SAVING THE LAST GREAT PLACES ON EARTH

GLOBAL FIRE INITIATIVE

Technical Report

An Ecological Assessment of Fire and Biodiversity Conservation Across the Lower 48 States of the U.S.

February 2007

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Cover Photo: A Nature Conservancy-led prescribed burn in Arizona. ©Ronald L. Myers

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contents

contents

List of Tables

List of Figures

executive summary

"To study fire is to inquire into one of the informing processes of the earth; to manage fire is to perform one of the defining acts of human beings. That, distilled, is the sufficient and necessary reason to understand fire." **(Pyne et al. 1996)**

This report presents the findings of an assessment of the ecological role and integrity of fire regimes across the lower 48 states of the U.S. Frequent fire return intervals dominate fire regimes across the assessment area. Approximately 80% of ecosystems, major habitat types, Nature Conservancy regions and the Conservancy's portfolio of conservation areas of biodiversity significance (conservation areas) are moderately to highly departed from their ecological reference conditions. Fire regime conditions do not differ substantially within versus outside the Conservancy's conservation areas, nor within versus outside federally-administered lands. Technical fire capacity and conservation actions targeted at abating fire-related threats across the Conservancy and partner organizations vary considerably and do not necessarily parallel the degree and extent of altered fire regime conditions across the U.S. nor within the Conservancy's priority conservation areas. To maintain and restore fire's ecological roles in ecosystems and, therefore, effectively conserve biodiversity, the Conservancy and partners must:

1. Restore the ecologically-appropriate roles of fire in forests, woodlands and shrublands where alteration has or will result in uncharacteristically severe fires and negative contributions to climate change.

2. Influence protected area and land management strategies, wildland fire use and fire exclusion policies to allow fire to more effectively play its ecological roles in more places.

3. Proactively reform fire, land use and air quality policies and timber harvest and domestic animal grazing plans and activities that alter fire regimes and fuel characteristics.

4. Educate policy-makers, decision-makers and the public in anticipation of inevitable conflicts between maintaining fire's ecological roles and the increasing expansion of human development into the wildland-urban interface.

5. Eliminate, influence or mitigate the impacts of housing and infrastructure development on ecologically-appropriate fire regimes and intact, large, roadless landscapes.

6. Leverage conservation actions through fire science, building effective capacity and fostering partnerships with governmental and non-governmental organizations that share goals for fire regime restoration.

Fire's ecological roles and sources of its alteration must be considered in conservation planning, prioritization, partnerships, taking action and measuring results. Maintaining and restoring fire's ecological roles in areas of high biodiversity value is tantamount to effective conservation wherever the Conservancy works.

1 fire & biodiversity conservation

Fire is a key process in many ecosystems around the world (Agee 1993; Hardesty et al. 2005; Myers 2006; Pyne et al. 1996). Fire can also be ecologically destructive; for example, where fire exclusion has caused a build-up of fuel and altered fire behavior, or where fire frequency has increased in ecosystems with species that have not evolved in the presence of fire. Too much, too little or the wrong kind of fire can threaten biodiversity health, often with negative consequences for ecosystem sustainability and human health and livelihoods (Brown & Smith 2000; Smith 2000; Hardesty et al. 2005; UN FAO 2006). In the U.S., the majority of ecosystems are fire-dependent (Shlisky et al. In prep.). Fire influences processes such as nutrient cycling, vegetation dynamics and species composition (Brown & Smith 2000; Smith 2000). Altered fire regimes can eliminate native species, accelerate soil erosion, degrade water quality and fish habitat, catalyze desertification, and alter ecosystem structure and wildlife habitat (Hassan et al. 2005). Changes in land use patterns and policies, such as rural development into wildlands, fire exclusion, tree plantations and agricultural conversion have contributed to changes in fire regimes in many areas of the U.S. (Weaver 1943; Cooper 1960; Covington & Moore 1994; Keane et al. 2002; Dellasala et al. 2004; Stephens & Ruth 2005). Changes in fire dynamics can also interact with other threats, such as climate change, invasive species, grazing, land clearing, inappropriate logging and landscape fragmentation (Keane et al. 1999; Dale et al. 2001; Brooks et al. 2004; Hardesty et al. 2005; Myers 2006), confounding efforts toward effective biodiversity conservation.

Frequent fire is a natural process in this longleaf pine community in Georgia. Photo by Mark Godfrey.

2 fire & climate change

The potential impacts of climate change, and how these changes will interact with fire's roles in ecosystem function across the U.S., are outside the scope of this assessment. Specific analyses of the impact of returning fire regimes to ecologically acceptable fire frequencies on climate have not been done. However, changes in fire regimes as a result of climate change are anticipated to have substantial implications from an ecological perspective (Hassan et al. 2005; Turner et al. 1997). Climate change is increasing fire frequency and extent by altering the key factors that control fire: temperature, precipitation, humidity, wind, ignition, biomass, dead organic matter, vegetation species composition and structure, and soil moisture (IPCC 2001). Warmer temperatures, decreased precipitation over land, increased convective activity, increased standing biomass due to CO2 fertilization, increased fuel accumulation from dying vegetation, and large-scale vegetation shifts comprise the most significant mechanisms through which global warming increases or decreases the incidence and dynamics of fire (Hassan et al. 2005, IPCC 2001). In mid-altitude conifer forests of the Western U.S. with no significant human activity or fire exclusion, an increase in spring and summer temperatures of 1°C since 1970, earlier snowmelt and longer summers have increased fire frequency 400% and burned area 650% in the period 1970–2003 (Westerling et al. 2006).

The Nature Conservancy is studying the interactions of climate change and altered fire regimes in this alpine meadow in Yunnan Province, China. Photo by Barry Baker.

Analyses of potential future conditions project that climate change will increase fire in all biogeographic realms (Nepstad et al. 1999; Williams et al. 2001; Mouillot et al. 2002; Hoffman et al. 2003; Flannigan et al. 2005). It is likely that over a long period of time, the integrated reduction in greenhouse gas emissions through avoided deforestation, restoration of ecosystems that are now burning at higher severities and extents due to fire exclusion, and reduction in inappropriate burning of fire-sensitive systems would eventually outweigh any short-term release of carbon resulting from actions taken to restore fire regimes in fire-dependent systems.

Biodiversity conservation goals cannot be achieved without considering the ecological roles of fire and the sources of altered fire regimes, as well as the need to maintain the roles of fire in ecosystem resilience in the face of climate change.

3 the global fire initiative & this report

The Nature Conservancy's Global Fire Initiative works with others to restore and maintain ecologically appropriate fire regimes by:

- Increasing our scientific understanding of the ecological roles of fire;
- Enabling public policies and implementing effective strategies to conserve the ecological roles of fire;
- Facilitating collaboration and networking among public and private partners with mutual conservation goals; and
- Building internal and external capacity to address fire-related threats to biodiversity.

Integrated Fire Management[1] is the Initiative's framework for reconciling the fire-related needs of both people and ecosystems (Myers 2006).

This report aims to improve our scientific understanding of the ecological roles of fire such that effective conservation strategies can be developed at appropriate ecological scales to maintain intact, or restore degraded fire regimes and abate the sources of altered fire regimes. We present the results of an assessment of the ecological roles of fire and the integrity of fire regimes across the lower 48 states of the U.S. These analyses use recently released data from the LANDFIRE Rapid Assessment (LFRA) project (see sidebar), and results are displayed at five levels:

- Lower 48 states of the U.S.;
- Major habitat types within the lower 48 states (Dinerstein et al. 1995);
- Nature Conservancy administrative regions;
- Inside and outside the Conservancy's portfolio of conservation areas of biodiversity significance (conservation areas); and
- Inside and outside federally-administered lands.

We also present national and regional recommendations for taking conservation action based on these findings.

[1] Integrated Fire Management is defined as an approach to addressing the problems and issues posed by both damaging and beneficial fires within the context of the natural environments and socio-economic systems in which they occur, by evaluating and balancing the relative risks posed by fire with the beneficial or necessary ecological and economic roles that it may play in a given conservation area, landscape or region (Myers 2006). For more information: http://www.nature.org/initiatives/fire/strategies/art18357.html.

4 data & methods

Three metrics — reference conditions, fire regime groups and fire regime condition class — can be used to describe the ecological roles of fire and determine its current ecological status across landscapes, regions and major habitat types.

Reference conditions are estimates of the range of variability in ecological structure and process against which current conditions can be compared, and from which ecological departure can be calculated. For the LFRA, reference conditions were based on vegetation conditions prior to European settlement and include the influence of aboriginal burning. Reference conditions (Appendix A) for potential natural vegetation groups (Appendix B) were described and quantitatively modeled by over 250 regional fire and vegetation experts. These models quantified the frequency and severity of fire and other disturbances and the rates of vegetation growth. LFRA reference condition models were used to determine fire regime groups and to calculate fire regime condition class.

Fire regime groups (FRG) are a classification of recurring fire characteristics — including average fire frequency and severity — for a given ecosystem and can be used to describe the historical or ecological

LANDFIRE Rapid Assessment

In 2006, the LANDFIRE Rapid Assessment (LFRA) produced maps and models of potential natural vegetation groups, reference fire regimes, succession classes, fire regime departure from reference conditions, and fire regime condition classes for the conterminous U.S. LFRA models and mapping rules were developed through 12 expert workshops held across the U.S. Products were rapidly delivered, and are moderately accurate; they were designed to meet short-term national and regional fire management planning needs and provide a foundation for the implementation of the similar but more accurate LANDFIRE National project (covering all 50 states).

The LANDFIRE project, including the LFRA, is chartered under the Wildland Fire Leadership Council and is supported by the U.S. Department of Agriculture (USDA) Forest Service Office of Fire and Aviation Management, the U.S. Department of the Interior Office of Wildland Fire Coordination, and The Nature Conservancy. Principle LANDFIRE cooperators include the USDA Forest Service Rocky Mountain Research Station Missoula Fire Sciences Laboratory, the U.S. Geological Survey Center for Earth Resources Observation and Science, and global and state programs of The Nature Conservancy.

Visit www.landfire.gov for more information.

role of fire (Agee 1993; Brown 1995; Myers 2006). For LFRA, FRGs were defined as follows:

- Fire Regime I: 0–35 year frequency; low and mixed severity;
- Fire Regime II: 0–35 year frequency; replacement severity;
- Fire Regime III: 35–200 year frequency; low and mixed severity;
- Fire Regime IV: 35–200 year frequency; replacement severity; and
- Fire Regime V: 200+ year frequency; replacement severity.

Fire regime condition class (FRCC) is a relative measure of the departure of current vegetation and (where data are available) fire regime conditions, from ecological reference conditions (Hann et al. 2004). While FRCC may indicate the ecological status of fire regimes, since it includes vegetation conditions, it can be used more broadly as a measure of ecological departure. It is a valuable measure for conservation planning. For the LFRA, the current condition was mapped from Landsat imagery circa 1998 to 2001 and from the 1992 National Land Cover Database data, while reference conditions were defined by the LFRA reference condition models. FRCC classes are defined as follows:

- FRCC 1: 0–33% departed or within the natural range of variability;
- FRCC 2: 33–66% departed or moderate departure from the natural range of variability; and
- FRCC 3: 66–100% departed or high departure from the natural range of variability.

For this report, we performed a spatial analysis to summarize LFRA FRG (Appendix C) and FRCC (Appendix D) across the lower 48 states of the U.S., Nature Conservancy administrative regions (Appendix E) and major habitat types (Appendix F). Within these summary levels we also calculated the proportions of the three FRCC categories inside and outside of the Conservancy's conservation areas (Appendix G). At the level of the lower 48 states we calculated the proportions of the three FRCC categories inside and outside of federally-administered lands (Appendix H). For more information on data and methods see Appendix I.

> FRCC is a relative measure of the departure of current vegetation... from ecological reference conditions

4.1 Data Considerations

The LFRA data provide a moderate-resolution, rapid, nation-wide assessment. Through the engagement of hundreds of scientists and land managers and the testing of basic concepts across vegetation types, the LFRA is also enabling a more accurate and finer-resolution assessment through the LANDFIRE National products (Table 1). Interpretation of the LFRA data should be based on the understanding that the data were designed for national- to regional-scale strategic planning, broad ecological assessments and resource allocation. Therefore, we have restricted our presentation of the data to national and regional levels and focused on percentages and relative comparisons among regions rather than on interpreting absolute values.

Because consistent spatial data on current fire regime characteristics (e.g., fire frequency and severity) are not available for the entire U.S., LFRA FRCC results only measure the departure of current vegetation structure and composition from the reference condition. This measure can be more broadly interpreted as an indicator of ecological departure or as an imperfect, but best available proxy for the departure of fire regimes across broad geographical extents. While altered fire regimes certainly influence vegetation composition and structure, other factors can cause similar changes in vegetation. For instance, certain forest management and domestic animal grazing practices, climate change and invasive species can alter vegetation characteristics and influence the LFRA FRCC calculation. Given that current fire regime information (including the distribution, frequency and severity of fires) is not available nationally, vegetation departure is the best approximation of fire regime conditions that currently exists.

FRCC in the LFRA was only calculated for areas that have natural or semi-natural vegetation. It was not calculated for areas classified as agriculture, urban, water, snow, ice, barren, transportation, mines or quarries. It was also not calculated for wetlands or alpine areas due to their small extent. In this assessment, we discuss results for only those areas that are classified as FRCC 1, 2 or 3. To help interpret the results in the context of the entire landscape matrix, we include a table showing the percent of all mapped values on the FRCC map for the three major summary levels (lower 48 states, Conservancy administrative regions and major habitat types) in Appendix K.

In some cases the reference condition is based on historical information that may not reflect current climatic or biophysical conditions, and may not be synonymous with the desired future condition for a particular area due to social constraints. In these cases, FRCC may need to be

Table 1. Comparison of LANDFIRE project milestones: LANDFIRE Rapid Assessment and LANDFIRE National.

Attribute	LANDFIRE Rapid Assessment	LANDFIRE National
Production Schedule	1 year 2004–2005	5 years 2004–2009
Extent	Lower 48 states	Entire U.S.
Appropriate Application Scale	National to regional levels	National to landscape levels
Examples of Potential Applications	■ National and regional strategic planning ■ Regional/state prioritization	■ National and regional strategic planning ■ Regional/state prioritization ■ Fire management planning ■ Conservation and ecosystem management plans

supplemented to be useful for developing conservation goals or measuring conservation status or results.

Two major habitat types that intersect the conterminous U.S. were excluded from this assessment: (1) flooded grasslands and savannas; and (2) tropical and subtropical grasslands, savannas and shrublands. These types were not assessed because their main distribution is outside of the lower 48 states and they do not represent sufficient area to provide meaningful results given the resolution of the LFRA data.

Regional variation in the creation of the conservation area data within the Conservancy makes it difficult to compile a complete and consistent national dataset of these areas. The layer used in this analysis did not include conservation areas for three ecoregions (Aspen Parkland, Dakota Mixed-Grass Prairie and Fescue-Mixed Grass Prairie) that had incomplete ecoregional assessments.

5 results: distribution of fire regime types & FRCC groups

5.1 Lower 48 States

Analyses of the ecology and status of fire regime conditions across the lower 48 states reveal five primary characteristics important to biodiversity conservation:

1. Frequent fire regimes dominate approximately 65% of the lower 48 states (Figure 1; Appendix C), although regional variations exist (discussed below).

2. Approximately 80% of the lower 48 states is moderately to highly departed from reference conditions, leaving only 20% within the range of variability described by the reference condition (Figure 2; Appendix D).

3. There are differences in the integrity of fire regimes depending on the ecological roles of fire in the ecosystem (Figure 3), including:

   - Over 80% of high frequency/low and mixed severity (FRG 1), and low frequency/replacement severity fire regimes (FRG 5) are departed.

   - FRG 5 is the most highly departed (FRCC 3) of all FRGs. FRG 5 primarily includes forests and deserts that burn with low frequency, such as those found in the Pacific Northwest, Southwest or Northeastern U.S.

   - High frequency/high severity fire regimes (FRG 2) have the highest proportion of land in agriculture (Appendix K).

4. There is no difference in the distribution of FRCC inside versus outside of the Conservancy's conservation areas (Figure 4). Within conservation areas where actions have been effectively targeted at restoring and maintaining fire regimes, we expect that landscape conditions are better on the ground[2] than the resolution of the LFRA allows us to assess.

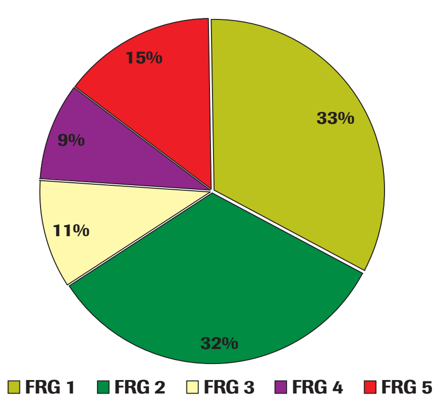

Figure 1. Fire regime groups in the lower 48 states.

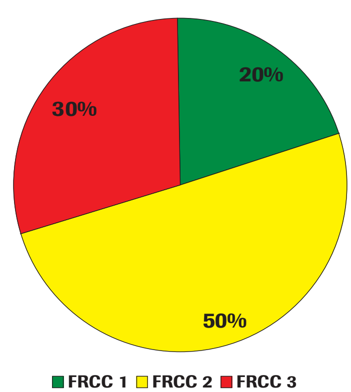

Figure 2. Fire regime condition class in the lower 48 states.

[2] FRCC can be calculated at any scale using the methodology documented in the FRCC Guidebook (Hann et al. 2004).

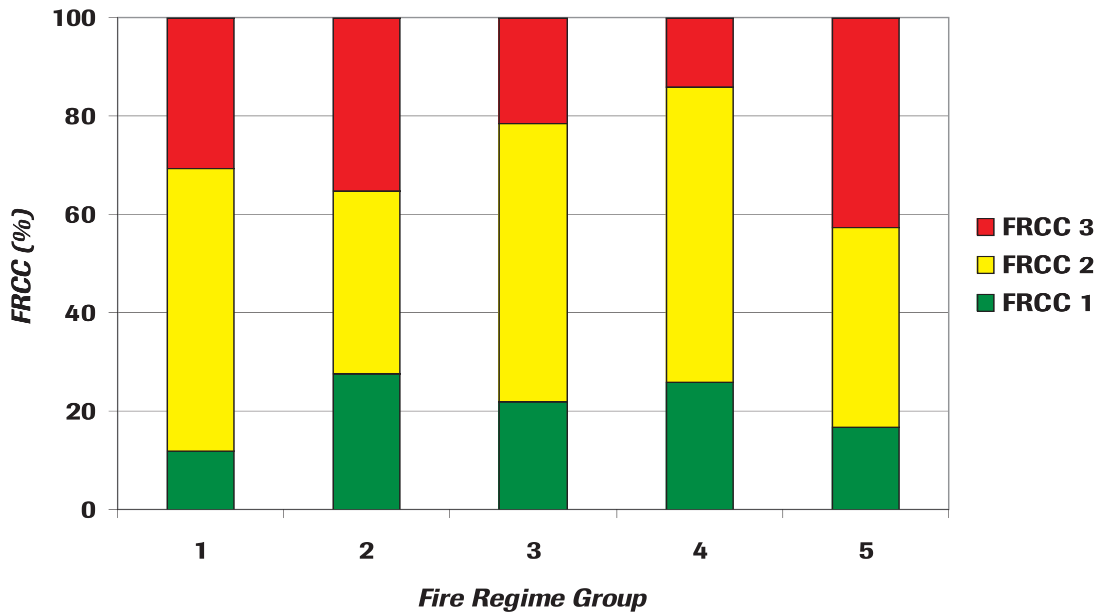

Figure 3. Fire regime condition class in fire regime groups in the lower 48 states.

5. There is no difference in the FRCC distribution inside versus outside of federally-administered lands (Figure 5). However, because the LFRA FRCC data were calculated for large geographic areas, they may mask local variation. Within federal lands where actions have been taken to restore and maintain fire regimes, we expect that conditions are better than indicated by LFRA data.

5.2 Nature Conservancy Regions

Analyses of the ecology and status of fire regime conditions across Nature

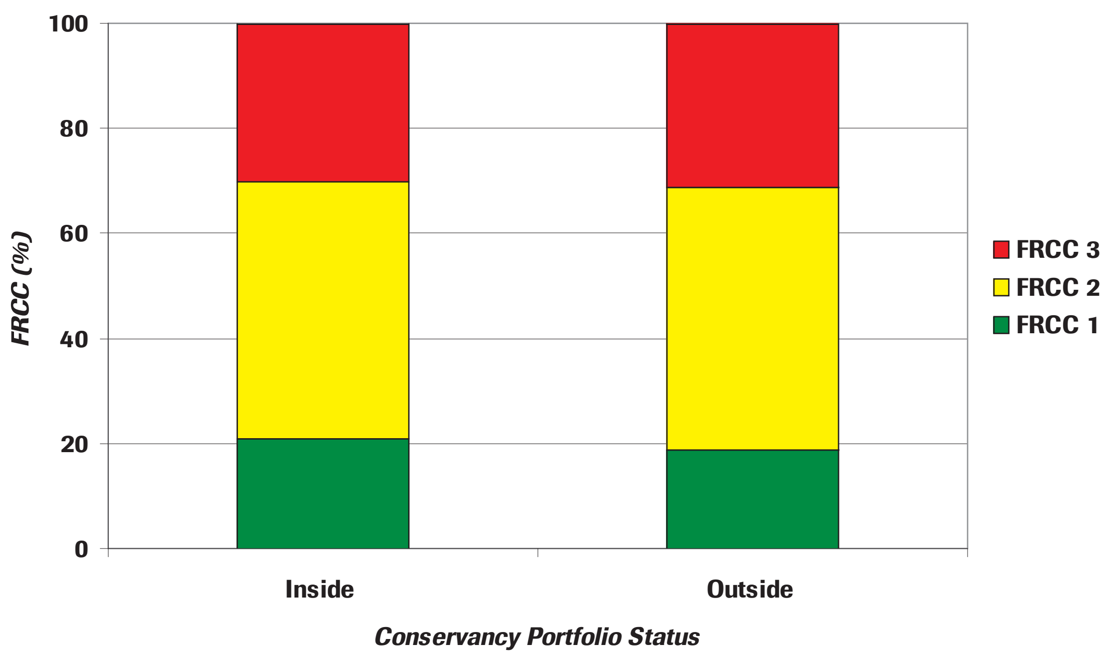

Figure 4. Fire regime condition class inside and outside of the Conservancy's conservation areas in the lower 48 states.

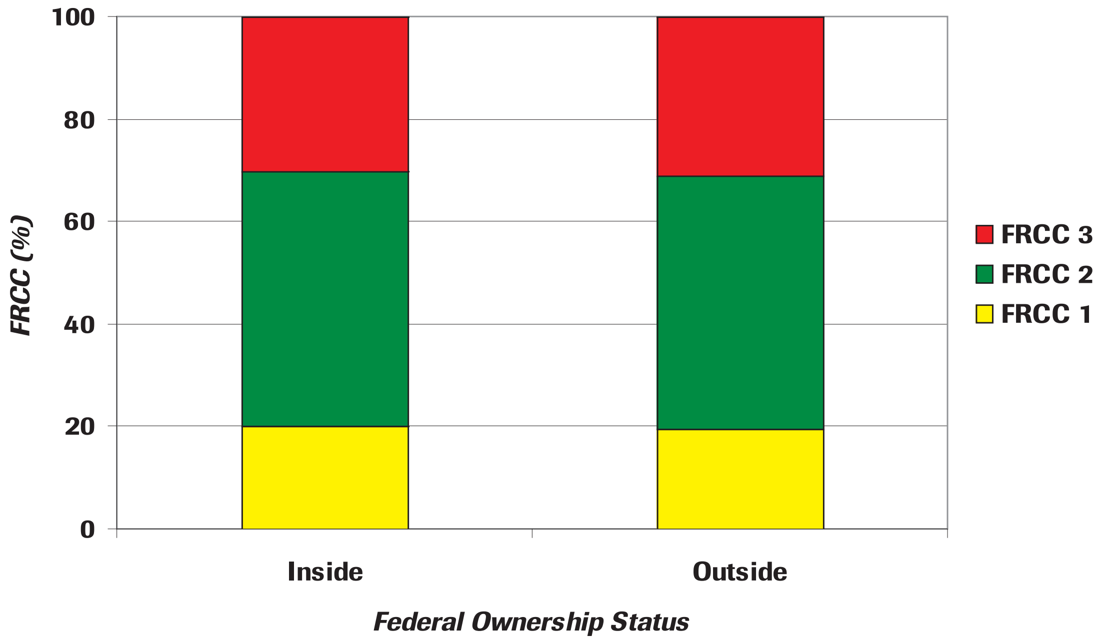

Figure 5. Fire regime condition class inside and outside of federally-administered lands in the lower 48 states.

Conservancy administrative regions of the lower 48 states reveal six primary characteristics important to biodiversity conservation:

1. Frequent fire regimes (FRG 1 and 2) cover more than 80% of the area in the Southern U.S. and Central U.S. regions (Figure 6).

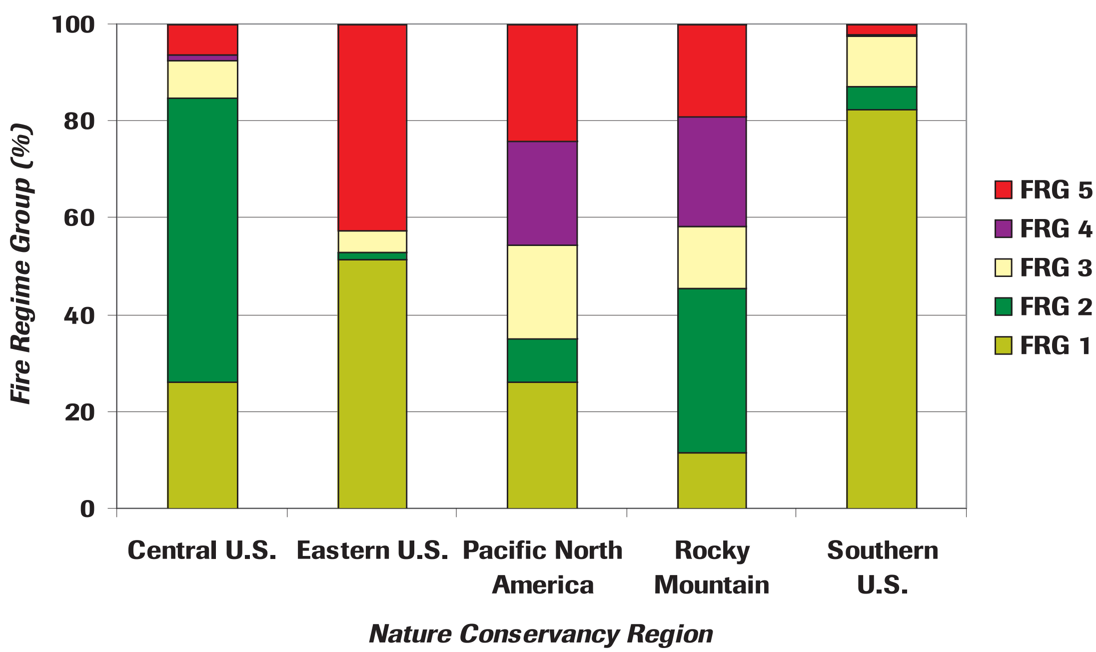

Figure 6. Fire regime groups in Nature Conservancy administrative regions in the lower 48 states.

2. Low frequency/replacement severity fire regimes (FRG 5) are more prevalent in the Eastern U.S. than in any other region (Figure 6).

3. Low frequency/replacement severity fire regimes (FRG 4) are concentrated in the Pacific North America and Rocky Mountain regions (Figure 6). These fire regimes can be complex to understand and manage due to the diversity of landscape structure, composition and fire behavior.

4. Fire regimes are moderately to highly departed across all Conservancy regions assessed (Figure 7).

5. Nearly half of the land in the Central U.S. region has been converted to agriculture (Appendix K). This will come as no surprise to Conservancy staff working in this area, where it is generally recognized that the relatively high degree of conversion poses challenges to restoring and maintaining fire regimes in adjacent conservation areas. In Central U.S. grasslands for example, the reference fire regime is predominantly characterized by frequent, replacement severity fires that burned extensively. Agricultural and urban conversion of lands surrounding conservation areas often constrains the ecologically appropriate use of fire where it is perceived to pose a risk to agriculture, ranching or housing, or where it simply limits fire size.

6. On average, there is little difference between conditions inside versus outside conservation areas in Nature Conservancy regions (Figure 8). Within conservation areas where actions have been taken to restore and maintain fire regimes, we expect that conditions can be better than indicated by LFRA data.

5.3 Major Habitat Types

Analyses of the ecology and status of fire regime conditions across major habitat types of the lower 48 states reveal eight primary characteristics important to biodiversity conservation:

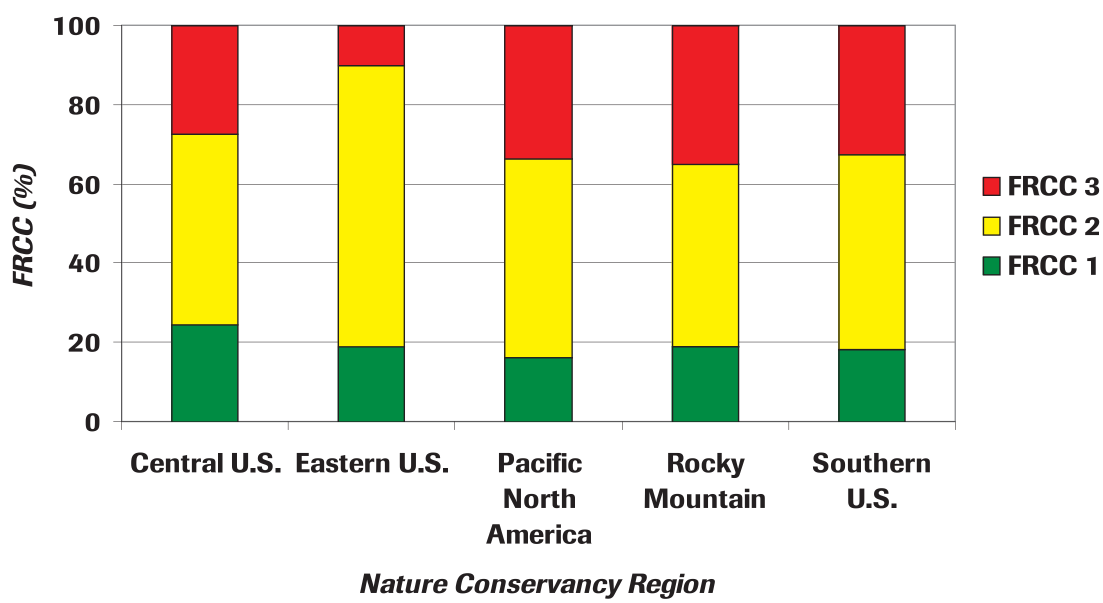

Figure 7. Fire regime condition class in Nature Conservancy administrative regions in the lower 48 states.

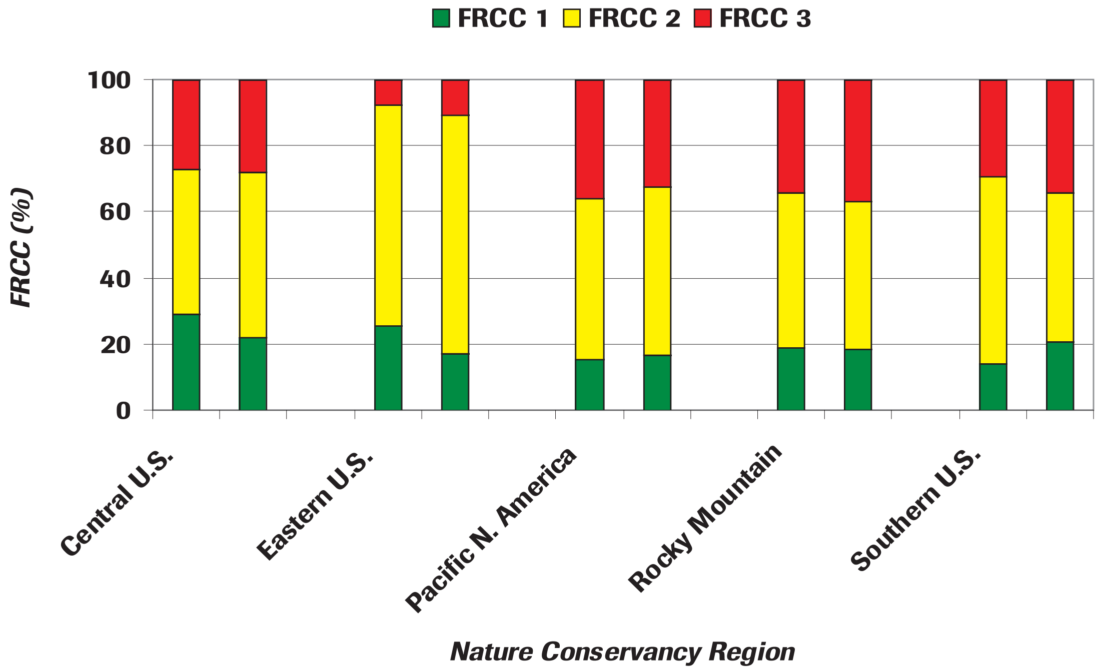

Figure 8. Fire regime condition class inside and outside Nature Conservancy conservation areas, by administrative region. For each pair, bars on the left represent FRCC distribution inside conservation areas; bars on the right represent FRCC distribution outside these areas.

1. Deserts and xeric shrublands have a diversity of fire frequencies and intensities (Figure 9).

2. Mediterranean forests, woodlands and scrub are dominated by both frequent and infrequent fire regimes (FRG 1 and 4; Figure 9).

3. Temperate broadleaf and mixed forests are dominated by both high and low

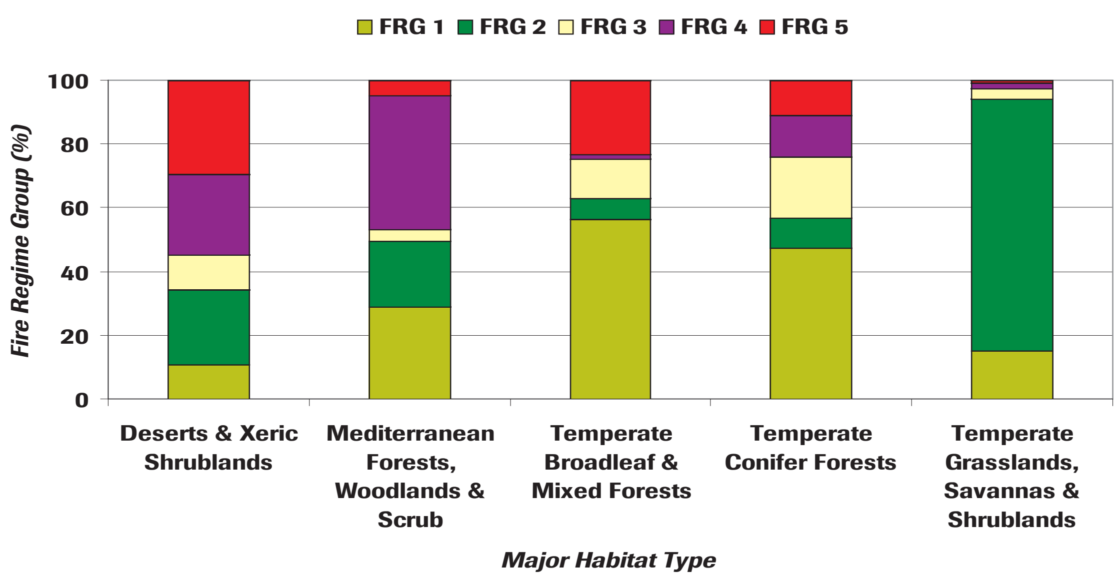

Figure 9. Fire regime groups in major habitat types in the lower 48 states.

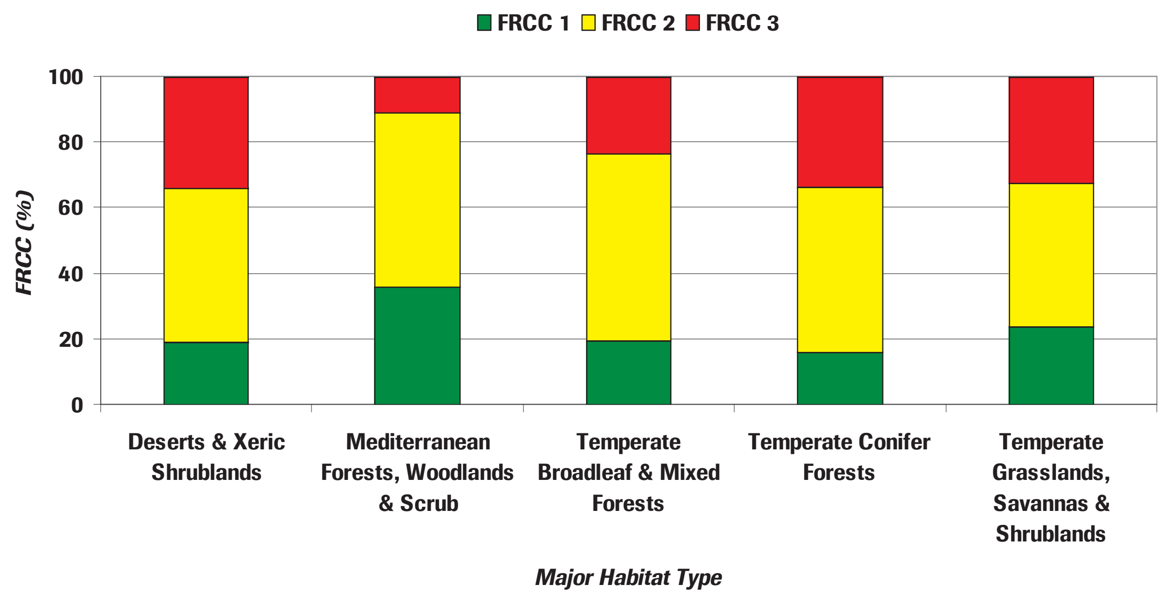

Figure 10. Fire regime condition class in major habitat types in the lower 48 states.

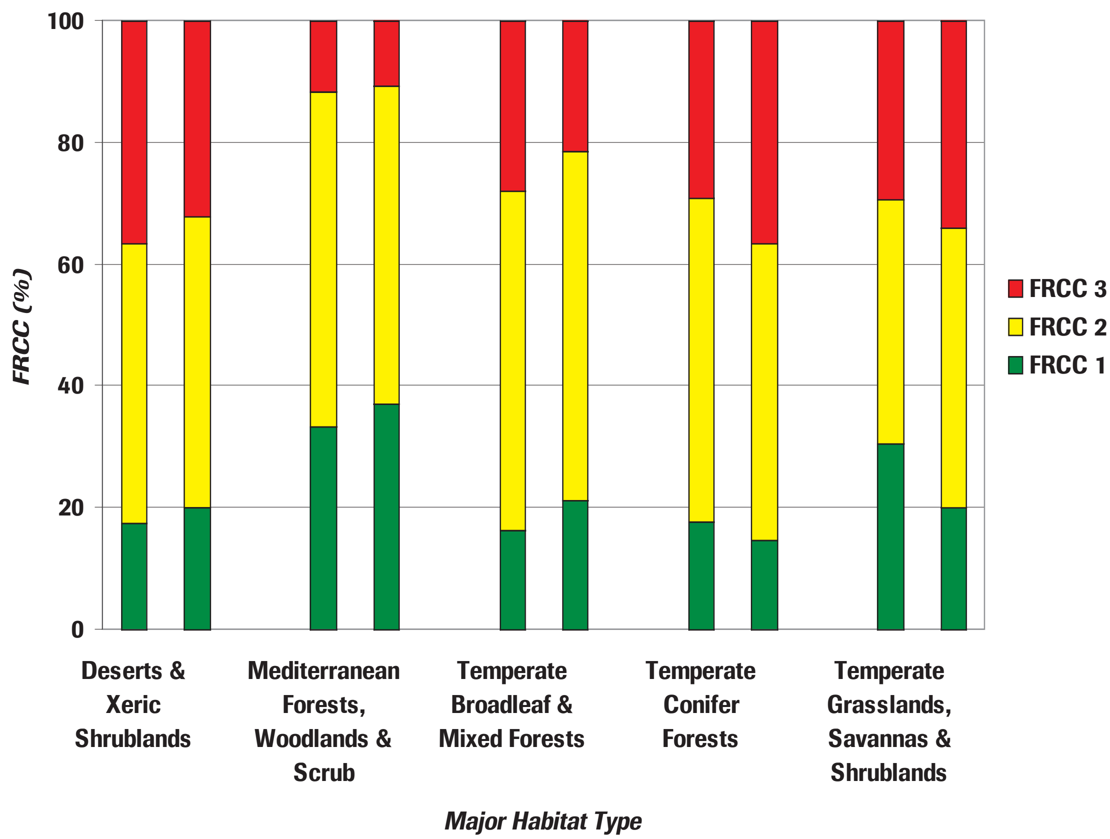

Figure 11. Fire regime condition class inside versus outside the Nature Conservancy's conservation areas within major habitat types in the lower 48 states. For each pair, bars on the left represent FRCC distribution inside conservation areas; bars on the right represent FRCC distribution outside these areas.

frequency fire regimes (FRG 1 and 5; Figure 9).

4. Nearly 50% of temperate coniferous forests are classified as having high frequency/low and mixed severity fires (FRG 1; Figure 9).

5. Nearly 80% of temperate grasslands, savannas and shrublands are classified as having a high frequency/replacement severity fire regime (FRG 2; Figure 9).

6. FRCC departure is moderate to high across all major habitat types (Figure 10).

7. Mediterranean forests, woodlands and scrub have more area in FRCC 1 than any other major habitat type[3] (Figure 10).

8. There is very little difference between conditions inside versus outside conservation areas within major habitat types (Figure 11).

Non-native invasive species such as cheat grass (*Bromus tectorum*) can drastically alter the way fire behaves in ecosystems, in addition to changing species composition. At a stand scale, this shrubland would be classified as FRCC 3. Photo by John Randall.

[3] This result appears contrary to the Conservancy's 2015 Habitat Assessment (The Nature Conservancy 2006), which indicates that globally the Mediterranean major habitat type is poorly conserved. It is possible that alterations to Mediterranean type fire regimes do not alter vegetation composition and structure enough to be detectable by LFRA methods. However, there is disagreement among experts about whether the current fire frequency and severity in some Mediterranean types, such as chaparral, has been altered from the reference condition. In any case, 26% of the Mediterranean type has been converted to agriculture according to the LFRA (Appendix K), and the remaining examples of this type in the lower 48 states of the U.S. may have very high conservation value globally.

6 sources of altered fire regimes

The primary sources of altered fire regimes across the lower 48 states include:

- Fire exclusion and suppression, and air quality policies that constrain the amount of prescribed burning that can occur in particular geographic areas.
  — Since the development of the fire suppression-focused Smokey Bear campaign in 1944, uniform fire suppression has been the main goal of fire managers in the U.S. Increased scientific understanding of fire ecology has demonstrated that this has been detrimental to forest health in many situations. Fire exclusion and suppression often cause increases in forest density, encroachment of woody species into grasslands, savannas and shrublands (that are naturally kept open by frequent fire), and habitat fragmentation (Weaver 1943; Cooper 1960; Miller & Rose 1999; Dellasala et al. 2004).

- Lack of public support for maintaining and restoring fire's ecological roles.

- Timber harvest, agriculture and domestic animal grazing activities that alter fuel type, amount and continuity.
  — Ecosystems with low frequency/high severity fire regimes (FRG 5) may be disproportionately affected by activities that alter ecosystem structure and species composition. For example, in western Washington and Oregon, the long-interval fire frequencies of the Douglas-fir-hemlock-wet mesic forests (LFRA 2005a) may have not been substantially altered in fire frequency or severity, but logging has likely altered the structure, fuel characteristics and fire behavior of these systems. In the northeastern U.S., some northern hardwood-hemlock forests (LFRA 2005b) have been simplified through single tree selection harvest practices. Under the reference condition these forests would have included shade-tolerant species such as sugar maple and hemlock as well as moderately shade-tolerant species such as yellow birch, black cherry, white pine and balsam fir (LFRA 2005b). In many areas, selective removal of the moderately shade-tolerant species in favor of maple has resulted in forest stands with departed structure and composition.

- Invasive species that change fuel types, amounts and distribution, and alter vegetation flammability.
  — Many ecosystems with long fire return intervals, particularly desert

Housing developments such as this one in Iowa's Loess Hills can hinder managers' ability to use fire to restore ecosystems. Photo by Matt Graeve.

Prescribed burning is an important management tool across the U.S. in many places of high biodiversity significance. Photo by Kelly Pohl.

systems, have been extensively invaded by non-native species, and this may have been a driver of FRCC departure in some systems in the LFRA. For example, in the desert Southwest, many of the creosotebush shrublands with grasses (LFRA 2005c) are considered highly departed (FRCC 3). The LFRA reference model description for this type indicates that currently "alien annual grasses can comprise 66-97% of the total annual biomass in this system" (LFRA 2005c). Non-native annual grass invasion can increase fine fuel loads and the possibility that fire will spread once ignited, pushing fire regime conditions outside the natural range of variability.

- Climate change, which causes shifts in vegetation, as well as changes in temperature and moisture conditions that drive fire frequency and severity.
- Housing and infrastructure development and the fragmentation, fire exclusion policies or human-caused ignitions that follow result in altered fuel continuity and uncharacteristic fire frequencies. In areas with a relatively high human housing and development density (e.g., eastern U.S.), this can be at odds with conservation where there is public resistance to restoring the ecological roles of fire.

7 state & regional fire capacity

7.1 The Nature Conservancy's Fire Capacity

The Conservancy is the only global conservation organization with an in-house cadre of hundreds of practitioners trained in fire management and the application of prescribed fire for the benefit of biodiversity. The Conservancy plays a unique role among conservation organizations in this respect due to its capacity to demonstrate ecologically-appropriate prescribed burning, and its technical expertise, which is respected by our partners.

Despite the ubiquitous threat of altered fire regimes across the U.S., fire-related capacity varies substantially across the Conservancy's U.S. programs. Internal operational fire-related capacity includes the presence of staff qualified as burn bosses[4] (Figure 12), and/or fire-trained personnel building their skills to put fire on the ground within the next year. In-house capacity also allows the Conservancy to instruct in wildland fire training courses, building both internal and partner capacity. Important non-operational fire capacities include participation in the U.S. Fire Learning Network[5] and partner-

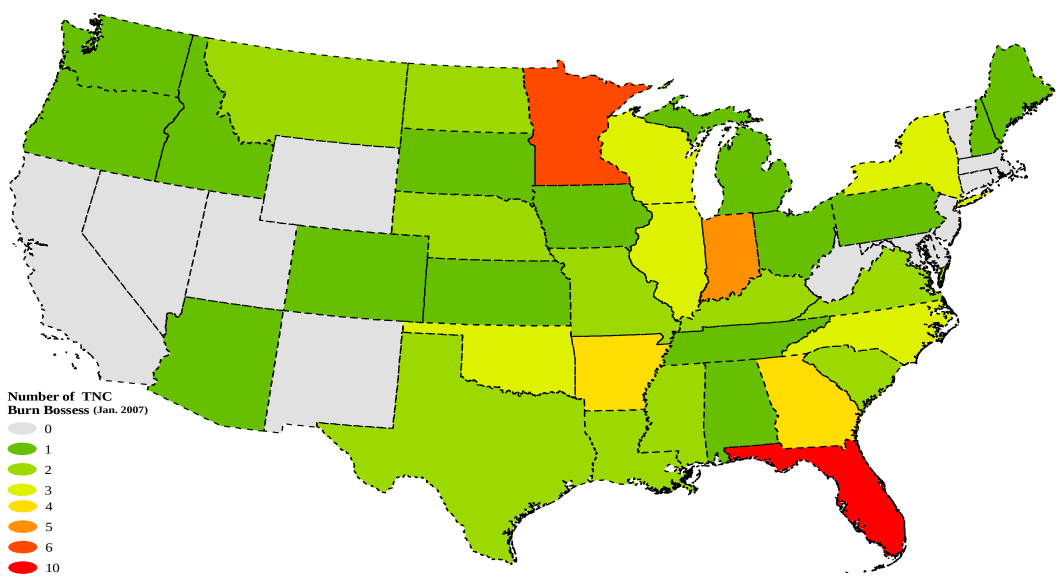

Figure 12. Distribution and number of qualified burn bosses within Nature Conservancy state programs in the lower 48 states as of January 2007.

[4] Burn bosses implement fire management strategies on the ground, often through prescribed fire.

[5] The U.S. Fire Learning Network seeks to overcome barriers to implementing ecologically-appropriate fuels reduction and restoration projects. Operating at local, regional and national levels, the Network is engaged in over 70 multi-agency, community-based projects in a process that accelerates the restoration of landscapes that depend on fire to sustain native plants and animals.

Table 2. Total Nature Conservancy acres prescribed burned by region, July 2005 – June 2006.

Nature Conservancy Conservation Region	Total Acres Prescribed Burned
Pacific North America	2,446
Central U.S.	62,643
Southern U.S.	31,796
Eastern U.S.	944
Rocky Mountain	275
TOTAL	90,104

ships with public and private land managers to influence landscape and/or public land management and abate fire-related threats. Nature Conservancy state programs without operational fire capacity, but that are working in other ways (e.g., landscape or regional fire planning, influencing public lands management), include Alaska, Idaho, Nevada, New Mexico, Tennessee and Wyoming. States currently without operational or non-operational fire-related capacity include Connecticut, Hawaii, New Jersey, Rhode Island, Utah (except small research burns), Vermont and West Virginia.

7.2 Prescribed Burning on Conservancy & Federal Lands

The Conservancy burns approximately 100,000 acres per year for biodiversity benefit on our own lands (Table 2), depending

Table 3. Acres prescribed burned and burned under wildland fire use as reported by National Interagency Coordination Center (NICC) in calendar years 2005 and 2006 (http://www.nifc.gov/nicc).

	Prescribed Burns	WFU	TOTALS	Prescribed Burns	WFU	TOTALS
NICC Region	2005			2006		
Alaska	626	168,595	169,221	12,039	317	12,356
Northwest	106,652	36,752	143,404	136,397	12,288	148,685
Northern CA	72,417	792	73,209	55,420	1,522	56,942
Southern CA	18,739	11,777	30,516	9,533	22,157	31,690
N. Rockies	77,025	56,391	133,416	91,469	34,641	126,110
E. Great Basin	59,632	85,510	145,142	67,110	38,702	105,812
W. Great Basin	13,155	141	13,296	4,471	3,349	7,820
Southwest	196,195	118,362	314,557	117,552	36,242	153,794
Rocky Mountain	116,333	7,175	123,508	86,452	10,230	96,682
Eastern	210,531	11	210,542	199,129	1,697	200,826
Southern	1,373,000	3,641	1,376,641	1,860,049	3,836	1,863,885
TOTALS	2,244,305	489,147	2,733,452	2,639,621	164,981	2,804,602

on annual weather conditions and availability of implementation funding. This scale of prescribed burning is comparable to that done by the National Park Service (NPS) nationally each year, although NPS burns an additional ~100,000 acres per year using wildland fire use[6] (http://www.nifc.gov/stats/index.html). The vast majority of prescribed burning on Nature Conservancy lands occurs in the Central and Southern U.S. regions (Table 2). Federal and state land management agencies[7] burn approximately 2.8 million acres per year through prescribed fire or wildland fire use (Table 3). The vast majority of prescribed burning occurs in the southern U.S. (Figure 13, as reported for the Southern National Interagency Coordination Center [NICC] region, and Table 3), and wildland fire use is primarily used in the western U.S. where large, contiguous federal land areas enable the policy to be implemented without putting human communities or economic resources at risk (Table 3). Like for the Conservancy, the total number of acres burned by federal and state partners per year depends on annual weather conditions and availability of implementation funding.

While the geographic boundaries of Nature Conservancy and NICC regions (http://www.nifc.gov/nicc/) differ slightly, it is clear that the Conservancy fills a unique niche in its use of prescribed fire in the Central U.S. (where there is a relatively small amount of federal land), on private lands, and in our influence of ecologically-based prescribed burning techniques. Based on the degree of altered fire regimes, and the relatively small extent of total prescribed burning in the western U.S., both the Conservancy and our federal agency partners have a long way to go to effectively reintroduce fire into western U.S. ecosystems at ecologically-relevant scales.

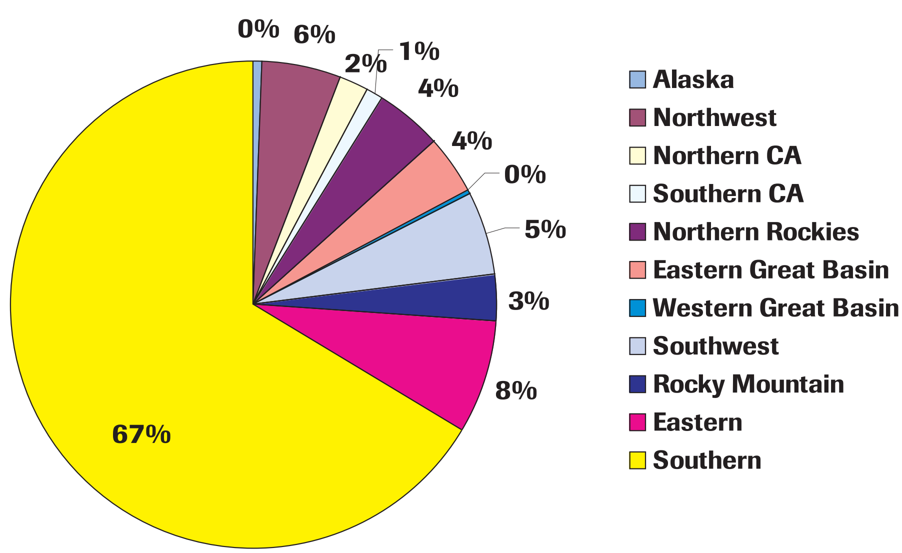

Figure 13. Percentage of acres burned by prescribed fire and wildland fire use in calendar year 2006 by U.S. federal and state land management agencies as reported by the National Interagency Coordination Center.

[6] Wildland fire use for resource benefit (WFU) is a practice that allows natural ignitions to burn under predetermined conditions, both facilitating a means for fire to play its ecological roles, while providing a lower-cost alternative to other types of restoration and maintenance actions.

[7] U.S. Department of Agriculture Forest Service, and U.S. Department of the Interior Bureau of Land Management, Fish and Wildlife Service, National Park Service, Bureau of Indian Affairs. Some, but not all area prescribed burned by state agencies is included in this number.

8 taking action: recommendations consistent with 2015 goal strategies

8.1 National Recommendations

This assessment documents that fire regime conditions across the U.S. are extensively altered, although there are areas that are currently intact and require action to maintain healthy ecological conditions. Effective biodiversity conservation requires that we take immediate action and inspire others toward similar actions. We must work at national, regional and landscape levels to address the sources of fire-related threats, and restore and conserve a representative network of functional ecosystems where fire is allowed to play its ecological roles. Based on the results of this assessment, following are six primary recommendations for taking conservation action that apply across all U.S. Nature Conservancy regions and major habitat types. More specific recommendations by Nature Conservancy region follow these general recommendations:

1. **Restore the ecologically-appropriate roles of fire in forests, woodlands and shrublands where alteration has or will result in uncharacteristically severe fires and negative contributions to climate change.** Restoration will increase ecosystem resiliency and reduce ecosystem vulnerability to climate change, while also reducing uncharacteristic contributions to global carbon emissions. We must also ensure that carbon sequestration actions do not inhibit our ability to maintain fire's roles. Take conservation action now to reintroduce fire into degraded fire regimes, particularly those with high frequency fire regimes, before inaction leads to irretrievable loss of biodiversity health.

2. **Influence protected area and land management strategies, wildland fire use and fire exclusion policies to allow fire to more effectively play its ecological roles in more places.** In particular, assess where wildland fire use is feasible, and where proactive collaboration with public land managers is necessary to increase its use. Fire regimes are not necessarily intact, and biodiversity is not necessarily effectively conserved, where there is some degree of land protection, such as on public lands.

3. **Proactively reform fire, land use and air quality policies and timber harvest and domestic animal grazing plans and activities that alter fire regimes and fuel characteristics.** Increase public funding to implement restoration actions for fire-dependent ecosystems. Assess the viability of creating markets for the woody biomass products of fire regime restoration for energy production and cottage industries. Biomass utilization is a market-based conservation strategy that can pay for removal of wood and biomass, reduce fuel levels to more ecologically sustainable levels and enable the reintroduction of fire into fire-dependent ecosystems. Model landscape applications of ecologically-appropriate fire where it is compatible with human resource use, and promote certification, incentive systems, and regulatory approaches that allow fire to play its ecological roles.

4. **Educate policy-makers, decision-makers and the public in anticipation of inevitable conflicts between maintaining**

fire's ecological roles and the increasing expansion of human development into the wildland-urban interface. Increase public understanding of the contribution of healthy fire regimes to human well-being, and build constituencies that support restoring fire's roles. Develop methodologies for valuing the services that healthy fire regimes provide, such as watershed protection and wildlife habitat, and innovate cost-effective solutions for funding and sustaining these services.

5. **Eliminate, influence or mitigate the impacts of housing and infrastructure development on ecologically-appropriate fire regimes and intact, large, roadless landscapes.** Developments that provide housing, energy, water or transportation to human populations often create barriers to restoring fire regime dynamics, or facilitate human-caused ignitions beyond ecologically-sustainable fire frequencies. Channel compensation payments from infrastructure development to the restoration of fire regimes in priority areas.

6. **Leverage conservation actions through fire science, building effective capacity and fostering partnerships with governmental and non-governmental organizations that share goals for fire regime restoration.** Engage in Fire Learning Networks to build constituencies and implement actions for fire regime restoration at ecologically-relevant extents. Enhance Nature Conservancy and partner capacity for fire management through increased staffing, training, mentoring and fire staff exchanges, and establishment of new partnerships. Ensure conservation plans use the best available information on reference fire regimes, current fire regime status and fire-related threats. Use and refine LANDFIRE data as a baseline measure of fire regime conditions, and as a continuing measure of the on-the-ground results of conservation actions.

8.2 Regional Recommendations

The following are specific key recommendations by Nature Conservancy region for addressing fire and biodiversity conservation in the lower 48 states:

Region	Summary of Results	Recommendations
Central U.S.	■ Frequent fire regimes comprise over 80% of ecosystems. ■ Fire regimes are moderately to highly departed (FRCC 2 & 3) in over 70% of the region. ■ Non-federal temperate grasslands, savannas and shrublands dominate this region. ■ This region has the greatest proportion of lands converted to agriculture and other non-natural cover types. ■ Relatively high levels of prescribed burning implemented on Conservancy lands. ■ Little prescribed burning accomplished by federal agency partners.	■ Maintain and/or increase internal and external technical fire capacity to restore and maintain the ecological roles of fire to fill geographic gaps in state and national agency fire capacity. ■ Leverage demonstrations of ecologically-based Integrated Fire Management to educate policy- and decision-makers, land managers and the public about the roles of fire and needs for conserving its ecological role. ■ Influence policies such as the Farm Bill, and agencies that work on private lands, such as the Natural Resources Conservation Service to include incentives for private landowners to integrate ecologically-based fire management into land management activities.

Region	Summary of Results	Recommendations
Eastern U.S.	■ 51% of region dominated by high frequency/low and mixed severity fire regimes (FRG 1) and 42% dominated by infrequent, high severity fire regimes (FRG 5). ■ Fire regimes moderately to highly departed (FRCC 2 & 3) in over 80% of region. ■ Non-federally-administered temperate broadleaf and mixed forests dominate the region. ■Relatively high density of urban and exurban development.	■ Expand landscape demonstrations of ecologically-based Integrated Fire Management to educate policy-makers and decision-makers, land managers and the public about the roles of fire and needs for conserving its ecological role in highly fragmented landscapes. ■ Influence air quality policies that constrain ecologically-appropriate levels of prescribed burning to allow for the restoration of the roles of fire. ■ Partner with state and private land managers to include landscape objectives to restore the roles of fire in ecosystems.
Pacific North Amer.	■High diversity of fire regimes and major habitat types. ■Fire regimes are moderately to highly departed (FRCC 2 & 3) in over 80% of this region. ■Includes the only Mediterranean habitat type in the U.S. ■Relatively high proportion of federal lands. ■Low Nature Conservancy technical fire capacity. ■Relatively low levels of prescribed burning accomplished by Conservancy and federal agency partners. ■Relatively high rate of population growth.	■ Influence fire and land development policies and technical fire capacity internally and externally to enable the implementation of wildland fire use for resource benefit. ■ Partner with federal land management agencies to develop forest and resource plans that are based on the best available scientific information and serve to maintain or restore the ecological roles of fire. ■ Increase the amount of prescribed burning on public and private lands. ■ Pay special attention to maintaining and restoring fire in biologically diverse and fire-dependent Mediterranean ecosystems. ■ Investigate the use of economic incentives to remove excess biomass, such as stewardship contracting and development of infrastructure and markets for small diameter biomass utilization. ■ Continue to promote and prioritize the maintenance of intact (FRCC 1) forests and grasslands.
Rocky Mtn.	■ High diversity of fire regimes and major habitat types, including most of the deserts and xeric shrublands in the U.S. ■ Fire regimes moderately to highly departed (FRCC 2 & 3) in over 80% of this region. ■ Relatively high proportion of federal lands. ■ Low Nature Conservancy technical fire capacity. ■ Relatively low levels of prescribed burning by Conservancy and federal agency partners. ■ The Colorado Front Range is rapidly growing in population.	■ Expand landscape demonstrations of ecologically-based Integrated Fire Management to educate policy-makers and decision-makers, and the public about the roles of fire and needs for maintaining and restoring its ecological role. ■ Influence air quality policies that constrain prescribed burning to allow for the restoration of the roles of fire. ■ Partner with federal, state and private land managers to include landscape objectives to restore the roles of fire in ecosystems in forest and resource plans. ■ Influence fire and land development policies and expand technical fire capacity internally and externally to enable the implementation of wildland fire use for resource benefit. ■ Investigate the use of economic incentives to remove excess biomass, such as stewardship contracting and development of infrastructure and markets for small diameter biomass utilization.

Region	Summary of Results	Recommendations
Southern U.S.	■ Over 80% of the region is dominated by high frequency/ low and mixed severity fire regimes (FRG 1) ■ Fire regimes are moderately to highly departed (FRCC 2 & 3) in over 80% of this region. ■ Non-federally-administered temperate conifer forest and temperate broadleaf and mixed forests dominate the region. ■ Relatively more Nature Conservancy technical fire capacity resides in this region than elsewhere in the lower 48 states.	■ Maintain and leverage demonstration landscapes and internal fire expertise to ensure effective conservation and restoration of frequent fire regimes at ecologically relevant extents across multiple ownerships. ■ Influence prescribed burning techniques used by federal, state and private partners to ensure they are ecologically appropriate. ■ Use demonstrations and other means to educate the public, and policy-makers and decision-makers about the ecological roles of fire and reduce resistance to ecologically appropriate prescribed burning. ■ Encourage or influence economic incentives such as certification, stewardship contracting, and markets for small diameter biomass utilization to ensure fire is allowed to play its ecological roles.

9 resources

9.1 LANDFIRE National Products

The LFRA was designed to be an interim product and to fill data needs until the full implementation of the LANDFIRE project (LANDFIRE National) is complete. LANDFIRE National products will be useful for analyzing smaller areas, perhaps at the sub-regional and ecoregional levels. LANDFIRE spatial data can be used to target places where finer resolution, on-the-ground landscape assessments are needed to identify where fire regimes may be degraded, and where they might be feasibly restored. User-friendly, quantitative reference models can also be used to test on-the-ground outcomes of alternative conservation actions, or of alternative climate change or land use assumptions (sensu Merzenich et al. 2003; Forbis et al. 2006). Due to differences in methodology it is likely that the LANDFIRE National results will differ from the LFRA results in some cases. LANDFIRE National data are currently complete for the western U.S., and will be complete for the entire U.S., including Alaska and Hawaii, by 2009.

Experts review models during a 2005 LANDFIRE Rapid Assessment modeling workshop in Arkansas. Photo by Jeannie Patton.

To download data and see the schedule for completion of LANDFIRE National products, go to: http://www.landfire.gov.

9.2 Contacts

For more information on the Conservancy's Global Fire Initiative, visit our web site at tncfire.org or contact initiative staff (Table 4).

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LACFLN = Latin American & Caribbean Fire Learning Network

FLaP = Fire, Landscapes & People, a partnership among the Conservancy, US Dept. of Agriculture and US Dept. of the Interior.

GFI = Global Fire Initiative

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appendix a: lfra potential natural vegetation groups

Description

LFRA Reference Condition Models help to synthesize the best available knowledge on vegetation dynamics and quantify the natural range of variability in vegetation composition and structure. Models consist of two components: (1) a comprehensive description and (2) a quantitative, state-and-transition (box) model, created in the public domain software VDDT (Vegetation Dynamics Development Tool; Beukema et al. 2003).

LFRA vegetation models were based on a simple, standardized five-box model that combines three generic succession stages with two canopy cover classes. Each class is specifically defined for individual models. Variations on this standardized model were also developed. Models were developed in 2004-2005 during workshops across the conterminous U.S. where regional vegetation and fire ecology experts synthesized the best available data on vegetation dynamics and disturbances for vegetation communities in their region. A peer review process following workshops garnered additional expert input and offered an opportunity to refine models.

Quantitative models are based on inputs such as fire frequency and severity, the probability of other disturbances, and the rate of vegetation growth. Inputs are derived from literature review and expert input during and after modeling workshops. Models simulate several centuries of vegetation dynamics and produce outputs such as the percent of the landscape in each class and the frequency of disturbances. Outputs are checked against available data whenever possible, and are peer-reviewed during and after expert workshops.

Model descriptions and quantitative outputs were used in the LFRA to help define and map potential natural vegetation groups (Appendix II), or the vegetation communities that are likely to exist under the natural range of variability in biophysical environments and ecological processes, including fire and other disturbances. Models are used as reference conditions to calculate FRCC. A complete description of the methodology used to develop LFRA vegetation models can be found in the "*LANDFIRE Rapid Assessment Modeling Manual*" (The Nature Conservancy et al. 2005).

On the pages that follow are (1) one example of a reference model description, and (2) a graphic of the quantitative model for the northern mixed grass prairie potential natural vegetation group.

Rapid Assessment Reference Condition Model

The Rapid Assessment is a component of the LANDFIRE project. Reference condition models for the Rapid Assessment were created through a series of expert workshops and a peer-review process in 2004 and 2005. For more information, please visit www.landfire.gov. Please direct questions to helpdesk@landfire.gov.

Potential Natural Vegetation Group (PNVG)

R4PRMGn **Northern Mixed Grass Prairie**

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Vegetation Type

Grassland

Dominant Species*

AGSM, KOMA, STIPA, BUDA, BOUT, CAFI

General Model Sources

- [x] Literature
- [ ] Local Data
- [x] Expert Estimate

LANDFIRE Mapping Zones

30, 39, 31, 40, 33

Rapid AssessmentModel Zones

- [ ] California
- [ ] Great Basin
- [ ] Great Lakes
- [ ] Northeast
- [x] Northern Plains
- [ ] N-Cent.Rockies
- [ ] Pacific Northwest
- [ ] South Central
- [ ] Southeast
- [ ] S. Appalachians
- [ ] Southwest

Geographic Range

Northeastern Montana, western North and South Dakota, northeastern Wyoming, western Nebraska.

Biophysical Site Description

Elevations range from 1,300 to 4,000 feet. Temperatures range between extremes of hot summers and cold winters that are typical of a continental climate. Precipitation increases from west (12 in.) to east (24 in.). Two-thirds of the precipitation occurs during the growing season. Soils vary, but are generally aridicols in the west and mollisols in the east. Soils in the northern Great Plains, west of the Missouri River in the Dakotas, northwestern Nebraska, northeastern Wyoming and Montana are formed from sandstone and shales. These soils range from clayey, fine-loamy, to fine silty soils of mixed origin in level and hilly-undulating lands with major contributions from loess, eolian sand, alluvium, and mountain outwash.

Vegetation Description

This vegetation type is characterized by the dominance of cool-season grasses such as western wheatgrass and needlegrasses. Warm-season grasses like grama grasses and buffalo grass are common and usually increase in dominance following heavy disturbance. Needleleaf sedge is very common throughout this vegetation type, especially in sandy soils. Needleleaf sedge tends to be very drought-resistant.

Disturbance Description

The northern mixed-grass prairie is strongly influenced by wet-dry cycles. Fire, grazing by large ungulates and small mammals such as prairie dogs and soil disturbances (i.e. buffalo wallows and prairie dog towns) are the major disturbances in this vegetation type. From instrumental weather records, droughts are likely to occur about 1 in every 10 years. Historically, there were likely close interactions between fire and grazing since large ungulates tend to be attracted to post-fire communities. Average fire intervals are estimated at 8-25 years, although in areas with very broken topography fire intervals may have been greater than 30 years. Fires were most common in July and August, but probably occurred from about April to September. Seasonality of fires influences vegetation composition. Early season fires (April - May) tend to favor warm-

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.

season species, while late season fires (August - September) tend to favor cool-season species. Replacement fire in our model does remove 75% of the above ground cover as assumed in the literature. However, we don't think loss of the above ground cover by the replacement fire will necessarily induce a retrogression back to an earlier seral stage because the main component of dominant grasses remains unharmed to insure the continuity of the seral stage. We used 3 levels of native ungulate grazing intensities: heavy with at least 80% biomass removal, moderate with about 60% removal, and light with 40% or less removal. We assumed that light grazing would not alter the community enough to change classes, but increasing grazing intensity would move the community back to earlier stages.

Adjacency or Identification Concerns

This PNVG transitions to tallgrass prairie to the east, sagebrush steppe to the west, and sandhills prairie, shortgrass prairie and southern mixed-grass prairie to the south. In the western part of this PNVG, big sagebrush can invade with heavy grazing or absence of fire. Cheatgrass currently is increasing in portions of this PNVG.

This PNVG is similar to the PNVG R0PGRn from the Northern and Central Rockies model zone.

Scale Description

Sources of Scale Data ☐ Literature ☐ Local Data ☑ Expert Estimate

Historically, fires probably ranged in size from 1000s to 10,000s of acres. The variation depends on build-up of fuels which were influenced by precipitation and grazing. Extent of weather influences (wet-dry cycles) would have been very widespread.

Issues/Problems

Model Evolution and Comments

Ortmann in his review, suggested that in addition to fire, drought and grazing, insect outbreaks (Rocky Mountain locust) would have impacted all classes.

*Succession Classes***

Succession classes are the equivalent of "Vegetation Fuel Classes" as defined in the Interagency FRCC Guidebook (www.frcc.gov).

Class A **29 %**

Early1 Open

Description

Very short-stature vegetation resulting from prairie dog disturbance. A variety of forb species such as fetid marigold, scarlet globemallow, and curlycup gumweed tend to dominate this class. Common grass species include purple three-awn, buffalo grass, and saltgrass. Greasewood may be present in lowland areas. Fringed sagebrush can also be a component of this class. The fuels in this class are generally too sparse to carry fire.

Dominant Species* and Canopy Position

DYPA Upper
GRSQ Upper
SPCO Upper
ARPU9 Upper

Upper Layer Lifeform

☑ Herbaceous
☐ Shrub
☐ Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	10 %	30 %
Height	Herb Short <0.5m	Herb Short <0.5m
Tree Size Class	no data	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.

Class B **12 %**

Early2 Open

Description

Grasses such as buffalo grass, blue grama, dropseeds, and upland sedges dominate this class. Forbs like scarlet globemallow, scarlet gaura, skeleton weed, and dotted gayfeather are common in this class. Prickly pear, man sage, fringed sage, and broom snakeweed occur in this class. Prickly pear tends to increase with heavy grazing.

Dominant Species* and Canopy Position

BUDA Upper
BOGR2 Upper
CAFI Upper
SPORO Upper

Upper Layer Lifeform

☑ Herbaceous
☐ Shrub
☐ Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	15 %	45 %
Height	Herb Short <0.5m	Herb Short <0.5m
Tree Size Class	no data	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class C **18 %**

Mid1 Open

Description

Blue grama, western wheatgrass, needlegrasses, prairie junegrass, upland sedges, and little bluestem are common grasses. In some areas species such as big bluestem, sand bluestem, prairie sandreed and bluebunch wheatgrass are locally common. Common forbs include scurfpea, prairie coneflower, Rocky Mountain beeplant, scarlet globemallow, and dotted gayfeather. Prickly pear, man sage (Artemisia ludoviciana), fringed sage, snowberry and broom snakeweed occur in this class.

Dominant Species* and Canopy Position

BOGR2 Mid-Upper
AGSM Upper
STIPA Upper
CAFI Middle

Upper Layer Lifeform

☑ Herbaceous
☐ Shrub
☐ Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	30 %	60 %
Height	Herb Short <0.5m	Herb Medium 0.5-0.9m
Tree Size Class	no data	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class D **25 %**

Late1 Open

Description

Vegetation community in this class is very similar to Class C, although western wheatgrass and needlegrasses are the most common species. In some areas western wheatgrass forms dense stands. Fewer forbs occur in this class than in Class C. Prairie junegrass is more common in this class than previous classes.

Dominant Species* and Canopy Position

AGSM Upper
STIPA Upper
CAFI Middle
BOGR2 Mid-Upper

Upper Layer Lifeform

☑ Herbaceous
☐ Shrub
☐ Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	50 %	80 %
Height	Herb Short <0.5m	Herb Tall > 1m
Tree Size Class	no data	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.

Class E **16 %**

Late2 Closed

Description

Vegetation community is similar to Class D but needle grasses tend to be more prevalent, especially during years with wet springs. Forbs are sparse. Litter layer tends to be relatively thick and continuous.

Dominant Species* and Canopy Position

STIPA Upper
AGSM Upper
BOGR Mid-Upper
CAFI

Upper Layer Lifeform

☑ Herbaceous
☐ Shrub
☐ Tree

Fuel Model 1

Structure Data (for upper layer lifeform)

	Min	Max
Cover	80 %	100 %
Height	Herb Short <0.5m	Herb Tall > 1m
Tree Size Class	no data	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Disturbances

Disturbances Modeled

☑ Fire
☐ Insects/Disease
☑ Wind/Weather/Stress
☑ Native Grazing
☐ Competition
☑ Other: prairie dog disturbance
☑ Other drought + grazing

Historical Fire Size (acres)

Avg: 10000
Min: 1000
Max: 100000

Sources of Fire Regime Data

☑ Literature
☐ Local Data
☑ Expert Estimate

Fire Regime Group: 2

I: 0-35 year frequency, low and mixed severity
II: 0-35 year frequency, replacement severity
III: 35-200 year frequency, low and mixed severity
IV: 35-200 year frequency, replacement severity
V: 200+ year frequency, replacement severity

Fire Intervals (FI)

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class. All values are estimates and not precise.

	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	15	8	25	0.06667	67
Mixed	30	15	35	0.03333	33
Surface					
All Fires	10			0.10001	

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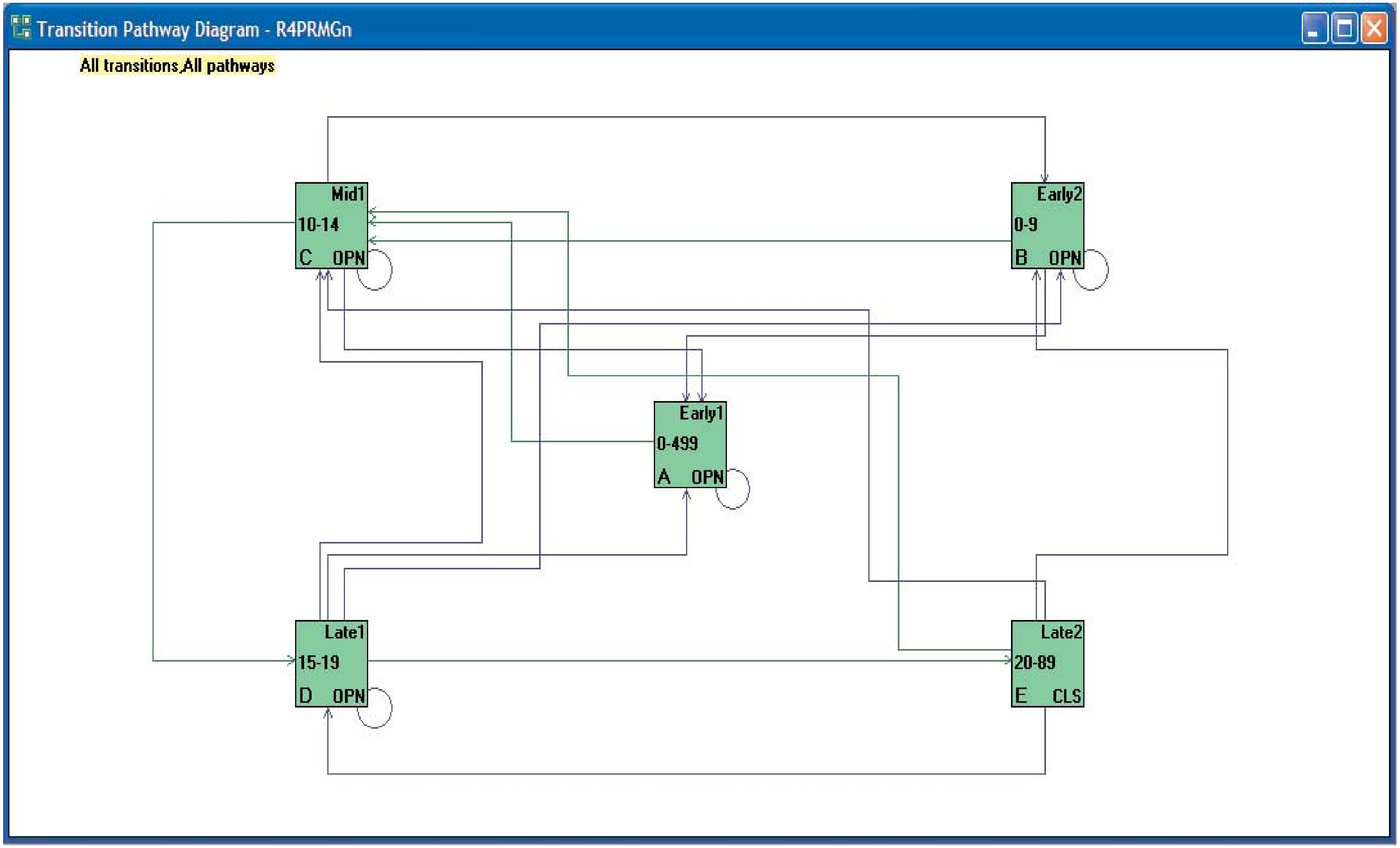
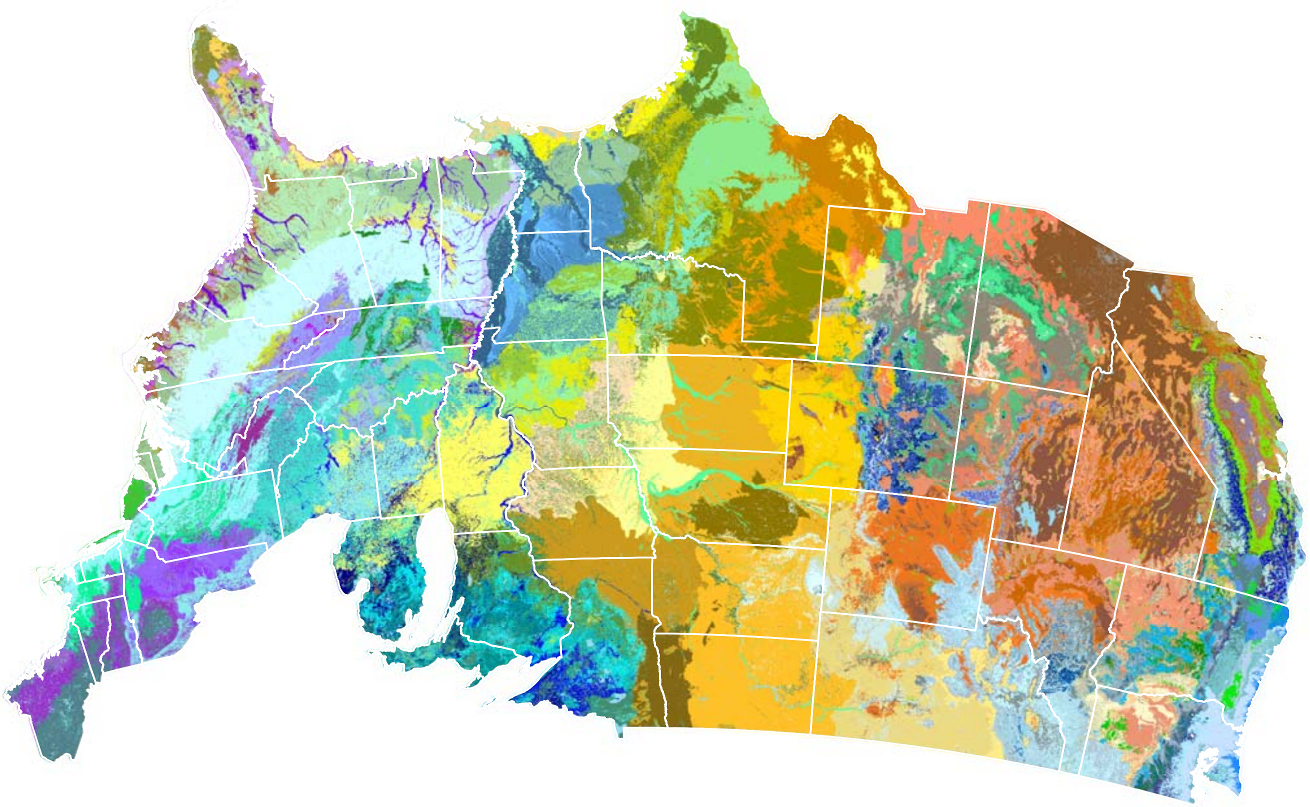

Transition Pathway Diagram - R4PRMGn
All transitions,All pathways
Mid1
10-14
C OPN
Early2
0-9
B OPN
Early1
0-499
A OPN
Late1
15-19
D OPN
Late2
20-89
E CLS

appendix b: lfra potential natural vegetation groups

Potential Natural Vegetation Groups (PNVG) define vegetation communities that are likely to exist under the natural range of variability in biophysical environments and ecological processes, including fire and other disturbances. During a series of 12 week-long workshops held throughout the conterminous U.S. over 250 local experts collaborated to refine the LFRA PNVG classification, write LFRA PNVG descriptions, quantitatively model each LFRA PNVG, and assign mapping rules for each LFRA PNVG. Mapping rules for each LFRA PNVG were defined using any combination of the following data sets: Coarse-Scale FRCC Assessment PNVGs (Schmidt et al. 2002), ecological regions, precipitation, growing degree days, elevation, aspect, slope, topography, soil texture (percent sand, silt, clay, and coarse), soil depth, and existing vegetation.

Potential Natural Vegetation Groups



LFRA PNVG Model Code*	Vegetation Type	LFRA PNVG Name
R#ABAMlw	Forested	Pacific Silver Fir--Low Elevation
R#ABAMup	Forested	Pacific Silver Fir--High Elevation
R#ABLA	Forested	Subalpine Fir
R#AGSP	Grassland	Bluebunch Wheatgrass
R#ALME	Grassland	Alpine & Subalpine Meadows & Grasslands
R#DFHEdy	Forested	Douglas-fir Hemlock-Dry Mesic
R#DFHEwt	Forested	Douglas-fir Hemlock-Wet Mesic
R#DFWV	Forested	Douglas-fir Willamatte Valley Foothills
R#JUPIse	Woodland	Western Juniper Pumice
R#MCONdy	Forested	Mixed Conifer - Eastside Dry
R#MCONms	Forested	Mixed Conifer - Eastside Mesic
R#MCONsw	Forested	Mixed Conifer - Southwest Oregon
R#MEVG	Forested	California Mixed Evergreen North
R#MGRA	Grassland	Idaho Fescue Grasslands
R#MTHE	Forested	Mountain Hemlock
R#OAPI	Woodland	Oregon White Oak/Ponderosa Pine
R#OWOA	Woodland	Oregon White Oak
R#PICOpu	Forested	Lodgepole Pine - Pumice Soils
R#PIJEsp	Woodland	Pine Savannah - Ultramafic
R#PIPOm	Forested	Dry Ponderosa Pine - Mesic
R#PIPOxe	Forested	Ponderosa Pine - Xeric
R#REFI	Forested	Red Fir
R#SAWD	Woodland	Subalpine Woodland
R#SBDWlw	Shrubland	Low Sagebrush
R#SBMT	Shrubland	Mountain Big Sagebrush (Cool Sagebrush)
R#SPFI	Forested	Spruce - Fir
R#SSHE	Forested	Sitka Spruce - Hemlock
R#TAOAco	Forested	Oregon Coastal Tanoak
R#WGRA	Grassland	Marsh
R0GFDF	Forested	Grand fir/Douglas-fir/Larch Mix
R0GFLP	Forested	Grand fir/Lodgepole/Larch/Douglas-fir mix
R0JUNIan	Woodland	Ancient Juniper
R0LPDFnr	Forested	Lower Subalpine Lodgepole Pine
R0LPSFcr	Forested	Lower Subalpine--Wyoming & Central Rockies
R0MCCH	Forested	Mixed Conifer-Upland Cedar/Hemlock

LFRA PNVG Model Code*	Vegetation Type	LFRA PNVG Name
R0MGRA	Grassland	Mountain Grassland
R0MTSB	Shrubland	Mountain Shrub--non Sagebrushes
R0PGRn	Grassland	Northern Prairie Grassland
R0PICO	Forested	Persistent Lodgepole Pine
R0PIPObh	Forested	Ponderosa Pine-Black Hills-High Elevation
R0PIPObl	Forested	Ponderosa Pine-Black Hills-Low Elevation
R0PIPOnp	Forested	Ponderosa Pine-Northern Great Plains
R0PIPOnr	Forested	Ponderosa Pine Northern & Central Rockies
R0PPDF	Forested	Ponderosa Pine - Douglas-fir
R0PSMEco	Forested	Cold Douglas-fir
R0PSMEdy	Forested	Xeric Interior Douglas-fir
R0PSMEms	Forested	Warm Mesic Interior Douglas-fir
R0RIPA	Shrubland	Riparian--Wyoming
R0SBBB	Shrubland	Basin Big Sagebrush
R0SBDW	Shrubland	Low Sagebrush Shrubland
R0SBMT	Shrubland	Mountain Big Sagebrush Steppe & Shrubland
R0SBWYwy	Shrubland	Wyoming Big Sagebrush
R0SPFI	Forested	Upper Subalpine Spruce-Fir - Central Rockies
R0WBLP	Forested	Whitebark Pine & Lodgepole Pine-Upper Subalpine Northern & Central Rockies
R0WERC	Forested	Western Red Cedar
R0WLLPDF	Forested	Western Larch-Lodgepole Pine-& Douglas-fir Mix
R1ABCO	Forested	Interior White Fir--northeastern California
R1ALME	Grassland	Alpine Meadows Barrens
R1ASPN	Forested	Aspen with Conifer
R1CAGR	Grassland	California Grassland
R1CHAP	Shrubland	Chaparral
R1CHAPmn	Shrubland	Montane Chaparral
R1MCONns	Forested	Mixed Conifer - North Slopes
R1MCONss	Forested	Mixed Conifer - South Slopes
R1MEVGn	Forested	California Mixed Evergreen
R1MTME	Grassland	Wet Mountain Meadow/Lodgepole Pine-Subalpine
R1OAWD	Woodland	California Oak Woodlands
R1PICOcw	Forested	Sierra Nevada Lodgepole Pine - Cold Wet Upper Montane
R1PICOdy	Forested	Sierra Nevada Lodgepole Pine - Dry Subalpine

LFRA PNVG Model Code*	Vegetation Type	LFRA PNVG Name
R1PIJE	Forested	Jeffrey Pine
R1PIPO	Woodland	Ponderosa Pine
R1PSMA	Forested	South Coastal Mixed Evergreen/Big Cone Douglas-fir
R1RFWF	Forested	Red Fir / White Fir
R1RFWP	Forested	Red Fir / Western White Pine
R1SABU	Shrubland	Saltbush
R1SAGEco	Shrubland	Coastal Sage Scrub
R1SCRBnc	Shrubland	Coastal Scrub/Coastal Prairie
R1SESE	Forested	Coast Redwood
R1WEHB	Grassland	Herbaceous Wetland
R2ASMClw	Forested	Aspen with Conifer--Low to Mid-Elevations
R2ASMCup	Forested	Aspen with Conifer--High Elevations
R2ASPN	Forested	Stable Aspen / Cottonwood - No Conifers
R2BLBR	Shrubland	Blackbrush
R2CHAPmn	Shrubland	Montane Chaparral
R2CRBU	Shrubland	Creosotebush Shrublands With Grasses
R2MGCOws	Grassland	Mountain Meadow---Mesic to Dry
R2MGWAws	Grassland	Great Basin Grassland
R2MSHBwt	Shrubland	Mountain Shrubland with Trees
R2MTMA	Shrubland	Curlleaf Mountain Mahogany
R2PIJU	Woodland	Juniper & Pinyon Juniper Steppe Woodland
R2PIPO	Forested	Interior Ponderosa Pine
R2PSMEdy	Forested	Great Basin Douglas-fir - Dry
R2SBBB	Shrubland	Basin Big Sagebrush
R2SBDW	Shrubland	Black & Low Sagebrushes
R2SBDWwt	Shrubland	Black & Low Sagebrushes with Trees
R2SBMT	Shrubland	Mountain Big Sagebrush
R2SBMTwc	Shrubland	Mountain Big Sagebrush with Conifers
R2SBWY	Shrubland	Wyoming Big Sagebrush Semi-Desert
R2SBWYse	Shrubland	Wyoming Sagebrush Steppe
R2SBWYwt	Shrubland	Wyoming Big Sagebrush Semi Desert with Trees
R2SDSH	Shrubland	Salt Desert Shrub
R2SFPI	Forested	Spruce-Fir / Pine Subalpine
R3ASMC	Forested	Aspen with Spruce-Fir
R3ASPN	Forested	Stable Aspen without Conifers

LFRA PNVG Model Code*	Vegetation Type	LFRA PNVG Name
R3BCLPsw	Woodland	Bristlecone/Limber Pines Southwest
R3CHAPsw	Shrubland	Interior Arizona Chaparral
R3DESH	Shrubland	Desert Shrubland without Grass
R3DGRA	Grassland	Desert Grassland
R3DGRAst	Grassland	Desert Grassland with Shrub & Tree
R3MASB	Shrubland	Mountain Sagebrush (Cool Sage)
R3MCONcm	Forested	Southwest Mixed Conifer--Cool\Moist with Aspen
R3MCONwd	Forested	Southwest Mixed Conifer--Warm\Dry with Aspen
R3MEBO	Woodland	Mesquite Bosques
R3MGRA	Grassland	Montane & Subalpine Grasslands
R3MGRAws	Grassland	Montane & Subalpine Grasslands with Shrubs or Trees
R3MSHB	Shrubland	Mountain Mahogany Shrubland
R3OCWO	Woodland	Madrean Oak Conifer Woodland
R3PGm	Grassland	Plains Mesa Grassland
R3PGmst	Grassland	Plains Mesa Grassland with Shrubs or Trees
R3PGRs	Grassland	Shortgrass Prairie
R3PGRsws	Grassland	Shortgrass Prairie with Shrubs
R3PGRswt	Grassland	Shorgrass Prairie with Trees
R3PICOif	Forested	Central Rocky Mountains Lodgepole Pine - Infrequent Fire
R3PIJUff	Woodland	Pinyon Juniper - Mixed Fire Regime
R3PIJUrf	Woodland	Pinyon Juniper - Rare Replacement Fire Regime
R3PPDF	Forested	Ponderosa Pine Douglas-fir - Southern Rockies
R3PPGO	Forested	Ponderosa Pine Gambel Oak - Southern Rockies & Southwest
R3PPGRsw	Woodland	Ponderosa Pine Grassland Southwest
R3QUGA	Shrubland	Gambel Oak
R3RIPAfo	Forested	Riparian Forest with Conifers
R3RIPAgr	Forested	Riparian Deciduous Woodland
R3SDSH	Shrubland	Salt Desert Scrubland
R3SHST	Shrubland	Southwest Shrub Steppe
R3SHSTwt	Shrubland	Southwest Shrub Steppe with Trees
R3SPFI	Forested	Spruce - Fir
R4NESP	Grassland	Nebraska Sandhills Prairie
R4NOFP	Woodland	Great Plains Floodplain
R4OASA	Grassland	Oak Savanna
R4OKHK	Woodland	Oak Woodland

LFRA PNVG Model Code*	Vegetation Type	LFRA PNVG Name
R4PRMGn	Grassland	Northern Mixed Grass Prairie
R4PRMGs	Grassland	Southern Mixed Grass Prairie
R4PRTGc	Grassland	Tallgrass Prairie - Central
R4PRTGn	Grassland	Northern Tallgrass Prairie
R4PRTGse	Grassland	Southern Tallgrass Prairie East
R4WODR	Woodland	Northern Great Plains Wooded Draws & Ravines
R5BSOW	Woodland	Interior Highlands Dry Oak/Bluestem Woodland/Glade
R5BSSA	Grassland	Bluestem - Saccahuista
R5DGRA	Grassland	Desert Grassland
R5FOWOdm	Forested	Interior Highlands Dry-Mesic Forest & Woodland
R5GCPF	Forested	Gulf Coastal Plain Pine Flatwoods
R5GCPP	Forested	West Gulf Coastal Plain Pine -- Uplands + Flatwoods
R5GCPU	Forested	West Gulf Coastal Plain Pine-Hardwood Woodland/Forest Upland
R5LOSApa	Woodland	Oak Woodland / Shrubland / Grassland Mosaic
R5MQSA	Woodland	Mesquite Savanna
R5OAHIdy	Woodland	Interior Highlands Oak-Hickory (Pine)
R5OASA	Grassland	Oak Savanna
R5OHSA	Woodland	Oak-Hickory Savanna
R5PIBS	Woodland	Pine Bluestem
R5PRBL	Grassland	Blackland Prairie
R5PRSG	Grassland	Southern Short/Mixed Grass Prairie
R5PRTG	Grassland	Southern Tallgrass Prairie
R5SHNS	Shrubland	Shinnery Oak - Mixed Grass
R5SHNT	Shrubland	Shinnery Tallgrass
R5SHST	Shrubland	Southwestern Shrub Steppe
R5SOFPif	Forested	Southern Floodplain
R5SOFPrf	Forested	Southern Floodplain - Rare Fire
R5XTMB	Forested	Cross Timbers
R6BSOH	Grassland	Mosaic of Bluestem Prairie & Oak-Hickory
R6COLLff	Forested	Conifer Lowland Embedded in Fire Prone System
R6COLLif	Forested	Conifer Lowland Embedded in Fire Resistant Ecosystem
R6FPFOgl	Forested	Great Lakes Floodplain Forest
R6GLSF	Forested	Great Lakes Spruce Fir
R6GLSFif	Forested	Minnesota Spruce Fir Adjacent to Lake Superior & Drift & Lake Plain

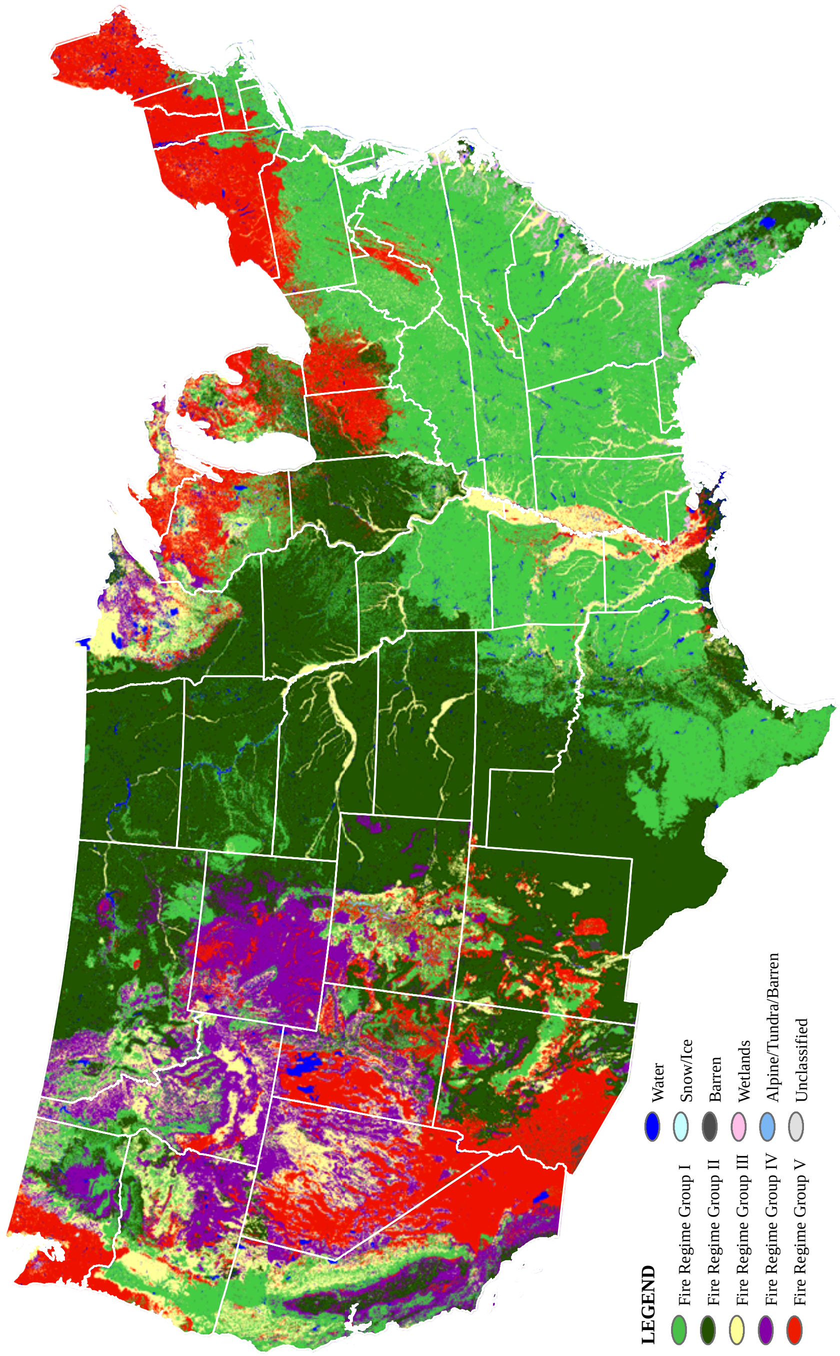
LFRA PNVG Model Code*	Vegetation Type	LFRA PNVG Name
R6JAPI	Forested	Great Lakes Pine Forest: Jack Pine
R6JAPIop	Woodland	Great Lakes Pine Barrens
R6JPOPMN	Woodland	Jack Pine / Open Lands with Frequent (high) Fire Return Interval
R6MABA	Forested	Maple Basswood
R6MBMHW	Forested	Great Lakes Maple-Basswood Mesic Hardwood Forest
R6MBOA	Forested	Maple Basswood Oak Aspen
R6NHHEgl	Forested	Northern Hardwood-Hemlock Forest (Great Lakes)
R6NHMB	Forested	Northern Hardwood Maple Beech Hemlock
R6NOKS	Woodland	Northern Oak Savanna
R6OAHI	Forested	Oak Hickory
R6PIOK	Forested	Pine Oak
R6RPWPff	Forested	Red Pine-White Pine with Frequent Fire
R6RPWPif	Forested	Red Pine-White Pine with Less Frequent Fire
R6WPHEff	Forested	Great Lakes Pine Forests: White Pine Hemlock Frequent Fire
R6WPHEif	Forested	White Pine Hemlock
R7APOK	Forested	Appalachian Dry-Mesic Oak Forest
R7BEMA	Forested	Beech-Maple
R7EPWM	Woodland	Eastern Woodland Mosaic
R7NEFP	Forested	Northeast Floodplain
R7NESF	Forested	Northeast Spruce-Fir Forest
R7NHHE	Forested	Northern Hardwood Hemlock
R7NHMC	Forested	Eastern White Pine Northern Hardwood
R7NHNE	Forested	Northern Hardwoods Northeast
R7NHSP	Forested	Northern Hardwoods-Spruce
R7NMAR	Grassland	Northern Coastal Marsh
R7OAPIdx	Woodland	Eastern Dry-Xeric Oak Pine
R7PIBA	Woodland	Pine Barrens
R7ROPI	Woodland	Rocky Outcrop Pine - Northeast
R7SESF	Forested	Southeastern Red Spruce - Fraser Fir
R8BSOB	Grassland	Bluestem Oak Barrens
R8FPFOpi	Forested	Bottomland Hardwood Forest
R8HEWP	Forested	Hemlock - White Pine - Hardwood
R8MMHW	Forested	Mixed Mesophytic Hardwood
R8OACOm	Forested	Appalachian Dry Mesic Oak Forest
R8OAKxe	Forested	Eastern Dry-Xeric Oak

	Vegetation Type	LFRA PNVG Name
R8OHPI	Forested	Appalachian Oak Hickory Pine
R8OKAW	Woodland	Oak - Ash - Woodland
R8PIECap	Woodland	Appalachian Shortleaf Pine
R8PIVlap	Forested	Appalachian Virginia Pine
R8PRWMe	Grassland	Eastern Prairie Woodland Mosaic
R8SAHE	Forested	Southern Appalachian High-Elevation Forest
R8TMPP	Woodland	Table Mountain/Pitch Pine
R9AWCF	Forested	Atlantic White Cedar Forest
R9BKBE	Grassland	Southeast Gulf Coastal Plain Blackland Prairie & Woodland
R9EGSG	Grassland	Everglades Sawgrass
R9FPMA	Grassland	Floodplain Marsh
R9LLBS	Woodland	Longleaf Pine/Bluestem
R9LLMU	Woodland	Longleaf Pine Mesic Uplands
R9LLSH	Woodland	Longleaf Pine - Sandhills
R9MAPR	Grassland	Everglades Marl Prairie
R9MARF	Forested	Maritime Forest
R9MEFL	Forested	Mesic-Dry Flatwoods
R9OADM	Forested	Loess Bluff & Plain Forest
R9OHPI	Forested	Coastal Plain Pine Oak Hickory
R9PAPR	Grassland	Palmetto Prairie
R9PCSA	Grassland	Pond Cypress Savanna
R9PCSN	Shrubland	Pocosin
R9PIRO	Woodland	Pine Rocklands
R9POPI	Woodland	Pond Pine
R9SFPM	Forested	South Florida Coastal Prairie Mangrove Swamp
R9SFSP	Woodland	South Florida Slash Pine Flatwoods
R9SMAR	Grassland	Southern Tidal Brackish to Freshwater Marsh
R9SOFP	Forested	Southern Floodplain
R9SPSC	Forested	Sand Pine Scrub
R9WPSAat	Woodland	Atlantic Wet Pine Savanna
R9WPSAgu	Grassland	Gulf Coast Wet Pine Savanna
RAAlpine	Alpine	Generic Alpine/Tundra/Barren
RABarren	NonVeg	Barren
RASnwIce	NonVeg	Perennial Snow/Ice
RAWater	NonVeg	Water

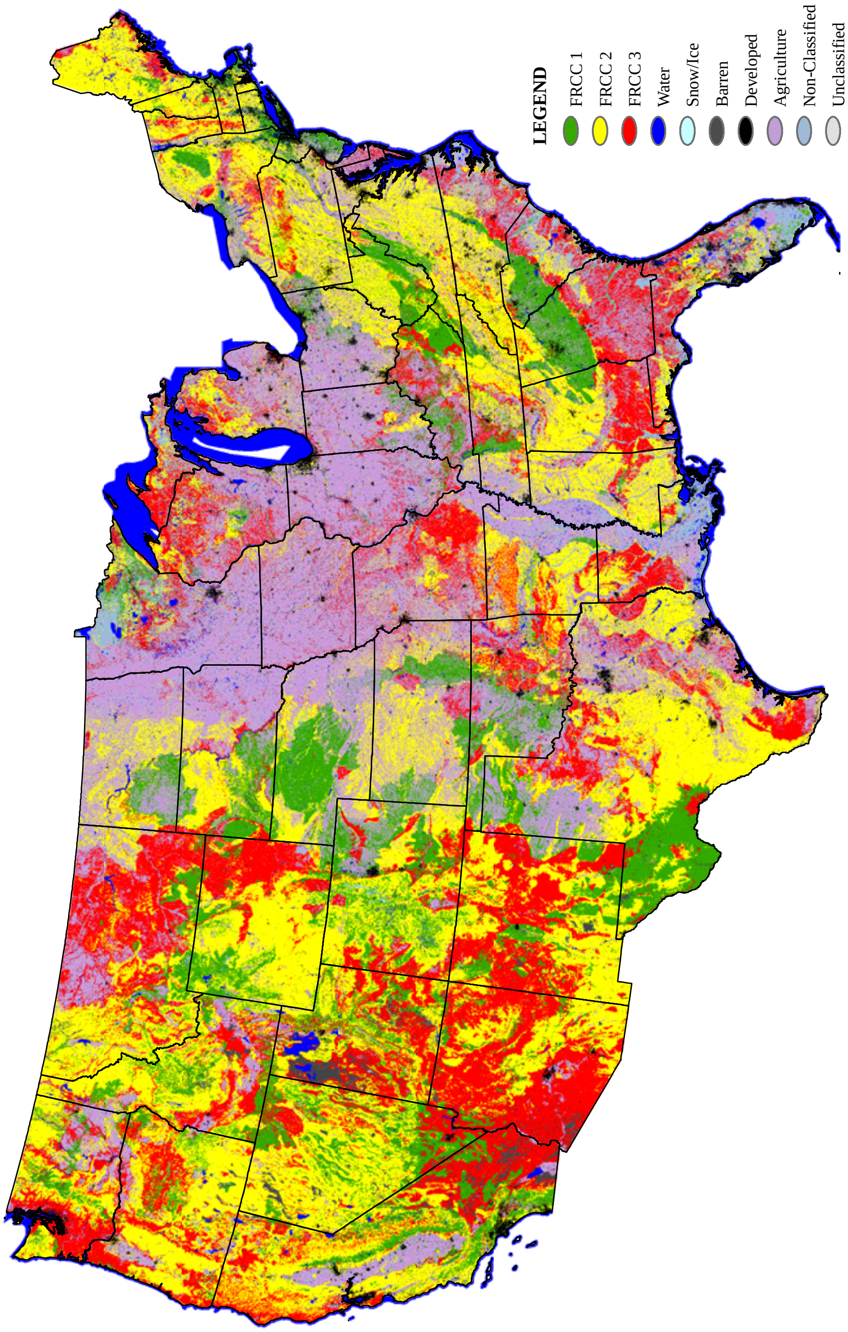
LFRA PNVG Model Code*	Vegetation Type	LFRA PNVG Name
RAWetHb	Wetland	Generic Herbaceous Wetland
RAWetWd	Wetland	Generic Woody Wetland
RAUnclss	Unclassified	Unclassified

*The first two digits of the code represent the LFRA modeling zone: R# = Northwest; R0 = Northern Rockies; R1 = California; R2 = Great Basin; R3 = Southewest; R4 = Northern Plains; R5 = South Central; R6 = Great Lakes; R7 = Northeast; R8 = Southern Appalachians; R9 = Southeast.

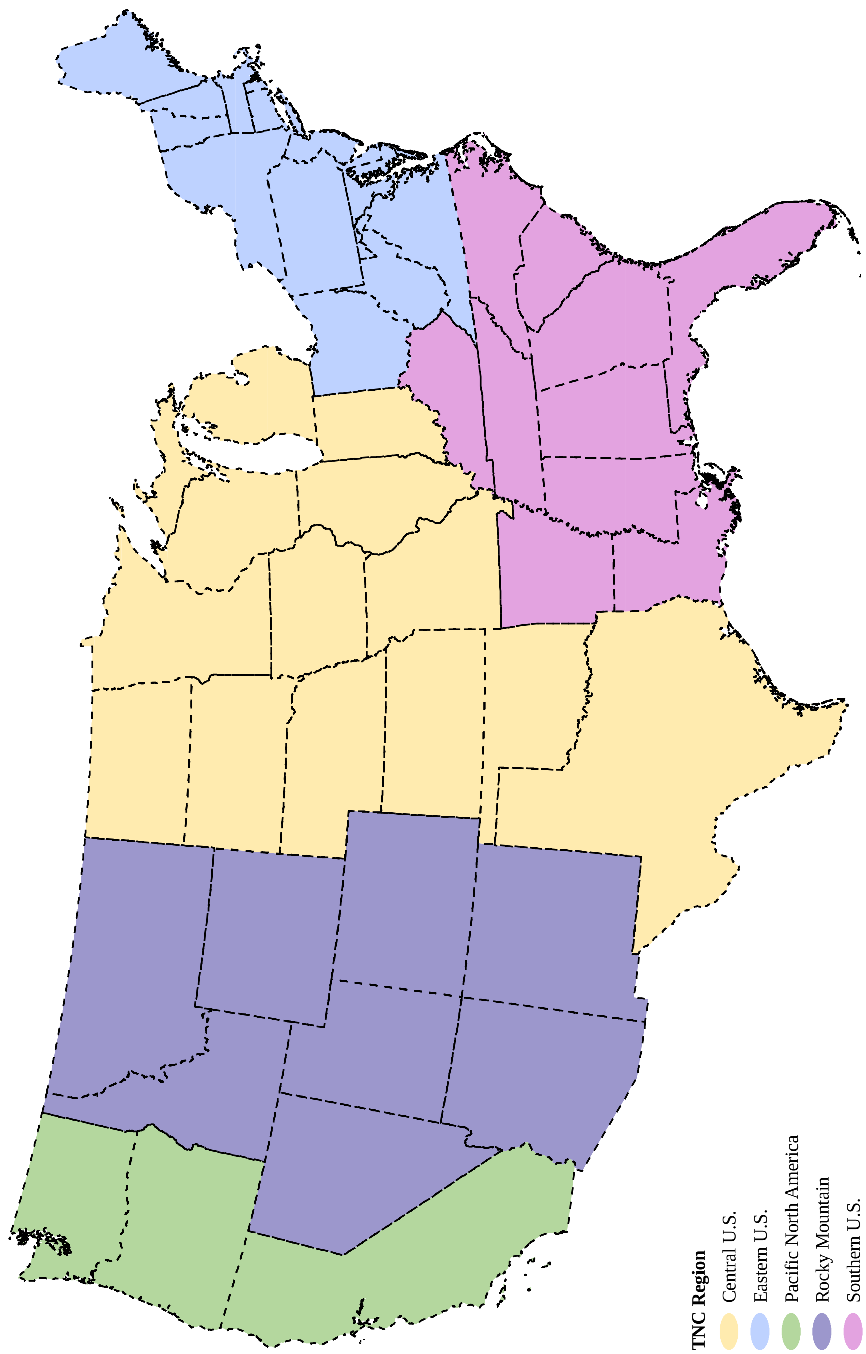
appendix c: lfra fire regime groups



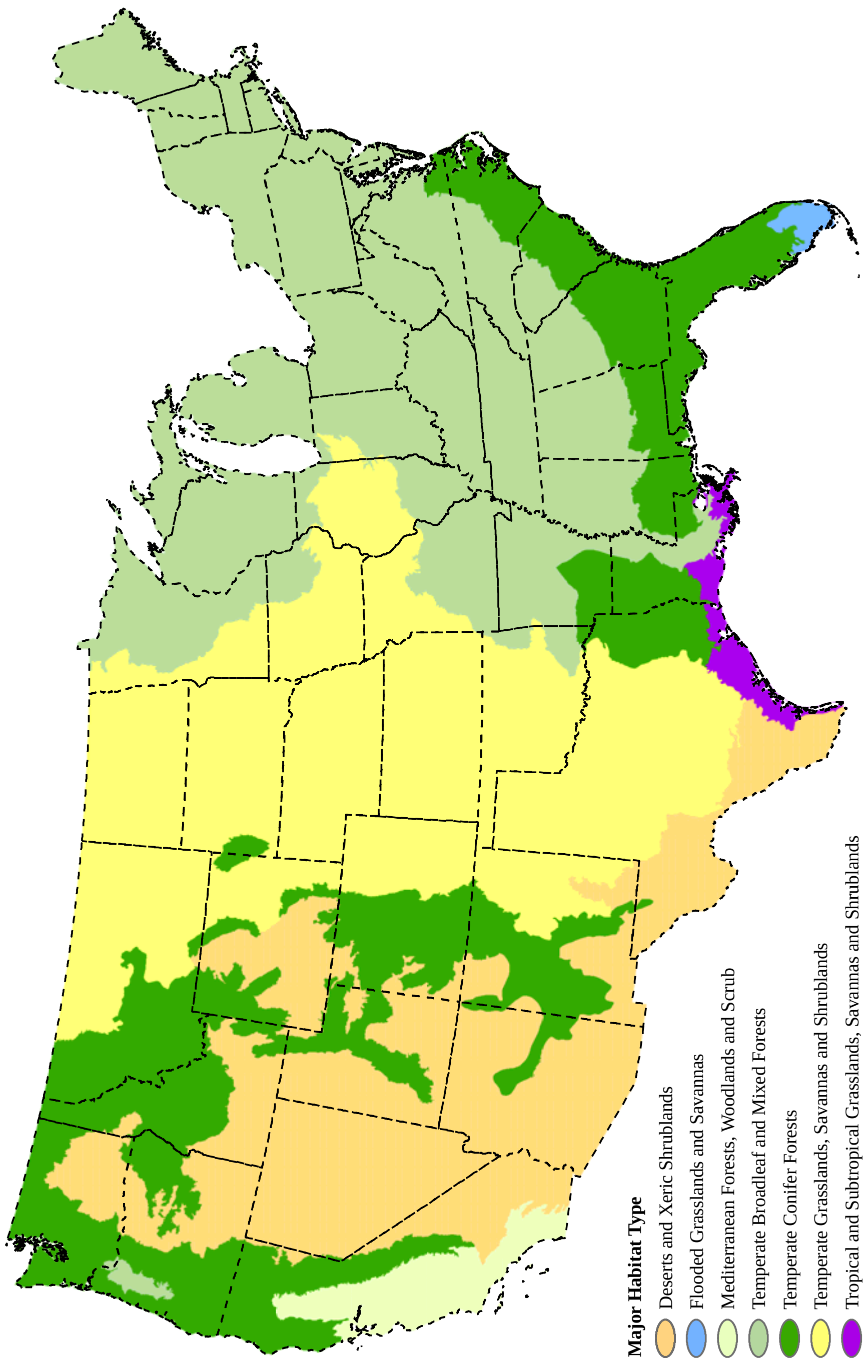
appendix d: lfra fire regime condition class



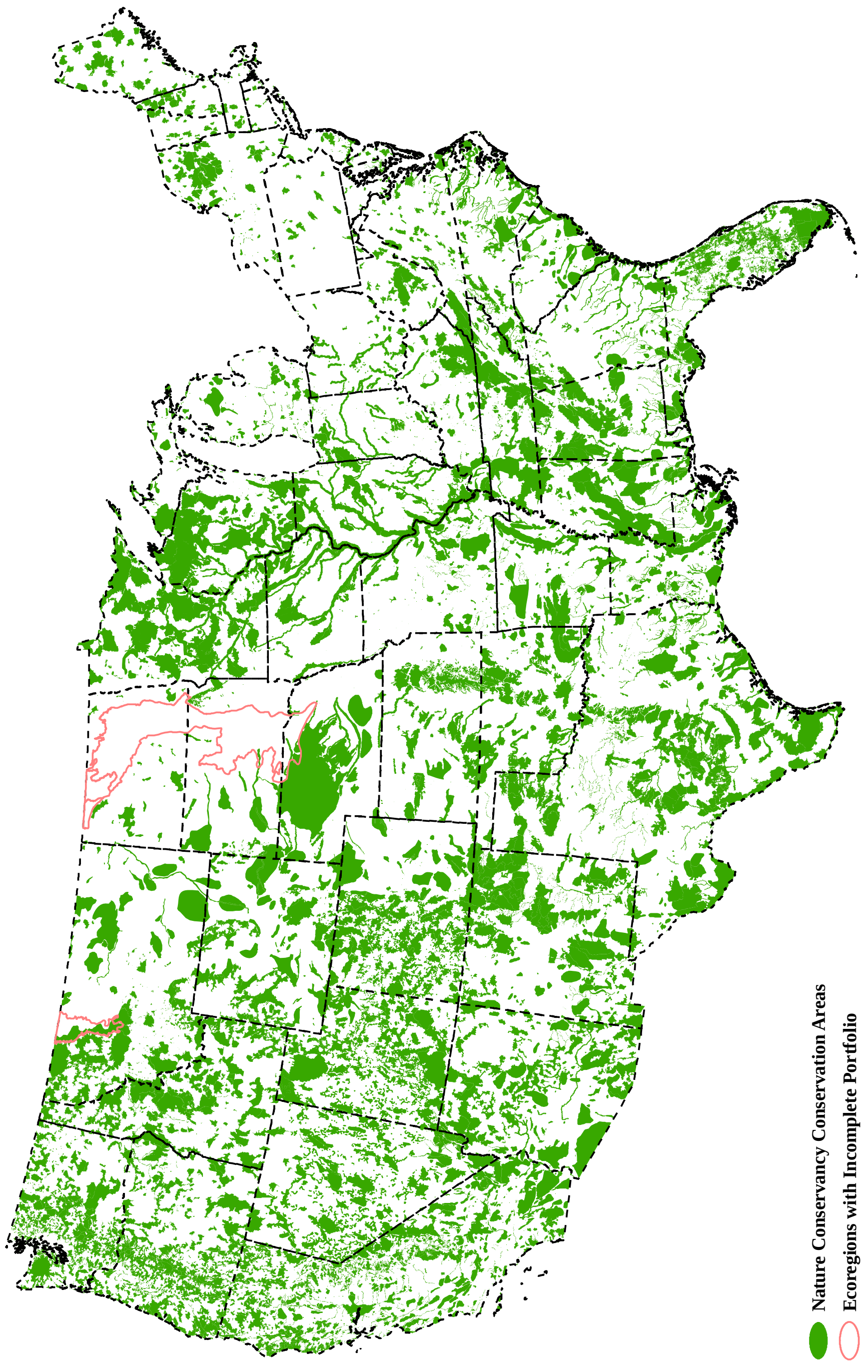
appendix e: nature conservancy administrative regions in the lower 48 states



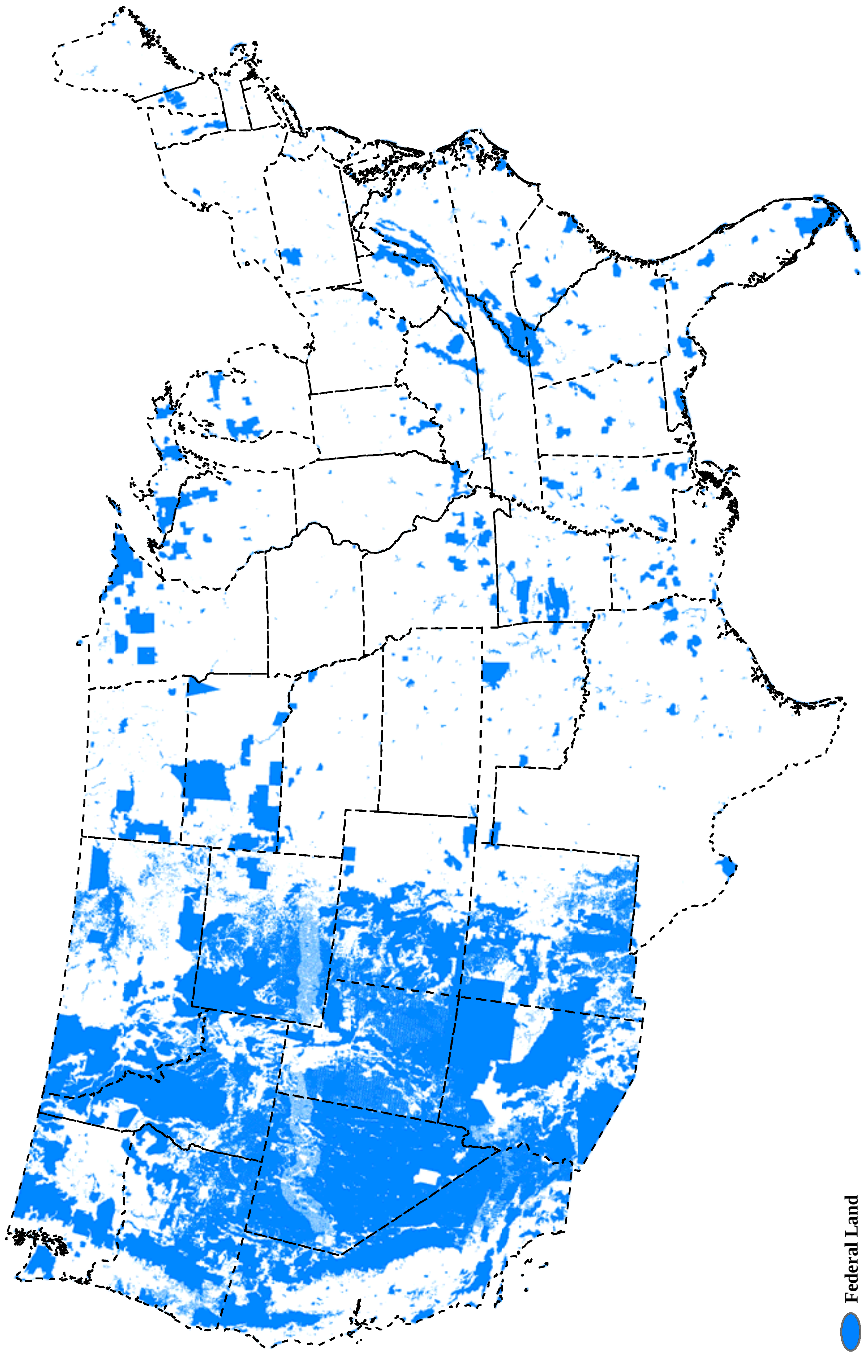
appendix f: major habitat types in the lower 48 states



appendix g: nature conservancy conservation areas in the lower 48 states



appendix h: federally administered lands in the lower 48 states



appendix i: spatial data & analysis methods

The spatial data layers used in this report are described below and on the following pages.

Data Layer	Description	Source
LFRA Fire Regime Group	Conceptual groupings that describe the frequency and severity of fire that would occur across landscapes under the natural range of variability, including the influence of aboriginal burning. LFRA FRGs include: Fire Regime I: 0 to 35 year frequency; low and mixed severity Fire Regime II: 0 to 35 year frequency; replacement severity Fire Regime III: 35 to 200 year frequency; low and mixed severity Fire Regime IV: 35 to 200 year frequency; replacement severity Fire Regime V: 200+ year frequency; replacement severity Fire regime groups were assigned for each LFRA PNVG based on the LFRA PNVG reference condition model.	LFRA Grid
LFRA Fire Regime Condition Class	LANDFIRE Fire Regime Condition Class (FRCC) is an indicator of landscape departure of current vegetation structure and composition from the natural range of variability, as estimated by Pre-European settlement conditions. In LANDFIRE, FRCC is summarized by vegetation type over large scale ecological regions (Appendix J). Vegetation structure and composition are surrogates for fuel composition, fire frequency/severity/pattern, and other associated disturbances, such as insect and disease mortality, grazing, severe winds, and drought. FRCC 3 is defined as greater than 66% departed from the reference condition and implies that a system is highly departed from the natural range of variability of vegetation characteristics. FRCC 2 is defined as 33 to 66% departed from the reference condition and implies that a system is moderately departed from the natural range of variability of vegetation characteristics. Biodiversity in areas classified as FRCC 3 or 2 is likely departed from pre-European conditions, and actions may be needed to restore biodiversity, such as integrated fire management, removal of invasive species, or other management activities. FRCC 1, defined as less than 33% departure, implies that a system is likely within the natural range of variability of vegetation characteristics. Actions may be needed to keep these areas within the natural range of variability and conserve biodiversity, such as integrated fire management, prevention of invasive species, or other management activities	LFRA Grid
Conservancy Regions	Boundary of The Nature Conservancy's administrative units in the lower 48 states of the U.S. Regions include: Central U.S., Eastern U.S., Pacific North America, Rocky Mountain, and Southern U.S.	ESRI States Coverage

Major Habitat Types	**A "relatively large unit of land or water containing a characteristic set of natural communities that share a large majority of their species, dynamics, and environmental conditions (Dinerstein et al. 1995)." These units represent broad patterns of biological organization and diversity on earth.**	**TNC, 2006 Terrestrial Ecoregions shapefile**
Nature Conservancy Conservation Areas	**The portfolio is one version of a solution set to represent comprehensively, the biodiversity of an ecoregion in an efficient and effective manner. Portfolios are designed to best achieve the conservation goals set for targets in the least number of places and areas of lands and waters. Current conservation and resource management practices, land ownership, levels of threats, and costs of implementing conservation actions are all considered when selecting geographic priorities for a portfolio.**	**TNC, 2005 US Portfolios shapefile, updated for 12 ecoregions**
Federally Administered Lands	**Lands in federal ownership including Department of Defense, U.S. Forest Service, Bureau of Indian Affairs, Fish and Wildlife Service, National Park Service, Bureau of Land Management and Bureau of Reclamation.**	**Source unknown, coverage**

Several preprocessing steps were needed to modify existing data sets for this analysis.

1. Created boundary grids for Nature Conservancy administrative regions from the ESRI states_2m coverage.

2. Converted the major habitat type shapefile to a grid.

3. Converted the federal lands coverage to a grid.

4. Updated the Conservancy's conservation area shapefile. At the time we began our analysis the most current spatial dataset for the Conservancy's conservation areas was a July 2005 shapefile. This layer did not have information for seven ecoregions that had not completed their ecoregional plans at the time the dataset was created. We obtained an August 2006, Northwest conservation areas shapefile with more current information for four of the missing ecoregions and eight other adjacent ecoregions covering parts of the Pacific North America and Rocky Mountain regions. We used the August 2006 dataset to update the July 2005 dataset creating the December 2006 conservation areas dataset used in this analysis, which covered all but three ecoregions in the Lower 48 states of the U.S. Ecoregions that were missing or updated from the conservation areas datasets are shown on the next page.

5. Projected all data to the LFRA projection (Albers Conical Equal Area).

6. Created grids of FRG and FRCC for each Conservancy region by merging LFRA mapzone (see map on following page) grids together using the regional boundary grids created in step 1 as the analysis mask.

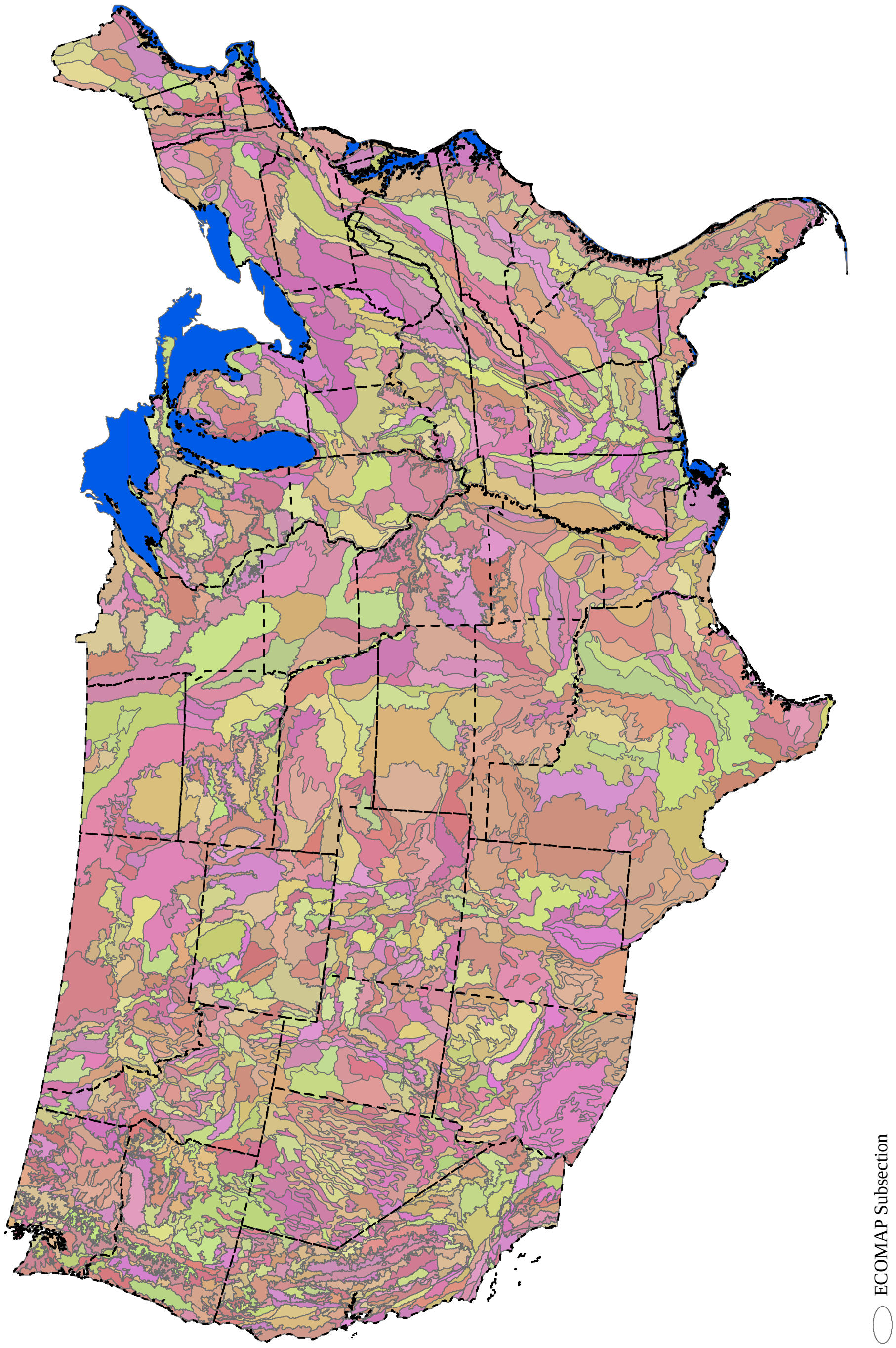
After preprocessing was complete, we combined the regional FRG and FRCC grids (step 6) with other datasets (see GIS calculations table on following page) and used the attribute tables to calculate FRG and FRCC for each level of interest: lower 48 states of the U.S., Conservancy regions and major habitat types.

Ecoregions missing from July 2005 portfolio shapefile	Ecoregions updated using August 2006 NW portfolio shapefile	Ecoregions missing from December 2006 portfolio shapefile
• Aspen Parkland • Dakota Mixed-Grass Prairie • East Cascades - Modoc Plateau • Fescue-Mixed Grass Prairie • North Cascades • Okanagan • West Cascades	• Canadian Rocky Mountains • Columbia Plateau • East Cascades - Modoc Plateau • Great Basin • Klamath Mountains • Middle Rockies - Blue Mountains • North Cascades • Okanagan • Pacific Northwest Coast • West Cascades • Willamette Valley - Puget Trough - Georgia Basin: Temperate Broadleaf and Mixed Forests • Willamette Valley - Puget Trough - Georgia Basin: Temperate Conifer Forests	Aspen Parkland Dakota Mixed-Grass Prairie Fescue-Mixed Grass Prairie

GIS Calculation	Method
FRCC in Major Habitat Types	combined FRCC grid for each region with the major habitat type grid
FRG in Major Habitat Types	combined FRG grid for each region with the major habitat type grid
FRCC in Nature Conservancy Conservation Areas	masked the FRCC grid for each region with the portfolio shapefile and combined with the major habitat type grid
FRCC in Federally-Administered Lands	combined FRCC grid for each region with the federal lands grid

appendix j: ECOMAP subsections

LFRA FRCC was calculated for each LFRA PNVG within an ECOMAP sub-section (see map on following page). More information on ECOMAP can be found at www. http://www.fs.fed.us/emc/rig/.


ECOMAP Subsection

appendix k: percentage of area for every mapped value on the FRCC map

	FRCC1	FRCC2	FRCC3	Water	Snow/Ice	Barren	Urban/ Transportation/ Mines/Quarries	Agriculture	Wetlands/ Alpine/Others	Unclassified/ Unknown
Lower 48 States										
	12	30	19	5	<1	1	2	26	4	<1
Fire Regime Group										
FRG1	8	39	21	<1	<1	<1	3	26	3	<1
FRG2	15	20	18	<1	<1	<1	1	43	3	<1
FRG3	15	38	14	<1	<1	<1	1	19	13	<1
FRG4	23	53	12	<1	<1	1	1	8	1	<1
FRG5	12	30	31	<1	<1	4	2	17	3	<1
Water	<1	<1	<1	99	<1	<1	<1	<1	<1	<1
Snow/Ice	<1	<1	<1	<1	99	<1	<1	<1	<1	<1
Barren	<1	<1	<1	<1	<1	99	<1	<1	<1	<1
Wetlands	<1	<1	<1	<1	<1	<1	1	7	91	2
Alpine/Tundra/Barren	<1	<1	<1	<1	<1	<1	<1	<1	98	1
Unclassified/Unknown	<1	<1	<1	<1	<1	<1	7	43	49	<1
Nature Conservancy Region										
Central U.S.	11	21	12	2	<1	<1	2	47	5	<1
Eastern U.S.	12	44	6	3	<1	<1	5	26	4	<1
Pacific North America	13	40	27	1	<1	4	2	12	1	<1
Rocky Mountain	16	40	31	1	<1	3	1	8	1	<1
Southern U.S.	10	26	17	3	<1	<1	3	27	14	<1

	FRCC1	FRCC2	FRCC3	Water	Snow/Ice	Barren	Urban/ Transportation/ Mines/Quarries	Agriculture	Wetlands/ Alpine/Others	Unclassified/ Unknown
Major Habitat Type										
Deserts & Xeric Shrublands	16	40	29	1	<1	5	1	7	<1	<1
Mediterranean Forests, Woodlands & Scrub	23	34	7	1	<1	2	6	26	1	<1
Temperate Broadleaf & Mixed Forests	10	30	12	3	<1	<1	4	35	7	<1
Temperate Conifer Forests	12	39	26	2	<1	1	2	10	7	<1
Temperate Grasslands, Savannas & Shrublands	12	22	16	1	<1	<1	1	45	2	<1