SCIENCE-BASED STRATEGIC PLANNING FOR HAZARDOUS FUEL TREATMENT

David L. Peterson and Morris C. Johnson

A scientific foundation coupled with technical support is needed to develop long-term strategic plans for fuel and vegetation treatments on public lands. These plans are developed at several spatial scales and are typically a component of fire management plans and other types of resource management plans.

Such plans need to be compatible with national, regional, and local strategies for fuel treatments, as well as other aspects of resource management.

Scientific documentation provides principles and tools that inform management decisions about fuel treatments (Peterson and others 2005), contribute to the application of best management practices (Johnson and others 2007), and support implementation of treatments to attain desired conditions.

> The focus of fuel treatment is typically on reducing hazardous surface fuel and crown-fire hazard. The effects of fuel treatment on vegetation, wildlife, aquatic resources, and economic values also need to be considered.

Science-based fuel treatment planning by land management agencies includes:

- A *consistent decision process* for identifying and planning fuel treatments,
- *High-quality data* for landscapes where treatments are proposed, and
- An *accountability process* for documenting and evaluating treatments.

A Consistent Decision Process

We propose a management/science collaboration framework for decisionmaking with an interdisciplinary (ID) team (table 1) comprised of:

1. Local resource managers (such as from a Forest Service ranger district or Bureau of Land Management district or field office)—it is helpful to have

Table 1—*Primary responsibilities of members of an interdisciplinary team working to develop an integrated fuel treatment plan.*

Team member	Responsibilities
Local Resource Managers	Geospatial data bases (fuel, vegetation, historical fire occurrence, wildlife, hydrology), natural resource expertise, management objectives and desired conditions, guidance on local regulatory and political issues (sensitive species, air quality, etc.).
Resource Specialists	Consistent ID team process, guidance on national and regional regulatory and policy issues including NEPA, natural resource expertise.
Research Scientists	Scientific expertise in natural resources, modeling and decision support, consistent application of scientific data, ongoing scientific consultation.
Local Stakeholders	Opportunities for collaboration with local residents and business; economic, esthetic, and environmental concerns.
Facilitator	Efficient and productive ID team meetings, documentation and reporting of proceedings, communication among ID team members.

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technical specialists in fire, silviculture, wildlife, hydrology, economics, and social science;
2. One or more high-level resource specialists with expertise in planning and National Environmental Policy Act (NEPA) processes;
3. One or more research scientists;
4. Local stakeholders (municipal officials, business representatives, nongovernmental organizations); and
5. A facilitator.

This is an ideal team composition that might not always be attainable. It is also desirable to have an upper-line manager or someone on the team with clear decisionmaking authority.

Decisions about fuel treatment planning vary according to spatial scale and are prompted by different issues and decision criteria (table 2). Most available information and analyses have been developed for small-scale application. It is inappropriate to simply expand these to broader spatial scales. Scaling up information and analyses can be done, but only with the knowledge

Table 2—*Different strategic questions are appropriate for fuel planning at different spatial scales.*

Spatial Scale	Issues and Decision Criteria
One to a few forest stands	What is the potential for unplanned fire with unacceptable results or costs? What are desired fire behavior and fire effects, and which fuels should be removed to attain them?
	Which kinds and spatial arrangement of treatments would most effectively modify fire behavior, allow fire to be successfully suppressed, and attain desired future conditions for multiple resource objectives?
	What are specific options for fuel treatments and the quantitative and qualitative costs/benefits associated with each?
	What is the expected duration of effectiveness for each fuel treatment?
	Which logistic considerations and risks must be addressed to successfully conduct the fuel treatment?
Small to moderate watersheds (approx. 5th to 6th field hydrologic unit code [HUC])	Which stands or groups of stands are at highest risk for crown fire due to fuel accumulation?
	Which resources (such as habitat, water quality) and other assets (such as buildings, communication facilities) are at high risk from fire due to fuel accumulation?
	Which locations, if treated, would allow the creation of fuel conditions that would reduce fire hazard and facilitate successful fire suppression?
	Where are fuel treatment options limited or restricted due to administrative prohibitions, limited access, high risk, or low probability of success?
Large watershed (approx. 4th field HUC and larger)	Which resources (such as habitat, water quality) and other assets (such as buildings, communication facilities) are at high risk from fire due to fuel accumulation and require priority allocation of effort?
	Which locations provide the greatest strategic opportunity for fuel treatments that would facilitate attainment of desired conditions (such as reduce large-scale fire hazard, facilitate successful fire suppression)?
	Do opportunities exist for long-term biomass utilization and other sustainable means of revenue production?
	Where are fuel treatment options limited or restricted due to administrative prohibitions, limited access, high risk, or low probability of success?

that error (or larger confidence intervals) will likely be introduced into decisionmaking.

The ID team needs to consider which decision systems and tools are most appropriate to inform the decision process at each spatial scale (Peterson and others 2007). The focus of fuel treatment is typically on reducing hazardous surface fuel and crown-fire hazard, but the effects of fuel treatment on vegetation, wildlife, aquatic resources, and economic values also need to be considered.

A Decision Framework

NEPA analyses or similar types of decision frameworks are required for many aspects of forest management, including fuel treatments. A framework (outlined below) can be used for the analysis of individual fuel treatments, as well as for broad-scale fuel treatments across landscapes:

1. *Desired conditions* must be clearly defined for fuel treatments at all spatial scales for which treatments are considered. Attainment of these conditions normally includes:
    - Reduced fuel loading at locations that currently have heavy accumulations of hazardous fuel;
    - Reduced potential for crown fire, intense surface fire, and undesirable fire effects on vegetation and other resources; and
    - Reduced potential for adverse fire effects on local communities and structures.

2. *Consequences of fuel treatments* can be evaluated through a series of questions for alternative fuel treatment options (table 3). Most of the categories and questions in table 3 can be applied to most scales at which fuel treatment planning is done. To ensure that specific needs are addressed, other categories and questions can be added.

The expert knowledge of local fire managers is critical in estimating large-scale fire behavior and fire patterns—with or without fire-spread modeling.

Interdisciplinary Team Process

Evaluating fuel treatment alternatives requires synthesis of existing information and expert knowledge.

Testing of strategic placement of treatments by resource managers will add data in the years ahead and provide information that can be shared and applied in other locations.

Map-based evaluation of alternatives should focus primarily on:

- Spatial patterns of existing fuel and vegetation,
- Likely ignition sources,
- Potential fire spread,
- Fire suppression strategy,
- Fire effects, and
- Future resource conditions.

While simulation models such as FARSITE (Finney 1998) can be used to measure potential fire spread, individual ID teams need to decide if they have sufficient technical capability to reliably run simulation models. Expert knowledge of local fire managers is critical in estimating large-scale fire behavior and fire patterns—with or without fire-spread modeling.

Because such information is needed to develop long-term spatial strategies for fuel treatments, spatial patterns of fuel treatments that effectively control fire spread across large landscapes are a topic of great interest. At present, empirical data on which to base optimization of spatial patterns are sparse. The scientific basis for addressing placement of fuel treatments across complex landscapes is minimal. However, testing of strategic placement of treatments by resource managers will add data in the years ahead and provide information that can be shared and applied in other locations.

Elimination rules—including steep slopes, riparian areas, and higher elevation forests with high fuel moistures—exclude these portions of the landscape where fuel treatments are unlikely. While removing these locations from consideration reduces the area where fuel treatment is evaluated and constrains the pattern of fuel treatment options, the eliminated locations can still affect (and be affected by) how treatments influence fire patterns.

Fire spread is an important analytical issue at larger spatial scales, but other fire effects (such as tree mortality and smoke emissions) must also be evaluated. The decision framework described above can also

Table 3—*A series of questions can be used to evaluate the consequences of fuel treatments.*

Category	Questions
Wildfire and Fuel	What are the effects on crown fire hazard? What are the effects on surface fire hazard? Can future fires be suppressed when necessary? At what interval will fuel need to be treated in the future? Which treatments will be needed? What are the cumulative effects of multiple treatments on wildfire potential?
Vegetation	What are the effects on large trees and snags? What are the effects on sensitive plant species? What are the effects on exotic species? What patterns of forest species, habitats, and structures will develop?
Wildlife	What are the effects on critical habitat structures and animal populations? What are the effects on sensitive animal species? What patterns of animal habitat will develop through time?
Aquatic Systems and Water	What are the effects on water quality? What are the effects on water supply? What are the effects on fish habitat? What are the effects on riparian systems?
Soils	What are the effects on sediment production and delivery? What are the effects on soil fertility and long-term productivity? What are the effects on long-term soil carbon dynamics?
Air	What are the effects on the production of particulates and gases? What are the effects on visibility? What are the effects on carbon emissions? What are threats to air quality if no action is taken?
Cultural Resources	What are the effects on archeological sites and other cultural resources?
Local Community Involvement	Are there opportunities for collaboration with local citizens? What are the effects on recreational activities? What are the effects on resource-based activities (livestock grazing, hunting, etc.)?
Economics	What is the economic cost of the proposed treatment? What is the potential economic benefit of the proposed plan to the Federal Government? What is the potential economic benefit to employment and revenue in local communities? What kinds of contracts and institutional arrangements can be used?
Health and Safety	What are the effects on the health and safety of people in local communities? What are the effects on the health and safety of Federal employees, contractors, and firefighters?
Regulatory	Is any significant legislation, including HFRA, relevant to the proposed plan? Which local governmental units will be affected? Which local organizations, institutions, and individuals need to be informed of the proposed plan?

be used to consider specific ecological, social, and economic effects.

High-Quality Data

Landscapes being considered for fuel treatments need accurate geographic information system (GIS) coverage of fuel properties. It is ideal to have as much real fuelbed data as possible with amount and resolution of the data appropriate for the specific application (Peterson and others 2007). If recent and accurate fuelbed data are not available, they can be derived for multiple fuel strata from the Fuel Characteristic Classification System (<http://www.fs.fed.us/pnw/fera/fccs>).

Some national forests have mapped stylized fuel models that provide a low-resolution classification of surface fire behavior adequate for current fire spread modeling. Sometimes, existing vegetation classifications and other management data (such as stand inventory) can be used to infer fuel properties.

The required accuracy and resolution of fuel data depend on the scale of application. For forest stands and individual projects, accurate high-resolution data are needed. If onsite data are unavailable, the Natural Fuels Photo Series (<http://www.fs.fed.us/pnw/fera/research/fuels/photo_series>) can be useful for rapid, yet accurate, assessment of fuelbed properties. For large watersheds and national forests, more generic fuel classifications may be sufficient. Classifications from remote-sensing imagery can also be useful.

The ID team should assess existing data and, if necessary, recommend collection of new data and development of fuel classifications. Cooperation between fuel specialists and scientists can be especially helpful in developing accurate maps. The ID team needs to state criteria for data quality on any given management unit. ID team members need to also agree on how much time and budget should be allocated to develop the fuel database. Derivation of the data should be carefully documented, regardless of the accuracy and resolution of final databases.

Accountability Process

Accountability is required for fuel treatment programs by the Healthy Forests Restoration Act of 2003 (HFRA). This is a logical component of science-based management. Measuring the outcomes of fuel treatment programs provides feedback to the adaptive management process, ensuring that long-term decisionmaking and planning can be continually improved.

Three types of fuel treatment monitoring guarantee accountability:

1. Implementation monitoring,
2. Effectiveness monitoring, and
3. Validation monitoring.

Monitoring is implemented as follows:

1. *Implementation Monitoring: When, where, and how are treatments conducted?* All treatments are tracked in a database including date, location, area, type of treatments, and lead personnel. Accurate data on thinning prescriptions, burning prescriptions, and surface fuel treatments are especially valuable. It is critical that all treatments are georeferenced so that they can be included in GIS coverages compatible with adjacent management units.

2. *Effectiveness Monitoring: What change in condition of fuel and other resources was attained?* The condition of fuel and other relevant resources is quantified before and after treatments. Although HFRA requires only a representative sample, monitoring 100 percent of treatments is a more credible approach to documenting effectiveness. Pre- and post-treatment measurements of forest structure, surface fuel, and crown fuel are critical. Periodic post-treatment monitoring can measure temporal changes in forest structure, fuel, plant species composition, wildlife habitat, erosion, and hydrology. The interval for subsequent measurements will vary by resource.

3. *Validation Monitoring: Did the treatment meet objectives for desired conditions?* To attain desired conditions, long-term performance of fuel treatments must be documented to achieve full accountability. If a wildfire spreads through a treated area, then fire characteristics can be

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documented. For example, if a crown fire drops to a surface fire (under severe weather conditions), the treatment could be considered successful. Or, if a crown fire is not impeded, the treatment could be considered unsuccessful. Objectives for vegetation, wildlife, and hydrology can also be assessed. Validation is best tracked through a GIS database in which wildfire locations and fire effects (such as severity classes in terms of tree mortality) are overlain on fuel treatment locations. The number of validations in the empirical database will increase over time, providing feedback to adaptive management.

Adaptive Learning Through Collaboration

The efficiency and value of collaboration will improve with experience. As methods are refined, the quantitative rigor and consistency of specific applications will improve over time. It is anticipated that this effort will grow from case studies and demonstrations to formal collaboration between management and research.

Empirical data are critical for improving fuel management at all spatial scales. These data and learning experiences should be communicated in a timely way through scientific publications, reports, meetings, and Web-based materials. Resource management personnel have the responsibility to ensure that this technical communication occurs and that credible scientific information is available.

Instituting science-based strategic planning for integrated fuel and vegetation treatment is a challenging but necessary requirement for both the implementation of the HFRA and sustainable resource management. Applying science-based approaches will contribute to high-quality plans and reduce the likelihood of appeals that challenge scientific credibility.

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If sufficient progress is made in developing successful fuel treatment programs—including science-based documentation of planning and on-the-ground applications—good models for fuel planning will emerge. To enhance adaptive fuel management, successful models of collaborative planning need to be broadly shared.

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References

Finney, M.A. 1998. FARSITE: Fire Area Simulator-model development and evaluation. Res. Pap. RMRS-RP-4, Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Johnson, M.C.; Peterson, D.L.; Raymond, C.L. 2007. Guide to fuel treatments in dry forests of the western United States: Assessing forest structure and fire hazard. Gen. Tech. Rep. GTR-PNW-686. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Peterson, D.L.; Johnson, M.C.; McKenzie, D.; Agee, J.K.; Jain, T.B.; Reinhardt, E.D. 2005. Forest structure and fire hazard in dry forests of the western United States. Gen. Tech. Rep. GTR-PNW-628. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Peterson, D.L.; Evers, L.; Gravenmier, R.A.; Eberhardt, E. 2007. A consumer guide: tools to manage vegetation and fuels. Gen. Tech. Rep. GTR-PNW-690. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. ■

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HOW MUCH FUEL IS ACCEPTABLE?

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United States Department of Agriculture
Forest Service

Looking Back…

The Future of Fire Control – 70 Years Ago

“. . . Forestry’s present store of information and accepted skills and techniques in fire control is meager. Consequently, the instruction provided in professional schools is entirely out of proportion to the importance of fire control in the field of forestry practice. The young forester finds himself ill-prepared for the job which often consumes the greater part of his efforts—fire control.”

> John R. Curry, senior silviculturist, Forest Service, California Forest and Range Experiment Station, from his article “The Future of Fire Control” published in *Fire Control Notes,* Volume 1(5) August 1937. *(Fire Control Notes* is the forerunner of *Fire Management Today.)* For more of Curry’s insightful observations seven long decades ago, see “Looking Back” on page 31.

Coming Next…

The next issue of *Fire Management Today* (68[1] Winter 2008) will feature wildland fire equipment. From the early 1900s—when retrofitted horse-drawn farm equipment served as rustic apparatus—to today’s state-of-the-art remote control devices, dedicated researchers and developers have continuously challenged themselves by devising high-quality and safe firefighting equipment. Today, some equipment is still retrofitted or recycled from surplus military equipment, while other fire apparatus proves to be the conception of innovation. With today’s ever-advancing technology, wildland fire equipment centers located across this country supply the resources and support to meet the demands of the 21st century.

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