Stewardship and Fireshed Assessment: A Process for Designing a Landscape Fuel Treatment Strategy

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Abstract
Natural resource land managers today face a difficult challenge of developing a cohesive fuels and vegetation management strategy that addresses the widely acknowledged wildfire threat. Treatments must also be compatible with a wide variety of other land management goals, such as managing for wildlife habitat, watersheds, and forest health. In addition, funding will always be a limiting factor for management of public lands; managers will always have to prioritize and strategize where funding provides the most benefits. Stewardship and Fireshed Assessment (SFA) is an interdisciplinary, collaborative process for designing and scheduling fuels and vegetation management treatments across broad landscapes to help natural resource managers balance goals for reducing potential for large, severe wildland fires with other ecological and social goals. The approach for modifying landscape-scale fire behavior (how large it gets, where it burns, and how severely it affects communities, habitats, and watersheds) is anchored in the concept that, by using a carefully designed pattern of treatment areas, managers can treat a fraction of the landscape to achieve intended modifications in wildland fire behavior. The SFA process uses existing data, robust assumptions, and data models in a geographic information system to provide a rapid assessment that informs land managers and the public on the trade-offs of different management strategies. The SFA process implements the "Plan, Do, Check, Act" model of the Forest Service's Environmental Management System. Using the concepts of active learning, this type of assessment is designed to increase public participation and understanding of forest management and develop support for forest restoration. Ultimately, it is hoped that active public dialog will help garner advocacy for a balance of active and passive management, and hopefully, reduce controversy and conflict regarding individual hazardous fuel projects.

Keywords: Stewardship and Fireshed Assessment, fireshed, fireshed assessment, fuel treatments, fire modeling, learning in action, collaborative planning, work planning, cumulative effects

Introduction

Since 1999, national focus has been placed on addressing the problem of wildland fire effects to communities and forest resources. This has resulted in the National Fire Plan, 10 Year Comprehensive Strategy, Healthy Forest Initiative and the Healthy Forest Restoration Act which provide direction, funding, and performance measures to address the hazardous fuels problem across the country. Both Congress and the public are concerned with ensuring efficient and effective use

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of funds directed for hazardous fuels reduction. In particular, managers are being asked to demonstrate how treatments are addressing threats to communities along the wildland urban interface. Thus, land managers are challenged with evaluating not only how individual treatments change wildfire behavior but also how patterns of treatments collectively perform at the landscape-scale to reduce the size and severity of wildland fires.

Despite this emphasis, implementation of fire and fuels management direction by Federal land management agencies has come under criticism in 27 separate Government Accountability Office (GAO) reports since 1999 (summarized in GAO-05-147). Collectively, these GAO reports reference the inability of federal land management agencies to adequately assess landscape strategies for hazardous fuels treatment, set priorities, develop out year plans, and collaborate with partners. However, a recent GAO report (GAO-04-705) noted: "One [approach] that appears promising for national implementation is the Fireshed Assessment process, an integrated interdisciplinary approach to evaluating fuel treatment effectiveness at reducing fire spread across landscapes."

The Stewardship and Fireshed Assessment (SFA) process is a rapid assessment process that has been developed for the national forests in California. The SFA process frames and evaluates the performance of hazardous fuels treatments at a landscape-scale, where treatments are designed to change the outcome of a "problem" fire in a particular landscape. A "problem" fire is a hypothetical wildfire that could be expected to burn in an area that would have severe or uncharacteristic effects or result in unacceptable consequences. While the primary objective of strategic treatments is to reduce the wildfire risk to communities in the wildland urban interface, treatments must also be designed to integrate broader stewardship objectives, such as improving forest health, meeting habitat needs, and maintaining and improving watershed conditions. Given these multiple objectives, it is important that a landscape treatment strategy be reasonable and feasible and critically, that it have public support. This is accomplished by evaluating treatment scenarios, which are combinations of treatment locations, treatment prescriptions, and implementation timelines, in an open and transparent manner. Through repeatedly testing and improving assumptions, public understanding of ecological processes, the effects of management, and management constraints and opportunities can be enhanced.

The individual Fireshed Assessment is a core component of the SFA process. The landscape is divided into firesheds, which are conceptually analogous to watersheds. These firesheds surround areas of similar wildfire threat, where a similar response strategy could be used to influence the wildfire outcome. Given that it is impossible to treat all of the hazardous fuels across a landscape, the identification and prioritization of the most critical and beneficial hazardous fuels to treat is critical. A Fireshed Assessment is based on the premise that fuels treatments strategically located to modify fire behavior can positively affect the outcome of a wildland fire by limiting the area severely burned and reducing negative effects on communities, habitat, and watersheds. The underlying assumption is that as landscape-scale wildfire behavior is modified over time, fire suppression and fire management opportunities will be enhanced, leading to fires that are less damaging and less costly (Finney et al. 1997).

Ultimately, managing landscapes to influence potential large wildfires requires careful prioritization and scheduling of fuels treatments across large areas over time. Since federal, state, and private lands are often intermingled, developing a coordinated program of work requires close collaboration with other landowners and interested parties. Hence, two critical pieces must come together to change large wildfire outcomes: (1) collaboration and coordination with other agencies, landowners, and the interested public and (2) on-the-ground implementation of a program of work, which establishes spatial locations, priorities, and schedules for multiple hazardous fuel treatment projects, ideally across all land ownerships in an area.

Core Components

Stewardship and Fireshed Assessment describes an overarching assessment process that is composed of several analytical and process components. The focus of SFA is collaborative resource problem-solving. In a dynamically linked system, each component informs and learns from other parts of the SFA process. Table 1 provides a brief description of the core components of the SFA process.

Table 1. Core Components of the SFA Process

SFA Component	Description
Fireshed Assessments	Characterization of the potential "problem" fire. Map and description of treatments that could be implemented to address the threats from a problem fire. Considers existing fuel conditions, treatment opportunities, and resources of value.
Spatially Explicit Program of Work	Schedule and map showing how needed work can be accomplished in annual increments. Tests costs and feasibility of doing entire program over time. Provides temporal and spatial display of future activities to inform project-level cumulative effects analyses.
Individual Project Evaluations	Detailed site-specific analyses of individual projects that implement the program of work.
Project Implementation	Actual on-the-ground implementation of individual projects.
Project Feedback and Monitoring	Review of actual treatments compared to planned treatments to determine if assumptions were reasonable and identify minor and major adjustments that may be needed.
Fireshed Assessment review and update	Review project feedback and trends of actual implementation to assess if overall strategy is still feasible and desirable. Revise individual assessments as needed.
Program of Work update, review, and adjustment	Review and modify out-year Program of Work, treatment strategy, and/or treatment scenario.
Bioregional or Regional evaluation	Assess trends of conditions to inform bioregional strategies.

The SFA process is not just "another planning exercise." It is also not something that can be easily packaged into a standard "cookbook" because it dynamically responds to local ecological and social data and issues. It is designed to assist local land managers and their staffs in the development and implementation of a strategy designed to accomplish hazardous fuel treatments in a logical and feasible manner.

The process can be used to streamline the planning process so that more dollars and resources can be used for project implementation and monitoring.

Successful implementation of the SFA process depends upon understanding and adopting key principles related to: 1) learning in action; 2) data, models and addressing uncertainty; 3) monitoring and feedback for adaptive management; and 4) collaboration and advocacy. This paper will first describe the importance of those principles and then provide a description of the steps involved with the first component of the SFA process, completing Fireshed Assessments.

Learning in Action

Learning in action is the fundamental principle at the heart of the SFA process. Learning in action occurs when highly functioning teams or groups work together effectively to identify and solve problems (Garvin 2000). Such groups are characterized by adaptability and flexibility as well as respect and trust among all members and their peers. Successfully using the SFA process occurs when all participants adopt and apply the tenets of learning in action.

The process of conducting Fireshed Assessments and developing a program of work is an ideal platform for learning in action. During the process, participants work together to identify and analyze problems and explore possible solutions. Natural resource problems, such as addressing wildfire threats, are ideally suited to a learning environment because they possess several key characteristics (Garvin 2000, p 123) as shown in Table 2. Participants learn by developing and testing the performance of spatial patterns of treatments in meeting landscape-scale goals and objectives. The knowledge of local conditions, by both managers and the public, greatly facilitate learning in action because discussions can focus on real-world scenarios rather than hypothetical situations.

Table 2 - Problem characteristics that stimulate learning

1. They are significant (the issues matter to people in the organization).
2. They are complex (the solution is not obvious).
3. They are multifunctional (participants must work across boundaries).
4. They involve difficult people issues (the problems are organizational as well as technical).
5. They are action-oriented (the goal is to do something, not simply analyze a situation).
6. They are ill-structured (participants must frame and define problems as well as solve them).
7. They involve surprises (neither the data nor the results are completely predictable).

A key outcome of collaboration and learning in action is bi-directional learning. Agency partners and the public learn about the ecological and social dilemma of managing for multiple resources (Allen and Gould 1986; USDA Forest Service 2004, pp 38-42) and land managers learn about the limits of scientific certainty and public concerns for balancing management of resources.

Data, Models and Addressing Uncertainty

The SFA process takes advantage of an array of modeling tools to assess the potential of different treatment scenarios to meet landscape-scale goals. The modeling tools facilitate the evaluation of scenarios. However, models are not required to complete the assessment process. Rather, successful completion requires a group to work through a series of data gathering and synthesis steps. The process is focused on asking the right questions at the right scales, rather than a specific modeling tool or suite of tools.

Participants use existing data, recognizing that incomplete or imprecise data are the norm in natural resource management. Definitive cause and effect relationships are rarely known for most ecological systems, particularly related to the effects of management. Without these relationships, it is difficult to know what data to collect that would inform managers on the effects of management actions. The SFA process requires participants to make robust assumptions to fill these knowledge and data gaps using the best available information. Credibility is derived by openly declaring, discussing, and documenting these assumptions, and then moving forward with the assessments. The initial assessments can be based on coarse-scale assumptions, which are evaluated and replaced with finer-scale assumptions as more information becomes available. Sensitivity testing helps to identify which assumptions are likely to have the most influence on outcomes and are good candidates for further refinement. In general, assumptions that affect the short-term and local conditions are more critical to refine than those that affect long-term and landscape outcomes.

Computer models and computer data processing with databases, spreadsheets, and geographic information systems facilitate rapid assessment. A core suite of vegetation attributes are used to generate fuel models, wildlife habitat types, and forest health characteristics. This efficient use of data eliminates discrepancies that would occur if each resource area used different vegetation data to assess outcomes.

By modeling scenarios, experimentation and learning occur before significant resources (time and money) are committed to planning. In addition, competing assumptions can be explored and evaluated before decisions are made on where and how to implement on-the-ground projects. Results from learning in action inform the design of future projects at both the local level as well as at higher levels. Testing and improvement of assumptions also occurs during the modeling phase, planning phase, and implementation phase of a hazardous fuels treatment strategy.

Monitoring and Feedback for Adaptive Management

The challenge of natural resource management is not just the inherent uncertainty related to our current state of knowledge of forest dynamics and the relationship of management to ecosystem functions, but also the range of public knowledge and understanding of these ecological and social systems. This inherent uncertainty contributes to costly delays in implementing projects due to the increased efforts required to document the rationale for risk-taking and explain all of the potential outcomes from both taking an action as well as not taking any action. An adaptive management approach can be a powerful way to address this uncertainty and support collaboration and advocacy.

Both formal Adaptive Management (Kendall 2001; USDA Forest Service 2004, pp 64-88) and informal adaptive feedback are important to refining data and assumptions. Since formal adaptive management studies conducted in a research framework may require many years before findings can be documented, monitoring and evaluation of trends and observational inferences are used as feedback to test and refine assumptions. It is expected that learning occurs during the sensitivity testing mentioned above and that key assumptions are identified for more rigorous evaluation. Since time and funding prohibits studying all potential uncertainties, focused and purposeful evaluation of priority questions must occur and is facilitated by the collaborative environment of the SFA process. After Action Reviews or learning after doing is another important method to gather information and inform future actions and occurs throughout the entire process (Garvin 2000).

The Forest Service has adopted an Environmental Management System[5] (EMS) to systematically review and lessen the environmental impacts of its programs (Executive Order 13148, April 21, 2000). This EMS process uses a "Plan-Do-Check-Act" loop to make incremental and continual improvement. The SFA process follows this same continual improvement loop, using Adaptive Management and adaptive feedback to fulfill the "Check" part of the loop.

Collaboration and Advocacy

Collaboration is the cornerstone for successfully developing and implementing a strategy aimed at changing large wildfire outcomes and meeting other resource goals and objectives. Land managers are expected to work hand-in-hand with other agencies, groups, and individuals in designing and scheduling treatments. Key collaborators include Federal, State, and local government agencies; American Indian tribes; stakeholders, including fire safe councils, communities with Community Wildfire Protection Plans, and adjacent landowners; and interested organizations and individuals. The Healthy Forests Restoration Act of 2003 emphasizes collaboration during the preparation of hazardous fuels reduction projects, and regional efforts such as the Forest Service's Sierra Nevada Forest Plan Amendment directs managers to develop treatment patterns "using a collaborative, multi-stakeholder approach" (USDA Forest Service 2004, p. 49).

Fireshed Assessments, conducted in a collaborative environment, are expected to yield the following key outcomes: (1) development of a broadly supported strategic, spatial, multi-year program of work consistent with landscape-scale goals and objectives; (2) shared involvement, understanding, trust, and coordination among agency partners, stakeholders, collaborators, and the public; and (3) information (including activities and data from other ownerships) that can be used to inform regional and project-scale cumulative effects.

An important aspect in gaining collaborative support is to develop a common set of performance measures that can be used to evaluate the extent that potential strategies meet landscape objectives. Performance of a strategy is evaluated at two scales: 1) at the treatment or stand scale; and 2) at the landscape scale. At the treatment or stand scale, fire effects are simulated by evaluating changes in vegetation attributes based on the type of treatment that might occur at the treatment location. Often prescriptions are defined as a series of treatments; for example an untreated area may require 3 entries of prescribed fire with 3 to 4 foot flame lengths over a 15-year period to accomplish desired fuel conditions. For a rapid, coarse scale assessment, it is only this final condition that is modeled to assess performance, while still recognizing that the fuel environment will be different after these interim treatments than in the final outcome. At the landscape scale, fire effects are measured by differences in projected changes in fire spread, in flame length (fire intensity), fire size (acres burned) and the overall efficiency of the treatment pattern. Using the predicted changes in vegetation structure, assessing potential outcomes for other resources, such as wildlife habitat, forest health, and watershed condition allows a collaborative discussion around balancing treatments with effects to these other resources.

Steps to Conduct a Fireshed Assessment

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[5] Unpublished data available on Forest Service Washington D.C. headquarters web site: http://www.fs.fed.us/emc/nepa/ems/index.htm

Assemble baseline data

Fireshed Assessment is conducted rapidly using available information and computer models to simulate tree growth, treatments, and wildfires. The models depend upon Forest Service vegetation mapping linked to Forest Inventory and Analysis (FIA) plot data. This linkage allows the Forest Vegetation Simulator (Stage 1973) and Stand Visualization System (McGaughey 2004) to be used to characterize vegetation across the landscape. The vegetation information is updated to account for recent treatments and disturbances (forest mortality from insects and disease and wildfires) since creation of the vegetation map so that fuel model types and habitat types can be assigned. All of this information is managed through a geographic information system using vector and grid data along with databases and spreadsheets. Maps, tables, charts and graphs are all created to display the status of data and facilitate collaborative discussion about the current condition.

Determine wildfire threats by describing the "problem" fire(s) across the landscape.

A key step to building collaborative support for the location and intensity of treatments is to establish agreement on the threat to be addressed. A variety of exploration techniques are used to help identify the fire threat and conditions for problem fires that are of greatest concern for impacts to lives, property, forests, and watersheds.

The nature of the "problem" fire varies widely in different geographic areas, based upon vegetation types, fuels, weather, and topography. In California, "problem" fires are typically the few wildfires that escape initial attack and are therefore the most costly and damaging fires. The "problem" fire in the forested lands in the Sierra Nevada burns where there is an alignment of hot aspects (south and southwest aspects), deep river drainages, and winds. Fires in these drainages often spot across the river and develop multiple fire fronts and access in the canyons is often limited and dangerous for firefighters once the fire escapes initial attack. These fires typically become large over several days of active burning. "Problem" fires in forests in the northern portion of the state are often the result of multiple lightning fires, erratic winds, and an inversion layer resulting in large fires in steep topography with heavy vegetation. In southern California, the "problem" fire situation often occurs when multiple ignitions during Santa Ana wind conditions result in large, wind-driven fires that threaten multiple communities.

Agreeing on the threat in a fireshed allows diverse groups to work together to explore potential solutions and objectively compare different solution strategies. When the group is committed to addressing a problem, opportunities for compromise and rational tradeoff discussions become possible. The Fireshed Assessment process is designed to foster an environment where agreement on the problem and exploration of potential solutions can be done in a manner that advocacy for a solution strategy for a particular location becomes possible.

Examining the assessment area's fire history is the primary method for determining the characteristics of the fire threat. Exploring the size, duration, and spatial pattern of fires that have escaped initial attack in the past provides tremendous insight into the types of fires that are likely to occur in the future. An interagency agreement is in place between the Forest Service's Pacific Southwest Region and the State of California to annually map large fires across the state. Federal fires over 10 acres and state fires larger than 100 acres since the early 1900's have been mapped and are updated annually with new fires. This arrangement provides a rich source of information for evaluating trends in wildfires across the state and is a tremendous resource to land managers.

Calibrate the fire models and validate the fuels and vegetation data.

One of the best methods for building confidence in the tools and databases is to use them to reconstruct past fires. Models like FARSITE (Finney 2004) and FLAMMAP (Finney 2005) are used to "re-create" a nearby, recent wildfire through simulations. During this process, local calibration of the fuel model data and weather conditions occurs so that the fire models more accurately simulate real fire behavior. Fuel model validation includes examining the assignment of fuel model, height to live crown, and crown bulk density attributes (Stratton 2004, van Wagtendonk 1996, Weatherspoon and Skinner 1996). Weather condition validation includes appropriate values for wind direction and strength, temperature, relative humidity, nighttime humidity recovery, fuel moisture levels, the presence of inversions, and other parameters that have influenced past "problem" wildfires. In addition to these fuel conditions and fire weather parameters, assumptions about the duration of the fire (number of active burning periods), potential ignition locations, and spot fire rates are documented. The calibration and gaming step allows the group to have an open and transparent discussion concerning the assumptions and limitations associated with fire behavior modeling. This sets the stage for simulating the potential "problem" fires across the landscape.

Delineate firesheds to frame the assessment area.

Based on similarities in historical large fires and potential "problem" fires, the broader landscape (e.g., a national forest) is divided into firesheds. Unlike watersheds, firesheds may vary widely in size depending on how fuel types (e.g. grass, brush, or forest) and local topography (e.g. steep canyons, foothills, or high elevation/alpine) and weather (e.g. hot south-facing slopes, cool drainages and north slopes, upslope winds, or wind chutes) influence potential fire behavior. Fireshed boundaries are also influenced by the values they contain (e.g. communities in the wildland urban interface, domestic water supplies, high value infrastructure, habitats for wildlife species of concern, or unique natural areas) and by fire management opportunities (e.g. full suppression or wildland fire use). Firesheds cover large areas, usually encompassing several times the size of the largest potential problem fire. The purpose of delineating firesheds is to identify areas that are sufficiently large to assess the effectiveness of fuel treatments at changing the outcome of a large wildfire. Fireshed boundaries are not fixed and are defined at a coarse scale. Fireshed boundaries will change over time as fuel conditions and the characteristics of the fire threat change in response to management and natural changes in the landscape.

Develop a treatment pattern and prescription scenario aimed at reducing the negative effects of the "problem" fire.

The approach for modifying landscape-scale fire behavior used in the national forests of California is anchored in the concept of treating a fraction of the landscape in the right places to achieve intended modifications in wildland fire behavior. The landscape-scale fire modification strategy is based on the premise that disconnected fuel treatment areas arranged in an appropriate overlapping pattern interrupting the general direction of fire spread are theoretically effective in reducing overall fire spread. Finney (2001) suggests that fire spread rates can be reduced, even outside of treated areas, as a fire is forced to flank areas where fuels have been reduced or otherwise modified. From a mathematical standpoint, Finney calculates that strategically treating a small proportion of the landscape (20 to 30 percent) can have the same change in landscape fire spread rates as randomly treating higher proportions of the landscape (60 percent). Theoretically then, for a given burning duration, a wildfire in the treated landscape should be smaller and have more areas burning at lower intensity when compared to the same wildfire burning in the untreated landscape. While fire suppression is not actively included in the simulations, logically, fire suppression opportunities should be greater where fires are burning less intensely and with a lower rate of spread.

The most effective pattern would be to align overlapping treatments oriented to the direction of expected fire spread. For each fireshed, a default treatment pattern is identified considering the expected fire behavior under "problem" fire conditions and the size a fire can get before it typically escapes suppression on initial attack. Using this pattern as a template, the assessment team identifies potential treatment areas, considering operational feasibility (e.g. equipment access, steep slopes and machinery limitations), environmental sensitivity (e.g. habitats, soils, archaeological sites), and logistical constraints (e.g. proximity to private lands, costs, limitations on operating season). The local knowledge of participants is critical in ensuring that all identified treatment areas are physically feasible to implement and reasonable in terms of costs and likelihood of accomplishment since the efficiency and effectiveness of the treatment pattern is evaluated under the assumption that all treatments are actually implemented.

Each treatment location is assigned a treatment prescription designed to create more desirable fire behavior (Agee and Skinner 2005). Specifically, surface fuels are reduced, crown base height is increased where ladder fuels are a problem, and canopy fuels are reduced as needed to reduce the potential for crown fire spread (Stephens 1998, Agee et al. 2000, Scott and Reinhardt 2001, Agee and Skinner 2005). Both the treatment location and treatment prescription are guided by the local management direction that may limit the extent of changes allowed in the diameter of trees removed or canopy cover that must be retained. These changes are simulated by changing the fuel models within the treatment areas.

The combination of the treatment pattern and individual treatment areas with assigned prescriptions constitute a simulation scenario. Each scenario generally follows a theme that applies a distinct spatial strategy to attempt to solve the problem situation. Usually, several simulation scenarios, each with different spatial strategies, are tested. These scenarios are not alternatives in the sense of the National Environmental Policy Act (NEPA), they are meant to allow exploration of short-term and long-term effectiveness, efficiency, and feasibility of different courses of action. They will help to frame alternatives to be more formally evaluated at a later time as individual projects are ready for site-specific evaluation.

This process is accomplished by projecting geographic information system displays onto a whiteboard using a laptop computer and LCD projector. The collaborative group then uses dry erase pens to delineate potential treatment areas which are then captured by heads-up digitizing. During this process, all members of the group are encouraged to participate in drawing potential treatment areas and the entire group is encouraged to openly discuss the perceived pros and cons of a potential treatment. By rotating the drawing amongst all group members, different perspectives on treatment considerations and design are brought to the discussion.

This can be extremely powerful for groups that are not used to working in a truly integrated interdisciplinary manner and when diverse stakeholders participate in the process. To ensure that this step moves quickly, the group must consciously remember that this is a coarse scale assessment and is not site-specific project planning.

Test and adjust treatments and consider additional scenarios

Understanding how fires are projected to spread and affect vegetation, soils, air, and water is very important in evaluating the performance of a scenario. Fire effects are modeled so that the projected differences between several possible outcomes can be characterized. At a minimum, four outcomes are assessed for each scenario, as displayed in Table 3.

Table 3. Comparison Outcomes for Scenario Assessment

	No Wildfire	Wildfire
No Treatment	No treatment and no wildfire occurs. Vegetation growth simulated for 20 years.	No treatment, but wildfire occurs. No treatment after wildfire and post-fire vegetation growth simulated for 20 years.
Treatment	Treatment occurs and no wildfire follows. Post-treatment vegetation growth simulated for 20 years.	Treatment occurs and then wildfire occurs. No treatment after wildfire and post-fire vegetation growth simulated for 20 years.

The FARSITE and FLAMMAP models generate the key parameters of flame length, fire type, rate of spread, and fire size. This information is overlaid with vegetation information and used to calculate projected vegetation changes The Fire and Fuels Extension (Reinhardt and Crookston 2003) of the Forest Vegetation Simulator (FVS) (Stage 1973) and the First Order Fire Effects Model (FOFEM) (Reinhardt et al. 1997) use flame length and fire type to predict mortality of the dominant tree species found in the vegetation database. FVS is used to predict the additional mortality that may be indirectly caused by fire – for example from fire damage or post-fire insect infestations.

The FVS system (Dixon 2003) and the Stand Visualization System (SVS) (McGaughey 2004) are used to describe and display forest characteristics in both tabular and graphic formats. This base information can then be used to evaluate many different resource effects. For example, forest health is examined by evaluating stand structure and stand density parameters (Reineke 1933) and wildlife habitat is evaluated by cross-walking the vegetation data into the California Wildlife Habitat Relationship habitat types (CA Dept. of Fish and Game 2002) to assess changes in the amount of breeding, foraging and dispersal habitats for wildlife species of interest. This same base vegetation data can also be used to evaluate cumulative watershed effects, scenic visual quality, and other vegetation-based changes of interest to the collaborative group.

Once an initial assessment is done, the assessment team considers making adjustments to treatment location and treatment prescriptions based on what they learn from the fire simulation exercises. Often teams find that there are "holes" in their pattern of treatments. The FARSITE modeling can identify areas where the distance between treatment areas is too great or oriented in the wrong direction relative to slope or predominant winds, allowing a potential "problem" fire to become too large before it bumps into a treatment area. The FLAMMAP modeling can identify areas where the fire is likely to be a surface fire and where it is likely to be active and passive crown fire types. If the modeled "problem" fire could get large but is mostly of a surface fire type, then additional treatment areas might not be needed. In other areas, the team may find that the shape of a treatment area could be modified so that fires might not burn through them as fast or spot over them as easily. In other areas, there may be limited or no opportunities to feasibly develop treatments. The assessment team uses fire modeling to learn how fire spreads across their landscapes under many different wind conditions, ignitions patterns, and fire durations. Each round of simulation provides more insight into the potential pattern of treatments.

In addition to the treatment location, the assessment team can adjust the treatment prescription. Selecting a different prescription changes what is modeled to be removed and what is left. Fires are then modeled against these changes and the projected results are evaluated. The fire gaming is a process that requires multiple iterations, each time adjusting treatment locations, changing prescriptions, and evaluating scenarios based upon the collective learning of the collaborative group.

Discussion

Fireshed assessment involves a rapid, iterative process to guide interdisciplinary teams along a logical, step-by-step process to design, test, and schedule fuels and vegetation management projects to meet reduce landscape-level fire hazard while achieving multiple resource objectives. Collaboratively defining the problems to address in a landscape allows agencies, working directly with the public, to develop scenarios and use a process of gaming to evaluate and compare the tradeoffs between strategies. Using the concept of learning in action, assumptions and data limitations are noted, and computer models such as FARSITE, FLAMMAP and the Forest Vegetation Simulator are used to simulate and evaluate changes across the landscape.

Once individual fireshed assessments are done across the entire landscape (e.g. a national forest or entire management area), the scope of the entire identified workload can be assessed. Individual treatments are grouped into proxies for projects that could be implemented in a given year. This allows costs, outputs, and cumulative effects to be aggregated for each proxy project.

Then, based upon factors such as expected funding, organizational infrastructure, treatment costs, industry and contractor capacity, community support, and administrative and regulatory limits, proxy projects can be grouped into a program of work. The program of work is not simply a list of upcoming projects with generalized project descriptions and locations. Instead, it is a spatially-explicit road map of where and when the vegetation and fuels treatments that implement an overall strategy are likely to occur. In addition, the program of work provides the rationale for (1) why specific areas are slated for treatment and (2) the timing of each project in the overall schedule. Typically, the program of work describes details for the first 5 years, but it is grounded in a schedule to complete all of the anticipated treatments. Typically this spans about 10-20 years based upon expected budgets and limits on the amount of treatments that can be physically accomplished each year. The program of work not only shows where activities are planned, it also shows areas that may be either deferred from treatment or approached under a different fire and fuels strategy, such as wildland fire use.

Once a spatially explicit 5-year program of work is completed across the forest, the performance of the schedule in meeting forest, regional, and national goals and objectives and its impacts can be assessed over time. The performance and impact results can inform the need for changes or refinements to the schedule. The program of work should be robust enough to: (1) allow land managers to make adjustments as budgetary, environmental, legal, and social conditions change; (2) game different outcomes as a result of these adjustments; and (3) determine when adjustments or a major change in the overall strategy should be evaluated. Decision makers should be able to communicate how the program of work is expected to change outcomes for potential wildfires, forest health, habitats, and watersheds both internally within the agency as well as with external groups.

The individual Fireshed Assessments and program of work can then be used to assess the projected effectiveness of treatments to provide protection to communities as well as estimate changes to other resources such as wildlife habitats and watershed condition. Because these models can simulate changes over time, they are an ideal platform to assess projected cumulative effects at scales from the landscape to a forest to a bioregion. The ability to rapidly integrate adaptive feedback from participants helps build confidence in the process, which is an important first step at re-gaining the public's trust in management of their lands.

The ideal situation would be where fuels are compatible with fire as a disturbance agent over space and time, such that fire plays its ecological role in shaping and maintaining vegetation and the social effects of fire in the environment are acceptable. This initial strategy to use strategically placed treatments is intended to be a short-term "triage" to moderate the rate of forests affected by large, uncharacteristically severe wildfires. This is designed to provide the opportunity for land managers to devise longer-term management strategies that address the larger, holistic social and ecological issue of forest health and forest sustainability.

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