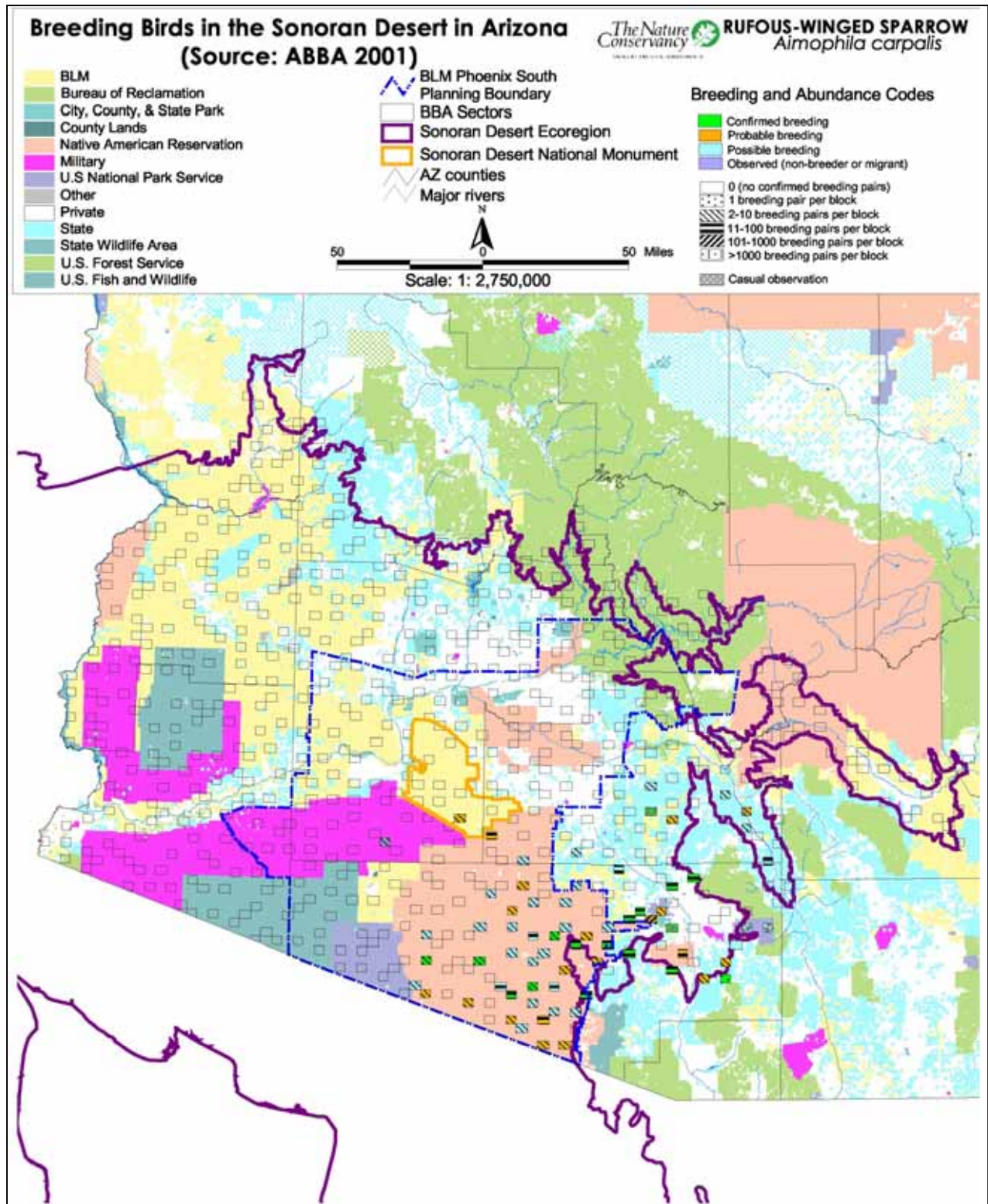


FIGURE C.44 Arizona Breeding Bird Atlas Survey Data for the Rufous-Winged Sparrow within the Sonoran Desert in Arizona

in several regional conservation efforts. It is a priority species recommended by Arizona Partners in Flight for conservation in Desert Grassland habitat (Latta and others 1999), a USFWS bird of conservation concern in the U.S. portion of the Sonoran Desert (USFWS 2002a), and a priority species in the Pima County Habitat Conservation Plan (Pima County 2001). Rufous-winged sparrows are also protected under the Migratory Bird Treaty Act. Some areas of former rufous-winged sparrow habitat have been lost as a result of inappropriate livestock management and urban development (Lowther and others 1999, Pima County 2001); however, over the past 50 years the number of known locations of this species has increased, possibly due to improved grazing management (Pima County 2001).

The best source of information on the status of rufous-winged sparrows is the Arizona Breeding Bird Atlas surveys (ABBA 2001). Christmas Bird Counts (CBC) and North American Breeding Bird Surveys (BBS) have found few rufous-winged sparrows (Lowther and others 1999). The majority of the BBA blocks with rufous-winged sparrows are from the Altar and Avra Valleys and the Tohono O’odham Nation (Figure C.44). The ABBA surveys found rufous-winged sparrows on one priority block on the SDNM in xeroriparian habitat within the Sand Tank Mountains (ABBA 2001; Figure C.42). Breeding status was not confirmed in this survey block but was classified as “probable” because of male territorial (singing) behavior. Breeding Bird Atlas blocks were absent from the SDNM portion of the Vekol Valley, but rufous-winged sparrow are known to nest there (Turner and others 2000). The ABBA surveys picked up the sparrows in the tobosa grasslands on the Tohono O’odham Nation (Figure C.42).

A tobosa grassland is also present on the top of Table Top Mountain in the Mountain Uplands natural community (Morrison and others 2003); however, rufous-winged sparrows were not recorded in the ABBA survey block in this region (Figure C.42). This species may range up to 1,400 meters (4,593 feet) on flat or gently sloping land (Pima County 2001), so it is possible that the sparrows are found in some years on the grassland mesa-top that can reach an elevation of 1,233 meters (4,045 feet). Furthermore, because of this species’ specific habitat requirements, its patchy distribution within its range, and its relatively low numbers, it is difficult to detect rufous-winged sparrows and confirm their breeding status using the general BBA survey methodology (T. Corman, pers. comm.). As a result, targeted surveys for this species may be necessary to confirm breeding localities.

Arizona Partners in Flight has the following recommendations for the conservation of this species (Latta and others 1999):

- implement grazing management, on state and federal administered lands, that uses alternate grazing regimes or light to moderate utilization in prime habitat
- maintain blocks of habitat between developments or green belts within developments
- limit development and retain natural plant communities in floodplains.

The BLM will meet these recommendations for rufous-winged sparrows on the SDNM, as the monument proclamation (Clinton 2001) restricts development in the monument and sparrow habitat is located south of Interstate 8 (livestock grazing will be discontinued south of Interstate 8 after existing permits expire).

Stresses and sources of stress.—Table C.20 identifies potential stresses and sources of stress confronting the rufous-winged sparrow. Brood parasitism by brown-headed cowbirds has been reported infrequently since the late 1800s. One survey in 1969 found the rate of brood parasitism to be seven brown-headed cowbird eggs out of 90 rufous-winged sparrow nests (Lowther and others 1999). Earlier accounts, however, noted brood parasitism in as many as one-half of monitored rufous-winged sparrow nests (Lowther and others 1999). Arizona Breeding Bird Atlas surveys found brown-headed cowbirds throughout the Sonoran Desert in 449 survey blocks (Figure C.45) in habitats with altered land cover (69

TABLE C.20 Rufous-Winged Sparrow: Stresses and Sources of Stress

Stress	Source of Stress	Geographic Scope of Potential Impacts	Comments or Source of Information
Habitat loss	Historic loss of preferred habitat associations (Sonoran savanna grasslands in the Altar and Santa Cruz Valleys, Arizona) due to overgrazing in the 19 th century	Regional	Brown (1994).
Habitat degradation (change in vegetation composition and structure)	Agriculture and urban development	Regional	Lowther and others (1999).
	Spread of invasive non-native plants	Regional and SDNM	Pima County (2001). The specific invasive non-native plants that may affect rufous-winged sparrow habitat were not identified.
Altered population composition	Cowbird brood parasitism in riparian areas and mesquite woodland	Regional and possibly on the SDNM	Latta (1999). See Figure C.45 for brown-headed cowbird breeding status in the Sonoran Desert.

survey blocks [15%] in agriculture and urban environments), as well as in areas with native vegetation (ABBA 2001). Forty-six percent (205 survey blocks) of brown-headed cowbird localities in the Sonoran Desert were in desert vegetation and 29% in wetland vegetation (130 survey blocks). Nineteen percent (86 survey blocks) were in xeroriparian washes (ABBA 2001). The two ABBA survey blocks in or near the SDNM where rufous-winged sparrows were located are also sites where brown-headed cowbirds were recorded (in “probable” and “confirmed” breeding status; Figure C.45).

Rufous-winged sparrows may be particularly sensitive to shifts in climate because their abundance and breeding cycle is so closely tied to rainfall. The general models of climate change in the southwestern U.S. include predictions of increased winter precipitation up to five millimeters per day (0.2 inches/day) by 2090 (Southwest Regional Assessment Group 2000). The effects of future El Niño events and global climate change on rufous-winged sparrow habitat and the timing of breeding have not been estimated.

Mapping and Information Needs

Mapping comments.—The distribution, breeding status, and breeding pair abundance data for rufous-winged sparrow and brown-headed cowbird (Figures C.42, C.44, and C.45) were obtained from the Arizona Breeding Bird Atlas (ABBA 2001) surveys. These surveys were based on data collected over an eight-year period (1993 to 2000; Wise and others 2001). Survey blocks were absent from the Desert Grassland natural community on the SDNM, but the species was noted to breed there (however, specific information on breeding density or the year the species was cited was not provided; Turner and others 2000).

Pima County (2001) modeled potential rufous-winged sparrow habitat in Pima County based on vegetation (mixed grass-scrub, sacaton scrub, paloverde-mixed cacti, mesquite, and urban areas), elevation from 400 to 1,400 meters (1,310 to 4,590 feet), and low slopes/flat areas. A similar model

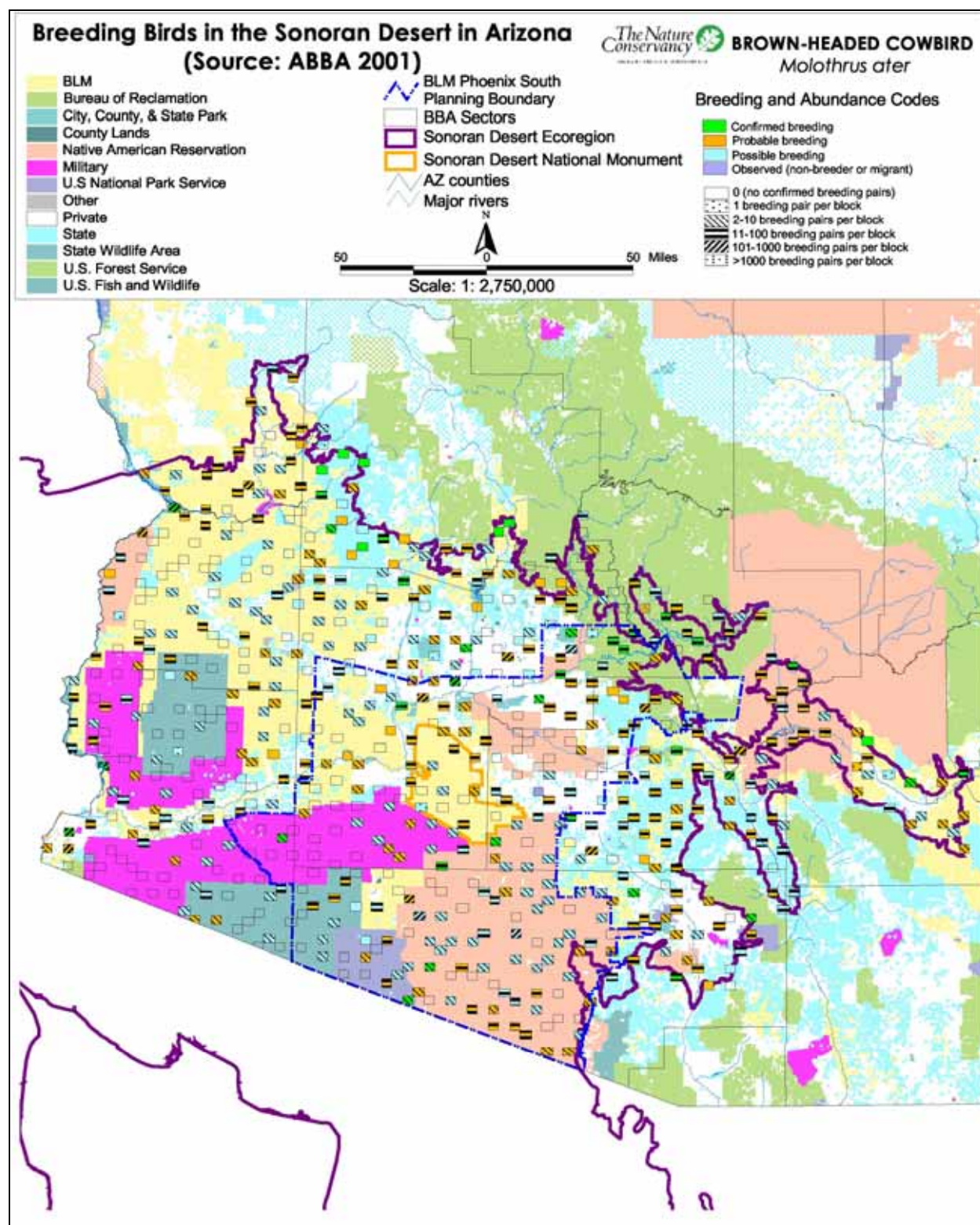


FIGURE C.45 Arizona Breeding Bird Atlas Survey Data for the Brown-Headed Cowbird within the Sonoran Desert in Arizona

applied to the SDNM would have limited value because the sparrow is at the northwestern edge of its range on the monument. These parameters, however, could be used to identify potential breeding sites in the broad areas where rufous-winged sparrows have been documented on the monument: in the Sand Tank Mountains and Vekol Valley.

Information needs.—No monitoring or research programs are currently known to exist for this species (Pima County 2001). As previously mentioned, it is difficult to confirm rufous-winged sparrow nesting using ABBA survey methodology and, furthermore, BBA survey blocks were absent from the Vekol Valley on BLM-managed land. Therefore, targeted surveys may be necessary on the SDNM to locate existing breeding populations and acquire baseline data on sparrow abundance and density. Plot data from Morrison and others (2003) could be used to identify areas with abundant native grasses in Paloverde-Mixed Cacti-Mixed Scrub on Bajadas, Valley Xeroriparian Scrub, and Braided Channel Floodplain natural communities where rufous-winged sparrow populations may occur.

Although inappropriate grazing management has been implicated as a source of stress to rufous-winged sparrows, no scientific studies have been conducted that correlate sparrow populations with grazing management (Pima County 2001). The SDNM presents a unique research situation for studies on rufous-winged sparrow populations in the Vekol Valley. This area is currently part of the South Vekol grazing allotment; however, grazing will cease once the current permits expire because of stipulations in the monument proclamation (Clinton 2001). Morrison and others' (2003) plot data provide baseline information on vegetation composition, structure, and condition. Baseline population on sparrows would complement the habitat data and changes in both vegetation and sparrow population could be assessed over time with the cessation of grazing in this region.

Other questions to answer on rufous-winged sparrows on the SDNM and throughout its range include: do rufous-winged sparrows nest in the Mountain Upland natural community on Table Top mountain? Do other areas exist on the SDNM where rufous-winged sparrows historically occurred? To what extent does brown-headed cowbird parasitism affect this species on the SDNM? What are the effects of El Niño weather patterns on rufous-winged sparrow breeding timing and nest success? How is global climate change likely to affect rufous-winged sparrow habitat and breeding biology?

Other research questions suggested by Arizona Partners in Flight (Latta and others 1999) include the following:

- determine how urbanization affects this sparrow
- study what causes sparrow irruptions
- determine if predation is a problem
- study to what extent brown-headed cowbird parasitism affects this species
- determine if rufous-winged sparrows breed more than once depending on habitat
- determine if fragmentation affects this species

The above questions could be research topics for graduate students or scientists interested in rufous-winged sparrows on the SDNM and surrounding lands. Such research would provide the BLM with useful information that could inform management of this species where it occurs on the SDNM and elsewhere.

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C.5 MAMMALS

One guild and one individual species were selected as conservation elements.

C.5.1 Bat Guild

Overview

Species included in the bat guild.—This guild is composed of three native species of bats that are known to roost or forage on the Sonoran Desert National Monument (SDNM): California leaf-nosed bat (*Macrotus californicus*), cave myotis (*Myotis velifer*), and lesser long-nosed bat (*Leptonycteris curasoae yerbabuenae*).

Rationale for selection as a conservation element.—*Specialized species, Federal Listed Endangered.* The lesser long-nosed bat is a federal Endangered species. Each of the species within the guild relies on the availability of caves and mines to roost in. These landform features are not captured by the natural community conservation elements. In addition, each species uses other community types, such as xeroriparian areas, high-density saguaro stands, and tinajas, to meet their food and water requirements. Roosting colonies of bats, particularly maternal colonies during the birthing season, are vulnerable to disturbance. Controlled light and temperature conditions are important for each species. Recreational use of caves/mines is a threat to roosting bats because of the effects of direct disturbance and the potential to affect cave/mine microclimates. Lesser long-nosed bats are not presently known to roost on the SDNM, though a few individuals have been observed foraging in the Sand Tank Mountains. These bats differ from most other bat species in that the traditional means of protecting roost sites by installing “bat-friendly” gates across cave/mine entrances may inhibit the movement of this species. To the extent that the SDNM provides potential roost sites for this species, the actions taken to protect bat roost sites in general need to account for the needs of the lesser long-nosed bat.

Specific habitat needs on the SDNM.—Most of what is known of the status and habitat needs of the bat guild on the SDNM and vicinity is from research undertaken on the Barry M. Goldwater Range (BMGR), including the former Area A in the Sand Tank Mountains that is now part of the SDNM. Studies conducted in this general area include cave and mine surveys (Dalton and Dalton 1994, Dalton and Dalton 1999), foraging and activity patterns of the California leaf-nosed bat (Dalton and others 2000, Dalton 2001), and foraging patterns, diet, and roosts of lesser long-nosed bats (Howell 1993, Dalton and others 1994). In addition, an assessment of the effects of military overflights on lesser long-nosed bats was conducted on Organ Pipe Cactus National Monument (Dalton and Dalton 1993). The Maricopa Mountains have not been surveyed for bats. This region of the SDNM likely provides foraging habitat for cave myotis and California leaf-nosed bats, and it also may have roost sites that have not yet been discovered. Although the Maricopa Mountains do not have many mines or large caves, even small caves and shelter sites that are likely present in the Maricopas could serve as significant roost sites and potentially harbor several hundred bats (D. Dalton, pers. comm.).

The primary habitat need of all guild members on the SDNM is roost sites that are protected from disturbance. In relation to the natural communities described and mapped by Morrison and others (2003), the bat guild on the SDNM is most closely associated with Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes and Bajadas natural communities and embedded xeroriparian natural communities (Valley and Mountain Xeroriparian Scrub and Braided Channel Floodplains). Additional information on the specific habitat needs and seasonal occurrences of the bats on the SDNM are described below.

- **California leaf-nosed bat.** The California leaf-nosed bat is a resident species that does not migrate or hibernate and has been found in great numbers at several roosts on the SDNM (Dalton and Dalton

1994, Dalton and Dalton 1999; Figure C.47). California leaf-nosed bats are active in the Sand Tank Mountains year-round. More than a hundred roost sites are available in the Sand Tank Mountains, most of which are small shelter sites that have only a few bats and a few that are major roost sites in mines or caves with a maximum of a few hundred individuals (D. Dalton, pers. comm.). This species switches roost sites and foraging habitat seasonally and daily, such that it is difficult to pinpoint an individual roost or area that is most important on the SDNM (Dalton 2001). The California leaf-nosed bat uses desert trees as night shelters and feeding/digesting sites (D. Dalton, pers. comm.); as a result, natural communities and areas of the SDNM with numerous scattered trees are important as foraging sites. Xeroriparian scrub provides seasonal foraging areas for California leaf-nosed bats. This species avoids foraging in xeroriparian scrub during the winter when cold air pools in the washes (D. Dalton, pers. comm.). During the winter bats don't use night roosts and seem to use higher slopes and mountaintops more than in the summer (Dalton 2001). California leaf-nosed bat foraging areas were identified in the Sand Tank Mountains by Dalton and others (2000) and are reproduced in Figures C.48 and C.49. In relation to Morrison and others' (2003) natural community descriptions on the SDNM, these foraging areas primarily include Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes and Bajadas, Valley Xeroriparian Scrub, Mountain Xeroriparian Scrub, and Braided Channel Floodplain natural communities. California leaf-nosed bats also may forage in xeroriparian areas embedded within Creosotebush-Bursage Desert Scrub and Mountain Upland natural communities in some areas and during certain times of year. Tinajas and other water sources also provide foraging opportunities for this species. California leaf-nosed bats are consistently caught at mist nets over water.

- **Cave myotis.** This species is found on the SDNM in the summer. It migrates to locations above 1,829 meters (6,000 feet) in the winter to hibernate. One cave myotis colony has been recorded from the SDNM in the Sand Tank Mountains (Figure C.47; note that the other cave myotis locality displayed in Figure C.47 near Gila Bend was not a roosting colony). The cave myotis colony in the Sand Tank Mountains is a bachelor colony consisting of several hundred males (Dalton and Dalton 1999, D. Dalton, pers. comm.). The SDNM or adjoining lands likely have a summer maternity colony of cave myotis, possibly in a mine in the Vekol Valley (D. Dalton, pers. comm.). Cave myotis forage in xeroriparian natural communities as well as over tinajas, springs, and other developed water sources. Roosts are typically situated within several miles of water sources (see Figure C.47 for the distribution of water sources on the SDNM).
- **Lesser long-nosed bat.** This bat is migratory and spends its winter in Mexico and Central America. It follows the bloom of columnar cacti of the Sonoran Desert along its northern migration and moves to southeastern Arizona to feed on agave pollen on its return trip south. Roosting colonies of the lesser long-nosed bat have not been found on the SDNM; however, the monument is located within foraging distance of colonies of these strong-flying bats, and it is also possible that the bats could colonize roost sites in the future. Dense stands of saguaro, such as those on the bajadas of the Sand Tank Mountains spanning the SDNM and BMGR, represent good foraging habitat for lesser long-nosed bat (T. Tibbitts, pers. comm.). Evidence was found by Dalton and Dalton (1994) that lesser long-nosed bats were using a natural shelter as a transitory roost site in the Sand Tanks Mountains. Resurvey efforts of 175 natural roost sites (caves and rock shelters) from 1997 to 1999 did not lead to any evidence of lesser long-nosed bat roosting in the Saucedo and Sand Tank Mountains (Dalton and Dalton 1999). In another study six light-tagged individuals were potentially sighted foraging in the Sand Tank Mountains (Dalton and others 1994). If the lesser long-nosed bat is seasonally present on the SDNM, it is not currently abundant.

The presence of organ pipe cactus (*Stenocereus thurberi*) and desert agave (*Agave deserti*) on the SDNM provides habitat components that may support lesser long-nosed bat use of the area for foraging. Organ pipe cactus pollen, nectar, and fruit is a food source for lesser long-nosed bats. In

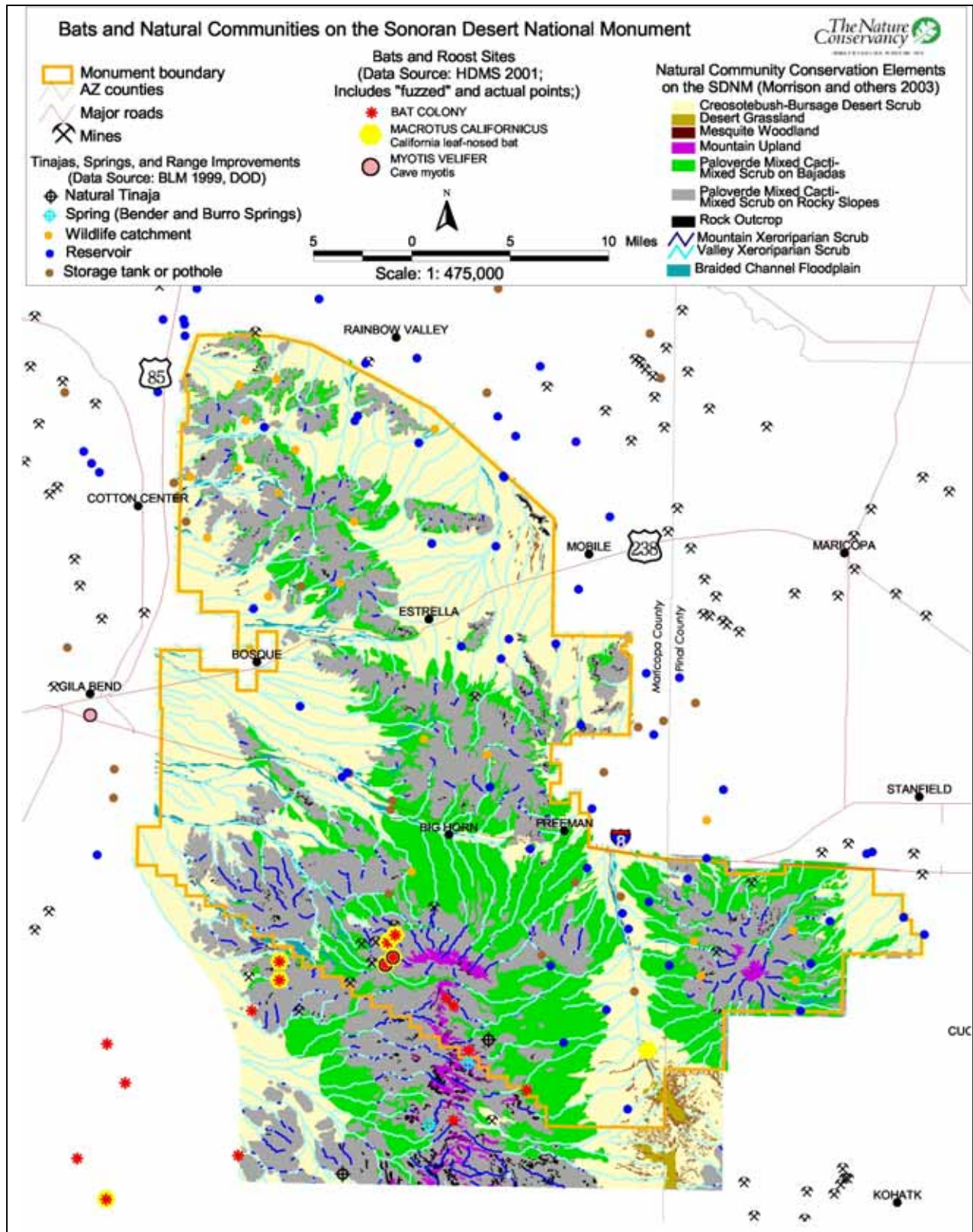


FIGURE C.47 Locations of Bat Roost Sites and Natural Communities on the Sonoran Desert National Monument and Vicinity

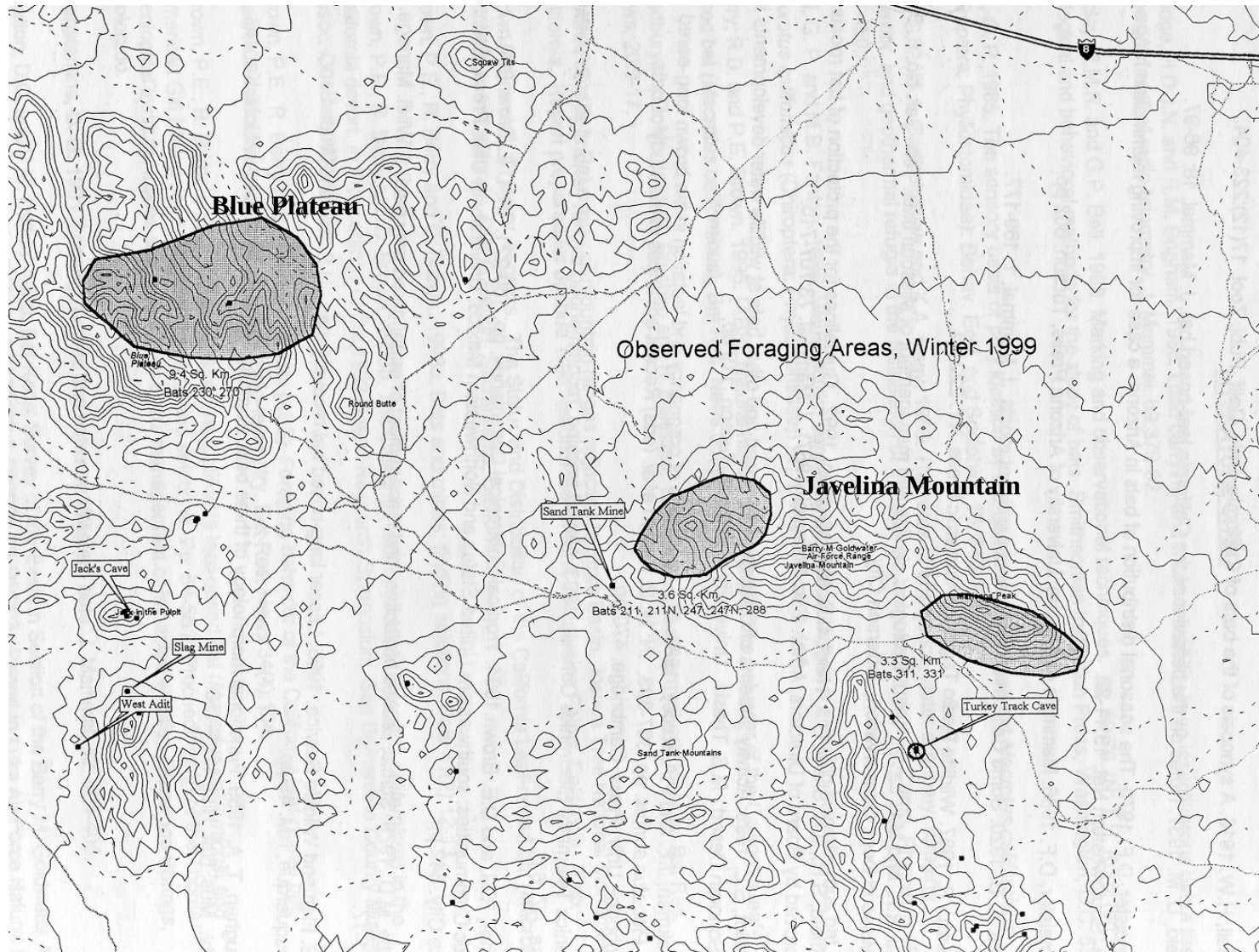


FIGURE C.48 Winter Foraging Habitat of the California Leaf-Nosed Bat (*Macrotus californicus*) in the Sand Tank Mountains (from Dalton and others 2000)

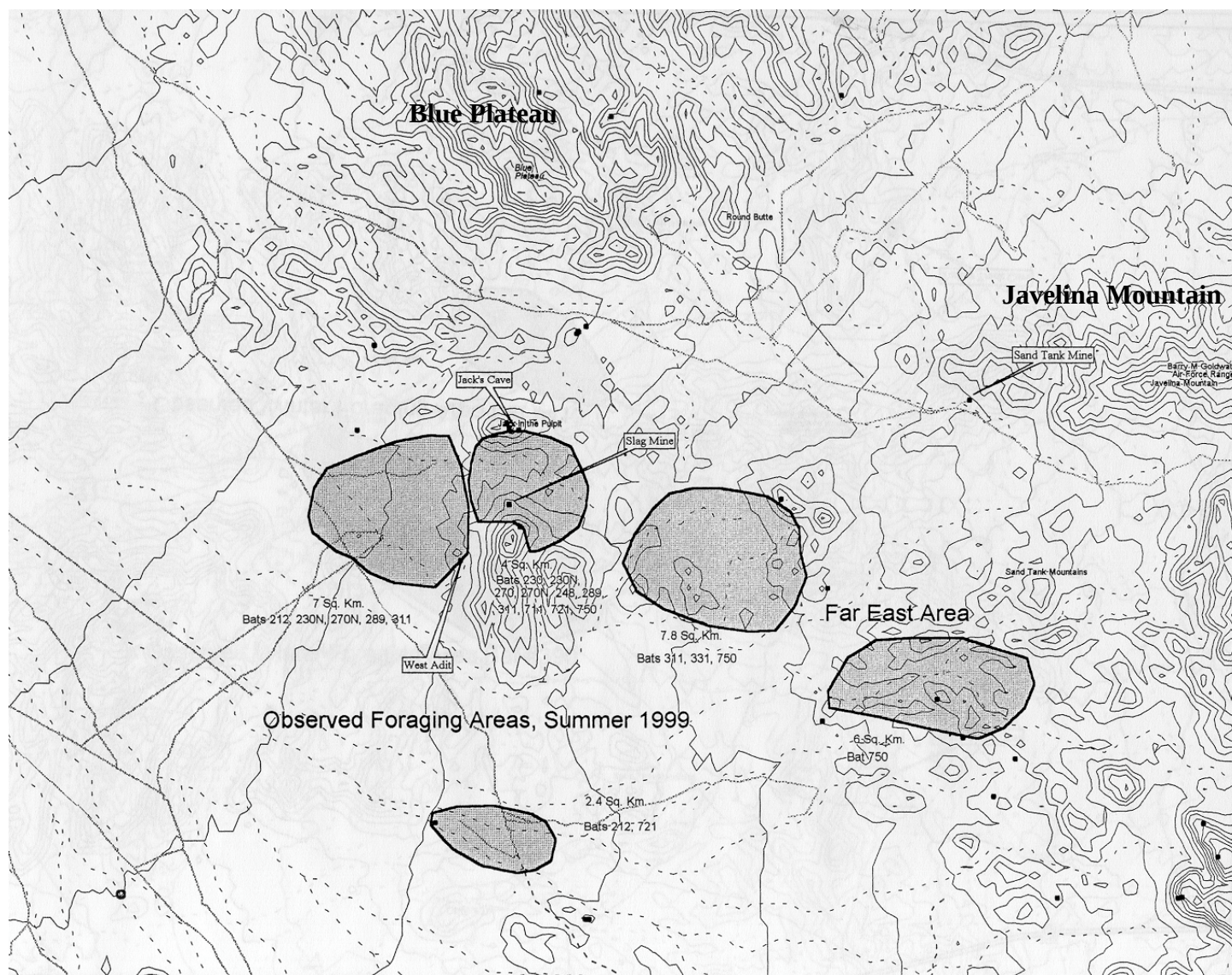


FIGURE C.49 Summer foraging habitat of the California leaf-nosed bat (*Macrotus californicus*) in the Sand Tank Mountains (from Dalton and others 2000)

addition, the bat is an effective pollinator and seed disperser of this cactus. The SDNM has one of the most northern representations of organ pipe cactus on south-facing slopes of Javelina Mountain (Turner and others 2000), and it is possible that lesser long-nosed bats were responsible for the dispersal of the seeds of this cactus to the Sand Tank Mountains (T. Tibbitts, pers. comm.). In addition to columnar cactus pollen, nectar, and fruit, the patchily distributed, small populations of desert agave within the Sonoran Desert in Arizona are thought to provide a secondary source of food (pollen) to lesser long-nosed bats in the spring. Moreover, successful reproduction of this agave may depend to some extent on pollination by lesser long-nosed bats (Howell 1993). Desert agave has been recorded from the Maricopa, Sand Tank, and Table Top Mountains on the SDNM (Turner and others 2000).

Ecological Characteristics

Some of the information below is taken from Hall and others (2001).

Habitat associations.—Habitat associations are described below by species.

- **California leaf-nosed bat.** California leaf-nosed bats are found in Sonoran desertscrub. They roost and raise their young in mines or caves usually below 1,067 meters (3,500 feet) (Bradshaw 1961). In Arizona the California leaf-nosed bat is generally found below the Mogollon Rim at elevations below 1,222 meters (4,009 feet), and it is a year-round resident in the Sonoran Desert (Hinman and Snow 2003). These bats will use the same day roosts as other bats, but they tend to segregate to the rear of the roosting site (Bradshaw 1961). This species does not hibernate and requires warm mines or caves as roost sites. In winter roosts this species is found in mines over 30 meters (100 feet) back from the entrance where temperatures are up to about 27 °C (80 °F) (AGFD 2001b). California leaf-nosed bats cannot survive exposure to temperatures below freezing for an extended period of time (AGFD 2001b). Xeroriparian corridors and large tinajas are important foraging areas (T. Tibbitts, pers. comm.), as are areas with high densities of saguaro because they attract many insects (L. Smith, pers. comm.).
- **Cave myotis.** Hoffmeister (1996) provides a general description of habitat associations for this species. Cave myotis use mine shafts, tunnels, caves, and the underside of bridges as roost sites within the desertscrub habitats of the Sonoran Desert. The species usually roosts near the entrances of mine shafts or tunnels and, as a result, can use tunnels as short as 30 meters (100 feet). Of the nine species of *Myotis* that occur in Arizona, the cave myotis shows the greatest correspondence with Sonoran Desert habitats (Hoffmeister 1996). Xeroriparian corridors and large tinajas are important foraging areas (T. Tibbitts, pers. comm.), as are areas with high densities of saguaro because they attract many insects (L. Smith, pers. comm.). Roosts are situated within several miles from water sources (Dames and Moore 1996, Hoffmeister 1996).
- **Lesser long-nosed bat.** This species is associated with areas of dense columnar cacti in the spring and at higher elevations in areas of high agave density in oak-piñon forests in the summer and fall. Lesser long-nosed bats roost during the day in caves or mines, where they require total darkness and a specific temperature range (T. Tibbitts, pers. comm.). Lesser long-nosed bat records in Arizona indicate an elevation ranges from 363 to 2,233 meters (1,190 to 7,320 feet) (Hinman and Snow 2003). From April to July, lesser long-nosed bats are found below 1,067 meters (3,500 feet), and they are found up to around 1,678 meters (5,500 feet) from July to late September or October (Hinman and Snow 2003).

Food and water requirements.—Food and water requirements are described below by species.

- **California leaf-nosed bat.** The California leaf-nosed bat captures its insect prey (crickets, grasshoppers, beetles, moths) from foliage, from the ground, or in flight. It may occasionally feed on cactus fruit (Hoffmeister 1996). This species is highly adapted to arid habitats and does not require drinking water (Phillips and Wentworth Comus 2000).
- **Cave myotis.** Cave myotis are insectivorous and catch prey in flight using echolocation. They forage at various heights and tend to fly close to vegetation (NatureServe 2003). They are opportunistic feeders and their diet may vary depending on the season and habitat (NatureServe 2003). This species drinks from free water at tanks, tinajas, and guzzlers (L. Smith, pers. comm.).
- **Lesser long-nosed bat.** In Arizona the lesser long-nosed bat feeds on nectar and pollen from saguaro and organ pipe cactus flowers in early summer. Later in the summer and in early fall they feed on agave pollen and nectar (Hinman and Snow 2003). They also feed on ripe fruit of columnar cacti at the end of the flowering season (Hoffmeister 1996). This species is known to feed from hummingbird feeders at night in some “sky island” mountain ranges in southeastern Arizona (Hinman and Snow 1996). Lesser long-nosed bats can be found drinking at tinajas (T. Tibbitts, pers. comm.).

General life history.—General life-history traits are described below by species.

- **California leaf-nosed bat.** California leaf-nosed bats are year-round residents in southern Arizona and, because of the year-round availability of food, they do not need to hibernate or migrate (Hoffmeister 1986). Breeding takes place in the fall, and the embryo develops slowly through the winter and then speeds up development in the spring. Young (born singly or as twins) are born in May or June (Phillips and Wentworth Comus 2000). Populations in most caverns are about the same size in winter and summer; however, some nursery colony sites may be occupied all year, whereas others are not occupied in winter (Hoffmeister 1986).
- **Cave myotis.** Some cave myotis individuals in southern Arizona migrate in the winter to locations in the southernmost part of the state above 1,830 meters (6,000 feet) to hibernate; however, most individuals probably migrate outside of Arizona to the south (Hoffmeister 1986). According to Hoffmeister (1996) nursery colonies may support from 50 to 15,000 female bats. Males arrive in southern Arizona from winter hibernation sites in March (Fitch and others 1981). Large numbers of females arrive by early May, and by mid-May they disperse to maternity colonies. Males remain in roosts of less than 100 individuals until they join females in large maternity colonies during June and July (Fitch and others 1981). Young are born in mid-June. Females leave the nursery colonies in August. Individuals seem to show fidelity to roost locations (D. Dalton, pers. comm.).
- **Lesser long-nosed bat.** This bat migrates from southern Mexico and arrives in southern Arizona in mid-/late-April. Females arrive at nursery colonies already pregnant, and a single young is born to each female from early May until late June (Hoffmeister 1996). Maternity colonies may number in the hundreds to thousands or even tens of thousands in some locations (Hinman and Snow 2003). Males form separate, smaller colonies (Hinman and Snow 2003). The lesser long-nosed bat has acute vision and feeds on night-blooming columnar cacti flower pollen, nectar, and fruits during its migration in the spring. It moves east and south to higher elevations to feed on agave nectar in the fall. This species is a strong flier that is capable of flying 22.5 km/hr (14 mph) and tens of kilometers during nightly foraging bouts (Howell 1993, Pima County 2001). Some populations in Baja California are non-migratory and feed on cactus and agave flowers year-round (Fleming 1991).

Biotic interactions.—Biotic interactions are first described for the California leaf-nosed bat and cave myotis combined and then for the lesser long-nosed bat.

- **California leaf-nosed bat and cave myotis.** These species are often found using the same roost site during the summer months. Roost site habitat partitioning may occur, allowing co-occurrence of the species and minimizing competition. Cave myotis is also often found in association with Brazilian free-tailed bats (*Tadarida brasiliensis*) and/or Yuma myotis (*Myotis yumaensis*) in other parts of its range in Arizona (Hinman and Snow 2003).
- **Lesser long-nosed bat.** These bats are crucial pollinators of many plants. They play a key role in the reproductive success of organ pipe cactus (*Stenocereus thurberi*) and cardon (*Pachycereus pringlei*) and are important saguaro pollinators. Without lesser long-nosed bats, the pollination success of *Agave palmeri* dropped to 1/3000th of normal (Fleming 1991).

Landscape context.—Landscape context is described below by species.

- **California leaf-nosed bat.** The California leaf-nosed bat is a resident, non-migratory species. It is known to move between roost sites. Major barriers to or matrix requirements for these movements between roost sites are unknown. Pima County (2001) states that the California leaf-nosed bat requires 125 hectares (310 acres) for a home range. Dalton (2001) found that radioed bats in the Sand Tanks Mountains moved a maximum distance of 10 kilometers (6.2 miles) in nightly foraging activities. The total area encompassing all day roosts and observed foraging areas of 38 bats was 177 km² (17,700 hectares [68 mi²]) (Dalton 2001). The foraging and roosting habitat area reported by Dalton is significantly larger than the home range requirement reported by Pima County (2001), possibly because Dalton's estimate includes the area used by a population of bats and was not calculated based on a single individual's use.
- **Cave myotis.** This species is migratory and is found in Arizona primarily outside the winter months (NatureServe 2003). Cave myotis are year-round residents in the eastern portion of their range (Kansas and Texas; NatureServe 2003). Those that overwinter in Arizona move from summer habitat to cold moist mine tunnels above 1,830 meters (6,000 feet) in southeastern Arizona (Fitch and others 1981, Hinman and Snow 2003). Most are thought to migrate south for the winter (Hoffmeister 1986). Migration routes or corridors are not known. Two estimates of home ranges for a population (individuals occupying one or several mine tunnels that are in close proximity) in southeastern Arizona were 932 and 1,619 km² (360 to 625 mi²) (Hinman and Snow 2003).
- **Lesser long-nosed bat.** These bats are migratory and depend on many habitats and roosting sites in southern Arizona and Mexico. Little is known about the specific migration corridors used by this species (Pima County 2001). Pima County (2001) states that the lesser long-nosed bat requires 2,153 hectares (5,320 acres) for a home range.

Status, Threats, and Management

Distribution.—Figures C.50, 51, and 52 display the distributions of the California leaf-nosed bat, cave myotis, and lesser long-nosed bat, respectively.

Conservation status.—The Nongame Branch of the Arizona Game and Fish Department (AGFD) supported the development of the Arizona Bat Conservation Partnership, which is a collaboration between AGFD and many other agencies and organizations to coordinate research and bat conservation efforts in the state. This group has issued a strategic plan to guide bat conservation in the state and direct efforts on

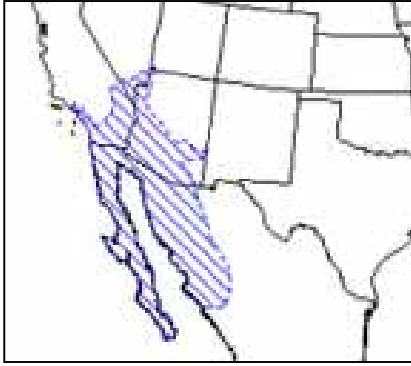


FIGURE C.50 Distribution of the California Leaf-Nosed Bat (*Macrotus californicus*). From Bat Conservation International (2002).



FIGURE C.51 Distribution of Cave Myotis (*Myotis velifer*). * = isolated or questionable records. From Bat Conservation International (2002).

bat research, inventory and monitoring, management, and education (Hinman and Snow 2003). The Western Bat Working Group (WBWG) facilitates communication on bat ecology and conservation between 20 U.S. states and Canadian provinces. The Western Bat Working Group has developed a Regional Bat Species Priority Matrix, which is a system of categorizing the conservation status of bats throughout their range in western North America. The goal of the Priority Matrix is to help governments and organizations prioritize bat research, management, and conservation. The Priority Matrix ranks the status of a species within each ecoregion in which it occurs throughout its distribution in the west (WBWG 1998). The WBWG (1998) Priority Matrix ranking scheme has three levels:



Figure C.52 Distribution of the Lesser Long-Nosed Bat (*Leptonycteris curasoae*). * = isolated or questionable records. From Bat Conservation International (2002).

1. **Red or High:** Species at high risk of imperilment based on available information on distribution, status, ecology, and threats.
2. **Yellow or Medium:** Species for some conservation concern exists, particularly because of a lack information to fully evaluate the species' status and threats.
3. **Green or Low:** Species that have stable populations and that are unlikely to have status changes in the near future. Localized concerns may exist for these species, but the overall status is believed to be secure.

Although not globally rare, some concern exists for all species in the bat guild because their populations are thought to be declining and they are particularly vulnerable at roosting sites, where large numbers of individuals (up to many thousands) are often found. The conservation status of each species in the bat guild, including the WBWG Priority Matrix Ranks, are discussed below.

- **California leaf-nosed bat.** This species has a global rank of G4, which signifies that it is uncommon but not rare and its global populations are not considered vulnerable in most of its range (NatureServe 2003). Some concern, however, still exists for this species because warm winter roost sites are limited and populations have been reduced due to roost abandonment caused by disturbance at roost

sites by vandalism, recreationists, and scientists (AGFD 2001b). The California leaf-nosed bat is ranked High by WBWG (1998), is a BLM Sensitive Species (BLM 2000d), and is classified as Wildlife of Special Concern in Arizona (AGFD 1996). The California leaf-nosed bat also is identified as a priority vulnerable species for protection in Pima County in the Sonoran Desert Conservation Plan (Pima County 2001).

California leaf-nosed bat roosting locations and foraging habitat have been studied in the Sand Tank and Saucedo Mountains (Dalton and Dalton 1999, Dalton and others 2000, Dalton 2001). Active roosts have also been documented at 11 sites throughout the BMGR in the Sand Tank and Saucedo Mountains (Noonan Group), Mohawk Mountains (Red Cross Mine), Copper Mountains (Old Soak, Betty Lee Mine, and Buck Peak), Wellton Hills (Wellton Hills Mine and Poorman), and Gila Mountains (Fortuna Mines) (Dalton and Dalton 1994, Dames and Moore 1996).

- **Cave myotis.** Cave myotis is a BLM Sensitive Species (BLM 2000d) that is ranked Medium by WBWG and has a Global Rank of G5. The cave myotis seems to be uncommon on the SDNM. Only one roosting site has been found near Sand Tank Well, at an elevation of 719 meters (2,360 feet) (Dalton and Dalton 1994). In addition, cave myotis individuals were captured near AGFD guzzlers at three sites located in the Sand Tank Mountains, one site in the Saucedo Mountains, and one site east of Javelina Mountain (Dames and Moore 1996). The species (not associated with a roost) also was documented near Gila Bend outside the SDNM boundary (Figure C.47).
- **Lesser long-nosed bat.** The lesser long-nosed bat is a federal Endangered species in the U.S. and is listed as Threatened in Mexico. It has a global rank of G4T3T4, which signifies that the species is apparently secure (G4) but that the subspecies status ranges from vulnerable (T3) to apparently secure (T4) (NatureServe 2003). The lesser long-nosed bat is ranked High by WBWG (1998). It is a U.S. Forest Service Sensitive Species (USFS 2000) and a Wildlife of Special Concern in Arizona (AGFD 1996). The lesser long-nosed bat also is identified as a priority vulnerable species for protection in Pima County in the Sonoran Desert Conservation Plan (Pima County 2001). A large colony (16,000 to 19,000 females) of lesser long-nosed bats is present in the Copper Mountains on Organ Pipe Cactus National Monument, and an additional colony of 5,000 females occurs on Cabeza Prieta National Wildlife Refuge. Two colonies are present on the Tohono O'odham Reservation in undisclosed locations.

Stresses and sources of stress.—Table C.21 identifies potential stresses and sources of stress confronting members of the bat guild. The main potential threat to the bat guild on the SDNM is disturbance at roost sites. Roosting colonies of bats are vulnerable to disturbance, particularly during the birthing season. Bat colonies in the Sand Tank Mountains, particularly at Sand Tank mine, are vulnerable to disturbance by recreational uses (D. Dalton, pers. comm.). People may unintentionally disturb resting bats at roosts by entering caves and mines, which can cause permanent abandonment of the site. By entering roost sites people also may cause a change in the microclimate, which can make the site unsuitable for bats (T. Tibbitts, pers. comm.). In other regions people have purposely killed entire bat populations at roost sites (Belwood and Waugh 1991, L. Smith, pers. comm.). One strategy to prevent disturbance at roost sites is to gate mine or cave entrances using a “bat-friendly” design (with appropriately sized slots through which the bats can easily enter/exit the site). Poorly designed gates, however, may impact airflow and temperature at roosts (Tuttle 1977), or they may dramatically increase predation of bats that must slow down to fly through the gate slats (Kennedy 2002). Gates also are conspicuous and can draw unwanted attention to the site. In addition, lesser long-nosed bats are fast fliers that may not respond well to bat gates (T. Tibbitts, pers. comm.). An effective alternative to gates that can be used to prevent access to bat roosts is to fence the perimeter of the site with barbed wire and warning signs (T. Tibbitts, pers. comm.). Bat experts should be consulted to evaluate whether a gate is needed around roost sites and, if so, how to appropriately design and install it.

TABLE C.21 Bat Guild: Stresses and Sources of Stress

Stress	Source of Stress	Geographic Scope of Potential Impacts	Comments or Source of Information
Habitat/roost site disturbance (all species)	Recreation, vandalism, scientific research.	Regional and SDNM	Belwood and Waugh (1991). Bats at Sand Tank mine are vulnerable to disturbance (D. Dalton, pers. comm.)
	Inappropriate gating of abandoned mines.	Regional	Poorly designed mine enclosures can negatively impact some bats and/or roost microclimate (Tuttle 1977, Kennedy 2002). Lesser long-nosed bats may not respond well to bat gates meant to protect colonies of other bat species (T. Tibbitts, pers. comm.)
	Activities associated with mining, including mine closures, mine reclamation, or active mining activities.	Regional	Belwood and Waugh (1991), Pima County (2001).
Illness or mortality of adults (cave myotis and California leaf-nosed bat)	Pesticide spraying in agricultural areas causing poisoning of adults or reduced insect populations.	Regional	Reidinger (1972). Bats foraging along the Gila and Colorado Rivers are vulnerable in Arizona (T. Tibbitts, pers. comm.).
Habitat loss	Urban development (cave myotis).	Regional	NatureServe (2003).
	Over-harvesting of agave (lesser long-nosed bat).	Regional	Over-harvesting of wild agave in Mexico for the tequila industry reduces available autumn habitat and food sources.

The impacts on bats (or on their quality and/or quantity of invertebrate food sources) of pesticide spraying on agricultural lands surrounding the SDNM have not been evaluated. Impacts of pesticides are not likely to be great because the known bat colonies are in the southern portion of the SDNM near the BMGR. Areas closer to agricultural lands, including the Maricopa Mountains, have not been surveyed for bats.

Mapping and Information Needs

Mapping comments.—Figure C.47 displays bat colony sites and California leaf-nosed bat and cave myotis occurrence on the SDNM and surroundings in relation to mine localities, natural communities, and natural and developed water sources. Bat occurrence information is from the Heritage Data Management System (HDMS). Locality points do not exist for lesser long-nosed bats in this area. Point localities are displayed at a coarse scale that does not disclose sensitive site information and includes both “fuzzed” and actual points. Natural communities shown in Figure C.47 are from Morrison and others (2003). Mines are from Arizona Land Resource Information System (ALRIS) and wildlife waters, tanks, tinajas, springs,

and reservoirs are from shapefiles derived from the BLM and BMGR. Additional information on mapping for the California leaf-nosed bat and lesser long-nosed bat is provided below.

- **California leaf-nosed bat.** Current documented roosting sites are mapped by Dalton and Dalton (1994, 1999). Winter and summer foraging sites for individual radioed bats in the Saucedo and Sand Tank Mountains are mapped by Dalton and others (2000) and Dalton (2001). Reproductions of Dalton and others (2000) maps of the foraging areas used by all bats radioed in survey efforts in the winter and summer of 1999 are displayed in Figures C.48 and C.49. These maps do not include some additional foraging areas identified by Dalton (2001).

Pima County (2001) modeled the potential habitat for this species in Pima County based on known occurrence of roosts, an elevation range of 195 to 1,400 meters (640 to 4590 feet), slope and carbonates (to identify potential areas for mines and caves), vegetation (highest values for paloverde-mixed cacti), and hydrology (perennial streams, intermittent streams, and springs). A similar model could be developed for potential habitat for California leaf-nosed bats to guide survey efforts in the Maricopa Mountains on the SDNM.

- **Lesser long-nosed bat.** Colonies of this species are not known from the SDNM, but areas of high-density saguaro in the Sand Tank Mountains are potential foraging areas (current or future). Morrison and others' (2003) data on saguaro abundance and demography could provide an initial data set that could be used to identify and map potential foraging areas on the SDNM.

Pima County (2001) modeled the potential habitat for this species in Pima County based on elevation (200 to 2,000 meters [656 to 6,560 feet], depending on the season), caves and abandoned mines on moderate to steep slopes, carbonate substrates, vegetation (highest values for semidesert grassland and paloverde-mixed cacti communities), perennial springs, and intermittent streams.

Information needs.—Few to no studies have been conducted on the presence of the species in the bat guild outside the Sand Tank Mountains. The Maricopa and Table Top Mountains may have significant populations of bats, which could be vulnerable to disturbance. Effective means of protecting bat cave/mine roost sites from unauthorized access are needed that provide an adequate deterrent to human entry, but will not negatively impact cave microclimate or prevent colonization by lesser long-nosed bats. Additional information is needed on habitat partitioning and potential competitive interactions between California leaf-nosed bats and cave myotis at roost sites. Some species of bat have difficulty drinking or foraging from water sources that have a roof or other covering. Additional information is needed to evaluate whether this is the case for the species in the bat guild.

C.5.2 Desert Bighorn Sheep (*Ovis canadensis mexicana*)

Overview

Taxonomy.—Numerous subspecies of bighorn sheep (*Ovis canadensis*) are recognized throughout their range in western North America. In the southwestern U.S. and northern Baja California, four subspecies are traditionally recognized: *Ovis canadensis nelsoni*, *O. c. cremnobates*, *O. c. mexicana*, and *O. c. weemsi* (Hoffmeister 1986). Some experts recognize two subspecies in Arizona: *O. c. mexicana* and *O. c. nelsoni*; however, it is difficult to differentiate the subspecies based on morphology (Hoffmeister 1986). The taxonomy is not well resolved and based on mitochondrial DNA (*mtDNA*) and morphology some authors suggest that only one subspecies of bighorn sheep occurs in Arizona: *O. c. nelsoni* (reviewed by NatureServe 2003). Genetic and/or morphological differentiation may be expected to increase as bighorn sheep populations become progressively more fragmented and isolated and additional research is needed to resolve taxonomic uncertainties. Regardless of whether it is considered a distinct subspecies, the population of desert bighorn centered in the desert southwest, which is identified by some as *O. c. mexicana*, is the taxonomic unit selected as a conservation element for the Sonoran Desert National Monument (SDNM).

Rationale for selection as a conservation element.—*Area-dependent, Regionally vulnerable.* Bighorn sheep populations have dramatically declined throughout their range from historic levels. In the desert southwest populations potentially may become fragmented and isolated by roads and fences. As a result, the desert bighorn sheep can be considered a regionally vulnerable subspecies. Desert bighorn sheep have been documented from all the mountain ranges on the SDNM with a combined population that was once considered one of the few robust and viable populations left in Arizona (BLM 1995). In recent years, however, bighorn numbers have dropped on the SDNM and concern exists for their long-term viability (B. Henry, pers. comm.). As an area-dependent species, desert bighorn sheep require large, unfragmented landscapes to maintain population viability. Although traditionally desert bighorn sheep have been managed as if they solely occurred within a mountain range, a landscape approach to management is needed, as the flats between mountain ranges may act as important corridors for sheep to gain access to other ranges for foraging and lambing. Sheep quickly and cautiously disperse between mountain ranges by crossing the shortest route. Finally, habitat management activities associated with desert bighorn sheep are controversial and deserved focused attention. Management actions intended to “improve” habitat for desert bighorn sheep potentially could have unintended adverse impacts to non-target species and natural communities. As a result, management of this species should be viewed in a broader ecosystem context.

Specific habitat needs on the SDNM.—Important features of desert bighorn sheep habitat are cliffs, rock outcrops, and talus slopes, which are used as escape terrain. In relation to the natural communities described and mapped on the SDNM by Morrison and others (2003), desert bighorn sheep are most closely associated with Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes, Mountain Upland, and Rock Outcrop natural communities. Desert bighorn sheep move seasonally, however, between the uplands and bajadas and also travel across desert valley between mountain ranges. Desert bighorn habitat, as mapped by the BLM, encompasses 117,522 hectares (290,401 acres) or 58.5% of the SDNM and includes representations of all natural communities as mapped by Morrison and others (2003) except Mesquite Woodland and Desert Grassland (Figure C.53). As an area-dependent species, desert bighorn sheep are potentially associated with any of the natural communities on the SDNM. The SDNM is important for the conservation of desert bighorn sheep as it encompasses a functional landscape of interconnected mountain ranges and valleys, as well as portions of corridors to adjoining landscapes on the Barry M. Goldwater Range (BMGR) and Tohono O’Odham Nation and to the Sierra Estrella. The most critical habitat need of desert bighorn sheep on the SDNM is to maintain movement corridors between mountain ranges located within the monument and on adjoining lands. Some important areas for

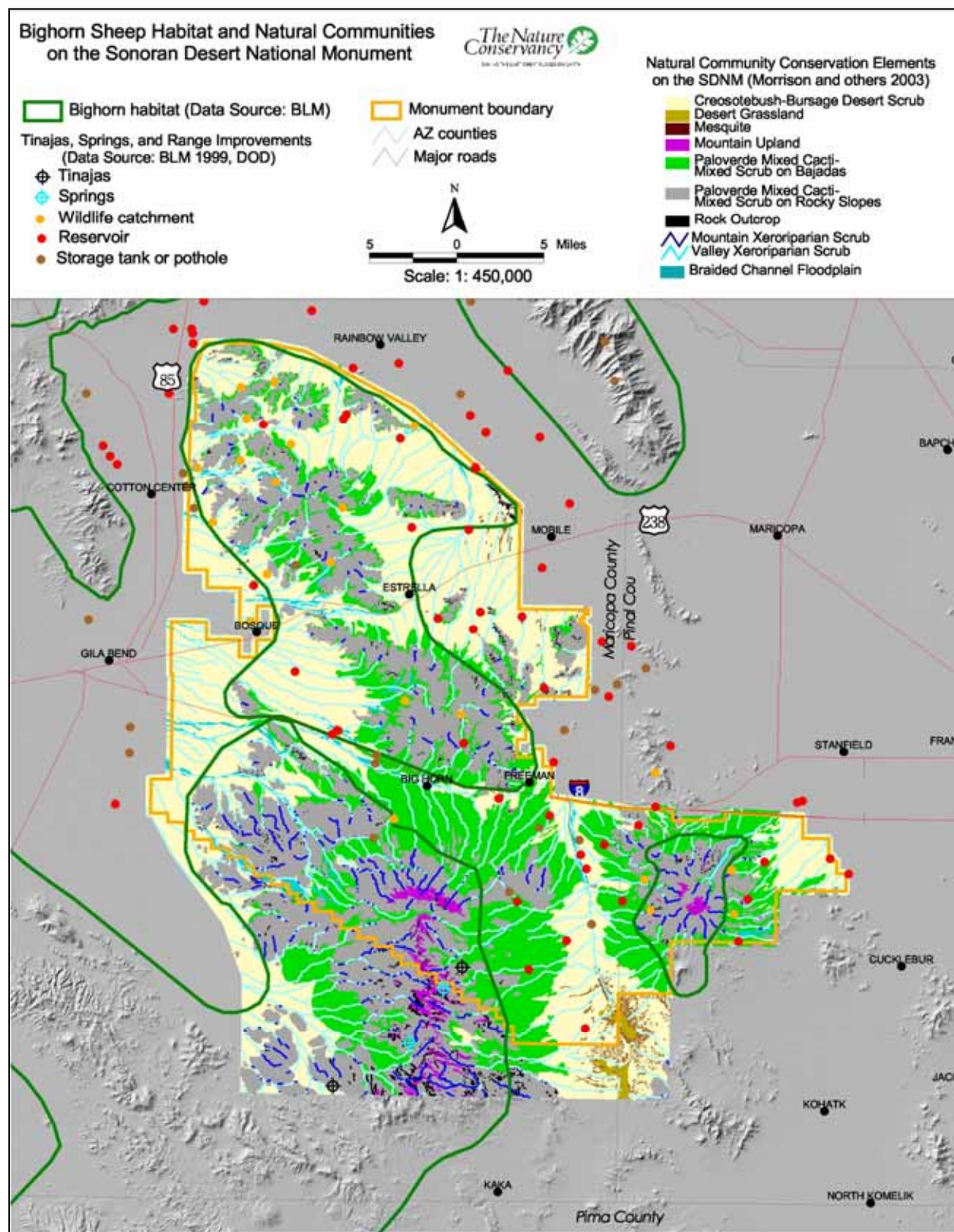


FIGURE C.53 Desert Bighorn Sheep Habitat and Natural Communities on the Sonoran Desert National Monument and Vicinity

desert bighorn sheep movement on the SDNM already present movement obstacles for bighorn, such as Interstate 8 and Route 238. It is essential that impediments to movement are minimized by: (1) enforcing appropriate speed limits on paved roads; (2) limiting the use of fencing, or using “sheep-friendly” fencing, where fencing is necessary; and (3) avoiding, or at least mitigating, the effects of new utility corridor or road development on existing movement corridors. More detailed information is provided in the **Landscape context** section.

Ecological Characteristics

Some of the information below is taken from Hall and others (2001).

Abundance.—The amount of vegetation available for foraging has a strong effect on sheep abundance and population densities. Population density within a mountain range also may be determined in part by differences in geomorphology. Sheep prefer mountainous areas that have a more complex and variable slope, with aspect changes and dips that provide vegetation and microhabitat diversity, than areas where the mountains rise more abruptly (L. Smith, pers. comm.). The section on **Conservation status** provides local population estimates.

Habitat associations.—Desert bighorn are found in dry, generally inaccessible mountainous areas, in foothills near rocky cliffs, and near seasonally available water sources. Association of browse plants, especially jojoba (*Simmondsia chinensis*) with big galleta (*Pleuraphis rigida*), forms important habitat (Monson and Sumner 1980). Water sources that are used most often tend to be free of dense vegetation or other visual obstructions. Desert bighorn sheep habitat is farther from bajadas and has fewer large boulders and less sheet-rock than areas not used by sheep. Moreover, areas that are used by sheep are rugged and steep, with average slopes > 55%. Areas abandoned by sheep tend to be fire-suppressed [likely in areas where plant communities are fire-adapted] and have tall vegetation (Krausman and others 1999).

Food and water requirements.—Desert bighorn forage on grasses, sedges, and forbs (in green and dried conditions), as well as on prickly pear, cholla cactus (*Opuntia* spp.) shoots, and flowers of succulents (for example, agaves). Grasses, including big galleta, are important in the northern and eastern part of their range and are favored when available. Browse becomes more important in the fall and winter (between growing seasons) and in the southern and western parts of the desert bighorn sheep’s range. In the northeastern part of its range, jojoba is the most important year-round foraging plant (Monson and Sumner 1980). Other important browse species include acacias (*Acacia* spp.), paloverde (*Cercidium* spp.), ironwood (*Olneya tesota*), mesquite (*Prosopis* spp.), fairy duster (*Calliandra eriophylla*) leaves, twigs, and flowers, Mormon tea (*Ephedra* spp.) stems, and desert mistletoe (*Phoradendron californicum*). Desert bighorn sheep can survive 10 or more days in summer without drinking, in part by eating water-rich forage that includes barrel cacti (*Echinocactus* or *Ferocactus* spp.) (NatureServe 2003). The importance of surface water to desert bighorn has been investigated by many with inconsistent results (Krausman and others 1999). Differences in results may show a climate dependency or may even be based on differences in the preformed water content of available forage (Krausman and others 1999).

General life history.—Desert bighorn sheep form small groups of two to three individuals; however, group size can range from one to 16. Larger group sizes may reflect better habitat and population health (Monson and Sumner 1980). Typically mature males form bachelor herds for much of the year. Males separate from females and young shortly before the lambing season. Older males dominate in the breeding season, but declines in condition are noted for males older than 10 years-of-age (NatureServe 2003). Females become reproductively active at two years-of-age (NatureServe 2003). In southwestern Arizona, desert bighorn sheep have an extended mating period with the result that the birth of lambs has been documented in all months except October (Krausman and others 1999). Lambing generally peaks in

March, with usually one, and rarely two offspring produced (NatureServe 2003). Gestation is approximately 175 days (NatureServe 2003). Young are weaned in four to six months (NatureServe 2003) and only about one-third of the lambs survive their first year. Lamb recruitment depends on plant availability and water content of foraging plants. Harsh climate and inadequate winter rains can cause lamb abortions or death in the summer.

Biotic interactions.—A positive correlation is present between brittlebush (*Encelia farinosa*) and plantain (*Plantago* spp.) spring flowering and lamb survival. Brittlebush is not a food source, but it is a good surrogate for ascertaining climate conditions and general plant flowering and forage availability (L. Smith, pers. comm.). The role of predation in affecting bighorn sheep abundance and distribution is not well understood. Predation may exert its greatest effect on desert bighorn sheep not by direct mortality, but by forcing females and young to use less productive habitat in or near escape areas (NatureServe 2003). Predators include mountain lions (*Felis concolor*), which can have significant impacts on remnant or transplant herds (NatureServe 2003). Coyotes (*Canis latrans*) are significant predators in some areas and can kill up to 80% of the year's lambs (NatureServe 2003). On Cabeza Prieta National Wildlife Refuge, Simmons (1969) reported that predation on desert bighorn sheep seemed insignificant. A study on Pusch Ridge in the Santa Catalina Mountains suggested that fire suppression caused brush encroachment that may have led to better mountain lion habitat and contributed to the demise of the desert bighorn sheep populations there (L. Smith, pers. comm.). Some desert bighorn sheep populations suffer from competition for water sources with mule deer (*Odocoileus hemionus*) and competition for food from livestock (Monson and Sumner 1980).

Landscape context.—Desert bighorn sheep require large, unfragmented landscapes to maintain population viability. Males have larger home ranges and travel more widely than females. One study in Utah showed a mean home range of 61 km² (23.8 mi²) for males and 24 km² (9.4 mi²) for females (Krausman and others 1999). Desert bighorn sheep migrate altitudinally. They use upland areas in the summer and concentrate in sheltered valleys in the winter. Although traditionally desert bighorn sheep have been managed as if they solely occurred within a mountain range, a landscape approach to management is needed, as the flats between mountain ranges may act as important corridors to gain access to other ranges for foraging and lambing (Krausman and others 1999) and for gene flow between established populations and colonization of currently unexploited habitat (Simmons 1969). Bleich and others (1990) argued for the recognition of the conservation importance to sheep of “nontraditional” habitat connecting mountain ranges that sheep used as movement corridors, as well as the importance of small areas of mountainous habitat that are not permanently occupied by sheep but that may serve as “stepping stones” within movement corridors.

Typically bighorn sheep make valley crossings quickly during mild weather and by the shortest routes possible across flat terrain back into mountainous habitat (Monson and Sumner 1980). Male bighorn sheep tend to make between-mountain moves more frequently than females. The longest inter-mountain dispersal route reported by Simmons (1969) was about 13 kilometers (eight miles); however, he also describes the movement of one dye-marked bighorn sheep that ended up 50 kilometers (31 miles) from where it was marked. In a study of radio-collared bighorn sheep in southwestern Arizona, one ram moved from the Little Horn Mountains to the New Water Mountains (~30 km [18.6 miles]), to the Eagletail Mountains (~50 km [31 miles]), to the Gila Bend Mountains (~32 km [19.8 miles]), and finally to the Tank Mountains (~40 km [24.8 miles]) in a one month period (B. Henry, pers. comm.).

Desert bighorn sheep populations may become fragmented and isolated by roads and fences. Figure C.54 displays desert bighorn sheep habitat, surface water developments, and potential barriers to movement (roads and fences) on the SDNM and surroundings. Figure C.55 shows desert bighorn sheep habitat within the BLM Phoenix South Planning Area. Movement areas shown in Figure C.54 have been delineated based on a general knowledge of sheep behavior (B. Henry, pers. comm.; additional

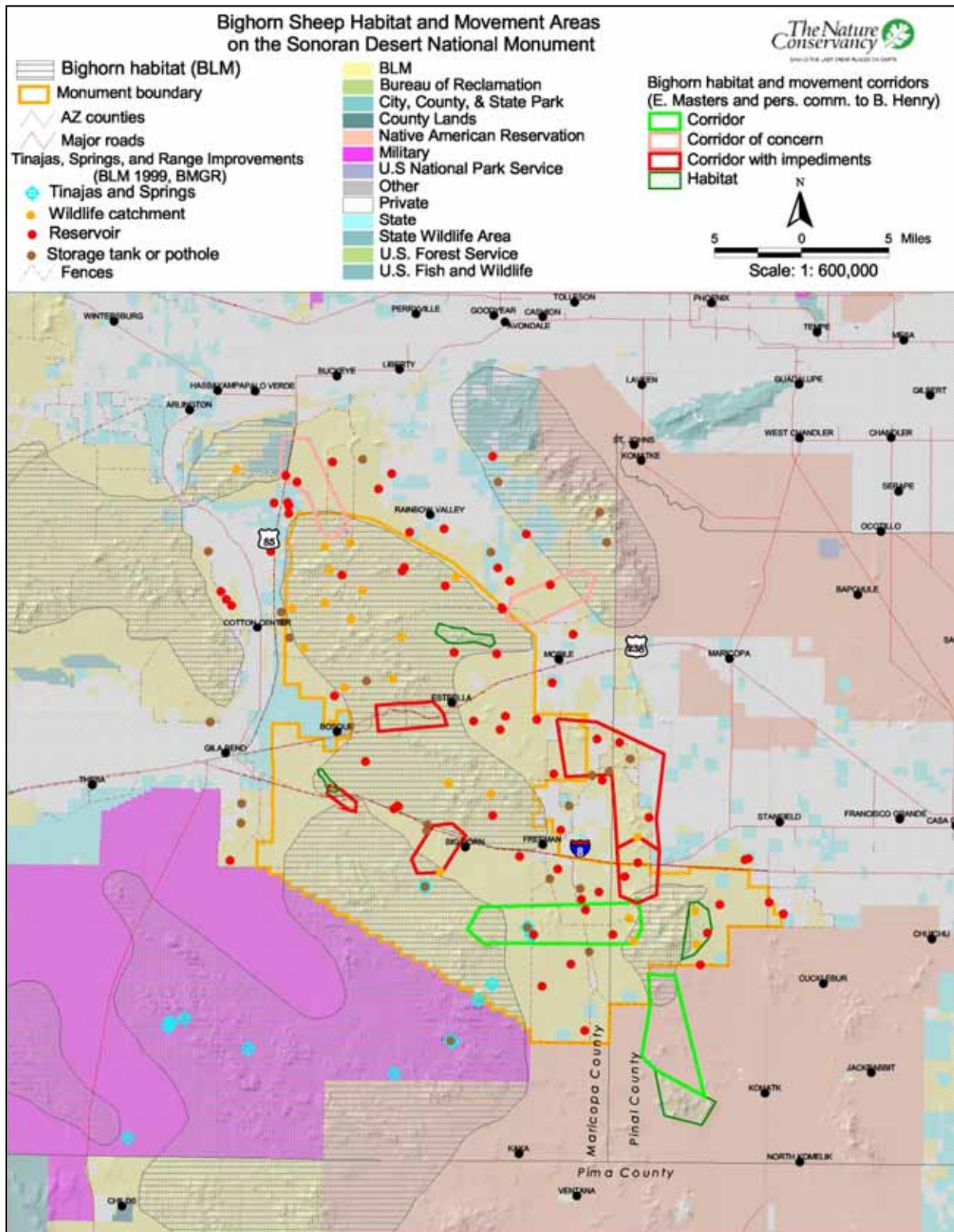


FIGURE C.54 Desert Bighorn Sheep Habitat and Movement Areas on the Sonoran Desert National Monument and Vicinity

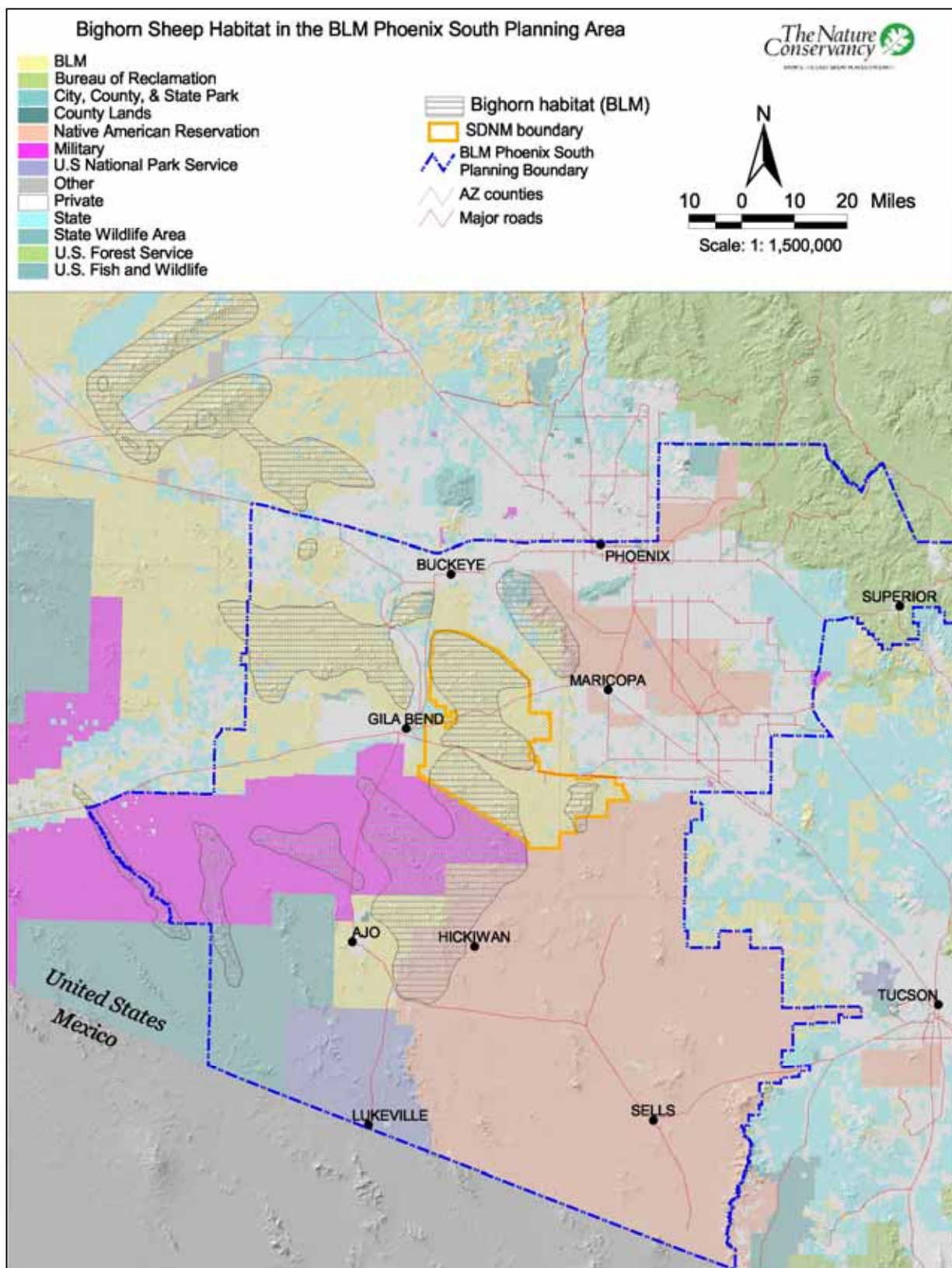


FIGURE C.55 Desert Bighorn Sheep Habitat in the Bureau of Land Management South Phoenix Planning Area

information is provided in the **Mapping comments** section, which also explains some of the apparent differences in the mapping of habitat polygons between the figures). It is apparent from Figures C.54 and C.55 that barriers to sheep movement are present in the region. Paved roads including Interstate 8, Interstate 10, Route 238 (Maricopa Road), and Route 85 are barriers that separate mountain ranges and bighorn habitat on the SDNM and surroundings. Route 85, Interstate 10, Interstate 8, and Route 238 are fenced, which is an additional impediment to movement. Route 238 is fenced only on the south side of the road at present; however, an Environmental Assessment is underway to evaluate the impacts of fencing the north side of the road. Bighorn are able to get under fences along some drainages, at culverts, and/or where “sheep-friendly” fencing is installed (M. Cochran and B. Henry, pers. comm.).

Monson and Sumner (1980) speculated that in a number of places where desert bighorn sheep exist as isolated populations they might not survive. In the southwestern U.S. all populations with less than 50 individuals went extinct within 50 years (Berger 1990). In recent surveys all mountain ranges on the SDNM were estimated to have less than 50 sheep each (see **Conservation status** section), so it is essential that connectivity be maintained across the area to have the potential for long-term viability of this population.

Status, Threats, and Management

Historic and current distribution.—The historic range and current distribution of three subspecies of desert bighorn sheep in the U.S. is depicted in Figure C.56. The distribution of desert bighorn sheep is naturally fragmented in many areas because of the Basin and Range physiography and discontinuous nature of habitat throughout the region (Valdez and Krausman 1999). Throughout the range of desert bighorn sheep, local extirpations and subsequent reintroductions from local or more distant populations have occurred (NatureServe 2003).

Conservation status.—Bighorn sheep (*Ovis canadensis*) have a Global Rank of G4, which indicates that across their entire range they are apparently secure, uncommon, but not rare (NatureServe 2003). Their numbers, however, are declining in many parts of their range. The *mexicana* subspecies has a global rank of G4T3T4Q, which signifies that this subspecies is of questionable status and its status ranges between vulnerable (T3) to apparently secure (T4) (NatureServe 2003). This taxon is subject to special protection in Mexico (*Protección Especial*). Two populations of desert bighorn sheep (*Ovis canadensis*) are listed as Endangered in the U.S.: within the Sierra Nevada and peninsular ranges of California.

The total population of *O. canadensis* across Mexico, the U.S., and Canada in pre-Columbian times is estimated to have been from 1.5 to 2 million (Seton 1929, as cited by McCutchen 1995). Declines throughout its range were noted from the 1850s to the early 1990s, due primarily to excessive hunting, competition and disease from domestic sheep and other livestock, and human-caused habitat alteration. By 1960 the overall population of bighorn in the U.S. was estimated to be between 15,000 and 18,200 (Buechner 1960, as cited by McCutchen 1995).

From 1960 to 1980 desert bighorn sheep disappeared from four mountain ranges in Arizona and were judged to be declining in 14 other ranges (Krausman and others 1999). In 1978 the population estimate for Arizona was between 2,100 to 2,600 individuals, with most found in the western third of the state. The majority of the population was found in Yuma County, in the mountain ranges extending to the Cabeza Prieta National Wildlife Refuge. Desert bighorn sheep were relatively abundant in the Kofa, Plomosa, and Chocolate Mountains (Monson and Sumner 1980). Suitable habitat exists on the Tohono O’odham Reservation, but populations declined there dramatically and were estimated to be less than 50 in 1972 (Monson and Sumner 1980). Sheep populations in Sonora are not well studied, but the species disappeared from the uplands east and north of Highway 2. Population estimates as of 1991 estimated a

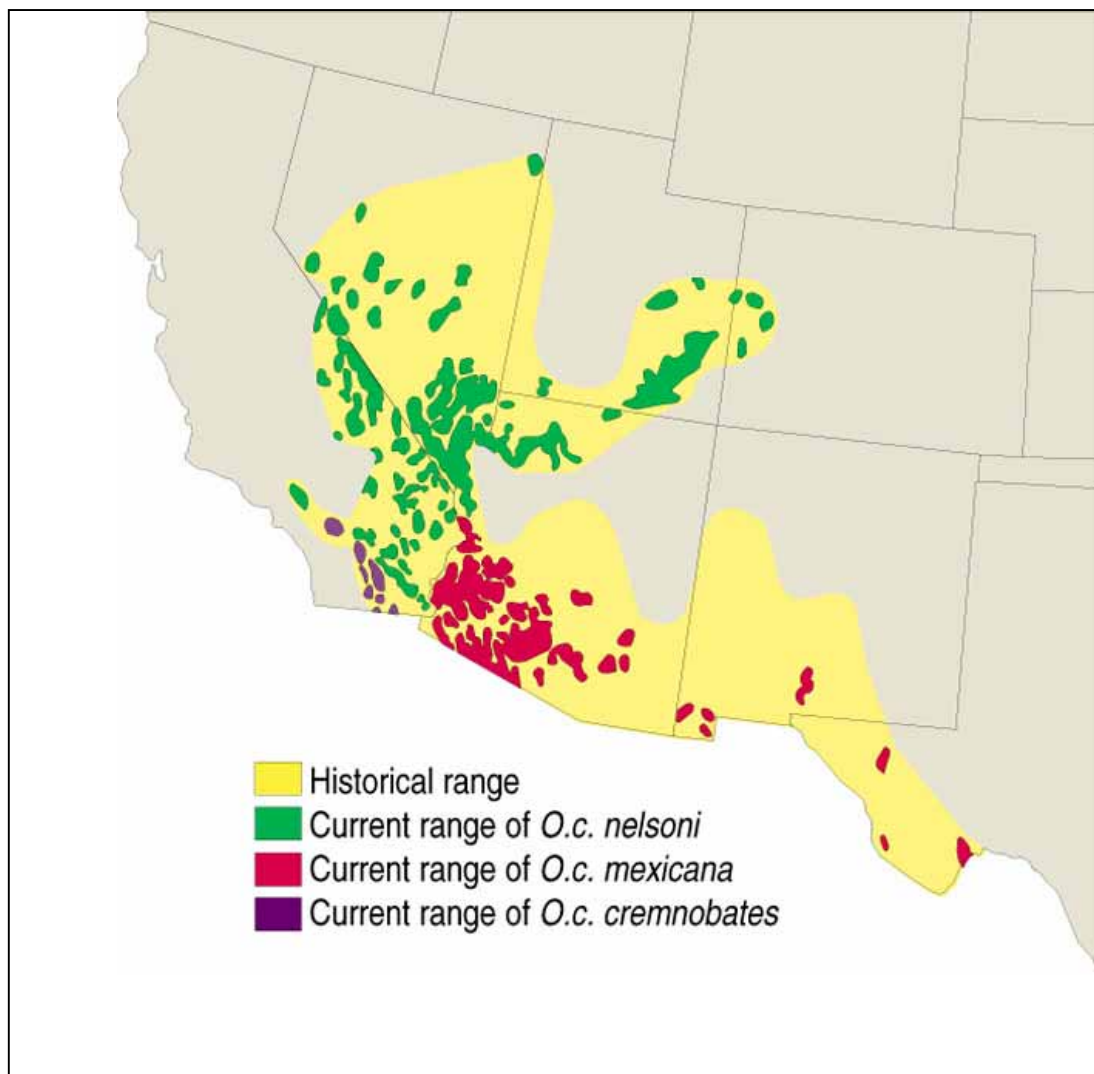


FIGURE C.56 Historical Range and Current Distribution of Three Subspecies of Desert Bighorn Sheep in the United States. From McCutchen (1999).

total of 23,055 desert bighorn sheep in North America, with 6,500 sheep in Arizona (Valdez and Krausman 1999).

Table C.22 provides an estimate of desert bighorn sheep population numbers by state for 1993 and compares it with estimates from 1960. Although the overall population trend increased between the two periods, population numbers were still quite low in 1993. Moreover, since 1990 desert bighorn sheep populations have continued to decline significantly and the species' distribution even more reduced from its historic range (Krausman and others 1999). Contributing factors include: (1) habitat loss; (2) habitat fragmentation resulting from dam, canal, fence, and road construction; (3) presence of invasive species such as feral burros; (4) overgrazing; (5) domestic sheep diseases; and (6) recreational activities (Krausman and others 1999, Valdez and Krausman 1999; see **Stresses and sources of stress** section). Overall desert bighorn sheep are an ecologically fragile species, which is adapted to limited habitats that are increasingly fragmented (Valdez and Krausman 1999). Future conservation actions must minimize land uses that result in additional fragmentation of habitats.

TABLE C.22 Population Status and Trends of Desert Bighorn Sheep in the United States: 1960 to 1993¹

State	Population Estimate by Year	
	1960	1993
Arizona	3,000 to 3,500	6,000
California	2,140 to 2,450	4,300 to 4,325 ²
Colorado	0	475
Nevada	1,500 to 2,000	5,294
New Mexico	400 to 500	295
Texas	25	401
Utah	Remnant	2,200 to 2,250
Total	7,065 to 8,475	18,965 to 19,040

¹See McCutchen (1995) for data sources.

²In California, Nelson's bighorn (*Ovis canadensis nelsoni*) population trends are upward. Peninsular bighorn (*O.c. cremnobates*) populations are lower and are of concern (McCutchen 1995).

Desert bighorn sheep are known to occur in all mountains of the SDNM. These ranges once had what was considered to be robust, healthy populations of bighorn sheep (BLM 1995). Recent surveys, however, indicate population declines (Table C.23), the cause(s) of which is unknown (B. Henry, pers. comm.). The population estimates in Table C.23 were provided by the Arizona Game and Fish Department (AGFD) for desert bighorn sheep on mountain ranges on the SDNM and nearby mountain ranges. These estimates were derived from aerial surveys conducted by AGFD. Surveys followed a set protocol and population estimates were calculated using an estimator that relies on frequencies of observed group sizes. Surveys are conducted for particular mountain ranges every three years. A similar decline in abundance of other mammals, including deer and javelina, has also been observed in the region, with lower densities present than what would be expected based upon habitat (B. Henry, pers. comm.). Populations of desert bighorn sheep in the Maricopa Mountains had previously been low but climbed and peaked in the early 1990s. Current sheep numbers in these mountains is now below the previous low level (B. Henry, pers. comm.).

TABLE C.23 Population Estimates of Desert Bighorn Sheep on the Sonoran Desert National Monument and Adjacent Mountain Ranges¹

Mountain Range	Population Estimates (Number of Sheep) by Year								
	1994	1995	1996	1997	1998	1999	2000	2001	2002
Maricopa Mountains			149			60			24
Sierra Estrella			27			41			
Sand Tank Mountains		73			41			37	
Table Top Mountains		30			11			6	
Sauceda Mountains		98			103			40	

¹Population estimates from B. Henry (pers. comm.).

Movement of desert bighorn sheep likely occurred historically throughout the mountain ranges on the SDNM, the Sierra Estrella, and other surrounding ranges. Long distance movements are most commonly initiated by rams and are considered necessary to maintain genetic viability. Movement also occurs between breeding and lambing areas and between foraging sites. These movements occur today, but are limited due to habitat fragmentation. As previously mentioned, bighorn populations below 50 individuals were not found to be viable in the long-term (Berger 1990). Therefore, to maintain a viable population of

desert bighorn sheep on the SDNM it is critical that (1) sheep are managed as a metapopulation and (2) connectivity is maintained between mountain ranges within the SDNM and between the SDNM and surrounding lands. As shown in Figure C.54, numerous impediments already limit sheep movement between ranges on the SDNM and surrounding lands, including paved roads and fences. Existing and planned future agricultural lands and urban development outside the SDNM boundaries also serve to fragment habitat and hinder movement between mountain ranges. Desert bighorn sheep in the Sand Tanks Mountains can move relatively unimpeded—today—to other core population areas on the BMGR, Cabeza Prieta National Wildlife Refuge, and Organ Pipe Cactus National Monument. This area provides desert bighorn sheep with a large landscape that is free of most of the significant threats that this species encounters in many other parts of its desert range, including large roads, recreational activities, and large populations of burros (L. Smith, M. Cochran, pers. comm.). The “former Area A” fence in the Sand Tanks, however, was identified as a potential barrier for sheep movement across the BMGR and SDNM (May 2003 experts workshop). Because of recent and dramatic population declines of sheep in the Maricopa Mountains, the viability of desert bighorn sheep is questionable in this range. The sheep population in the Sierra Estrella is relatively more robust than in the Maricopa Mountains; however, the continued persistence of desert bighorn sheep in these ranges will rely on maintaining connectivity via the Rainbow Valley (B. Henry, pers. comm.).

The BLM has a rangewide plan for managing desert bighorn sheep habitat on public lands (BLM 1988b). According to this plan, 80% of desert bighorn sheep habitat is on federal lands, the majority of which is BLM land (3.5 million hectares [8.8 million acres]). The BLM considers a viable population of bighorn sheep to be 100 ± 20 individuals. Based on this viability estimate, the agency classifies desert bighorn sheep habitat into three categories:

- Category I: those with existing viable populations
- Category II: remnant herds capable of supporting ≥ 80 individuals
- Category III: unoccupied habitat areas that are capable of supporting ≥ 80 individuals.

The goal of BLM is to maintain and/or enhance habitat for desert bighorn sheep in Category I areas, enhance habitat for sheep in Category II areas, and maintain and enhance habitat to allow reintroduction and reestablishment of viable populations in Category III areas. The rangewide plan recognizes 33 areas classified as Category I habitat (eight in Arizona), 58 areas as Category II (12 in Arizona), and 24 areas as Category III (one in Arizona: the Gila Box). These areas were selected as priorities because: (1) they were considered to be capable of supporting viable populations of desert bighorn sheep, (2) the BLM has substantial management responsibility and control over the habitat, and (3) few conflicting land uses were identified. Two areas were identified in the rangewide plan that include portions of the SDNM: the Sand Tanks/Table Top/Sauceda/Betamote/Coffee Pot Mountain (Category I) and the Maricopa Mountains (Category II). At the time of the plan, the former area had an estimated population of 200 and potential of 240 individuals, whereas the latter had an estimate of 20 but a potential for 200 individuals.

Additional information is needed to understand the cause of the recent declines in desert bighorn sheep abundance in these areas and to manage and protect sheep habitat as suggested by the BLM’s range-wide plan. Guidelines set forth in the rangewide plan include: (1) providing maximum habitat protection to lambing grounds, migration routes, mineral licks, and areas within 1.6 kilometers (one mile) of permanent water; (2) regulating excessive use by recreationists on important areas used by desert bighorn sheep; (3) minimizing construction of roads in sheep habitat and to eliminating roads that no longer serve a definite purpose; (4) using only three-strand fences with a smooth bottom wire and avoiding fencing of desert bighorn sheep waters; and (5) managing livestock grazing to mitigate potential impacts or conflicts with desert bighorn sheep (BLM 1988b).

Stresses and sources of stress.—Table C.24 identifies potential stresses and sources of stress confronting the desert bighorn sheep. As previously discussed in the **Landscape context and Conservation status** sections, the primary threat to bighorn sheep on the SDNM is habitat fragmentation. At a workshop held in May 2003, experts identified habitat fragmentation as a threat to bighorn sheep along Interstate 8, Highway 85, Route 238, across the Rainbow Valley, and the fence demarcating the former Area A (between the BMGR and SDNM). Paved roads and other barriers isolate bighorn sheep populations and can lead to genetic isolation and population declines. Current and future urban (and industrial) expansion of Phoenix and other communities surrounding the SDNM, such as Buckeye, Maricopa, and Mobile, are future threats. Associated with urban expansion toward the foothills and mountain ranges is increased human recreation, which can result in constant harassment of sheep. Recreationists (especially with dogs) in desert bighorn habitat cause sheep to flee, cause them to use valuable energy, and prevent them from resting in the shade and from ruminating. Harassment can prevent bighorn sheep from locating water or preferred foraging areas and can cause illness and death (L. Smith, pers. comm.). The majority of recreational impacts on the SDNM are currently in the accessible valley bottoms or bajadas where there is little threat to bighorn populations. Increased recreational uses in the mountains could become a future threat to bighorn.

It is not known if competition between livestock and desert bighorn sheep occurs on the SDNM; however, Morrison and others (2003) found that most impacts to the natural communities attributed to livestock occurred in the Creosotebush-Bursage natural community, where bighorn spend minimal time except when making long-distance movements between mountain ranges. Fencing associated with livestock allotments, however, may pose a barrier to sheep movement (Hall and others 2005).

A climatic change to hotter, drier conditions could negatively affect sheep populations in the future. Additional research is needed to understand the effect of water enhancements on bighorn, as some studies suggest that water development could inadvertently harm desert bighorn by providing water to their predators or to competitors who are more dependent on water than desert bighorn (for example, feral burros, coyotes, and mountain lions).

Mapping and Information Needs

Mapping comments.—Desert bighorn sheep habitat polygons displayed in Figures C.53 to C.56 were acquired from the BLM Phoenix Field Office. Sheep movement areas shown in Figure C.54 were initially produced by Elroy Masters of BLM and were revised by Stephanie Weinstein based on additional information provided by Bob Henry of AGFD. “Habitat” polygons in the Table Top Mountains on the SDNM and Little Vekol Mountains on the Tohono O’odham Nation were added by Elroy Masters and were not initially delineated as desert bighorn sheep habitat by the BLM. Other “habitat” polygons within BLM-delineated desert bighorn sheep habitat areas, for example, in a spur of the Sand Tank Mountains north of Interstate 8 and the east-west ridge in the North Maricopa Mountains, were identified because they are sites where small numbers of sheep are regularly seen in aerial surveys (B. Henry, pers. comm.). Corridors delineated in red are those that likely served as historic movement areas but which have limited use today because of barriers (heavy traffic and/or paved roads). The polygon connecting the Table Top Mountains with the South Maricopas (outside the monument boundary) is not likely to be used today because of numerous impediments to dispersal. Corridors displayed in light green may not be commonly used, but represent occasional movement corridors that have few barriers at present and are important to maintain. Polygons outlined in pink (“corridor of concern”) are categorized as such because they are outside the boundary of the SDNM and are surrounded by state and private lands near Buckeye and the Rainbow Valley, where development is expected to increase in the future.

TABLE C.24 Desert Bighorn Sheep: Stresses and Sources of Stress

Stress	Source of Stress	Geographic Scope of Potential Impacts	Comments or Source of Information
Habitat fragmentation and loss of genetic diversity	Habitat is fragmented by roads, fences, canals, and altered habitat (urban, agricultural development)	Regional and SDNM	Bleich and others (1990), NatureServe (2003), Hall and others (2005). Habitat fragmentation reduces the probability of recolonization after local extinction (extirpation). Local extirpation is accompanied by a loss of genetic diversity at the level of the metapopulation. Populations with less than 100 individuals are vulnerable to extirpation (Berger 1990).
Habitat loss and degradation	Numerous sources of stress (current and/or historic) include: overgrazing with domestic stock, excessive off-road vehicle use, mining, spread of invasive non-native plants, fire suppression (causing shrub encroachment), and usurpation of water sources.	Regional	NatureServe (2003), Hall and others (2005).
Disease and parasitism (Pasteurella bacteria and acute bronchopneumonia)	Domestic sheep, primarily a historic source of stress	Regional and SDNM	NatureServe (2003). The BLM prohibits sheep grazing on BLM land within 14.5 kilometers (9 miles) of bighorn habitat (B. Henry, pers. comm.). Goats were reported by hunters in the Maricopas in recent years and may have been a disease vector to bighorn (B. Henry, pers. comm.). Considered to be a slight threat on the SDNM (May 2003experts workshop).
Excessive competition	Competition for forage with domestic stock (cattle, sheep, burros); primarily a historic source of stress but may still be a factor in some areas.	Regional	NatureServe (2003).
Behavioral/physiological changes	Recreation in bighorn habitat	Regional and SDNM	Considered to be a slightly possible threat (May 2003experts workshop).

TABLE C.24 Desert Bighorn Sheep: Stresses and Sources of Stress—continued

Stress	Source of Stress	Geographic Scope of Potential Impacts	Comments or Source of Information
Climate change	Drought	Regional and SDNM	The severity of this stress is unknown. Additional research is needed on the role of water developments in mediating this stress.

Information needs.—The beneficial/adverse effects of water enhancement on desert bighorn sheep populations and non-target species (such as desert bighorn sheep predators, invertebrates, plants, and amphibians) need to be scientifically investigated. Dr. Paul Krausman (University of Arizona) is leading a four-year study on the effects of permanent water on the productivity and recruitment of desert bighorn sheep on mountain ranges within Cabeza Prieta National Wildlife Refuge and the BMGR. Desert bighorn sheep will be satellite-collared and monitored to track their responses to water removal. Additional information is needed to understand what factors have caused population declines of desert bighorn sheep on the SDNM (such as loss of genetic diversity and fragmentation, habitat change, grazing conflicts, and predation). Research priorities as outlined in the BLM’s rangewide plan (BLM 1988b) include the following: (1) disease and genetics; (2) nutritional requirements; (3) impacts of domestic livestock and feral animals, including competition for forage, space, and water; (4) habitat evaluation techniques; and (5) developing guidelines for implementing a methodology for mitigation and habitat improvement.

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APPENDIX D OTHER SPECIES AND GUILDS CONSIDERED BUT NOT SELECTED AS CONSERVATION ELEMENTS

Ten species (or subspecies) and one guild (containing six species or subspecies) were evaluated as potential conservation elements for the Sonoran Desert National Monument (SDNM); however, they were not selected at this time (Table D.1). Some of the species and the guild were considered as potential conservation elements because they were carried over from work to develop a biodiversity management framework on the Barry M. Goldwater Range (BMGR) (Hall and others 2001). Regional scientific and agency specialists recommended additional species as potential conservation elements at an experts workshop held in May 2003. We evaluated each of these ten species and the guild against the fine-filter screening criteria (specialized, regionally vulnerable, keystone, or area-dependent species; see Chapter 5 for more detailed information on fine-filter criteria) by consulting the scientific literature, as well as the Bureau of Land Management (BLM) and other agency or scientific experts. We concluded that insufficient evidence is available to warrant selecting these species and guild as conservation elements at this time. Additional information may reveal that any one of them may serve as a conservation element for the SDNM in the future.

The following sections provide brief descriptions of the species/subspecies/guild that were considered as conservation elements and the rationale for why they were not selected at this time. An overview of characteristics associated with these elements is presented in Table D.1. In addition, in section D.4 we provide information on BLM Sensitive Species and U.S. Fish and Wildlife Service (USFWS) Birds of Conservation Concern that occur on the SDNM, whether they were selected as conservation elements, and, if not, how their management needs are addressed.

D.1 PLANTS

Six additional plant species were considered as potential conservation elements.

D.1.1 California Colubrina (*Colubrina californica* [= *Colubrina texensis* var. *californica*])

This species is also known as California snakewood or the Las Animas colubrina. California colubrina is a large shrub that is endemic to the Sonoran Desert Ecoregion and is fairly widely distributed. It is documented, however, from only a few, widely separated localities in southeastern California, Arizona, northern Baja, and northern Sonora (Turner and others 1995). California colubrina was suggested as a conservation element by botanists at an experts workshop in May 2003 because the species is rare across its widespread distribution and it reaches its easternmost extent in the Sand Tank Mountains on the SDNM. We evaluated whether this species met the fine-filter criteria as a regionally vulnerable species and concluded that not enough is known about the distribution, abundance, population status, and threats to this species to support selecting it as a conservation element of the SDNM at this time. Some additional information on the species is presented below.

California colubrina is found on rocky or gravelly slopes, steep gullies, or sandy desert washes, primarily below 763 meters (2,500 feet) elevation (AGFD 1998). California colubrina has its best expression in loamy soils mixed with granite or coarse sand and is a rare associate of the Valley and/or Mountain Xeroriparian Scrub natural communities (S. Rutman, pers. comm.; May 2003 experts workshop). California colubrina was formerly identified as a category-2 candidate species for listing under the

TABLE D.1 Characteristics of Additional Species/Subspecies/Guild Considered but not Selected as Conservation Elements of the Sonoran Desert National Monument

Common Name	Scientific Name	G Rank ¹	Combined G Rank ¹	S Rank (AZ) ¹	Distribution ²	BMGR Element ³	Sonoran Desert Ecoregion Element ⁴	Fine-Filter Screening Criteria Considered	Comments
Plants									
California colubrina	<i>Colubrina californica</i>	G4	G4	S2S3	E	No	No	Regionally vulnerable	
Crucifixion thorn	<i>Castela emoryi</i>	G4	G4	SR	E	Yes	Yes	Regionally vulnerable	
Night blooming cereus	<i>Peniocereus greggii</i>	G3G4	G3	S3S4	L	No	No	Regionally vulnerable	Protected by CITES, Appendix II.
Thornber's fishhook cactus	<i>Mammillaria thornberi</i>	G4	G4	S4	E	No	No	Regionally vulnerable	Protected by CITES, Appendix II.
Varied fishhook cactus	<i>Mammillaria viridiflora</i>	G4	G4	S4	L	No	No	Regionally vulnerable	Protected by CITES, Appendix II.
Tumamoc globeberry	<i>Tumamoca macdougallii</i>	G4	G4	S3	E	No	No	Regionally vulnerable	Listed Endangered (1986 to 1993); Priority Vulnerable Species in Pima County; BLM and U.S. Forest Service Sensitive Species.
Reptiles									
Western leaf-nosed snake	<i>Phyllorhynchus decurtatus perkinsi</i>	G5T5	G5	S5	L	Yes	No	Specialized species	Included in valley bottom reptile guild.
Western shovel-nosed snake	<i>Chionactis occipitalis</i>	G5	G5	S5	L	Yes	No	Specialized species	Included in valley bottom reptile guild.
Sidewinder	<i>Crotalus cerastes</i>	G5	G5	S5	L	Yes	No	Specialized species	Included in valley bottom reptile guild.

TABLE D.1 Characteristics of Additional Species/Subspecies/Guild Considered but not Selected as Conservation Elements of the Sonoran Desert National Monument—continued

Common Name	Scientific Name	G Rank ¹	Combined G Rank ¹	S Rank (AZ) ¹	Distribution ²	BMGR Element ³	Sonoran Desert Ecoregion Element ⁴	Fine-Filter Screening Criteria Considered	Comments
Desert iguana	<i>Dipsosaurus dorsalis</i>	G5	G5	S5	L	Yes	No	Specialized species	Included in valley bottom reptile guild.
Southern desert horned lizard	<i>Phrynosoma platyrhinos calidiarum</i>	G5T5	G5	S5	L	Yes	No	Specialized species	Included in valley bottom reptile guild.
Long-tailed brush lizard	<i>Urosaurus graciosus shannoni</i>	G5T3T4Q	G3		E	Yes	No	Specialized species	Included in valley bottom reptile guild; a state rank is not available for the subspecies, but <i>U. graciosus</i> is ranked S5 in Arizona (NatureServe 2003).
Ground snake	<i>Sonora semiannulata</i>	G5	G5	S5	W	No	No	Regionally vulnerable	Priority Vulnerable Species in Pima County
Pima leaf-nosed snake	<i>Phyllorhynchus browni browni</i>	G5T5	G5	S5	E	No	No	Regionally vulnerable, specialized species	Maricopa leaf-nosed subspecies (<i>P. browni lucidus</i>) was a conservation element for the Sonoran Desert Ecoregion.
Mammals									
Kit fox	<i>Vulpes macrotis</i>	G4	G4	S4	W	Yes	No	Regionally vulnerable, keystone, area sensitive	
White-tailed deer	<i>Odocoileus virginianus</i>	G5	G5	S5	W	No	No	Regionally vulnerable	

¹Global (G) and state (S) rank codes are defined in Appendix A, Table A.1.

²Distribution codes are defined in Appendix A, Table A.4.

³Based on conservation element information contained in Hall and others (2001).

⁴Based on Sonoran Desert Ecoregion conservation target information contained in Marshall and others (2000).

Endangered Species Act (AGFD 1998). California colubrina is tracked by the California Native Plant Society as a rare plant in California, but is not considered endangered in the state because of its isolated and remote habitat (CNPS 2002; D. Tibor, pers. comm.). The Heritage Data Management System (HDMS) tracks California colubrina in Arizona. The species has been documented at 22 locations in Arizona in Maricopa, Yuma, La Paz, and Pinal counties, including two populations on the SDNM in the northwestern portion of the Sand Tank Mountains (HDMS 1999, 2002). Vehicle use in washes occupied by California colubrina could potentially have negative impacts on recruitment by causing seedling mortality (S. Rutman and P. Warren, pers. comm.); however the plant is generally found in remote and rugged areas where vehicle use is limited.

D.1.2 Crucifixion thorn (*Castela emoryi* [= *Holacantha emoryi*])

This species is one of three plants in the Sonoran Desert with the common name of crucifixion thorn. *Castela emoryi* should not be confused with another plant commonly called crucifixion thorn (*Canotia holacantha*) that is associated with the Mountain Upland natural community on the SDNM. In contrast, *Castela emoryi* is found on the periphery of xeroriparian areas on loamy flats. On the BMGR *Castela emoryi* seems to be most closely associated with the Valley Bottom Floodplain Complex natural community, as described and mapped by Hall and others (2001). Botanists initially expressed concern over the status of *Castela emoryi* during the process of evaluating and selecting conservation elements for the BMGR (Hall and others 2001). At that time these regional experts thought that *Castela emoryi*'s management needs were not adequately captured by the natural community coarse filter because: (1) its habitat associations are not well-understood and are somewhat unpredictable; (2) its populations are small and widely scattered across its distribution; and (3) populations may be in decline because of low levels of reproduction, seed dispersal, seedling establishment, and slow growth rates. As a result of these observations on the BMGR, *Castela emoryi* was selected as a preliminary conservation element of the SDNM (Weinstein and others 2002). Further evaluation, however, of its status and discussion of this species at an experts workshop in May 2003 cast some doubt on its regional vulnerability.

Although it is not a common species in the Sonoran Desert, *Castela emoryi* seems to be less rare than previously thought (S. Rutman, pers. comm.). In addition, *Castela emoryi* is a clonal species that spreads by rhizomes and, once established, it is long-lived and tough (S. Rutman and R. Felger, pers. comm.). Sexual reproduction and seedling production is a periodic event (S. Rutman and R. Felger, pers. comm.). Wild-collected material from crucifixion thorn is commercially valuable in the medicinal plant industry (Moore 1989, NatureServe 2003), and the harvest of roots and stems has resulted in local impacts on populations of crucifixion thorn near Ajo (S. Rutman, pers. comm.). Wild harvesting has not been documented on the SDNM and is unlikely to become a threat because the species is not common or abundant. On the SDNM, the species can be found in the Vekol Valley, Table Top Mountains (Turner and others 2000), and near North Tank in association with a Mesquite Woodland natural community southwest of the Espanto Mountains (Morrison and others 2003). In sum, *Castela emoryi* was not selected as a conservation element because the evidence is insufficient to justify that it is regionally vulnerable in the Sonoran Desert or that the SDNM provides a regionally significant opportunity to protect this species. One of the largest populations of *Castela emoryi* is on land managed by the El Centro Field Office of the BLM (Sanders 2002).

D.1.3 Night Blooming Cereus (*Peniocereus greggii*)

The night blooming cereus is a cryptic cactus that resembles branches of a tree or shrub; however, it is quite showy when it flowers. Two varieties of this cactus are recognized: (1) *Peniocereus greggii* var. *greggii*, which is found in the Chihuahuan Desert in southern New Mexico, western Texas, and Chihuahua and Zacatecas, Mexico, and (2) *P. g.* var. *transmontanus*, which occurs in Sonora, Mexico and southern Arizona (NatureServe 2003). The species is protected by CITES (Convention on International Trade in Endangered Species of Wild Flora and Fauna; Appendix II) and was formerly identified as a category-2 candidate species under the Endangered Species Act. Because the USFWS discontinued the practice of identifying and tracking category-2 candidate species in 1996, limited information is available on the status of the night blooming cereus.

Night blooming cereus was recommended as a potential conservation element at an experts workshop in May 2003. It was suggested that this species might be an appropriate conservation element because it seems to be a rare associate of the Creosotebush-Bursage Desert Scrub natural community on the SDNM, is sensitive to habitat alteration, and may be subject to collection pressure (P. Morrison, pers. comm.). Threats noted by NatureServe (2003) specifically to the Chihuahuan Desert variety of night blooming cereus (*P. g.* var. *greggii*) include habitat loss, illegal collection for landscaping, and inappropriate grazing management practices (cattle and goats eat the cactus and/or damage nurse plants). NatureServe (2003) also reports that a limited commercial demand exists for night blooming cereus as a medicinal plant. Additional consultation, however, with botanists and the literature suggests that this species is widely distributed, may be locally abundant, and is often more common than what is obviously visible as it is cryptic unless it is flowering (NatureServe 2003; S. Rutman, P. Warren, and R. Felger, pers. comm.). In addition, because it usually grows beneath nurse plants such as creosotebush (*Larrea tridentata*) and desert trees, it is somewhat protected from disturbances such as from vehicular traffic on or off roads (P. Warren, pers. comm.). Although this species may indeed be rare on the SDNM, we do not have sufficient evidence to suggest that the night-blooming cereus is regionally vulnerable and/or that the SDNM is a regionally significant locality for its conservation.

D.1.4 Thornber's Fishhook Cactus (*Mammillaria thornberi*)

Thornber's fishhook cactus was recommended as a conservation element of the SDNM by Richard Felger in the May 2003 experts workshop. This small cactus is endemic to the Sonoran Desert and can be distinguished from the more common Graham's fishhook cactus (*Mammillaria grahamii* var. *grahmii*) by its growth form and spine color (Phillips and others 1981). Thornber's fishhook cactus has a restricted range, as it is known only from southwestern Arizona and northwestern Sonora southward to sandy plains southwest of Caborca (Felger 2000). Thornber's fishhook cactus is found on sandy or silty soils under shrubs on floodplains and alluvial fans at elevations from 244 to 732 meters (800 to 2,400 feet) (Benson 1982, Rutman 1985). On the SDNM Thornber's fishhook cactus has been reported from only the east side of the Vekol Valley where it has been found in a narrow zone on the lower bajada. Here it occurs beneath triangle leaf bursage (*Ambrosia deltoidea*), often on the east side of foothill paloverde (*Cercidium microphyllum*) (R. Felger, pers. comm.). Thornber's fishhook cactus is tolerant of alkaline soils where it may be common to abundant in association with saltbush (*Atriplex polycarpa* or *A. linearis*) (S. Rutman, pers. comm.). It also occurs at lower densities in Creosotebush-Bursage Desert Scrub or other vegetation types (S. Rutman, pers. comm.). The highest density reported of Thornber's fishhook cactus in southern Arizona was found at the Tucson Mountain District of Saguaro National Park, with an average density of 1.5 clusters per 100 m² (1,110 ft²) in the study area and as high as 4.7 clusters per 100 m² (1,110 ft²) (Rutman 1985). At Saguaro National Park, Thornber's fishhook cactus density was higher on granite-derived sandy loam soils than on coarser soils or those derived from other parent types (Rutman 1985). Thornber's fishhook cactus populations also have been reported from the Avra Valley and the Tohono O'odham Reservation (Phillips and others 1981). Some of the cactus' habitat, particularly where

associated with saltbush, has been impacted or converted to agricultural uses. Other threats to Thornber's fishhook cactus and its habitat include illegal collecting, urban development, inappropriate livestock management practices, and lowering of the water table (Phillips and others 1981, Rutman 1985).

Thornber's fishhook cactus was once proposed for listing as a Threatened species and its occurrence in Arizona was tracked by the HDMS. The proposal for listing was withdrawn after it was found to be more abundant than previously thought. The species is no longer tracked in the HDMS. Based on this information, it does not seem that Thornber's fishhook cactus meets the fine-filter criteria of being regionally vulnerable. Furthermore, the SDNM does not contain saltbush desert scrub habitat, the habitat in which the Thornber's fishhook cactus may attain relatively high densities and where, outside the boundary of the SDNM, the cactus may be particularly vulnerable to habitat loss.

D.1.5 Varied Fishhook Cactus (*Mammillaria viridiflora*)

Varied fishhook cactus was recommended as a conservation element for the SDNM by Richard Felger in the May 2003 experts workshop. This species is distributed principally in mountainous areas in western New Mexico and southeastern Arizona; however, its distribution also includes local populations in Sonoran Desert mountain ranges. On the SDNM the varied fishhook cactus has been documented on rocky slopes and in small rocky basins above 730 meters (2,395 feet) elevation above Bender Spring in the Sand Tank Mountains and on Table Top Mountain (R. Felger, pers. comm.). It may be vulnerable to trampling by scientists or recreational users of the SDNM because it is highly localized on open, partially barren rocky headlands (R. Felger, pers. comm.).

The varied fishhook cactus has a global rank of G4, which indicates that it is widespread and uncommon but not rare and that it is not vulnerable across most of its range (NatureServe 2003). This species was formerly tracked by HDMS in Arizona, but it is no longer tracked because it was found to be more abundant than previously thought. In 1999 the HDMS database included records for 33 populations of varied fishhook cactus from Pima, Yavapai, Maricopa, Mohave, La Paz, Pinal, Gila, Graham, and Cochise counties (HDMS 1999). Although the varied fishhook cactus may have some localized threats (such as trampling by humans), its habitat is fairly remote and the evidence is insufficient at this point to conclude that the cactus meets the fine filter screening criteria as a regionally vulnerable species. We conclude that with appropriate management of the coarse filter natural communities, including the Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes, Rock Outcrop, and/or Mountain Upland natural communities, the management needs of the varied fishhook cactus will be adequately addressed.

D.1.6 Tumamoc Globeberry (*Tumamoca macdougallii*)

Tumamoc globeberry is a tuberous perennial vine that is visible above ground only during the growing and reproductive season, which occurs after the summer monsoon rains. Even at this time the plant is highly cryptic because it grows beneath nurse plants such as creosotebush and mesquite (*Prosopis* spp.). An extensive review of information relating to the ecology and management of this species is available on the Fish and Wildlife Information Exchange (FWIE 1996).

The USFWS listed the Tumamoc globeberry as Endangered under the Endangered Species Act in 1986. At the time of listing, 30 populations of the plant had been recorded within its restricted U.S. distribution (wholly contained within Pima County, Arizona) that in the aggregate contained approximately 433 adults and 1,867 juveniles (USFWS 1986). In addition, five populations composed of 60 individuals had been recorded from Sonora, Mexico. At the time of listing, all but one of the known populations in the United States were facing imminent threat from urban and agricultural expansion. In addition to habitat destruction or modification, other threats facing Tumamoc globeberry were collection or vandalism, disease or predation, and livestock grazing (trampling of individuals located under trees or shrubs)

(USFWS 1986). Critical habitat was not designated for Tumamoc globeberry because it has a restricted distribution and it was thought that description and maps of its habitat would make it more vulnerable to taking and vandalism (USFWS 1986). The construction of the Central Arizona Project (CAP) aqueduct was expected to negatively impact Tumamoc globeberry habitat and therefore resulted in numerous studies and a program to relocate and monitor affected plants (FWIE 1996). Additional surveys for Tumamoc globeberry conducted after listing expanded the known geographic range of the species northward to southern Pinal and Maricopa counties, Arizona, and southward to southern Sonora, within 80 kilometers (50 miles) of the Sinaloa border (Reichenbacher 1990). Studies also found that Tumamoc globeberry was found to be less habitat-specific and more abundant than initially thought, with populations occurring in a variety of soil types and habitat associations in the Sonoran Desert. Based on this information, the species was removed from protection under the Endangered Species Act in 1993 (USFWS 1993).

Tumamoc globeberry was recommended as a conservation element for the SDNM by Sue Rutman in the May 2003 experts workshop. At the workshop it was suggested that this species remains regionally vulnerable because, since the plant's delisting, large areas of its former habitat in Sonora, Mexico have been lost and converted to buffelgrass (*Pennisetum ciliare*) pastures (S. Rutman and M. Falk, pers. comm.). Furthermore, Tumamoc globeberry is sensitive to management and is usually found in undisturbed soils (Pima County 2001; R. Felger, pers. comm.). The plant grows beneath trees and shrubs where it is vulnerable to trampling by shade-seeking livestock, and once the understory is opened up by livestock, Tumamoc globeberry tubers may be vulnerable to predation by foraging animals such as javelina (FWIE 1996).

Although the above information provides some evidence that Tumamoc globeberry is regionally vulnerable, the Fish and Wildlife Information Exchange reported in 1996 that the population trends of Tumamoc globeberry are not well known: some local populations have decreased, some have been eliminated, while others have increased during the same time period (FWIE 1996). The population on the SDNM is located in the Vekol Valley, which is at the northern extent of Tumamoc globeberry's range. The Vekol Valley population had the lowest reported density of all the Tumamoc globeberry populations studied by Reichenbacher (1990), with 0.10 plants per hectare (0.25 plants per acre; a total population of 40 plants). In light of the above information, we determined that we did not have sufficient information on: (1) Tumamoc globeberry's current status and trends throughout its range and (2) the relative significance of the SDNM to the species' conservation to support selection of the species as a conservation element at this time.

The Arizona Game and Fish Department (AGFD) recommends that agencies should continue to track this plant, populations should be monitored to some extent, and new occurrences of this species should be searched for in areas subject to development (AGFD 2000). Tumamoc globeberry is a Priority Vulnerable Species in the Sonoran Desert Conservation Plan (Pima County 2001) and it is tracked by the HDMS of AGFD. Tumamoc globeberry is considered a Sensitive Species by the BLM and U.S. Forest Service (USFS) and, prior to its removal from the endangered species list in 1993, the BLM and USFS made a commitment to monitor the status of the plant on plots established on their lands for five years following delisting (USFWS 1993). The USFS has monitored populations of Tumamoc globeberry in Sabino Canyon since 1984, and the BLM established permanent plots to monitor Tumamoc globeberry on BLM-managed lands in the Avra Valley and on the SDNM in the Vekol Valley. The two plots established in the Vekol Valley have been monitored from 1990 to 2000 (Table D.2). In 1990, 37 individuals were found and tagged and since then few individual have been consistently observed. John Anderson (BLM) and Stephanie Weinstein (TNC) revisited the monitoring plots in the Vekol Valley in November 2003 and relocated 3 individuals (Table D.2). Although the area is not fenced from cattle, evidence of cattle impacts in the area of the plots, such as cattle trails, dung, or damage to nurse plants or

TABLE D.2 Monitoring Data for Tumamoc Globeberry in the Vekol Valley, Sonoran Desert National Monument (1990 to 2003)¹

Plant	Overstory	1990	1992	1994	1995	1996	1997	1998	1999	2000	2003
1	Creosotebush	J	D	M	M	M	M	M	M	M	
2	Mesquite	J	M	M	M	M	M	M	M	M	M
3	Mesquite	J	H=6	M	M	M	M	M	M	M	M
4	Mesquite	J	M	M	M	M	M	M	M	M	M
5	Mesquite	J	H=10	M	M	M	M	M	M	M	M
6	Mesquite	J	M	M	M	M	M	M	M	M	M
7	Mesquite	J	M	M	M	M	M	M	M	M	M
8	Mesquite	J	H=6	M	M	M	M	M	M	M	M
9	Mesquite	J	M	M	M	M	M	M	M	M	M
10	Mesquite	J	H=10	H=10	H=17	H=10	M	H=1	M	M	M
11	Mesquite	J	D	H=13	H=21	H=40	H=23	H=2	H=28	H=27	H=15
12	Mesquite	A	M	M	M	M	M	M	M	M	M
13	Mesquite	J	M	H=15	H=15	M	M	H=1	H=1	H=9	M
14	Mesquite	J	M	H=6	H=17	M	H=15	H=3	H=36	H=17	H=57
15	Mesquite	J	H=2	M	M	M	M	M	M	M	M
16	Creosotebush	J	M	M	M	M	M	M	M	M	M
17	Creosotebush	J	H=4	M	M	M	M	M	M	M	M
18	Creosotebush	J	M	M	M	M	M	M	M	M	
19	Creosotebush	J	M	M	M	M	M	M	M	M	
20	Creosotebush	J	M	M	M	M	M	M	M	M	
21	Mesquite	J	M	M	M	M	M	M	M	M	
22	Mesquite	J	M	M	M	M	M	M	M	M	
23	Mesquite	J	M	M	M	M	M	M	M	M	
24	Creosotebush	J	M	M	M	M	M	M	M	M	
25	Creosotebush	J	M	M	M	M	M	M	M	M	
26	Creosotebush	J	H=12	H=55	H=20	H=28	H=60	H=9	H=55	H=72	P
27	Creosotebush	A	D	M	M	M	M	M	M	M	
28	Mesquite	J	M	M	M	M	M	M	M	M	
29	Creosotebush	A	Tall	M	M	M	M	M	M	M	
30	Creosotebush	A	Tall	M	M	M	M	M	M	M	
31	Creosotebush	J	M	M	M	M	M	M	M	M	M
32	Creosotebush	J	M	M	M	M	M	M	M	M	M
33	Creosotebush	J	M	M	M	M	M	M	M	M	
34	Creosotebush	J	M	H=2	M	M	M	M	M	M	
35	Creosotebush	A	M	M	M	M	M	M	M	M	M
36	Creosotebush	J	Small	H=3	H=6	M	M	M	M	M	M
37	Creosotebush	J	M	M	M	M	M	M	M	M	M

¹**Legend:** Years are federal fiscal years. J = juvenile, A = adult, M = missing, D = detached stem, H = height in centimeters. Data for 2003 (Observers: J. Anderson and S. Weinstein): as above and P = present (stem or other sign of plant was present but we were unable to measure it because of state of senescence). A blank space indicates that the overstory plant where the Tumamoc globeberry individual(s) should be found was not relocated, whereas M indicates that the overstory plant and/or the Tumamoc globeberry tags were located but no individual was found.

other vegetation, were not observed. The plots are in a remote area of the monument and are unlikely to be subject to human disturbances.

D.2 REPTILES

One guild and two additional snake taxa were considered as conservation elements.

D.2.1 Valley Bottom Reptile Guild

The valley bottom reptile guild was selected as a conservation element for the BMGR (Hall and others 2001). As defined for the BMGR, the guild included the following six species: (1) western leaf-nosed snake (*Phyllorhynchus decurtatus perkinsi*), (2) western shovel-nosed snake (*Chionactis occipitalis*), (3) sidewinder (*Crotalus cerastes*), (4) desert iguana (*Dipsosaurus dorsalis*), (5) southern desert horned lizard (*Phrynosoma platyrhinos calidiarum*), and (6) long-tailed brush lizard (*Urosaurus graciosus shannoni*). These species were selected as conservation elements on the BMGR because they are specialized on low desert valley bottom habitats and the BMGR represents the heart of many of these species' distribution and abundance (Hall and others 2001). We initially included this guild as a conservation element for the SDNM because of the potential opportunities for coordinated management with the BMGR. We decided to drop this guild as a conservation element, however, based on additional consultation with Dr. Philip Rosen and other specialists present at the May 2003 experts workshop. In comparison with the BMGR, the SDNM has little areal coverage of the low, dry, sparsely vegetated valley bottom habitats associated with the Lower Colorado River Valley subdivision of the Sonoran Desert that constitutes the heart of the distribution of this guild. Although all of the above species are either documented from or are likely to occur on the SDNM, the monument represents the easternmost portion of the range of the species in the guild and the habitat on the monument is relatively mesic in comparison and is marginal for most of these species.

D.2.2 Pima Leaf-Nosed Snake (*Phyllorhynchus browni browni*)

The Pima leaf-nosed snake is a subspecies of the saddled leaf-nosed snake (*Phyllorhynchus browni*). The Pima leaf-nosed snake was evaluated as a potential conservation element for the SDNM because it is a relatively rare snake with a restricted distribution in the Sonoran Desert in Arizona and northern Sonora. In addition, the subspecies may have specialized habitat needs as a soil burrower that eats lizard eggs. Another subspecies of the saddled leaf-nosed snake, the Maricopa leaf-nosed snake (*Phyllorhynchus browni lucidus*) was selected as a conservation element of the SDNM and is described in detail in Appendix C. Some authors do not distinguish between the subspecies of the saddled leaf-nosed snake so some information on the Maricopa leaf-nosed snake provided in Appendix C is also relevant to the Pima leaf-nosed snake. Many collection records do not differentiate between the Maricopa and Pima leaf-nosed snake subspecies. Some records of the saddled leaf-nosed snake near Gila Bend and Ajo are likely the Pima leaf-nosed snake subspecies (P. Rosen, pers. comm.). The Pima leaf-nosed snake is also relatively abundant in appropriate habitat on the Tohono O'odham Nation and Organ Pipe Cactus National Monument (Rosen and others 1996; P. Rosen, pers. comm.). In the vicinity of the SDNM, the Pima leaf-nosed snake has been collected on Route 238 three kilometers (1.8 miles) east of Gila Bend (A. Holycross, pers. comm.). The Pima leaf-nosed snake was not selected as a conservation element because in comparison with its close relative, the Maricopa leaf-nosed snake, it is more abundant and widespread and, as a result, the evidence is not conclusive that it is regionally vulnerable.

D.2.3 Ground Snake (*Sonora semiannulata*)

The ground snake is widely distributed from southwest Idaho to southern Baja California and from southeastern California to east-central Texas (Stebbins 1985). The ground snake is a small nocturnal

snake that eats insects, scorpions, and centipedes. Dr. Philip Rosen recommended this species as a conservation element for the SDNM because the rare and vulnerable valley form of the species is likely to occur in the Vekol Valley on the monument.

Throughout its range the ground snake shows marked geographic variation. In Arizona several distinct varieties are described, including a form from the Santa Cruz River floodplain near Eloy, the Sulfur Springs Valley, the San Simon Valley, and the mountain slopes near Tucson and across southeastern Arizona (Pima County 2001). The ground snake is not tracked by the HDMS and is a secretive snake that is poorly known. The ground snake was identified as a Priority Vulnerable Species in the Sonoran Desert Conservation Plan (Pima County 2001). The taxonomy of the ground snake is complicated. Some varieties are morphologically distinct and have restricted geographic distributions, which may merit taxonomically recognizing them as distinct species or subspecies (Rosen 2003). Two morphs of the ground snake in southern Arizona are ecologically separated: a coral-banded form that occurs on desert grassland foothills and slopes extending into lower Madrean Oak Woodlands and a dorsal-striped form that is found in desert valleys (Rosen 2003). The valley form of the ground snake has been recorded from Marana along the Avra Valley Road to Eloy, near Red Rock (where it is relatively abundant), and the Santa Cruz Flats (Rosen 2003). The valley form of the ground snake lives in desert valleys on hard clay and silty soils within which it is difficult for a snake to burrow. The ground snake is thought to require the subsurface moisture that is contained within these poorly drained soils (Pima County 2001). The main threat to the ground snake is habitat destruction, though it has been found to tolerate some habitat modifications such as farm buildings (Pima County 2001). The ground snake is threatened by habitat destruction in Pinal County and is likely to occur on lands that are slated for development in the Marana area (Rosen 2003). The ground snake has not been documented on the SDNM but is likely to occur in the tobosa (*Pleuraphis mutica*) grassland in the Vekol Valley (Rosen 2003; P. Rosen, pers. comm.). The snake has been recorded from the tobosa grassland on the Tohono O'odham Nation (Pima County 2001).

The ground snake was not selected as a conservation element for the SDNM at this time because: (1) its population status on the monument is unknown and (2) its taxonomy is unresolved. As a result, we conclude the evidence is insufficient to justify that the valley form is regionally vulnerable and the SDNM is important for conservation of the taxon. It is assumed that if present on the SDNM, the management needs of the ground snake will be adequately addressed by appropriate management of the coarse filter natural communities, including the Desert Grassland natural community.

D.3 MAMMALS

Two additional mammal species were considered as conservation elements.

D.3.1 Kit Fox (*Vulpes macrotis*)

The kit fox was initially selected as a conservation element for the BMGR (Hall and others 2001) and was carried over as a preliminary conservation element for the SDNM (Weinstein and others 2002). In contrast to other Sonoran Desert predators such as the coyote (*Canis latrans*), bobcat (*Lynx rufus*), or mountain lion (*Felis concolor*), which are widely distributed and habitat generalists, the kit fox is limited to the Mojave and Sonoran Deserts and is specialized on low valley bottom desert habitats with friable soils suitable for digging. We evaluated this species as a potential conservation element by conducting a thorough review of the literature and consulting with kit fox biologists and agency experts. We initially hypothesized that the kit fox may meet the fine-filter screening criteria based on three potential characteristics: (1) regional vulnerability, (3) keystone species, and/or (3) area-sensitive species. We encountered, however, inconclusive evidence and a lack of consensus among the experts and literature consulted that the kit fox met any one of these characteristics. As a result, we did not select kit fox as a

conservation element of the SDNM at this time. A summary of some of the information used to evaluate the kit fox as a conservation element is presented below.

The evidence is inconclusive that the kit fox is regionally vulnerable. The Global Heritage Status Rank for *Vulpes macrotis* is G4. Throughout the species' range its state ranks are S1 (critically imperiled; Colorado, Idaho and Oregon), S3 (vulnerable; California and Utah), and S4 (apparently secure; Nevada, Arizona, New Mexico, and Texas), respectively (NatureServe 2003). The subspecies of kit fox in the San Joaquin Valley in California (*Vulpes macrotis mutica*) is federal listed as Endangered, due primarily to a severe reduction in habitat; less than 7% of the native vegetation cover in the San Joaquin Valley remained undeveloped by 1979 (USFWS undated). The San Joaquin kit fox will tolerate some level of habitat alteration, for example, by using culverts as den sites (Egoscue 1956, O'Farrell and Gilbertson 1986). Habitat loss has occurred to a lesser extent in other portions of the kit fox's range. Outside the San Joaquin Valley the effect of habitat loss on kit fox abundance and conservation status is largely unknown, and these kit fox populations do not have any protection status. The AGFD classifies the kit fox as a furbearing and predatory mammal. Trapping and hunting of kit fox is permitted throughout much of Arizona including on the SDNM from August 1 to March 31 (AGFD 2003c). It is difficult to evaluate trends in kit fox populations in Arizona based on hunting or trapping data because the AGFD tracks three species of foxes as a group: kit fox, red fox (*Vulpes vulpes*), and gray fox (*Urocyon cinereoargenteus*). Despite this limitation in the data, it appears that direct take has minimal pressure on kit fox populations at present. Kit fox fur is currently of little commercial value (AGFD 2002); consequently, over 95% of foxes trapped or hunted in Arizona are gray foxes. In 1999 the total harvest of all three fox species was 470 individuals taken by 58 trappers and 4,900 foxes taken by 14,500 hunters (AGFD 2001c). The objective of the AGFD is to maintain an annual harvest of 3,000 to 5,000 of all three fox species combined (AGFD 2001c).

Although some concern exists regarding the future of the kit fox in parts of its range, a lack of consensus was present among the biologists consulted that the species requires additional management attention than what is provided by protecting its habitat alone (S. Barrett, B. Henry, and D. Steele, pers. comm.). The primary threat to the kit fox across its range is loss of native habitat due to industrial, agricultural, and residential development in low desert valleys. Other factors contributing to the decline of the kit fox, and the San Joaquin subspecies in particular, include: (1) poisoning programs that reduce prey abundance and cause unintended kit fox poisonings (Schitoskey 1975, McGrew 1979, O'Farrell and Gilbertson 1986, O'Farrell 1987, NatureServe 2003); (2) illegal shooting (Morrell 1972); (3) predation by coyote, red fox, and domestic dogs (Ralls and White 1995); and (4) competition for prey with coyote, particularly when coupled with prey declines and drought (White and Garrott 1997, Cypher and Spencer 1998). Kit foxes are frequent road kill, as they are attracted to warm, paved roads at night (Egoscue 1956) and they scavenge for food along roadsides during periods of low prey abundance (Morrell 1972). The effect of off-highway vehicle use on the kit fox is inconclusive (O'Farrell and Gilbertson 1986).

We also evaluated the kit fox as a keystone species in Creosotebush-Bursage Desert Scrub in the Sonoran Desert. We hypothesized that kit foxes may serve a keystone role because of their top position in the food chain through which they may shape trophic structure and prey population dynamics within a community (Fisher 1981, Terborgh and others 1999). Other studies, however, suggest that the kit fox is an opportunistic feeder that varies its diet based on the abundance of the most common small mammal within its home range (McGrew 1979) and that kit fox population dynamics are largely driven by "bottom up" processes. For example, researchers have shown that short-term fluctuations in precipitation affect prey abundance, which in turn influences kit fox reproductive success, home range size, and density (Zoellick and Smith 1992, White and Ralls 1993, White and others 1994, White and Garrott 1999). Kit foxes dig numerous burrows that are used by many taxa as shelter from heat and predators (Egoscue 1956); however, many other species also dig holes in the Sonoran Desert and it is not known if the dens dug by kit foxes are disproportionately important as shelters for other species.

The third fine-filter criteria that we considered was area-sensitivity. Area-sensitive species are those that require large unfragmented lands to meet their life cycle requirements. For example, the desert bighorn sheep (*Ovis canadensis mexicana*) was identified as an area-sensitive conservation element because it uses mountainous areas as escape from predators and foraging and lambing habitat, but it also requires unfragmented connections to intermontane valleys and adjacent mountains for dispersal and genetic exchange to maintain viable populations (detailed information on desert bighorn sheep is presented in Appendix C). The area needs and effect of habitat fragmentation on the kit fox is not as clear as it is for desert bighorn sheep. A review of the relevant literature is provided in the following paragraph.

Kit foxes home ranges are local to intermediate in scale and range from 1.1 km² to 14.2 km² (0.4 to 5.5 miles²) (reviewed by Zoellick and Smith 1992). Kit fox home range size differs based on sex, individual body size, and habitat characteristics, including prey availability (Egoscue 1956, Daneke and others 1984, Zoellick and Smith 1992). Kit foxes have not been studied on the SDNM, but in Creosotebush-Bursage Desert Scrub in nearby Tonopah, Arizona, mean kit fox home ranges were 9.8 km² (3.8 miles²) for females and 12.3 km² (4.8 miles²) for males and densities ranged from one fox per 3.6 to 4.6 km² (1.4 to 1.8 miles²) (Zoellick and Smith 1992). Nightly movements within home ranges ranged from 8.6 to 26.3 kilometers (5.3 to 16.3 miles) and differed between males/females and seasons. Males traveled longer distances than females and male movement distances were greatest during the breeding season (Zoellick and others 1989). Kit foxes use different natural community types for hunting, denning, and dispersal, so their management needs may not be wholly captured at the level of the coarse filter. Den sites are not always located in areas of abundant prey, and kit foxes have been found to travel more than a kilometer (0.6 miles) to hunting areas that contain more productive prey communities, such as in vegetated dunes or foothills (Egoscue 1956). Kit foxes have been documented to periodically make long distance dispersal movements from the natal den to areas outside their established home ranges. The importance of these movements is not well understood, but long distance movements of up to 120 linear kilometers (about 75 miles) have been reported for a collared kit fox (Daneke and others 1984). In a 16-year study of 209 radioed juvenile San Joaquin kit foxes, Koopman and others (2000) reported that 33% of the radioed individuals dispersed, and significantly more males than females dispersed. The mean dispersal distance was 7.8 kilometers (4.8 miles) and dispersal distances ranged from 1.8 to 32.3 kilometers (1.1 to 20.0 miles). Because of their habitat and spatial needs, kit foxes may be vulnerable to habitat fragmentation or may require a particular configuration of habitats across a landscape. Zoellick and others (1989) documented that kit foxes use xeroriparian areas as travel corridors. The limitations to dispersal in agricultural or urban settings are not known and represent an important information need for the kit fox in fragmented landscapes (Koopman and others 2000). Kit fox mortality is higher in areas close to human habitation where it may become road kill or subject to increased predation by domestic dogs and coyotes (Ralls and White 1995; B. Henry, pers. comm.). As the lands surrounding the SDNM become increasingly urbanized in the future, kit fox habitat between the monument and surrounding areas will become increasingly fragmented. Additional information is needed to determine if the SDNM and adjoining areas is of sufficient size to support viable kit fox populations, when considering the potential future land uses surrounding the monument.

D.3.2 White-Tailed Deer (*Odocoileus virginianus*)

White-tailed deer are widely distributed from southern Canada through most of the United States and Mexico to Central and South America. Up to 30 subspecies of white-tailed deer have been recognized in North America; however, recent genetic analyses have not supported the status of some subspecies (NatureServe 2003). In Arizona white-tailed deer are of small size and some taxonomists classify them as a separate subspecies, *Odocoileus virginianus couesi* (Hoffmeister 1986). Although Arizona's white-tailed deer populations are classified as the Coues subspecies by AGFD, this subspecies is not recognized by NatureServe, a network of Natural Heritage programs and repository of biodiversity information

(NatureServe 2003). In Arizona white-tailed deer are mostly found in areas with predictable summer precipitation in chaparral and in oak and pine woodlands (AGFD 2002). They are most common in the southeastern mountains of Arizona but can range up to the edge of the Mogollon Rim, in the White Mountains, and on the Colorado Plateau to the San Francisco Peaks, Bill Williams Mountains, and Bradshaw Mountains (AGFD 2002, Hoffmeister 1986). Relict populations of white-tailed deer occur at low densities in isolated, high, and relatively mesic mountain ranges in the Sonoran Desert, including in the Ajo, Growler, Saucedo, and Sand Tank Mountains (Brown and Henry 1981, Hoffmeister 1986). White-tailed deer abundance in these areas has always been small but has appeared to have declined in recent years based on survey and hunt data (B. Henry and D. Urquidez, pers. comm.).

The white-tailed deer was recommended as a conservation element at the May 2003 experts workshop by representatives from AGFD. On the SDNM white-tailed deer are found in high elevation and remote areas of the Sand Tank Mountains. This population is of special significance to the AGFD as one of the most northern and western populations of white-tailed deer in Arizona Upland habitat (D. Urquidez, pers. comm.). The AGFD collects data on white-tailed deer in the Sonoran Desert during aerial surveys for desert bighorn sheep. In 1981 David Brown and Bob Henry reported that white-tailed deer had likely been extirpated from the Sand Tank Mountains, as well as from numerous other ranges in the Sonoran Desert (Brown and Henry 1981). Recent sightings of white-tailed deer in the Sand Tank Mountains suggest that they have persisted at low densities (B. Henry, pers. comm.). They have been sighted as recently as early January 2004, when a doe was observed resting beneath a crucifixion thorn (*Canotia holacantha*) bush (likely in the Mountain Upland natural community; D. Griffin, pers. comm.). Although the white-tailed deer is a significant and unique component of the biodiversity of the SDNM, we did not select it as a conservation element at this time because it did not fit the screening criteria. The subspecies is widespread and is not regionally vulnerable throughout its range, though its continued occurrence on the SDNM may be at risk because of climate change (or extended drought). Additional information on the status of white-tailed deer in the Sonoran Desert and on the SDNM is presented below.

In addition to the reported population declines of white-tailed deer in the Sand Tank Mountains, Brown and Henry (1981) also documented extirpations of white-tailed deer from the Tucson, Silverbell, Tortolita, Puerto Blanco, Agua Dulce, Bates, Salt River (South), and probably the Picacho Mountains. These authors also noted declines in white-tailed deer populations in the Saucedo and Ajo Mountains. Brown and Henry (1981) suggest that increased duration and severity of early summer and fall droughts since 1950 may be responsible for declines and local extinctions of white-tailed deer in the Sonoran Desert. It is during this time that does are pregnant, and prolonged drought can reduce the availability of herbaceous vegetation such that it negatively impacts doe condition and doe and/or fawn survival. These climatic conditions also have likely been responsible for confining the deer to mesic microhabitats in good range condition. Overgrazing by livestock can exacerbate the effects of drought on white-tailed deer by reducing herbaceous cover, which increases evapotranspiration rates and decreases the effectiveness of summer precipitation (Brown and Henry 1981). In the face of these stresses in the Sonoran Desert, it has been suggested that the more arid-adapted mule deer (*Odocoileus hemionus*) may outcompete white-tailed deer in some areas (Brown and Henry 1981).

A concern does exist for the long-term viability of white-tailed deer on the SDNM because of the small population size and the ongoing drought/climate change. Other stresses to white-tailed deer, such as inappropriate grazing management practices, are likely to be minimal in the Sand Tank Mountains. This is true particularly in the region that was formerly Area A of the BMGR, which has not been grazed in decades. The AGFD plans to construct water developments in the Sand Tanks Mountains that are aimed for use specifically by white-tailed deer (D. Urquidez, pers. comm.). Obstacles to connectivity likely are not present across the BMGR/SDNM boundary, as deer can easily cross the existing fence (B. Henry, pers. comm.).

D.4 BUREAU OF LAND MANAGEMENT SENSITIVE SPECIES AND U.S. FISH AND WILDLIFE SERVICE BIRDS OF CONSERVATION CONCERN OCCURRING ON THE SONORAN DESERT NATIONAL MONUMENT

As a check to see if any species important to BLM was missed in our evaluation of potential conservation elements, we separately evaluated all BLM Sensitive Species (BLM 2001) and USFWS Birds of Conservation Concern (USFWS 2002a) that occurred on the SDNM to see which qualified as fine-filter conservation elements and which did not. Table D.3 summarizes the applicable information on these species. Ultimately, some species were selected as conservation elements either individually or as part of a guild, whereas others either were considered adequately captured for management purposes by their association with one or more coarse-filter natural community or the SDNM was considered as marginally important for their conservation.

TABLE D.3 Bureau of Land Management Sensitive Species and U.S. Fish and Wildlife Service Birds of Conservation Concern Occurring on the Sonoran Desert National Monument

Common Name	Scientific Name	BLM Sensitive Species	USFWS Birds of Conservation Concern	Conservation Element on SDNM	Associated Natural Community (when captured by the coarse filter)	Comments
Plants						
Arizona Sonoran rosewood	<i>Vauquelinia californica sonorensis</i>	Yes	No	No	Mountain Upland	Assumed to be captured by the coarse filter.
Kofa Mountain barberry	<i>Berberis harrisoniana</i>	Yes	No	No	Mountain Upland	Assumed to be captured by the coarse filter.
Tumamoc globeberry	<i>Tumamoca macdougallii</i>	Yes	No	No	Creosotebush-Bursage Desert Scrub	Assumed to be captured by the coarse filter. This species was evaluated in detail for selection as a conservation element but it was not clear that it met the screening criteria as a regionally vulnerable or specialized species.
Reptiles						
Chuckwalla	<i>Sauromalus obesus</i>	Yes	No	No	Rock Outcrop	Assumed to be captured by the coarse filter.
Rosy boa	<i>Charina trivirgata</i> (= <i>Lichanura trivirgata</i>)	Yes	No	No	Rock Outcrop	Assumed to be captured by the coarse filter.
Birds						
Bell's vireo	<i>Vireo bellii</i>	No	Yes	No	Mesquite Woodland	Typically found in dense mesquite riparian areas and streamside thickets. Subject to cowbird parasitism in some regions but populations appear to be stable in the Sonoran Desert (Phillips and Wentworth Comus 2000). The SDNM is not the best place in the ecoregion to protect this species (lack of habitat or large populations). Recorded from four of 20 Breeding Bird Atlas (BBA) survey blocks on the SDNM (ABBA 2001).

TABLE D.3 Bureau of Land Management Sensitive Species and U.S. Fish and Wildlife Service Birds of Conservation Concern Occurring on the Sonoran Desert National Monument--continued

Common Name	Scientific Name	BLM Sensitive Species	USFWS Birds of Conservation Concern	Conservation Element on SDNM	Associated Natural Community (when captured by the coarse filter)	Comments
Bendire's thrasher	<i>Toxostoma bendirei</i>	No	Yes	No	Possibly some or all of: Creosotebush-Bursage Desert Scrub, Paloverde-Mixed Cacti-Mixed Scrub communities, Xeroriparian Scrub communities, and Braided Channel Floodplain.	Assumed to be captured by the coarse filter. Breeds in the desert, especially in association with creosotebush, yucca, and tall cholla cactus (Ehrlich and others 1988). Threats are largely unknown and it occurs at relatively low densities with a patchy distribution. (NatureServe 2003). Recorded from nine of 20 BBA survey blocks on the SDNM (ABBA 2001).
Black-chinned sparrow	<i>Spizella atrogularis</i>	No	Yes	No	Paloverde-Mixed Cacti-Mixed Scrub communities	The SDNM is not likely the best place in the ecoregion to protect this species (no confirmed breeding on SDNM based on available data). Recorded from only one of 20 BBA survey blocks on the SDNM (ABBA 2001).
Burrowing owl	<i>Athene cunicularia</i>	<i>hypugea</i> ssp.	Yes	No	Creosotebush-Bursage Desert Scrub	The primary threat is habitat loss (for example, due to intensive agriculture), habitat degradation (for example, via control of burrowing mammals), and habitat fragmentation (NatureServe 2003). The SDNM is not the best place in the ecoregion to protect this species (no populations within the monument proper). Recorded from zero of 20 BBA survey blocks on the SDNM (ABBA 2001).

TABLE D.3 Bureau of Land Management Sensitive Species and U.S. Fish and Wildlife Service Birds of Conservation Concern Occurring on the Sonoran Desert National Monument--continued

Common Name	Scientific Name	BLM Sensitive Species	USFWS Birds of Conservation Concern	Conservation Element on SDNM	Associated Natural Community (when captured by the coarse filter)	Comments
Crissal thrasher	<i>Toxostoma crissale</i>	No	Yes	No	Valley Xeroriparian Scrub and Mesquite Woodland	Assumed to be captured by the coarse filter. Unclear if the species meets criteria for conservation element selection. Widespread in the ecoregion and not regionally vulnerable based on available information. Recorded from eight of 20 BBA survey blocks on the SDNM (ABBA 2001).
Elf owl	<i>Micrathene whitneyi</i>	No	Yes	No	Paloverde-Mixed Cacti-Mixed Scrub communities	Assumed to be captured by the coarse filter and by the primary excavator (cavity) guild. Unclear if the species meets criteria for conservation element selection. Widespread in the ecoregion and not regionally vulnerable based on available information (however, from NatureServe [2003]: "Major threats are loss of riparian habitat due to invasion of salt cedar (<i>Tamarix chinensis</i>), agricultural clearing, flood control, de-watering, overgrazing, and bank stabilization projects. Also loss of desert scrub habitat due to agricultural conversion and urbanization (for example, Tucson and Phoenix areas)." Recorded from nine of 20 BBA survey blocks on the SDNM (ABBA 2001).
Gila woodpecker	<i>Melanerpes uropygialis</i>	No	Yes	Yes	Fine-filter element	See Appendix C.
Gilded flicker	<i>Colaptes chrysoides</i>	No	Yes	Yes	Fine-filter element	See Appendix C.

TABLE D.3 Bureau of Land Management Sensitive Species and U.S. Fish and Wildlife Service Birds of Conservation Concern Occurring on the Sonoran Desert National Monument--continued

Common Name	Scientific Name	BLM Sensitive Species	USFWS Birds of Conservation Concern	Conservation Element on SDNM	Associated Natural Community (when captured by the coarse filter)	Comments
Gray vireo	<i>Vireo vicinior</i>	No	Yes	No	Unknown	The primary breeding distribution for this species in Arizona is above the Mogollon Rim. In steep decline in Arizona. Recorded from zero of 20 BBA survey blocks on the SDNM (ABBA 2001).
Lark bunting	<i>Calamospiza melanocorys</i>	No	Yes	No	Unknown	This species winter range includes portions of the Sonoran Desert. Breeding habitat is primarily in sagebrush plains. Recorded from only one of 20 BBA survey blocks on the SDNM (ABBA 2001).
Le Conte's thrasher	<i>Toxostoma lecontei</i>	No	Yes	Yes	Fine-filter element	See Appendix C.
Loggerhead shrike	<i>Lanius ludovicianus</i>	Yes	Yes	No	Possibly Paloverde-Mixed Cacti-Mixed Scrub communities	Assumed to be captured by the coarse filter. The species is widespread and common in some areas but has been declining throughout North America since the 1960s, particularly in the northeastern and north-central regions of the U.S. (NatureServe 2003). Its status in the Sonoran Desert appears to be secure at present. Recorded from 18 of 20 BBA survey blocks on the SDNM (ABBA 2001).
Rufous-winged sparrow	<i>Aimophila carpalis</i>	No	Yes	Yes	Fine-filter element	See Appendix C.
Sage sparrow	<i>Amphispiza belli</i>	No	Yes	No	Unknown	This species winter range includes portions of the Sonoran Desert. Breeding habitat is primarily in sagebrush and saltbush plains in the Mojave Desert and Great Basin. Recorded from only one of 20 BBA survey blocks on the SDNM (ABBA 2001).

TABLE D.3 Bureau of Land Management Sensitive Species and U.S. Fish and Wildlife Service Birds of Conservation Concern Occurring on the Sonoran Desert National Monument--continued

Common Name	Scientific Name	BLM Sensitive Species	USFWS Birds of Conservation Concern	Conservation Element on SDNM	Associated Natural Community (when captured by the coarse filter)	Comments
Yellow warbler	<i>Dendroica petechia</i>	No	<i>sonorana</i> ssp.	No	Unknown	This species is not typically found in the Sonoran Desert. In Arizona, it favors wet habitats, especially willows and alders. Recorded from four of 20 BBA survey blocks on the SDNM (ABBA 2001).
Mammals						
Califomia leaf-nosed bat	<i>Macrotus californicus</i>	Yes	No	Yes	Fine-filter element	See Appendix C.
Cave myotis	<i>Myotis velifer</i>	Yes	No	Yes	Fine-filter element	See Appendix C.

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APPENDIX E MAY 13, 2003 EXPERTS WORKSHOP

BIODIVERSITY ELEMENTS ON THE SONORAN DESERT NATIONAL MONUMENT: STRESSES AND CONSERVATION OPPORTUNITIES

E.1 PARTICIPANTS

Twenty-four individuals attended the workshop from eleven different organizations. These included (listed alphabetically by last name):

Nina Chambers, Sonoran Institute
Gene Dahlem, Bureau of Land Management (BLM)
Dave Dalton, Roper Scientific
Rebecca Davidson, Arizona Game and Fish Department (AGFD)
Erik Enderson, Drylands Institute
Russ Engel, AGFD
Richard Felger, Drylands Institute
Pam Foti, Northern Arizona University (NAU)
Anne Gondor, The Nature Conservancy (TNC)
John Hall, TNC
Karen Kelleher, BLM
Megan Kram, BLM
Rob Marshall, TNC
Elroy Masters, BLM
Peter Morrison, Pacific Biodiversity Institute (PBI)
Chuck Patterson, NAU
Phil Rosen, University of Arizona
Sue Rutman, Organ Pipe Cactus National Monument (ORPI)
Tim Tibbitts, ORPI
Dale Turner, TNC
Dan Urquidez, AGFD
Stephanie Weinstein, TNC
Rob Winthrop, BLM
Betsy Wirt, Luke Air Force Base

E.2 WORKSHOP FINDINGS

The workshop findings are divided into three main sections: (1) discussion of conservation elements, (2) presentations of research and data currently being collected on the Sonoran Desert National Monument (SDNM), and (3) discussion of stresses to and sources of stress for the conservation elements.

E.2.1 Discussion of Conservation Elements

Stephanie Weinstein presented information on each of the natural community conservation elements and the proposed species conservation elements, including how the selected species meet the fine-filter criteria, details on their distribution, conservation status, and the information needed to determine whether certain species or guilds should be retained as a conservation element. This information provided a

starting point for discussion with the group on whether modifications of the conservation element list were needed.

The main findings on each of the conservation elements (and on additional species that were recommended to add to the conservation element list) are presented below. Comments specific to particular participants are cited, where appropriate. The decision and justification for whether to keep, add, or drop the species as a conservation element is provided (in bold); where applicable, the additional information that is needed to evaluate whether the element should be added or dropped is noted. Since the workshop, some additional research and discussion on conservation elements has taken place. Any major findings since the workshop associated with the conservation elements are noted.

Acuña Cactus (Echinomastus erectocentrus var. acunensis)

Findings.—

- Documented on the SDNM from a single individual found in one location in the Sand Tank Mountains (found by Peter Holm and Betsy Wirt).
- It is difficult to find and likely additional occurrences are present on the monument than what is currently known (S. Rutman).
- It is potentially threatened by illegal collection (especially during flowering when it is more conspicuous), because it is not grown in the cactus trade (R. Felger and S. Rutman). Theft is suspected to occur on Organ Pipe Cactus National Monument.
- Localities on the monument should not be disclosed in any public documents to ensure its protection.

Decision.—Keep as conservation element (regionally vulnerable, federal Candidate)

Crucifixion Thorn (Castela emoryi / = Holacantha emoryi)

Findings.—

- This species was originally chosen as a conservation element because it was considered regionally vulnerable.
- Sue Rutman suggests that the species should be taken off the list of conservation elements because she has found it to be more common than previously thought (since 2001, during the experts workshop for the Barry M. Goldwater Range (BMGR) when it was first suggested as a conservation element).
- It is a long-lived, clonal species that spreads by rhizomes and is found on the periphery of riparian zones on loamy flats. Once established, it is clonal and tough. Sexual reproduction and seedling production is an occasional/periodic event. (S. Rutman and R. Felger).
- Wild harvest of roots and stems for medicinal use can have a local impact (population near Ajo; S. Rutman).
- Richard Felger doesn't agree that the species should be taken off the list of conservation elements because it is an unusual plant that could draw public attention ("poster plant") to the SDNM. It is the longest-lived species on the monument along with creosote, and is easily monitored.

Decision.—Evaluate regional vulnerability.

Post-workshop evaluation.—Not added as conservation element. Evidence insufficient to justify that the species is regionally vulnerable in the Sonoran Desert or that the SDNM provides a regionally significant opportunity to protect the species.

Recommendations for Additional Plant Conservation Elements

Some confusion occurred among participants between choosing conservation elements and indicator species (the latter of which that might be evaluated during monitoring, but which are not necessarily chosen as conservation elements). John Hall clarified the difference between indicators used for monitoring purposes and conservation elements.

The floristics of the monument are not fully explored. Some additional plants that may be rare or sensitive to management should be considered as conservation elements. Those suggested by participants are discussed below.

Night-Blooming Cereus (Peniocereus greggi var. transmontanus)

Findings.—

- Recommended as a conservation element by Peter Morrison because it is a representative of a natural community (Creosotebush-Bursage Desert Scrub) that is subject to threats including habitat alteration and collection pressure.
- *Peniocereus greggi* is not rare and is widely distributed. It is more common than what is obviously visible because it is difficult to find unless flowering (R. Felger and S. Rutman).

Decision.—Requires further evaluation against fine-filter criteria.

Post-workshop evaluation.—Not added as conservation element. This species is widespread, abundant, and is often found in high densities where it occurs. It is generally protected from disturbance where it grows under nurse trees and shrubs (Peter Warren, pers. comm.).

California Colubrina (Colubrina californica [= Colubrina texensis var. californica])

Findings.—

- Recommended as a conservation element by Sue Rutman as an alternative to *Castela emoryi*. It is a widely distributed plant that is found in very few sites, in medium to large washes in sandy, loamy soils, and is more common in California. The monument represents its eastern extension into Arizona, where it is found only in Maricopa County. Sue has seen it in the Saucedo and Sand Tank Mountains, near Coffee Pot, in Sand Tank Wash (Blue Plateau), and near Hat Mountain.
- The monument is unique because it is “where east meets west”: at the interface of the Arizona Uplands and Lower Colorado River Valley Subdivisions. This species is found at the eastern edge of the interface (B. Wirt).

Decision.—Requires further evaluation against fine-filter criteria.

Post-workshop evaluation.—Not added as conservation element. Available information is insufficient to evaluate its distribution, abundance, population status, and threats.

Tumamoc Globeberry (Tumamoca macdougalii)

Findings.—

- Recommended as a conservation element by Sue Rutman as a species that is regionally vulnerable. This species was formerly listed as federal Endangered, but it was de-listed based on a commitment by the federal agencies that it would be managed and because it was found to be

more common than previously thought in Sonora. The SDNM is potentially significant for the species' conservation as it represents the northernmost location for the species. It has been severely impacted by grazing where it occurs in the Vekol Valley.

- It is hard to find unless it is during the growing/fruiting season (end of the summer rainy season). It is a widespread plant that is probably not rare, but may be rare on the monument and is sensitive to management (R. Felger).

Decision.—Requires further evaluation against fine-filter criteria.

Post-workshop evaluation.—Not added as conservation element based on insufficient information about the species' overall status and trend across its range and, because of its relative rarity on the SDNM, the relative significance of monument populations to its conservation.

Saguaro (Carnegiea gigantea)

Findings.—

- Recommended by Betsy Wirt as a conservation element. It is easy to manage because one can easily see effects of management on populations. Agave species are similar and also should be considered as a conservation element. Saguaro draws attention from the public and funding agencies. A weakness with the Conservancy analysis on the Barry M. Goldwater Range was that saguaro was not included as a species conservation element.
- Discussion covered whether to include saguaro as a separate species element or to change the name of the natural communities to highlight saguaro's presence (for example, Saguaro-Paloverde-Mixed Cacti-Mixed Scrub). Discussion also covered whether or not saguaro is a keystone species.
- Saguaro are emphasized in the monument proclamation (G. Dahlem).

Decision.—Add as conservation element (significant social value, possible keystone species).

Thornber's Fishhook Cactus (Mammillaria thornberi)

Findings.—

- Recommended by Richard Felger as a conservation element.
- *Mammillaria thornberi* is not locally rare but has a restricted range and is endemic to the Sonoran Desert. It is found on the lower bajada on the east side of the Vekol Valley in a narrow band at the ecotone between Creosotebush-Bursage Desert Scrub and Paloverde-Mixed Cacti-Mixed Scrub on Bajadas..

Decision.—Requires further evaluation against fine-filter criteria.

Post-workshop evaluation.—Not added as conservation element based on the species being more abundant than previously thought and because the habitat within which it can attain relatively high densities, Saltbush Desert Scrub, does not occur on the SDNM.

Varied Fishhook Cactus (Mammillaria viridiflora)

Findings.—

- Recommended by Richard Felger as a conservation element.
- This species is widespread (mostly a mountain species in western New Mexico and southeastern Arizona), but desert populations are highly localized.

- *Mammillaria viridiflora* is located on the SDNM above Bender Spring and on Table Top Mountain on rocky slopes and in small rocky basins. It could be vulnerable to trampling (by biologists and others) because it is found in open, partially barren rocky headlands.

Decision.—Requires further evaluation against fine-filter criteria.

Post-workshop evaluation.—Not added as conservation element based on the species being more abundant than previously thought and remote habitat.

Spike Moss (Selaginella arizonica)

Findings.—Significant and unique representations on some north-facing rocky slopes (S. Rutman).

Post-workshop evaluation.—After the workshop, Stephanie Weinstein and John Hall consulted with Peter Morrison to determine whether *Selaginella* slopes should be identified as a natural community conservation element. We determined that it would be difficult to map and/or model the occurrence of *Selaginella*-dominated slopes on the SDNM for this project, but these areas will be described as a unique subtype of the Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes natural community.

Native Grass Group

Findings.—

- Perennial plants are the first indicators of change in vegetation communities, so they should be represented on the conservation element list (S. Rutman).
- The monument has the best expressions of intact Sonoran Desert perennial grass assemblages in southern Arizona. These have been lost in much of the Sonoran Desert (including at Organ Pipe Cactus National Monument); as a result, where they occur they are significant and need to be protected (S. Rutman).
- Our knowledge of grass communities is lacking. They should be represented as separate species conservation elements (or a species assemblage) (S. Rutman).
- Three types of grass assemblages occur on the SDNM: (1) lowland valley bottom grasses; (2) mountain tops; and (3) invasive grasses, which have the ability to change vegetation structure and composition. Where these assemblages occur the grasses are the dominant species, though other species are present. An assemblage of the first type corresponds in part to the Desert Grassland natural community and an assemblage of the second type corresponds to portions of the Mountain Upland natural community. Each of these are special areas that need to be identified and managed appropriately (R. Felger).
- Big galleta grass (*Pleuraphis rigida*) and bunch grasses in general have been reduced from their historic distributions (P. Morrison).
- The grass component on the rocky slopes and bajadas of the Sand Tank Mountains needs to be conserved. This component is missing on Organ Pipe Cactus National Monument. *Pleuraphis mutica* occurs in the valley bottoms, *Muhlenbergia porteri* occurs on the creosotebush flats (but not in the valley bottoms).
- The mesa-top of Table Top Mountain is unique (includes a tobosa grassland) and should be identified/described separately from the Sand Tank Mountain Uplands community (R. Felger).
- Discussion covered how to include grass assemblages as a conservation element. Are they separately mappable units or should they simply be included as part of the natural community descriptions (for example, as part of the Mountain Upland community where they occur in the Sand Tank Mountains and on the Table Top Mountain mesa and in the Desert Grassland in the

- Vekol Valley)? Or should they be included as species-level conservation elements and be described by point-locations collected during Pacific Biodiversity Institute's (PBI) field work?
- Elroy Masters expressed his concern that we don't know why grasses are not present in some areas (if it is due to management or other factors such as soil and precipitation).
 - Lowland Sonoran Desert grasslands are extremely rare today, but may have been much more widespread in Arizona Upland valley floors prior to grazing. The SDNM is one of the few places where this habitat remains and where there is the opportunity for restoration (P. Rosen)

Decision.—Add as a species group conservation element (regionally vulnerable; grass species included are not individually rare, but as a group they tend to be missing components of Sonoran desertscrub communities). Use PBI point data to identify localities of greatest species richness and abundance. Work with PBI and other experts to determine what grass species should be include in the assemblage.

Ephemeral Water-Breeding Amphibian Guild

Findings.—

- Species included in discussion were: Sonoran Desert toad (*Bufo alvarius*), red-spotted toad (*Bufo punctatus*), Sonoran green toad (*Bufo retiformis*), Couch's spadefoot (*Scaphiopus couchii*), western narrow-mouthed toad (*Gastrophryne olivacea*), and lowland burrowing tree frog (*Pternohyala fodiens*).
- Phil Rosen had suggested prior to the workshop that the Great Plains toad (*Bufo cognatus*) should be added as part of the guild. Erik Enderson and Dale Turner agree that it should be added. The Great Plains toad occurs on the SDNM. Competitive interactions between this species and other members of the guild are possible. Like the Colorado River toad (*B. alvarius*), the Great Plains toad does well in permanent waters.

Decision.—Add *Bufo cognatus* to the guild.

Valley-Bottom Reptile Guild

Findings.—

- Species included in discussion were: western leaf-nosed snake (*Phyllorhynchus decurtatus perkinsi*), western shovel-nosed snake (*Chionactis occipitalis*), and Maricopa leaf-nosed snake (*Phyllorhynchus browni lucidus*). Additional species of significance that would be part of the guild, but have not yet been confirmed to occur on the SDNM include: Pima leaf-nosed snake (*Phyllorhynchus browni browni*), Tucson shovel-nosed snake (*Chionactis occipitalis klauberi*), and the ground snake (*Sonora semiannulata*).
- Dale Turner suggests that this guild isn't appropriate for the SDNM. The species are rarely seen and are difficult to find, and their habitat requirements are scarcely known. It would be difficult to assess their status.
- Rebecca Davidson relayed Roy Averill-Murray's written comments that stated that the conservation of this guild would also benefit desert tortoise through conservation of corridors used by tortoise for genetic interchange between mountain ranges.
- The guild may be of management value if it serves to prevent paving of roads (D. Turner).
- **Note:** Phil Rosen was not present during this discussion, but was consulted privately regarding these comments later in the workshop.

Decision.—Drop the guild from the list of conservation elements.

Post-workshop evaluation.—Add the Maricopa leaf-nosed snake (*Phyllorhynchus browni lucidus*) and Tucson shovel-nosed snake (*Chionactis occipitalis klauberi*) as individual species conservation elements based on their regional vulnerability and the importance of the SDNM for their conservation.

Red-backed Whiptail (*Aspidoscelis xanthonota* [= *Cnemidophorus xanthonotus* = *C. burti xanthonotus*])

Findings.—

- Recommended to be added as a conservation element.
- It is a rare species with a restricted distribution. It seems to occur within Pleistocene relict plant associations. Viable populations exist on the SDNM. Its taxonomy is unresolved and it may prove to be composed of several distinct races.
- The SDNM may be the best opportunity to protect the species. Other occurrences are on Organ Pipe Cactus National Monument and on the Tohono O’odham Reservation.
- Illegal collection is a threat.

Decision.—Add as a conservation element (regionally vulnerable).

Rufous-Winged Sparrow (*Aimophila carpalis*)

Findings.—

- Chosen as a conservation element because it is regionally vulnerable, but insufficient data exists to determine whether the SDNM has sufficient populations or habitat for this species (not many Arizona Breeding Bird Atlas blocks were sampled in appropriate habitat on the SDNM, such as in the Vekol Valley).
- Rufous-winged sparrows would be expected to occur on the lower rocky bajada slopes in association with grasses, in the former Area A, and in the Vekol Valley (T. Tibbitts).

Decision.—Keep as a conservation element (specialized species, regionally vulnerable).

Cactus Ferruginous Pygmy-Owl (*Glaucidium brasilianum cactorum*)

Findings.—

- Did not discuss in terms of fine-filter criteria. Workshop participants determined that it will remain a conservation element.
- Monument includes potential reintroduction (recovery) habitat.

Decision.—Keep as a conservation element (regionally vulnerable, federal listed as Endangered).

Le Conte’s Thrasher (*Toxostoma lecontei*)

Findings.—

- Chosen as a conservation element because it is regionally vulnerable, but data were insufficient to determine the relative importance of the SDNM for conservation of this species.
- Occurs in the Vekol Valley and in the eastern portion of the BMGR (B. Wirt).
- Prior to designation of the SDNM, Troy Corman relayed information on this species to Rob Marshall. He commented that Le Conte’s thrasher is hard to find (so may be under-represented in the Arizona Breeding Bird Atlas dataset), and the monument is near the northeastern edge of its distribution. The SDNM is an important area for Le Conte’s thrasher because it includes some genetic diversity found within its distribution (R. Marshall).

- This species is an associate of the valley bottoms. The community (coarse filter) approach might not capture its needs because Le Conte's thrasher has shifted its habitat use from areas that were saltbush (*Atriplex polycarpa*) to Creosotebush-Bursage Desert Scrub (R. Marshall and J. Hall).

Decision.—Keep as a conservation element (specialized species, regionally vulnerable).

Primary Cavity (Excavator) Guild

Findings.—

- Species included in the discussion as part of the guild were: gilded flicker (*Colaptes chrysoides*), Gila woodpecker (*Melanerpes uropygialis*), and ladder-backed woodpecker (*Picoides scalaris*).
- Tim Tibbitts recommended adding northern flicker to the guild. It occurs on the SDNM and creates cavities in saguaros that it uses as nest sites. The monument potentially falls within the interbreeding zone between gilded and northern flickers.

Decision.—Evaluate northern flicker occurrence on the SDNM.

Post-workshop evaluation.—Not added as a conservation element within the guild. Northern flicker was not found in any Arizona Breeding Bird Atlas (BBA) survey blocks within the monument or near its boundaries, and the species was found in only 5 out of 59 BBA blocks in the Sonoran Desert. The zone of hybridization between northern and gilded flickers is north and east of the SDNM, so it is unlikely that northern flickers are breeding in the vicinity of the monument.

Desert Bighorn Sheep (Ovis canadensis mexicana)

Findings.—

- Information on movement corridors is important in the assessment of desert bighorn sheep and is not shown on the maps presented at the workshop.
- The population on Table Top Mountain may be moving on and off the Tohono O'odham Nation, as seen in population fluxes in the area (D. Urquidez).

Decision.—Keep as a conservation element (area-dependent, regionally vulnerable).

Kit Fox (Vulpes macrotis)

Findings.—

- Chosen as a conservation element because it may be regionally vulnerable (subspecies in California is federal and state-listed Endangered; found in valley bottoms that are subject to development). It also digs many burrows that are used by numerous other species.
- Bob Henry suggested that you could monitor abundance/important areas for kit fox by locating fox burrows in aerial surveys (R. Engel).
- Discussion of addition of a burrowing mammal guild instead of kit fox. *Dipodomys* and *Neotoma* species are more important than kit fox and other species for providing burrows and for impacts on plants (S. Rutman).
- Discussion covered the role of BLM to manage kit fox populations on the SDNM if the species is vulnerable outside its boundaries.

Decision.—Evaluate regional vulnerability of kit fox with additional experts.

Post-workshop evaluation.—Not added as a conservation element. The evidence was inconclusive and a lack of consensus occurred among the experts consulted and the literature that the kit fox met any of the characteristics to be considered: (1) regionally vulnerable, (2) keystone species, or (3) area-sensitive species.

Bat Guild

Findings.—

- Species included in discussion as part of the guild were: lesser long-nosed bat (*Leptonycteris curasoae yerbabuenae*), California leaf-nosed bat (*Macrotus californicus*), and cave myotis (*Myotis velifer*).
- Lesser long-nosed bat roosts are not recorded from the SDNM, but BLM must address potential foraging habitat within an 80-kilometer (50-mile) radius of known roosts (E. Masters).

Decision.—Keep guild as a conservation element (specialized species, guild includes the lesser long-nosed bat, which is federal listed as Endangered).

White-Tailed Deer (*Odocoileus virginianus couesi*)

Findings.—

- Recommended by Dan Urquidez as a conservation element.
- The population in the Sand Tank Mountains is at the edge of its range in Arizona Upland habitat.

Decision.—Requires further evaluation against fine-filter criteria.

Post-workshop evaluation.—We continued to evaluate/discuss with BLM whether to add white-tailed deer as a conservation element based on fine-filter criteria. Additional information on white-tailed deer was acquired in conversations with Dan Urquidez and Bob Henry (AGFD). The main points are noted here. The population of white-tailed deer in the Sand Tank Mountains is isolated from the main core population in southeastern and central Arizona where they are found at higher elevations in oak woodlands and grasslands. Within the Sonoran Desert white-tailed deer are scattered on the Tohono O'odham Nation (Baboquivari Mountains) and in the Ajo, Sand Tank, and Saucedo Mountains. White-tailed deer populations are small in the Sonoran Desert and are decreasing (based on sightings during desert bighorn sheep surveys, a high of 16 deer were seen in 1992, five were seen in 1995, and none were seen in 1998 and 2001—though it is expected that they remain albeit in small numbers). The Sonoran Desert populations of white-tailed deer are unique in that they occur on desert mountaintops, they are isolated, and population sizes are small. These populations are at risk to local extinction. Movement corridors and locations of source populations are not known. Highways are not as much a barrier to white-tailed deer movement as they are to other animals, but this has not been studied. Any activity or event that alters existing vegetation is a potential threat to white-tailed deer. The AGFD has proposed wildlife waters in the Sand Tank Mountains specifically targeted for white-tailed deer. We decided not to add white-tailed deer as a conservation because the subspecies is widespread and is not regionally vulnerable throughout its range.

E.2.2 Presentations

Presentations were given by:

- Anne Gondor, The Nature Conservancy. Anne presented preliminary analyses and maps that display the spatial distribution of two potential threats to conservation elements: roads and livestock grazing.
- Nina Chambers, Sonoran Institute. Nina presented information on socioeconomic and development trends in the communities surrounding the SDNM.
- Pam Foti and Chuck Patterson, Northern Arizona University. Pam and Chuck presented their preliminary findings of their study on recreational impacts on the SDNM.
- Peter Morrison, Pacific Biodiversity Institute. Peter presented his work on mapping the natural communities on the SDNM, as well as preliminary results of his ongoing work in Phase 2 of the project: an ecological condition assessment for each of the natural communities and a non-native plant assessment.

The main points from the presentations and important discussion points that ensued are summarized below.

Road Density and Potential Zone of Influence of Cattle Grazing (Anne Gondor)

Road density.—

- A road density map was produced using data from BLM route inventory, the BMGR inventory, and ESRI Streets data. This is a preliminary analysis that is meant to show the types of spatial analyses that could be done to evaluate stresses. This analysis considers the physical presence of roads and routes as a stress (habitat fragmentation). It does not take into account the type of road or its level of use. Results draw attention to areas bordering the monument with high road densities.
- A source of error is overlapping roads/routes (which Anne tried to minimize but some may remain, which would result in road densities that appear greater than what exists). Peter Morrison found that the BLM route inventory has some inaccuracies. BLM staff was interested to know what inaccuracies were found. The BMGR inventory was done earlier than the route inventory for BLM.
- Peter Morrison emphasized that use level and type of road surface is important information to have (these were not included in the analysis). Sue Rutman recommended Arizona Department of Transportation (ADOT) as a source for determining volume and type of use of major routes.

Potential grazing impacts.—

- A map was produced that showed points of congregation of cattle: tanks, troughs, unfenced reservoirs, corrals, etc. (data sources are BLM grazing improvements and Arizona Department of Water Resources). These points were buffered (1 km, 3 km, and 5 km) to show a potential zone of influence of cattle, based on movement distances away from the point. This analysis is preliminary and simplified. It assumes equal cattle access across all points on the landscape. For example, the buffer distance around each point is the same, independent of adjacent landform, slope and natural community type even though cattle do not exert the same influence on steep, rocky slopes as on valley bottoms and dry washes. The vast majority of land on the SDNM is within the 5 kilometer buffer.
- The analysis assumes that the grazing improvements are all currently active. Gene Dahlem notes that some of the waters on the map are no longer active. The ADWR tanks are those whose rights have been filed. Dale Turner noted that some existing tanks are missing from the map.
- This analysis highlighted the need and importance of an up-to-date spatial layer on waters and grazing improvements for the SDNM.

Socioeconomic Condition and Trends in Counties and Communities Adjacent to the SDNM (Nina Chambers)

- Nina provided the group with a summary of the attributes of the communities surrounding the monument. Sonoran Institute is compiling information aggregated by county (Maricopa, Pinal, Pima) and by community (Buckeye, Casa Grande, Gila Bend, Maricopa, Phoenix, Ajo, Globe, Marana, Sells, Tucson, and Yuma) to evaluate socioeconomic conditions and trends that may affect the SDNM. Data include information on demographics, education, employment, income, housing, and commuting.
- Census data reveal different patterns of growth in the communities surrounding the SDNM. On the western side (for example, Ajo, Sells, and Gila Bend), economic growth is not great, the communities are poor, and they have a low education attainment. These communities are growing slowly and are looking for development that assists their labor-based economies (for example, power plants in Gila Bend). North of the SDNM (for example, Buckeye) communities have a strong agricultural base that may buffer the monument from urban development; however, they are growing rapidly and have a large area of land that could be developed. The Interstate 10 corridor to the east of the SDNM represents an area with a stable economic base, rapid growth, and urbanization pressures.
- The next steps will be (1) to run a series of community meetings in which the Sonoran Institute will members of the communities how they plan/expect to grow and (2) to analyze how these predicted growth trends relate to the stresses on the conservation elements.
- Dale Turner suggested looking at county parcel data to evaluate subdivided land and future growth areas. The agricultural buffer on the north end of the SDNM may already be subdivided. Maricopa county has digital parcel data available.
- The area north of Table Top Mountain is already heavily subdivided. The north Vekol Valley has 172 hectares (430 acres) for sale with a 600 unit development planned (P. Morrison).
- Simulation software is a powerful tool that can be used to integrate land use and demographic data, to visualize population growth, and to identify potential impact pathways (National Aeronautic and Space Administration work with BLM out of Prescott College is an example of such software development; R. Winthrop).
- The SDNM has one of the last remaining intact underground water systems (R. Felger). The Vekol Valley Wash is tapped but is not being used. How likely is this to change with population growth? What are the potential impacts on the natural communities?

Recreation Impact Assessment (Pam Foti and Chuck Patterson)

- Variables inventoried include (not a complete list) the presence/absence of: campsites, social trails, campfire evidence, litter, trash dumping, damage to saguaros/other cacti/trees/shrubs, all-terrain vehicles (ATV)/off-highway vehicles (OHV) impacts, shooting impacts, evidence of livestock use/packstock use, human-caused site erosion, human-caused streambank impacts, biological soil crust impacts, and desert pavement impacts.
- This work does not evaluate the timing of use or number/type of users. Evaluators look directly at on-the-ground impacts.
- Impacts that have been seen on the SDNM include vehicle use off road, social trails, trash, dumping (brush, non-native vegetation, construction materials, concrete, furniture), cluster campsites (large camping areas for families/groups of 50 or more sites), shooting ranges, dump areas (associated with OHV use and camping), smuggling/illegal use impacts along the Vekol Valley road to the Vekol Valley Grassland Area of Critical Environmental Concern.
- Areas with the greatest impacts are associated with main highways and transportation network (Interstate 8, Route 238, Vekol Valley Road, and Pipeline Road). Areas of high impact include

the Butterfield Stage Route, Margee's cove, the west end of the Maricopas, the Vekol Valley, and train-spotting sites.

- Areas farther from the interstate corridor and main highways have fewer impacts. Impacts in the former Area A are those related more to the pristine camping experience. This area requires a permit for entry, is gated, and sees minimal use. North of the SDNM (outside the monument boundary) fewer impacts occur—access is via unmaintained roads, drainages, and washes.
- Next steps are to enter data into a database, develop GIS layers, and archive photos.
- Peak time of use is hunting season, and use drops off in hot summer months (S. Rutman).

Natural Community Mapping and Condition Assessment on the SDNM (Peter Morrison)

Description of Phase 1.—Natural community mapping and initial characterization.

- Ten natural communities mapped on SDNM include: Creosotebush-Bursage Desert Scrub, Paloverde-Mixed Cacti-Mixed Scrub on Bajadas, Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes, Mountain Upland, Desert Grassland, Valley Xeroriparian Scrub, Mountain Xeroriparian Scrub, Mesquite Bosque, Braided Channel Floodplain, Rock Outcrop. Developed/disturbed areas also were mapped.
- Hydrology layers that are available for the area (used to map xeroriparian scrub communities) are at 1:100,000 scale. Peter estimates that this underestimates xeroriparian scrub by 3 to 10 times.
- Gene Dahlem noted that OHV use will be a management priority of the SDNM Resource Management Plan, so the inadequacies of xeroriparian mapping should be explained. Peter thought that many of these smaller washes are not easily navigated by OHVs.

Description of Phase 2.—Condition assessment of natural communities, invasive plant assessment and refinement of natural community mapping and characterization.

- Assessments will be done at both a coarse and fine scale. The coarse-scale analysis will include landscape-scale aerial photography and remote sensing imagery, including historical imagery. At the fine scale, PBI is conducting field-based assessments at selected sites across the SDNM that represent each natural community across its natural variation (environmental gradients and geographic areas) and across disturbance gradients.
- Sampling methods include sampling along a disturbance gradient: such as taking a single disturbance source (for example, cattle tank) and laying plots out along a transect, all within the same natural community, at different distances from that disturbance source. Dale Turner suggested placing the transect in such a way that you track the disturbance gradient across a single landform.
- Preliminary observations on patterns of non-native species distributions do not show a high correlation with roads, except for major (paved) roads (Interstate 8, Route 238). Sue Rutman agrees that the SDNM is “floristically pure” and invasive non-native plants are just beginning to explode.
- Pacific Biodiversity Institute found a high diversity of non-native species on Interstate 8, with potential for spread from the roadside into natural areas. Richard Felger noted that Interstate 8 has been well-sampled for non-native plants and that Peter's work is not likely to have found new species.
- Blading roadsides appears to be an effective way to manage invasive non-native plants found on roadsides. Sue Rutman noted that the west side of Route 238 (Maricopa Road) was recently bladed and this resulted in removal of invasive non-native plants. The eastern portion of Route 238 (managed by ADOT) was not bladed and still has these species present.
- A major source of invasive non-native plants is Highway 85 (S. Rutman). Pacific Biodiversity Institute is not sampling this area. Arizona Department of Transportation and Southwest Exotic Plant Mapping Program (SWEMP) may have additional data on invasive non-native species presence on interstates.

- Peter mentioned additional disturbance elements and stressors to the natural communities, including: levels of grazing pressure, vehicles on highways and roads, hydrological alteration, vehicle use off road, mining, recreation, altered fire regimes, climate change, and air pollution from urban areas.

E.2.3 Stresses and Sources of Stress

The Nature Conservancy provided a handout with definitions and examples of stresses and sources of stress. The workshop participants then discussed stresses to the conservation elements, the sources of stress (including both historic and current sources), the severity of the stress, and the geographic scope of the impact of the stress (including stresses that have either a local or regional impact).

Stresses and sources of stress were discussed for the following conservation elements:

- desert tortoise
- primary excavator (cavity) guild
- desert bighorn sheep
- ephemeral water-breeding amphibian guild
- cave/mine-roosting bat guild.

The main findings and discussion points on stresses and their sources are found in Table E.1.

Pervasive threats—those that are not specific to a particular conservation element—also were discussed in the workshop. These include the following:

Migrants: Undocumented Immigrants and Drug Smugglers

Migrant traffic includes effects of both undocumented immigrants and drug smuggling activities. Bureau of Land Management planning should address these activities as they occur on the SDNM.

Communication with Border Patrol is important, but once they are involved BLM will have less control over management (T. Tibbitts). Impacts of migrants include: reduced personal safety, trash, off-road pursuits, creation of new roads, starting wildland fires, presence of lookouts on ridge tops (potential disturbance of desert bighorn sheep and/or their habitat), and camping in mines. Migrants are moving north of Interstate 8 and east of Table Top Mountain. Areas affected on the SDNM include: Vekol Wash and Vekol Valley Road, Maricopa Mountains, and Antelope wash. In addition, east of the former Area A and south of I-8 are major impact areas for Creosotebush-Bursage Desert Scrub and Paloverde-Mixed Cacti-Mixed Scrub on Bajadas (G. Dahlem and P. Morrison).

Mega Drought

Research by Julio Betancourt (U.S. Geological Survey) suggests that we may be entering an extended period of drought that could have far-reaching consequences for existing natural communities.

Buffelgrass (*Pennisetum ciliare*) and Fountain Grass (*P. setaceum*)

The spread of these two invasive non-native species has the potential to dramatically alter existing natural communities by adding fine fuels sufficient to carry fire in Sonoran Desert ecological systems that are not adapted to fire.

TABLE E.1 Stresses and Sources of Stress to Conservation Elements

Conservation Element	Stress	Severity of Stress	Geographic Scope of Impact: Local or Regional	Source of Stress	Comments/Sources
Desert tortoise	Altered/disturbed habitat	Low probability of occurrence	Espanto and Maricopa Mountains	Illegal collection of boulders for landscaping	B. Wirt, G. Dahlem, D. Urquidez
	Altered composition; road development			Road kill on paved and unpaved roads, including by off-road vehicle traffic	B. Wirt, P. Morrison
	Altered composition; excessive predation		B. Wirt placed landfills on map; areas where undocumented immigrant (UDI) traffic is heavy	Raven predation	B. Wirt; undocumented immigrants increase trash along trails and campsites, which leads to increases in raven abundance and more predation (T. Tibbitts; source: observed and unpublished data on ORPI).
	Resource competition	Unknown on SDNM	Documented in Mojave Desert (regional stress)	Competition for forage with cattle	D. Turner
	Respiratory disease	No evidence yet, but could occur in future	Espanto Mountains should be watched for respiratory disease	Area of high human impacts	B. Wirt
	Potential fragmentation		Rainbow Valley		Future development (habitat conversion) could remove this dispersal corridor.
Primary excavator (cavity) guild	Resource competition	Low with the potential to increase with growth, development and agriculture	Johnson well, Perimeter of SDNM	European starlings (outcompete for nest sites/cavities)	Lots of starling habitat in area, including urban areas, yet are found in the middle of the SDNM (T. Tibbitts).
	Habitat loss/degradation		High use recreation areas (Pipeline Road and Butterfield Pass)	Recreational shooting of saguaro; saguaro collection	C. Patterson; S. Rutman

TABLE E.1 Stresses and Sources of Stress to Conservation Elements—continued

Conservation Element	Stress	Severity of Stress	Geographic Scope of Impact: Local or Regional	Source of Stress	Comments/Sources
Primary excavator (cavity) guild—continued	Habitat alteration			Any factor that may affect saguaro recruitment and demographics	Need to monitor saguaro recruitment and demographics (S. Rutman).
	Behavioral alteration	Questionable/low	Interstate 8 corridor	Interstate traffic noise	P. Morrison (group questioned validity of this stress and placed it as low priority)
Desert bighorn sheep	Harvesting/Poaching	Slight		Permitting process revised every 3 years	P. Morrison suggested this as a stress, and D. Urquidez discussed permitting process. D. Urquidez doesn't think poaching is a problem, as it is not economical
	Climate change			Drought	D. Urquidez and R. Engel thought that Kofa population is doing better than on SDNM because more water sources (including wildlife waters) are available to sheep in the Kofas.
	Habitat fragmentation	Major factor	Along major highways: Interstate 8, Highway 85, Route 238, Rainbow Valley, former Area A fence	Roads; fences	R. Engel; B. Wirt; R. Felger; D. Urquidez
	Resource competition	Unknown/questionable		Cattle	P. Morrison suggested this threat competition with cattle, but disagreement about this existed within the group. D. Urquidez, R. Engel, and E. Masters disagreed. D. Urquidez stated that it isn't possible to identify desert bighorn sheep presence from scat.
	Behavioral/physiological changes	Slight possibility		Recreation, especially people with their dogs; urban growth	B. Wirt; D. Urquidez
	Disease	Slight		Domestic goats and sheep of private land owners (BLM doesn't allow grazing of goats)	D. Urquidez; R. Engel

TABLE E.1 Stresses and Sources of Stress to Conservation Elements—continued

Conservation Element	Stress	Severity of Stress	Geographic Scope of Impact: Local or Regional	Source of Stress	Comments/Sources
Ephemeral water-breeding amphibian guild	Excessive competition for resources (effect on <i>Gastrophryne olivacea</i> , <i>Pternohyla fodiens</i> and <i>Bufo retiformis</i>);v altered composition (abundance)	Slight	Vekol Valley	<i>Bufo cognatus</i> and <i>B. alvarius</i> Competition for resources due to semi-/permanent water sources	<i>B. cognatus</i> can breed before others and outcompete other native anurans in semi-/permanent waters (E. Enderson, conjecture). The relationship between hydroperiod and species composition/competition is dynamic and not well understood (P. Rosen). Question of maintaining spreader dikes (check dams, levees, berms) for native species after grazing terminates in 2008. These spreader dikes are impacting plant communities as well as the amphibians. The decision to maintain them (or eliminate them) will not be in the SDNM resource Management Plan (G. Dahlem).
	Resource competition	Low/slight	Gila River and stock tank northeast of SDNM have non-native amphibian species; possibility for them to move into the SDNM	Non-native Rio Grande leopard frog in Gila River	Rio Grand Leopard frog takes over perennial water (P. Rosen).
	Altered hydrology	Unknown. Would not take effect until termination of grazing (2008).	Vekol Valley bermed areas	If spreader dikes are not maintained, sedimentation will fill in ponds behind berms and will change the hydroperiod of water collection areas.	The effects of removal (or lack of maintenance) of the spreader dikes are unknown. Further analysis needed with experts to display structure of berms and patterns of sedimentation. Spreader dikes are elegant archeological sites (R. Felger). Ak-Chin farming sites provide examples for restoration approaches (B. Wirt, R. Felger). S. Rutman found that this was not successful on Organ Pipe Cactus National Monument (OPRI). R. Felger replied that they need maintenance to function properly.

TABLE E.1 Stresses and Sources of Stress to Conservation Elements—continued

Conservation Element	Stress	Severity of Stress	Geographic Scope of Impact: Local or Regional	Source of Stress	Comments/Sources
Ephemeral water-breeding amphibian guild—continued			Areas important for conservation: Vekol Valley		E. Enderson doesn't think the Heritage Data Management System occurrence points are accurate/current for areas outside the Vekol Valley. Additional surveys are needed. D. Urquidez found <i>B. retiformis</i> and <i>G. olivacea</i> at Big Tank, off a tributary just north of Vekol Wash (outside the SDNM boundary).
	Collection/ altered composition (abundance)			Collection of <i>Bufo retiformis</i>	The SDNM is the only place that one can collect without detection. Worth \$60/individual in the trade (E. Enderson).
Bat guild	Behavior/ physiology changes		Sand Tank mine	Human disturbance at roost sites	This mine should be gated to prevent disturbance (D. Dalton).
			Other areas to survey for lesser long-nosed bats: open tinajas (preferably without roofing); Vekol Valley, and Bender Spring		Information needs: recommend surveying other areas for roosts and mist netting at tinajas on the SDNM, especially for lesser long-nosed bats. Light-tagging studies didn't find lesser long-nosed bats on SDNM but these were tagged at Copper Mountain on ORPI, so these individuals likely didn't make it to the former Area A (T. Tibbitts). BLM must address potential foraging habitat (for lesser long-nosed bats) within a 50-mile radius of roosts (E. Masters).
	Unknown	Limited		Geocaching not a threat to bats; recreational mining	G. Dahlem; K. Kelleher disagrees and considers geocaching a potential future threat; currently there are two sites on SDNM.

Population Growth

In addition to the trends that Nina Chambers discussed in her presentation on communities surrounding the SDNM, Gila Bend is expected to increase in population by 10 times with the subdivision of the Paloma Ranch site (a site where mountain plover occur; B. Wirt).

Noise

Consistent noise from Interstate 8 has an effect on wildlife (P. Morrison). Participants did not reach a consensus on this comment. Research on the BMGR did not show an effect of low-altitude overflights on wildlife species (D. Urquidez).

Inappropriate Road Use and Development

Sue Rutman discussed the need to evaluate the current route/road inventory in terms of which roads are most appropriate for increased use. Road placement is key to maintaining natural communities. On Organ Pipe Cactus National Monument (ORPI), many roads that are currently used were old mining and ranging roads and were not created to handle the level and intensity that result from current uses. Roads on Pleistocene surfaces (including desert pavements) are fragile and turn to “moon dust”, which causes people to drive around and create new tracks. On ORPI braided channel floodplains are severely impacted, roads are turning into washes, and washes are turning into roads. She urged the BLM to be open-minded about road placement and perhaps consider creating new roads.