

An Examination of Broad Policy Options Available Within the Cohesive Strategy

The Report of the National Science and Analysis Team

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DRAFT

Table of Contents

COVER PHOTO CREDITS

All photos were obtained from InciWeb (Incident Information System www.inciweb.org) and were compiled by Serra Hoagland, USDA FS Eastern Forest Environmental Threat Assessment Center.

TOP
Left to right: Oregon Badger Butte Fire (Mike Dolan, Fire Professional), fire crew on West Texas Fires (Texas US Forest Service), a line of retardant streaks the ridge on the Arizona Horseshoe 2 Fire (Kent Ellett, District Ranger Nogales National Forest).

BOTTOM
Aerial view of the Honey Prairie Fire. April 30, 2011. Georgia Okefenokee National Wildlife Refuge. (Howard McCullough, USFWS).

Illustrations

Figures

Tables

INTRODUCTION

The National Cohesive Wildland Fire Management (Cohesive Strategy) is an intergovernmental effort involving Federal, state, local and Tribal governments and non-governmental organizations to collaboratively address growing wildfire problems in the United States. The intent of the strategy is to provide clear guidance on roles and responsibilities for all parties, emphasizing the shared responsibility necessary among stakeholders and partners. Three primary areas and goals have been identified:

1. Restore and Maintain Resilient Landscapes – Landscapes across all jurisdictions are resilient to disturbances in accordance with management objectives.

2. Create Fire Adapted Communities – Human populations and infrastructure can survive a wildland fire. Communities can assess the level of wildfire risk to their communities and share responsibility for mitigating both the threat and the consequences.

3. Response to Wildfire – All jurisdictions participate in making and implementing safe, effective, efficient risk-based wildland fire management decisions.

Through an iterative and collaborative process among many stakeholders, the Regional Strategy Committees have assembled a comprehensive list of actions and activities within the regional action plans that would collectively advance the goals of the Cohesive Strategy. The recommended actions span multiple issues, ranging from vegetation management, response coordination and training, community preparedness, wildfire prevention, and other related activities. All recommendations have been vetted in regional forums and are based upon practical understanding of the issues involved. The unfortunate reality is that resources and funding likely are insufficient to fully implement all recommendations, making further analysis and prioritization essential.

The next logical step in the development of the Cohesive Strategy is a spatial (and perhaps temporal) prioritization of actions and activities based upon a rigorous analysis of available information. Spatial prioritization may illustrate barriers outside of mere resources constraints that hinder or prevent some recommendations from being followed. It is also true that relatively few actions are likely to be universally profitable; most will vary substantially in effectiveness or efficiency depending upon local conditions.

In late 2012, the National Science and Analysis Team (NSAT) was asked to explore various potential national policy options for achieving the national goals of the Cohesive Strategy and to identify the trade-offs and risks inherent in each option. The purpose of this analysis is to provide a broad strategic overview of the issues that could be informative in subsequent decision-making processes. For example, options explored here can help inform choices among more detailed activities described within regional action plans or suggest where actions could be focused across the nation. This report summarizes the findings of the NSAT in regards to potential policy options that would be implemented across the country. Here, "policy options" are broadly interpreted as strategic direction that would lead to maintain, emphasize, or de-emphasize the various mixes of management actions in different contexts and locations.

Framing the Issue from a Historical Perspective

Wildland fire, albeit from natural or human causes, has played a prominent role in shaping the landscapes of North America for millennia. There is a rich literature on the ecological role of fire in North American ecosystems, and widespread appreciation of the historical role that human settlement patterns have had in changing the frequency, extent, and location of fire. We do not review the literature here, but instead recommend several recent and accessible summaries such as Stein and others' (2013) report, *Wildfire, wildlands, and people: Understanding and preparing for wildfire in the wildland-urban interface—a Forests on the Edge report* and references therein.

One point that is universally accepted is that nearly all of the natural vegetation communities across North America historically burned—many quite frequently. The intensity with which they burned was a function of both the biophysical environment and the frequency of ignition. In general, more frequent burning is associated with less intense or severe wildfires. Conversely, regions that burned infrequently generally experienced higher severity fires that often consumed much of the aboveground biomass. This pattern arises naturally from the accumulation of biomass (fuel) between fire events, absent of any other disturbance or activity that would remove the standing fuel. Ecologists use the concept of historical fire regime and fire regime groups (FRG) to characterize this tension between fire frequency and fire severity and their ecological implications (Table 1, from Stein and others [2013]).

Of note is the relatively high frequency of fires in FRG I, which historically averaged 35 years or less between fire events. This fire regime group includes many of the fire-adapted forest types across the county and is the dominant fire regime group within nearly 30% of the counties within the conterminous 48 states (Figure 1), comprising over 850,000 square miles. If one presumes that this area experienced a fire return interval of 35 years (the upper bound), then a lower bound estimate of 23,640 square miles (>15 million ac) would have burned on average each year within this area alone. Such estimates are crude, but they provide a sense of perspective when compared to the annual acres burned in the recent decade, 2002-2011. Our best estimate of annual area burned in these same counties is roughly 3,600 square miles, or less than 1/6 of the historical lower bound. Another way of stating this is that the average time between wildfires has increased sixfold, suggesting average fire return intervals approaching 210 years or more within these landscapes. It's not surprising that many fires that occur now are of higher severity than in the past or that substantive shifts in forest vegetation away from fire-adapted species are occurring. The issue may not be quite so severe in some forested areas of the Southeast under active prescribed fire regimes; a recent survey reported 6.5 million acres of prescribed fire activity for silvicultural purposes in 2011.

Table 1. Historical natural fire regimes, with examples

Fire regime group	Percent of wildland in this group[a]	Fire frequency[b] (years)	Fire severity[c]	Description/ definition	Examples
I	25	0–35	Low to mixed	Low-severity fires that leave most dominant overstoryd vegetation intact; can include mixed-severity fires replacing up to 75 percent of overstory	Lower elevation Ponderosa pine forests in the West; Pine and oak forests in the Southeast
II	19	0–35	High	High-severity fires that consume at least 75 percent of overstory vegetation	Grassland areas across the central United States; Chaparral stands throughout the West
III	22	35–200	Mixed to low	Generally mixed-severity fires; can also include low-severity fires	Mixed deciduous-conifer forests of the upper Midwest and Northeast; Western Douglas-fir forests
IV	12	35–200+	High	High-severity fires that consume or kill most of the aboveground vegetation	Lodgepole pine in the Northern Rockies; Isolated areas of the Great Lakes and New England regions
V	16	200+	Any severity	Infrequent fires that consume or kill most of the aboveground vegetation	Wetter forests in much of Maine, northern Pennsylvania, and parts of the West

[a] The column does not add up to 100 percent because 6 percent of all wildlands do not fall into any of these categories.
[b] Historical average number of years between fires (prior to European settlement).
[c] Historical effect on the trees and plants most commonly found in each wildland type (prior to European settlement).
[d] The term overstory refers to all above-ground vegetation.

Sources: Barrett and others 2010, Brown 2000, Hardy and others 2001, Rieman and others 2005, Schmidt and others 2002, USDA Forest Service 2012.

The changes in fire regime are not limited to just FRG I; calculations for the historical grassland areas within FRG II yield similar results. Estimates of the areas burned historically in FRG III, IV, and V are problematic due to the wide range in fire return intervals. A previous analysis by the NSAT suggested increased fire return intervals throughout the US except for some areas of the Southwest and Great Basin (CS Phase I report, Appendix A). Further evidence is suggested by the relative distribution of fire historically and more recently. Figure 2 depicts the percentage of area burned by wildfire (2002-2011) that has occurred within counties associated with each fire regime group (relative to total area burned), as compared to the percentage land area within those same counties (relative to total area). Given the expected fire return intervals in each of the groups, one would expect that there would be a higher percentage of area burned in FRG I and II relative to their landmass; roughly equal proportions in FRG III and IV; and a smaller percentage of area burned in FRG V. The actual pattern is quite different than expected. FRG I and II have burned roughly proportional to their landmass, which is consistent with the observation above concerning reduction in the area burned. FRG III has burned in roughly the same proportion as FRG V, which suggests that fire return intervals have either increased in FRG III (less area burned), decreased in FRG V (more area burned), or some combination of the two. Perhaps the most striking observation concerns FRG IV. The proportion of the total area burned in FRG IV is roughly twice its land base, suggesting a disproportionate chance of large, high-severity fires occurring in areas of FRG IV. Although it's plausible that the annual area burned in FRG IV nationally is within the historical range of variation, it is unlikely that the spatial pattern of these fires has remained unchanged due to land conversion and the cumulative effects of development and suppression.

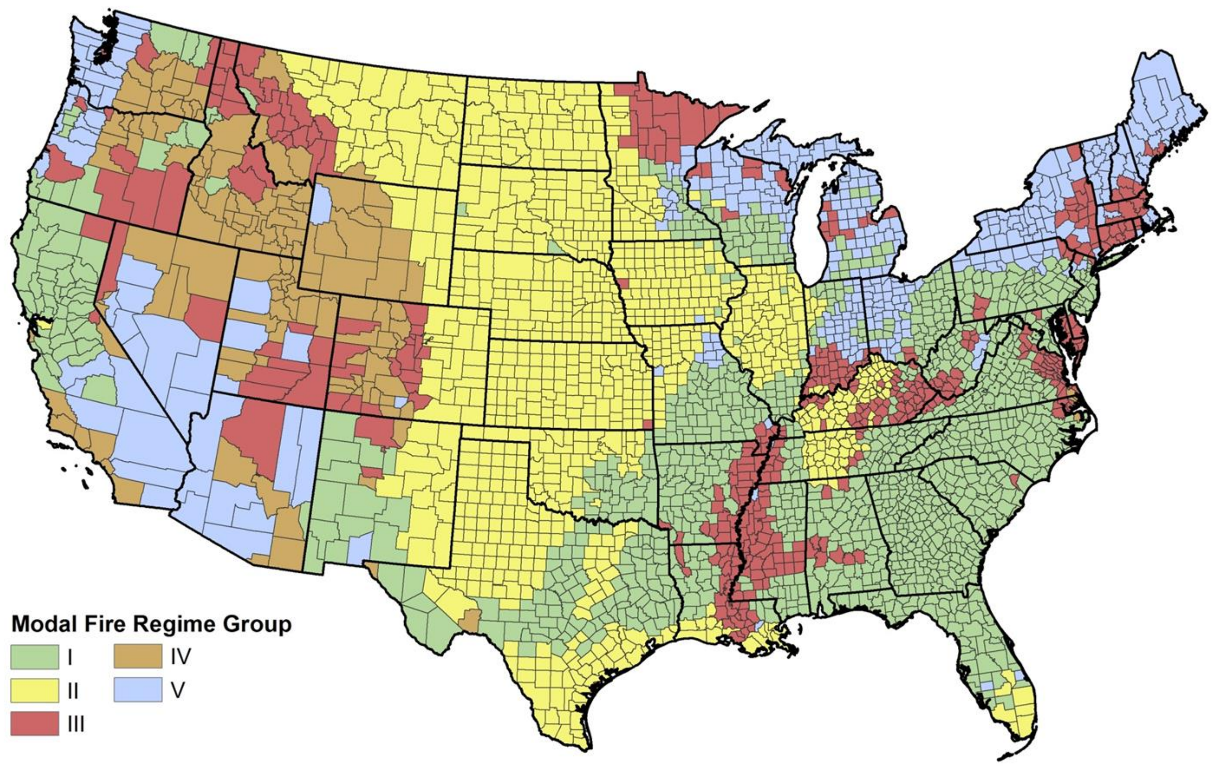
Understanding these broad-scale changes in fire regimes is essential to crafting an effective Cohesive Strategy. Fire regimes are intrinsically and fundamentally connected to accumulation of fuels and subsequent extreme fire behavior when wildfires inevitably occur. Human development and suppression postpone wildfires; they do not exclude them except in unusual circumstances. The basic biophysical environment remains conducive to wildfire and is unlikely to change in a way that would mitigate wildfire occurrence[1]. Fuels do not simply disappear in the absence of wildfire in fire-adapted ecosystems. Either they accumulate and wait for the next fire to occur, or some form of active fuels management such as prescribed fire or mechanical treatment is required. The importance of historical perspective is that it provides a benchmark for areas where returning natural vegetation to near-historical conditions is a primary objective.

A fundamental conflict in wildland fire management is that restoring historical conditions is neither practical nor desirable in many locations. The degree to which wildfires or prescribed fire can be tolerated within a given landscape depends upon community values and objectives. Where fuels cannot be managed to match historical levels, then adjustments must be made within human communities to accommodate a new normal in fire behavior. For forested systems, this likely means progressive transition from historical FRG I or III to a new FRG IV and the less frequent, higher severity fires that come with the transition. Higher severity fires lead to higher suppression difficulty, higher risks to firefighter and public safety, and greater social

[1] Some northern hardwood forests of the East may be the exception to this general rule. As human burning has decreased, compositional and structural changes within these forests have caused them to become more fire resistant.

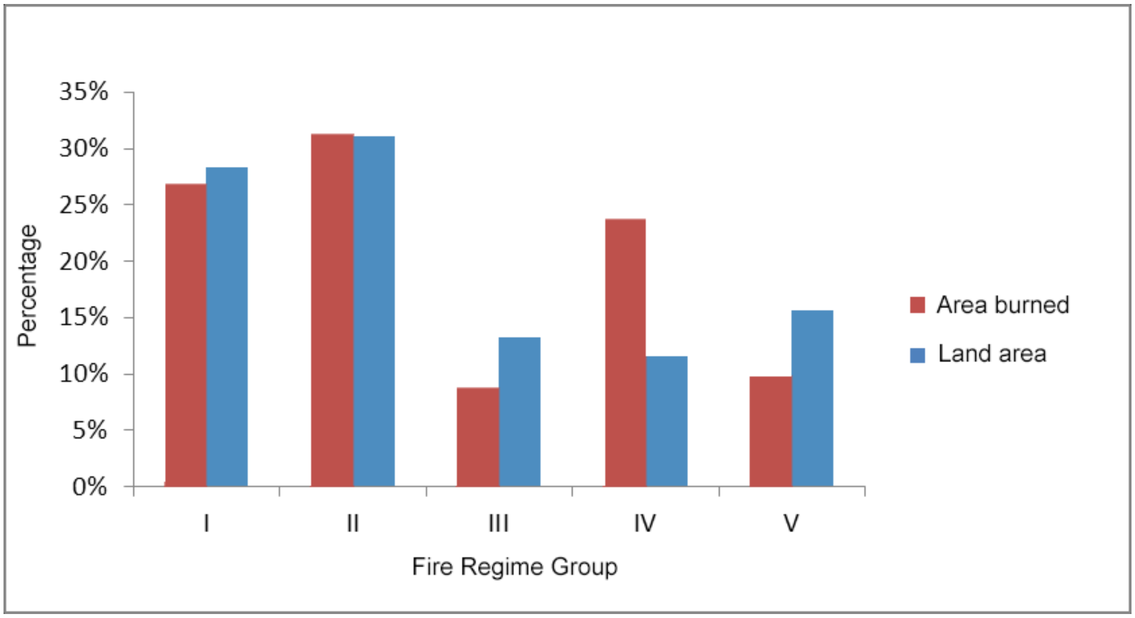
or ecological damage when they occur. Changes in rangeland and shrubland systems are more speculative and will depend upon the mix of new species that move into these systems (e.g., invasive grasses such as cheat grass versus encroachment by woody species such as juniper).

Figure 1. Modal (most common) fire regime group value within each county. Fire regime group data provided by LANDFIRE.



The aforementioned changes in fire regime are just one component of the overall historical changes that have occurred across the United States. Much has been written about the concomitant growth and expansion of the wildland urban interface and the risks from wildfire that it brings. Again, we refer readers to the Stein and others (2013) report for an overview of this issue. We have incorporated many of the data sets referenced by Stein and others (2013) in our own analyses, described below.

Figure 2. Bar chart showing the relative percentage of land area occurring in counties with modal FRG I – V, versus the relative percentage of area burned in those same counties (2002-2011). Both red bars and blue bars individually sum to 100%.



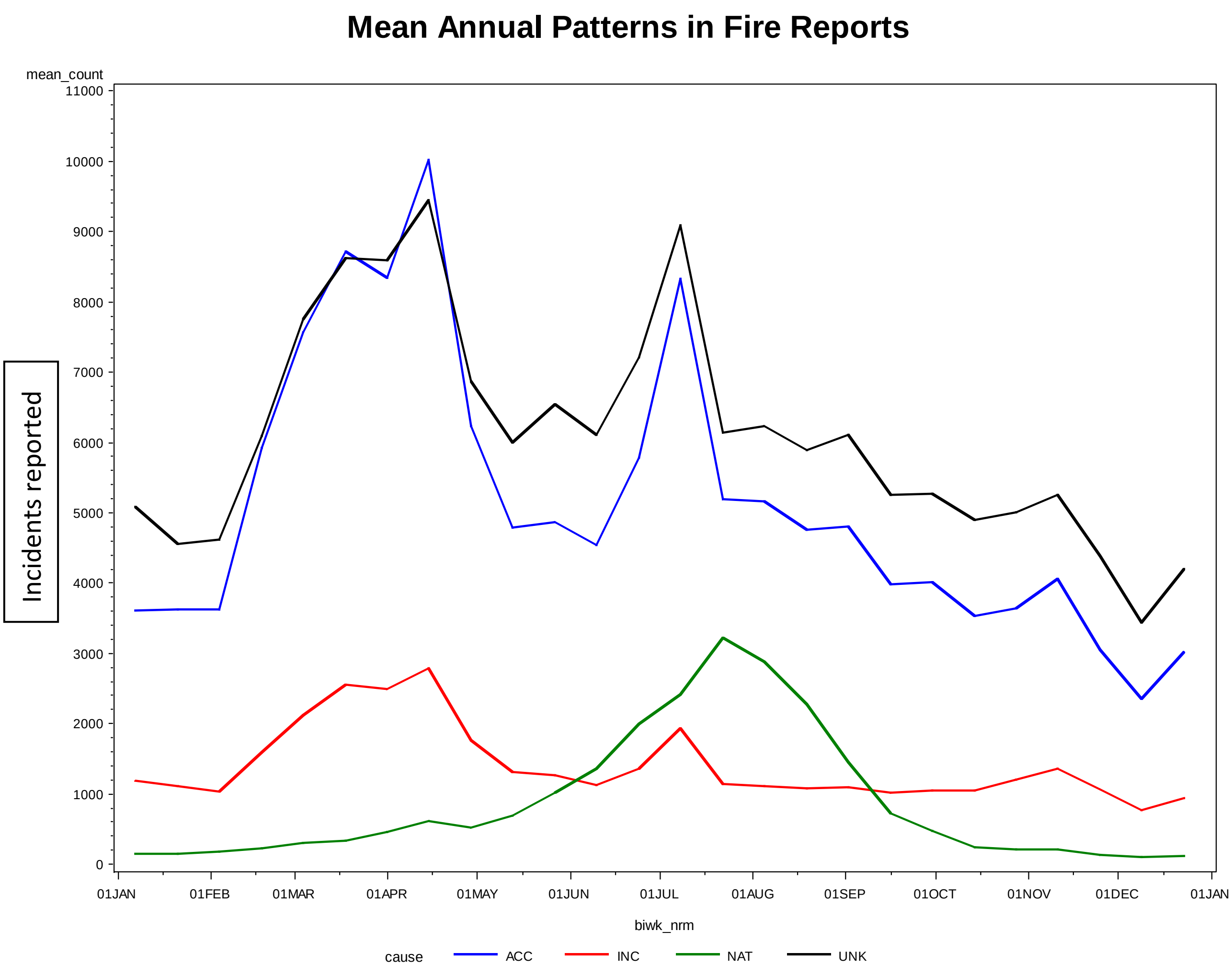
Conclusion: *Historical patterns of natural fire regimes suggest that considerably more area burned nationally each year than is burning today. The net effect is a gradual transition to less area burning, but with higher intensity than occurred historically*.

Natural versus Anthropogenic Fire

The historical fire regimes discussed above are a function of the underlying biophysical environment, natural ignitions, and burning patterns of Native American tribes prior to European settlement. Present day regimes are also strongly affected by the biophysical influences of vegetation, climate, and natural ignitions, but the human footprint and its effect on fire regimes is radically different than before. At the risk of oversimplifying the issue, one can broadly divide the nation into two principal regimes, natural and anthropogenic. In the natural regime, fire occurrence and extent is primarily driven by environmental variables including vegetation and weather, and natural ignitions sources—primarily lightning. The anthropogenic or human-driven regime reflects the overriding importance of human-caused ignitions and the influence of suppression activities. Unlike the historical fire regimes, these two regimes cannot be spatially disaggregated cleanly. That is, both can be operating within the same geographical landscape. At any particular point on a landscape (or point in time), one or the other may be dominant but not exclusive.

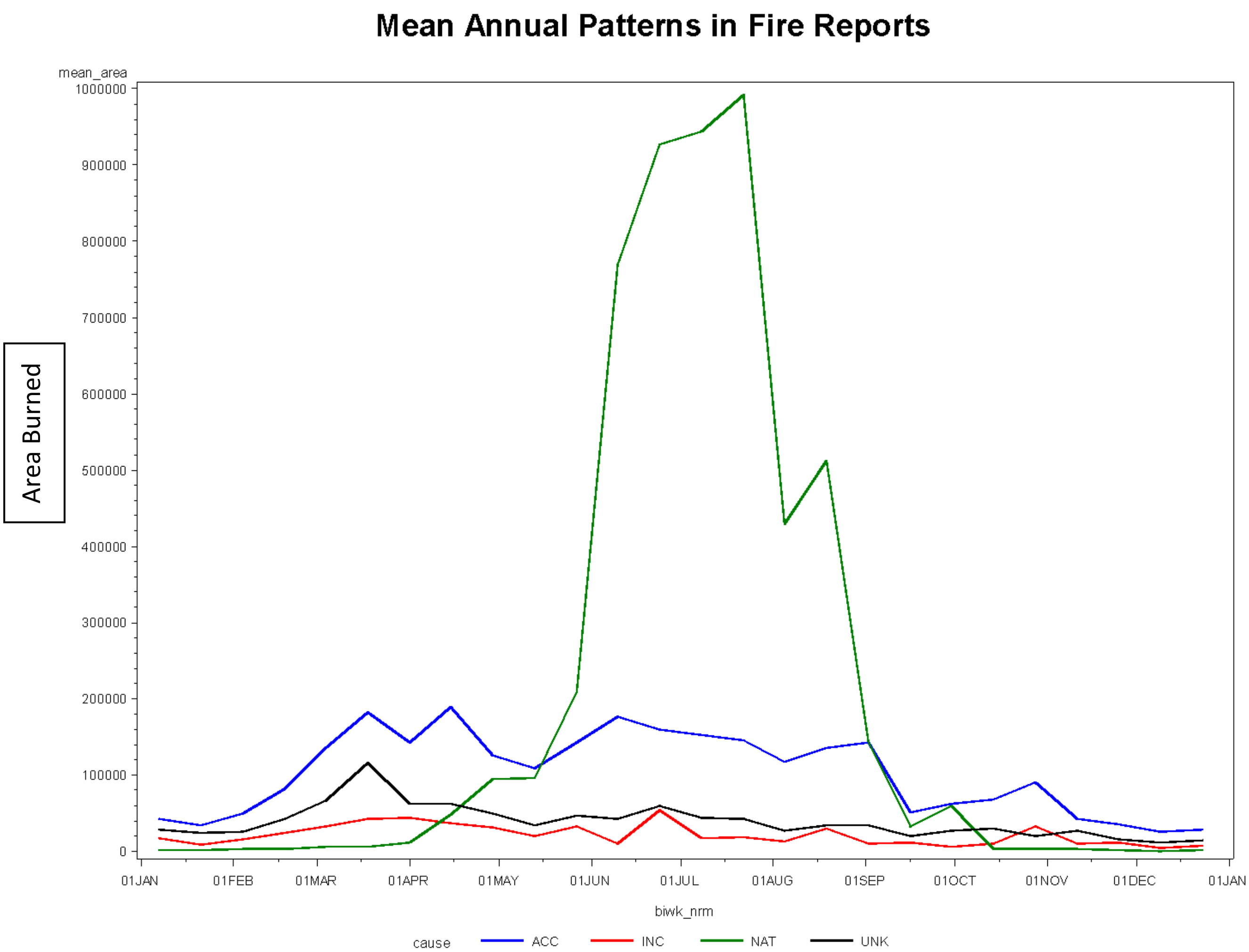
We can illustrate the difference between the natural and anthropogenic regimes by looking at seasonal patterns of wildfire occurrence and the area burned by fires of different causes.

Figure 3 depicts the bi-weekly pattern of fire occurrence attributed to four different causes: accidental (ACC), incendiary (INC), natural (NAT), and unknown (UNK), compiled from a combination of data sets (details can be found in Appendix 8). The most common reported causes are accidental and unknown. The close agreement in time between unknown and accidental fires suggests that most unknown fires are highly likely to be accidental; thus we combine the two for many analyses and use the combined sum when referring to accidental ignitions. Figure 3 also indicates the close agreement in time between accidental and incendiary ignitions, both anthropogenic. In contrast, natural ignitions have a very strong and consistent seasonal pattern that rises in the spring, peaks in the summer, and declines in the fall. Figure 3. Smoothed time trace of wildfire incidents reported and attributed to different causes throughout the United States, 2002-2011.



In Figure 4, we show the contrasting pattern of annual area burned as a result of these different causes. Clearly, the area burned due to natural ignitions dwarfs that from other causes through late spring and the summer season. The implications of the differences between an anthropogenic and a natural regime are important, which will become clearer in our discussion of policy options below. Additional details on the temporal and spatial patterns of the different regimes can be found in the appendices.

Figure 4. Smoothed time trace of area burned from incidents attributed to different causes throughout the United States, 2002-2011.



The observation that relatively few natural ignitions disproportionately account for much of the area burned is consistent with the more general trend that much of the area burned across the nation can be attributed to relatively few fires. For example, our summary of available data shows that the top 3% of fires in terms of individual[2] fire size account for over 90% of the total

[2] Includes multiple fires managed as a single complex.

area burned nationwide. Another way of viewing this is that if an additional 1% of the fires in the US were to reach the size of the current top 3%, the total area burned would increase by 30%.

Conclusion: *Natural and anthropogenic fire regimes are distinctly different, but equally important. Natural ignitions account for a smaller proportion of the incidents, but a disproportionate amount of the area burned. Anthropogenic ignitions account for the bulk of the reported incidents and occur throughout the nation.*

ANALYTICAL APPROACH

The preceding discussion of fire regimes is necessarily broad and glosses over the considerable variation that exists throughout the nation. Indeed, one could argue that every state, county, management unit, or community has its own unique fire regime, history, and special circumstances. Such differences are important when planning at the local level but can be overwhelming when trying to develop a national strategy. On the other hand, generalities can only be taken so far before they no longer have any relevance to specific locations. One of the challenges within our analysis has been to find an adequate level of both generalization and specification that allows us to highlight important differences while also recognizing commonalities.

Data spanning a broad spectrum of environmental, socioeconomic, and fire related statistics have been assembled in order to support development of the Cohesive Strategy. These data have been summarized and consolidated to the county level in order to provide a common unit of analysis across data sets. This has allowed us to integrate data from multiple sources and discern relationships among driving factors and influential variables. It also allows us to create national maps that can highlight many of the intra- and inter-regional or state similarities and differences.

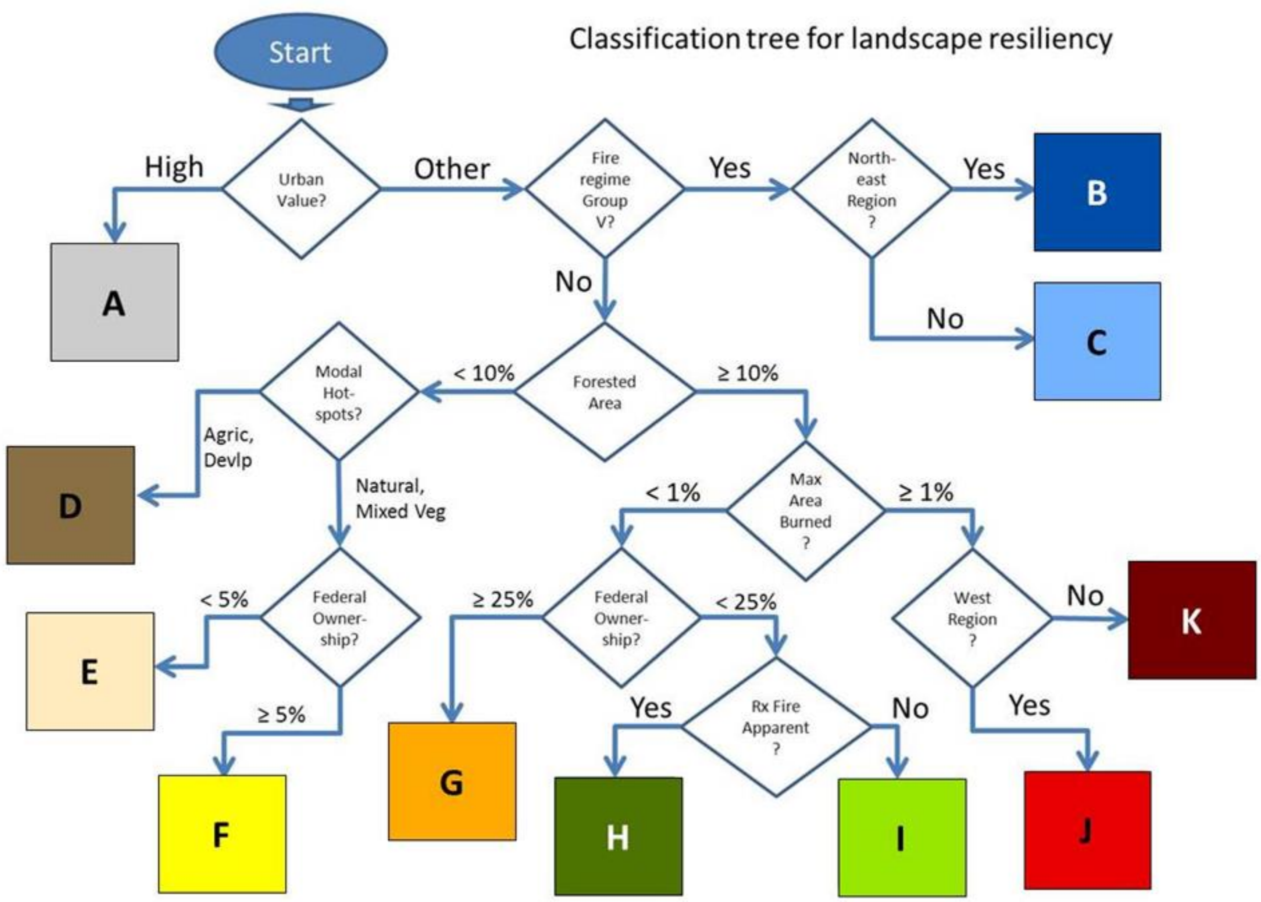
Even county-level summaries pose challenges, however, to completing a national analysis. There are 3109 counties in the conterminous United States and each one has its own unique story. Our efforts are not directed at telling those unique stories, but rather to highlight the similarities and differences that we find among the counties and use those common attributes to develop a manageable set of narratives that can be linked to nationwide policy options.

For the purposes of our analysis, grouping counties along two principal themes of landscape resilience and risk to communities provides a serviceable classification system. Counties are grouped together based upon the similarities among them with respect to key variables that are relevant to the principal themes. Two different techniques were used to better match the nature of the themes and patterns within the data.

Landscape Resiliency Classes

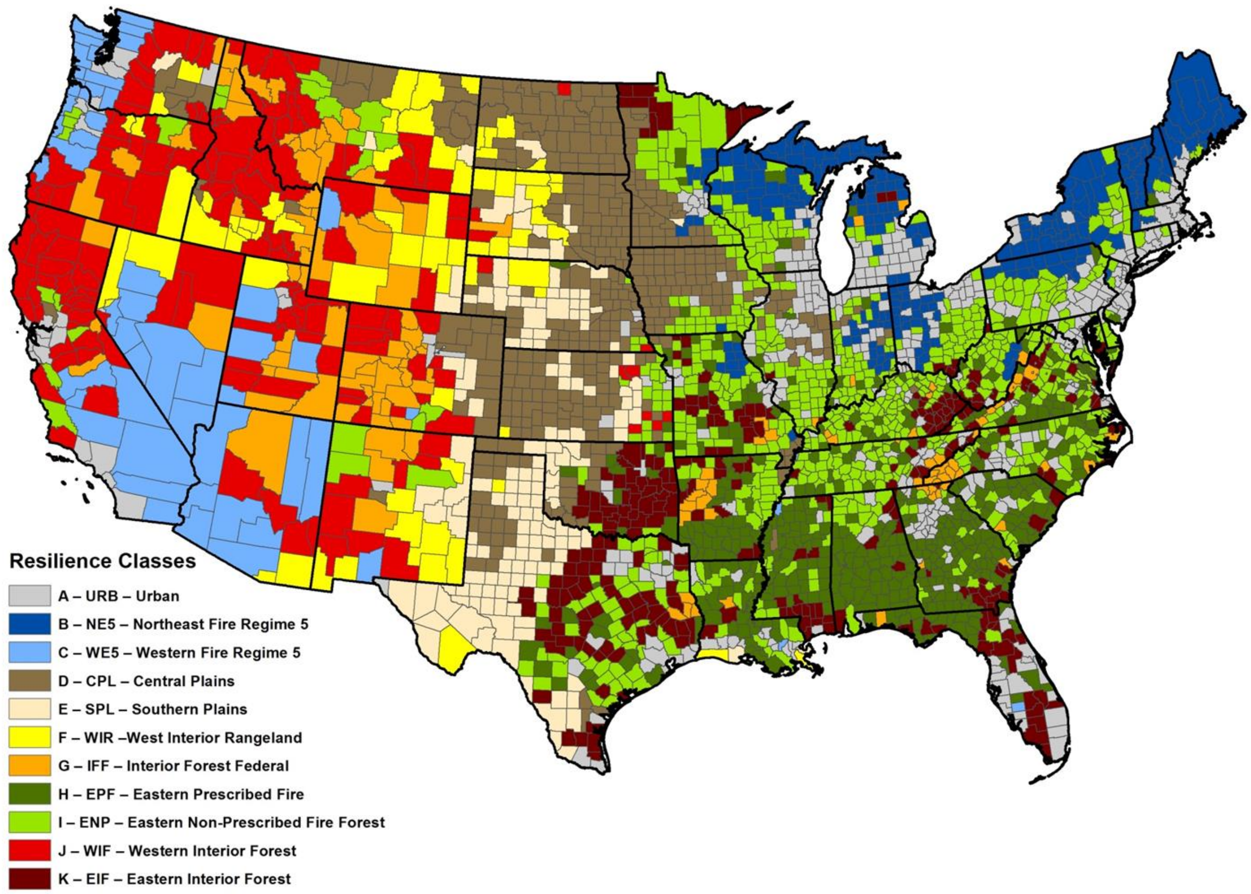
Relative to the theme of landscape resiliency, counties were assigned to different "resiliency classes" using a technique known as a classification tree. A classification tree begins with all counties in a single group and then progressively divides them into more similar subgroups based on the value of key variables. Each junction in the classification tree involves a dichotomous division based on a single variable. The classification tree used the relative urban landcover within a county, the modal fire regime, geographical region, area forested, federal ownership, and various measures of fire occurrence to assign counties to one of eleven classes (Figure 5). Classes were arbitrarily labeled A through K (Figure 5). The classes tend to have a strong geographical association due to the influence of regional similarities in landcover and fire regimes; a notable exception is the urban class (Class A), which follows the general pattern of population density and urban development.

Figure 5. Classification tree used to subdivide counties based on variables relevant to the topic of landscape resiliency.



The nature of each class is revealed by looking at both the variables used in the classification tree and the broader range of variables that we have for each county. From this perspective, one can develop a narrative that generally applies to the counties within each class. Furthermore, the narratives help to inform a discussion of possible management options or policies that would be most effective in advancing the goal of landscape resiliency within each class. We use resiliency classes in this manner in the discussion of policy options below. Additional details and discussion of the features of each resiliency class can be found in Appendix 3.

Figure 6. Map of the geographical distribution of the eleven resiliency classes across the conterminous United States.



Conclusion: *Counties have been classified using a relatively small set of variables into various "resiliency classes" that share common attributes. Examining multiple variables reveal both similarities and differences among counties relative to the theme of landscape resiliency.*

Community Clusters

A central tenet within the Cohesive Strategy goal of promoting fire adapted communities is that wildfires threaten communities and the values that people within them hold dear. The risk to communities and values can be viewed as the intersection of three principal elements: wildfire occurrence and extent, homes and communities, and social and economic resources (Figure 7). The first of these simply captures the magnitude of the hazard posed by wildfire. The second reflects the principal values at stake. The values threatened include buildings, homes, infrastructure, public and firefighter safety, public health, and many of the benefits that communities derive from the landscapes around them. Quantifying all of the values that could be threatened by wildfire across the nation is impractical. For our purposes, we have chosen to focus on homes that are located within the wildland urban interface or intermix area (WUI) as a surrogate for many of the tangible values that are at risk. We recognize that homes lost does not capture all of the values that are affected by wildfire, but losing a home is one of the most profound human experiences outside of loss of life. In the public eye, the number of homes lost in a wildfire is often equated with the magnitude of the overall damage. For example, consider the headline in an Associated Press story widely reported on June 13, 2013, “Black Forest Fire: At Least 360 Homes Destroyed, Most Destructive Fire in Colorado History.” A quote from the article is telling: “The blaze in the Black Forest area northeast of Colorado Springs is now the most destructive in Colorado history, surpassing last year's Waldo Canyon fire, which burned 347 homes, killed two people and led to $353 million in insurance claims.” At the time of the article, the fire was still burning, fatalities were uncertain, and no insurance claims or other assessment of damages had been completed. Whether the article may have been premature in its claim is immaterial to the central point that homes are essential to the conversation about risk to communities.

The final element in the intersection of risk concerns the capacity of a community to prepare for, respond to, or recover from a wildfire event. There’s an emerging literature on the concept of social vulnerability to catastrophic events. Researchers have generally looked at a combination of demographic and economic information in order to assess the vulnerability of individuals, families, and communities. Our analysis incorporated survey data on family incomes, education, and indicators of household stress to suggest relative vulnerability, while also considering metrics of economic activity within a county.

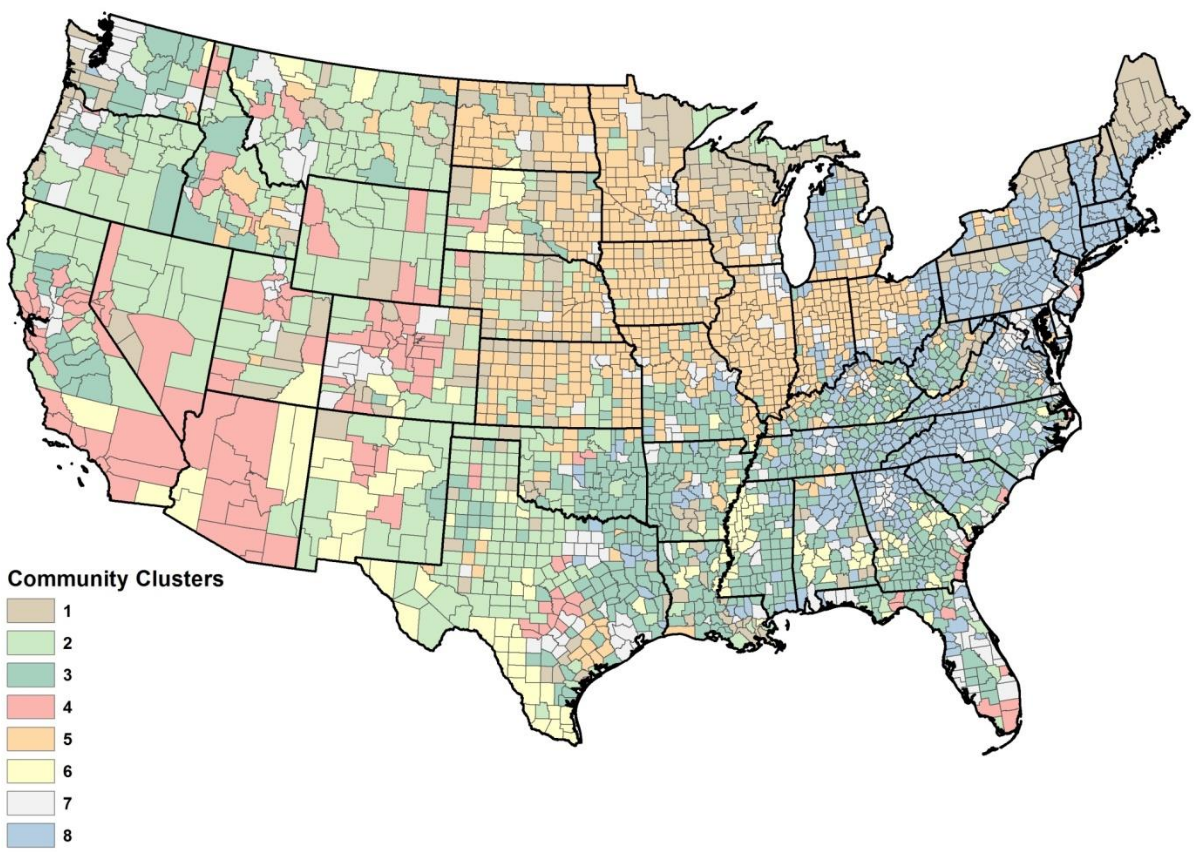
Figure 7. Conceptual diagram of the intersection of three principal elements contributing to risk to communities.

A statistical technique known as cluster analysis was used to group counties using a set of six core variables: maximum area burned, ignition density, WUI area score, WUI density score, demographic stress, and demographic advantage. The latter four variables are composite variables derived through statistical factor analyses. Factor analysis is a statistical method for reducing the total number of variables considered while retaining much of the information contained within them. A total of seventeen variables were used in two separate factor analyses to create four of the variables used in the cluster analysis. The clustering process was managed such that it would provide no more than 15 clusters with at least 40 counties within each cluster. Cluster analysis was used because it provided a cleaner separation of counties when considering all variables simultaneously, as opposed to sequentially as in a classification tree. (Further details on the underlying data and the clustering technique are available in Appendices 4 and 8.)

The end result of the cluster analysis is a set of eight "community clusters" that are simply numbered 1 to 8 in no particular order. All community cluster types can be found in each of the three geographic regions, albeit in decidedly different proportions (Figure 8). Geographical affinity of several clusters is apparent, but is not as strong as with the resiliency classes. This result highlights the fact that there are counties with similar fire histories, WUI patterns, and socioeconomic attributes scattered throughout the country. We use the community clusters to develop narratives that in turn are used in the discussion of policy options below, much as we have with the resiliency classes. Additional details and discussion of each community cluster can be found in Appendix 4.

Conclusion: *Counties have been grouped using a relatively small set of variables into various "community clusters" that share common attributes. Examining multiple variables reveals both similarities and differences among counties relative to the theme of risk to communities.*

Figure 8. Spatial distribution of community clusters.



Intersecting Resiliency Classes and Community Clusters

The most vexing problems in wildland fire management cannot be solved by looking solely at landscape conditions, nor is a community perspective adequate by itself. It is the combination or intersection of the two that defines the most difficult issues. Placing the community clusters in juxtaposition with the resiliency classes creates a combination class that provides an environmental context to the communities, while simultaneously adding a social dimension to the landscape.

The intersection of the community clusters with the resiliency classes and the number of counties in each combination class is shown in Table 2. Note that blank spaces indicate that no counties fell within the intersection. It is important to realize that this is the number of counties, not the spatial extent covered by each combination class; differences in county size across the country affect the distribution of area.

Table 2. The number of counties within the conterminous 48 states that fall within each combination of community cluster and resiliency class.

Resiliency Classes	Community Clusters								
	1	2	3	4	5	6	7	8	Grand Total
A	8	3	31	30	71	4	129	194	**470**
B	68	5	6		78	1	6	56	**220**
C	15	5	6	12		9	7		**54**
D	56	38	29	2	265	5	14		**409**
E	22	76	7	3	28	22	1		**159**
F	2	32	6	8	12	7	1		**68**
G	18	24	28	12	4	8	20	17	**131**
H	29	8	189	8	30	54	42	99	**459**
I	62	18	145	7	207	24	60	192	**715**
J		69	24	38	7	4	8		**150**
K		40	135	13	15	16	17	38	**274**
Grand Total	**280**	**318**	**606**	**133**	**717**	**154**	**305**	**596**	**3109**

An interesting observation from this table is that relatively few of the possible combinations do not have one or more counties fall within them. This spread across combinations is reflective of the considerable diversity that is found across the United States. It also highlights the challenges that arise when one tries to make generalizations. Fortunately, the total number of combinations (79) is manageable, and there are distinct patterns that suggest common narratives. Although a resiliency class may be distributed across all community clusters (or vice versa), they are not independent. That is, there is a distinct pattern of association between the two such that certain combinations occur more frequently than they would by chance alone. For example, resiliency class A, which represents a landscape dominated by human development, is disproportionately associated with community clusters seven and eight, which are primarily urban and suburban communities, respectively. Similarly, resiliency class D has a strong association with community cluster five, both of which are often associated with counties dominated by agricultural development. The association between classes and clusters is a reflection of both the human footprint on landscapes, and conversely how biophysical landscapes have influenced human development. We describe many of the unique attributes of each combination in Appendix 5.

One can ask whether the combination of landscape and communities is sufficient to cover all the complexities and issues that are involved in wildland fire. For example, can you distinguish between areas with different levels of response capacity, the complexities of mixed land ownership, and overlapping jurisdictional responsibilities? We examined many of these issues and considered whether an additional classification system(s) might be necessary. Our conclusion is that the two-dimensional system that we've developed is adequate for addressing the issues at hand. Those few issues that exhibit geographical patterns that cannot be explained with the combination classes can be examined using other means.

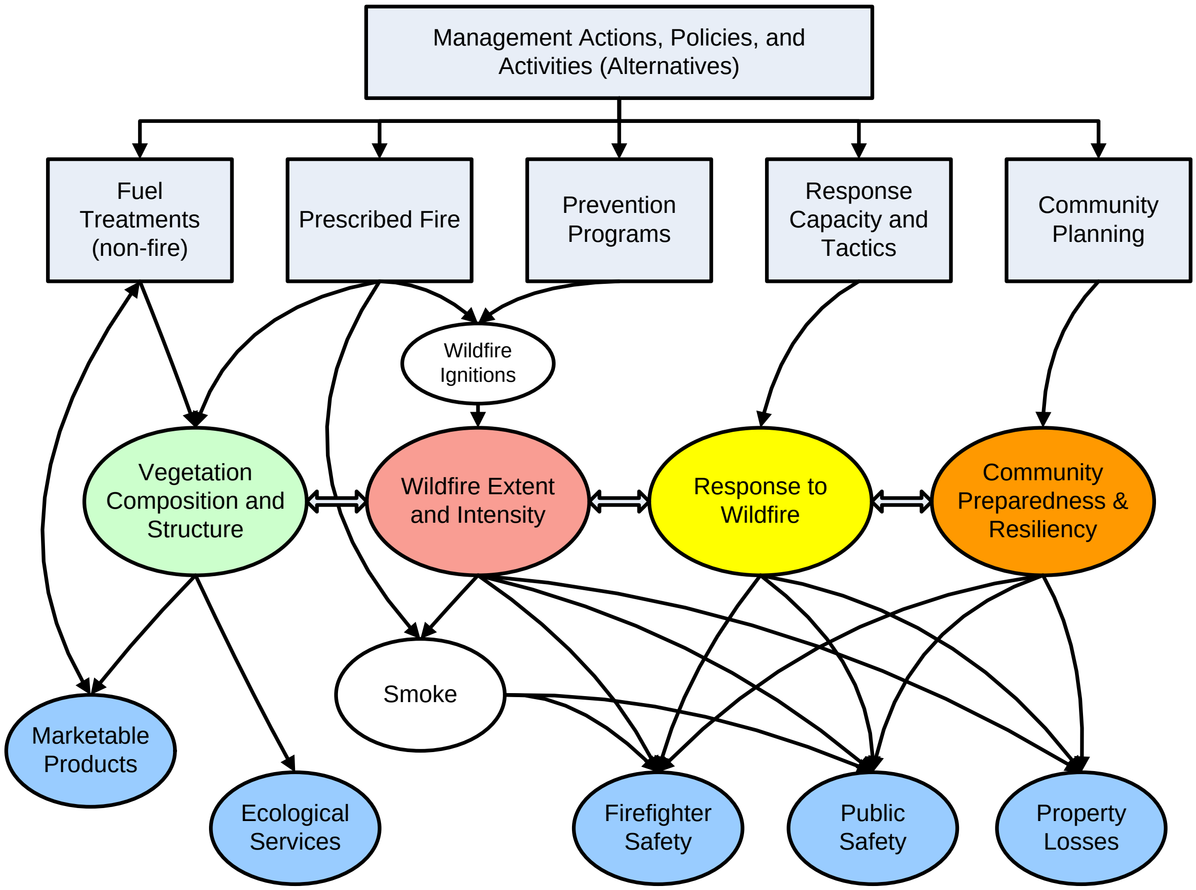
Conclusion: *The combination of resiliency classes and community clusters provides a powerful mechanism for being able to see both the environmental and social dimensions of the landscape simultaneously.*

Policy Options

Wildland fire is a complex phenomenon that encompasses numerous interacting social, ecological, and physical factors. In the Phase II report of the NSAT, we suggested that the Cohesive Strategy can be viewed conceptually as a collection of management actions, policies, and activities that collectively influence four major interacting processes: vegetation composition and structure, wildfire extent and intensity, response to wildfire, and community preparedness and resiliency (Figure 9). These processes in turn influence the goods and services received from forests and rangelands, firefighter and public safety, and homes and property affected by fire.

This basic conceptual model can be applied at any scale. That is, the relationships hold whether the area of concern is a local land-management unit or community, or whether national policies are being considered. During the Phase III process, the regional strategy committees and others suggested a wide range of actions and activities, most of which conveniently fit within the major categories identified in our conceptual model.

Figure 9. Simple conceptual model of the major anthropogenic factors involved in wildland fire management (gray), principal interacting processes (various colors), and values affected by fire (blue).



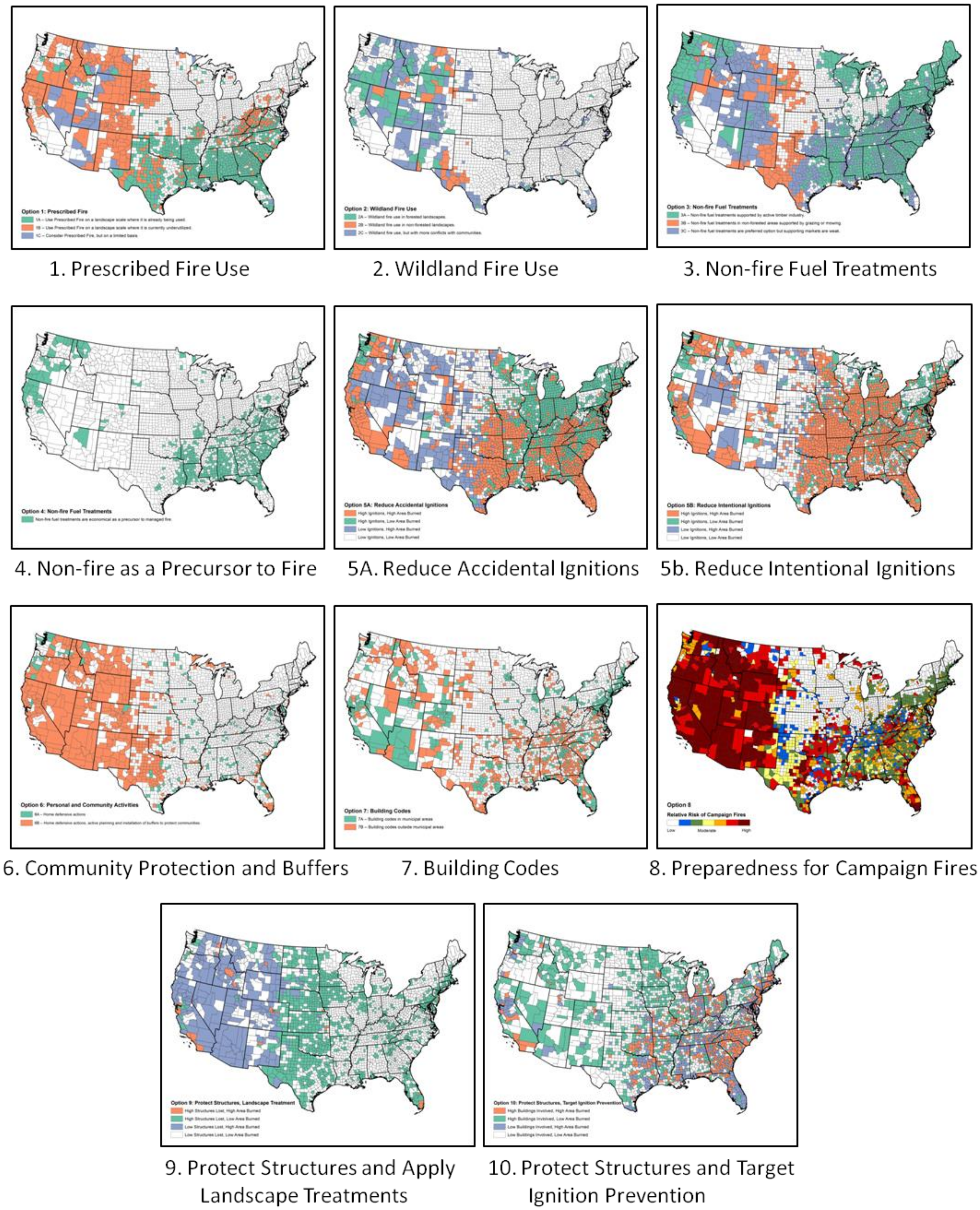
For the purposes of the national analysis, the Wildland Fire Executive Council and other advisory groups helped identify a series of options that might be considered from a national perspective. In the discussions below, we briefly identify the objective of each option and use the information inherent in the resiliency classes and community clusters to identify areas of the country where each option logically might be applied. The summaries here are intentionally terse; additional detail is available in the appendices. Table 3 and Figure 10 provide a quick reference to the options and maps of their spatial extent. Options are numbered for ease of reference only; the numbers have no bearing on priority or importance.

Following the presentation of options, we discuss implications of implementing these options and highlight the nature of trade-offs that are inherent in choices among them.

Table 3. Options considered and mapped.

Theme	Option	Description
Prescribed Fire	1A	Expand or maintain programs in areas of current use
	1B	Expand programs into areas where use is currently lacking
	1C	Use prescribed fire on a limited basis
Managing Wildfire for Multiple Benefits	2A	Apply tactic in forested systems
	2B	Apply tactic in non-forested systems
	2C	Apply tactic, but with awareness of community risk
Fuel Treatment other than Prescribed Fire	3A	Treatment opportunities supported by forest products industry
	3B	Non-forest areas with opportunity for treatment
	3C	Treatment opportunities limited by economic markets
	4	Treatments are economical as a precursor to prescribed fire
Managing Ignitions	5A	Reduce accidental human-caused ignitions
	5B	Reduce human-caused incendiary ignitions
Home and Community Actions	6A	Focus on home defensive actions
	6B	Focus on combination of home and community actions
	7A	Adjust building and construction codes, municipal areas
	7B	Adjust building and construction codes, non-municipal areas
Response	8	Prepare for large, long-duration wildfires
	9	Protect structures and treat landscape fuels
	10	Protect structures and target prevention of ignitions

Figure 10. Thumbnail maps of the various options. Larger versions of the maps along with additional details can be found in Appendix 6.



Prescribed Fire

Prescribed fire is one of the most effective and cost-efficient means of managing vegetation for multiple purposes, including hazard reduction, ecosystem restoration or maintenance, silviculture, and others. Broad areas of the country have the potential for prescribed fire use based on their natural fire regime, vegetation, and level of human development. Previously, we developed maps of potential for prescribed fire use in both forested and non-forested systems (Appendix 8). These maps provide a baseline from which we can further identify areas for prioritization. Our emphasis is on broad-scale application of prescribed fire, focusing on counties where a significant portion of each county could benefit. We recognize that prescribed fire can be applied nearly everywhere for very specific reasons; such local concerns are not captured here.

Additional consideration is that prescribed fire is not without risk, as fires can escape the prescribed perimeter or produce hazardous smoke if not managed correctly. Implementing a prescribed fire regime, therefore, requires properly trained personnel, resources, and the willingness on the part of the landowners and nearby communities to accept the downsides of prescribed fire in exchange for the potential benefits.

Our suggested first priority for the use of prescribed fire is that it be maintained or expanded in areas where it is currently being used (Option 1A). These areas logically have the necessary training and experience to implement a prescribed fire program and also suggest community acceptance and tolerance. Our analysis of probable areas of prescribed fire use used remotely sensed data and other reports to suggest that many counties throughout the Southeast and scattered counties in the Northeast and West are currently and substantively using prescribed fire.

The second priority would be to focus on areas where prescribed fire has been identified as suitable, yet the evidence for current, widespread application is less compelling (Option 1B). These include many areas in the West as well as counties in the central Appalachians. Implementing prescribed fire regimes in these regions likely will require additional training and resources, as well as outreach and coordination with the communities that are most likely to be affected.

The third area for prioritization (Option 1C) includes those counties that have areas suitable for prescribed fire, but perhaps not to the extent as in 1A or 1B. As an example, these include counties where the proportion of the total area suitable for prescribed fire is small, but it occurs in remote areas in relatively large contiguous blocks. These include Western counties with areas of low road density where more than 25% of the total county area is suitable for prescribed fire.

Conclusion: *Prescribed fire is a very useful tool that has the potential for widespread application. We identified three areas for prioritization which in total comprise 55% of the land area of the conterminous 48 states.*

Managing Wildfire for Multiple Benefits

Managing wildfire for multiple benefits refers to either a strategic or tactical choice to utilize unplanned ignitions in order to achieve management objectives similar to those associated with prescribed fire. Policies vary, but this tactic has traditionally been restricted for use in federal wilderness areas, national parks, or other remote areas and only under specific conditions or circumstances. Federal wildland fire policies allow its use more generally, whereas many state and local jurisdictions are explicitly prohibited from implementing any strategy other than full suppression on wildfires. Like prescribed fire, allowing wildfires to burn for the purposes of ecosystem restoration or hazard reduction has inherent risk. These risks must be balanced with the potential benefits on an individual incident basis, which requires both pre-incident planning at the landscape scale and sophisticated incident management.

We identified areas that might be suitable for managing wildfire for multiple benefits by looking first at those areas where prescribed fire was deemed suitable. We then highlighted counties where managing wildfire for multiple benefits in forested landscapes seems plausible (Option 2A), separate from those counties dominated by non-forest vegetation where this tactic might also be applied (Option 2B). Both Options 2A and 2B are characterized by rural areas with few roads, low numbers of ignitions (mostly natural), moderate flame intensities, and large contiguous blocks of natural vegetation. The forested areas have a high percentage of federal ownership (primarily Forest Service, BLM, or NPS) and a mix of FRG I, II, and IV. Non-forested areas include counties with low federal ownership and FRG II and IV.

We also identified a third set of counties where the landscape characteristics might benefit from managing wildfire for multiple benefits, but the community attributes would suggest potential conflict (Option 2C). Community concerns would necessarily lead to greater restrictions and control on incident management objectives.

Conclusion: *Managing wildfire for multiple benefits is a useful tactic, but it has limited potential for application across the landscape because of its inherent risk; it also may be prohibited by state and local policies or statutes.*

Fuel treatments using mechanical, biological, or other non-fire methods

A variety of methods traditionally have been used for controlling fuels and reducing hazard that do not involve fire directly. These include mechanical thinning and clearing debris in forests or mowing in grasslands, among others. Non-mechanical methods can involve livestock grazing to reduce fine fuels in rangeland systems, or the use of herbicides on understory vegetation within forests and woodlands. The advantages of such methods are that they do not share the inherent risks associated with fire and can often be applied with a greater level of control over both the location, timing, and desired outcome of the treatment.

An added advantage of mechanical treatments in forested ecosystems is the potential to utilize the removed biomass for other purposes. For example, forest thinning might result in understory trees being utilized for wood chips or specialty products that can be made from small-diameter trees. If markets exist for the byproducts of the treatment, then there is a greater chance of being able to economically offset the cost of treatments. We identified areas where an active timber market might offset some of the cost of mechanical treatments in forests by using data about timber jobs, mill production, and forested area available for mechanical treatment (Option 3A). These counties occur throughout the northeast and southeast, within the Pacific Northwest, and scattered in the interior West.

Note that we are not asserting that commercial timber harvest is equivalent to fuels management. There are regions where intensive forest management for commercial products can lead to reduced fuel loadings, greater access, enhanced control over both wildfire and prescribed fire, and generally reduced wildfire threat. There are also areas where selective harvest can leave behind excessive timber slash or debris, promote uncontrolled growth of the understory, encourage spread of invasive species, and generally exacerbate fuel conditions. Much depends on the strength of local markets and landowner incentives to leave conditions better following harvest than before.

A second set of counties include those non-forest areas where combinations of mechanical (mowing) or biological control (grazing) appear feasible (Option 3B). These include the range and grasslands systems where frequent—even annual—control of vegetation might be advantageous. Economic costs and benefits will vary locally and depend on treatment type.

The third set of counties included in this option include those where mechanical treatment in forests offers considerable benefit, but where evidence of economic markets to support such activities is weak (Option 3C). These include major areas of the interior West, central Texas and Oklahoma, and scattered counties throughout the Southeast and Northeast.

A variant on the theme of non-fire fuel treatments is an option in which mechanical treatment is viewed as a precursor to safer and more expanded use of prescribed fire. Essentially, this involves an intersection of Options 1 and 3A. The net result is Option 4, which includes many southeastern counties, the Pacific Northwest, and scattered interior counties.

Conclusion: *Fuel treatments involving mechanical, biological, or chemical methods offer many advantages in terms of greater control over the outcome and reduced risk of unintended* *consequences. The disadvantage may be higher economic cost, which can be offset in some locations by active economic markets for the byproducts of the treatments.*

Managing Ignitions

Human ignition of wildfires is perhaps the most pervasive and universal issue associated with wildland fire throughout the United States. In the conterminous 48 states, more reported incidents began with human-caused ignitions than from natural ignitions in 98% of the counties. The area burned from these human-caused fires exceeds that from natural ignitions in 94% of the counties. Only in the remote interior West is the pattern reversed (see Appendix 6 for more detail). Thus, programs that target the prevention of human-caused ignitions have the potential to substantively affect wildland fire occurrence and extent in essentially every county. Such programs are most effective when they focus on the underlying causes of these human-caused ignitions in each location and tailor the prevention programs to specific causal factors and community dynamics.

There are many different types of human-caused ignitions, but for our purposes we refer to two primary categories: accidental and incendiary. Accidental causes include all of the usual culprits such as debris burning, fireworks, equipment, campfires, and others. Incendiary fires include malicious arson events or other incidents where fires were set intentionally using incendiary devices. We also choose to distinguish counties where there are higher-than-normal numbers of human caused incidents (the median is used to define "normal"), versus those counties where the area burned by human caused ignitions exceeds the national median.

The first option under this theme highlights counties where the intent or focus would be to substantively reduce the number of accidental ignitions (Option 5A). The two classes of higher-than-normal ignition density and higher-than-normal area burned are used to create a four-color map with low-low, high-low, low-high, and high-high combinations. Counties falling into the high-high combination are found predominantly in the southeastern and south-central states and in the far West. The Northeast has a high percentage of the high-ignition-density, low-area-burned counties, while the interior West displays the bulk of the low-ignition-density, high-area-burned counties.

The second option under this theme similarly focuses on areas experiencing higher than normal incendiary ignitions or the area burned by such fires (Option 5B). There is more congruence between ignition density and area burned with incendiary fires than with accidental fires. Thus, large portions of the East and more populated counties of the West exhibit a combination of both high incendiary ignitions and high area burned.

The data sets assembled by the NSAT include a broad set of community metrics and more detailed causal information that can be explored to target specific causal factors within the various community contexts. For example, debris burning is one of the principal causes of accidental fires; its occurrence varies considerably among community clusters.

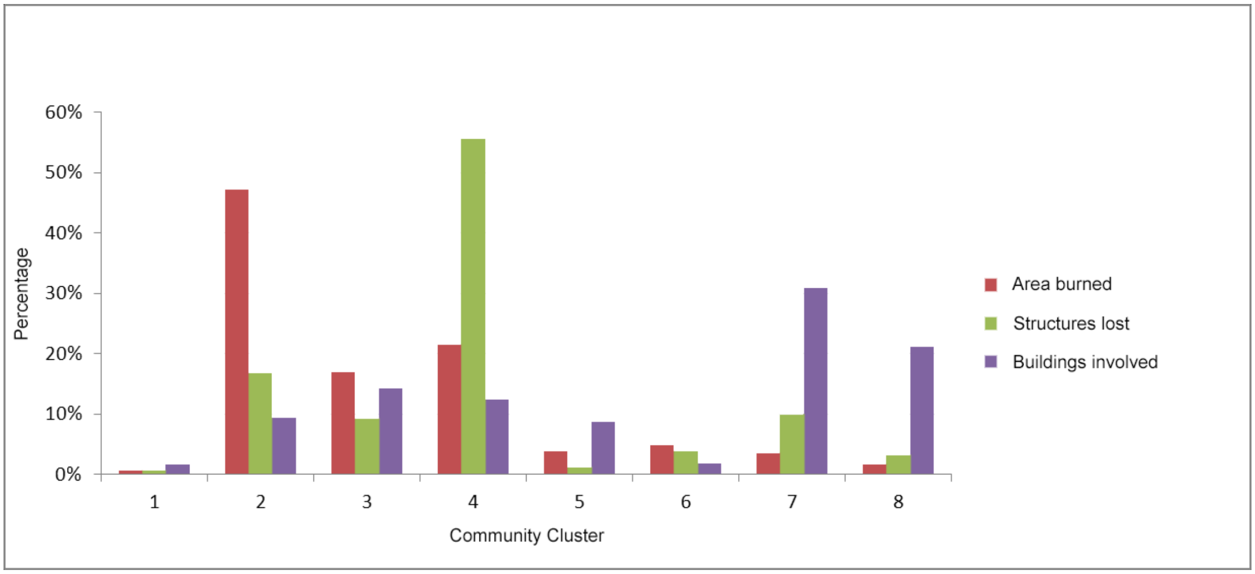
Conclusion: *Human caused ignitions, whether accidental or incendiary, are a universal problem that affects much of the United States. Targeting regions or counties with higher-than-normal levels of activity could prove productive, especially if targeted at specific causes.*

Home and Community Protection

Many of the programs that are intended to reduce losses to homes and communities from wildfires focus on the immediate vicinity of the home or the surrounding community. Reducing the likelihood that a wildfire burning in adjoining vegetation will ignite homes or other structures is one of the most effective avenues to reducing losses. Many actions can be taken by the individual homeowner, but others require concerted effort at the community level to be effective. Similarly, community efforts without commensurate attention by local home and business owners are unlikely to succeed. Therefore, our first premise is that property owners should take actions to reduce the ignitability of homes and other structures wherever they are in proximity to flammable vegetation. Data on the incidence of buildings involved in outdoor fires suggests that essentially all communities share this experience and would benefit from more attention by property owners. Beyond that first step, there are areas of higher risk where additional emphasis on home or community efforts might be placed.

It is useful to look at historical patterns of where structures have been lost or buildings have been involved in incidents to identify areas of possible prioritization. Figure 11 presents a series of bar charts that show the relative area burned, proportion of structures lost, and proportion of buildings involved for each of the eight community clusters. The chart is scaled such that each set of bars sums to 100%. One can readily observe that the largest proportion of area burned and many of the structures lost occur in community cluster 2, while much of the area burned and the largest proportion of structures lost occur in community cluster 4. Thus, both community clusters 2 and 4 are obvious candidates for greater focus on both community-level planning and individual structure protection. Community cluster 6 shares many of the same attributes with clusters 2 and 4 where it occurs in the West. Additional information on the configuration of the wildland urban interface in these three clusters reinforces the need for community level planning, given that fires that threaten homes often originate beyond the perimeter of the community itself.

Figure 11. Bar chart showing the relative area burned (red bars), proportion of structures lost (green bars), and proportion of buildings involved (purple bars) for each of the eight community clusters.



For mapping purposes, we identified counties with high levels of exposure in the WUI along with relatively high levels of wildfire extent as a representative sample of counties where focusing on individual structures is likely to be effective regardless of community-level activities (Option 6A). Additional counties where the combination of structure protection and community planning and coordinated action seems essential are identified separately (Option 6B).

One approach to making homes and other buildings more resistant to ignition is to focus on building materials and construction techniques. Similarly, communities can be designed or managed in ways that enhance response effectiveness or mitigate risk. Changes in building codes are more likely to be effective when targeted at areas of new construction in high-hazards areas. Building standards are more easily applied to new construction and development than to existing structures. Such standards engage individual property owners and enhance the effectiveness of additional community-wide actions. Counties with increasing WUI area or increasing WUI home density growth—the latter being more closely aligned with increasing home construction overall—are places where such standards are most likely to have a significant effect. Because municipal and non-municipal areas tend to exhibit varying levels of ability to implement building standards, we have mapped them separately (Options 7A and 7B).

Conclusion: *Protecting homes from ignition by wildfire is a practical step that is applicable anywhere homes can be found adjacent to natural vegetation. Similarly, coordinated action at the community level has practical advantages everywhere, but is essential when wildfires* *originate outside the perimeter of the community and threaten the entire community. New construction offers opportunities that may not be available elsewhere.*

Initial and Extended Response to Wildfires

The United States benefits from an extensive and sophisticated wildland fire response organization that comprises of thousands of separate local, state, Tribal, and Federal entities. Each organization has a specific jurisdictional responsibility for initial response. They also coordinate and share resources and responsibilities as fires become larger and exceed the local capacity for response. Fortunately, local response capacity is generally adequate for controlling or extinguishing the majority of wildfires. The relatively small percentage of fires that escape initial response are hugely important, however, as they account for a disproportionate percentage of the area burned, damage to homes and communities, and injuries and fatalities. They also command a major portion of the total suppression costs expended nationwide.

Coordinated response is a complex nationwide issue. Various and multiple institutional arrangements have been negotiated and developed across the country to meet the challenge of delivering the appropriate resources and personnel required for each incident. The regional strategy committees and others examined various ways of improving coordination within their regions and have suggested actions for improvement. Implementing these recommendations will require working through the details among the various national, regional, and local governance organizations. Analyzing the implications of these various recommendations is beyond the scope of our national analysis. We suggest, however, that some of the data sets that we have accumulated could be useful within the more regional and local discussions of these issues.

At the national level, it is possible to highlight patterns that suggest areas of greater concern, or alternatively where a combination of response with other policy options might play out differentially. That is, response is essentially the last line of defense and action. It comes after fires have started and there is little else to be done except respond. As we suggested previously, there are no reasons to expect wildfires to suddenly diminish in either occurrence or extent. An effective and safe response organization is essential. One way to ensure that our collective response organization is also efficient (i.e., uses resources to maximum advantage) is to match it with other management options.

Because large wildfires are so important, we begin by mapping the likelihood of observing a large, long-duration wildfire. These “campaign fires” are defined as being greater than 1 square mile in extent and at least two weeks in duration (from report to containment). Our ten-year record of events provides a sample of where such fires occur. Extrapolating that sample to all combinations of resiliency classes and clusters generates a national map that reflects the relative likelihood of experiencing a campaign fire within each county; Option 8 would prioritize preparedness based on this likelihood. The resulting map indicates that much of the West, Southeast, and mid-Atlantic regions display areas of higher probability, as well as scattered counties of the upper Midwest.

A second option related to larger fires focuses on the relationship between area burned (as reported in federal and state records) and structures lost (as reported in the nationwide ICS-209 incident reporting system). We created an index of the rate at which structures are lost relative to the area burned and compared the rate of loss to the area burned itself. A four color map reflecting the intersection of those two indices revealed an interesting pattern. The combination of high rates of structure loss with low area burned is dominant in the Central Plains and Eastern regions. Conversely, the interior West exhibits most of the area with high rates of area burned, but relatively lower rates of structures lost per unit area burned. Counties exhibiting a combination of both high area burned and high structure loss rates are few in number, but highlight some of the most problematic counties in the country from a response perspective. Option 9 would prioritize structure protection in combination with efforts to reduce fire size based on these patterns.

The final response option is most relevant to initial response, which often is the responsibility of a local fire department or agency. We examined data from the National Fire Information Reporting System (NFIRS) and computed indices of the numbers of buildings involved per incident and the relative frequency of reported accidental human-caused ignitions. The intersection of higher-than-normal values for these variables indicate that the number of buildings involved per reported incidents is one of the few variables lacking a strong geographical pattern. In contrast, the relative frequency of accidental ignitions tends to be higher in the East and more populous areas of the West. The intersection of these two variables has an interesting pattern that illustrates the widespread extent of this issue and offers a guide to prioritization of structure protection with prevention efforts. Reducing human caused ignitions should result in a commensurate reduction in the workload of local response organizations and considerably less risk to structures throughout much of the East and populous Western counties. Throughout much of the remainder of the country, there is an expectation that buildings will be involved in many local incidents, even if the number of responses is relatively low.

Conclusion: *Initial and extended responses is a complex issue. Examining data on area burned, structures lost, and patterns of accidental ignitions provides a backdrop for understanding some of the response challenges facing local, state, tribal, and federal fire departments and agencies.*

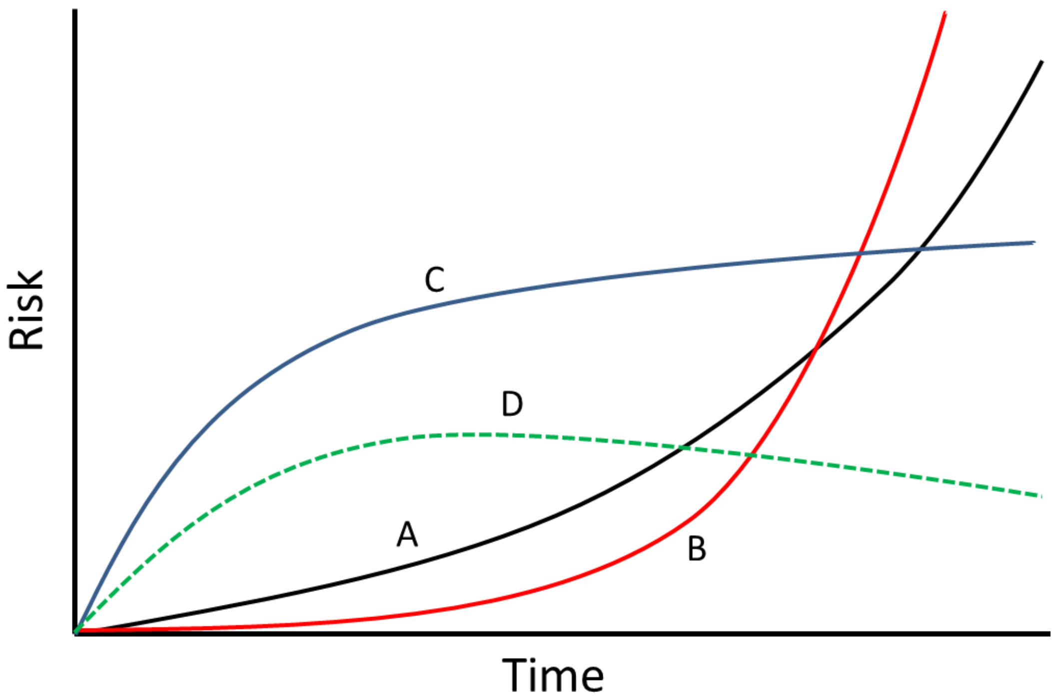
IMPLICATIONS AND CONCLUSIONS

The policy options that are described above differ from the usual menu of alternatives that are often presented in planning documents in that they are not mutually exclusive. One might think of them as a buffet from which one can select one, two, or more to implement in a given location. Indeed, there is no inherent reason why all options could not be implemented within a given county if appropriate. Our efforts to map out the various options are an attempt to show where they would be most reasonable or potentially effective, not to exclude their use from other locations. We also intentionally have identified options or described them in such a manner as to avoid antagonistic interactions. The Cohesive Strategy has as its foundation three interacting and synergistic goals; we followed that structure in our own analysis. Finally, our purpose in developing the classification systems for counties was to create a common set of narratives that would be broadly applicable, not identify individual counties for a particular prescription. Therefore, if errors in our data or interpretation erroneously led to a misclassification of a county, we anticipate that more localized planning efforts would correct such errors and adjust county-level recommendations appropriately.

Each of the preceding sections ended with a brief conclusion. The implied policy implications of those conclusions, whether stated or not, are essential to crafting a national cohesive strategy. For example, our first conclusion was that historical fire regimes suggest more area burned historically than today. The implication is that fuel loads on much of the landscape are higher than historically, continue to accumulate, and are likely to lead to larger, higher-intensity fires. As a nation, we must either accept and prepare for that eventuality or take active steps to reduce fuels. As noted in the discussion of the options, many efforts to reduce fuels have their own inherent risk. Thus, we are faced with a set of choices that involve inherent trade-offs.

We can visualize the temporal nature of these trade-offs as a series of hypothetical curves reflecting the level of risk or expected losses over time under different policy scenarios (Figure 12). The black line (Line A) in Figure 12 can be conceptualized as the business-as-usual scenario in which risk progressively increases and losses mount as we fight an uphill battle against accumulating fuel loads. One alternative scenario might involve greater investment in response capacity and protection of homes and communities (Line B). Over the short term, the losses do not increase as dramatically as under the business-as-usual scenario, but at some point the accumulation of fuels overwhelms the increased suppression capacity and losses mount to the point that they actually cross over the trajectory of the business-as-usual scenario. One might make a plausible argument that this is the historical trajectory that we now find ourselves on because of investments that have been made in the past. A third scenario assumes that greater investments are made in reducing fuels at the expense of investments in suppression or community protection (Line C). This scenario results in a trajectory wherein the risk increases in the short term, but then plateaus at some level higher than the current level of risk. Finally, one can imagine a scenario in which fuel treatments, suppression, and community protection all receive greater levels of investment and lead to a trajectory in which risk goes up in the short-term but then plateaus and perhaps even comes down over time (Line D).

Figure 12. Hypothetical trajectories of risk over time under four investment scenarios: business as usual (A), increased suppression and community protection (B), investment in fuel treatment at the expense of other options (C), favorable combination of investments in all sectors.



The trajectories shown in Figure 12 are mainly applicable to regions where fuel loading is a driving factor in the wildland fire equation, which includes much of the Southeast and the West. Areas of the Northeast where the driving issues are primarily ignitions, homes, and response could be represented by different, but comparable trajectories. Clearly, the actual shape and magnitude of these curves would vary considerably throughout the country. Our intent here is to simply show the nature of the inherent trade-offs, not to suggest that we have the necessary data, skill, or clairvoyance to accurately quantify these trajectories.

Another way to think about the implications of the policy options described above is to recognize that the number of options that are suitable or applicable to a given county is proportional to the complexity of the wildland fire issues at that location. One can also presume that more options or issues generally require greater levels of effort and resources to resolve.

This is not to say that solving a single issue is necessarily less expensive than solving multiple issues. There are counties where a single issue is so challenging and intractable that the resources required exceed those required in a different county with more issues, but each one being less contentious.

Building a National Strategy

The ultimate goal for the Cohesive Strategy is about finding balance. This balance is encapsulated within the vision statement, "*Safely and effectively extinguish fire, when needed; use fire where allowable; manage our natural resources; and as a Nation, live with wildland fire*." Finding balance is a sociopolitical exercise, not a scientific analysis. Every choice that can or will be made involves a question of value. Unfortunately, not everything is a win-win solution. Choices made at a national or regional level to emphasize one option or set of activities over another invariably involve differential effects on different constituencies.

Our analysis does not attempt to define a national solution or make recommendations for regional or local action. Rather, our hope is that we can help illuminate some of the issues and complexities involved in wildland fire management using the wealth of data and analytical techniques available to us.

The broad policy options can be combined in ways that suggest a template for a national strategy. This outline would be based on the premise that the first priority is to maintain a safe and effective response organization. This presumes that immediate threats are the most important—and wildfires are an immediate threat throughout the country. Although our analysis does not suggest widespread deficiencies in suppression capacity, there are locations that could benefit from greater investment. Improved coordination, communication, and training enhance efficiency and belong in any prudent regional or national strategy as long as costs are reasonable.

It would be shortsighted, however, to assume that suppression is the only priority. Ample evidence suggests a trajectory of increasing risk that cannot be headed off by simply adding more suppression resources. Relatively inexpensive, effectual, and broadly applicable actions head the list of additional priorities. Of those considered, options that focus on anthropogenic ignitions are logical next choices. Human caused ignitions are a widespread issue that is relatively inexpensive to affect, especially when prevention programs are carefully targeted. A third area for prioritization would be activities that focus on individual homes or structures and community-level protection. Large wildfires that threaten entire communities are relatively rare, yet their impact in both reality and public perception commands massive suppression efforts that drain local and national resources. Efforts that engage communities are not necessarily expensive, engender public support, and work in tandem with other actions.

Finally, the gradual accumulation of wildland fuels is perhaps the most difficult and challenging issue to address. An analogy can be made to walking up the down escalator. One has to be moving just to stay in place; the only way to move up is to move faster than the escalator is moving down. Current estimates of areas being treated intentionally or burned in wildfires would suggest that we are falling further behind in many of our fire-adapted landscapes. In some areas, the principal means of reducing fuels appears to be wildfires, over which we have little apparent control. Broadscale efforts to reduce fuels across the landscape can be expensive and time-consuming, which suggests a coordinated and strategic effort is required. Benefits will not be achieved overnight. Prescribed fire and managing wildfire for multiple benefits have the greatest potential for treating large areas at lower cost than mechanical treatments, but they have inherent risk that must be addressed at a local level. Mechanical, biological, or chemical treatments play an important role wherever they are economically feasible.

Conclusion

This summary report is intended to provide an overview of the data that were accumulated, methods used, and options that were explored. It should be readily apparent that much discussion and conversation remains. In addition to this summary report, more complete and technical documentation is available, which has been referenced herein as a series of appendices. These appendices will be shared and discussed with the Wildland Fire Executive Council and other advisory groups and used in internal discussions regarding the outline of a recommended national strategy. Implementation of that strategy will involve both national executives and a cascading series of regional and local officials. Final implementation will require concerted effort on the part of numerous individuals and stakeholders.

The analysis described here is intended to inform broad and strategic discussions among intergovernmental stakeholders. Analytical capability and utility far beyond what is presented within this report is available, and future potential analysis focused at a different scale and/or scope can be explored.

We expect the various agencies and organizations to avail themselves of this information and data for their own use and deliberative processes. The National Science and Analysis Team will be available to assist as appropriate with accessing, interpreting, and using this information.