Fire Management Lessons Learned

Evolving Fire Management Programs

on the
George Washington and Jefferson National Forests of Virginia, West Virginia, and Kentucky
and
Sequoia National Forest and Giant Sequoia National Monument of California

Prepared for
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and
Wildland Fire Lessons Learned Center

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Executive Summary

Washington Office Fire and Aviation Management Staff of the U.S. Forest Service tasked the Adaptive Management Services Enterprise Team (AMSET) with documenting innovative and evolving fire management programs on the George Washington and Jefferson National Forests and the Sequoia National Forest and Giant Sequoia National Monument. These fire management programs, with the support of Forest leadership, are taking proactive steps to address agency direction in developing and maintaining fire resilient forests while assuring firefighter and public safety, and economic efficiency.

Historical fire data, GIS, case study information, and interviews with key members of the fire programs and Forest leadership were used in the development of this *Lesson Learned* case study.

While these two Forests are separated by more than 2,500 miles and represent vastly different ecological systems with disparate fire regimes; several common practices have allowed these Forests to become progressive fire management leaders.

Important Commonalities Between the Two Forests

- Significant fire events occurred which caused Forest leadership to acknowledge that existing practices were not sustainable if functioning ecosystems were to be maintained.
- Forest leadership embraced the concept that they were managing fire-adapted systems and that fire could be used as a tool to improve overall forest health.
- By managing wildfire for both protection and resource benefit objectives, firefighter/public safety and ecosystem health could be improved.
- Critical habitats for sensitive species could be enhanced by managing wildfire for integrated objectives.
- The cost per acre of wildfire operations decreased when management actions were tailored to the threats and opportunities presented.
- Agency and Forest direction exists which allows these units to utilize a wide variety of fire management practices in meeting land management and public safety goals.

The use of the authorities which allow wildfires to be managed for protection as well as resource objectives have benefits beyond allowing fire to perform a more natural role in these fire-adapted systems. The reduced need for large numbers of ground-based firefighters and aviation resources on managed fires is associated with incident-specific safety improvements. For example, firefighters on these incidents often engage the fire only from existing control features, thus increasing the probability of success.

Beyond improved safety, both Forests reported observing that the larger burned areas associated with fire managed under these evolving strategies are resulting in landscape level improvement in fuel conditions. This allows the Forests to focus their available fuels funding on key locations closer to communities and improvements.

This strategic shift in fire management does not come without leadership support. Key human factor and commonalities seen in these two successful fire management programs:

- Insightful leaders are responsible for driving the organizational change.
- Support from key partners and stakeholders are critical to sustain these programs through time.
- Resistance to organizational change is common among employees, but this resistance decreases as program successes become obvious.
- Shared risk between line officers and fire staff is necessary for the long-term success of these programs.

Since the evolution of the fire management programs on these Forests has been tied to particular individuals or small groups of Forest leaders, it is important to assure that these successful practices are sustained into the future.

Four keys to the future success of these programs are identified in the case study:

1. Incorporating successful fire management practices into day-to-day operations.
2. Remembering the seminal events that lead to the organizational paradigm shift.
3. Assuring that policy and enabling documents support resilient land management practices.
4. Maintaining strong partnerships with important stakeholders and the public.

Each national forest in the system has unique challenges in meeting the goals of developing and maintaining healthy, fire resilient forests, while simultaneously assuring for the safety of the public and firefighters. Both the George Washington and Jefferson National Forests and the Sequoia National Forest have demonstrated that, through the thoughtful use of existing agency authorities, these goals are within reach.

1. Introduction

The U.S. Forest Service (USFS) Washington Office tasked the Adaptive Management Services Enterprise Team (AMSET) with working with staff on the George Washington and Jefferson National Forests (GWJ) and Sequoia National Forest and Giant Sequoia National Monument (SQF and GSNM) to explore how they have adapted their fire management programs to be successful in protecting life and human values—while still moving landscape conditions toward the Land and Resource Management Plan's Desired Conditions**.** These Forests stand apart from others in the degree to which they use unplanned ignitions to achieve resource benefits. This report documents how these fire management programs have evolved over the last ten years.

In order to understand how the fire management programs on these national forests and national monument have evolved, AMSET interviewed their staffs and employees about the progression of their programs. The interviews focused on four "themes":

- 1: Organizational Culture
- 2: Safety
- 3: Economics
- 4: Natural Resource Effects and Data Modeling

Separated by 2,500 miles, the GWJ and SQF National Forests have very different histories, yet both have fire management programs that are implementing fire policy in innovative ways. Though wildfires pose risks to human safety and natural resources, evolving fire management strategies moved these Forests away from responding to all wildfires with the sole objective of minimizing fire size. Now, fire managers view some ignitions as opportunities to move landscape conditions closer to desired conditions—as defined in their Land and Resource Management Plan [LRMP, see text box].

Land and Resource Management Plans and Desired Conditions

Each federal land management unit must have a Land and Resource Management Plan (LRMP) that provides a strategic framework that helps guide land management decisions. Usually the LRMP defines the desired conditions—describing the ecological, economic, and social attributes that characterize the outcome of land management. Desired conditions are not commitments or final decisions that approve projects. Some may be achievable only over the long term (USDA Forest Service 2005).

Background

In the mid-1990s the Forest Service began a paradigm shift to a holistic ecosystem management strategy that allowed for the use of wildfire for resource benefit purposes. Increased knowledge about ecosystem function revealed that many local forest systems were at risk of high-severity fire. With the growing occurrence of damaging wildfires, Congress and the administration increased fuels management funding, allowing Forests to address this risk through the strategic use of prescribed burning and other treatments.

The 1995 National Wildland Fire Policy acknowledged the scientific basis for and intent by the federal land management agencies to consider the use of wildfire to achieve resource benefits. With this policy came organizational change which allowed individuals with a non-traditional vision of fire management to influence wildfire response. Guidance provided further clarity on wildfire terminology, implementation, and decision support tools, as well as direction for interagency collaboration. The 2009 Guidance for Implementation of Federal Fire Policy further clarifies the policy and terminology, which is essentially unchanged from the 1995 policy, allowing for the management of wildfires to seek beneficial outcomes from these incidents when and where they are expected to occur [see text box].

Fire Terminology

The 2009 Guidance for Implementation of Federal Wildland Fire Management Policy includes the following excerpts: The intent of the framework is to solidify that the full range of strategic and tactical options are available and considered in the response to every wildland fire. These options are to be used to achieve objectives described in Land and Resource Management Plans and/or Fire Management Plans. A wildland fire may be concurrently managed for one or more objectives and objectives can change as the fire spreads across the landscape. Wildland fire is a general term describing any non-structure fire that occurs in the wildland. Wildland fires are categorized as either *wildfires* (unplanned ignitions or prescribed fires that are declared wildfires) or prescribed *fires* (planned ignitions). Nine guiding principles are foundational for Federal Wildland Fire Management Policy. The first and foremost is firefighter and public safety—this being the first priority in every fire management activity.

2. George Washington and Jefferson National Forests

Following the four themes listed in the previous section (1. Organizational Culture; 2. Safety; 3. Economics; 4. Natural Resource Effects and Data Modeling), the GWJ case study is presented here first, followed by the SQF case study. An overall lessons learned section that presents culminating themes for both case studies is presented in Section Five of this report. The interview questions used for both case studies are listed in Appendix A.

The GWJ, the largest national forest in the Southern Region, is one of the largest blocks of public land in the eastern U.S. It is the closest national forest to Washington DC. The land ownership pattern within the Congressional boundary of the Forest is extremely fragmented with a complex wildland urban interface (WUI) zone. The boundary of the GWJ is 5,527 miles in length, approximately the same distance as a round trip from Washington, DC to Seattle. Discontinuous blocks of National Forest System lands are common in eastern Forests as compared to the larger continuous National Forest System Lands in many western Forests and large national parks. This land ownership pattern creates a setting where fires can impact the public, private property, and local jurisdictions quickly [Figure 1].

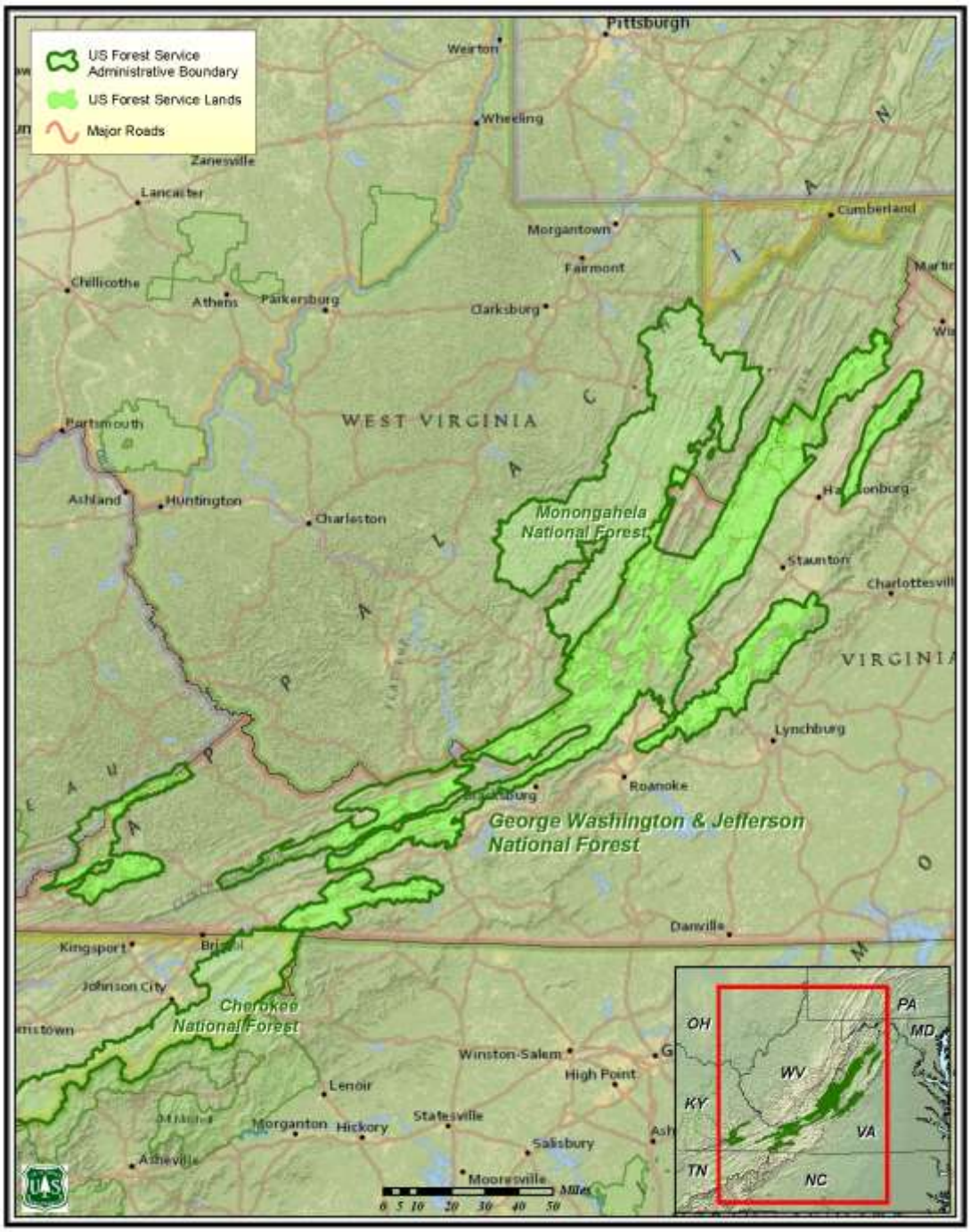
Theme 1: Organizational Culture

The evolution of the fire management program on the GWJ is a story willingly told by many employees and non-governmental organizations. During the early 1980s, Forest staff began questioning the use of aggressive suppression tactics on all wildland fires. Ecosystem management concepts were new and evolving, but were not being supported under a fire strategy that was focused on aggressive suppression of all unplanned ignitions.

A former Deputy Forest Supervisor's past experience from early in his career in Louisiana led the Forest to a new understanding regarding wildfire management practices. Instead of aggressive direct attack that could increase safety risks and costs, he favored a containment strategy based on the use of roads for burnout operations. This strategy resulted in more efficient and safer fire suppression actions that resulted in larger burned areas—but at fire severity levels which improved forest and fuel conditions.

In the 1990s, the GWJ had very few firefighting resources to address their existing fire activity. For years, the Forest was unable to handle the logistical requirements of a large wildfire and was forced to use costly regional incident management teams (IMTs) for large fire support. Forest staff decided a better way to manage large wildfires was to use their limited number of firefighters to contain the fires at logical, natural barriers such as roads, trails, and wet drainages. Doing so reduced firefighter exposure to potentially hazardous conditions, reduced the length of work shifts, and reduced costs.

Figure 1. Map of George Washington and Jefferson National Forests and vicinity.



This successful outcome demonstrated to Forest managers that alternative management responses were practicable and could be effective.

This shift in fire suppression strategy was accompanied by an increase in fire and ecosystem research that revealed the value of fire as a mechanism to manage ecosystems. A watershed point in ecosystem management on the GWJ was triggered by new knowledge from cooperative research burns with The Nature Conservancy that the Peter's Mountain Mallow—listed as an endangered species in 1986 (http://www.fws.gov/northeast/pdf/PetersMountainMallow.pdf)—could benefit from prescribed fire to restore the frequent fire regimes on which the species depends. Dendro-chronological research (fire scar dating) funded through the Joint Fire Sciences Program (JFSP) had shown a huge fire deficit in local forest systems. Fire scar chronology indicated that fires occurred frequently (every 2-14 years) throughout the 18th to early 20th (1726-1930) centuries (GWJ LRMP; Aldrich *et al.* 2010).

Other Significant Influences on Fire Management

The Glenwood-Pedlar District Ranger indicated there were two additional major reasons which lead to the continuing evolution of the fire management program in 1997:

- Forest staff decided to stop engaging in nighttime firefighting for safety reasons. This was partly due to significant gypsy moth infestations that resulted in extensive tree mortality and snag creation which made night time operations highly dangerous.
- Forest staff realized that fires on the Forest were generally not damaging ecosystem values, and frequent fire was important to maintain rare or threatened, fire dependent species.

The 2006 Peavine Fire was a significant event involving the use of progressive fire management strategies. The Forest chose not to utilize aggressive direct attack tactics to meet the primary objective of limiting fire size. Instead, managers backed-off from these tactics and used existing road networks for burnout operations to contain the fire. The result was 3,000 acres that resembled a planned prescribed burn with no apparent fire suppression damage or loss in resource value. This successful outcome demonstrated to Forest managers that alternative management responses were practicable and could be effective.

In 2007, the Straw Pond Fire began from a lightning strike and burned 402 acres on the GWJ. This fire was managed under the guidance of the Southern Region Fuels Program Manager. Initially, Forest staff were concerned about managing fires for resource benefit objectives without a previously-approved written plan. At that time, it was a commonly held practice that a fire-use management plan tiered off the Fire Management Plan (FMP) and LRMP was required to manage a fire for resource benefit. The Regional Fuels Manager was able to clarify that—according to the *2004 Strategy for Federal Fire Policy Implementation*—if managing wildfires to achieve desired outcomes would implement the LRMP and FMP, then a third tier plan was not required and resource benefit could be included as a fire management objective. The Straw Pond Fire was the Forest's first documented wildfire where resource benefits were included among the management considerations.

GWJ Wildfire Incidents that Highlight the Fire Management Journey

Forest staff selected a short list of wildfires considered transformational in the evolution of the fire management program (Table 1). These fires provided both positive and difficult lessons learned and are referenced in other sections of this report. Example fires that highlight *"extreme"* circumstances, such as high cost, large fire size, safety issues, and natural resources affected are also included. Fire costs are discussed in greater detail in the *"Economics Theme"* later in this document.

Since 2006, GWJ fire strategies have moved away from a minimize-fire-size response and focus on containing fires which escape initial attack (IA) within a "bigger box" designed to take advantage of existing barriers to fire spread.

Table 1. Selected GWJ wildfires illustrating the transformation of the fire management program.

Fire Year Fire Name	Fire Cause	Management Strategy[1]	Management Outcome	Days of Active Management[2]	Acres
1999 Rough Mountain	lightning	Control fire to smallest possible size in Wilderness.	Fire was controlled in difficult terrain. Narrow safety margins and high costs were identified, including multiple medium helicopters (and incident with rotor-strike in river dip-site).	1	30
2001 Lost	lightning	Control fire size.	Very high suppression costs compared to fire size, location, and rain forecasted. Aerial costs (multiple medium helicopters) contributed to high cost.	6	710
2002 Marbleyard	lightning	Control fire size in Wilderness.	Type 1 IMT-managed fire utilizing extensive burnout operations leading to unnecessary higher severity fire effects. Firefighter injury required emergency helispot construction and medevac from within Wilderness.	16	2,935
2002 Stumphole	lightning	Limit fire size.	Burned in very rough, rocky terrain; managed to pre-existing control lines and features.	17	158
2006 Peavine Complex	arson	Manage using existing containment lines. Eleven fires had merged into four fires, managed in one large containment box.	Fires were managed in one big box by grouping management actions and utilizing a single leadership team. Existing roads used for containment which reduced firefighter exposure and suppression costs.	4	2,871

Fire Year Fire Name	Fire Cause	Management Strategy[1]	Management Outcome	Days of Active Management[2]	Acres
2007 Straw Pond	lightning	Managed for natural resource objectives using existing containment lines. Very dry conditions prevented successful utilization of handline alone.	Natural resource benefits, road network used for burnout operations to contain fire. The location near the 2002 Marbleyard Fire provided a chance to "do it differently" in the same area, first fire use type strategies employed.	5	402
2008 St. Mary's	misc.	Manage fire using existing containment lines. Very dry conditions prevented successful utilization of handline alone.	Type 3 IMT backed off of direct lines to use burnout operations and existing firelines, including: roads, trails, and wet drainages to achieve containment, safety and time efficiencies.	2	4,505
2008 Stone Coal	lightning	Natural resource objectives.	Natural resource benefits; fire in view of large metropolitan area; extensive media coverage.	10	820
2010 Big Hollow	lightning	Limit fire size, low moisture conditions and limited staff. Fire burned in the same area as 1999 Rough Mountain Fire.	Escaped IA, managed with bigger box, including constructed dozer line. Burnout operation successful as part of final control. Resource benefit observed, i.e. canopy closure reduced, plus gaps created & open understory.	4	118
2010 Long	lightning	Limit fire size, low moisture conditions and limited staff, ordered external resources due to lack of local resources, political concerns, and public safety.	Safety hazards largely mitigated by monitoring from afar. Fire cold trailed and snagged for safety when conditions warranted. Fire size was limited being inside the 2008 St. Mary's Fire perimeter.	6	12
2010 Fassifern	lightning	Limit fire size, low moisture conditions and limited staff, fire started on lower slope and ran to top of ridge.	Suppression was successful when fire exceeded Maximum Management Area, used aggressive tactics and dozer lines. No detrimental fire effects; overall resource benefits were positive. Fire provided a few years of reduced potential fire behavior in light WUI area.	5	416

Fire Year Fire Name	Fire Cause	Management Strategy[1]	Management Outcome	Days of Active Management[2]	Acres
2010 Glenwood Complex	lightning	Limit fire size, low moisture conditions and limited staff, manage multiple lightning strikes in close proximity that burned together, natural resource objectives.	Terrapin Fire: utilized cold trailing and limited handline construction, resulting in cost savings and limiting firefighter exposure. Falling Rock Fire: primarily backing fire that was minimally staffed, some direct handline installed, eventually burned into the James River Face Wilderness, extinguished in a rain event. Natural resource benefits occurred. Firefighter exposure was greatly limited.	8	835
2010 Phillips	lightning	Protection and ecosystem objectives.	Fire managed within "large box". Lines consisted primarily of existing roads, trails, and streams. Minimal burnout performed. Managed during leaf-fall until extensive rain.	30	162
2011 Chestnut Ridge	arson	Limit fire size. Started in extreme conditions (power line, high winds) and ran to top of hill, WUI threatened.	A short Type 1 IMT used due to very limited staff (early spring fire). No significant negative fire effects, helped forest structure, used bigger box because it escaped IA; snow event extinguished the fire.	13	914
2012 Easter Complex	railroad, arson, campfire, misc.	Safely manage 6 fires at one time during dry and windy conditions; manage fire size to existing barriers where possible and protect private lands.	Near peak of spring fire season, conditions were a "perfect storm" of weather and fuel conditions, became largest fire event since 1930s in western Virginia for acreage burned and organization. Burned almost the entirety of two Wilderness areas; used point protection strategies along private lands and indirect attack from existing roads, trails, and natural barriers used as control features.	ranged from 12 to 20 days each	39,537
[1] In addition to the primary responsibility to provide for firefighter and public safety.					
[2] Days of active management were derived from the fire reports (FSH 5109.14) from the date of the initial action to the date of the suppression strategy attainment.					

Not all wildfires are considered good candidates for management to include natural resource benefit objectives. Often times the Forest continues to aggressively suppress unwanted and potentially damaging fires with management decisions based on public and firefighter safety, values-at-risk, public

concern, weather, and the availability of firefighting resources. Under current fire management strategies, when an *unwanted wildfire* escapes initial action, firefighters are expected to disengage from aggressive direct attack and implement actions to contain the fire using existing barriers, while still attempting to limit fire size.

When a fire is located in a candidate area for including resource benefit as a primary objective, an indirect fire control strategy can be implemented—as long as firefighter and public safety can be assured under this strategy. The ability to meet resource objectives, reduce fire costs, and lower fireline exposure for firefighters makes the implementation of an indirect strategy a preferred option for both firefighters and resource managers.

Forward-looking Forest leadership has helped to encourage employees to embrace this new fire management approach. While some employees are still resistant to the transition away from an aggressive fire suppression response on *all* fires, in general, employees are thinking more *"outside the box"* and support managing wildfires under a strategy that allows for firefighter and public safety, as well as ecosystem benefits and lower costs. Jefferson National Forest revised its LRMP in 2004 and incorporated fire use concepts. The George Washington National Forest LRMP is currently being revised with a final decision expected in the near future. This plan revision contains direction for managing both planned and unplanned ignitions based on current policy.

Public Support for the GWJ Fire Program

Forest employees described a range of familiarity, understanding, and acceptance of fire as a management tool to improve the resilience of forested lands. Many longtime residents of the area support prescribed fire because of its historic use for clearing land for settlement and maintaining open conditions along with improving wildlife (game) habitat. Staff noted a difference in the level of acceptance of fire on the landscape between longtime residents and people who have moved to the area from urban centers. An issue that the Forest is addressing is temporary closures on portions of the Appalachian National Scenic Trail—required during the management of some fires due to public safety concerns. This is a problem shared with the Sequoia National Forest where the Pacific Crest National Scenic Trail may be closed due to potential public safety concerns from wildfire. Both Forests recognize the need to accommodate hikers as part of fire management strategy.

Late winter and early spring burning in the southern United States has been an ongoing and acceptable tradition for centuries. There is little opposition here to prescribed burns. One employee said that the farther south you go on the Forest, the less information is requested by the public about burning. However, smoke management is an increasing concern as population density continues to increase adjacent to the Forest. Smoke is a more significant concern to those accustomed to urban lifestyles compared to rural living. In general, the GWJ reports that longer duration smoke from low-intensity fires is better accepted by the public than shorter duration, dense smoke associated with more intense fires. The local public is interested when they see smoke, and the GWJ uses local television news and newspapers to distribute information regarding both wildfires and prescribed fire activities. For prescribed burns, this Forest uses preapproved fact sheets to hand out to the public while the website (InciWeb.org) is used for larger or long duration fires.

Because the majority of the local public is not familiar with federal fire management policy and terminology, the Forest is concerned about sending mixed messages to the public regarding wildfire management. The goal in Public Affairs on the Forest is to use clear language to describe a fire situation

and not attempt to explain national wildland fire management policy. The Forest Public Affairs Specialist (PAS) explained that, locally, there is a general unfamiliarity with managing wildfires for resource benefits, and that the Forest emphasizes the primary fire objectives of public and firefighter safety in describing why and how they manage wildfires before discussing other objectives. The public readily understands the decision to contain fires at roads, trails and existing barriers. While explaining the ecological benefits of fire is currently a secondary consideration, the PAS said more outreach and education about the role of fire in the Forest is a goal for his staff.

Stakeholder Support for the GWJ Fire Program

Stakeholders are extensive in such a populated area and on a Forest with so many miles of public/private land boundaries. Stakeholders who are most active include the natural resource agencies of Virginia, West Virginia and Kentucky, more than 100 volunteer fire departments, The Nature Conservancy, Forest visitors (hikers, campers, hunters), and adjacent landowners.

The PAS described how the partnership with The Nature Conservancy through the Fire Learning Network (FLN) is making significant progress in outreaching to community groups. The FLN provides a forum for conservation groups, state management agencies, and private land owners to interact with other community interest groups (http://www.conservationgateway.org/topic/fire-learning-network, see Figure 2). Another available fire science information network is the Consortium of Appalachian Fire Managers and Scientists (http://www.cafms.org/) which is supported in part through the Joint Fire Science Program.

Some state natural resource agencies in Virginia, West Virginia, and Kentucky, as well as local fire departments have expressed concerns about the "bigger box" strategy used by the GWJ. This concern reflects these agencies' primary mission of providing for public safety and the protection of private lands as compared to the integrated land management mission associated with the GWJ. The GWJ provides for public and firefighter safety first as their highest priority. When possible, the Forest also considers opportunities to manage fires for natural resource benefits. Forest staff has acknowledged a continuing need to engage the leadership of volunteer fire departments to explain the mitigation efforts that are in place to assure public safety during wildfire incidents.

Figure 2. Collaborative efforts, such as those facilitated by the Fire Learning Network, include field trips and fact sheets.

Implementation Barriers and Facilitators to Changing or Evolving the Fire Management Philosophy and Strategies

Barriers to evolving fire management practices

- The recent perception that a stand-alone fire use management plan is required to manage wildfires for multiple objectives.
- When trying to manage multiple fires, logistical support needs often require the Forest to utilize an incident management team.
- It is problematic for the Forest to staff long duration fires during late fall or early winter because of the lack of local staff and limited availability of western fire crews.
- Multiple day closures to the Appalachian National Scenic Trail due to fire management activities are problematic due the impact on through hikers. This is particularly true for late spring and early summer fires.
- Drainages used as a natural fire breaks have become less reliable as recent Eastern hemlock mortality is increasing fuel loads and passageways are created through fallen trees across wet drainages.
- Smoke management issues occur more often in fall and winter due to cooler, shorter days, less wind, and more temperature inversions.
- Local fire departments often need convincing that fires can be managed for both protection and natural resource objectives concurrently.
- Initial fire size is often used as a trigger for aggressive suppression. Smaller fires are normally suppressed, leading to fewer opportunities to manage a fire for resource benefits.
- The extensive WUI zone [see text box] limits the size of managed fires. Fires near Wilderness boundaries are often suppressed in order to provide protection to adjacent private lands.
- Fires near the Blue Ridge Parkway can create management issues including public safety impacts due to reduced driving visibility from smoke. While the Parkway could serve as a barrier to fire spread, it is not fully utilized as such due to the potential impacts to public safety and recreation use. Fires also require additional coordination and joint command with National Park Service.

Wildland Urban Interface

Wildland Urban Interface (WUI) is the line, area, or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels (NWCG 2011). Through the Healthy Forests Restoration Act (2003, P.L. 108-148), Congress increased funding for hazardous fuel reduction projects with the stipulation that 50 percent or more of these funds must be expended within WUI areas. For fire management, the WUI zone often includes additional complexities not usually found in more remote or unpopulated areas of public land.

- Conflicting interests between prescribed fire operations and managed wildfire can create staffing difficulties. Accomplishing preplanned prescribed fire goals/targets was a reason why some fires were aggressively suppressed rather than allowed to evolve into a longer duration fire incident. Because there is simply not enough staff to do both, the Forest must choose accomplishments in one program over the other.

Positive influences on fire management practices

- Spring prescribed burning in southern states helps build support for the fire management program. Burning has been part of the regional culture for centuries and provides opportunities for employees to hone basic firefighting skills.

- The fire season on the Forest is now almost year round, creating many opportunities for using fire.

- Due to the large amount of escaped "outdoor" burns on private property, Virginia Department of Forestry has a law that prohibits prescribed burning before 4 p.m. This legislation initially created a barrier for the Forest's prescribed burn program. However, in 1996, federal agencies were successful in negotiating an exemption from this statute.

- As broadleaf litter gets packed with snow and ice, fire behavior is reduced, generally lowering fire behavior and the complexity of prescribed fires in the following months.

- Fuels types are such that fires typically burn actively when aligned with slope and wind, but rapidly slow and lose intensity after transitioning into a backing orientation.

- Backing fires reduce smoke impacts to communities because emissions are spread out over time. The public prefers longer burning backing fires because fewer emissions are produced per unit of time.

- Creeks are usually excellent containment lines in the spring due to increased flow—unless Eastern hemlock mortality has increased dead fuel loading and avenues for fire spread.

- Fewer arson fires occur now than in the recent past. This is partly due to increased partnerships and a growing understanding of the effects of fire on natural resources and public safety.

- Improved cooperation and coordination between agencies and collaborators has led to a wider acceptance of integrated fire management strategies. This is particularly evident with the Blue Ridge Parkway, Shenandoah National Park, The Nature Conservancy, National Wild Turkey Federation, and the Virginia Department of Forestry.

- Local Forest staff are acquiring improved fire management skill sets due to the increased exposure to managing larger and longer duration wildfires.

Benefits and Losses of the Shift in Fire Management Strategy

Mixed benefits and losses – depending on fire situation/management

- The reintroduction of backing- or slow-moving fire across the landscape is generally accepted as improving ecosystem health, except where fire opens forest canopies in which invasive plants may proliferate if already established in adjacent areas. This is especially a concern in designated Wilderness areas.

Losses

- Unacceptable amounts of large tree mortality (scorch and heat damage) may occur when head fires burn with greater intensity under intact canopies.

- The loss of homes or infrastructure in the WUI has not been a problem on the Forest. However, ongoing home construction and recreation sites adjacent to forested areas have the potential to exacerbate this problem.

Benefits

- There have been few large fires that significantly damaged forest resources.

- Managing fires in the *"bigger box"* teaches inexperienced firefighters that it's *"not the end of the world to let the woods burn*" and provides learning opportunities for landscape-level fire behavior.

- The GWJ now manages more of its extended attack wildfires for resource objectives in conjunction with protection objectives. This has allowed fire managers opportunities to gain experience and refine their strategies and tactics.

- FireWise programs are reducing potentially hazardous conditions on private lands in the WUI.

- Examples of improved fire management efficiencies include: (see previous Table 1 for details)
    - 2006 Peavine Complex
    - 2008 St. Mary's
    - 2010 Glenwood Complex (Terrapin and Falling Rock Fires)

Regional Fire Program Journey Steps – Creating Bridges and Overcoming Obstacles

The GWJ fire program has demonstrated incremental improvements in the Forest's ability to manage wildfires utilizing a combination of protection and resource benefit objectives, as well as varying fire management strategies. This section of the report provides feedback from a few individuals that highlight the journey, obstacles, and evolutionary steps of the fire programs elsewhere in the eastern United States. The complexity of this topic exceeds the scope of this case study and requires extensive exploration in the future. Several fire management programs within the Southern Region of the Forest Service have a similar evolutionary path as the GWJ. Some are at different stages of this journey.

Unique terrain and weather patterns associated with the Forests of the Southern Region of the Forest Service create difficulties in comparing program evolutions. Fire frequency patterns and fire staffing also vary widely in the Region. The GWJ is located on the northern edge of the Southern Region and touches the southern edge of the Eastern Region of the Forest Service [see Figure 1]. The western side of the Appalachian divide borders parts of the GWJ, creating a rain shadow effect along the Appalachian Plateau. This effect leads to remarkably different precipitation and wildfire occurrence patterns within this geographic area.

For example, the Monongahela National Forest immediately north and west of the GWJ has few natural or human-caused fires and generally uses an "eliminate fire" strategy for fire management due in part to the Forest's limited operational capacity. In contrast, in their fire management approach, the national forests in Arkansas and Louisiana apply similar protection and ecosystem objectives as the GWJ.

One Fire Management Officer (FMO) described the evolution of the fire management program as being based on several factors, including many factors mentioned previously in this document. Additional factors include:

- Changes in national policy recognizing fire use as a management strategy that acknowledges the role of fire as a natural process.
- Observations that larger fire sizes came with ecological benefits comparable to prescribed fires conducted during the same season.
- The realization that employing point protection and other fire control tactics with a "bigger box" strategy can improve fire safety and promote resource benefits on both lightning- and human-caused fires.

An FMO in North Carolina highlighted some obstacles they are addressing as their program evolves. This FMO explained how they need to employ a different fire management strategy than the GWJ, as their Forests range from the coastal plains to the Appalachian Mountains—covering three distinct ecosystems. The eastern Forests in North Carolina have larger WUI components which constrain fire management options, while the two western Forests have mountainous ecosystems with large wilderness areas. Some of the obstacles noted from North Carolina, and some that have been found on the GWJ, include:

- Managing long-term fires in areas where smoke management issues can have negative ramifications for agency line officers (decision makers).
- Some Southern Region leadership has concerns that long-term fire events can tie-up Forest personnel needed to accomplish other non-fire program targets. This situation can result in longer public impacts from smoke emissions.
- Some Forests do not have many natural ignitions and therefore have few candidate fires to manage.
- Some staff believe that national fire policy was written for the western states, and that they have different challenges which are not addressed in current policy.

A Southern Region Fire Ecologist focused her input on landscape-scale fire regime management as an opportunity to break barriers and create links between programs. Because ecosystem resilience depends on fire processes across the entire region, staff transfers and sharing lessons learned between multiple Forests helps the continuing evolution of the use of fire to achieve resource benefit objectives.

This Fire Ecologist believes that institutional change toward a more progressive land management strategy can be attributed to small organizational processes, such as participation in conference calls, field trips which highlight successful programs, and encouragement of learning across regional and ecological boundaries. Discussions of historical conditions help managers envision what the outcomes of a fire management program looks like on the landscape. Native American landscape management trends can also provide guidance (Brown 2000, Abrams and Nowacki 2008, Anderson 2005, Williams 2002, http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev3_000384.pdf).

A South Carolina Ecologist said the consistent trend of large prescribed fires in the coastal plain and piedmont areas is based on the culture of *both* the staff and public. The Forest Leadership Team has made spring burning a priority program of work. An AFMO observed that change is happening in the Eastern Region as lessons learned from neighboring Regions and Forests are integrated into their fire program. Use of the FLN (Fire Learning Network) and fire consortia information network has provided a streamlined mechanism to share information between the geographically separated Forests. (http://www.firescience.gov/JFSP_consortia.cfm and Figure 3).

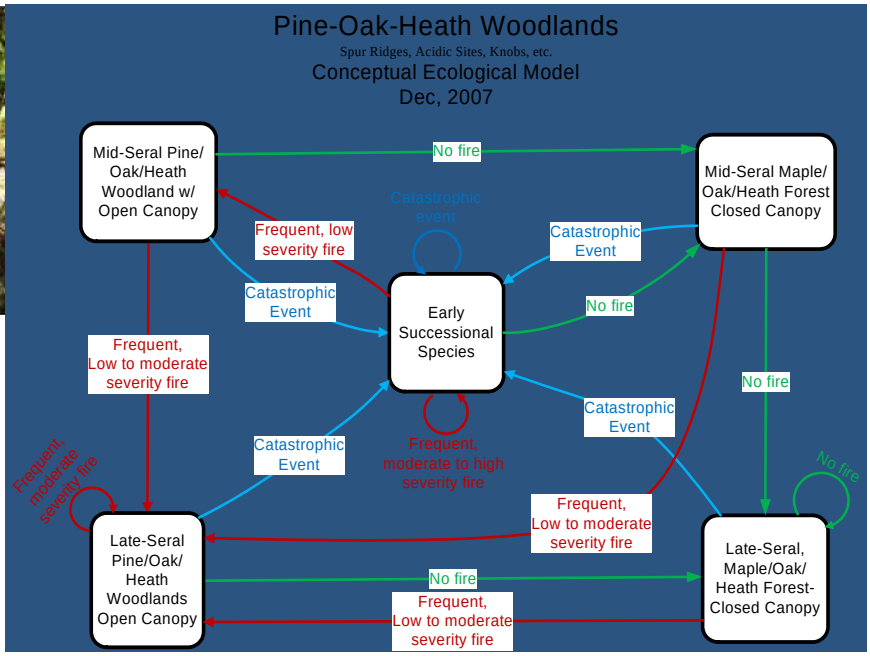


Figure 3. Fire Learning Network's activities include monitoring fire effects (picture above) and ecosystem trajectory planning through ecological modeling concepts (graphic on right).

Theme 2: Safety

The evolution of fire management strategies have led to tactics that have mitigated some safety risks to firefighters. In Theme 1 (Organizational Culture), improving firefighter safety was the primary reason that fireline tactics have evolved toward utilizing existing barriers as control features. Improved safety was achieved by staffing large fires with fewer firefighters; limiting work on steep slopes at night; and utilizing indirect suppression tactics that rely on roads, trails, and defendable barriers to reduce firefighter exposure.

Night fireline operations have been minimized due to increasing snag exposure associated with gypsy moth mortality in large hardwood trees, especially oaks. When feasible, firefighters on the GWJ avoid working under closed forest canopies, especially during the summer. Closed canopies trap smoke and heat which can adversely impact employees' health and safety. The strategy of using open areas and existing barriers reduces the need to work under closed canopies and also reduces the amount of fireline construction required. This is an important safety mitigation action as fireline construction during times of oppressive heat and humidity has a negative impact on firefighter safety.

2012 was a record season on the GWJ for acres burned and no aerial retardant was used. Use of Type 2 and Type 3 helicopters to support indirect attack and provide fire reconnaissance and mapping has increased under this new strategy. However, the use of helicopters for troop shuttles has decreased, leading to fewer firefighters exposed to the hazards associated with helicopter operations.

Use of indirect strategies has also reduced aviation risk by reducing the aviation support required on fires. Only limited amounts of aerial retardant have been used on the GWJ, with only 11 drops made in the ten years prior to 2011. With the closure of the local reload base and the establishment of large retardant avoidance areas in 2011, aerial retardant is now a tool which has limited applicability on the Forest.

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Approximately all GWJ employees (about 200) are qualified as “militia” who primarily fill support roles during wildfires. Militia members have primary duties other than firefighting, but have completed at least minimum level fire training. This is about half the number of militia than in past decades due to the “downsizing” of the Forests since consolidation of the GW and J in 1995. About half the current militia members are arduous -duty qualified and can assist with fireline actions when their workload allows.

Limited core fire staff and arduous duty militia often requires Forests to back off direct attack strategies due to lack of personnel. Along with the smaller militia, a lower number of firefighters have extensive fireline experience within the current workforce. The lack of available and qualified fire personnel often dictates the need to abandon direct attack tactics, even on relatively small fires. A Zone Fire Management Officer stated that his zone has 18 line-qualified staff spread over almost 500,000 acres of three Ranger Districts. He considers it a positive outcome when they are able to staff initial attack with six to eight firefighters.

The ability of local cooperators to augment the forces of the GWJ is minimal. While cooperators do provide support on multi-jurisdictional fires, agency missions and staffing often impact the ability to fully engage cooperators in an integrated operation.

Theme 3: Economics

Management strategies have influenced costs [as shown in Table 2 below]. According to GWJ staff, when wildfires burn in the same areas multiple times, the cost per acre of suppression does not significantly change. Table 2 illustrates that—beginning in 2006—the average cost per acre for wildfire management has been reduced through implementation of more thoughtful fire management tactics, while the cost of using a full suppression strategy on fires has continued to rise over the last decade.

Table 2. GWJ wildfires illustrating changing costs related to fire management program changes.

Year	Fire Name	Cause	Days of Active Management[1]	Acres	Approximate Total Cost	Average Cost per Acre
1999	Rough Mountain	lightning	1	30	$200,000	$6,667
2001	Lost	lightning	6	710	$1,200,000	$1,690
2002	Marbleyard	lightning	16	2935	$1,191,300	$406
2002	Stumphole	lightning	17	158	$600,000	$3,797
2006	Peavine Complex***	arson	4	2,871	$260,000	$91
2007	Straw Pond	lightning	5	402	$500,000	$1,244
2008	St. Mary's	misc.	2	4,505	$710,000	$158
2008	Stone Coal	lightning	10	820	$150,000	$183
2010	Roaring Run	lightning	7	165	$50,000	$303
2010	Fore Mt.	lightning	1	2.5	$4,000	$1,600
2010	Big Hollow	lightning	1	118	$100,000	$847
2010	Long	lightning	6	12	$15,000	$1250
2010	Fassifern	lightning	5	416	$200,000	$481
2010	Glenwood Complex	lightning	8	835	$400,000	$479
2010	Phillips	lightning	30	162	$30,000	$185
2011	Pickle Branch	unknown	4	665	$100,000	$150
2011	Chestnut Ridge	arson	13	914	$7,870	$9
2012	Easter Fire Complex	railroad, arson, campfire, misc.	ranged from 12 to 20	39,537	$2,674,000	$68

[1] Days of active management were derived from the fire reports (FSH 5109.14) from the date of the initial action to the date of the suppression strategy attainment.

*****2006 began the trend of more wildfires being managed for protection and ecosystem objectives.**

An example of a "turning point" for management on the GWJ was the 1999 Rough Mountain Fire. While this lightning-caused fire burned only 30 acres, it had a suppression cost of nearly $200,000. A near-miss helicopter incident (rotor-strike with tree in a dip-site) was also associated with the suppression operations. Due to the fire costs and the safety concerns associated with this fire, the Forest began managing more wildfires with broader objectives, including both protection and ecosystem enhancement goals.

Through the use of existing barriers as fire control features, fire suppression damage associated with the use of heavy equipment was minimized, and the GWJ was able to minimize the fiscal impacts of rehabilitation even under this unprecedented level of wildfire activity.

During the 2012 spring fire season, nearly 40, 000 acres burned. These wind-driven fires exceeded the Forest's historic maximum annual wildfire acres burned by more than four times. In response to this abnormally active spring fire season, the GWJ focused on point protection strategies along private lands and indirect attack using existing roads and barriers as control features. Where necessary to protect private lands, dozer or plow lines were also constructed.

After this spring 2012 fire season, the GWJ conducted suppression-related rehabilitation and requested both Burned Area Emergency Rehabilitation (BAER) and fire suppression repair assistance based on a combination of circumstances, including: un-rehabilitated dozer lines, historic level of burned acres, potential for spread of non-native invasive plants from adjacent areas, and the inability of local staff to address rehabilitation needs while still attempting to accomplish planned project implementation goals.

Due to the rapid post-fire vegetation response and an intact duff layer protecting the soil, rehabilitation activities were focused on critical segments of dozer lines. Areas with steep slopes and bare soils were treated with water bars, seeding, and straw mulching. Through the use of existing barriers as fire control features, fire suppression damage associated with the use of heavy equipment was minimized, and the GWJ was able to minimize the fiscal impacts of rehabilitation even under this unprecedented level of wildfire activity.

By managing wildfires in larger areas, the GWJ accomplished some ecological restoration while addressing built-up fuel conditions on the landscape. Large suppression repair/rehabilitation costs are often avoided under the current management strategy employed on the Forest.

Theme 4: Natural Resource Effects and Data Modeling

The concerns over the effects associated with high-severity fire is not as great on the GWJ as on western forests—where longer-term ecological impacts are associated with these type of fires. While fire severity is not of great concern on the GWJ, the unintended effects of fire suppression activities—including the spread of invasive species, use of fire lines as illegal ATV trails and smoke impacts on the public— continue to be associated with fire management actions here. Through the use of less impactful fireline tactics, these potential impacts can be mitigated to varying degrees while forest restoration is accelerated as more acres are burned at low and moderate severities during wildfires. When combined with the ongoing prescribed burn program, these burned acres continue to introduce more fire into the fire-dependent ecosystems of the GWJ.

Figure 4. Vegetation structure changes based on incremental prescribed burn treatments.

Evick Knob – Burned 3 times | **Fore Mountain – burned 2 times** | **Hidden Valley – Burned 3 times**

Forested ecotypes that rely on fire processes represent 80 percent of the 1.8 million acres comprising the GWJ. Fire is a critical component for ecosystem resilience of oaks, American chestnut, grass and shrublands [Figure 4] as it serves as the principle mechanism of landscape and ecosystem renewal. Land management objectives prescribe ecosystem structural diversity in order to maintain habitat for many species [Appendix B].

Due to past agency fire suppression policy, open woodlands which are created and maintained through fire disturbance are a rare habitat condition on the landscape. Most forested acres are in a mature, *closed* canopy condition. This condition has led to an increase in shade tolerant/fire intolerant species and the decline of oaks. Entire woodland communities, such as shortleaf pine, table mountain pine, and pitch pine, rely on fire to reproduce and effectively compete with other species. Species composition and habitat structure are currently out-of-balance on the Forest. Thus, fire is now viewed by land mangers as the tool required to return these systems closer to pre-settlement conditions.

Following fire events, reduced fuel loads as well as reduced fire behavior is evident for three to five years. With a year-round growing season, vegetation recovers rapidly after fire. Measures of ecosystem resilience such as Fire Regime Condition Class (FRCC) and Fire Regime Interval Departure have limited usefulness on the GWJ as vegetation recovers very quickly [Figure 5]. The Forest is currently dominated by FRCC 3 with forest ecosystems needing disturbance on a seven-year average to maintain an FRCC 1.

Fire Regime Condition Class

Fire Regime Condition Class (FRCC) uses an index of 1 (within the normal fire regime range) to 3 (high departure from that range). Fire regime is often a five-group classification based on fire frequency and fire severity. Reference (i.e. natural or historical) fire regimes may be different from current regimes as measured by FRCC departure metrics http://www.frames.gov/partner-sites/frcc/frcc-home/.

Figure 5. A prescribed fire monitoring photo point in the Southern Appalachian Mountains that illustrate the rapid vegetative growth over two years—as is typically found in most of the USFS Southern Region.

Immediate post-burn

1-year post-burn

2-years post-burn

In order to change FRCC toward Condition Class 1, the Forest would need to burn an average of 150,000 acres per year. During the last 10 to 12 years, GWJ staff has accomplished 135 prescribed burns totaling approximately 76,000 acres with an average burn size of 500 to 3,000 acres (Table 3).

These burns units are actively managed within a maintenance burning program. Based on anticipated budgets, 40 new prescribed burn units are planned during the next 10 years involving an additional 40,000 acres. A single year maximum of nearly 22,000 acres of prescribed burning was accomplished in 2008 (Table 3). Based on these figures, prescribed fire alone cannot be relied on to burn the number of required acres to move the Forest to FRCC 1.

Figure 6. The GWJ's Mill Creek Prescribed Burn, shown here, has been burned three times. Notice the open woodland condition and reestablishment of warm season (little bluestem) grasses, in addition to pine regeneration.

Table 3. GWJ prescribed and wildfire acreage based on internal Forest data and FACTS (USFS 2013).

Year	Prescribed Fire (planned ignitions)	Wildland Fire (unplanned ignitions)
2000	5,136	2,216
2001	5,850	2,126
2002	5,550	6,414
2003	10,395	59
2004	13,619	141
2005	16,067	554
2006	6,676	3,287
2007	10,455	8,454
2008	21,755	12,088
2009	15,293	1,107
2010	20,590	2,263
2011	7,069	6,506
2012	15,436	41,586

Figure 7 illustrates the 10- and 20-year burn severity trends—based on Monitoring Trends in Burn Severity (MTBS 2011)—for the Southern Geographic Area Coordination Center (GACC) and the subset of Kentucky, Virginia, and West Virginia.

Figure 7. Wildfire burn severity (MTBS) for 1990-2010 for the Southern GACC (left side) and for 2000-2010 in Kentucky, Virginia, and West Virginia.

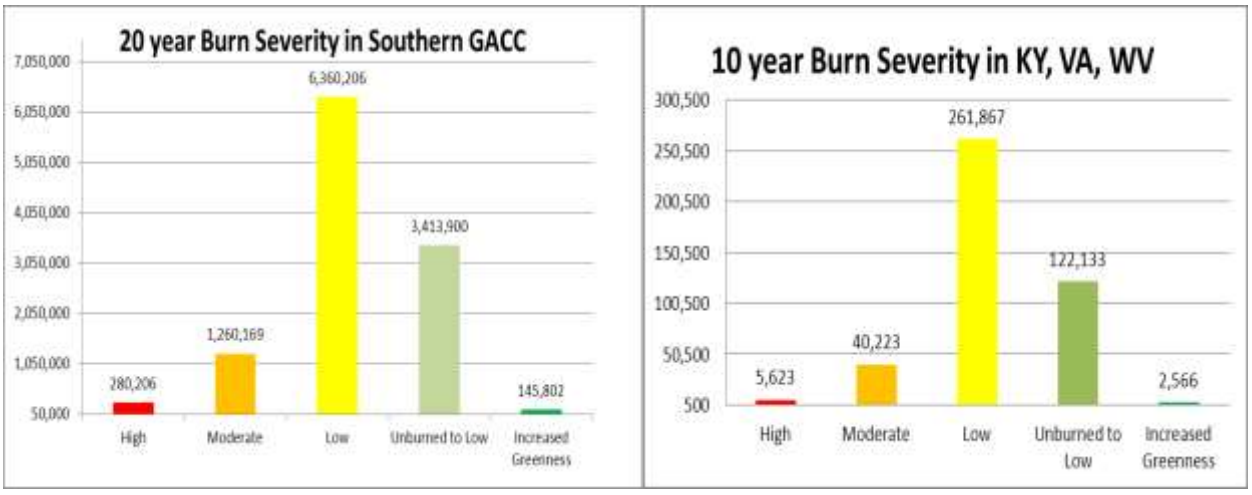


Figure 8. GWJ fire severity maps (MTBS data) illustrating the 2002 Marbleyard Fire (left side) and the 2010 Falling Rock Fire of the Glenwood Complex (right side). Fire severity legend applies to both maps.

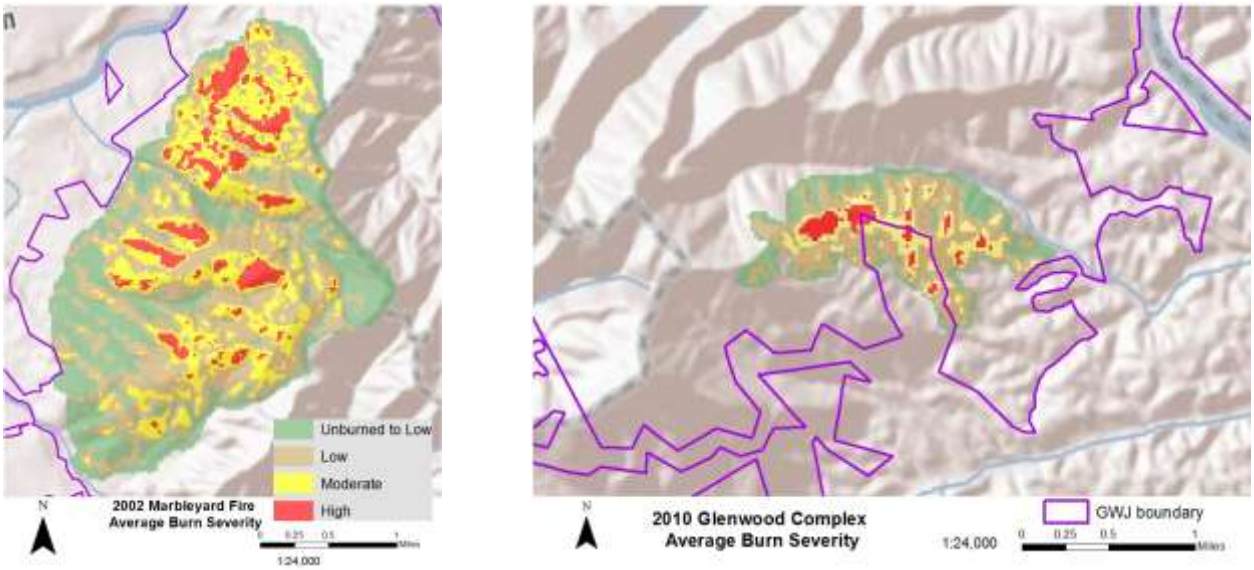


Figure 8 shows mapped burn severity for the 2002 Marbleyard Fire (managed to control fire size) and the 2010 Falling Rock Fire (managed for protection and ecosystem objectives). Based on a comparison of satellite imagery one year after each fire, fire severity for both these fires are similar with only 8 to 9 percent of the fire area classified as high severity (MTBS 2011). These two example fires have similar severity distributions to regional and state level fire severities, with the majority of acres falling within the low and unburned severity categories.

Smoke management is an evolving issue for the GWJ as population growth continues in and adjacent to the national forest. Emissions do not change significantly between burned and unburned areas as vegetation recovers rapidly after fire. First entry burns may actually increase subsequent fuel loading and therefore potential emissions as the burn consumes understory fuels which rapidly recover, but creates additional available fuels from mortality in the mid-story and canopy.

The First Order Fire Effects Model (FOFEM; Keane *et al.* 2012) was used to determine emissions from a fire burning in a well-managed fuel treatment unit versus a fire burning in a unit where fire has been excluded for up 15 years (Table 4). The model shows an approximate 74 percent reduction in particulates (PM_{10} and $PM_{2.5}$) when burning in the lighter fuel of an actively managed unit. Less smoke production reduces downwind effects on any potential sensitive smoke receptor (communities).

Table 4. Total Smoke Emissions (lbs./acre) comparison between 3 and 15 year old southern rough fuel type based on FOFEM modeling for a spring burn under moderately dry conditions.

Fuel loading category and vegetation type	PM_{10}	$PM_{2.5}$
3-year old rough long-leaf pine	58	50
15-year old rough long-leaf pine	224	190

The use of progressive fire management strategies and targeting desired ecosystem effects on the landscape will be an integral part of the overall forest and wildfire management program for the GWJ.

The Virginia Department of Environmental Quality (DEQ) regulates air quality for the GWJ and has identified nearby Richmond and Washington, D.C. as non-attainment areas. The Forest has reached agreement with DEQ that prescribed burning does little to degrade the regional air quality and is not a factor in the non-attainment areas. While smoke management planning is part of the Forest's prescribed burn plans, there is no requirement to submit smoke management plans to the DEQ. In addition, the Forest is not required to obtain the DEQ's permission to conduct burns.

Portable DataRam particulate monitors are used on occasion for some prescribed burns to monitor smoke impacts to local communities. One Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring station is located near the James River Face Wilderness—providing annual information about the effects of fires on air quality in this area.

Negative effects of wildfire or prescribed burns on natural resources are not common. Soils are rarely impacted by fires because the moist duff layer is seldom fully consumed and it therefore protects the underlying soils. Water quality remains nearly unchanged when fire managers use existing barriers for firelines as soil disturbance associated with fireline construction is minimized. Little erosion occurs from the burned areas as vegetation regenerates quickly. Dr. Carol Croy, Forest Wildlife Biologist, explains: "Prescribed burning generally helps to mitigate the effects of ongoing soil and water acidification (by acid deposition), by providing a temporary flush of cations through ash creation, that increases soil and water pH.".

Cultural resources are generally not affected by fires. When dozer or plow lines are necessary, archaeologists advise on line locations in order to avoid disturbance of cultural sites. Viewsheds are often improved by fire as vegetation is thinned by fire. Viewshed management is especially important along the heavily used Blue Ridge Parkway and Appalachian National Scenic Trail. Visual effects from fire are minimal as burned areas rapidly revegetate. Impacts to trails can become problematic after fires due to illegal all-terrain vehicle use on newly created firelines.

As the Forest's fire management strategy has evolved, large tree retention has generally increased. Recently burned forests result in greater fire resilience. A reduced shrub component and increases in grass cover are the main contributors to reduced mature tree mortality in subsequent fires. As the Forest moves toward the LRMP desired condition of an uneven-age class landscape, prescribed burns of higher intensity are used to *"punch holes"* or kill small patches within the overstory. Some resistance to this practice is expressed from people who are not familiar with the landscape characteristics of an uneven-aged stand.

The rapid vegetation growth associated with the GWJ requires frequent fire in order to maintain a healthy and fire resilient landscape. Partially due to limited hazardous fuels budgets, fuel treatments have been implemented on only a small percentage of the landscape, creating *"minuscule"* beneficial change. The lack of budgetary support for a broader prescribed fire program increases the importance

of—when feasible—managing wildfires to reduce built-up fuels and improve overall fire resilience of the forest systems.

Attempting to increase prescribed fire acreage during times of decreasing budgets is an ongoing issue for the Forest. The Forest is planning for the placement of future burn projects. This plan allows the Forest to take advantage of burned areas from wildfires, using the perimeter of these fires as control points for future prescribed burns. Under current funding and staffing levels, maintenance burning of areas currently under management is the highest priority for the Forest so gains made to date from past burns are not lost. The presence of existing control lines (human or natural barriers) often drives the decision on burn location when new, or initial treatment areas, are added to the current program. This strategy is utilized in order to reduce burn preparation costs.

The complex nature of the land ownership pattern also effects decisions on the placement of new treatment units. Private land often inhibits the ability to design burn units with a high probability of being successfully treated. The use of Wyden Agreements[1] to treat on private lands is increasingly necessary to design logical treatment areas and benefit ecosystems on a landscape scale. The use of progressive fire management strategies and targeting desired ecosystem effects on the landscape will be an integral part of the overall forest and wildfire management program for the GWJ.

[Lessons Learned from this section are summarized in Section 5 (Lessons Learned) of this report.]

[1] The Wyden Amendment (Public Law 105-277, Section 323 as amended by Public Law 109-54, Section 434) authorizes the Forest Service to enter into cooperative agreements to benefit resources within watersheds on National Forest System lands. Agreements may be with willing Federal, Tribal, State, and local governments, private and nonprofit entities, and landowners to conduct activities on public or private lands for the following purposes: Protection, restoration, and enhancement of fish and wildlife habitat and other resources; Reduction of risk for natural disaster where public safety is threatened; or, a combination of both.

3. Sequoia National Forest and Giant Sequoia National Monument

Theme 1: Organizational Culture

In 1990 on the Sequoia National Forest (SQF) the lightning-ignited Black and the Stormy fires grew together into a high-intensity crown fire that burned 24,600 acres. Approximately 57 percent of the fire area had high-severity fire effects (Figure 9). In 1990, this fire's size and severity was viewed as a rare occurrence by most Forest staff. However, the timber harvest and plantation planting practices, as well as years of fire exclusion, had created widespread fuel conditions supportive of high-intensity fire.

Ten years later, in 2000, the 75,000-acre Manter Fire provided a second example of the increasing fire intensity potential across the Forest. Post-fire data indicated that 22 percent of the fire area burned at high intensity while another 31 percent displayed moderate burn severity effects (Figure 9). The Manter Fire cost $16.6 million to suppress and nearly $1 million was spent on BAER (Figure 13 in Theme 4).

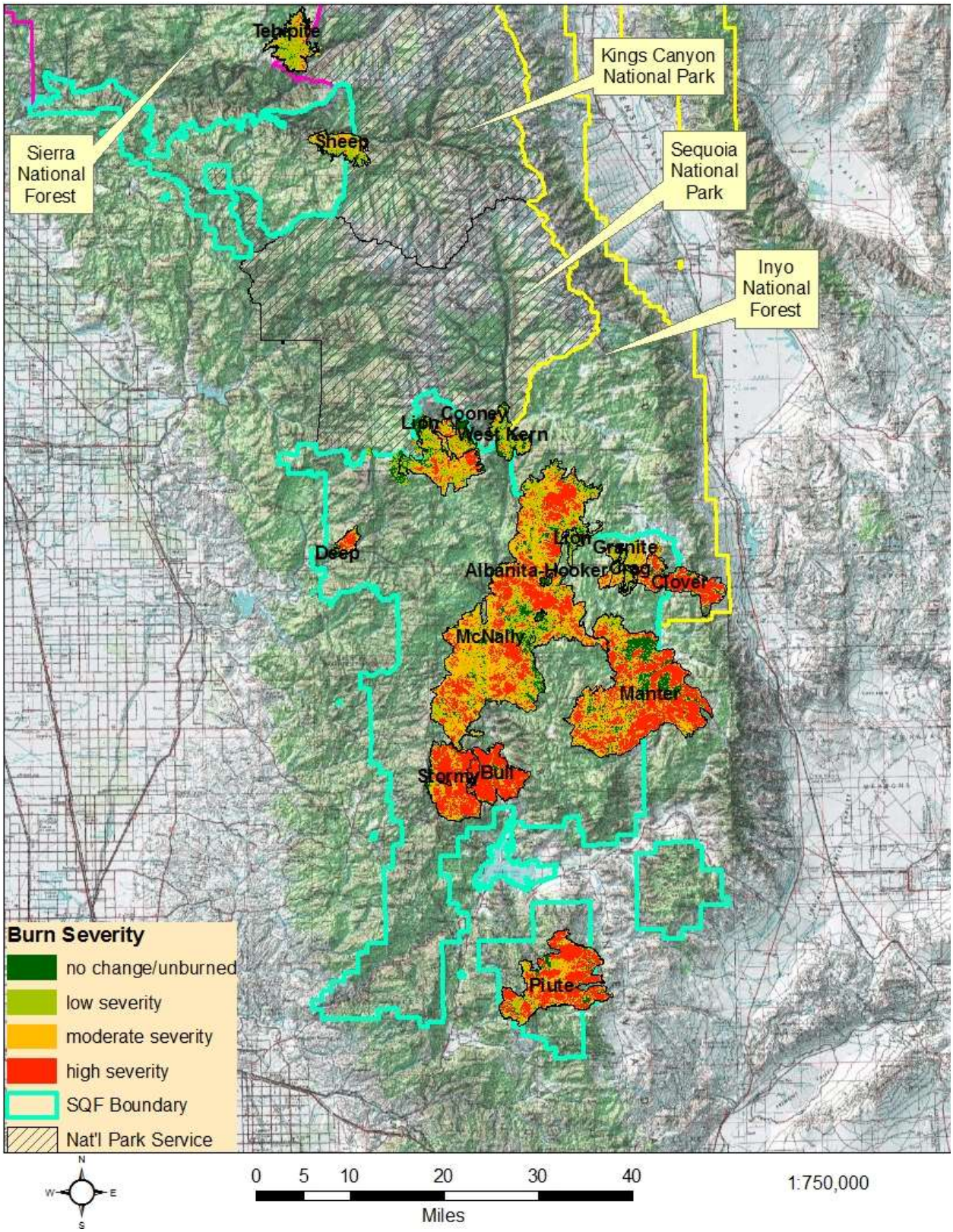
A new pattern of large, high-severity wildfires was emerging on the Forest. According to the Forest's Wildlife Biologist, Teresa Benson, the Manter Fire *"awoke a sense of urgency because this fire impacted wildlife habitat like no other fire experiences."* She realized vast forested areas were at risk of large, damaging fires that could significantly impact wildlife populations or cause species extirpation (ex. Pacific Fisher, Goshawk, and California Spotted Owl).

In 2002, the McNally Fire was contained at 150,700 acres, with several more thousand acres burned at unnaturally high severity on the Sequoia and Inyo national forests. Effects of the McNally Fire included:

- Soil burn severity: 52 percent moderate and high severity, 33 percent low severity, and 15 percent unburned (Figure 9).
- Aquatic resource and fisheries impacts in the North Fork Kern River drainage included expected sedimentation increase up to 870 percent.
- Nineteen spotted owl protected activity centers were affected; eight burned at moderate to high severity.
- Significant fragmentation/loss of habitat for *"old forest"* dependent species (Pacific Fisher, Marten, Goshawk, and California Spotted Owl).
- Twenty structures and 1,500 acres of private land burned.
- Twenty miles of the county road were washed away or covered by landslides.
- Total suppression cost was approximately $58 million; about $3.5 million spent on emergency rehabilitation. An additional $400,000 was allocated for long-term fire restoration.

Following the completion of the Forest Fire Management Plan in 2003, the Forest began to address its widespread deteriorating forest conditions by managing wildfires for resource benefit objectives. The 2003 Cooney Fire was a turning point for SQF fire management because the fire was managed on 1,928 acres of montane forest for a cost of only $120,000. Managing the Cooney Fire represented a challenge to fire managers unaccustomed to managing fire as a natural process on the Forest. Later that season, management of the West Kern Fire was comparatively less contentious following the success of the Cooney Fire.

Figure 9. Burn Severity of selected fire inside and bordering Sequoia National Forest.



In 2003, the 4,500 acre Albanita-Hooker Fire was the first large fire managed for resource benefits on the southern district of the Forest. This fire burned for more than 60 days. Some Forest,as well as Regional Office, staff had concerns that the fires were burning too hot and getting *"out of control"* (exceeding their Maximum Manageable Areas). During interviews for this report, the current Forest Fire Management Officer (FFMO) referenced a 2005 report (Fites-Kaufman *et al*.) that analyzed fire severity categories and effects of the Albanita-Hooker Fire and other fires on the Stanislaus National Forest. The findings of this report significantly improved the overall comfort level of line officers (decision makers) assigned the responsibility for management of these types of fire objectives. The usefulness of this report helped create a culture of fire effects monitoring on future fires managed under a protection and resource benefit strategy.

While the majority of fires on the SQF which present opportunities for ecosystem restoration are in designated wilderness areas, in 2008 the SQF used similar tactics to those utilized by the GWJ (previously described), and utilized existing control features for two fires outside of the wilderness. These two fires burned within predefined natural barriers to fire spread. One fire was contained using roads and trails. The second fire remained unstaffed and was monitored from afar until season-ending rains occurred. The District Ranger (DR) and District Fire Management Officer (DFMO) stated that while locations exist for managing wildfires up to approximately 1,000 acres outside the wilderness, the protection of adjacent private property remains a high priority for forest fire management.

SQF Wildfire Incidents that Highlight the Fire Management Journey

Forest staff created a list of wildfires considered transformational in the evolution of their fire management program (Table 5). These fires provided positive and difficult lessons learned to the Forest and are referenced in other sections of this report. Example fires that highlight *"extreme"* circumstances, such as cost, fire size, safety, and natural resources affected are also included. A Forest objective since 2003 has been to move away from an aggressive "eliminate fire" response on fires in wilderness or remote areas of the Forest and to incorporate ecosystem benefit as a fire management objective.

Table 5. Selected Sequoia NF wildfires illustrating the transformation of the fire management program.

Fire Year Fire Name	Cause	Management Strategy[1]	Management Outcome	Days of Active Management[2]	Reported Acres Burned
2000 Manter	unknown	Control fire size	Undesirable costs and natural resource damage.	50	75,000
2002 McNally	human	Control fire size	Undesirable costs and natural resource damage.	39	150,696
2003 Cooney	lightning	Natural resource objectives	First trial of fire use for resource objective management. Smoke concerns began conversation with air quality regulators. Validated internal fire use management strategies, including larger patches of higher severity effects. Natural resource benefits occurred.	137 (most activity was within 2 weeks)	1,850

Fire Year Fire Name	Cause	Management Strategy[1]	Management Outcome	Days of Active Management[2]	Reported Acres Burned
2003 West Kern	lightning	Natural resource objectives	Second trial of fire use for resource objective management and shared interagency management. Less tension than Cooney Fire. Reduced smoke related issues and longer active burning event, natural resource benefits.	114 (closer to 2 months of burning or spread)	7,968
2003 Albanita-Hooker	lightning	Natural resource objectives	Studied patch severity size which alleviated internal debates, natural resource benefits.	84	4,483
2004 Crag	lightning	Natural resource objectives, contain fire size	Converted from fire use to suppression designation. Costly, some natural resource benefits.	9	861
2005 Crag	lightning	Natural resource objectives	Longer term event, natural resource benefits.	84	1,185
2006 Tamarack	lightning	Natural resource objectives	Natural resource benefits, inside wilderness, "MIST" (Minimum Impact Suppression Techniques) analysis conducted.	155	4,654
2006 Maggie	lightning	Natural resource objectives	Balanced with recreation needs, trail system left open. MIST analysis conducted that built credibility and helped mitigate concerns; natural resource benefits.	155	2,097
2008 Clover	lightning	Contain fire size, natural resource objectives	Objectives transitioned from fire use to suppression, some debate regarding management strategies to contain fire size, some negative costs. Resource damage occurred in pinyon-juniper, and some natural resource benefits.	7	15,300
2008 Piute	human	Limit fire size, WUI threatened	Expensive (air resources utilized that were not tactically effective); natural resource damage.	33	37,026

Fire Year Fire Name	Cause	Management Strategy[1]	Management Outcome	Days of Active Management[2]	Reported Acres Burned
2009 Lion Complex (includes Granite Fire)	lightning	Natural resource objectives	Reestablish fire use program after complex/controversial Clover Fire. Intensely managed in terms of acres/day (proactive strategy with Air District, broken up like prescribed fire with daily check points). Air staff were content and suggested this as example management. Fire was contained by McNalley Fire area and roads. Occurred outside wilderness, burned plantation area (positive effects partly due to climate/mild weather). Natural resource benefits.	126	3,994
2010 Sheep Complex	lightning	Limited fire size and natural resource benefits	Natural resource benefits; successful interagency relations with National Park Service. Continue to strengthen relationship with Air Districts and Air Board. Established fire use strategies on the northern part of SQF, created opportunity for large-scale adjacent prescribed burn project (Boulder Creek).	101	9,020
2011 Lion	lightning	Limited fire size and natural resource benefits	Successful large-scale multiple objective fire. Cooperatively managed smoke with 3 local Air Districts and state Air Board. Improved relationships among all. Some natural resource concerns (fish habitat) were addressed with post-fire monitoring.	124	20,500
[1] In addition to the primary responsibility to provide for firefighter and public safety					
[2] Days of active management were derived from the fire reports (FSH 5109.14) from the date of the initial action to the date of the suppression strategy attainment.					

How have changes in fire management strategies been received within the organization?
Support for managing fires for other objectives than just minimizing fire size is slowly gaining acceptance on the Forest. Firefighter and public safety continue to be the highest priority, with property protection the second priority. Some internal resistance about the suitability of managing fires for resource objectives continues within the fire and forest management organization. While different acceptance levels and management concerns continue to exist, there is now a broader acceptance of fire on the landscape. The unique opportunity to enhance the fire resiliency of the forest by managing fires under these strategies is becoming better understood.

He [the District Ranger] was forced to embrace this fire management strategy, as the high-severity outcomes of recent large wildfires were no longer acceptable.

The southern-most District Ranger described his feelings regarding fires managed with resource benefit and protection objectives when he began his position in 2006. He said he was a *"risk taker by force"*, referring to the fact that a reasonable level of risk acceptance was required to allow fires to be managed to achieve resource objectives. However, he was forced to embrace this fire management strategy, as the high-severity outcomes of recent large wildfires were no longer acceptable.

Interagency planning efforts benefited the Sequoia's fire management program and improved the acceptance of fires managed for resource and protection objectives. The SQF shares boundaries with three federal land management units: Sequoia and Kings Canyon National Parks, Inyo National Forest, and the Central California District of the Bureau of Land Management (BLM). Since the late 1990s, the SQF and the Parks have had joint contingency plans for lightning-ignited fires starting in one jurisdiction and spreading to another. This interagency planning effort grew out of the desire to work together to benefit all the units' fire programs. This same type of planning occurred between the Park, Inyo National Forest, and the SQF in 2003 when the West Kern Fire burned a total of 7,353 acres across three jurisdictional units. Nearby, the Bureau of Land Management continues to implement a full suppression strategy, partly due to their smaller workforce, differing land management mission, and the shared boundary with the SQF being dominated by pinyon-juniper woodland (known for dynamic/volatile fire behavior [Figure 13]).

Programmatic and logistical changes have been made to fire operations on the Forest based on lessons learned from multiple fires managed for protection and LRMP objectives. These changes include modifying dispatch run cards to allow time to make decisions regarding suitable management strategies on new fires. Additionally, to support long-term fire management needs, the Forest has staffed three 10-person wildland fire modules. The modules assist fire managers in monitoring fire effects and fire growth and are also trained in fire suppression and help contain the fire spread as needed to meet objectives. Many fires which are early candidates to be managed for resource objectives are only accessible by trail or helicopter and logistical support is difficult. To address the unique logistical requirements of these fires, the Forest created crew-size kits for camping, food preparation, and sanitation that are maintained by each fire module.

SQF Public and Stakeholders Support

Various levels of support for this fire management approach exist in the communities surrounding the Forest. Often, the level of support is directly associated with the impacts that communities face from smoke generated during these long-term fire events. The greater the smoke impacts that communities have experienced, the lower the level of public support for these fire management strategies.

Given the same level of smoke impacts, individuals who live in close proximity to the fire are usually more tolerant of smoke than those who live farther away. Those who live closer to the fire feel they are being directly benefited by fire management efforts while those living farther away have expressed concern that they have to tolerate smoke that does not directly benefit them. Individuals who live in the communities on the east side of the Sierra Nevada along the Highway 395 corridor expressed these concerns during the Sheep and Lion fires.

Implementation Barriers and Facilitators to Changing or Evolving Fire Management Philosophy and Strategies

Barriers to Evolving Fire Management Practices

- Smoke concerns in Kennedy Meadows and Kernville (closest communities in the common downwind/down river areas of the Forest) and other WUI areas.
- Several private in-holdings in Golden Trout Wilderness that need to be protected.
- Human-caused fires can compete for staffing priorities with prescribed fires and fires managed for resource benefit and protection objectives.
- National and Regional direction (Preparedness Levels 4 and 5) to cease fires managed for resource benefit objectives or get approval to manage wildland fires to meet LRMP objectives (2004, 2012).
- Special use permittees, commercial pack stations, and outfitters believe that blackened areas and dead trees adversely impact business.
- Conflicting fire management policies between the Forest Service, National Park Service, Bureau of Land Management and Kern County Fire Department makes it difficult to deliver a concise message regarding fire to the affected public.
- WUI areas across the Forest add safety, social, economic, and infrastructure complexity to the fire management decision making processes. These interface issues decrease—but are not eliminated—in remote or designated wilderness locations.

Positive Influences on Fire Management Practices

- Proactive fire information programs within the agencies, availability of webcams across the Forest, air quality monitoring, and improved relations with the San Joaquin Valley Air Pollution Control District (APCD) all support fire management activities at the local level.
- Only a few Forest Service employees still believe that controlling fire size—or eliminating it—is appropriate on all fires.
- Being prepared for and attentive to lightning storms helps the SQF take advantage of natural ignitions and possible management options.
- Upward reporting and information flow to the Regional Office and the Geographic Area Coordination Center is critical to foster support for management actions. Being proactive with the dissemination of information can help *"diffuse anxiety".*
- Fires spreading from adjacent National Parks provide good opportunities to work with partners to fully integrate the concepts of fire for resource benefit at the landscape level.

Lessons Learned from Managing Fires with a Flexible—Rather than Rigid—Approach
[A Check List]

- ✓ Keep Situational Awareness keen—pay attention.
- ✓ Keep projecting into the future (worst case scenario spread rates/directions).
- ✓ Consider tactics for weather changes and sensitive/risky areas (sensitive features, values-at-risk, heritage resources, vegetation type, wildlife sites, and plantations).
- ✓ Use tactics across the spectrum to meet fire management objectives. Actively influence and change fire direction ("muscling" [see text box]) as appropriate.
- ✓ Develop and implement decision documents for "*what if"* type scenarios. Use FSPro to help understand potential rare fire spread events. Contingency planning should include smoke mitigation opportunities [Figure 9].
- ✓ Remain cognizant of national and regional preparedness levels and local draw-down which can affect firefighter availability.
- ✓ Take into consideration the Burning Index/Energy Release Component (BI/ERC), resistance to control, and fire effects when making decisions.
- ✓ ERC/BI/FSPro should be used as tools to support decisions and not hard thresholds that trigger automatic decisions. Given that so few opportunities to manage fires for resource benefit objectives exist, fire danger predictions should not be used as self-limiting decision points. Many human factors should be involved in making decisions. Models will not provide clear answers to all fire variables.
- ✓ Have a proactive attitude, regardless of fire size or spread.

Overall Lessons Learned

- Being opportunistic and having situational awareness can provide opportunities to manage fires under various weather patterns.
- During years of above average precipitation, fires will stop or slow at green vegetation. Therefore, more opportunities are available based on the relative resistance of the vegetation to fire spread. This can be true early in the fire season when fuel moisture is higher.
- During years with less than approximately 80 percent of average precipitation, fire spreads more easily and firefighters have fewer existing control opportunities. Dry years lead to a lower risk tolerance from line officers and Regional fire staff. Use of existing barriers to fire spread (old fire scars, fuels treatment areas, unburnable landscape features) can still allow for a full range of fire management opportunities. This can be true late in the fire season when fuel moisture is lower.
- Regional Office ***should*** encourage/endorse line officers to manage fires for resource and protection objectives when favorable conditions allow.
- Wet years generally equate to a taller grass crop, which can complicate fire management decision making by accelerating fire spread, especially in recently burned areas.
- Higher elevations generally equate lower overall risk due to less flammable fuels and an abundance of natural barriers to fire spread (such as rock outcrops).

Figure 10. Photos—taken northeast of the Clover Fire along Highway 395—show the smoke flowing down the eastern Sierra Nevada escarpment driven by a wave of strong westerly wind blowing over and down the escarpment. These winds are common along the Sierra Nevada Crest. Photos, by Julie Sheer, appeared in the June 23, 2008 *Los Angeles Times*.

Benefits and Losses of the Shift in Dire Management Strategies

Mixed benefits and losses – depending on fire situation/management

- The impacts of long duration fires on communities have been mixed. The public wants to be informed about fire activities and will be tolerant of smoke and fire management personnel in the community up to certain levels. Identifying when community sentiments move away from program support has proven difficult. This sentiment transition can influence fire decision making.
- Fires managed under resource and protection strategies have had mixed results in limiting the size of high-severity patches. This may affect habitat of special status species, such as spotted owl protected activity centers.

Losses

- Since the elimination of Fire Use Management Teams due to a change in federal fire policy, specialized experience in backcountry fire management has declined, such as use of pack stock for supply and equipment deliveries (http://www.wildlandfire.com/docs/fumt-historical.htm).

"*Muscling*" by Sequoia National Forest Fire Management Officer
What Does It Mean?

The term "muscling", used by the Sequoia National Forest, means actively adapting tactics to manage a fire with acceptable growth rates and spread locations. Tactics can range from direct suppression to allowing natural burn patterns to check fire spread. Management strategies are dependent on a combination of factors, including: fire location, fire behavior, smoke dispersion patterns, weather changes, changing LRMP land designations in relation to the fire's progression, and decision makers' risk tolerance. The FFMO uses the term "*lines of convenience*" (term is credited to CAL FIRE)—also called "areas of opportunity"—when choosing a strategic management area. Lines of convenience utilize natural barriers and landscape features to locate and install the most efficient and safe fire containment lines.

- Type 1 and 2 IMTs that specialize in all-risk incidents can be used to manage fires for resource and protection objectives but are associated with higher costs than when similar incidents are managed by Fire Use Management Teams.
- Agency and public perception about fires managed by IMTs is that the host agency (SQF) can no longer handle the complexities of the fire and needed to be replaced by personnel with greater fire management qualifications.

Benefits

- Crews (hotshots, Type 2 and fire modules) have adapted to meet the demands of all types of wildland fires.
- Fires can be "self-limiting" when interactions with old fire perimeters occur. The knowledge that fires on the Sequoia National Forest can be self-limiting reduces the risk to line officers who decide to manage fires under a resource and protection strategy (2008 Clover and 2011 Lion Fires [Vaillant 2009 and Ewell *et al.* 2012]).
- Use of formal and informal After Action Reviews involving fire staff, line officers, and stakeholders are key to understanding the outcomes of past incident management decisions and informing future decisions.
- Improved relationship with the San Joaquin Valley Air Pollution Control District (SJVAPCD). The SJVAPCD board of directors has instructed their compliance department to cooperate with federal land agencies to reduce hazardous fuels following the 2008 Tehipite Fire (located to the north of SQF on NPS and USFS land). This was a turning point fire for smoke management issues. Cooperation from the California Air Resources Board (CARB) has improved as seen in the California Wildland Fire Use communications protocol issued by CARB http://www.arb.ca.gov/smp/nif/nif.htm).

Regional Fire Program Journey Steps – Creating Bridges and Overcoming Obstacles

The SQF's fire management program is in a better position to manage wildfires for both natural resource benefit and protection objectives as compared to other forests in California. The following section includes input from individuals on the topic of implementing a fully integrated fire management strategy. The complexity of this topic exceeds the scope of this case study and requires extensive exploration in the future. Several fire management programs have evolved similarly to the SQF while others are just embarking on this journey.

The SQF is located at the southern end of the Sierra Nevada Range with fire regimes similar to its neighboring Sierran forests. In contrast, the very southern portion of the SQF—lower elevation areas such as Kern Valley and Kern Canyon—has fire regimes more characteristic of the three southernmost national forests in California, the Angeles, San Bernardino, and Cleveland national forests. Forest management direction for these low-elevation portions of the SQF is similar to those utilized in southern California, where wildfires are seldom managed with both resource and protection objectives.

Employing indirect containment tactics and managing a wildfire within a bigger box is less desirable in these more volatile fuel types (grass and shrublands), where large fires have recently burned at a higher frequency than their known historical fire return interval. The cycle of repeated large fires can

The Sequoia National Forest Ecosystem Staff Officer said their fire managers have a different attitude regarding fires managed with resource benefit objectives because of the FFMO's willingness to accept risks and his recognition of the ecological value of fire within some Sierra Nevada forest types.

jeopardize some native plant species through the process of "type conversion" while also threatening public safety and private property.

Managing a wildfire to meet both resource and protection objectives is often a matter of willingness by Forest leadership to assume the risk associated with allowing active fire on the landscape for longer durations than in the past. One FMO stated that managers' individual goals and willingness to accept risks can positively or negatively influence fire management choices. In most parts of southern California, history has shown the reluctance of Forest leadership to employ anything other than an intensive suppression response. This trend might need some reconsideration in specific areas when decision space is developed in the LRMPs.

The Stanislaus National Forest, several hundred miles north of the Sequoia, uses resource benefit strategies on wildfires. The Stanislaus LRMP allows this fire management strategy both inside and outside of wilderness areas. The Deputy FFMO on the Stanislaus believes that a lack of candidate fires in recent years is one reason why the Forest has seen a decrease in the number of fires managed with resource and protection objectives. A recent candidate fire (2012 Wheats Fire) located in the Carson-Iceberg Wilderness was managed with a full suppression strategy, controlled, and put out.

The use of this strategy was due to Forest Service, Region 5 direction requiring full suppression on all fires after August 7 of 2012. This direction was put in place by the Region to address drought conditions within most of California. The August 12 direction superseded earlier direction requiring Regional Forester approval to initiate fire management strategies other than aggressive full suppression (Leaders Intent – 2012 Fire Season letter, June 2012).

The SQF Ecosystem Staff Officer said their fire managers have a different attitude regarding fires managed with resource benefit objectives because of the FFMO's willingness to accept risks and his recognition of the ecological value of fire within some Sierra Nevada forest types. The Fire Staff Officer is able to balance ecological need for more fire in certain forest systems with the potential negative aspects of long duration wildfires.

Past successes using an integrated management strategy have created a comfort level when managing fires for both protection and resource benefit objectives and have allowed upper management to support a diverse approach to fire management activities. While many wildfires have resulted in both positive and negative effects (2008 Clover and 2010 Sheep Fires), each fire represents a step along the path of achieving the future desired conditions described in the LMRP.

Theme 2: Safety

It is the Forest's stance that firefighter and public safety have been enhanced by the application of fire management strategies that allow wildfires to be tactically managed for both protection needs and resource benefits. Key elements that support their position:

- Post-fire fuel loads often equate to a less hazardous fuel condition on future fires. Areas of snags should be avoided when possible.
- Fewer firefighters are generally required to staff fires managed with resource benefit and protection objectives than for aggressive suppression actions.
- Utilizing existing barriers and MIST provides a safer work environment for firefighters.
- Fewer flight hours are required to support ground operations. Air tanker use is focused on areas where active suppression is occurring.
- The sense of urgency to suppress the fire is reduced on these incidents, creating a more thoughtful approach to the fire management actions (example: reduced helicopter rappeller needs).
- Exposure of firefighters to smoke is reduced as direct fireline construction is minimally employed.
- The use of the Forest Service pack stock program to support wildfire efforts in remote areas reduces flight hours associated with logistical support. Pack strings are not greatly affected by smoke inversions or poor fireline visibility. They often deliver logistical support when aviation resources cannot.

Fire spread on portions of the SQF has been found to be self-limiting due to the existence of historic fire scars. The Forest has documented a reduction in fire behavior within the perimeters of these historic fires. On the southern portion of the Forest, multiple fire perimeters have constrained the extent of subsequent fires (Vaillant 2009). Notable examples of the effects of historic large fires on the landscape include the 2010 Danner and Grouse fires, which burned inside the 2002 McNally Fire perimeter. These fires displayed low-severity effects as the fire spread was driven primarily by log to log burning.

Only a small number of large fires have occurred on the central portion of the Forest. Therefore, drawing conclusions regarding fire spread and intensity on this segment of the Forest is not as clear as the southern portions. However, the 2011 Lion Fire exhibited signs self-limiting fire spread and reduced fire effects as the fire stopped adjacent to historic wildfire perimeters (Ewell *et al*. 2012).

Theme 3: Economics

Management strategies have influenced costs [as illustrated in Table 6 on next page]. The cost of solely using a fire containment strategy on fires has continued to rise over the last decade. However, as new fires interact with prior burned areas on the landscape, fire managers have opportunities to fill in the gaps between these fires by using the self-limiting nature of a fire resilient landscape. The SQF predicts that more fire footprints on the land are reducing future fire costs. While there is not currently enough data to support this prediction, the concept of self-limiting or extent constrained fires in the Sierra Nevada is widely accepted by fire researchers (Collins *et al.* 2007, Collins *et al*. 2009, and Stevens *et al*. 2009) and has also been observed on the adjacent Sequoia and Kings Canyon National Parks.

Table 6. SQF wildfires illustrating changing costs related to fire management program changes.

Fire Name	Year	Cause	Days of Active Management[1]	Reported Acres Burned	Approximate Total Cost	Average Cost per Acre
Manter	2000	unknown	50	75,000	$16,600,000	$221
McNally	2002	human	39	150,696	$58,000,000	$385
Cooney***	2003	lightning	137	1,850	$120,000	$65
West Kern	2003	lightning	114	7,968	$15,000	$2
Albanita-Hooker	2003	lightning	84	4,483	$150,000	$33
Crag	2004	lightning	9	861	$1,700,000	$1,974
Crag	2005	lightning	84	1,185	$300,000	$253
Tamarack	2006	lightning	155	4,654	$907,000	$195
Maggie	2006	lightning	155	2,097	$454,000	$217
Clover	2008	lightning	7	15,300	$8,320,000	$544
Piute	2008	human	33	37,026	$25,000,000	$675
Lion Complex (includes Granite Fire)	2009	lightning	126	3,994	$1,090,000	$273
Sheep Complex	2010	lightning	101	9,020	$1,600,000	$177
Lion	2011	lightning	124	20,500	$1,500,000	$73

[1]Days of active management were derived from the fire reports (FSH 5109.14) from the date of the initial action to the date of the suppression strategy attainment. Sheep Fire cost reported by the National Park Service (Form 209 on 11/23/13).

***2003 began the trend of more wildfires being managed for protection and ecosystem objectives.

Factors that traditionally influence higher fire cost include air operations and extensive logistical support, such as fires in remote or designated wilderness areas. In the past, the SQF spent as much as $40,000 to $50,000 per acre on single-tree fires, while Forest-wide suppression costs have averaged $800 to $900 per acre over the last decade. Large fires managed for resource and protection objectives have cost as little as $35 to $300 per acre.

Using pack strings instead of aviation resources to meet the logistical needs of wilderness fires not only reduces overall incident costs, but better aligns the Forest with wilderness management policy [Figure 11]. On the 2011 Lion Fire, the regional Forest Service Pack Team moved about 19 percent of the fire supplies (28,600 lbs.) for a cost average of $2.10 per pound. Helicopters were utilized to move the remaining supplies in external loads (about 81 percent or 123,750 lbs.) at an estimated average cost of $4.65 per pound. Time efficiencies and carrying capacity make a direct comparison of the two support mechanisms invalid, however, both methods meet a need in the management of backcountry fires.

Controlling suppression costs through integrated fire management decisions is highlighted by the 2005 Crag, 2008 Clover, and the 2011 Lion Fires. These fires were extent constrained to varying degrees by old fire perimeters, and required little or no control efforts where these fire perimeters touched or overlapped. The recent fires have been of shorter duration or complexity, in part due to the self-limiting influences of the reduced fuel profiles within the old burns.

Figure 11. Pack stock are utilized by managers during remotely located fires for equipment and supply delivery, such as on the 2011 Lion Fire, shown here.

Besides managing wildfire for a combination of protection and resource objectives, the SQF is affecting the landscape through hazardous fuels treatments. Based on accomplishment trends (approximately 6,000 acres annually), hazardous fuels treatments are being conducted on less than one percent of the Forest annually. Many of the treated acres occur in the WUI, where fewer incident management options are available. The SQF Ecosystem Staff Officer explained that regional planning direction requires that treatments be effective for 10 to 20 years [SNFPA guideline, USFS 2004, see text box]. Given the accomplishment trends and the need to maintain fuels treatment over time, the backlog of hazardous fuels on the Forest can never be addressed through the exclusive use of hazardous fuels treatments. This fact supports the strategy of managing suitable wildfires to address landscape level hazardous fuels conditions.

A positive fiscal outcome of having larger burned areas on the landscape is the ability of the Forest to conduct prescribed burns within and adjacent to these older fire perimeters. With fewer perceived control issues and less smoke production in retreated burn units, Forest staff anticipates that prescribed fire implementation costs will decrease. For example, the current Boulder Creek fuels reduction project was designed to utilize portions of the 2010 Sheep Fire as a fire control feature. (http://www.fs.fed.us/nepa/nepa_project_exp.php?project=36314).

Sierra Nevada Forest Plan Amendment (SNFPA)

The SNFPA, also called the "Framework", guides management of national forest lands located along the Sierra Nevada Mountains from the Sequoia National Forest north, to portions of the Modoc National Forest. The SNFPA references Finney's (1999) "speed bump" theory about strategic placement of fuel treatments totaling about 10 to 20 percent of the burnable landscape. To meet this target, the SQF would need to treat approximately 11,600 acres annually. In recent years, the Forest has approached meeting this target. It has surpassed the target when wildfires managed for LRMP objectives are included as treated acres. The intent of Forest leadership is to accelerate Forest restoration efforts by leveraging funding through partnerships for fuels management, including the Collaborative Forest Landscape Restoration Program (CLFRP).

Theme 4: Natural Resource Effects and Data Modeling

The effects of high-severity fire on Forest resources continue to be a focal point for Forest leadership on the SQF. A tool at the disposal of land managers is the ability to manage suitable natural ignitions to address the existing hazardous fuel profile found in many locations on the Forest to eventually achieve a landscape level change. As the Forest has adopted a more proactive stance regarding the use of wildfire to achieve benefits for natural resources, a reduction in overall fire severity has been noted on several of these managed fires. Landscape level fire restoration is still needed on the Forest. While the pace of restoration is slow, through the application of adaptive fire management strategies, the ability to improve the fire resilience on portions of the Forest appears obtainable.

On the landscape scale—because of recent changes in incident management—small steps in moving closer to historical fire regimes have occurred. Wildfires on the Sequoia and in many parts of California have mixed-burn severity effects [Figure 12], with regional trends showing an increase in burn severity (Miller *et al.* 2009). On the SQF, reduced burn severities have been reported as more newly burned and older burned areas begin to interact on the landscape in self-limiting or extent-constrained patterns. The potential of past fire patterns to influence future fire spread and intensity has been observed by both Forest staff and fire researchers. Several examples of this interaction can be found on the SQF (Vaillant 2009, Ewell *et al.* 2012).

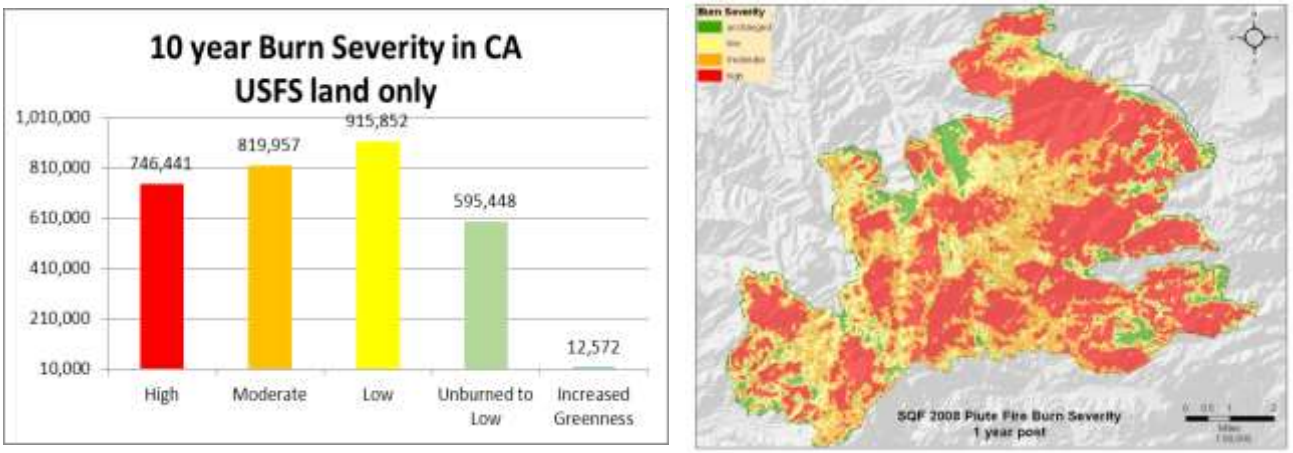


Figure 12. Burn severity from 2000-2010 on Forest Service lands in California (left side) and fire severity assessment map for the 2008 Piute Fire (right side), both from Monitoring Trends in Burn Severity [MTBS 2011].

Some wildlife species benefit from fire or are opportunistic users of vegetation/habitat that returns after fire. However, the pattern and size of fire severity patches can increase habitat fragmentation for some special status species. When fires are managed for ecosystem and protection objectives, the resulting pattern is often smaller patches of mixed severity that can maintain plant and animal diversity, preserve hydrologic systems, and continue soil viability.

When large areas with high-severity fire effects are followed by above average precipitation, the risk of increased erosion and flooding occurs. This was observed after the 2004 Deep and 2009 Power fires which negatively impacted the Tule River. The 2011 Lion Fire, which included resource benefit

objectives, was originally thought to have caused sediment damage to critical trout habitat. Subsequent monitoring, however, showed neutral to positive effects on riparian habitat.

Wildfires managed for integrated objectives generally have short-term negative effects to air quality, but, in the long term, create landscape fuel complexes which produce fewer emissions during subsequent fire events. Positive, long-term effects to air quality can continue as long as the fire areas are re-burned on a more frequent basis than was occurring under past management practices. For example, a case study on the 2011 Lion Fire included fuel consumption measurements and smoke emissions modeling based on the field data inputs into the First Order Fire Effects Model (FOFEM) (Keane *et al.* 2012). The study estimated smoke emissions were greater than the default amount for *"high natural load"* in FOFEM [Table 7]. Researchers suspected that fuel loads within the Lion Fire perimeter exceed those used in the "high" end of the emissions model. Because the area had not had fire in the previous 90 years, the Lion Fire could be considered an initial entry burn.

Increased use of webcams and air quality monitoring equipment, as well as cooperation and communication with Air Pollution Control Districts, have allowed greater smoke management credibility and flexibility because of the real-time access to air quality monitoring data and smoke conditions. By monitoring smoke emissions on subsequent fires which burn within the footprint of the Lion Fire, Forest managers will be in a position to inform air regulators that the trade-off for less smoke in the future is the management of candidate fires under today's excessively high fuel loads.

Table 7. Total Smoke Emissions (lbs./acre) for natural fuel loading of Sierra Nevada mixed conifer from FOFEM6.

Fuel Loading Category and Vegetation Type	PM_{10}	$PM_{2.5}$
Light/sparse natural load - Sierra Nevada mixed conifer	781	662
Typical natural load - Sierra Nevada mixed conifer	1,564	1,326
High natural load - Sierra Nevada mixed conifer	2,315	1,962

Documenting the effects from wildfires and prescribed fires is relatively new on the SQF. Nearby fire studies (Collins and Stephens 2010, Collins *et al*. 2011), as well as regional studies (North *et al*. 2009), can show trends that apply to the SQF. Keifer *et al*. (2006) found that ten years following prescribed fire, mean total fuel loads accumulated to 66 to 84 percent of pre-fire levels in ponderosa pine and mixed conifer forests and that most fuel accumulation appeared to occur within the first decade after fire.

Fire management decisions can have broad-reaching ecosystem implications. Visual Quality Standards (VQS) and fire management were initially perceived to be in conflict on the Forest. However, the Scenery Management System has since replaced the VQS and accounts for natural processes which change landscape appearances. Trails used as firelines also reduce visual impacts associated with fire management actions and have the collateral benefit of being improved and rehabilitated for future public use during these fires. In remote areas, the SQF uses MIST when appropriate. When fires are managed for integrated objectives in remote or wilderness areas, strategies utilizing existing barriers and pack stock supply deliveries help to support wilderness values and scenery management objectives.

Fires managed for integrated objectives are often natural ignitions occurring in remote areas of the Forest. These areas are not priority locations for hazardous fuel treatment projects. Community protection continues to be the overarching goal of the Forest's fuels treatment program. The distance

from backcountry locations to most communities means that without the integrated fire management strategy currently used by Forest leadership, backcountry fuels issues would seldom be addressed. Together, hazardous fuels treatments and fires managed for integrated objectives decrease fuel loading and modify fuel structure—increasing landscape scale changes due to management actions.

Table 6 illustrates the trend of prescribed and wildfire acreage on the SQF. During the last 13 years, prescribed burning totaled 14,197 acres with an average of 1,183 acres burned per year.

Table 6. Prescribed and wildfire acreage estimates based on internal Forest data, FRAP (Cal Fire 2012) and FACTS (USFS 2013).

Year	Prescribed Fires (planned ignitions)	Wildland Fires (unplanned ignitions)
2000	1289	58,225
2001	(not available)	3,809
2002	491	130,512
2003	517	9,836
2004	554	4,444
2005	399	2,891
2006	1,044	10,663
2007	782	7,434
2008	669	41,180
2009	1,722	6,057
2010	2,104	22,408
2011	2,612	22,674
2012	2,014	3,997

The SQF has observed that smaller fires managed for resource and protection objectives have higher rates of large tree retention and distribution than the larger wildfires managed to control fire size. In comparison, larger wildfires managed to control fire size are associated with rapid rates of spread and high surface fire intensities. Both of these features have a negative impact on large tree retention.

An ongoing concern associated with large, high-severity patches in burned areas is that trees killed during the fire eventually fall, contributing to heavy surface fuel accumulations in the future. As brush and herbaceous vegetation grows between the dead trees, the fuel complex again becomes supportive of high-intensity fire, creating a situation where site productivity is lost due to soil damage [Figure 13]. The SQF has established a goal of avoiding large areas (greater than 100 acres) of high-severity effects in pine and mixed conifer. A method to help limit the size of high-severity patches is the use of proactive firing operations to establish fire in a backing orientation away from the main fire, thus, creating a check to high-intensity fire runs.

Figure 13. Photo, taken eleven years after the Sequoia National Forest's 2000 Manter Fire, shows no obvious pinyon-juniper vegetation recovery.

Another evolving step of the fire management program on the SQF will be the integration of managing fires for protection and resource benefits into the WUI dominated west side of the Forest.

Understanding how to measure success when integrating multiple objectives on a fire continues to be a focus of Forest leadership. While protection objectives are easily defined and measured, measuring the effects of resource objectives is more complex. The Forest has asked the Pacific Southwest regional ecology program for a consistent and comprehensive monitoring effort to measure the impacts of fires managed for resource benefit objectives.

4. National Goals Tie Ecosystem Restoration Together with Fire and Fuel Management

Major threats to National Forest System ecosystem health include *large scale ecologically damaging* wildland fires (mega-fires), climate change, beetle epidemics and invasive species. While large high-severity fires are a present threat to forest systems, fire can sometimes be the answer to restore ecosystem health. Conversely many fires require a swift and aggressive suppression response to provide protection to these same resources or nearby communities.

Forest Service Chief Tidwell said, *"Accelerated restoration efforts demonstrate a shared vision where environmentalists, forest industry and local communities are working together to build healthier forests and contribute to local economies."* Through the Collaborative Forest Landscape Restoration Program (CFLRP), projects are coming online to address landscape restoration needs. While the SQF does not currently have a funded CFLRP, the Dinkey project on the Sierra National Forest, just north of SQF, focuses on reducing risk of catastrophic wildfires to WUI and recreational areas while restoring forest structure for wildlife through the use of timber harvest and prescribed fire. The Grandfather project south of GWJ in North Carolina focuses on the restoration of natural fire regimes for the benefit of wildlife and vegetation and to reduce wildfire costs and severity. (http://www.fs.fed.us/restoration/CFLRP/index.shtml/index.shtml).

The Forest Service has increased the pace of restoration efforts for National Forest System (NFS) lands. CFLRP provides funding for 20 new and continuing watershed restoration projects (http://www.usda.gov/wps/portal/usda/usdahome?contentid=2012/02/0039.xml&contentidonly=true). The Forest Service Chief is committed to restoring forests and bringing jobs to rural America through the use of partnerships with states, communities, tribes and others, while reminding Americans that it is vital to step up our efforts to safeguard our country's natural resources (http://www.fs.fed.us/publications/restoration/restoration.pdf).

The CFLRP strategy calls for action to expand the number of treated acres by 20 percent over the next three years. The program also has the potential to increase the pace of active forest management projects with objectives designed to address ecosystem health and community protection. These management actions include fuels reduction, forest thinning, timber harvesting, prescribed fire and a range of other strategies. Through the CFLRP, the estimated volume of forest products sold in 2014 will increase to 3 billion board feet, up from 2.4 billion board feet in 2011.

While CFLRP projects are a major step toward enhancing forest systems, the amount of land needing ecological restoration across the nation's forests is staggering—an estimated 65 to 82 million acres of NFS lands. A variety of landscape-scale integrated approaches are needed to meet this need before large-scale damaging wildland fires occur (Schultz et al. 2012). Even with the increased restoration funding through CFLRP, many acres of NFS lands that could benefit from low- to moderate-intensity fire lack funding for these needed treatments. Mixed-severity fires, when managed responsibly, help restore ecological processes and allow fire to return to its natural role in the ecosystem. Paired with hazardous fuel treatment projects, managing wildfires for integrated objectives can help the Forest Service achieve its goals of enhanced ecosystem resilience (North *et al*. 2009 and 2012).

5. Lessons Learned

Although separated by more than 2,500 miles, the George Washington and Jefferson (GWJ) and Sequoia (SQF) national forests represent two units in the National Forest System on the leading edge of fire management practices. These two Forests have begun a paradigm shift that recognizes fire to be managed as a natural and necessary process on the landscape. While these Forests are very different, common threads exist between the units which have guided the journey to a more holistic fire management program.

Commonalities

- Key individuals have played an important role in changing the focus of the fire management programs away from a traditional "eliminate fire" strategy to an integrated fire management approach where resource benefit is considered as part of the fire management decision process. These individuals have not always been Forest Supervisors. They include forest leadership and upper level fire staff.
- Key events helped move the Forests to begin their management shift. In the case of the GWJ, it was the combination of safety concerns, cost issues, and an urgency to meet LMP goals of restoring fire regimes. For the SQF, it began with a series of large and ecologically damaging fires in the early 2000s.
- Forest staff appreciated and advocated for the role that fire plays in developing and maintaining healthy forest systems.
- Early dissent from Forest employees is to be expected when a significant change in management practices begins. As successful implementation of these new practices occurs, employee support has increased.
- Involving key partners as part of the management evolution is important in acquiring and maintaining program support. On the SQF, involving the San Joaquin Air Pollution Control District and neighbors from the National Park Service has been key to their increased use of fire on the landscape.
- Land management direction on these Forests allowed for—and in the case of the SQF, encouraged—managing fires for both protection and ecosystem objectives. This direction provided the policy support for the use of innovative fire management strategies.
- The Forests report that their newer strategy has allowed them to address larger hazardous fuels issues without being wholly reliant on hazardous fuels funded projects. The GWJ and SQF are also better able to focus their limited fuels funding. In the case of the GWJ, it was the Virginia Department of Forestry and local fire departments for WUI or other areas where the use of integrated fire management strategies are less practicable.

As the Forests have managed the evolution of their fire programs, several benefits have been observed not only on the ground but also in the areas of firefighter and public safety and cost savings. These benefits that have been reported by the Forests include:

- **A decrease in the number of acres with highly volatile fuel structure.**
  - The SQF has documented cases in remote areas (2003 Albanita-Hooker Fire, 2005 Crag Fire, 2008 Clover Fire, 2011 Lion Fire) where historic fire scars have served as

partial or full barriers to fire spread. As greater portions of the landscape are burned, the effects of these fire-limiting features will increase, assisting in the control of future wildfires and providing improved opportunities for using more prescribed fire.

- The GWJ has achieved more acres of low flammability vegetation. As more acres are burned on shorter rotations through both prescribed fire and wildfires, fire hazard has decreased and forest health increased.

- **An increase in firefighter safety through the implementation of innovative strategies.**
  While accident records cannot be directly used to validate this claim, the Forests use the following examples to support this statement:
  - Fewer firefighters are assigned to fires managed with both protection and resource benefit objectives, thus, reducing firefighter exposure to hazardous conditions.
  - Fewer aviation resources are required to support these multiple objective wildfires, reducing exposure to hazardous flying conditions.
  - Less direct fireline construction is required under this fire management strategy. Through the use of existing control features, firefighters can engage the fire when and where they have a tactical advantage.
  - Firefighter and public safety is improved as more acres of flammable fuels transition to fuel complexes that do not support intense fire behavior.

- **A decrease in fire suppression costs (cost/acre).**
  Through the use of non-traditional fire suppression strategies, these two Forests have decreased fire suppression costs. The use of existing fire control features has limited the number of personnel and equipment required to successfully control a fire. The reduced reliance on ground and aerial firefighting resources has contributed to decreasing fire suppression expenditures. A decrease in the cost per acre is also attributable to an increase in acres burned under these new strategies. However, these burned acres trend toward low and moderate burn severity and are beneficial to the ecosystem processes in the long term.

- **Ecological enhancements can be measured.**
  While the two units have vastly different forest systems, fire plays a critical role in maintaining fire resilient landscapes in both units. Some key environmental enhancements reported by the two Forests include:
  - Fire processes are important in developing and maintaining critical habitat for some listed species. Both Forests noted that fire exclusion has led to areas of significant habitat loss.
    - The GWJ is concerned over continued forest canopy closure and fewer open woodland and shrubland areas due to a lack of fire disturbance processes.
    - The SQF has documented a significant loss in habitat due to high-severity crown fire which has been directly related to an overall lack of fire disturbance at the landscape level.

- Large tree retention has increased on the GWJ under new fire management practices. This key LMP goal is associated with decreasing fire intensity while increasing a mosaic of effects at a landscape level across the Forests.
- The self-limiting nature historically associated with fires in the Sierra Nevada is increasing on the SQF as more acres burn under low and moderate fire severity. Large tree retention is increasing as fire intensity decreases.
- Fires managed for integrated objectives have reduced the use of both hand and mechanical firelines. Reduced ground disturbance has the potential to reduce the spread and extent of invasive plant species which favor these disturbed sites. Cultural resources, once considered at risk from mechanical fireline construction, are better protected under this new strategy.

Managing Change into the Future

The potential exists for the organization to revert to past practices as leadership and key personnel leave the agency. Both Forests are currently undergoing organizational change that has been driven not only by past significant events but, to a great extent, by individuals from within the leadership group and the ranks of employees. Sustaining this organizational evolution is tied to several critical factors:

- **Engraining successful fire management practices into day-to-day operations.**
  By ensuring that all levels of the organization incorporate these evolving management practices into daily work assignments, the practices will become part of the cultural norm for the organization. Once established as an organizational norm, returning to past practices will become less likely.

- **Remembering the seminal events that lead to the organizational paradigm shift.**
  Assuring that leadership remembers what drove the change from past practices will help prevent a return to them. Use of the "*staff ride"* concept to revisit the time and events that lead to today's management practices, along with lessons learned studies, will help those new to the Forests value the current management strategies.

- **Assuring that enabling documents support integrated land management practices.**
  Assuring that current management practices are part of future decisions—from agency policy to land management plans to project specific NEPA decisions—will help ensure the continued evolution of these programs.

- **Maintaining strong partnerships with important stakeholders and the public.**
  Without the support of critical partners and the public served by these Forests, the programs, as evolving today, would not be able to continue. Assuring that key partners are involved and informed on fire management practices will help assure future support.

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8. Appendices

Appendix A – Initial Case Study Questions

The case study questions initially sent out to the Forests and used during the site visits and group discussions are listed here.

Interview Data Analysis Questions:

Theme 1: Organizational Culture

1. What was the triggering event or sequence of events that have led to the way fires are managed on your forest? Did certain people and/or job roles drive the changes?

2. How have these fire management decisions been met within the organization?

3. What has been the level of public/stakeholder support? Has support followed wildfire success/failures or other themes?

4. What, if any, have been your implementation barriers/facilitators to changing or evolving your fire management philosophy and strategy?

5. What have been the benefits/losses of your shift in fire management strategy?

Theme 2: Safety

1. Has firefighter exposure been reduced due to your fire management philosophy and strategy?

2. Has future fire behavior been reduced at a landscape level due to increased acres burned during managed wildfires?

Theme 3: Economics

1. What have been your average changes in suppression costs? Are you realizing suppression cost reductions? What data is available?

2. Have there been changes in BAER/rehabilitation needs based on shifting strategies? What data is available?

3. Is the need for hazardous fuels treatment (pre-planned projects) reduced by having more acres burned under wildfire management strategies? Are treatments less costly (or time consuming) on land where managed wildfire has previously burned? What data is available?

Theme 4: Resource Benefits

1. What have been the natural resource benefits/detriments of your fire management philosophy and strategy? Examples might include changes in air quality, water quality, recreation management, scenic/visual quality, wildlife habitat/forage, vegetation management, soil or hydrology.

Theme 5: Data modeling and comparisons
Further quantification of management decisions and outcomes may be illustrated based on some of the following.

1. Has there been an improvement of Fire Regime Condition Class (FRCC) at the landscape level? Use GIS modeling, Landscape Fire and Resource Management Planning Tools Project (LANDFIRE) layers (updated?) or regional fuel model layer.

2. Have there been impacts on future smoke production due to the increases in acres burned during fire management events? Compare emissions by use of the First Order Fire Effects Model (FOFEM) based on changed fuel loadings.

3. Have there been reductions/improvements in fire effects due to reduced burn severity in the long term, or due to changed fire return intervals? Which fires have burn severity data to use in GIS modeling? What have been the changes in burn severity?

4. Has there been an increase in large tree retention due to changes in wildfire management strategies? Site data from representative sample may highlight the benefits of carbon sequestration or benefits to wildlife habitat.

Theme 6: Other ideas

1. Please provide any other ideas or concepts that facilitated a change in fire management strategies or additional benefits or negative outcomes of these changes.

Appendix B – About the Forests

George Washington and Jefferson National Forests (GWJ)
Located in the central Appalachian Mountain region, the GWJ is roughly 280 miles inland from the Atlantic Ocean. The GWJ National Forests is one of the largest blocks of public land in the eastern United States comprising nearly 1.8 million acres. The Forests includes 1,664,110 acres in Virginia, 123,629 acres in West Virginia, and 961 acres in Kentucky. The Forests includes the Mount Rogers National Recreation Area and seven Ranger Districts. The George Washington National Forest was established in 1918 as the Shenandoah National Forest; the Forest was renamed after the first president in 1932. The Jefferson National Forest was founded in 1936 by combining portions of the Unanka and George Washington National Forests with other land. In 1995 the George Washington and Jefferson National Forests were combined into a single administrative unit (http://www.fs.usda.gov/gwj).

Sequoia National Forest and Giant Sequoia National Monument (SQF and GSNM)
Located in the southern Sierra Nevada Mountains, the SQF is roughly 140 miles inland from the Pacific Ocean. President Harrison established the Sierra Forest Reserve in 1893 with the southern portion of the Sierra Forest Reserve renamed the Sequoia National Forest in 1908. In 1910 President Taft named the southern half of the Sequoia the Kern National Forest, but in 1915 President Wilson signed legislation that dropped the Kern National Forest name and rejoined it with the Sequoia National Forest. The Giant Sequoia National Monument was designated by President Clinton in 2000 and encompasses 353,000 acres. The Giant Sequoia (*Sequoiadendron giganteum*) is the world's largest tree and occurs naturally only in a narrow 60-mile band of mixed conifer forest on the western slope of the Sierra Nevada Mountains. 65 to 75 sequoia groves are mapped in the Sierra Nevada with the species being dependent on a resilient fire regime for their health and ultimate longevity (http://www.fs.fed.us/r5/sequoia/).

Table B1. Sequoia and George Washington Jefferson National Forests

Characteristic	SQF & GSNM	GWJ
Average Annual Precipitation (in)	10 to 40	35 to 60
Climate	Mediterranean Mid-latitude Desert	Humid Subtropical
Counties with Forest Lands	3	22
Dominate Vegetation Types	Foothill Live Oak Woodland Mixed Chaparral Black Oak Woodland Ponderosa and Jeffrey Pine Mixed Conifer Forest Giant Sequoia Red Fir Forest High Elevation White Pines Pinyon Pine Woodland	Appalachian and Mixed Pine Hardwood Forests, Oak woodlands, Shrublands
Elevation Range (feet - ASL)	500 to 12,400	515 to 5,729
Fire Regime Groups*	I, III, IV, V	I, III
Gross Acres	1,186,128	1,788,700

*http://www.frames.gov/partner-sites/frcc/frcc-home

2012 Staffing	GWJ	SQF
Standard Fire Season	Year round, most fires occurring during March, April, November	May 1 through October 30
Fire Management Staff - Including dispatch, support and Ranger Unit fire overhead	18	33
Fire Support Militia – Forest employees who work in non-fire management positions, are Red Carded and can support fire operations.	200	95
Fire Engine	7 total staffed with: militia and shared positions; 4 are staffed regularly with 60/40 shared positions during the spring and fall	14 total staffed 5 to 7 days per week during fire season
Fire Hand Crew – 20 person Type 1	1	5
Fire Hand Crew – 10 person fuels crew	0	3
Contract 20 person Type 2 "Blue Card" Hand Crew	0	18 (hosted by SQF)
Fire Hand Crew – 20 person Type 2 Job Corp Crew	1-2	0
Fire Helicopter	2 exclusive use Type 3, 47 to 50 days each	2 exclusive use Type 2, 150 days each
Fire Dozer	5 Type 3 dozers, available to staff with militia as needed	0 (cooperator and contract dozers are used)
Fire Water Tender	0	1
Fire Prevention Patrol Units	0	17
Fire Lookouts	0	7
Total Regular Fire Management Personnel	49 regular (and 11 60/40 firefighter positions)	327 regular (and 365 contract "Blue Card" crew members)

What is the size and efficiency of your fire staff?

Do Forests' fire and fuels staff size relate to the amount of work they get done?

The comparison between GWJ and SQF is striking.

The GWJ should be recognized for this.