AN ECOLOGICAL ASSESSMENT OF THE BUREAU OF LAND MANAGEMENT'S CURRENT FIRE MANAGEMENT PLANS: Materials and Recommendations for Future Fire Planning

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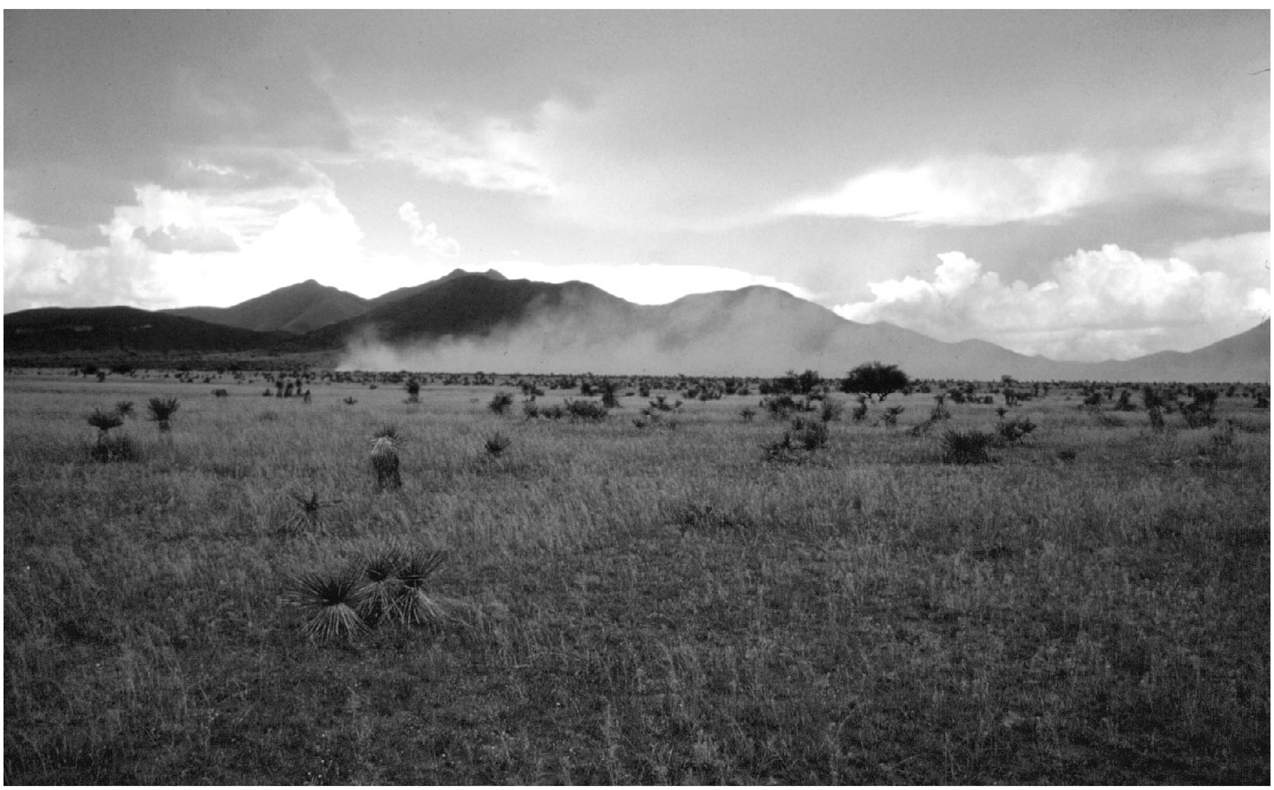

Grassland wildfire north of the Huachuca Mountains, AZ   Photo: P. Warren

The Nature Conservancy

SAVING THE LAST GREAT PLACES ON EARTH

EXECUTIVE SUMMARY

The Nature Conservancy entered into an agreement with the Bureau of Land Management (BLM) to review BLM's fire management plans statewide from an ecological perspective. The primary objectives of this work were to: (1) assess the accuracy, standardization, and ecological relevance of current Phase I fire management polygons and their fire prescriptions and (2) make recommendation for revising these polygons and prescriptions based on fire ecology and other considerations.

We reviewed current fire management plans for the 7 BLM field offices and found several areas where enhancements were warranted. To address a significant data gap we undertook a statewide assessment of grasslands, a major vegetation type managed by BLM. The primary objective of the assessment was to characterize the condition of BLM grasslands relative to their suitability for management with fire because fire is a primary tool for reducing shrubs and increasing perennial grass cover in native grasslands.

We used an expert-based approach interviewing 39 range management specialists from the Forest Service (USFS), Natural Resources Conservation Service, Bureau of Land Management (BLM), University of Arizona, Arizona State Land Department and The Nature Conservancy. Expert input was verified and corrected where necessary through extensive field reconnaissance and quantitative vegetation sampling at random sampling points. The accuracy of expert input was estimated at 74% and the final grassland map presumably exceeds this due to adjustments made during field work.

Six grassland types were identified including native grassland with low shrub cover, shrub-encroached native grassland with restoration potential using fire, non-native grassland, and former grassland that has undergone a type conversion from grassland to shrub land. BLM manages over 2,788,000 acres of current or former grassland in Arizona or 11% of these grasslands statewide. Vegetation changes in grasslands have been extensive. Native grassland with low shrub cover now are found only on 5,201,000 acres comprising 31% of current and former grasslands in the state. An additional, 5,656,000 acres of native grassland are shrub-encroached but restorable using fire; this represents 34% of current and former grasslands. However, shrub cover has exceeded a threshold of 35-40% on over 3,694,000 acres of historic (or former) grassland, producing a type conversion from grassland to shrubland. This corresponds to a 22% loss of grasslands to shrub encroachment statewide over the last 100-130 years. Non-native grasslands dominated by Lehmann lovegrass (*Eragrostis lehmanniana*) now cover 1,456,000 acres or 9% of current and former grasslands.

BLM manages over 1.4 million acres of open native and shrub-encroached but restorable native grasslands statewide or 13% of these grassland types. Thus, there is a significant opportunity for BLM to become statewide leaders in the management and restoration of grasslands using fire. Restoring grasslands with fire will prevent further loss of grasslands to shrub encroachment. However, restoring fire to grasslands will require some significant changes in grazing management on BLM land. Approximately, 56% of grasslands will need more than 3 growing seasons of rest before they can be burned and

43% will need more than 5 growing seasons. An estimated 29% of grasslands now have < 10% perennial grass cover; these areas likely will require much more lengthy periods of rest (e.g., 10-50 years) in order to restore the grass component. Finally, the statewide grassland assessment enabled us to make recommendations on fire management priorities in grasslands and resulted in a large dataset of field measurements and photo-points that may be useful to the BLM in monitoring the effect of fire management, grazing management and other actions.

We also conducted an analysis of fire occurrence data from 1980-2002 to determine where fires were occurring on the landscape and in what vegetation types. There were 3,617 Type 1 fires, burning a total of 450,020 acres on BLM land over the 22-year period. Most fires were small (median size: 0.4 acres) and the majority (67%) occurred in fire-adapted communities; among larger fires, 86% were in fire-adapted communities. These results demonstrate BLM's ability to effectively manage wildland fires and suggest that expanded wildland fire use by the BLM for resource benefit is warranted.

Current fire management plans lack information on fire ecology and they establish acreage targets for prescribed and wildland fire that result in longer fire return intervals than historically occurred in these fire-adapted vegetation communities. We developed a historic fire regime map for the vegetation communities in Arizona to assist BLM in making fire prescriptions that are ecologically relevant. We also compiled a fire literature bibliography on the effects of fire on the major vegetation communities and selected wildlife in Arizona. The bibliography contains citation information and complete abstracts for most of the 313 entries.

To assist BLM in the next round of fire management planning, we produced two additional deliverables. The first was a state-and-transition model for the Great Basin Transition Zone (GBTZ) vegetation, a mix of grassland, pinyon-juniper woodland, and sagebrush steppe. Using the model and Vegetation Dynamics Development Tool (VDDT) software, we investigated the effect on vegetation of changing from the historic to the current fire regime (i.e., fire suppression). Under the historic fire regime, the majority of GBTZ vegetation was open grassland (43%) with most of the remaining vegetation in open grass-sagebrush or open grass-pinyon-juniper (47%); there was little vegetation in closed canopy pinyon-juniper or sagebrush steppe. These vegetation percentages differed greatly from those obtained under the current fire regime. In this case, closed canopy pinyon-juniper was the dominant vegetation type (57%) and there was little open grassland (1%). These results suggest that pinyon-juniper woodland and sagebrush communities have increased at the expense of open grassland due to the last 120 years of fire suppression, a conclusion that is consistent with our grassland assessment. The second deliverable was a revised Wildland Urban Interface (WUI) layer for the state; this was developed using an expert's approach and on-the-ground knowledge of BLM staff.

Using the Federal Wildland Fire Management Policy (BLM 1995) for guidance, we revised existing Phase I polygon boundaries and designations using a hierarchical approach with 3 factors: (1) vegetation type and fire ecology, including current and historic vegetation structure and composition, current fuel loads and fire behavior, historic fire return intervals and endangered species concerns; (2) social and political concerns, including WUI areas and livestock management concerns; and (3) land ownership pattern. We believe that these revisions are more consistent with the best available information on fire ecology, consider BLM's demonstrated effectiveness in managing wildland fire; are in-line with current federal guidance on fire management, and give BLM greater flexibility in employing a range of fire management tools including wildland fire use. The result of these revisions was to decrease the percent acres in Category A from 73% in current plans to 52% primarily by re-classifying fire-adapted vegetation without WUI concerns, and in Category B from 7% to 3%. The largest change occurred in Category C, where wildland fire is desired but there are significant constraints to its use; the current plans designated only 13.7% of acres as Category C compared to 37% in our revised scheme. Finally, percent acres in Category D increased from 6% in current plans to 8% in our recommended revisions. Although only a small percentage increase, the location of the revised Category D has changed substantially and, if adopted, will result in significantly greater wildland fire use for resource benefits.

ACKNOWLEDGEMENTS

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* Denotes individuals who were integral in setting up and facilitating field office meetings.

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SECTION 1: INTRODUCTION

The Nature Conservancy entered into a Task Order agreement with the Bureau of Land Management (BLM) to review BLM's fire management plans statewide from an ecological perspective. The primary objectives of this work were to:

- assess the accuracy, standardization, and ecological relevance of current Phase I fire management polygons and their fire management prescriptions;
- develop an ecologically based approach to Phase I polygon designation; and
- using this approach, make recommendations for revising current Phase I polygon designations and their management prescriptions based on fire ecology and other considerations.

While Phase I polygon designations are no longer required for BLM's fire management plans, they still have great value in providing broad-scale direction for how fire is to be managed based on fire ecology, current vegetation condition, and other mitigating factors.

To the preceding objectives, we added another that was not specifically identified in the Task Order; this was to:

- develop spatial and non-spatial information that would assist BLM in improving the ecological relevance of the next round of fire management plans.

Toward this end, we met with BLM staff from the 7 field offices between March and May, 2003. These meetings were well attended and included fire management officers, fuels specialists, fire ecologists, wildlife biologists, range management specialists, NEPA planners, archaeologists, and GIS specialists. A primary goal of these meetings was to solicit staff input on data needs that would be useful in fire management planning. These information requests fell into four main categories; 1) data information needs, 2) spatial information needs, 3) literature information needs, and 4) other analyses.

The "data information needs" require the collection of new field data regarding the effect of fire on a variety of vegetation types and wildlife. The "spatial information needs" also require the collection of new data, however, it is in the form of spatially mapping the location and/or distribution of vegetation communities, exotic plant species, and Wildland Urban Interface (WUI) areas. The "literature information needs" were a call for access to the most up-to-date scientific information on the effects of fire on a variety of vegetation communities and wildlife, as well as information regarding the control and restoration of exotic plant species. Finally, the "other analyses" category includes additional field office requests that ranged from broad general needs to the compilation of information from a single individual expert on a topic. For a detailed list of information requests by field office, see Appendix A.

We incorporated a number of the "spatial information" and "literature information" needs that were most in line with our Task Order responsibilities into the scope of our project. This included a revision of the WUI risk layer developed by the State Office (see below) as well as the compilation of a fire literature bibliography focused on the effects of fire on the major vegetation communities and selected wildlife in Arizona.

We also reviewed current fire management plans and identified several shortfalls; these included:

- a lack of information about historic fire regimes and fire ecology for the major vegetation types that BLM manages;
- fire management prescriptions for Phase I polygons that resulted in fire return intervals for a variety of vegetation communities that were inconsistent with the historic (ecological) fire regime;
- no analysis of past wildfire occurrences to determine how many, how large, and where they occurred on the landscape;
- absence of a regional perspective on the extent and condition of grasslands, a major vegetation type managed by BLM; and
- lack of a prioritization scheme that identified sites in greatest need of fire management.

To address these needs, we undertook a statewide grassland assessment, building on an earlier effort that characterized the spatial extent and condition of grasslands in southern Arizona, southwestern New Mexico and northern Mexico (Gori & Enquist 2003). The expanded assessment enabled us to recommend priorities for fire management in grasslands and provided a large dataset of field measurements and photo-points that may be useful to the BLM in monitoring the effect of fire management, grazing management and other actions. We also conducted an analysis of fire occurrence data from 1980 to 2002 and created a historic fire regime map for the vegetation communities in Arizona (to assist in setting ecologically relevant fire management prescriptions).

While all of the preceding information will be useful to BLM, there was one deliverable that we created specifically to aid the Arizona Strip field office in the fire management planning process. This was a VDDT state-and-transition model for the Great Basin Transition Zone vegetation, a mix of several vegetation communities including Great Basin grassland, pinyon-juniper woodland and sagebrush steppe. We conducted several model runs and present one here that demonstrates the effects of current (fire suppression) vs. historic fire regimes on the vegetation. We hope this model will be useful to BLM staff and the public as a graphic representation of current and possible future vegetation conditions and as a tool for setting management goals and prescriptions to achieve desired conditions.

The following sections describe in detail the methodology, results, and conclusions for all of the assessments, analyses, and created or compiled information described above. In addition, in Section 5 we propose an ecologically based approach to Phase I polygon designation. This final section is a synthesis of all the above-mentioned information in the form of our recommended Phase I polygon revisions (another spatial layer). It is important to point out that all of the materials that we have developed including our proposed approach to Phase I polygon designation can be applied to Fire Management Units to ensure that their fire management prescriptions are ecologically relevant. (Fire

Management Units will replace Phase I polygons, Fire Management Zones and Representative Locations as the basic unit for fire management in the new Interagency Fire Management Plan.)

SECTION 2: ANALYSES

Statewide Grassland Assessment and Analyses

Introduction

Grasslands in Arizona have undergone dramatic vegetation changes over the last 130 years including encroachment by shrubs, loss of perennial grasses, and spread of non-native species (Humphrey 1963, 1987; Bahre 1991). These changes in grassland composition and structure have not occurred uniformly across the state and their extent and distribution is poorly understood at a regional scale. Moreover, these changes are dynamic and ongoing (Brown et al. 1997; Kepner et al. 2000). The purpose of this study was to rapidly assess and characterize the extent of the vegetation changes to grasslands and to identify the best remaining native grasslands and restorable grasslands for ecological management purposes. This information is particularly important for fire management because fire is a primary tool for reducing shrubs and increasing perennial grass cover in grasslands (McPherson 1995; Brunson et al. 2001). Furthermore, fire may affect the competitive dynamics of native and exotic grasses, potentially encouraging the spread of exotics at the expense of natives under certain circumstances (Robinett 1994). Identifying the best remaining native and restorable grasslands will assist the Bureau of Land Management (BLM) in prioritizing grassland areas for fire management and restoration. In addition, the assessment provides information relevant to the evaluation of Phase I polygons from an ecological perspective.

We used an expert-based approach to develop a broad-scale, rapid assessment of Arizona's grasslands, interviewing 39 range management specialists from the Forest Service (USFS), Natural Resources Conservation Service, Bureau of Land Management (BLM), University of Arizona, Arizona State Land Department, The Nature Conservancy and New Mexico Natural Heritage Program (Appendix B). Expert input was verified and corrected where necessary through extensive field reconnaissance and quantitative vegetation sampling at random sampling points.

The result was the development of a spatial layer and map (see Figure 1) that identifies the location and extent of Arizona's and the BLM's

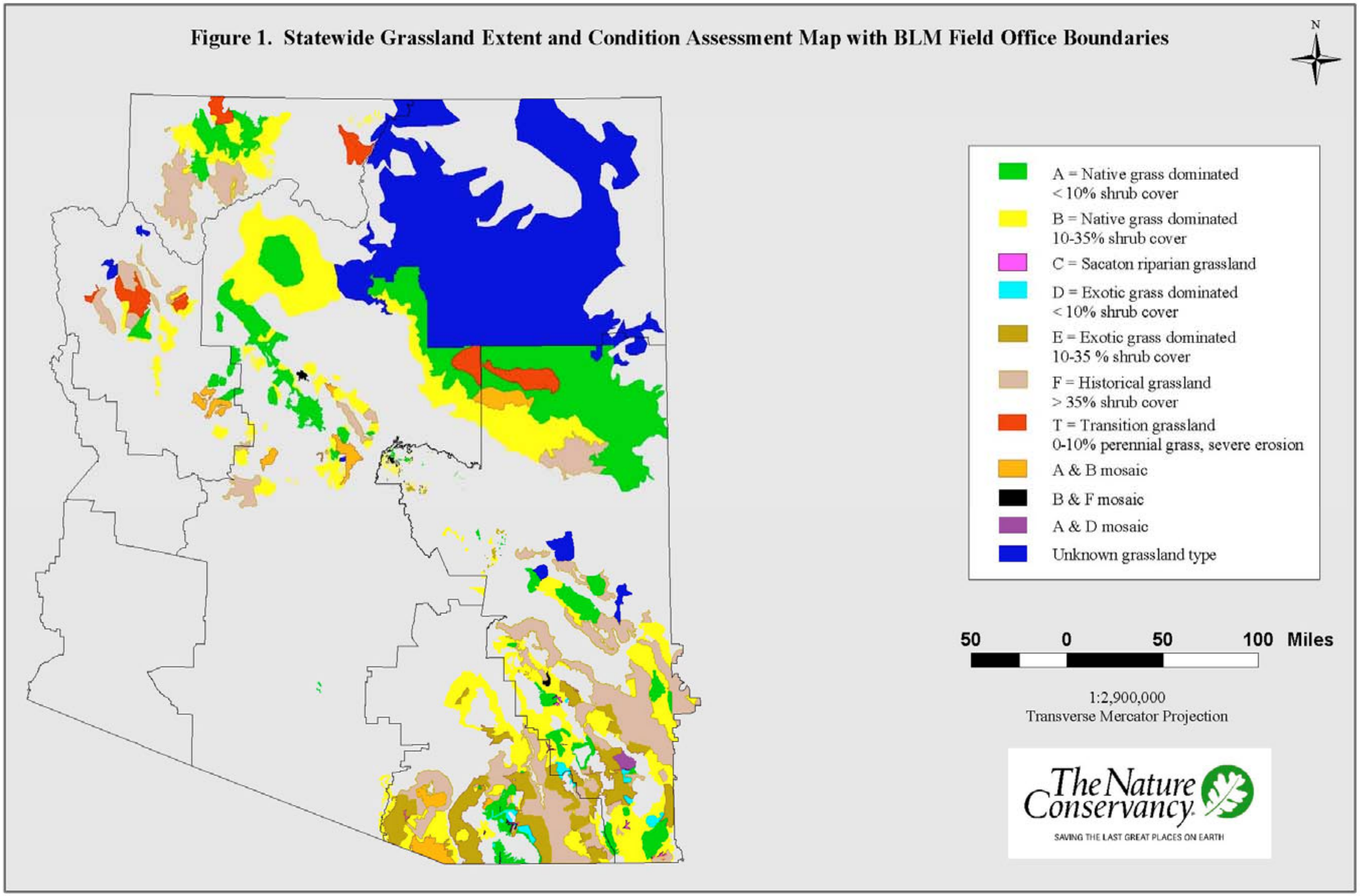
(1) best remaining native grasslands;

(2) non-native grasslands where introduced perennial grasses--primarily Lehmann lovegrass (*Eragrostis lehmanniana*) and Boer lovegrass (*Eragrostis chloromelas*)--are a common or dominant component of the grassland community;

(3) transition grasslands with very low perennial grass cover that are in need of improved grazing management;

(4) shrub-invaded native grasslands with restoration potential using grazing rest and prescribed fire (to reduce shrubs); and

Figure 1. Statewide Grassland Extent and Condition Assessment Map with BLM Field Office Boundaries



(5) former grasslands that have crossed an ecological threshold with respect to shrub encroachment resulting in a type conversion to desert shrubland; in this case, restoration using grazing rest and prescribed fire is no longer possible (permanent conversion) or may be possible only after extended periods of grazing rest, i.e., 40+ years, and recovery of perennial grasses (Gardner 1950; Glendening 1952; Smith & Schmutz 1975; Hennessey et al. 1983; Roundy & Jordan 1988; Valone et al. 2002).

Description of Grassland Classes:
We developed a series of grassland classes or types using information from range management experts and the literature to define threshold values for shrub cover (see references in McPherson 1997). The classes include:

Native grassland with low shrub cover, TYPE A: grassland with < 10% shrub cover whose herbaceous component is entirely or predominantly native perennial grasses and herbs; non-native perennial grasses are uncommon or absent. In the latter case, we did not specify a cover value for distinguishing uncommon from common but left this determination to the individual expert.

Shrub-invaded native grassland with restoration potential, TYPE B: grassland composed of native perennial grasses and herbs (non-natives absent or uncommon) with 10-35% total shrub cover and mesquite or juniper cover < 15%. A key characteristic of this type is its restoration potential--that is, shrub cover can be reduced using prescribed burns and the site restored back to TYPE A grassland either immediately or after some period of grazing rest (< 15 years) when sufficient fine fuels have accumulated for fire spread (Brunson et al. 2001).

Sacaton riparian grassland, TYPE C: grassland dominated by giant sacaton (*Sporobolus wrightii*) that occurs on floodplain terraces along drainages (Brown et al. 1979).

Non-native grassland with low shrub cover, TYPE D: grassland with < 10% shrub cover where non-native perennial grasses are common or dominant.

Shrub-invaded non-native grassland, TYPE E: grassland with 10-35% total shrub cover and mesquite or juniper cover < 15% and non-native perennial grasses are common or dominant; again, a defining characteristic for this type is its potential for shrub reduction using prescribed burns and “restoration” to TYPE D grassland.

Historic or former grassland, TYPE F: former grassland with > 15% canopy cover of mesquite and juniper combined and/or > 35% total shrub cover; perennial grass canopy cover usually < 1 %, always < 3 %; type conversion to shrubland that is either permanent or will require 40+ years of livestock exclusion for partial recovery of perennial grasses (Hennessey et al. 1983; Valone et al. 2002).

Methods

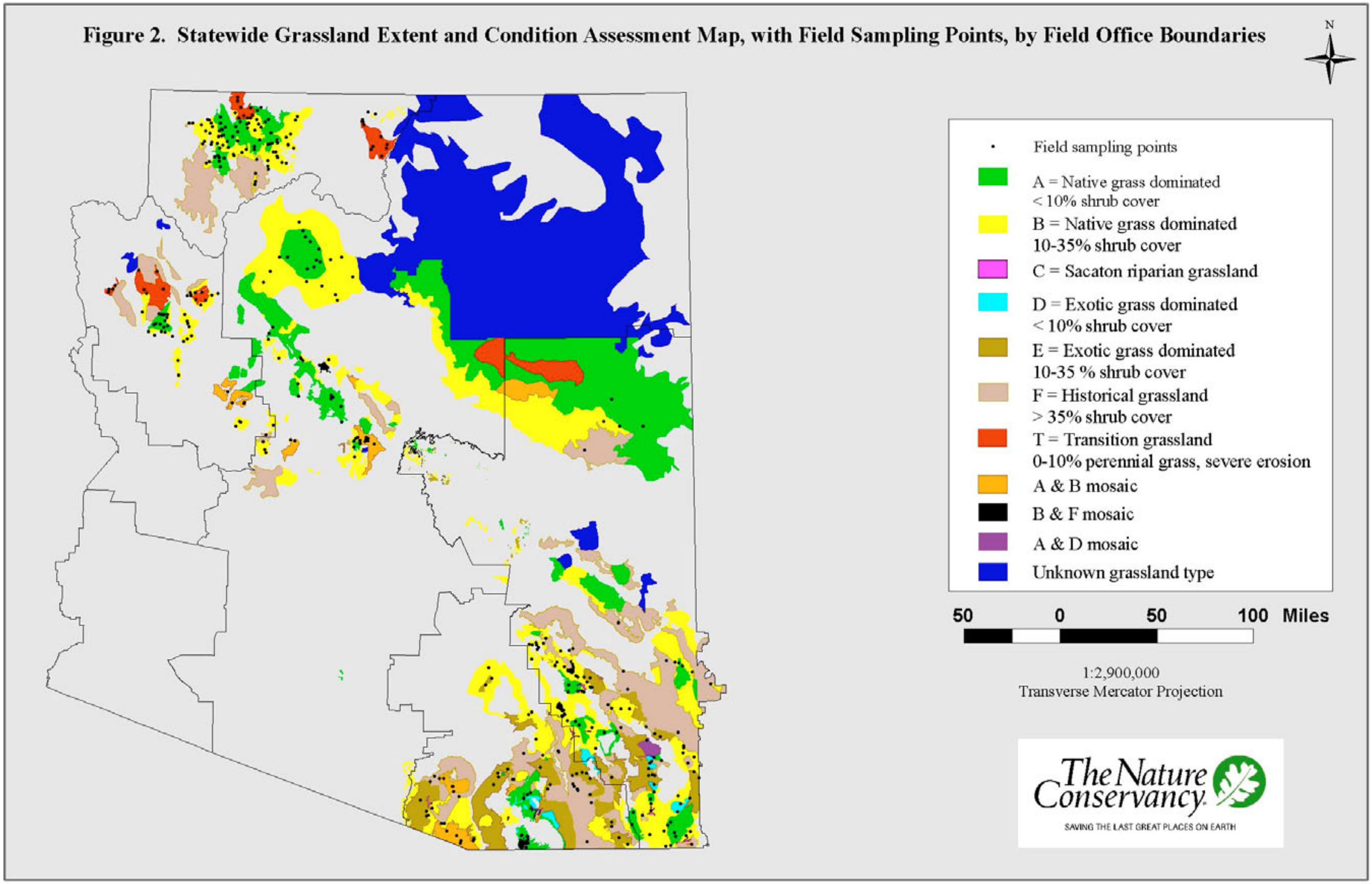
Development of Expert Maps:
We interviewed 39 range management specialists from several federal and state agencies, institutions and non-governmental organizations. These include the Bureau of Land Management, U.S. Forest Service, U.S.D.A. Natural Resources Conservation Service, University of Arizona, University of Arizona Cooperative Extension Service, Arizona State Lands Department, The Nature Conservancy, New Mexico Natural Heritage Program and Pacific Biodiversity Institute. All experts had considerable knowledge of local range conditions. Following an explanation of the classification system, experts delineated polygons representing current and former grassland on maps that we provided, assigning a grassland type to each polygon. The maps were 1:100,000, 1:150,000, or 1:250,000 digital raster graph (DRG) maps overlain with the GAP vegetation associations for Arizona or New Mexico (Arizona Gap Program 1998; Thompson et al. 1996). Experts were encouraged to use the GAP vegetation overlay as a guideline but to base their mapping and type assignments on personal experience. If an area was extremely heterogeneous, the polygon was assigned a combined type, for example Type A&B grassland or Type A&D grassland (see Figure 1), however, this was done only when a preponderant grassland type could not be identified. During the interview we also asked experts to identify potential grasslands, current and former, that were in need of further reconnaissance; these were designated as unknown grassland.

Polygons drawn on the hard-copy expert maps were digitized in Arcview 3.2 using an on-screen digitizing approach; the GAP vegetation layer and elevation contour lines from the DRG's were used as guides to more accurately define polygon boundaries. Individual ArcView GIS files ("shape" files) were made for each expert.

Field Verification:
We developed field maps of grassland-type polygons from individual expert shape files at scales ranging from 1:100,000 to 1:150,000; areas where experts overlapped and disagreed on the grassland type designation were highlighted. These maps included all paved and unpaved roads to facilitate orientation in the field and, in 2002, 25-30 random points that were used in the selection of field sampling sites; in 2003, sampling sites were selected at random distances along pre-identified roads that traversed grassland polygons.

We conducted 17 trips between May 2002 and August 2002 and 6 trips between May 2003 and December 2003 visiting a total of 436 (see Figure 2) sites in order to assess the accuracy of the expert-derived maps. Prior to departure, we inspected the field maps and 1:100,000 BLM land cover/land ownership maps to establish a proposed route that would take us through the major polygons in an area and provide access to the greatest number of random field sampling points. In addition, during the 2003 trips, we targeted polygons (and road segments) having a significant amount of BLM-managed land. Since it was logistically impossible to visit all polygons, native grasslands with low shrub cover (Type A), larger polygons of the other grassland types, and areas of disagreement between experts were targeted for visitation and sampling. In 2002, in instances where we could not hike to the approximate location of a random sampling point, we stopped along the

Figure 2. Statewide Grassland Extent and Condition Assessment Map, with Field Sampling Points, by Field Office Boundaries



road at a place that was closest to that point on federal or State land. No assessments were made on private land without the prior consent of the landowner. When sampling in the vicinity of a road (2002 and 2003), we walked 100-200 m perpendicular to the road before sampling to eliminate the effect of any disturbance from the road on vegetation. This included the occurrence of Lehmann lovegrass or Boer lovegrass, which frequently grew along roads. Unless these non-native grasses are widely distributed in an area (which can easily be determined by sight), we found that a distance of 100-200 m from the road was sufficient for them to completely disappear as a component of the herbaceous vegetation.

Field sampling was initiated with a rapid reconnaissance of the site for a period of at least 15 observer-minutes. We then estimated canopy cover (in percent) of all shrubs, of mesquite and juniper, and of perennial grasses to the nearest 5%. A species list of shrubs and perennial grasses was also made with the dominant grass and shrub identified. For the first 7 trips, canopy cover was estimated using 3-6 pace transects, each 150-200 meters in length, for a total of 400-600 sampling points per site (Avery 1975; Cook & Stubbendiek 1986). On later trips, ocular estimates of canopy cover were made, interspersed periodically with pace transects to maintain consistent cover estimates.

The abundance of exotic perennial grasses was ranked at each sampling site on an ordinal scale as dominant, common, scattered, rare, or absent (Shaver et al. 2000). To make this scale more quantitative and enhance consistency between observers and sampling trips, we used a modified frequency sampling method, recording the presence or absence of Lehmann lovegrass or Boer lovegrass in 4, 3-m x 3-m quadrats placed at 15 m intervals along transect lines. Transects were approximately 180 m in length with a total of 3-4 transects and 144-200 quadrats per site. Lehman and Boer lovegrass were considered rare at a site if frequency in quadrats was <10%, scattered if the frequency was 10-20%, and common or dominant if the frequency was >20%. Common was distinguished from dominant based on whether the combined canopy cover of non-native lovegrasses was or was not greater than any other single species at the site. Quantitative (frequency) sampling of non-native grass abundance was used in making assignments of non-native rank abundance during the first 7 trips in 2002; after this, ocular estimates of rank abundance were made.

In 2002, at each site we also ranked the potential for using prescribed or wildland fire to reduce shrubs and restore “open” grassland conditions, by assigning the site to a Grazing Rest Category (GRC).

- GRC 1 Fine fuels are continuous at the site and sufficient at the present time to permit fire spread and mortality or top-killing of shrubs (approximately 800-1000 kg/ha);
- GRC 2 Fine fuels discontinuous and amount insufficient to allow fire spread; grazing rest for a period $\leq$ 5 growing seasons is required for the build-up of fine fuels.

GRC 3 Fine fuels discontinuous and amount insufficient to allow fire spread; grazing rest for a period > 5 growing seasons required for the build-up of fine fuels.

GRC 4 Type conversion, fuels unlikely to build up to a level to permit fire spread because of excessive soil erosion and/or competition with shrubs.

In 2003, we refined this ranking scheme assuming that 3 growing seasons, rather than 5, was a reasonable amount of time from a financial standpoint for a rancher to rest a pasture or portion of an allotment before burning it. Thus, in addition to a Grazing Rest Category, sites were also assigned a Fire Potential Category (FPC) as follows:

FPC 1 Fine fuels continuous to discontinuous; grazing rest for a period of 0-3 growing seasons is required for the build-up of fine fuels to permit fire spread.

FPC 2 Fine fuels discontinuous and amount insufficient to allow fire spread; grazing rest for a period > 3 growing seasons is required for the build-up of adequate fine fuels.

Using the relationship between perennial grass cover and FPC in 2003, we assigned FPC values to sites sampled in 2002 using their perennial grass cover estimates and GRC values. All FPC and GRC rank determinations were made by Dave Gori based on experience conducting prescribed burns and with the recovery of grassland sites following the removal of livestock.

At each site we also noted any evidence of soil erosion such as the presence of rills, pedestals, terracettes, water flow, litter movement, and gullies. Using the Rangeland Health Evaluation methodology, the severity of erosion was given an overall ranking of extreme, moderate to extreme, moderate, slight to moderate or slight based on the condition of the site relative to reference areas (Shaver et al. 2000). Finally, 2-4 photographs were taken at each site and comments on any human-caused threats or impacts were made.

When driving through polygons to reach the random field sampling points, we recorded notes on the field maps indicating the grassland type we were passing through. If a discrepancy between the expert map and our assessment of the condition class arose, either at the assessment site or when driving between sites, we attempted to clarify the discrepancy with additional mapping. Often this was done by driving to a location that would provide an overlook of the area, at other times we did some additional driving on roads within the area in question to get a better sense of the extent of the contested area.

A portion of the field verification in both 2002 and 2003 was conducted during the spring-summer dry season following several years of below-average precipitation. Although this undoubtedly affected perennial grass cover and a site's Fire Potential and Grazing Rest categories, the grassland types (with the exception of Transition grasslands) were distinguished primarily on the basis of shrub canopy cover which was not strongly affected by the drought in most locations.

In addition to our field sampling points, we used shrub and perennial grass cover data derived from long-term monitoring plots (n= 93) to further assess the accuracy of the expert maps. The plots were located on the Muleshoe Ranch Cooperative Management Area and Aravaipa Canyon Preserve, in the Galiuro Mountains, Arizona, on the Gray Ranch in southwestern New Mexico, and on the San Rafael Short Grass Prairie Preserve in southeastern Arizona. The plots were not visited during the field assessment portion of the study but were last measured in 1998-2000 for the Galiuros plots, in 1992-1993 for the Gray Ranch plots and in 2000 for the San Rafael plots. A sub-sample of these monitoring plots, 4 plots from Muleshoe and 3 each from San Rafael and Aravaipa, were used in the calculations of grassland statistics by BLM field office (see below).

Map Modifications Based on Field Data:
The original expert maps were corrected based on data from field sampling points, notes made while traversing polygons, and field mapping. In 2002, expert polygon files were intersected with a hexagon-shaped grid surface (resolution of 50 ha) to facilitate the modification of polygon classifications and boundaries. After all corrections were made, the modified hexagon shape files were dissolved to generate continuous polygons of like grassland type for each expert. In 2003, polygon boundaries were modified as needed using an on-screen digitizing approach. In both years, expert maps were then merged together to create a full grassland coverage for the State. This layer was edited to remove sliver polygons inadvertently created in the dissolve and merge processes.

Transition Grasslands - A New Type:
After completion of the expert mapping and based on our 2003 field surveys we defined a new grassland type, Transition grasslands (Type T) as those with < 5% canopy cover of perennial grasses and/or severe soil erosion problems. We did this to identify "at risk" native grasslands in need of improved grazing management. Empirical data collected at the Jornada Experimental Range and by the Malpai Borderland Group suggests that when perennial grass cover is less than 5%, grazing rest may not result in vegetation recovery if soil movement and loss is severe (Hennessey et al. 1983; P. Warren, pers. comm.). Existing expert polygons were reclassified into this type if a strong majority of survey points within them fit the above definition. A total of 8 polygons were reclassified, 7 had low shrub cover (formerly Type A polygons), the other had > 10% shrub cover (formerly a Type B polygon).

Results and Discussion

Accuracy Assessment:
We estimated the accuracy of the original, uncorrected expert map as the percent of field sampling points and monitoring plots that "agreed" with the expert's determination for that area. Using this approach, 322 out of 436 sites or 74% were correctly classified by the experts. This level of accuracy compares favorably to that of land cover maps derived from the analysis of Landsat satellite imagery (Lauver & Whistler 1993; Ringrose et al. 1999; Kepner et al. 2000; Halvorson et al. 2001; Miller et al. 2003). It

is important to note that the accuracy of the final grassland map (Figure 1) should be greater than the above figures because it was revised and corrected based on field data.

Distribution of Grasslands in Arizona:
Experts identified over 24,500,000 acres as current or former grassland, comprising 34% of the land surface of Arizona; we assume that this represents the historic distribution and extent of grasslands in the state (Table 1). Of this, BLM manages 2,788,000 acres or 11% of current and former grassland in Arizona. Over 7,772,000 acres of potential grassland were identified by experts but not classified into a grassland type because their status and condition were unknown. Unknown grasslands (UNK) comprise 32% of the historic extent of grasslands statewide and they occur predominantly on Native American Trust Lands. We have excluded them from all percentage calculations associated with the relative abundance of different grassland types.

Open Native and Shrub-Invaded Grasslands:
The summary statistics for the area and relative abundance of the various grassland types underscore the extent of the vegetation changes (Tables 1-6). Only 5,201,000 acres or 31% of current and former grasslands still remain relatively shrub free and composed predominantly of native perennial grasses; we refer to these grasslands as Open Native (Types A, A&D). Transition grasslands (Type T) with predominantly low shrub cover and little to no perennial grass cover now occur on 683,000 acres, comprising 4% of current and former grasslands statewide. Approximately 5,656,000 acres or 34% of current and historic grasslands have experienced some level of shrub encroachment but can be restored back to open native grassland using grazing rest and fire; we refer to these grasslands as Restorable Native (Types B, A&B, B&F). However, shrub cover has exceeded a threshold of 35-40% on over 3,694,000 acres of historic (or former) grassland, producing a type conversion from grassland to shrubland (Type F). This corresponds to a 22% loss of grasslands statewide over the last 100-130 years.

This figure for grassland loss may be slightly overestimated since Valone et al. (2002) found that rest from grazing for 40- but not 20-years at a shrubland site resulted in an increase in perennial grass canopy cover from 2.5% outside an exclosure to 9.5% inside the exclosure. This represents only a partial recovery from a restoration standpoint because total fine fuels were still insufficient to carry a fire intense enough to reduce shrubs at the site. However, the results suggest that full recovery over longer time periods *may* be possible at certain sites depending on factors such as soil type, degree of soil erosion, and the identity of shrub species that occur there. In contrast, no increase in perennial grass cover was observed at another site following an increase in shrubs above the threshold value even after 50 years of grazing rest suggesting a permanent conversion from grassland to shrubland there (Hennessey et al. 1983).

Sacaton riparian grasslands (Type C) are rare in Arizona covering only 37,000 acres and comprising 0.5% of current and former grasslands (Table 1). Within the state, riparian grasslands are restricted to southeastern Arizona; the largest patch (5,800 acres) occurs in the headwaters of the Babacomari River, near Elgin, Arizona.

Table 1. Extent, in acres, and percent abundance of grassland types by land manager (BLM, ASLD, Private) and for Arizona overall (total).

Grassland Type	BLM Acres	% BLM Land	State Acres	% State Land	Private Acres	% Private Land	Total Acres	% All*
Open Native (A, A&D)	492,935	9	1,423,461	27	2,316,359	45	5,200,961	31
Restorable Native (B, A&B)	947,841	17	1,801,911	32	1,754,477	31	5,655,570	34
Riparian (C)	449	1	9,556	26	24,013	64	37,361	0
Exotic (D, E)	17,458	1	496,675	34	637,854	44	1,456,340	9
Historic (F)	1,049,033	28	1,090,623	30	867,641	23	3,694,395	22
Transition (T)	234,930	34	117,353	17	315,490	46	683,134	4
UNK	45,304	1	60,816	1	142,638	2	7,772,725	
Total	2,787,951	11	5,000,394	20	6,058,472	25	24,500,486	

* Value represents the percentage of the total grassland acreage for each grassland type excluding UNK grassland.

Table 2. Extent, in acres, and percent abundance of grassland types by land manager (BLM, ASLD, Private) and overall (total) for Safford Field Office.

Grassland Type	BLM Acres	% BLM Land	State Acres	% State Land	Private Acres	% Private Land	Total Acres	% All*
Open Native (A, A&D)	189,965	7	811,128	31	1,298,361	49	2,648,360	35
Restorable Native (B, A&B)	329,554	14	690,710	30	733,222	32	2,280,486	30
Riparian (C)		0	6,763	30	15,449	69	22,364	0
Exotic (D, E)	6,023	1	187,384	38	287,137	58	497,262	7
Historic (F)	468,641	24	458,971	24	388,428	20	1,918,161	25
Transition (T)	14,419	7	33,561	17	150,273	75	199,601	3
UNK	2,085	1	1,304	0	22,758	8	294,481	
Total	1,010,687	13	2,189,822	28	2,895,628	37	7,860,715	

* Value represents the percentage of the total grassland acreage for each grassland type excluding UNK grassland.

Table 3. Extent, in acres, and percent abundance of grassland types by land manager (BLM, ASLD, Private) and overall (total) for Tucson Field Office.

Grassland Type	BLM Acres	% BLM Land	State Acres	% State Land	Private Acres	% Private Land	Total Acres	% All*
Open Native (A, A&D)	33,417	17	29,864	15	80,830	42	193,472	6
Restorable Native (B, A&B)	29,807	3	429,823	42	253,535	25	1,016,756	32
Riparian (C)	449	3	2,792	19	8,564	57	14,997	1
Exotic (D, E)	11,436	1	309,290	32	350,527	37	957,316	30
Historic (F)	95,915	10	493,074	51	341,473	35	965,856	31
Transition (T)								0
Total	171,023	5	1,264,843	40	1,034,929	33	3,148,397	

*Value represents the percentage of the total grassland acreage for each grassland type excluding UNK grassland.

Table 4. Extent, in acres, and percent abundance of grassland types by land manager (BLM, ASLD, Private) and overall (total) for Phoenix Field Office.

Grassland Type	BLM Acres	% BLM Land	State Acres	% State Land	Private Acres	% Private Land	Total Acres	% All*
Open Native (A, A&D)	4,684	0	507,652	37	717,636	52	1,381,039	37
Restorable Native (B, A&B)	88,765	4	608,778	29	773,084	37	2,091,187	55
Riparian (C)								0
Exotic (D, E)		0	1	0	190	8	2,407	0
Historic (F)	7,586	4	102,365	52	39,714	20	195,337	5
Transition (T)		0	56,587	47	64,552	53	121,139	3
UNK	4,757	0	57,047	1	89,265	1	7,356,196	
Total	105,792	1	1,332,430	12	1,684,441	15	11,147,304	

* Value represents the percentage of the total grassland acreage for each grassland type excluding UNK grassland.

Table 5. Extent, in acres, and percent abundance of grassland types by land manager (BLM, ASLD, Private) and overall (total) for Kingman Field Office.

Grassland Type	BLM Acres	% BLM Land	State Acres	% State Land	Private Acres	% Private Land	Total Acres	% All*
Open Native (A, A&D)	2,429	2	36,180	33	71,242	64	111,314	13
Restorable Native (B, A&B)	84,089	26	124,223	39	96,503	30	317,760	37
Riparian (C)								0
Exotic (D, E)								0
Historic (F)	129,756	53	16,805	7	84,558	35	243,146	29
Transition (T)	63,007	35	11,914	7	97,144	54	179,975	21
UNK	17,287	35	1,194	2	19,265	39	48,782	
Total	296,567	33	190,315	21	368,712	41	900,977	

*Value represents the percentage of the total grassland acreage for each grassland type excluding UNK grassland.

Table 6. Extent, in acres, and percent abundance of grassland types by land manager (BLM, ASLD, Private) and overall (total) for Arizona Strip Field Office.

Grassland Type	BLM Acres	% BLM Land	State Acres	% State Land	Private Acres	% Private Land	Total Acres	% All*
Open Native (A, A&D)	258,809	75	38,838	11	41,798	12	344,307	23
Restorable Native (B, A&B)	419,056	85	36,941	8	7,359	2	490,482	32
Riparian (C)								0
Exotic (D, E)								0
Historic (F)	347,136	69	19,408	4	13,468	3	504,043	33
Transition (T)	157,505	86	15,291	8	3,522	2	182,419	12
UNK	21,175	29	1,272	2	11,350	15	73,267	
Total	1,203,681	75	111,750	7	77,496	5	1,594,517	

* Value represents the percentage of the total grassland acreage for each grassland type excluding UNK grassland.

Non-Native Grasslands:
The spread of non-native perennial grasses within grasslands has also been substantial. Boer lovegrass and, to a greater extent, Lehmann lovegrass are now common or dominant on 1,456,000 acres such that non-native grassland (Types D, E) comprises 9% of current and historic grasslands statewide (Table 7). The distribution of these grasslands is not uniform but restricted to southeastern Arizona where the two lovegrass species were initially introduced in the 1930's to prevent soil erosion and provide forage for livestock (Figure 1, Cox & Ruyle 1986). Although the current distribution of non-native grasslands is presumably a function of the species' physiological tolerances and soil type preferences, it seems likely that Lehmann lovegrass will continue its spread, increasing in abundance to the north, east and especially to the south in Mexico.

Cheatgrass (*Bromus tectorum*), a non-native annual, occurs in grasslands on the Arizona Strip. Experts did not identify any non-native grassland dominated by this species as cheatgrass is not uniformly distributed over extensive areas like Lehmann and Boer lovegrass are. Where cheatgrass occurs, it is patchily distributed, although in places it may be locally abundant (see discussion below).

Grasslands by Land Manager:
Most current and historic grasslands of known status in Arizona occur on private and State lands (Tables 1-6). However, BLM manages 493,000 acres or 9% of open native grasslands statewide (Types A, A&D). Most of these are located in Safford and Arizona Strip field offices (190,000 acres and 259,000 acres, respectively). Similarly, BLM manages 948,000 acres or 17% of restorable native grasslands statewide (Types B, A&B, B&F), again, most are located in Safford and Arizona Strip field offices (330,000 acres and 419,000 acres, respectively). ***Given these acreages, there is a significant opportunity for BLM to become statewide leaders in the management and restoration of native grasslands using fire***. Furthermore, considering land ownership patterns in Arizona, fire management in grasslands will require expanded partnerships between BLM, private landowners, and Arizona State Lands Department (Tables 1-6).

BLM manages only 1% of riparian grasslands (Type C) and 1% of the more than 1.4 million acres of non-native grasslands (Type D, E) in Arizona (Tables 1-6). In contrast, BLM manages 235,000 acres or 34% of transition grasslands statewide; most of these are located in Arizona Strip and Kingman field offices (158,000 acres and 63,000 acres, respectively). Although less abundant in absolute terms, transition grasslands are proportionately more abundant among grasslands types in Kingman than on the Arizona Strip (21% vs. 12% of current and former grasslands, respectively). More significantly, BLM manages over a million acres of former grassland that is now shrubland (Type F). This is 28% of former grasslands statewide, a figure that rivals the 23% in private ownership and the 30% on State lands. Most of the former grasslands managed by BLM are in Safford, Arizona Strip, and Kingman field offices (469,000 acres, 347,000 acres, and 130,000 acres, respectively). Since BLM manages 16% of current and former grasslands of known status statewide, these results suggest that the loss of grasslands due to shrub encroachment has been particularly severe on BLM land. This may be due to a number of factors including differences in climate, soils, fire history, grazing management and vegetation on BLM land compared to lands in other ownership.

Table 7. The number and percentage (in parentheses) of field survey points in grasslands in Fire Potential Category (FPC) 1 and 2 by BLM field office and for all field offices combined. A. All points within Field Office Boundary. B. Points falling on BLM-managed land. FPC 1—site will require ≤ 3 growing seasons of grazing rest before burning; FPC 2—site will require > 3 growing seasons of rest before burning. See text for further explanation.

A. All points

Field Office	**FPC 1**	**FPC 2**
ASFO (n = 92)	35 (38.0)	57 (62.0)
KFO (n = 46)	6 (13)	41 (87)
PFO (n = 47)	23 (48.9)	24 (51.1)
TFO (n = 36)	24 (66.7)	12 (33.3)
SFO (n = 60)	36 (60)	24 (40)
AZ Total (n = 281)	124 (44.1)	157 (55.9)

B. Points on BLM-Managed Land

Field Office	**FPC 1**	**FPC 2**
ASFO (n = 80)	32 (40)	48 (60)
KFO (n = 18)	1 (5.6)	17 (94.4)
PFO (n = 1)	0 (0)	1 (100)
TFO (n = 1)	1 (100)	0 (0)
SFO (n = 10)	7 (58.3)	3 (41.7)
AZ Total (n = 110)	41 (37.3)	69 (62.7)

Grassland Condition:

We analyzed data collected during field surveys in order to evaluate the condition of current grasslands and the feasibility of their fire management, former grasslands were excluded from the analysis. These data are summarized in Tables 7-10 for all sampling points and for points that occur on BLM-managed land.

Values for Fire Potential Category (FPC) and Grazing Rest Category (GRC) are related to the cover of perennial grasses and other herbaceous vegetation at sites; both estimate the amount of grazing rest required to accumulate sufficient fine fuels (800-1,000 lbs/acre) to carry a fire intense enough to reduce shrubs. Only 44% of grasslands (sites) statewide were in FPC 1, that is, will require 3 growing seasons or less of grazing rest before they can be burned. The remaining grasslands (56%) will need longer periods of rest. A comparison of Tables 7A and 7B indicates that, in cases where sample sizes were adequate, there was no significant difference in the percent distribution of sites in FPC 1 and FPC 2 when all points vs. only points on BLM land were considered. This suggests that grazing management and other factors affecting the cover of herbaceous vegetation are similar on BLM and adjacent private and State land.

There are, however, differences between field offices in the relative feasibility of fire management in grasslands. The proportion of grasslands (sites) in FPC 1 was 67% in Tucson Field Office, 60% in Safford, 50% in Phoenix, 38% in Arizona Strip and 13% in Kingman. On average, grasslands in Kingman and Arizona Strip will require more grazing rest before they can be burned than grasslands in the other field offices.

Analysis of the GRC data provides additional resolution to the grazing rest and fire management issue. Statewide, 25% of grasslands (sites) can be burned without any pre-burn grazing rest, 32-33% will require 1-5 growing seasons of rest, and 43% will require > 5 growing seasons of rest. Again, there was no significant difference in the proportionate representation of different GRC categories when all points vs. only points on BLM-managed land were considered. However, there were differences in the distribution of GRC values between field offices. Only 2% of grasslands in Kingman and 15-19% in Arizona Strip and Phoenix can be burned without grazing rest compared to 37% in Safford and 57% in Tucson. Furthermore, only 13% of current grasslands in Kingman will require 1-5 growing seasons of pre-burn rest prior to burning compared to 42-44% in Phoenix and AZ Strip, and 28-30% in Tucson and Safford. Thus, for Phoenix and AZ Strip, 60% of grasslands can be managed and restored with fire with $\leq$ 5 growing of grazing rest compared to 67% in Safford, 83% in Tucson and only 15% in Kingman. The remaining grasslands will need longer periods of rest prior to burning; this is particularly significant in Kingman where 85% of grasslands will require more than 5 growing seasons of rest before burning.

Consistent with the FPC and GRC results, 29% of native grasslands (sites) statewide had < 10% canopy cover of perennial grasses (Table 11). Again, range condition was best in Tucson with only 4% of sites having < 10% perennial grass cover and worst in Kingman at 73%; approximately 20% of the grasslands in Phoenix, Safford and AZ Strip have < 10% perennial grass cover. A comparison of Tables 11A and 11B indicates that, where sample sizes were adequate, there was no significant difference in the percentage of sites with low perennial grass cover when all points vs. only points on BLM land were considered.

The low perennial grass cover at a considerable number of grassland sites has led to soil erosion problems. Statewide, 21% of sites had Moderate-Severe or Severe erosion, 36% had Moderate erosion, and 44% of sites had from no to Slight-Moderate erosion. Trends in grass cover and in FPC and GRC values between field offices were roughly consistent with erosion severity measurements: Moderate-Severe or Severe erosion was recorded at 35% of grassland sites in Kingman Field Office, at 23% of sites in AZ Strip, and at 10-13% of sites in Phoenix, Safford and Tucson. Similarly, only 26% of sites in Kingman had Slight or less erosion (i.e., None or None-Slight) compared to 44-48% of sites in Phoenix, AZ Strip, and Safford field offices and 80% of sites in Tucson. The relatively severe soil erosion at almost a quarter of grassland sites in the State threatens the long-term viability of grasslands by reducing or eliminating grass seedling recruitment and facilitating shrub encroachment (McAuliffe 1995; Wood et al. 1982).

Table 8. The number and percentage (in parentheses) of field survey points in grasslands in different Grazing Rest Categories (GRC) by BLM field offices and for all field offices combined. A. All points within Field Office Boundary. B. Points on BLM-managed land. GRC 1—no grazing rest required, site has sufficient fine fuels to burn immediately; GRC 2—site will require ≤ 5 growing seasons of rest before burning; GRC 3—site will require > 5 growing seasons of rest before burning; GRC 4—site may not recover sufficient fine fuels to carry fire even after prolonged periods of rest due to changes in soil characteristics and erosion. See text for further explanation.

A. All Points

Field Office	GRC 1	GRC 1-2	GRC 2	GRC 2-3	GRC 3	GRC 4
ASFO n = 85	13 (15.2)	2 (2.4)	35 (41.2)	0 (0)	35 (41.2)	0 (0)
KFO n = 46	1 (2.2)	0 (0)	6 (13)	0 (0)	38 (82.6)	1 (2.2)
PFO n = 48	9 (18.7)	0 (0)	20 (41.7)	1 (2.1)	18 (37.5)	0 (0)
TFO n = 36	20 (55.6)	0 (0)	10 (27.8)	0 (0)	6 (16.6)	0 (0)
SFO n = 60	22 (36.7)	1 (1.7)	17 (28.3)	1 (1.7)	17 (28.3)	2 (3.3)
AZ Total n = 275	65 (23.6)	3 (1.1)	88 (32)	2 (0.7)	114 (41.5)	3 (1.1)

B. Points on BLM-Managed Land

Field Office	GRC 1	GRC 1-2	GRC 2	GRC 2-3	GRC 3	GRC 4
ASFO n = 73	13 (17.8)	1 (1.4)	30 (41.1)	0 (0)	28 (38.4)	1 (1.4)
KFO n = 18	1 (5.6)	0 (0)	1 (5.6)	0 (0)	15 (83.3)	1 (5.6)
PFO n = 1	0 (0)	0 (0)	0 (0)	0 (0)	1 (100)	0 (0)
TFO n = 1	1 (100)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SFO n = 10	4 (40)	0 (0)	4 (40)	0 (0)	1 (10)	1 (10)
AZ Total n = 106	19 (18.4)	1 (1)	35 (34)	0 (0)	45 (43.7)	3 (2.9)

Table 9. Erosion severity in grasslands, expressed as the number and percentage (in parentheses) of field survey points (locations) in different severity categories by BLM field office and for all field offices combined. A. All points within Field Office Boundary. B. Points on BLM-Managed Land. See text for further explanation of erosion severity categories.

A. All Points

Field Office	None	None-Slight	Slight	Slight-Moderate	Moderate	Moderate-Severe	Severe
ASFO	1	1	40	4	25	8	13
n = 92	(1.1)	(1.1)	((43.5)	(4.3)	(27.2)	(8.7)	(14.1)
KFO	2	3	7	3	15	6	10
n = 46	(4.4)	(6.5)	(15.2)	(6.5)	(32.6)	(13)	(21.8)
PFO	8	0	11	4	11	3	6
n = 43	(18.6)	(0)	(25.6)	(9.3)	(25.6)	(7)	(3.3)
TFO	8	0	16	3	2	0	1
n = 30	(26.7)	(0)	(53.3)	(10)	(6.7)	(0)	(12.2)
SFO	4	0	21	3	17	5	2
n = 52	(7.7)	(0)	(40.4)	(5.8)	(32.7)	(9.6)	(3.8)
AZ Total	23	4	95	17	70	22	32
n = 263	(8.7)	(1.5)	(36.1)	(6.5)	(26.6)	(8.4)	(12.2)

B. Points on BLM-Managed Land

Field Office	None	None-Slight	Slight	Slight-Moderate	Moderate	Moderate-Severe	Severe
ASFO	1	1	36	2	19	8	13
n = 80	(1.3)	(1.3)	(45)	(2.5)	(23.8)	(10)	(16.3)
KFO	1	0	4	3	5	3	3
n = 19	(4.8)	(0)	(19)	(14.3)	(23.8)	(14.3)	(23.8)
PFO	0	0	0	0	0	0	1
n = 1	(0)	(0)	(0)	(0)	(0)	(0)	(100)
TFO	0	0	0	0	1	0	0
n = 1	(0)	(0)	(0)	(0)	(100)	(0)	(0)
SFO	0	0	2	0	2	0	0
n = 4	(0)	(0)	(50)	(0)	(50)	(0)	(0)
AZ Total	2	1	42	5	27	11	17
n = 105	(1.9)	(1)	(40)	(4.8)	(25.7)	(10.5)	(16.1)

Table 10. The abundance of exotic grasses in grasslands, expressed as the number and percentage (in parentheses) of field survey points in different abundance categories, by BLM field office and for all offices combined. A. All points within Field Office Boundary. B. Points on BLM-managed land. Exotic species differ between field offices and include *Bromus tectorum* for ASFO; *Bromus rubens* for KFO and PFO, and *Eragrostis lehmanniana* and *E. chloromelas* in TFO and SFO. See text for further explanation of rank abundance categories for exotic species.

A. All Points

Field Office	Absent	Rare	Scattered	Common	Dominant
ASFO	64	10	5	11	3
n = 93	(68.8)	(10.8)	(5.4)	(11.8)	(3.2)
KFO	18	12	15	0	2
n = 47	(38.3)	(25.5)	(31.9)	(0)	(4.3)
PFO	45	0	2	0	0
n = 47	(95.7)	(0)	(4.3)	(0)	(0)
TFO	17	7	3	2	7
n = 36	(47.3)	(19.4)	(8.3)	(5.6)	(19.4)
SFO	40	3	3	6	8
n = 60	(66.7)	(5)	(5)	(10)	(13.3)
AZ Total	184	32	25	19	20
n = 283	(59.7)	(14.3)	(10.1)	(9.1)	(5.5)

B. Points on BLM-Managed Land

Field Office	Absent	Rare	Scattered	Common	Dominant
ASFO	56	8	4	10	3
n = 81	(69.1)	(9.9)	(5)	(12.3)	(3.7)
KFO	6	6	7	0	0
n = 19	(31.6)	(31.6)	(36.8)	(0)	(0)
PFO	1	0	0	0	0
n = 1	(100)	(0)	(0)	(0)	(0)
TFO	1	0	0	0	0
n = 1	(100)	(0)	(0)	(0)	(0)
SFO	10	0	0	0	0
n = 10	(100)	(0)	(0)	(0)	(0)
AZ Total	74	14	11	10	3
n = 112	(66.1)	(12.5)	(9.8)	(8.9)	(2.7)

Table 11. This summarizes the percentage of native grasslands (A, B, A&B, B&F, T) that have < 10 % perennial grass cover for each field office as well as statewide.

A. All Points

Field Office	Types A,B, A&B, B&F	Type T	All Types Combined
ASFO (n = 19)	11 (15.5)	8 (50.5)	19 (21.8)
KFO (n = 32)	22 (66.7)	10 (90.9)	32 (72.7)
PFO (n = 10)	10 (20.8)	0 (0)	10 (20.8)
TFO (n = 1)	1 (4)	0 (0)	1 (4)
SFO (n = 8)	8 (20.0)	0 (0)	8 (20.0)
AZ Total (n = 70)	52 (24.0)	18 (66.7	70 (28.7)

B. BLM Points

Field Office	Types A,B, A&B, B&F	Type T	All Types Combined
ASFO (n = 16)	9 (15.0)	7 (46.7)	16 (21.3)
KFO (n = 12)	5 (62.5)	7 (87.5)	12 (75.0)
PFO (n = 1)	1 (100)	0 (0)	1 (100)
TFO (n = 0)	0 (0)	0 (0)	0 (0)
SFO (n = 1)	1 (12.5)	0 (0)	1 (12.5)
AZ Total (n = 30)	16 (20.5)	14 (60.9)	30 (29.7)

How do we account for the soil erosion results and the fact that, on average, 56% of grasslands (sites) statewide will require > 3 growing season of grazing rest before burning, and 43% of grasslands will require > 5 growing seasons. The ongoing drought is undoubtedly a major contributor to the generally poor condition of grasslands but current grazing management practices are also playing a significant role. The combined effect appears to be particularly severe in Kingman due to the fact that average annual precipitation is only 8-10 inches, less than in most other grassland in Arizona, and during the drought precipitation has been reduced even further. Improvements in grazing management will require difficult decisions and tough actions by the BLM. However, the preceding analysis indicates that Arizona has already lost 22% of its historic grasslands due to shrub encroachment. If land managers cannot find ways to improve grazing management and to rest grasslands so that they can be managed and restored using fire then there is a risk of losing even more grassland to shrub encroachment. The resource capital in grasslands—that is, their perennial grasses—is being "drawn down" by shrub encroachment, soil erosion and levels of livestock utilization that are not in balance with annual productivity (and rainfall). Sustaining this capital for the long-term will require improvements in grazing management and the use of fire to reduce shrubs and increase perennial grass cover (Brunson et al. 2001).

Exotic Species and Fire Management:
Prescribed fire and wildfire can often result in the spread of non-native plant species at the expense of natives (Robinett 1994). Four non-native grasses commonly occur in Arizona grasslands: Lehmann lovegrass and Boer lovegrass, cheatgrass and red brome (*Bromus madritensis* subsp. *rubens*). Only red brome appears *not* to pose a threat to native grasslands and may actually facilitate shrub reduction during burns since it grows abundantly under the canopy of shrubs and increases fuels loads and fire intensity there. In addition, the relative abundance of red brome was not consistently recorded during field surveys in 2002. For these reasons, our comments concerning exotic species in grasslands will be primarily restricted to cheatgrass and the non-native lovegrasses.

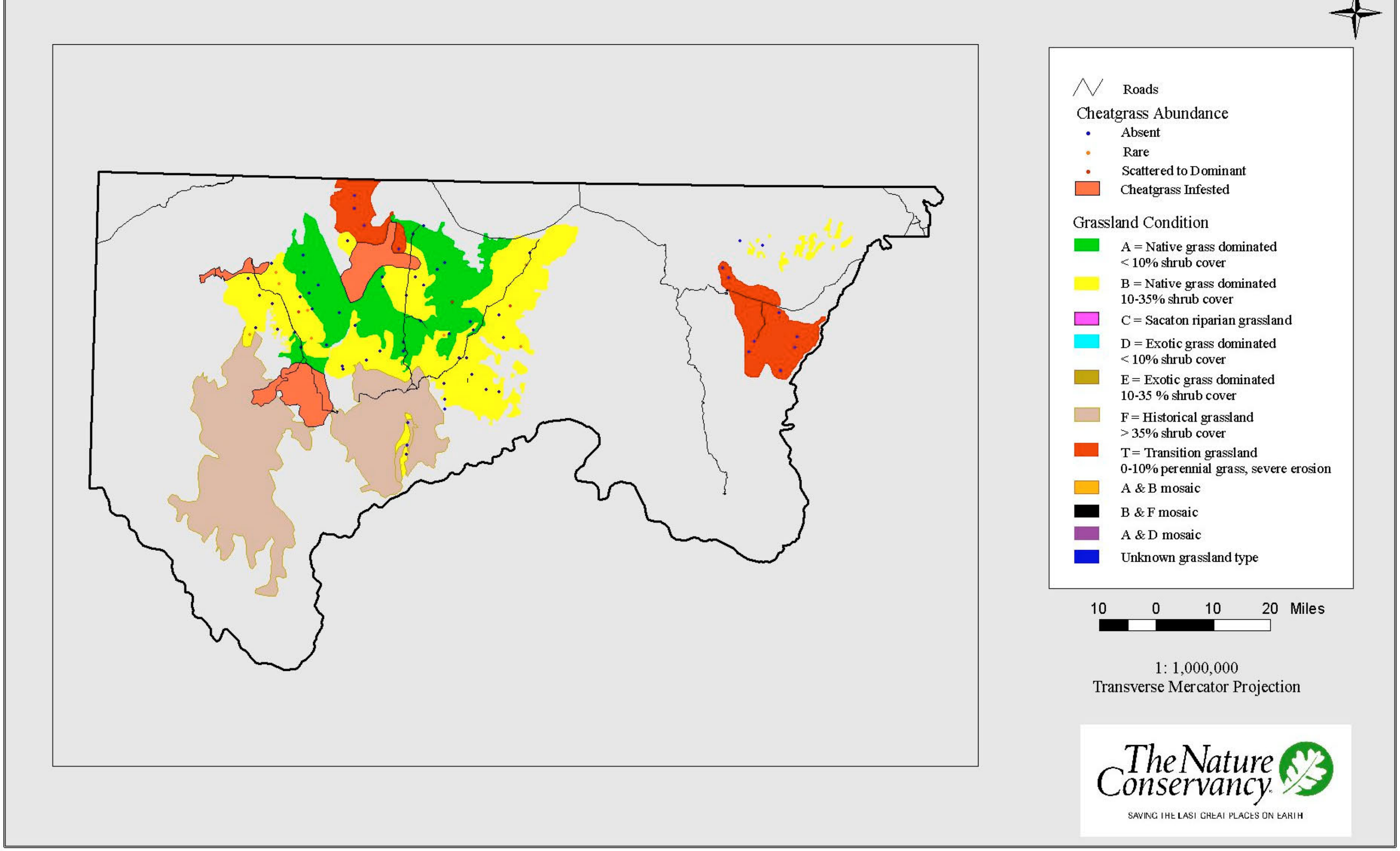
Knowledge of the distribution of non-native species and how they respond to burns relative to natives are both important in fire planning and management if maintenance of predominantly native plant communities is a resource objective. Our assessment provides the first broad-scale regional dataset on the location of non-native grasslands and on the distribution and abundance of exotic grasses within native grasslands. Non-native grasses were absent in 60% of sampling sites while rare or scattered in 25% of sites (Table 10). Statewide, 15% of sites had non-native species common or dominant. This figure is slightly higher than the relative abundance of non-native grasslands among current and former grasslands (9%) for two reasons. First, cheatgrass was locally abundant in native grasslands in places within the Arizona Strip field office boundary, although no non-native grasslands occur there. (Non-native grasslands were operationally defined as areas where non-native species were more or less uniformly distributed over large areas). Second, field sampling within the Safford field office was concentrated in southern Arizona where non-native grasslands of Lehmann lovegrass and Boer lovegrass occur compared to north of the White Mountains where they do not.

A closer look at each of the field offices is revealing. On the Arizona Strip, cheatgrass was common or dominant at 16% of sites, scattered at 5% of sites and absent or rare at 79% of sites. Sites with abundant cheatgrass (scattered-common, common, dominant) were not uniformly distributed across grasslands but were concentrated in certain areas. We drew polygons around these points and designated them as Cheatgrass Infested Areas. The location of Cheatgrass Infested Areas and sampling sites falling outside of them are shown in Figure 3. The presence of cheatgrass should be considered in fire planning and management. During our field surveys, we observed burned sites where cheatgrass was dominant and natives were rare or absent and other sites where native perennial grasses were vigorously growing and cheatgrass was rare (Figure 4). Without pre-burn information on species composition, it is unclear what effect the burns had on the spread and relative abundance of cheatgrass at the different sites. Since there are currently no quantitative studies bearing on this question, burns should be conducted cautiously in areas where cheatgrass is present and should be accompanied by pre- and post-burn monitoring.

In Kingman, both *Schismus arabicus* and red brome were found at our field sampling sites. *Schismus arabicus* was found only in the Detrital Valley while red brome was common or dominant at 4% of sites, was rare or scattered at 58% of sites, and was absent at 38% of sites. Red brome was also the only exotic grass we encountered in grasslands in the Phoenix Field Office, however, its presence was not consistently recorded at sampling sites there.

In Safford and Tucson field offices, Lehmann lovegrass and Boer lovegrass were common or dominant at approximately 24% of our sampling sites, all of which were located in non-native grassland polygons. The two lovegrass species were scattered in abundance in 6% of sites, rare at 10% of sites, and absent at 60% of sites. The distribution and relative abundance of Lehmann lovegrass and Boer lovegrass outside of non-native grasslands is shown in Figure 5. Lehmann lovegrass is known to increase at the expense of natives after fires (Robinett 1994), although the timing of burns may be an important factor in determining the outcome of this interaction. An ongoing study conducted by G. McPherson, R. Steidl, and students at the University of Arizona may soon clarify this issue (http://www.u.arizona.edu/~elg/fort.html); their study looks at the effect of burn seasonality on the post-burn abundance of native herbaceous species and Lehmann lovegrass. When completed, their study should be consulted prior to burning in non-native grasslands. Until then, prescribed burns and wildland fire use *are not recommended* in non-native grasslands and they should be conducted cautiously in native grasslands where Lehmann lovegrass is present. In the latter case, monitoring with the appropriate controls is advised in order to document any increase in Lehmann lovegrass abundance relative to natives.

Figure 3. Locations of Cheatgrass Infested Areas within the Arizona Strip Field Office Boundary

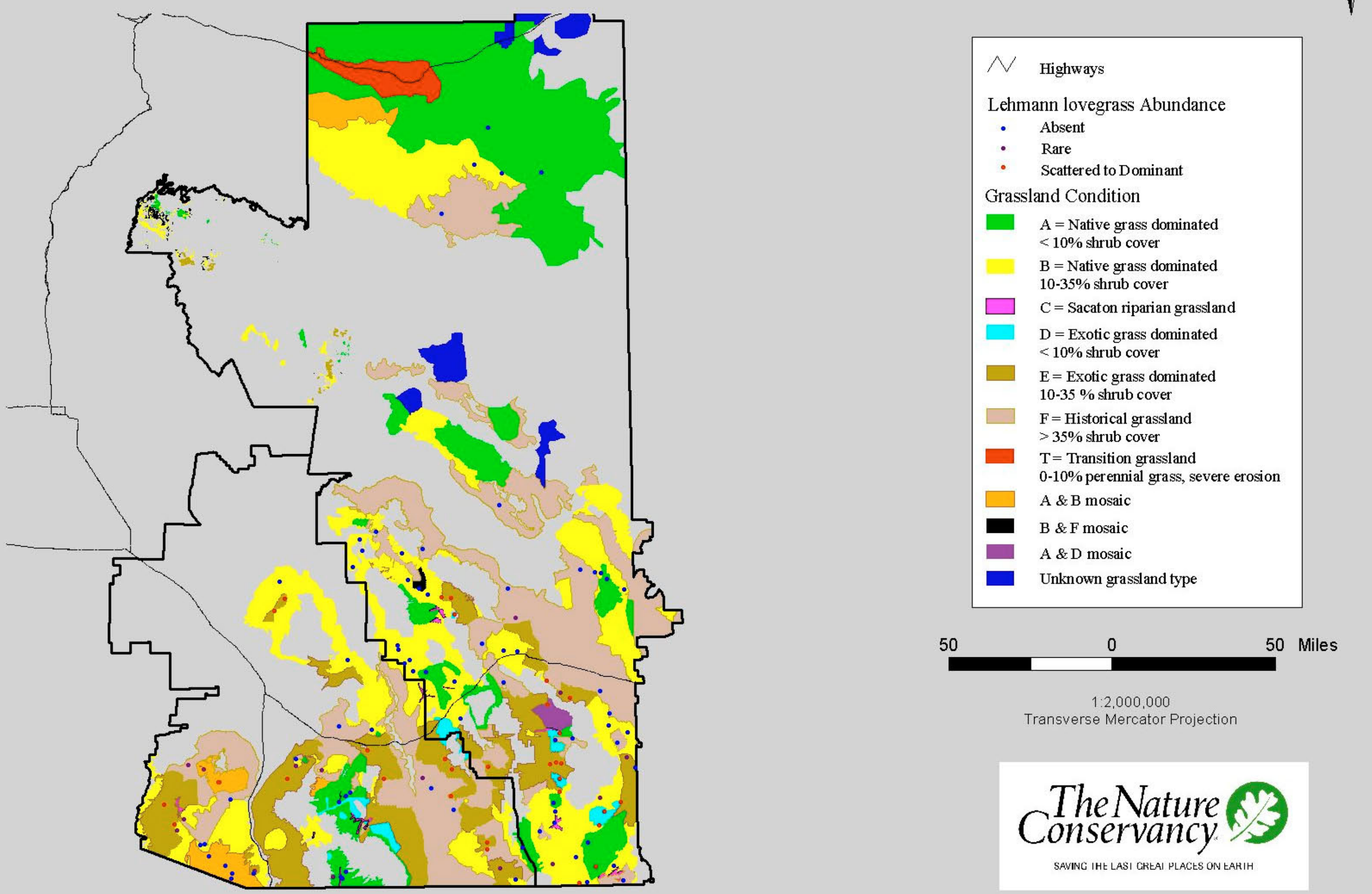


Low juniper cover and no cheatgrass present at burn site. Photograph taken at field sampling point AZB11.

Low juniper cover with cheatgrass infestation at burn site. Photograph taken at field sampling point AZB5.

Figure 4. Examples of positive (top) and negative (bottom) effects of fire within or near Cheatgrass Infested Areas within the Arizona Strip field office boundaries.

Figure 5. Locations of Lehmann lovegrass Risk Areas within the Tucson and Safford Field Office Boundaries



Conclusions

- Shrub encroachment has led to significant degradation and loss of grasslands statewide. Conservatively, we estimate this loss at 22% of historic grasslands.
- BLM manages over 1.4 million acres of open native and restorable native grassland; this presents a significant opportunity for BLM to become statewide leaders in the maintenance and restoration of grasslands using fire.
- Rangeland health is poor in many of the State's grasslands. As a result, restoration and management of grasslands using fire is feasible but will require some significant but temporary changes in grazing management. In fact, 56% of grasslands will need more than 3 growing seasons of grazing rest before burning, and 43% of grasslands will need more than 5 growing seasons.
- The recent drought has caused a massive sagebrush die-off on the Arizona Strip with good perennial grass cover persisting in the understory of dead shrubs; this creates an unprecedented opportunity for the large-scale restoration of grasslands using fire.

Grassland Management Priorities

One of the primary goals of the statewide grassland assessment was to identify and prioritize grasslands that would benefit from fire restoration management, fire maintenance management, and grazing restoration management. In general, fire restoration management is directed at Restorable Native grasslands (Type B, A&B, B&F; see preceding section); the best available scientific information indicates that fire will benefit these grasslands by reducing shrubs and increasing the vigor and cover of perennial grasses (Cable 1967; Wright 1974; Archer & Smiens 1991; Brunson 2001). Fire maintenance management is directed at Open Native grasslands (Types A, A&D); these grasslands will also benefit from periodic burning (to keep encroaching shrubs from increasing) and the maintenance of an appropriate historic fire regime (e.g., 7-10 year fire frequency for semi-desert grasslands, 10-30 years for Great Basin grasslands). Grazing management practices that maintain or increase current perennial grass cover and that minimize impacts in drainage bottoms from cattle tanks (construction and maintenance) will benefit both Restorable Native and Open Native grasslands and should be an integrated component of fire management in these grassland types. Grazing restoration management is directed at Transition grasslands (Type T). Due to the low perennial grass cover, the abundance of bare ground, and severe soil erosion problems, these grasslands are in immediate need of grazing rest to prevent further degradation and to maintain them as grasslands (i.e., prevent type conversion). Once perennial grass cover has been restored, an appropriate fire regime should be established to maintain a diverse herbaceous plant community and shrub cover at < 10%.

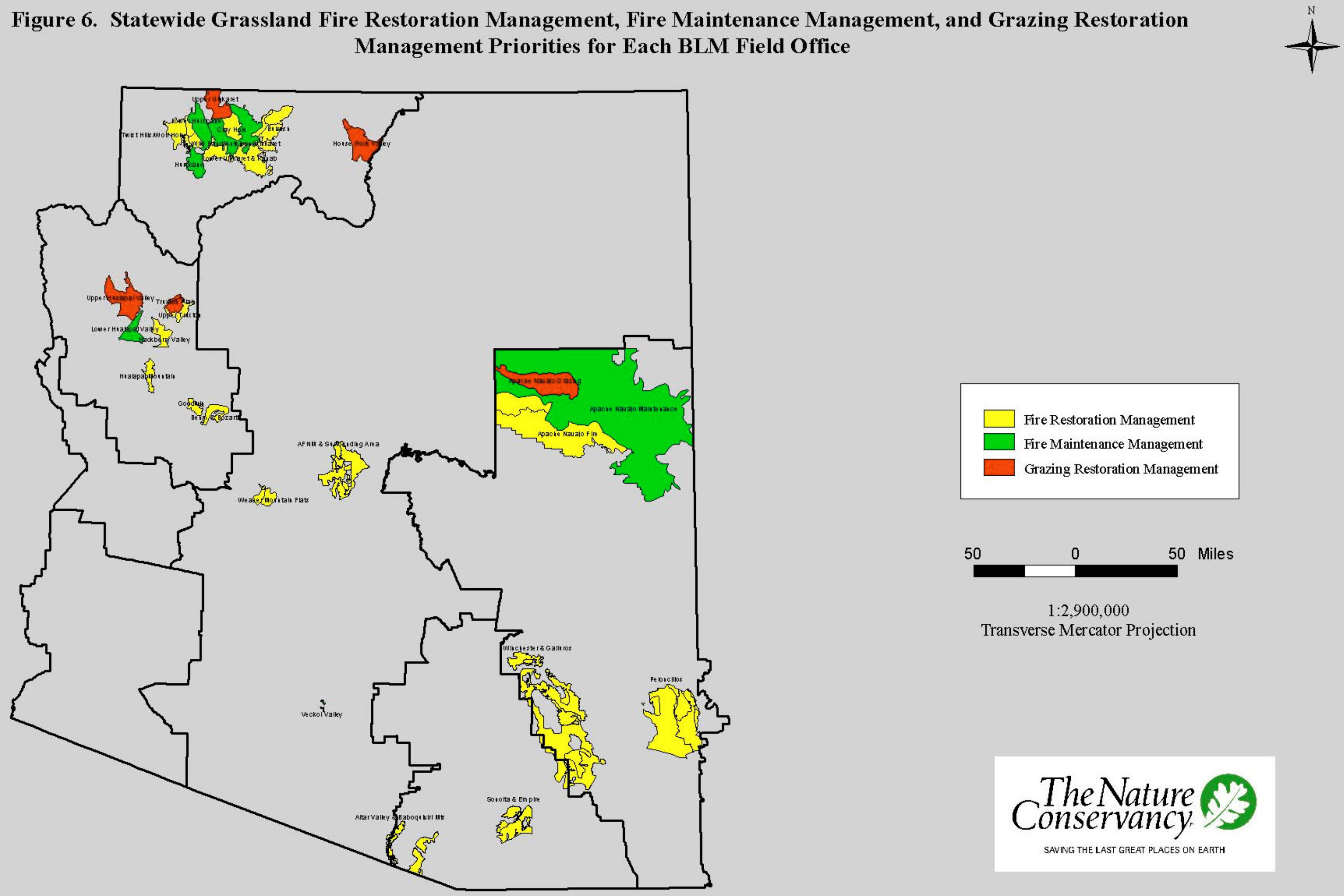
Below, we recommend priority areas for the three management categories for each field office (Figure 6). Within each management category, priorities are listed in order of decreasing importance; that is, the first listed is the highest priority.

Arizona Strip Field Office

Fire Restoration Management Priorities:
Lower Uinkaret and Kanab Plateaus (117,863 acres); these areas support a mix of perennial grasses and shrubs on the hillslopes and dense sagebrush (*Artemisia tridentata*) and blue grama (*Bouteloua gracilis*) in the valley bottoms. The amount of sagebrush encroachment into these valley bottoms is high, but the current drought conditions have caused extensive sagebrush mortality; high blue grama cover persists in the understory. This has created an excellent opportunity to restore these valley bottom grasslands to a shrub free aspect using fire. However, burns should probably be conducted under relatively cool, moist conditions to reduce the risk that the high fuel loads will produce fires of sufficient intensity to kill perennial grasses.

Bulrush Area along BLM Road 109 (104,545 acres); this area is characterized by moderate shrub cover (mean canopy cover: 16%) and poor perennial grass cover (mean canopy cover: 7%). The area is relatively free of cheatgrass, which makes it a good candidate for grazing rest followed by prescribed and wildland fire use to decrease

Figure 6. Statewide Grassland Fire Restoration Management, Fire Maintenance Management, and Grazing Restoration Management Priorities for Each BLM Field Office



shrubs, such as rabbitbrush (*Chrysothamnus sp*.), and snakeweed (*Gutierrezia sarothrae*) and increase perennial grass cover.

Clay Hole Valley (53,635 acres); this area is also characterized by moderate shrub cover (range: <5% to 18% canopy cover) and fair perennial grass cover (mean canopy cover: 12%). The northern portion of the Clay Hole area has a significant problem with cheatgrass infestation (see Figure 3). We recommend that prescribed fire be used in the southern portion of this area to decrease encroaching shrubs such as snakeweed and rabbitbrush, while experimental burns be conducted in areas near and in cheatgrass locations. The goal of these experimental burns is to determine if, and under what circumstances, fire can be used to decrease encroaching shrubs without increasing the extent and abundance of cheatgrass.

Twist Hills and Wolf Hole Valley complex (106,973 acres); this area supports a mixture of the aforementioned encroaching shrubs (snakeweed, rabbitbrush, and sagebrush; mean canopy cover: 20%) with good perennial grass cover (mean canopy cover: 26 %). Unfortunately, this area is bounded on the north and south by Cheatgrass Infested Areas. Within this complex and surrounding areas, there are sites that have responded positively (increased perennial grass and reduced shrub cover) and negatively (decreased shrub cover, cheatgrass dominant) to recent fires (Figure 4). This suggests to us that initially fire should be conducted on an experimental basis in the area and post-burn effects monitored again, to determine whether the benefits of fire can be realized (reduced shrubs) without an increase in the spatial extent/abundance of cheatgrass.

Fire Maintenance Management Priorities:

The Lower Hurricane Valley (85,815 acres); this area is characterized by excellent perennial grass cover (mean canopy cover: 45%), intact (not incised) valley bottoms due to the lack of cattle tanks, and low shrub cover (mean canopy cover: < 4%). Given its size and high quality, we have identified the Lower Hurricane Valley as the largest intact Great Basin grassland in Arizona. For this reason, we recommend that special attention be given to maintaining high perennial grass cover, low shrub cover, and intact drainage/valley bottoms in this superlative grassland.

Wild Band Valley, Antelope Valley, and Lower Uinkaret Plateau complex (190,921 acres); this large area is characterized by good perennial grass cover (mean canopy cover: 29%) and low shrub cover (mean canopy cover: 9%). It has more serious issues with erosion in the vicinity of cattle tanks and in drainage bottoms where livestock congregate but still, with some improvement here, is an ideal area for BLM to showcase its fire and grazing management in Great Basin grassland.

Hurricane Valley (57,302 acres); this area is also characterized by good perennial grass cover (mean canopy cover: 30%) and low shrub cover (mean canopy cover: 8%). However, the area has a significant problem with cheatgrass. Thus, the goal should be to maintain the open intact perennial grassland with periodic fire, as needed, to reduce shrubs, while not increasing the cover and extent of cheatgrass. Initially, experimental burns and monitoring are recommended for the reasons described above.

Grazing Restoration Management Priorities:

House Rock Valley and Upper Uinkaret Plateau (109,232 acres and 73,186 acres, respectively); both areas are in serious need of grazing rest; the lack of herbaceous ground cover has also caused serious erosion problems. According to an NRCS rangeland expert, these areas have the potential to be restored back to functioning grassland communities if grazing pressure is removed. Without a change in management, the grass component in these areas will most likely be irreversibly lost, as continued soil erosion will produce surface characteristics that prevent germination and establishment of perennial grass seedlings (Hennessey et al. 1983; Gibbens et al. 1986; Wood et al. 1982).

Kingman Field Office

Fire Restoration Management Priorities:

Goodwin Mesa (22,861 acres); this large, extensive mesa top has fair perennial grass cover (single site: 25% canopy cover) and moderate shrub cover (single site: 18%). Its size, contiguous BLM ownership, and mesa top location make it an excellent site for prescribed and/or wildland fire use. We recommend re-establishment of the historic fire regime (10-30 year fire return interval) to reduce shrubs and increase perennial grass cover.

Truxton Plains, Upper Elevations (30,629 acres); the area is characterized by open native grassland that is being heavily encroached upon by juniper from the surrounding hill slopes. Almost entirely under BLM ownership, the area would benefit greatly from the re-establishment of a 10-30 year fire return interval. Both prescribed and wild land fire use could be used to achieve this goal, however, grazing rest is needed (mean canopy cover of perennial grass: 5%) so that adequate fine fuel loads are present to ensure mortality of shrubs and young trees during burns.

Hackberry Valley (44,506 acres), Behm and Bozarth Mesa Complex (41,760 acres); these areas are characterized by low to moderate shrub cover (range: < 5% to 20% canopy cover) and variable perennial grass cover (range: < 1% to 20% canopy cover). Given their size and quality, the two sites are good candidates for BLM to engage and work with partners. A cooperative fire and grazing management effort with State and private landowners should focus on (1) increasing existing perennial grass cover and, (2) re-establishing a 10-30 year fire return interval to maintain an open, low-shrub aspect in these grasslands.

Hualapai Mountains Foothills (29,682 acres); the area is characterized by moderate shrub cover (mean canopy cover: 15%) and variable perennial grass cover (range: 3-16% canopy cover). Given the elevated shrub cover, we recommend that BLM work cooperatively with State and private land owners to increase the current perennial grass cover and restore a 10-30 year fire return interval to this grassland community. Because black grama (*Bouteloua eriopoda*) is common among perennial grasses here, we also recommend that experimental burns and monitoring be conducted to determine the species' response to different burn prescriptions and how these interact with precipitation patterns. Prescribed burning has been shown to negatively affect cover and biomass of black grama but only when burns were conducted during periods of drought (Reynolds & Bohning 1956; Cable 1967, 1973; Gosz & Gosz 1996; Drewa & Havstad 2000). However, the species is a common, and often a dominant, component of semidesert grasslands which historically experienced recurrent fire at 7-10 year frequencies (McPherson 1995; Kaib et al. 1996).

Fire Maintenance Management Priorities:
Lower Hualapai Valley (52,141 acres); this area is characterized by variable perennial grass cover (range: 1-10% canopy cover) with low shrub cover (mean canopy cover: 7%). While the bulk of the Lower Hualapai Valley is not under BLM ownership, this area may be an excellent place to engage and work with partners. A cooperative fire and grazing management effort involving BLM, State Lands and private landowners should (1) increase existing perennial grass cover and (2) return a 10-30 year fire return interval to this grassland.

Grazing Restoration Management Priorities:
Truxton Plains, Valley Bottom (33,686 acres) and the Upper Hualapai Valley (133,610 acres); both areas are badly in need of grazing rest (mean perennial grass canopy cover: < 2%). According to several NRCS range experts, these areas have the potential to be restored back to proper functioning grasslands if grazing pressure is removed. If there is not a change in the management the perennial grass component in these areas will probably be irreversibly lost due to severe soil erosion, lack of seed sources, and soil surface characteristics that are inhospitable for seedling establishment.

<u>Phoenix Field Office</u>

Fire Restoration Management Priorities:
Agua Fria National Monument and surrounding grasslands (188,502 acres); this area is a mix of open native and native restorable grasslands with low to moderate shrub cover values (range: <5% to 20 canopy cover). The area would benefit from maintaining or increasing current perennial grass cover (mean canopy cover: 9%) and re-establishing a 7-10 year fire return interval (to reduce shrubs). The Phoenix Field Office is currently working cooperatively with the USFS on the National Monument to tackle this priority issue; expanding the partnership to include State Lands and private landowners would permit BLM to work in the surrounding (contiguous) grasslands.

Weaver Mountain Flats (43,947 acres); this area is characterized by moderate shrub cover and would benefit from maintaining or increasing the current perennial grass cover and reintroducing a 7-10 year fire return interval. Land ownership is a mix of BLM, State and private land so that fire management will require a partnership between BLM and interested landowners.

Fire Maintenance Management Priorities:
Vekol Valley Grasslands on the Sonoran Desert National Monument (2,441 acres) , although small in size , this site represents one of the few remnant tobosa grasslands in the area. It is currently surrounded by invasive shrubs such as mesquite (*Prosopsis*

velutina) and creosote *(Larea tridentata)* which, in time, will encroach into this grassland without maintenance of high perennial grass (*Hilaria mutica*) canopy cover and a 7-10 year fire return interval. This area would also be an excellent site for collaborating with the Tohono O'odham Nation, as more extensive and intact tobosa grassland stands exist on their land adjacent to the Monument boundary.

Tucson Field Office

Fire Restoration Management Priorities:
Sonoita Grasslands and Empire Cienega National Conservation Area (111,930 acres); the area is characterized by variable shrub cover (range: < 5% to 39% canopy cover) and high perennial grass cover (mean canopy cover: 53%) although mesquite and other invasive shrubs are increasing throughout the area. We recommend maintaining the high perennial grass cover through continued good grazing management and conducting periodic prescribed burns to re-establish a 7-10 year fire return interval. Burns should be accompanied by monitoring to determine if Lehmann lovegrass, which is present at the site, is spreading in response to the burns. The area is a mix of BLM, State and private land; the Sonoita Valley Planning Partnership provides a forum to plan and implement landscape-scale fire restoration with interested landowners.

Altar Valley-Baboquiviri Mountains (92,546 acres); the area is characterized by fair perennial grass cover (range: 17-22% canopy cover) and moderate shrub cover (range: 14-25% canopy cover). This is a good site for the BLM to engage and work collaboratively with partners. A cooperative fire and grazing management effort involving the BLM, US Fish and Wildlife Service, State Lands, Altar Valley Alliance and other interested private landowners should attempt to maintain or increase perennial grass cover and re-establish a 7-10 year fire return interval.

Safford Field Office

Fire Restoration Management Priorities:
Peloncillos Wildland Fire Use Area (454,511 acres); this area is characterized by low to moderate shrub cover (range: < 5% to 20% canopy cover) and generally low perennial grass cover (mean canopy cover: 16%); it is a mix of open native, restorable native, and former grassland types. Given its size and diversity of grassland types, we recommend that BLM improve grazing management (i.e., increase existing perennial grass cover) so that wildland fire can be used on a landscape scale to reduce shrubs and invigorate perennial grasses and herbs. Re-establishment of the historic fire regime (7-10 year fire return interval) is also recommended.

Winchester-Galiuro Mountains (650,620 acres); this area is characterized by low to high shrub cover (range: < 5% to 56%) and poor to excellent perennial grass cover (range: < 1% to 54% canopy cover; mean: 20%); it is a mix of open native, restorable native and former grassland types. The size, remoteness, and biodiversity value of the site make it an excellent place for BLM to expand its collaborative work with partners. A cooperative fire and grazing management effort by BLM, State Lands, TNC and other private landowners should focus on maintaining or improving perennial grass cover, reducing invasive shrubs as needed, and re-establishing a natural, historic fire regime.

Apache-Navajo Grasslands (564,216 acres); this area of Great Basin grassland is characterized by moderate to high levels of juniper encroachment (single site: 23% canopy cover). There is past and current evidence of juniper "pushing" throughout the area which appears to have been successful in restoring perennial grass cover. Fire is another restoration tool. We recommend that the BLM work in partnership with the State Land Department and private land owners to implement prescribed burns and wildland fire use with the goal of restoring grasslands there and re-establishing a 10-30 year fire return interval.

Fire Maintenance Management Priority:
Apache-Navajo Grasslands (2,030,292 acres); part of a larger, contiguous Great Basin grassland system, this area is characterized by low shrub cover (mean: < 5% canopy cover) and fair to good perennial grass cover (range: 30-44% canopy cover). Our field reconnaissance was somewhat limited in this area so that our figures for perennial grass cover may not adequately characterize the entire area. Still, we recommend that the BLM work in partnership with State and private landowners to maintain or increase perennial grass cover and re-establish a 10-30 year fire return interval; the latter will maintain the diversity of herbaceous vegetation and keep encroaching shrubs from increasing.

Grazing Restoration Management Priorities:
Peloncillos Wildland Fire Use Area (498,463 acres); see above comments on grazing management.

Apache-Navajo Grasslands (199,601 acres); part of a larger, contiguous Great Basin grassland system, this area is characterized by low shrub cover and low perennial grass cover. We recommend that the BLM work in partnership with State and private landowners to improve grazing management and increase perennial grass cover. Without a change in management, the grass component will most likely be lost as continued erosion and soil movement will prevent establishment of perennial grass seedlings (Hennessey et al. 1983; Gibbens et al. 1986; Wood et al. 1982).

Analysis of Fire Occurrences: 1980 to 2002

In response to field office requests for more information on where fires were occurring on the landscape and in what vegetation types, we analyzed BLM's fire occurrence data from 1980 to 2002. Our analysis was restricted to Type 1 fires, or fires that occur on "BLM land protected by the BLM", because the dataset for other fire types was incomplete. Our analysis identified the number of fires, median acres burned, minimum and maximum acres burned, and total acres burned for all Type 1 fires grouped by the following categories: land owner, topography, elevation, and fuel model; these statistics were summarized for the state and for individual field office (Tables 12 - 32). A statewide assessment of the number and size of fires that occurred within fire-adapted and non fire-adapted vegetation communities was also completed (Figure 7, Table 32).

There were 3,617 Type 1 fires, burning a total of 450,020 acres on BLM land over the 22-year period (Table 12). Median fire size was 0.4 acres. The majority of Type 1 fires, especially those in the larger size classes (4,512 to 21,276 acres), occurred in fire-adapted vegetation communities (Table 12). The size of fires ranged from 0.1 acres to 21,276 acres with the greatest number of acres burned in flat and rolling topography (149,018 acres), between 2,501 and 4,500 feet in elevation (290,551 acres), and in the annual grass (A) fuel model (338,055 acres; Tables 13 – 15). A visual assessment of fire occurrences confirms the above description of BLM's 22-year fire history (see Figure 7); in addition, it points to a preponderance of small fires that occur at the transition zone between desert and other vegetation communities and along the Colorado River and major highways.

While the analysis results for each district primarily parallel the statewide findings, below are the summary findings for each district.

Arizona Strip District:
There were 1,523 Type 1 fires, burning a total of 182,116 acres of BLM land from 1980-2002. Median fire size was 0.1 acres. Fires ranged in size from 0.1 acres to 16,816 acres with the greatest number of acres burned in flat and rolling topography (72,047 acres), between 2,501 and 5,500 feet in elevation (153,110 acres), and in the annual grass (A) fuel model (146,696 acres; Tables 16 – 19).

Phoenix District:
A total of 1,134 Type 1 fires were reported, burning 152,113 acres of BLM land during the 22-year period. Median fire size was 1.0 acres. Fires ranged in size from 0.1 acres to 21,276 acres with the most acres burned in flat and rolling topography (53,391 acres), between 2,501 and 4,500 feet in elevation (133,735 acres), and in the annual grass (A) fuel model (137,409 acres; Tables 20 – 23).

Safford District:
There were 457 Type 1 fires, burning a total of 61,853 acres of BLM land from 1980-2002. Median fire size was 3.9 acres. Fires ranged in size from 0.1 acres to 14,560 acres with the greatest number of acres burned in flat and rolling topography (149,018 acres), between 2,501 and 4,500 feet in elevation (133,735 acres), and in the annual grass (A) fuel model (338,055 acres; Tables 24 – 27).

Yuma District:
A total of 503 Type 1 fires occurred over the 22-year period, burning 53,938 acres on BLM land. Median fire size was 0.5 acres. Fires ranged in size from 0.1 acres to 15,980 acres with most acres burning on the middle 1/3 of the slope (29,090 acres), between 0 and 500 feet in elevation (23,381 acres), and in the mature brush (B) fuel model (47,330 acres; Tables 28 – 31).

Conclusions

Statewide, most of the Type 1 fires that have occurred over the past 22 years were small in size (i.e., median fire size = 0.4 acres), and were located primarily in fire-adapted vegetation communities (Figure 7, Table 32). In addition, there were relatively few large fires (i.e., 4,512 to 21,276 acres) and 86 % of these occurred in fire-adapted communities. Together these results demonstrate the BLM's ability to effectively manage wildland fires and they suggest that, in the future, wildland fires can be used by the BLM for resource benefit in fire-adapted vegetation communities.

Table 12. Analysis of number of type 1 fires, median acres burned, minimum and maximum acres burned, and total acres burned by type 1 wildfires between 1980 and 2002, for nine ownership categories for all BLM field offices combined.

Land Owner	Number of Fires	Median Acres Burned	Min and Max Acres Burned	Total Acres Burned
BLM	3,617	0.4	0.1 – 21,276	450,019.7
BIA	9	3.0	0.1 – 2,500	2,933.6
NPS	1	2.0	2 - 2	2.0
FWS	8	27.5	0.1 – 2,560	3,948.3
USFS	2	80.2	0.4 - 160	160.4
Other Federal	3	30.0	3 - 500	533.0
State	178	2.0	0.1 – 10,301	20,033.2
Private	140	4.0	0.1 – 4,120	14,671.1
Tribal	11	1.0	0.1 - 40	48.10

Table 13. Analysis of number of type 1 fires, median acres burned, minimum and maximum acres burned, and total acres burned by type 1 wildfires between 1980 and 2002, in nine topographic categories for all BLM field offices combined.

Topography of Fire	Number of Fires	Median Acres Burned	Min and Max Acres Burned	Total Acres Burned
Ridgetop	371	1.0	0.1 – 14,560	73,023.9
Saddle	104	0.5	0.1 – 6,185	18,191.1
Upper 1/3 of Slope	454	0.3	0.1 – 5,135	29,506.7
Middle 1/3 of Slope	322	1.0	0.1 – 15,980	54,157.0
Lower 1/3 of Slope	317	1.0	0.1 – 9,380	64,670.4
Canyon Bottom	182	1.0	0.1 – 2,762	11,308.9
Valley Bottom	508	1.0	0.1 – 8,717	51,817.6
Mesa or Plateau	242	2.0	0.1 – 6,445	40,970.8
Flat or Rolling	1,472	0.2	0.1 – 21,276	149,018.2

Table 14. Analysis of number of type 1 fires, median acres burned, minimum and maximum acres burned, and total acres burned by type 1 wildfires between 1980 and 2002, in ten elevational categories for all BLM field offices combined.

Elevation (ft) of Fire	Number of Fires	Median Acres Burned	Min and Max Acres Burned	Total Acres Burned
0-500	431	0.5	0.1 – 3,408	25,449.0
501-1,500	285	1.0	0.1 – 2,500	10,378.5
1,501-2,500	444	1.0	0.1 – 8,682	43,872.7
2,501-3,500	785	1.0	0.1 – 21,276	182,989.8
3,501-4,500	600	2.0	0.1 – 10,301	107,560.5
4,501-5,500	811	0.1	0.1 – 16,816	68,928.8
5,501-6,500	399	0.1	0.1 – 14,560	46,807.5
6,501-7,500	140	0.1	0.1 – 3,297	4,374.9
7,501-8,500	50	0.2	0.1 – 1,350	1,985.7
8,501 +	4	0.2	0.1 – 0.5	1.0

Table 15. Analysis of number of type 1 fires, median acres burned, minimum and maximum acres burned, and total acres burned by type 1 wildfires between 1980 and 2002, in seventeen fuel model categories for all BLM field offices combined.

Fuel Model	Number of Fires	Median Acres Burned	Min and Max Acres Burned	Total Acres Burned
Annual Grass (A)	1,994	1.0	0.1 – 21,276	338,055.4
Mature Brush (B)	448	1.0	0.1 – 15,980	58,516.2
Open Pine w/ Grass (C)	194	0.2	0.1 – 1,350	3,618.0
Southern Rough (D)	2	3352.5	5 – 6,700	6,705.0
Hardwood Litter (E)	3	0.1	0.1 - 50	50.2
Interior Brush (F)	986	0.1	0.1 – 1,751	18,018.5
Short-needled Closed Conifer (H)	3	0.3	0.3 - 10	10.6
Heavy Slash (I)	2	30.1	0.2 - 60	60.2
Medium Slash (J)	3	0.5	0.1 - 197	197.6
Light Slash (K)	21	0.1	0.1 - 197	216.5
Perennial Grass (L)	101	4.0	0.1 – 4,120	15,688.9
Marsh Grass (N)	43	1.0	0.1 – 4,471	8,395.2
Dense Brush (O)	2	182.5	15 - 350	365.0
Southern Pine (P)	2	14.0	3 - 25	28.0
Mixed Conifer Hardwood (R)	0	1.0	1 - 1	1.0
Sagebrush w/ Grass (T)	151	2.5	0.1 – 13,312	42,069.3
Closed Long-needle Pine (U)	13	0.5	0.1 - 340	359.8

Table 16. Analysis of number of type 1 fires, median acres burned, minimum and maximum acres burned, and total acres burned by type 1 wildfires between 1980 and 2002, for nine ownership categories for the Arizona Strip field office.

Land Owner	Number of Fires	Median Acres Burned	Min and Max Acres Burned	Total Acres Burned
BLM	1,523	0.1	0.1 – 16,816	182,116.1
BIA	0	0	0	0
NPS	0	0	0	0
FWS	0	0	0	0
USFS	0	0	0	0
Other Federal	0	0	0	0
State	28	0.1	0.1 - 80	160.0
Private	25	.05	0.1 - 209	410.6
Tribal	0	0	0	0

Table 17. Analysis of number of type 1 fires, median acres burned, minimum and maximum acres burned, and total acres burned by type 1 wildfires between 1980 and 2002, in nine topographic categories for the Arizona Strip field office.

Topography of Fire	Number of Fires	Median Acres Burned	Min and Max Acres Burned	Total Acres Burned
Ridgetop	173	0.1	0.1 –13,312	28,656.5
Saddle	37	0.1	0.1 – 2,918	5,846.0
Upper 1/3 of Slope	237	0.1	0.1 – 2,850	7,744.2
Middle 1/3 of Slope	134	0.1	0.1 - 5,479	7,762.5
Lower 1/3 of Slope	123	0.1	0.1 - 8,000	18,804.9
Canyon Bottom	77	0.1	0.1 – 2,762	5,423.5
Valley Bottom	102	0.1	0.1 – 8,717	23,134.1
Mesa or Plateau	100	0.1	0.1 – 2,390	13,267.8
Flat or Rolling	593	0.1	0.1 - 16,816	72,047.2

Table 18. Analysis of number of type 1 fires, median acres burned, minimum and maximum acres burned, and total acres burned by type 1 wildfires between 1980 and 2002, in ten elevational categories for the Arizona Strip field office.

Elevation (ft) of Fire	**Number of Fires**	**Median Acres Burned**	**Min and Max Acres Burned**	**Total Acres Burned**
0-500	0	0	0	0
501-1,500	4	2.0	0.1 – 10	14.1
1,501-2,500	77	0.5	0.1 – 8,682	23,121.6
2,501-3,500	182	0.1	0.1 – 13,312	69,154.1
3,501-4,500	191	0.1	0.1 –7,406	36,962.0
4,501-5,500	649	0.1	0.1 - 16,816	46,994.4
5,501-6,500	330	0.1	0.1 – 1,554	4,048.5
6,501-7,500	102	0.1	0.1 - 241	407.8
7,501-8,500	41	0.5	0.1 – 1,350	1,984.2
8,501 +	0	0	0	0

Table 19. Analysis of number of type 1 fires, median acres burned, minimum and maximum acres burned, and total acres burned by type 1 wildfires between 1980 and 2002, in seventeen fuel model categories for the Arizona Strip field office.

Fuel Model	**Number of Fires**	**Median Acres Burned**	**Min and Max Acres Burned**	**Total Acres Burned**
Annual Grass (A)	424	1.0	0.1 – 16,816	146,696.3
Mature Brush (B)	7	0.2	0.1 – 60	61.8
Open Pine w/ Grass (C)	149	0.1	0.1 – 1,350	2,261.9
Southern Rough (D)	0	0	0	0
Hardwood Litter (E)	3	0.1	0.1 - 50	50.2
Interior Brush (F)	906	0.1	0.1 – 1,751	12,311.5
Short-needled Closed Conifer (H)	1	10.0	10 - 10	10.0
Heavy Slash (I)	2	30.1	0.2 - 60	60.2
Medium Slash (J)	3	0.5	0.1 - 197	197.6
Light Slash (K)	12	0.2	0.1 - 197	205.7
Perennial Grass (L)	15	20.0	0.1 – 2,500	3,902.3
Marsh Grass (N)	0	0	0	0
Dense Brush (O)	0	0	0	0
Southern Pine (P)	0	0	0	0
Mixed Conifer Hardwood (R)	1	1.0	1 - 1	1.0
Sagebrush w/ Grass (T)	45	0.2	0.1 – 13,312	16,908.8
Closed Long-needle Pine (U)	8	2.3	0.1 - 6	19.4

Table 20. Analysis of number of type 1 fires, median acres burned, minimum and maximum acres burned, and total acres burned by type 1 wildfires between 1980 and 2002, for nine ownership categories for the Phoenix and Kingman field offices.

Land Owner	Number of Fires	Median Acres Burned	Min and Max Acres Burned	Total Acres Burned
BLM	1,134	1.0	0.1 – 21,276	152,113.1
BIA	4	200.3	0.1 – 2,500	2,900.6
NPS	0	0	0	0
FWS	1	35.0	35 - 35	35.0
USFS	1	0.4	0.4 – 0.4	0.4
Other Federal	1	30.0	30 - 30	30.0
State	111	5.0	0.1 – 10,301	17,859.7
Private	84	5.0	0.1 – 4,120	13,015.0
Tribal	9	1.0	0.1 - 2	8.0

Table 21. Analysis of number of type 1 fires, median acres burned, minimum and maximum acres burned, and total acres burned by type 1 wildfires between 1980 and 2002, in nine topographic categories for the Phoenix and Kingman field offices.

Topography of Fire	Number of Fires	Median Acres Burned	Min and Max Acres Burned	Total Acres Burned
Ridgetop	134	2.0	0.1 – 6,000	17,243.9
Saddle	49	0.5	0.1 – 3,887	4,219.0
Upper 1/3 of Slope	158	1.8	0.1 – 5,135	19,240.7
Middle 1/3 of Slope	131	2.0	0.1 – 1,497	10,797.4
Lower 1/3 of Slope	131	2.0	0.1 – 9,380	39,326.0
Canyon Bottom	72	2.5	0.1 – 700	3,930.5
Valley Bottom	128	1.0	0.1 – 5,471	13,150.4
Mesa or Plateau	112	3.0	0.1 – 6,445	24,662.0
Flat or Rolling	432	0.7	0.1 - 21,276	53,391.9

Table 22. Analysis of number of type 1 fires, median acres burned, minimum and maximum acres burned, and total acres burned by type 1 wildfires between 1980 and 2002, in ten elevational categories for the Phoenix and Kingman field offices.

Elevation (ft) of Fire	Number of Fires	Median Acres Burned	Min and Max Acres Burned	Total Acres Burned
0-500	19	0.5	0.1 – 1,300	2,068.3
501-1,500	173	1.0	0.1 – 2,500	7,957.6
1,501-2,500	332	1.0	0.1 – 1,730	19,672.3
2,501-3,500	457	1.0	0.1 – 21,276	89,669.9
3,501-4,500	184	2.0	0.1 – 10,301	44,064.6
4,501-5,500	91	4.0	0.1 – 4,824	16,970.6
5,501-6,500	41	0.5	0.1 – 3,887	4,901.9
6,501-7,500	35	0.3	0.1 - 340	654.1
7,501-8,500	9	0.1	0.1 – 0.5	1.5
8,501 +	4	0.2	0.1 – 0.5	1.0

Table 23. Analysis of number of type 1 fires, median acres burned, minimum and maximum acres burned, and total acres burned by type 1 wildfires between 1980 and 2002, in seventeen fuel model categories for the Phoenix and Kingman field offices.

Fuel Model	Number of Fires	Median Acres Burned	Min and Max Acres Burned	Total Acres Burned
Annual Grass (A)	1066	1.0	0.1 – 21,276	137,409.2
Mature Brush (B)	43	80.0	0.1 – 1,300	11,050.5
Open Pine w/ Grass (C)	45	2.0	0.1 - 545	1,350.1
Southern Rough (D)	2	3352.5	5 –6,700	6,705.0
Hardwood Litter (E)	0	0	0	0
Interior Brush (F)	53	0.5	0.1 - 526	948.9
Short-needled Closed Conifer (H)	2	0.3	0.3 – 0.3	0.6
Heavy Slash (I)	0	0	0	0
Medium Slash (J)	0	0	0	0
Light Slash (K)	7	0.1	0.1 - 10	10.6
Perennial Grass (L)	38	5.0	0.1 – 4,120	8,892.4
Marsh Grass (N)	0	0	0	0
Dense Brush (O)	1	15.0	15 - 15	15.0
Southern Pine (P)	1	25.0	25 - 25	25.0
Mixed Conifer Hardwood (R)	0	0	0	0
Sagebrush w/ Grass (T)	82	5.0	0.1 – 10,301	19,214.1
Closed Long-needle Pine (U)	5	0.1	0.1 - 340	340.4

Table 24. Analysis of number of type 1 fires, median acres burned, minimum and maximum acres burned, and total acres burned by type 1 wildfires between 1980 and 2002, for nine ownership categories for the Safford and Tucson field offices.

Land Owner	**Number of Fires**	**Median Acres Burned**	**Min and Max Acres Burned**	**Total Acres Burned**
BLM	457	3.9	0.1 – 14,560	61,852.5
BIA	0	0	0	0
NPS	0	0	0	0
FWS	0	0	0	0
USFS	1	160.0	160 - 160	160.0
Other Federal	0	0	0	0
State	20	27.5	0.1 - 530	1,711.1
Private	10	6.0	0.1 - 300	361.6
Tribal	1	40.0	0.1 - 40	40.0

Table 25. Analysis of number of type 1 fires, median acres burned, minimum and maximum acres burned, and total acres burned by type 1 wildfires between 1980 and 2002, in nine topographic categories for the Safford and Tucson Field Offices.

Topography of Fire	**Number of Fires**	**Median Acres Burned**	**Min and Max Acres Burned**	**Total Acres Burned**
Ridgetop	56	10.0	0.1 – 14,560	27,121.4
Saddle	18	26.0	0.1 – 6,185	8,126.1
Upper 1/3 of Slope	56	5.5	0.1 – 690	2,456.7
Middle 1/3 of Slope	52	25.0	0.1 – 1,300	6,189.7
Lower 1/3 of Slope	51	5.0	0.1 – 1,615	3,703.7
Canyon Bottom	26	1.5	0.1 – 615	1,579.9
Valley Bottom	100	2.3	0.1 – 4,471	8,179.2
Mesa or Plateau	21	10.0	0.1 – 400	1,674.5
Flat or Rolling	109	1.0	0.1 – 1,350	5,094.0

Table 26. Analysis of number of type 1 fires, median acres burned, minimum and maximum acres burned, and total acres burned by type 1 wildfires between 1980 and 2002, in ten elevational categories for the Safford and Tucson field offices.

Elevation (ft) of Fire	Number of Fires	Median Acres Burned	Min and Max Acres Burned	Total Acres Burned
0-500	0	0	0	0
501-1,500	4	6.0	0.1 - 30	42.9
1,501-2,500	23	5.0	0.1 - 96	460.8
2,501-3,500	138	2.3	0.1 - 614	4,478.7
3,501-4,500	224	3.0	0.1 – 6,185	26,133.9
4,501-5,500	70	8.5	0.1 - 965	4,938.8
5,501-6,500	27	45.0	0.1 – 14,560	24,757.1
6,501-7,500	3	15.0	1 – 3,297	3,313.0
7,501-8,500	0	0	0	0
8,501 +	0	0	0	0

Table 27. Analysis of number of type 1 fires, median acres burned, minimum and maximum acres burned, and total acres burned by type 1 wildfires between 1980 and 2002, in seventeen fuel model categories for the Safford and Tucson Field Offices.

Fuel Model	Number of Fires	Median Acres Burned	Min and Max Acres Burned	Total Acres Burned
Annual Grass (A)	405	4.0	0.1 – 14,560	45,836.5
Mature Brush (B)	2	36.6	0.1 – 73	73.1
Open Pine w/ Grass (C)	0	0	0	0
Southern Rough (D)	0	0	0	0
Hardwood Litter (E)	0	0	0	0
Interior Brush (F)	26	12.5	0.1 – 1,615	4733.1
Short-needled Closed Conifer (H)	0	0	0	0
Heavy Slash (I)	0	0	0	0
Medium Slash (J)	0	0	0	0
Light Slash (K)	1	0.1	0.1 – 0.1	0.1
Perennial Grass (L)	31	1.5	0.1 – 1,117	2,692.6
Marsh Grass (N)	2	2423.0	375 – 4,471	4,846.0
Dense Brush (O)	0	0	0	0
Southern Pine (P)	0	0	0	0
Mixed Conifer Hardwood (R)	0	0	0	0
Sagebrush w/ Grass (T)	22	4.3	0.2 – 3,297	5,943.8
Closed Long-needle Pine (U)	0	0	0	0

Table 28. Analysis of number of type 1 fires, median acres burned, minimum and maximum acres burned, and total acres burned by type 1 wildfires between 1980 and 2002, for nine ownership categories for the Yuma and Lake Havasu field offices.

Land Owner	Number of Fires	Median Acres Burned	Min and Max Acres Burned	Total Acres Burned
BLM	503	0.5	0.1 – 15,980	53,938
BIA	5	3.0	2 - 20	33.0
NPS	1	2.0	2 - 2	2.0
FWS	7	20.0	4 – 2,560	3,913.3
USFS	0	0	0	0
Other Federal	2	251.5	3 - 500	503.0
State	19	0.5	0.1 - 125	302.4
Private	21	5.0	0.1 - 300	883.9
Tribal	1	0.1	0.1 – 0.1	0.1

Table 29. Analysis of number of type 1 fires, median acres burned, minimum and maximum acres burned, and total acres burned by type 1 wildfires between 1980 and 2002, in nine topographic categories for the Yuma and Lake Havasu field offices.

Topography of Fire	Number of Fires	Median Acres Burned	Min and Max Acres Burned	Total Acres Burned
Ridgetop	8	0.1	0.1 – 1	2.1
Saddle	0	0	0 – 0	0
Upper 1/3 of Slope	3	25.0	0.1 – 40	65.1
Middle 1/3 of Slope	5	10.0	0.1 – 15,980	29,090.4
Lower 1/3 of Slope	51	5.0	0.1 – 1,615	3,703.7
Canyon Bottom	7	0.3	0.1 – 350	375.8
Valley Bottom	178	1.0	0.1 - 3,408	7,353.9
Mesa or Plateau	9	0.1	0.1 – 1,300	1,366.5
Flat or Rolling	338	0.5	0.1 – 3,352	18,485.1

Table 30. Analysis of number of type 1 fires, median acres burned, minimum and maximum acres burned, and total acres burned by type 1 wildfires between 1980 and 2002, in ten elevational categories for the Yuma and Lake Havasu field offices.

Elevation (ft) of Fire	Number of Fires	Median Acres Burned	Min and Max Acres Burned	Total Acres Burned
0-500	431	0.5	0.1 – 3,408	23,380.7
501-1,500	104	1.0	0.1 - 700	2,363.9
1,501-2,500	12	2.0	0.1 - 424	618.0
2,501-3,500	8	3.0	0.1 – 15,980	19,687.1
3,501-4,500	1	400.0	400 - 400	400.0
4,501-5,500	1	25.0	25 - 25	25.0
5,501-6,500	1	13,100	13,100 – 13,100	13,100
6,501-7,500	0	0	0	0.0
7,501-8,500	0	0	0	0.0
8,501 +	0	0	0	0.0

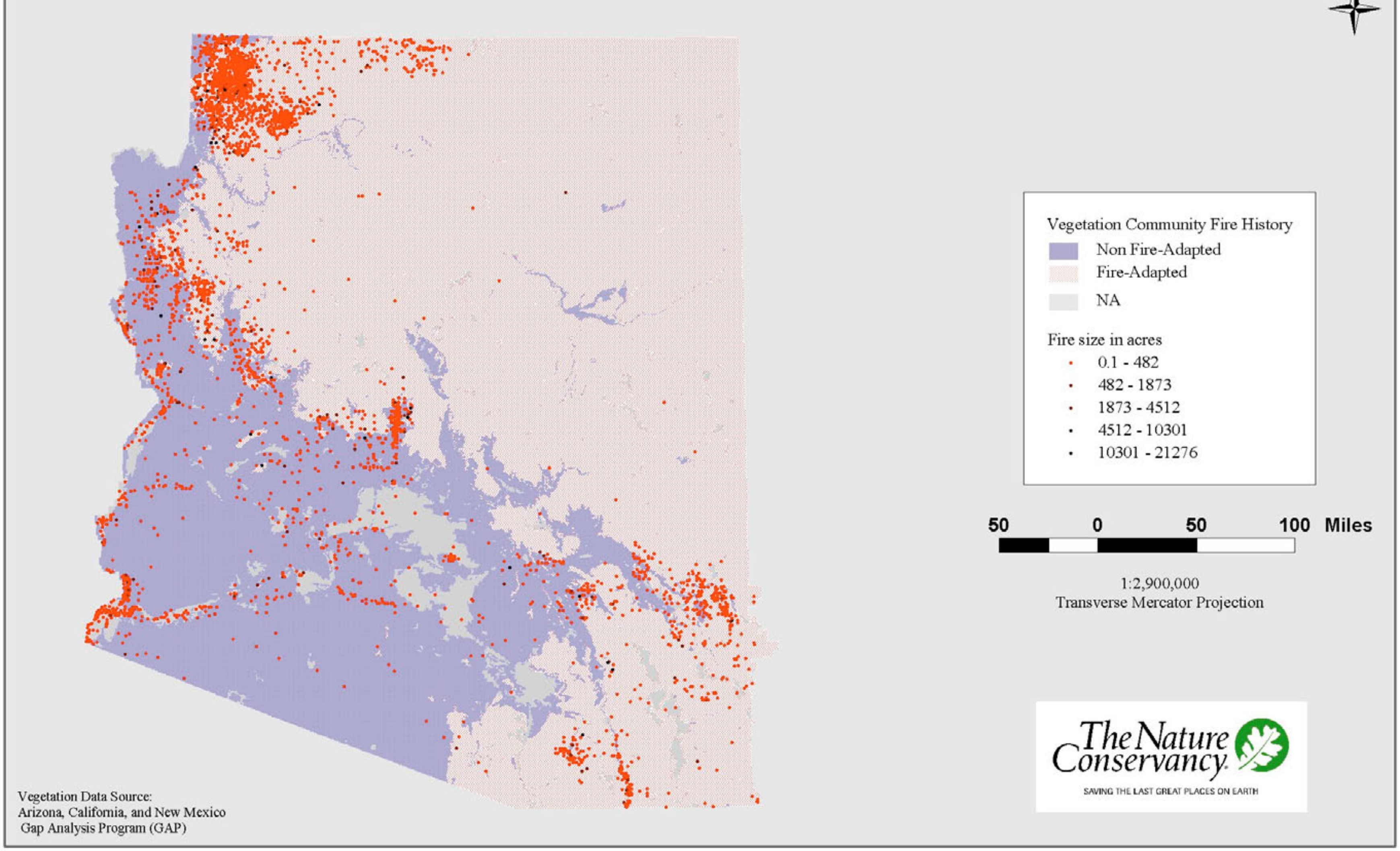
Table 31. Analysis of number of type 1 fires, median acres burned, minimum and maximum acres burned, and total acres burned by type 1 wildfires between 1980 and 2002, in seventeen fuel model categories for the Yuma and Lake Havasu field offices.

Fuel Model	Number of Fires	Median Acres Burned	Min and Max Acres Burned	Total Acres Burned
Annual Grass (A)	99	0.1	0.1 – 3,352	8,113.4
Mature Brush (B)	396	1.0	0.1 – 15,980	47,330.8
Open Pine w/ Grass (C)	0	0	0	0
Southern Rough (D)	0	0	0	0
Hardwood Litter (E)	0	0	0	0
Interior Brush (F)	1	25.0	25 - 25	25.0
Short-needled Closed Conifer (H)	0	0	0	0
Heavy Slash (I)	0	0	0	0
Medium Slash (J)	0	0	0	0
Light Slash (K)	1	0.1	0.1 - .01	0.1
Perennial Grass (L)	17	1.0	0.1 - 100	201.6
Marsh Grass (N)	41	1.0	0.1 - 890	3,549.2
Dense Brush (O)	1	350.0	350 - 350	350.0
Southern Pine (P)	1	3.0	3 - 3	3.0
Mixed Conifer Hardwood (R)	0	0	0	0
Sagebrush w/ Grass (T)	2	1.3	0.1 – 2.5	2.6
Closed Long-needle Pine (U)	0	0	0	0

Table 32. Analysis of total number of type 1 fires by size class, total number of fires in fire-adapted communities, and the total percent of fires occurring in fire-adapted communities between 1980 and 2002 for the BLM statewide.

Fire Size (acres)	Total Fires	Fires in Fire-Adapted Communities	Percent Fires in Fire-Adapted Communities
10,301 – 21,276	7	6	86
4,512 – 10,300	29	25	86
1,873 – 4,511	40	30	75
482 – 1,872	102	74	73
0.1 - 481	3,791	2,294	61

Figure 7. A Comparison of Type 1 Fire Occurrences for the Last 22 years with Fire History of Arizona's Vegetation Communities



SECTION 3: NEWLY CREATED OR COMPILED INFORMATION

Spatial Layers

After reviewing current BLM fire management plans and available data on vegetation cover and Wildland Urban Interface (WUI) risk areas, we determined that additional information was needed in several areas. To address these needs, we created the following statewide spatial layers for use in future fire management planning: current grassland extent and condition map, historic fire return interval map, revised WUI risk map, and revised (recommended) Phase I polygon designations (Table 33). Below is a brief description of each new spatial layer.

Grassland Extent and Condition:
See Section 2 describing the grassland assessment and accompanying spatial layer (Figure 1; Table 33).

Historic Fire Return Intervals:
Many vegetation communities in the Southwest experienced relatively frequent wildfires historically which shaped and maintained their species composition and vegetation structure (McPherson 1995; Swetnam & Baisan 1996). However fire suppression, through active means since the 1980's, and passively, through livestock grazing since the late 1800's, has essentially removed fire from these vegetation communities (Wright & Bailey 1982; Swetnam & Baisan 1996, McPherson 1997, Miller & Rose 1999). In forested communities, fire suppression has led to unnaturally dense canopies with many small diameter trees and little herbaceous cover (Covington & Moore 1994). Grassland communities in Arizona have also experienced dramatic changes. Encroachment by fire-intolerant trees and shrubs has left few grasslands open and shrub-free (this report; McPherson 1995, 1997; Kepner et al. 2000). In an effort to assist BLM in restoring fire to its natural ecological role, we created a detailed map of historic fire return intervals by vegetation community based on the most current scientific literature (Figure 8, Table 34). The vegetation communities used in the analysis were the same as those used in the Arizona Statewide Land Use Plan Amendment for Fire, Fuels and Air Quality Management; these were generated from the Arizona, California, and New Mexico GAP maps by Dynamac Corporation. This information should be useful at both the landscape and site levels to (1) identify fire-adapted vegetation communities, and (2) give a general target for the amount of prescribed and wildland fire needed to bring an area back to its historic fire regime.

Wild Land Urban Interface:
As part of our field office meetings, we queried BLM staff about the accuracy of the first draft of the Wildland Urban Interface (WUI) risk map created by Mike Fisher, Pam McAlpin and others from the State Office. BLM field staff indicated a number of problems with the map including omissions of important WUI areas. Using an experts approach, we asked meeting participants to improve the original map in one of three ways. The first was to have BLM staff draw boundaries of known WUI risk areas on hard-copy maps at various scales (ranging from 1:100,000 to 1:850,000) and then we

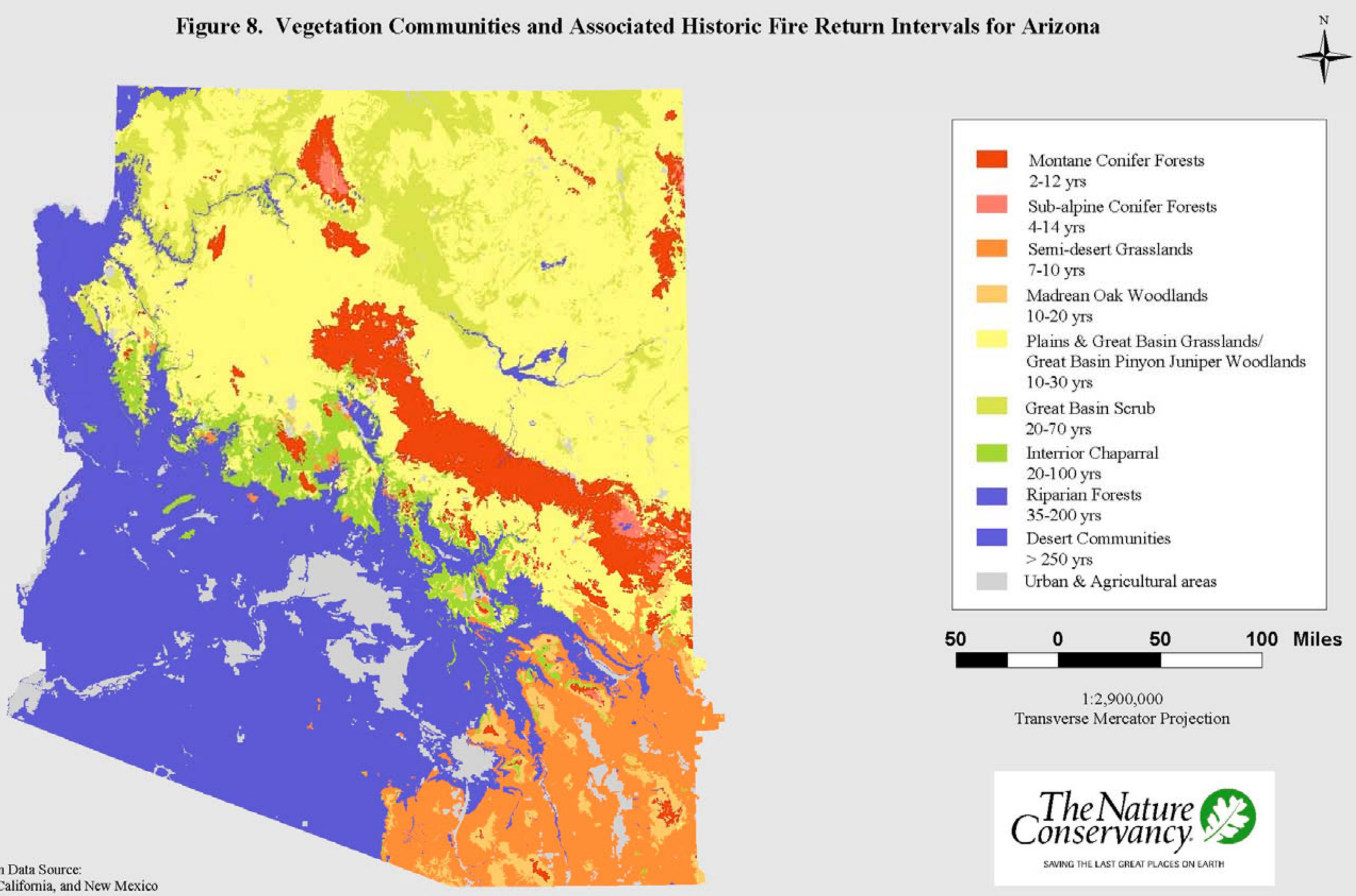
digitized those boundaries in Arcview (e.g., Kingman, Phoenix, and Yuma field offices). The second way was to have field office staff digitize WUI risk boundaries and send us the files (e.g., Lake Havasu). The third approach was to obtain files of WUI risk boundaries that were created by the field office for other projects. Specifically, the Arizona Strip Field Office created a WUI spatial layer for their Resource Management Plan planning process that includes the location of all structures and communities. Similarly, Tucson field office created a fine-scale WUI risk layer for the area surrounding the San Pedro River. Ultimately, this process resulted in three separate WUI files (Kingman_yuma_phx; Azstrip_wui, and Hazardratings) with varying levels of detail (Figure 9). The file generated from the first and second methods resulted in a broad-scale WUI risk map, while the third approach contained finer-scale information that is probably most useful at a site-planning level.

Phase I Polygons:
See Section 5 describing the Phase I polygon revisions and accompanying spatial layer (Figure 10; Table 33).

Table 33. Reference table of created and compiled information descriptions and associated file types and names.

Description	**File Type**	**File Name(s)**
Grassland extent and condition	ArcView 3.0	Grassland_extent_condition
Grassland assessment field sampling points	ArcView 3.0	Grassland_field_pts
Cheatgrass Infested Areas	ArcView 3.0	Cheatgrass_areas
Arizona's historic fire return interval	ArcView 3.0	Fire_return_interval
Wildland Urban Interface assessments	ArcView 3.0	AzStrip_wui Kingman_yuma_phx Hazardratings
Phase I polygon revisions	ArcView 3.0	Revised_phase1
Fire Literature Bibliography for Arizon's Vegetation Communities and Wildlife	MS Word	Fire_Literature_Bibliography
Fire Literature Bibliography for Arizona's Vegetation Communities and Wildlife	MS Procite	Fire_Literature
Grassland assessment photographic database	MS Excel	Grassland_Photo_Database
Grassland assessment photographic database	JPEG, TIFF	By field point site name
Final Report	PDF	Final_Report

Figure 8. Vegetation Communities and Associated Historic Fire Return Intervals for Arizona



Vegetation Data Source:
Arizona, California, and New Mexico
Gap Analysis Program (GAP)

Table 34. Identification of scientific literature sources used in the creation of the historic fire return intervals for Arizona's vegetation communities.

Vegetation Community	Historic Fire Return Interval (years)	Source(s)
Lower Sonoran Desert Scrub	> 250	Wright & Bailey 1982
Upland Sonoran Desert Scrub	> 250	Wright & Bailey 1982
Mohave Desert Scrub	> 250	Wright & Bailey 1982
Chihuahuan Desert Scrub	7 - 10	Is actually Semi-desert Grassland community (see Semi-desert Grassland resources)
Semi-desert Grassland	7 - 10	McPherson in McClaran & Van Devender 1995
Madrean Evergreen Woodland	10 - 20	USFS Fire Effects Information System , McPherson 1997
Plains & Great Basin Grassland	10 - 30	NRCS MLRU descriptions
Great Basin Desert Scrub	20 - 70	USFS Fire Effects Information System, Wright & Bailey 1982, Miller & Rose 1999, Miller & Tausch 2001
Great Basin Pinyon Juniper Woodland	10 - 30	USFS Fire Effects Information System, Wright & Bailey 1982
Interior Chaparral	20 - 100	Wright & Bailey 1982
Montane Conifer Forest	2 - 12	USFS Fire Effects Information System, Baisan & Swetnam 1990, Swetnam, Baisan, Caprio, & Brown 1992
Sub-alpine Grassland	10 - 20	Based on proximity to other fire regimes
Sub-alpine Conifer Forest	4 - 14	USFS Fire Effects Information System, Baisan & Swetnam 1990, Swetnam, Baisan, Caprio, & Brown 1992
Riparian	35 - 200	USFS Fire Effects Information System
Urban/Agricultural	NA	NA

Databases

Fire Literature Bibliography:

The Fire Literature Bibliography for Arizona's Vegetation Communities and Wildlife is a compilation of information from peer-reviewed and "gray" literature sources dealing with the effects of fire on the major vegetation communities and selected wildlife species in Arizona. The bibliography contains citation information along with a complete abstract for most of the 313 entries and is organized by the following vegetation communities: desert, Great Basin, interior chaparral, montane conifer, oak woodland, pinyon-juniper, riparian, and semi-desert grassland, as well as by desert tortoise and a fire general category. For riparian communities, we included general references on aquatic species and on riparian forest ecology and dynamics that we hope will be useful in the management of these sensitive habitats. It is accessible as a Word document (Fire_Literature_Bibliography.doc), a Windows ProCite searchable database (Fire_Literature.pdt) and in hardcopy format.

Grassland Assessment Photographic Database:
This database consists of digital copies of all photographs taken at each field sampling point in the State (Figure 2). Photographs were saved as either TIFF or JPEG images that range in size from 500 KB to 4.0 MB. An Excel spreadsheet (Grassland_Photo_Database.xls) was created that identifies the date, UTM location, site name, photograph name and comments associated with each photograph. We hope this is a valuable source of information for identifying current vegetation condition as well as a monitoring tool (repeat photography) for documenting vegetation trends in response to management.

<u>State-and-Transition Vegetation Model</u>

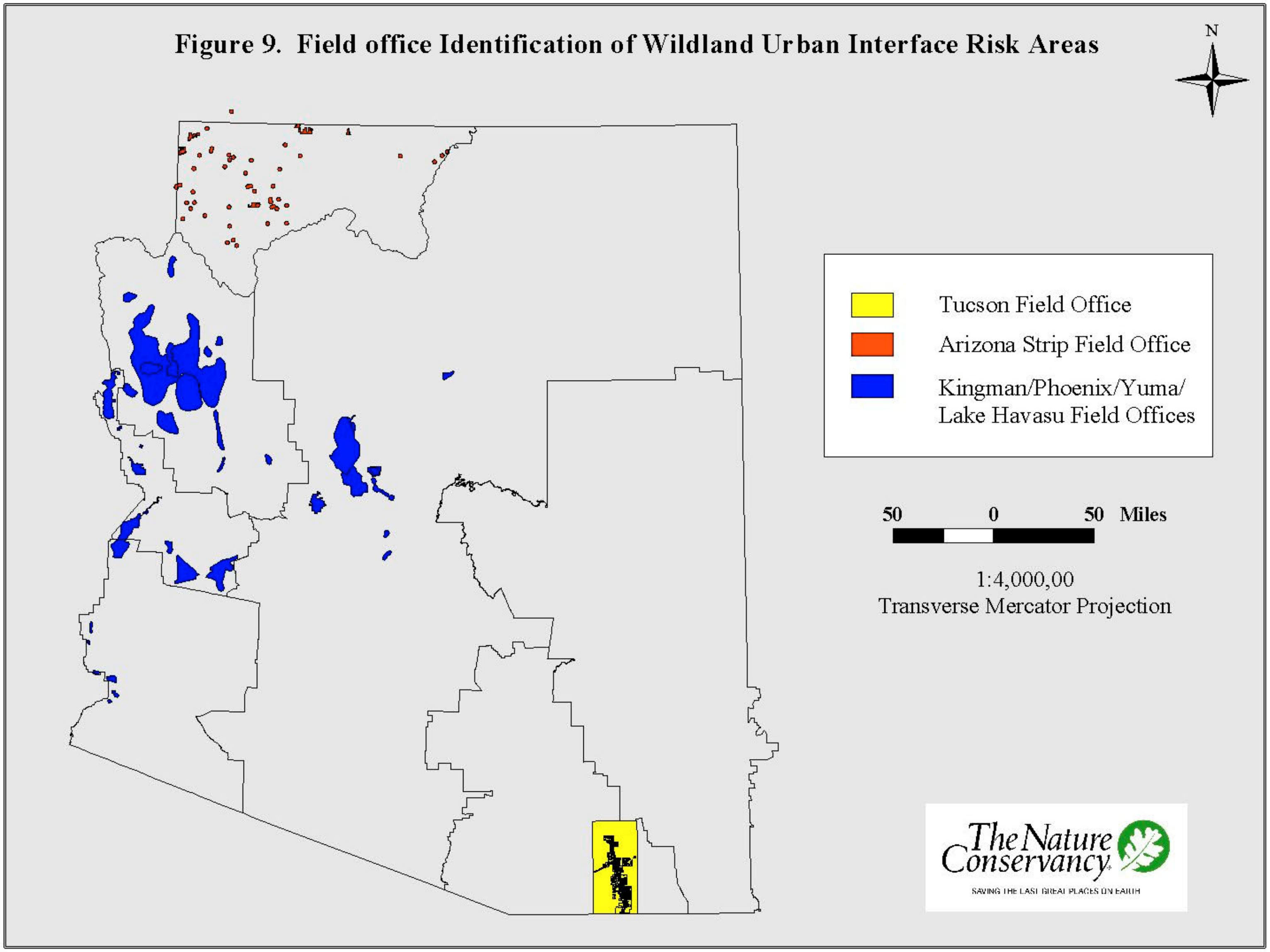
Great Basin Transition Vegetation:
In response to the Arizona Strip field office's need for better tools for fire management planning in the Great Basin Transition Zone, we developed a vegetation model using Vegetation Dynamics Development Tool (VDDT) software. This software allows the user to model succession as a series of vegetation states that differ in structure, composition, and cover and to specify the amount of time it takes to move from one vegetation state to another in the absence of disturbance. Various disturbance agents affecting the movement of vegetation between states can then be incorporated (e.g., surface fires, stand-replacing fires, grazing, insect outbreaks). By varying the types and rates of disturbance across the landscape, the effects of different management treatments, such as wildland fire use, fire suppression, prescribed burning, grazing practices, and mechanical fuel treatments, on future vegetation can be investigated.

The Great Basin Transition Zone VDDT model was created using information from the literature and from discussions with Tim Duck (Ecologist, Parashant National Monument) and Kathleen Harcksen (Assistant Monument Manager, Parashant National Monument). The resulting state-and-transition model identifies vegetation composition, structure, and woody canopy cover for each of its five states and the number of years that each state persists without disturbance (e.g., fire) before moving to another state (Figures 11 and 12). Given the Arizona Strip field office's goal to do planning at the field office level, we created a broad vegetation model that included several vegetation communities: Great Basin grassland, pinyon-juniper woodland, and sagebrush steppe. As an alternative approach we could have created separate models for each of the component vegetation communities but we felt that this level of detail was unjustified given the scale of the planning effort.

Using the model and VDDT software, we investigated the effect of a changing fire regime on Great Basin Transition Zone vegetation. As model input, we used the best available information from the literature to reconstruct historic and current fire regimes. The modeling results are summarized in Figure 13. Under the historic fire regime, the majority (43%) of Great Basin Transition Zone vegetation was in an open grassland state with most of the remaining vegetation in grass-sagebrush or grass-pinyon/juniper states (47%); there was little vegetation in closed canopy pinyon/juniper or sagebrush states (9%). These vegetation percentages differed greatly from those obtained from the current fire regime (i.e., fire suppression). Under this scenario, closed canopy pinyon/juniper was the dominant vegetation type (57%), with little open grassland remaining (1%). These results suggest that pinyon/juniper woodland and sagebrush communities have increased at the expense of open grassland due to the last 120 years of fire suppression. This conclusion is in line with our grassland assessment and a number of other studies that have documented these vegetation changes throughout the Southwest (Wright et al. 1979, Wright & Bailey 1982, Miller & Rose 1999, Miller & Tausch 2001).

These results illustrate the landscape-level vegetation changes that can be identified through the modeling process; they also raise questions for future investigation. Specifically, Tim Duck and Kathleen Harcksen suggested looking beyond historic and current fire regimes to see what effect other factors, such as grazing practices, insect outbreaks, mechanical treatments, and periodic drought, might have on the relative abundance of vegetation states. Ultimately, increasing the complexity of the model will improve its ability to more accurately describe current and potential vegetation states, which may be useful at a more detailed, site-planning level. However, there is still great heuristic value in a simple model that incorporates vegetation, historic fire regime, and fire management at a landscape level. We hope this model will be useful to BLM staff and to the public as a graphical representation of current and possible future vegetation conditions and as tool for identifying management actions that achieve desired conditions.

Figure 9. Field office Identification of Wildland Urban Interface Risk Areas



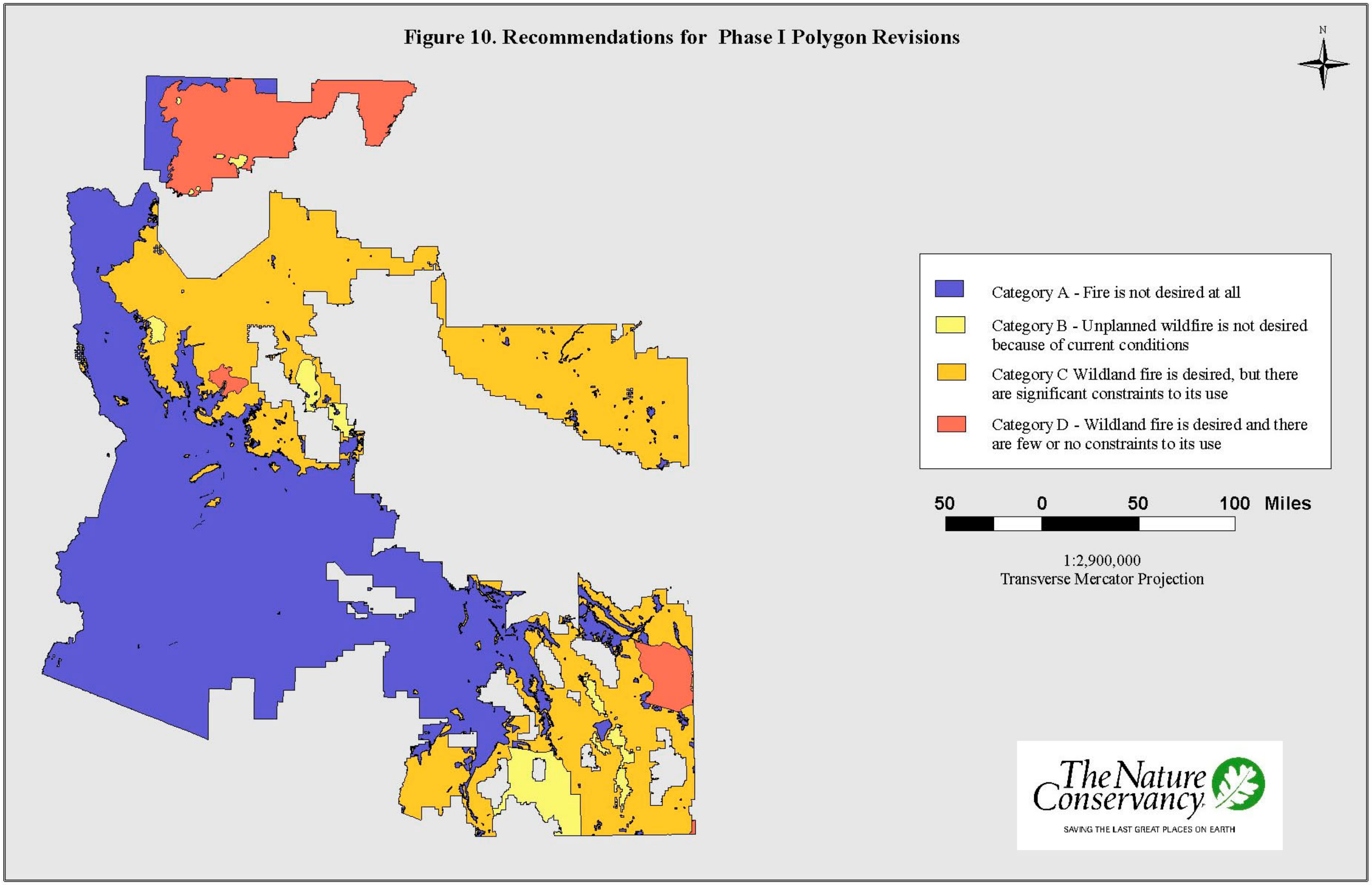


Figure 10. Recommendations for Phase I Polygon Revisions
N
Category A - Fire is not desired at all
Category B - Unplanned wildfire is not desired because of current conditions
Category C Wildland fire is desired, but there are significant constraints to its use
Category D - Wildland fire is desired and there are few or no constraints to its use
50 0 50 100 Miles
1:2,900,000
Transverse Mercator Projection
The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH

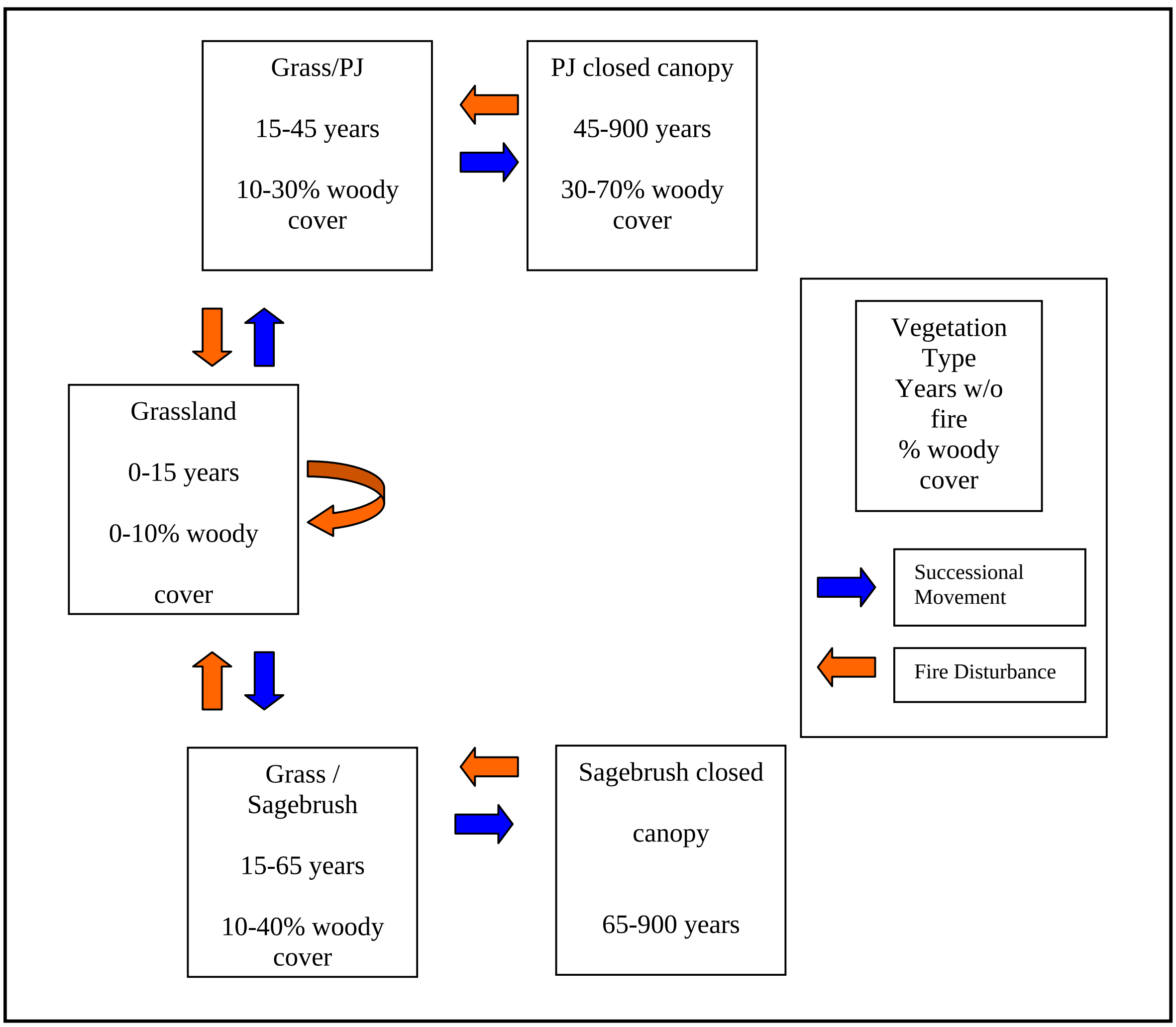


Figure 11. Diagram of Great Basin Transition Zone Vegetation Five Box State-and-Transition Model

Grass/PJ (10-30% woody cover)

PJ Closed Canopy (30-70 % woody cover)

Grassland (0-10 % woody cover)

Grass/Sagebrush (10-40 % woody cover)

Sagebrush Closed Canopy (40-70 % woody cover)

Figure 12. Photographic Model of Great Basin Transition Vegetation Model

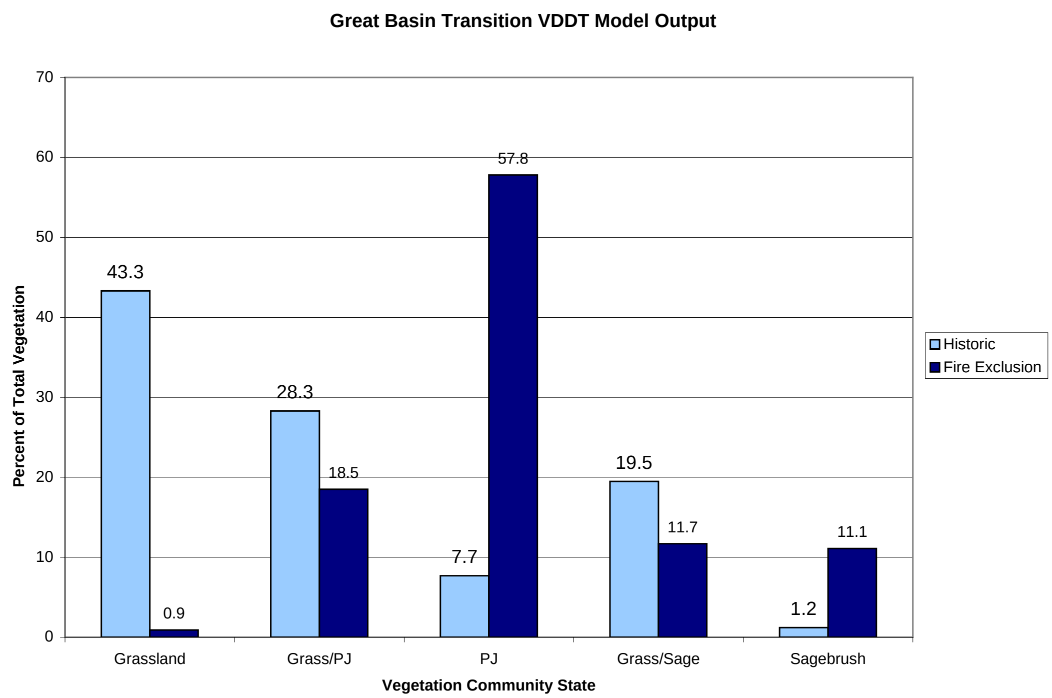


Figure 13. Output for Historic and Current Fire Regime Scenarios for the Great Basin Transition Zone Vegetation Model

SECTION 4: CURRENT FIRE MANAGEMENT PLANS

Current Phase I Polygons and Their Fire Management Prescriptions: A Review

Phase I polygons are designated into 1 of 4 fire management categories which provide broad direction on how wildland fire, prescribed burning, and other fuel treatments will be managed within the polygon boundaries. The recently completed Statewide Land Use Plan Amendment for Fire, Fuels and Air Quality Management (BLM 2003) defines these four fire management categories as follows:

> **Category A:** ***Areas where fire is not desired at all.*** This category includes areas where fire never played a large role historically in the development and maintenance of the ecosystem and areas where fire return intervals were very long. It also includes areas where mitigation and suppression are required to prevent direct threats to life or property.
>
> **Category B:** ***Areas where unplanned wildfire is not desired because of current conditions.*** These are ecosystems (including some WUI areas) where an unplanned ignition could have negative effects unless/until some form of mitigation takes place.
>
> Where fuel loading is high, BLM will use prescribed fire, biological, mechanical, and/or chemical treatments to mitigate the fuel loadings and meet resource objectives.
>
> **Category C:** ***Areas where wildland fire is desired but where there are significant constraints that must be considered for its use.*** These are areas where significant ecological, social or political constraints (such as air quality, threatened and endangered species considerations, or wildlife habitat considerations) limit wildland fire use.
>
> In areas where conditions are suitable for fire, BLM will emphasize prescribed fire and allow natually-ignited wildland fire to achieve resource objectives; otherwise BLM will utilize a combination of biological, mechanical, and/or chemical treatments.
>
> **Category D:** ***Areas where wildland fire is desired and there are few or no constraints for its use.*** These are areas where planned and unplanned wildfire may be used to achieve desired objectives such as to improve vegetation, wildlife habitat or watershed conditions.
>
> In Category D areas, BLM will emphasize prescribed fire and naturally-ignited fires to achiever resource objectives; fire suppression activities and biological, chemical and mechanical fuel treatments will be minimized.

To assess the standardization and ecological relevance of current Phase 1 polygons and their fire management prescriptions, we reviewed the existing fire management plans for the 7 BLM field offices and conducted two analyses. The first was a spatial analysis of Phase I polygon locations in relation to the distribution of vegetation communities where fire did and did not play an important ecological role in community development and maintenance. Our objective, here, was to identify Phase I polygons where the broad direction in fire management was or was not consistent with the ecological role of fire in their associated vegetation communities. The second analysis evaluated the target acreages for prescribed burns and wildland fire in Phase I polygons in the context of the historical (ecological) fire return interval for vegetation communities contained within them. In addition, we met with BLM staff from the 7 field offices between March and May, 2003, to (among other things):

1) improve our understanding of how Phase 1 and FMZ polygons were defined;
2) clarify some questions we had on polygon boundaries; and
3) identify, for key polygons, the major constraints (e.g., ecological issues, human development patterns, ranch improvements, land-ownership, endangered species concerns) to allowing wildland fire to burn for resource benefit.

A Review of Current Phase I and FMZ Polygons

The different fire management plans vary considerably in how Phase I polygons, FMZ's and Representative Locations (RL's) were defined, as well as in their hierarchical and spatial relationship to each other. In the Arizona Strip plan, Phase I and FMZ polygon boundaries were defined on the basis of vegetation; RL boundaries were defined on the basis of access, topography, and human settlement patterns. In general, one or more FMZ's were contained within Phase I polygons (as a result of using vegetation to define both) with a few exceptions. Staff felt that these exceptions, cases where single FMZ-RL polygons straddled the boundaries and occurred in two Phase I polygons, made little sense ecologically, or from a fire management standpoint, and were probably an artifact of digitizing polgyon boundaries from hard-copy maps for use in GIS. Staff provided us with a copy of an updated vegetation map for use in our Phase I polgyon revisions; this will also be the base-map used in their RMP revision.

In the Phoenix-Kingman plan, Phase I polygon boundaries were defined primarily on the basis of vegetation with land ownership playing a secondary role; there is a 1:1 correspondence between Phase I polygons and the FMZ-RL polygons. Our recommended revisions place less emphasis on land ownership (see Federal Wildland Fire Management Policy and IM No. 2002-034 for guidance) which enabled us to identify additional Phase I polygons for fire adapted vegetative communities embedded within the existing KA4 and PA4 polgyons.

In the Yuma-Lake Havasus plan, Phase I polygons and FMZ's were defined primarily on the basis of vegetation while RL's, were defined by vegetation and land ownership. Phase I polygons were subdivided into one or more FMZ-RL's. Boundaries of Phase I and FMZ polygons along the Colorado and Bill Williams rivers did not correspond precisely to the distribution of riparian vegetation as mapped by AZ GAP but included upland desert vegetation to varying degrees. Staff suggested these boundary discrepancies could be resolved by using the Bureau of Reclamation's riparian vegetation map instead of AZ GAP. We received a copy of this vegetation layer from Barbara Bowles.

Variation in how Phase I and FMZ-RL polygons were designated and in their spatial relationship to one another were considerable for the Tucson-Safford plan. Phase I and FMZ-RL polygons appeared to be defined, not by vegetation, but by differing social and political constraints on fire management; polygon boundaries were defined by land ownership, topography, and defensible fire break features, such as roads and drainage pathways. There was little evidence of a hierarchical structure or approach in designating Phase I and FMZ polygons. In some cases, FMZ RL's were composed of one to several Phase I polygons, or portions thereof, in other cases, Phase I polygons were composed of several FMZ-RL's. Lastly, staff concurred that the operational division of FMZ's into annual vs. perennial grasslands was applied incorrectly in designating FMZ's. That is, except for FMZ1 RL2 (SA3), grasslands in all FMZ 1 and FMZ 2 polygons are perennial. In revising polygon boundaries, staff were supportive of a hierarchical approach, starting with Phase I polygons defined on the basis of vegetation which, in turn, could be sub-divided into one or more FMZ-RL's (now called Fire Management Units) based on land ownership, topography and social, political and resource constraints on fire management. Staff also agreed that the total number of polygons should be reduced.

Fire Return Intervals Under Current Management

The effect of fire on vegetation depends largely on fire season and frequency and less so on fire behavior (McPherson 1995). Historic fire season and frequency (historic fire return interval) have been identified for different vegetation associations based on tree ring studies and inferences that assume the elevational continuity of fuels. In order to determine to what degree the current Fire Management Plans were allowing fire to function in its *natural* ecological role, we compared the known historic fire return interval for major vegetation types with the expected fire return interval under current management, for key Phase I polgyons. This analysis indicated that for some Phase I polygons and vegetation types, the expected fire return interval under current management (assuming annual wildfires are contained at the targeted acreage) was close to the historic fire return interval [Table 35; semi-desert grassland in Dripping Springs (TB2) and Altar Valley (TB3)]. However, for most polygons, the fire return interval under current management was significantly greater than the historic fire return interval [Table 35; e.g., semi-desert grassland, encinal oak woodland, Interior chaparral, in South and North Rim Aravaipa (SC1, SC2)].

There are more accurate methods for calculating current fire return intervals, however, this analysis underscores the fact that current fire management prescriptions for Phase I polygons (i.e., target acreages for wildland fire and prescribed burns) are too low to mimic the historic (ecological) fire return interval. Staff in all field offices readily acknowledged the need to ramp-up the use of wildland fire and prescribed burning but

Table 35. Example of historic vs. current Fire Return Interval analysis completed for selected field office polygons

Field Office	Polygon Name	Vegetation Description	Current Management	Historic Fire Return Interval	Current Fire Return Interval
Tucson	Dripping Springs (TB2)	82,411 BLM acres; 55,820 acres Sonoran desert scrub (68%); 17,887 acres s.d. grassland (22%); 7,427 acres chaparral (9%); 924 acres pinyon-juniper (1%)	confine unplanned ignitions to <500 acres at least 90% of time, using natural and man-made fuel breaks; desired burned acreage for semidesert grassland veg. is <1000 acres annually.	Approx. 8-10 yrs for s.d. grassland; 7-8 yrs for pinyon-juniper; ca. 25 years for chaparral	Approx. 18 yrs for s.d. grassland; 167 yrs for interior chaparral and P-J
Tucson	Altar Valley (TB3)	8,848 BLM acres; 3,586 acres of encinal oak (41%); 2,987 acres semidesert grassland (34%); 2,188 acres Sonoran desert scrub (25%);	confine unplanned ignition to public lands using natural and man-made fuel breaks; <500 acres per year at least 90 percent of the time	Approx. 8-10 yrs for s.d. grassland; 7-8 yrs for encinal	Approx. 17.5 yrs for s.d. grassland and encinal oak
Safford	South Rim Aravaipa (SC1)	69,874 total acres; 18,839 acres semidesert grassland (27%); 23,647 acres desert scrub-grassland transition (34%); 2,149 acres of Interior chaparral (03%); 6,358 acres of Encinal oak woodland (09%)	confine unplanned ignitions to <750 acres at least 90% of time under intensity levels 1-2 and <300 acres at intensity level 3; confine unplanned ignitions in riaparian area (Aravaipa or all riparian areas) to <100 acres per decade.	Approx. 8-10 yrs for semidesert grassland, desert scrub-grassland transition, 7-8 years for encinal woodland; approx. 25 yrs for interior chaparral	Approx. 93 years for semidesert grassland, desert scrub transition, encinal oak woodland and interior chaparral
Safford	North Rim Aravaipa (SC2)	Total: 55,468 acres; 5,801 acres interior chaparral (10%); 16,916 acres semidesert grassland (30%); 22,555 acres desert scrub-semidesert grassland transition (41%)	confine unplanned ignitions annually to <500 acres at least 90% of time.	Approx. 8-10 yrs for semidesert grassland, desert scrub-grassland transition; ca. 25 yrs for interior chaparral	Approx. 112 years for grassland, grassland-scrub transition, and interior chaparral

Field Office	Polygon Name	Vegetation Description	Current Management	Historic Fire Return Interval	Current Fire Return Interval
Kingman	Pine Lake (KB3)	58,292 total acres of which 48,064 acres are BLM, 211 acres Great Basin scrub (.004%), 1,120 acres Great Basin grassland (.02 %), 26,431 acres chaparral (55 %), 14,287 acres PJ (30 %), 5,340 ponderosa pine (11 %)	Burn up to 100 acres annually in ponderosa pine and maintain a 10 -year burn cycle. Burn up to 1000 acres annually in chaparral.	Approx. 2-9 yrs for ponderosa pine and 20-100 yrs for chaparral	Approx. 53.4 yrs for ponderosa pine; 26.5 yrs for chaparral
Phoenix	Harquahala (PB1)	12,642 acres of BLM and State Lands, 12,642 acres chaparral (100%)	Prescribed fire in the Harquahala mountains would be limited to 200 acres per year	Approx. 20-100 years for chaparral	Approx. 63 yrs for chaparral

identified 3 barriers to doing so. They were: (1) endangered species issues (i.e., desert tortoise in chaparral habitats); (2) grazing management concerns (i.e., increased burn acreages would be difficult to accommodate since a significant portion of individual allotments must be rested and burned on a decadal cycle); and, (3) the uncertainty regarding the effects of fire on vegetation communities and soils for specific vegetation types. These include fire effects in desert-chaparral transitions, effects on unburned old-growth chaparral, as well as the time course of perennial grass recovery in grasslands after burns.

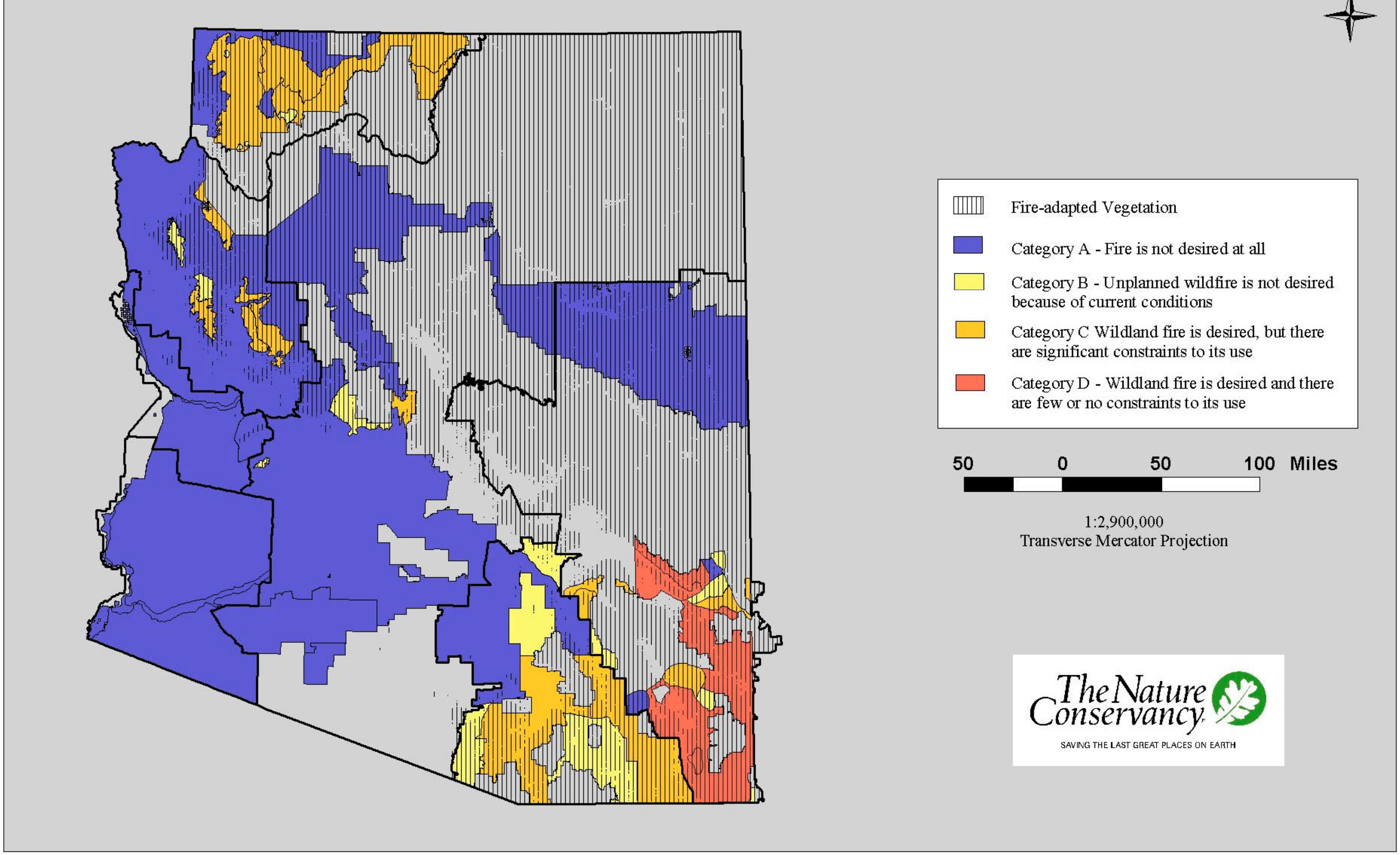
We developed the spatial layer of historic fire return intervals by vegetation community to assist BLM in setting fire management prescriptions that are ecologically relevant. Phase I polgyons and Fire Management Units (FMU) can be overlaid on the spatial layer and the ecological fire return interval determined. With some simple calculations, target acreages for prescribed burns and wildland fire can be set so that the ecological fire return interval (or fire frequency) is approximated.

Coarse-Scale Spatial Analysis of Phase I Polygons

To rapidly assess the ecological appropriateness of current Phase I polygon, we created a spatial layer of fire-adapted and non-fire adapted vegetation communities. To do this, we used the modified GAP vegetation layer for Arizona, New Mexico, and California that Dynamac Corporation developed for the the Arizona Statewide Land Use Plan Amendment for Fire, Fuels, and Air Quality Management, and classified vegetation communities as either fire-adapted or non-adapted based on information from the scientific literature. Vegetation communities that historically experienced very infrequent fire were classified as non fire-adapted (Riparian Forest and Desert Scrub); the remaining vegetation was classified as fire-adapted. We then superimposed current Phase I polygons on this layer (Figure 14).

There are extensive areas of fire-adapted vegetation in the central and northern portion of the State that are designated as Category A (where fire is not desired at all). The constraints to wildland and prescribed fire use in these areas appear to be largely land ownership patterns and not ecology. In contrast, in southeastern Arizona, there are large areas of non fire-adapted vegetation that lie within Category C or D polygons where wildland fire is desired. Our recommended revisions will attempt to make Phase I polygon designations more consistent with the fire ecology of vegetation communities that fall within them.

Figure 14. Comparison of Fire-adapted Vegetation Communities and BLM's Current Phase I Polygon Designations



SECTION 5. RECOMMENDATIONS FOR PHASE I POLYGON REVISIONS

An Ecological Approach for Designating and Revising Phase I Polygons

The Federal Wildland Fire Management Policy (BLM 1995) directs that:

1) fire management plans and activities will be based on the best available science;
2) wildland fire will be used to protect, maintain and enhance resources and be allowed to function, as nearly as possible, in its *natural* ecological role; and
3) fire as a critical natural process will be incorporated into activities *on a landscape scale and across agency boundaries*.

Based on this guidance, we propose the following hierarchical approach for designating (and revising) Phase I polygons:

Level I. *Vegetation Type and Fire Ecology*: this factor carries the greatest weight in polygon designation and considers:

- current and historic structure and composition of the vegetation
- current fuel loads and resulting fire behavior and intensity
- historic fire return intervals, and
- endangered species concerns.

For additional information on historic vegetation consult the Fire Regime Condition Class website (http://fire.org/free/) which has descriptions of all potential vegetation communities for the western US and the estimated relative abundances of their component seral or structural states.

Level II. *Social and Political Concerns:* this factor is less important in polygon designation than Level I (but more important than Level III) and considers:

- Wildland Urban Interface areas and issues
- Grazing concerns (i.e., temporary loss of forage, potential impacts to range improvements, etc.), and
- Special management designations (i.e., national monuments, wilderness areas, areas of critical environmental concern, etc.). Currently, only some wilderness areas have approved management plans and none provide specific direction on fire management.

Level III. *Land Ownership Pattern:* this factor is given least weight in polygon designation because recent federal directives clearly encourage agencies to plan for and implement fire management beyond jurisdictional boundaries. Current BLM fire management plans strongly emphasize land ownership in polygon designation causing many mismatches between polygon categories and the fire ecology of vegetation falling within them. By putting less weight on land ownership, our recommended revisions give BLM greater flexibility in working with partners. Given land ownership patterns, the management and restoration of grasslands on a landscape scale require partnerships between federal, State, and private land managers. Once catalyzed, these partnerships (e.g., Malpai Borderland Group) have numerous advantages including: greater financial resources for fire planning, management, research and monitoring, lower per-acre costs for prescribed burning, greater efficiency in managing and/or suppressing wildland fire, and increased access to different human communities for education and outreach.

In our experience, endangered species have not seriously constrained fire use over the long-term. Disagreements with the US Fish and Wildlife Service over fire management and endangered species have arisen due to a lack of credible scientific information on how fire affects species of concern. Prescribed burns, especially those that are done on an experimental basis, with replicated treatment and control plots, have provided excellent opportunities to collect this information. Once it is obtained, prescribed burns and wildland fire use have been permitted subject to the implementation of reasonable mitigation measures. An example of this involves the Lesser long-nosed bat (*Leptonycteris curasoae yerbabuenae*). The US Fish and Wildlife was concerned that fire use would negatively impact the bat because fires killed agaves, an important food source for the bat. A review of past prescribed burns and wildfires revealed that agave mortality never exceeded 10% (Warren and Gori, unpublished data). Subsequently, an experimental study demonstrated that germination and establishment of Palmer's agave (*Agave palmeri*) was significantly greater on burned plots compared to controls and that recruitment of young agaves following burns exceeded mortality on adults (Johnson 2001). Another study conducted near a large bat roost found that only a small fraction of the available nectar and pollen in agaves were used by bats (Slauson 1999). That is, agaves as a food source do not limit population size in Lesser long-nosed bats. In light of this information, the US Fish and Wildlife Service now requires only that agave mortality be monitored after a burn and that it not exceed 10%. The monitoring is easy to conduct and, to our knowledge, mortality has never exceeded 10%. There are other examples of how research and monitoring have resolved conflicts over fire use and endangered species (e.g., New Mexico ridgenose rattlesnake, *Crotalus willardi obscurus*, in the Peloncillo Mountains). Similarly, William Boyett, a wildlife biologist in the Kingman Field Office, is using a similar approach for the Hualapai Mexican vole (*Microtus mexicanus hualpaiensis*). Ultimately these examples suggest that, in most cases, the ecologically responsible use of fire should not detrimentally impact endangered species but rather can improve overall habitat in many fire-adapted vegetation communities.

Recommendations for Phase I Polygon Revision

We evaluated and revised current Phase I polygon boundaries and their designations using the ecological approach described in the previous section and all available spatial and non-spatial data (Figure 10). We used the modified GAP vegetation map produced for the Arizona Statewide Land Use Plan Amendment for Fire, Fuels, and Air Quality Management (BLM 2003) as the base map for these polygon revisions, but also considered the grassland assessment and the revised WUI layer. In general, areas that contained Sonoran and Mojave desert vegetation and riparian vegetation were classified as Category A. Areas with Chihuahuan desert scrub were designated as Category C based on the grassland assessment where experts classified most Chihuahuan desert scrub as historic grassland (Type F). Although this vegetation type normally lacks sufficient fuels to carry a fire, under extreme conditions it may burn, creating an opportunity for the re-establishment of perennial grasses once competing shrubs are removed. The C designation, then, gives BLM the flexibility to allow wildland fire to burn for resource benefit in a vegetation type where fires are rare and tend to be small. Most areas containing fire-adapted vegetation types were designated as either Category C or Category D. An exception to this was some of the Ponderosa pine forests, which were classified as Category B, in recognition of the elevated fuel loads that characterize this community type and the fact that wildfires are normally stand-replacing. The Category B designation gives BLM the option of conducting prescribed burns after thinning or other fuel reduction treatments. (Prescribed burns in Ponderosa pine can also be implemented without prior fuel treatment if prescriptions are developed that minimize the risk of severe fire effects.) Finally, WUI areas were designated as either Category A or B depending on the density of human settlement (concentrated vs. dispersed, respectively) and the fire ecology of the surrounding vegetation (not fire-adapted vs. fire adapted, respectively).

Statewide, the result of these revisions (Table 36) was to decrease the percent acres in Category A from 71% in current plans to 52%, and in Category B from 6% to 3%. The largest change occurred in Category C, where wildland fire is desired but there are significant constraints to its use; the current plans designated only 14% of acres as Category C compared to 37% in our revised scheme. Finally, percent acres in Category D increased from 6% in current plans to 8% in our recommended revisions. Although only a small percentage increase, the location of the revised Category D has changed substantially and, if adopted, will result in greater wildland fire use for resource benefits.

Table 36. Comparison of BLM's current Phase I polygons and our recommended revisions.

Phase I Category	Current	Revised
A	27,744,882	**19,954,050**
B	2,176,649	**1,246,366**
C	5,291,731	**14,387,224**
D	2,233,273	**3,073,967**
Total	37,446,535	**38,661,607**

* Total acreage is off by 1,215,072 acres due to the Safford Field Offices non-classified sections.

Based on discussions with field office staff and our own field reconnaissance, there are 4 major constraints that must be considered before allowing wildland fire to burn for resource benefits:

1) Wildland-urban interface issues and the loss of human structures/property;
2) Endangered species concerns;
3) Reduction of livestock forage over large areas resulting in financial hardship for livestock operators; and
4) Possibility of fire spread from fire-adapted plant communities into desert vegetation due to the continuity of fuels produced by non-native grasses and herbs.

None of these constraints are insurmountable in areas that we have designated as Category C or D, assuming they are addressed pro-actively in fire planning and management. For example, risk of property loss (i.e., structures) from wildland fire can be eliminated or greatly reduced through fuel reductions in WUI areas and around structures in rural areas using mechanical treatment and/or prescribed burns. Greater responsibility should also be placed on private landowners to reduce fuel loads on private land that adjoin BLM lands; this is especially true in pinyon-juniper woodlands and grasslands where mechanical or livestock-mediated fuel reduction can be implemented in a cost-effective manner. In fact, during our statewide field reconnaissance of grasslands we found only a handful of sites that had sufficient fine fuels to carry fire close to human structures and this situation is easily remedied using livestock.

Concern over impacts to endangered species may also constrain wildland fire use. However, in most cases this concern arises primarily due to the lack of credible scientific information on fire-effects (see previous section). Careful application of prescribed fire in an experimental setting with listed or sensitive species will provide the information needed to design appropriate wildland fire use prescriptions that minimize or alleviate fire-related impacts. Given the prevalence of fire-adapted vegetation communities in Arizona, we predict that prescribed and wildland fire will have either neutral, but more likely, positive effects on species of concern living in them. For example, at the Muleshoe Ranch CMA, upland watershed burns resulted in improvement in watershed condition and aquatic habitat and increases in native fish populations including Gila chub (*Gila intermedia*) populations (Brunson et al. 2001); Gila chub is currently proposed for federal listing as endangered. A number of other examples of positive effects of fire on listed or sensitive species are also known. These include the positive effects of fire on Palmer's agave recruitment and population size (Johnson 2001); *Agave palmeri* is an important food source for endangered Lesser long-nosed bats. Similarly, periodic burns in cienega wetland habitat have been shown to increase population size and flowering of Canelo Hills ladies' tresses orchid (*Spiranthes delitescens*), an endangered species (D. Gori, unpublished data) and wildland fire dramatically increased Wislizeni gentian (*Gentianella wislizenii*) populations, a USFS sensitive species, in the Chiricahua Mountains (Arizona Rare Plant Committee 2001). Finally, prescribed burns in fire-adapted long-leaf pine forests are being used to improve endangered Red-cockaded woodpecker habitat in the southeastern U.S. (e.g., James et al. 1997).

Another concern with wildland fire use is the possibility that all or a large portion of a rancher's forage production would be consumed by fire. Again, this can be prevented using prescribed burns or livestock to produce fire breaks and reduce fuel continuity, thereby preventing fire spread over an entire ranch. Furthermore, results of our grassland reconnaissance indicate that fuels are highly discontinuous due to livestock grazing, rock outcrops, areas with thin soils, and roads currently resulting in little to no risk of *widespread* fire in grasslands or pinyon-juniper woodlands. Furthermore, the long-term benefits in terms of increased quantity and quality of forage following burns should more than compensate for the short-term loss in forage production associated with wildland fire use.

Finally, the possibility that wildland fire in a fire-adapted community could spread into non-fire adapted (desert) vegetation presents another possible constraint to wildland fire use. This threat can be greatly reduced by fuels management in the interface of fire-adapted vs. non-adapted communities as well as the development of more restrictive wildland fire use prescriptions. An example of the latter might be to allow naturally ignited wildland fire to burn in all years *except after wet winters* when abundant, non-native grasses and herbs produce continuous fuels into desert habitats. In most other years, the risk of fire spread from chaparral or grassland into desert habitats is very low. Furthermore, coordinated field reconnaissance by BLM resource and fire staff prior to the fire season will provide better information on where high fuel loads may constrain wildland fire use near interface areas as well as areas where current fuel loads do not.

Polygon revisions and the justification for making them are discussed below for each field office.

<u>Arizona Strip Field Office</u>

Phase I polygons, or portions of them, containing Mojave desert vegetation were retained in Category A. Similarly, WUI areas around (and including) Fredonia and Colorado City were also designated as Category A. A small WUI area around the community of Hurricane was classified as Category B so that BLM could conduct prescribed burns in the surrounding grassland vegetation to protect dispersed structures there. Doing this would remove most constraints to wildland fire use in the adjacent Lower Hurricane Valley (Category D) except for the presence of cheatgrass there (see Figure 3 and discussion). The above WUI areas were defined using the new WUI spatial layer developed by the Arizona Strip Field Office (e.g., Azstrip_wui). Mt. Trumbull and other isolated Ponderosa pine forests were retained as Category B.

The remaining areas with fire-adapted vegetation were designated as Category D for the following reasons. The areas are remote, they occur in nearly contiguous blocks of BLM land, they possess many natural and human-made fuel breaks (e.g., rock outcrops, cliffs, areas of thin soils, poorly vegetated drainage bottoms due to livestock grazing, etc.) and there are few structures due to an extremely low population density. In fact, *de facto* wildland fire use is already occurring here. During our field reconnaissance we encountered a number of burns varying in size. These burns appeared to have beneficial effects on the vegetation including reductions in the density and cover of shrubs/trees and vigorous re-growth and establishment of perennial grasses and herbs.

Kingman Field Office

The most significant changes in Phase I polygons boundaries resulted from designating most areas with fire-adapted vegetation as Category C. Thus, interior chaparral, pinyon-juniper woodland and scrub, and grassland vegetation in current polygon KA4 was upgraded from Category A to Category C. Grassland sites that will benefit from this designation change (and fire use) include Truxton Plains, Hackberry Valley, Hualapai Valley and the foothills of the Hualapai Mountains. Land ownership in KA4 is mixed so fire use, prescribed or wildland, will require collaborative partnerships between the BLM, State Lands Department and private landowners. The Category C designation gives the BLM flexibility to develop these partnerships and to move their fire management from suppression to (pro)active fire use to achieve resource objectives. Similarly, the Cerbat Mountains were upgraded from Category B to Category C. Wildland fire use here is justified based on the vegetation (chaparral, pinyon-juniper), abundant natural fuel breaks, and the rugged, remote character of the area. It is unlikely that prescribed or wildland fire would move out of the mountains and threaten WUI communities to the west, except perhaps after winters with above-average precipitation when annual grasses and herbs increase fuel continuity.

The only other change of note was upgrading Goodwin, Behm, and Bozarth mesas from Category C to Category D. There are few constraints to wildland fire use in this area due to topography (e.g., broad, flat mesa tops isolated from the surrounding landscape by sheer, rocky cliffs) and the low density (absence) of human structures and developments (e.g., houses, power lines, communication sites, etc.).

Phoenix Field Office

Again, the most significant changes in Phase I polygons resulted from designating most areas with fire-adapted vegetation as Category C irrespective of land-ownership. Thus, most of polygon PA4 which is a mix of grasslands, pinyon-juniper scrub, and interior chaparral was upgraded from Category A to Category C. Similarly, PB2 (Bradshaw/Yarnell) which is composed predominantly of interior chaparral and pinyon-juniper-chaparral was upgraded from Category B to C. This area is sparsely populated and there seem to be few if any constraints for wildland fire use except for the concern that chaparral fires may negatively impact desert tortoise. More research and monitoring are clearly needed to adequately evaluate the desert tortoise concern; however, prescribed burns provide an excellent opportunity to collect relevant data. Still, the best-available information indicates that interior chaparral sustained relatively frequent fire historically (20 - 100 year fire frequency) suggesting that desert tortoise populations also experienced (and presumably persisted in the face of) periodic fire. In principle, we believe that desert tortoise populations are best managed by excluding fire from desert habitats (where fire was historically rare) rather than by trying to keep fire out of fire-adapted communities like chaparral. The former can be facilitated by reducing fuel loads in adjacent chaparral either through prescribed burns or wildland fire use, in the latter case, following dry winters when fine fuels (annual grasses/herbs) in the desert-chaparral transition are absent or discontinuous.

Several other changes of note include:
(1) Upgrading the Harquahuala Mountains (predominantly chaparral vegetation) from Category B to Category C; the preceding comments regarding chaparral and desert tortoise also apply here.
(2) Designating a WUI area in the Verde Valley as Category B; this gives BLM the flexibility of using prescribed burns to reduce fuel loads in surrounding grasslands, pinyon-juniper, and chaparral to protect dispersed structures there. This area was delineated using the new WUI layer (Kingman_yuma_phx).
(3) Upgrading the Cordes Junction area (PA1) from Category A to Category B; this area has significant WUI concerns but the new designation allows BLM to work cooperatively with the US Forest Service and State Lands Department to reduce fuels using prescribed burns.

Tucson Field Office

The most significant changes in Phase I polygons involved designating areas with fire-adapted vegetation as Category C and areas with desert or riparian vegetation as Category A. Thus, the grassland portions of current polygons TA1 (Sonoran Desert), TB1 (Oracle Grasslands), and TB2 (Dripping Springs Grasslands) were designated as Category C while their desert scrub portions became or were retained as Category A. Similarly, the current and former grassland portions of TC2 (Cochise Grasslands) were retained as Category C while portions of this polygon with desert or riparian vegetation were designated as Category A. The only other change was upgrading the Altar Valley Grassland polygon (TB3) from Category B to Category C. This designation gives BLM the option in working with partners (US Fish and Wildlife Service, State Lands, private landowners) to utilize the full range of fire management tools, including wildland fire, to reduce fuel loads and restore ecosystem health. We recommend that the BLM consult the grassland assessment map (Figure 1) for the location of non-native grasslands when developing fire management prescriptions for Category C polygons (or Fire Management Units). Finally, we retained B4 (Sierra Vista-Sonoita) as Category B in recognition of the growing WUI issues there.

Safford Field Office

There is limited Sonoran Desert vegetation in the Safford Field Office and this is restricted to portions of polygon SD1 (Ft. Thomas-Safford uplands) and SD2 (N. of Gila River). We downgraded these areas from Category D to Category A to reflect the fact that this community type is not fire-adapted. Phase I polygons, or portions thereof, containing grassland, former grassland, encinal oak woodland and/or interior chaparral were designated as Category C in recognition of the historic role that fire played in these communities. This was consistent with current designations for polygon SC5 (Saddleback Mtn.) and SC4 (Sheldon Mtn.) and resulted in upgrading polygon SA2 (Morenci) and SA3 (Texas Canyon) from Category A to Category C. Similarly, portions of polygon SD1, SD2 and SD3 (San Simon Valley) were downgraded from Category D to Category C. We did this in the case of SD1 and SD2 because of the proximity of fire-adapted vegetation types to Sonoran desert scrub and the resulting possibility that wildland fire could spread from the former to the latter in wet years when red brome was abundant. This and the presence of numerous towns along the Gila River pose significant (although not insurmountable) constraints to wildland fire use, thus justifying the Category C designation. In the case of SD3, the southern portion of this polygon contains little BLM land and subdivision is occurring on the west and east sides of the Chiricahua Mountains; these factors also pose significant constraints to wildland fire use making a Category C designation more appropriate. Finally, polygon SB1 (Muleshoe Ranch), SB2 (Guthrie Peak), SB3 (Upper S. Francisco River) and SB4 (Bowie Mtn.) were upgraded from Category B to Category C based on the (1) occurrence of grasslands, former grasslands and/or other fire-adapted vegetation within their boundaries; and (2) the rugged, remote, and sparsely populated character of these areas.

Other revisions include:

(1) creation of new polygons in the Sulphur Springs Valley containing active and abandoned agricultural land and dispersed human settlement; we designated these as Category B in recognition of the WUI issues and to give BLM the option of conducting prescribed burns to reduce fuel loads around structures and developments;

(2) addition of the Peloncillos Wildland Fire Use Area which was identified by BLM fire staff from the Safford Field Office and designated as Category D;

(3) Upgrading polygon SB5 (Guadelupe Canyon) from Category B to Category D. This area is remote, rugged, and sparsely populated; local ranchers (e.g., Malpai Borderland Group) have been working with TNC and federal and State agencies to allow wildland fire use. There are currently few constraints to wildland fire use, hence the Category D designation; and

(4) Upgrading polygon SA1 (Apache-Navajo) from Category A to Category C; this area contains extensive grasslands and pinyon-juniper savanna and woodland; ownership is a mix of BLM, State, National Park Service and private lands. This designation allows BLM to work with partners to restore fire to these vegetation communities (for additional discussion, see Grassland Management Priorities).

Yuma and Lake Havasu Field Offices

Current Phase I polygons containing riparian or desert vegetation were retained as Category A. Several new polygons were created around "islands" of chaparral vegetation including the Harcuvar Mountains; these were designated as Category C. These areas are remote, sparsely populated, under almost contiguous BLM ownership, and contain few structures and human developments. Thus, there are few constraints to wildland fire use except for the presence of desert tortoises in chaparral and desert-chaparral transition vegetation. The preceding comments regarding chaparral and desert tortoise apply here. Furthermore it is possible to write prescriptions for prescribed burns or wildland fire that will minimize impacts on the species. For example, prescribed burns could be conducted in the winter when tortoise are inactive or wildland fire could be used only following winters with below-average precipitation (when annual grasses and herbs are sparse/discontinuous in the desert-chaparral transition and fire is unlikely to spread into desert vegetation).

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Appendix A: Detailed description of data information, spatial information, and literature information needs, and other analyses requested by each field office.

Arizona Strip

Data Information Needs	Spatial Information Needs	Literature Information Needs	Other Analyses
Gather field data on the effects of fire on Great Basin transition zone vegetation *	Extend grassland assessment and mapping w/in FO boundary	Summarize existing information on the effects of fire on Great Basin transition zone vegetation *	Create a conceptual framework to assist in planning for the shifting mosaic of vegetation communities in the Great Basin transition zone
Gather field data on the effects of fire on riparian vegetation	Map relict old-growth stands of pinyon pine and juniper	Summarize existing information on the effects of fire on riparian vegetation	
Gather field data on post-burn recovery time of perennial grasses in grasslands and Great Basin transition zone vegetation*	Map the distribution of exotic annual grasses within FO boundary, identifying areas of high infestation	Summarize existing information on post-burn recovery time of perennial grasses in grasslands and Great Basin transition zone vegetation *	
Gather field data on the interaction of fire and grazing on vegetation response following burns		Summarize existing information on the interaction of fire and grazing on vegetation response following burns	

* This is a complex vegetation mosaic that includes grassland, sagebrush-pinyon-juniper savanna, sagebrush shrubland, pinyon-juniper woodland, pinyon-juniper-sagebrush woodland-scrub and transitions between them.

Appendix A (cont.): Detailed description of data information, spatial information, and literature information needs, and other analyses requested by each field office.

	Data Information Needs	Spatial Information Needs	Literature Information Needs	Other Analyses
Kingman				
	Gather field data on post-burn recovery time of perennial grasses in grasslands	Revise the Wildland Urban Interface map within FO boundary		Analyze fire occurrence data, looking at the number of fires and burn size by vegetation type.
	Gather field data on the effects of fire on riparian vegetation	Map the distribution of exotic annual grasses within FO boundary, identifying areas of high infestation		
	Gather field data on effects of fire and fire season on Interior chaparral and Interior chaparral-Sonoran Desert transition vegetation	Extend grassland assessment and mapping w/in FO boundary		
Phoenix				
	Data Information Needs	Spatial Information Needs	Literature Information Needs	Other Analyses
	Gather field data on the effects of fire, fire season, and time since last burn on Interior chaparral vegetation	Refine grassland assessment and mapping to include burn potential with ≤ 3 (or > 3) growing seasons grazing rest		
	Gather field data on the effects of fire on Desert tortoise populations in Interior chaparral and Interior chaparral-Sonoran Desert vegetation transition	Revise the Wildland Urban Interface map within FO boundary		
	Gather field data on the effects of fire on riparian vegetation	Map the distribution of exotic annual grasses within FO boundary, identifying areas of high infestation		

Appendix A (cont.): Detailed description of data information, spatial information, and literature information needs, and other analyses requested by each field office.

	Data Information Needs	Spatial Information Needs	Literature Information Needs	Other Analyses
Tucson				
	Gather field data on the effects of fire on riparian vegetation	Refine grassland assessment and mapping to include burn potential with ≤ 3 (or > 3) growing seasons grazing rest Map the distribution of exotic grasses within FO boundary, identifying areas of high infestation Revise the Wildland Urban Interface map within FO boundary		
Safford				
	Gather field data on the effects of fire on riparian vegetation	Refine grassland assessment and mapping to include burn potential with ≤ 3 (or > 3) growing seasons grazing rest Map the distribution of exotic grasses within FO boundary, identifying areas of high infestation Revise the Wildland Urban Interface map within their FO boundary		

Appendix A (cont.): Detailed description of data information, spatial information, and literature information needs, and other analyses requested by each field office.

	Data Information Needs	Spatial Information Needs	Literature Information Needs	Other Analyses
Yuma				
	Gather field data on the effects of fire on riparian vegetation	Revise the Wildland Urban Interface map within FO boundary	Summarize existing information on historic fire regime along lower Cololorado River and other streams; fire effects on saltcedar and native phreatophytes	Compile database and spatial layer for all restoration projects and treatments (prescribed burns, pole plantings, mechanical treatments), associated monitoring, and results to date for completed and ongoing projects along the Colorado River by federal, state agencies and tribes
			Control of and restoration techniques for Tamarisk-infested riparian areas	Summarize research results on fire effects on the Yuma clapper rail from Courtney Conway at The University of Arizona
Lake Havasu				
	Data Information Needs	Spatial Information Needs	Literature Information Needs	Other Analyses
	Gather field data on the effect of fire on Desert tortoise populations in the Harcuvar Mountains	Revise the Wildland Urban Interface map within FO boundary		
	Gather field data on the effects of fire on Interior chaparral vegetation in the Harcuvar Mountains			
	Gather field data on the effect of the Crossman Peak Fire on the Sonoran Desert vegetation			
	Gather field data on the effects of fire on riparian vegetation			

Appendix B. Name and affiliation of all grassland mapping experts.

Grassland Mapping Expert	**Affiliation**
Adams, Bob	National Resources Conservation Service
Ambos, Norm	United States Forest Service
Beamis, Ron	National Resources Conservation Service
Boles, Pat	Arizona State Land Department
Boyett, Bill	Bureau of Land Management
Brandau, Bill	Bureau of Land Management
Bunting, Whit	Bureau of Land Management
Cassady, Steve	National Resources Conservation Service
Curry, Kieth	Bureau of Land Management
Decker, Don	National Resources Conservation Service
Duncan, Chuck	United States Forest Service
Enquist, Carolyn	The Nature Conservancy
Fisher, David	National Resources Conservation Service
Gori, Dave	The Nature Conservancy
Haberstitch, Mark	The Nature Conservancy
Huling, Karlynn	National Resources Conservation Service
Lambeth, Byron	Bureau of Land Management
McAuliffe, Joe	Desert Botanical Gardens
McFee, Doug	United States Forest Service
McPherson, Guy	University of Arizona
Meade, Rachel	National Resources Conservation Service
Muldavin, Esteban	New Mexico Heritage Program
Pacific Biodiversity Institute	Pacific Biodiversity Institute
Parrott, Gary	National Resources Conservation Service
Reaves, Wade	Bureau of Land Management
Robertson, George	United States Forest Service
Robinett, Dan	National Resources Conservation Service
Sandberg, Bob	Bureau of Land Management
Schalau, Jeff	University of Arizona Cooperative Extension
Schoppmann, Kevin	Bureau of Land Management
Schussman, Heather	The Nature Conservancy
Spears, Jack	Bureau of Land Management
Stark, Larry	National Resources Conservation Service
Swope, Sarah	United States Forest Service
Thwait, Duane	United States Forest Service