3.4) Cost-effectiveness Analysis of Hazard Fuel Reduction Programs

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INTRODUCTION

Assessing the cost-effectiveness of fuel treatments presents many challenges. These challenges are accentuated when the fuel treatment under consideration is prescribed fire, especially when proposed fires will be applied over a large geographic area such as a watershed. Prescribed fire may be the most cost-effective fuel treatment for an area, especially in areas managed for ecosystem sustainability or restoration of natural patterns and processes. However, there are consequences that must be considered in evaluating prescribed fire as a treatment. Threats of escape and smoke pollution are two of the more obvious consequences. While prescribed fire treatments generally are lower in cost than other fuel treatments, i.e., mechanical thinning, fire also is more variable in its effects. This variability in treatment effect is especially evident in the spatial mosaic created by large-scale fire application. On the other hand, mechanical methods may not be suitable where land management objectives call for restoring or imitating natural patterns and processes over the landscape.

In Phase 1 of this project we elucidated some of these challenges through our problem analysis and construction of a prototype simulator for the Mineral King study area in Sequoia-Kings Canyon National Parks (Omi and others 1998). The problem analysis identified anticipated conceptual difficulties while other obstacles only became apparent as we proceeded to build the prototype.

In Phase 2 of this project our intent is to continue with prototype development and consider the feasibility of incorporating benefits in addition to reduction in fire hazard. In phase 1 we focused solely on reductions in burned area, treatment and suppression costs made possible by treatments of increasing larger areas using prescribed fire. Our intent in Phase 2 is to incorporate additional criteria, such as non-market values, emission estimates, and other indicators of overall value-at-risk.

In addition, we intend to examine issues related to extending the prototype to other suitable DOI units. For example, these could include other national parks, FWS refuges, or BLM areas managed as wilderness.

Our third objective in Phase 2 involves revision and updating of the program RXCOST (Omi and others 1992), initially provided to the NPS in 1992. This tool identifies upper and lower limits for proposed prescribed treatment costs, based on regression equations developed for hazard fuel reduction cost requests submitted to NPS-NIFC during the period 1989 to 1992. Since that time numerous changes have occurred in prescribed fire programs throughout the nation, such as expansion of total area treated due to policy changes and improvements in expertise in using fire as a management tool. Administrative changes have occurred, such as institution of NPS prescribed fire modules. These and other changes have motivated the need for updating the original RXCOST program.

The report summarizes progress to date in completing the Phase 2 objectives described above. In addition we suggest how managers might use some of the outcomes from our research efforts and identify potentially fruitful areas of further inquiry.

SUMMARY OF PROGRESS TO DATE

Objective: Develop the prototype simulator for the Mineral King study area

The prototype simulator developed in Phase 1 relies on FARSITE™ simulations, with and without treatment, to arrive at estimates for reductions in area burned by wildfire and resultant reductions in total cost (treatment cost + wildfire suppression costs). The foundation for these estimated savings is illustrated in **Fig. 3.4-1**, which shows the reduction in area burned by wildfires (x-axis) associated with various levels of prescribed fire application (y-axis). The graphic in **Fig.3.4-1** is taken from Omi and others (1998) to illustrate how the prototype simulator was constructed in the Mineral King study area of Sequoia-Kings Canyon National Park. **Fig. 3.4-1** also indicates that treatment of segments 1,2, and 4 (Rx 1,2,4) is a less desirable alternative to treating segments 1 and 4, since a higher number of acres treated (7740) would result in a smaller reduction in burned area (4021) than with Rx1,4. In other words, Rx1,2,4 is an inferior solution as are all other unlabeled points that lie above and to the left of a line connecting Rx4, Rx2,4, Rx1,4 and Rx1,2,3,4 in the figure. Further, tradeoffs associated with treating larger areas can be evaluated by moving upward along such a line and noting the resultant reduction in burned area.

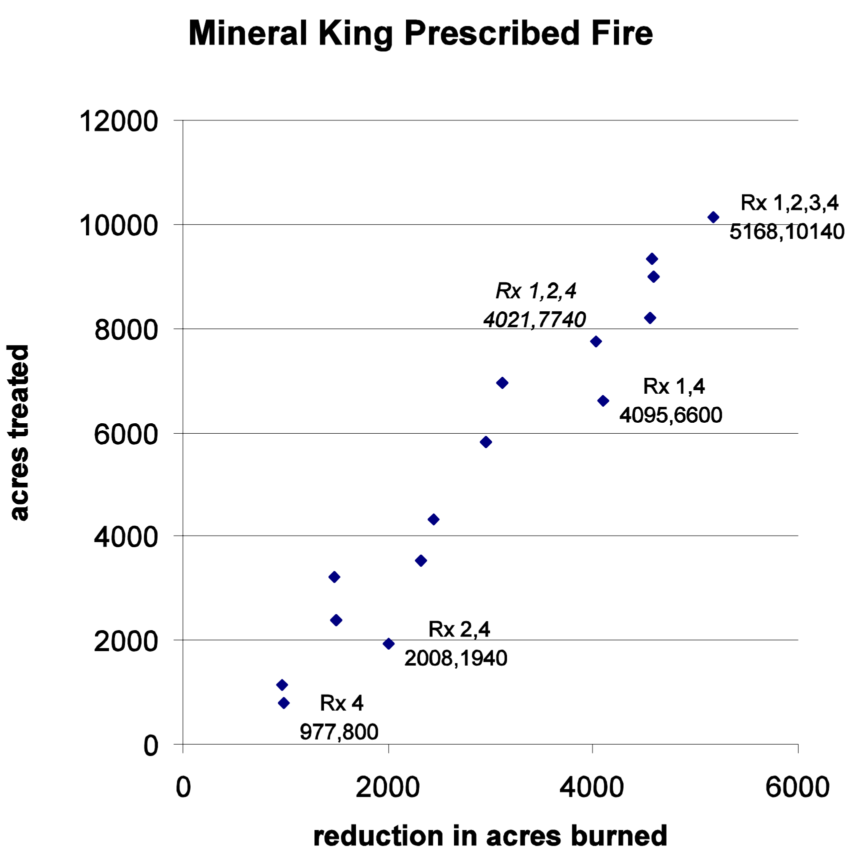

Figure 3.4-1. Reductions in burned area resulting from prescribed fire treatments based on FARSITEä simulations for the Mineral King study area. Treatment of segments 1 and 4 (Rx 1,4), a total of 6600 acres treated, result in a reduction of 4095 acres burned by wildfires. Other illustrative treatment combinations, treatment area, and burned area reductions are noted for treatment of segments 4 (Rx$), segments 2 and 4 (Rx2,4), 1,2, and 4 (Rx1,2,4), and 1,2,3,4 (Rx1,2,3,4). Other treatment combinations are graphed as unlabelled points.

Additional graphs can be produced once this fundamental relationship between treatment area and burned area is establishied. For our analysis we rely on our prior study of suppression costs from historic DI-1202 records (Omi and others 1995), and cost estimates for prescribed fire treatments from the RXCOST (Omi and others 1992) to examine cost savings from fuels treatment. For example Omi and others (1998) illustrated a variety of other graphic relationships, such as treatment cost vs. reduction in area burned (so-called cost-effectiveness frontier), and treatment cost vs. suppression cost savings.

In similar fashion, we are currently examining the feasibility of analyzing and incorporating additional contributors to values at risk, such as non-market resources (e.g., threatened and endangered species or scenic resources) as covered in Rideout and others (1997). Non-market valuation techniques under consideration include travel cost method (TCM) and contingent valuation method (CVM). As described in Rideout and others (1997) these techniques have been used for valuing both recreation and nonmarketed benefits of environmental resources (game birds, threatened and endangered resources, viewing birds, small game mammals, big game mammals, threatened and endangered mammals, water quality, fishing and other recreation, etc.).

We also are examining implications of incorporating smoke emissions from wild and prescribed fires into the analysis. The approach currently under consideration relies on emissions estimates derived for a hypothetical unit area (i.e., acre or hectare). For example, if fuel loadings (tons/ha) are estimable then fuel consumption and emission estimates can be generated for flaming and smoldering combustion in treated vs. untreated areas. The procedure relies on literature estimates for fuel consumption and emission factors during flaming and smoldering combustion (e.g. Ward and others 1993). For example, particulate emissions can be estimated as

$$E = w\ EF\ A \qquad (1)$$

where E = total emissions (g/m^2),
w = mass of fuel consumed (kg/m^2),
EF= emission factor (g/kg of fuel consumed), and
A = burned area (m^2).

Ward and others (1993) show how emissions and emission factors during flaming and smoldering can be estimated for a variety of smoke constituents. These include carbon monoxide (CO), green house gases CO_2 and CH_4), nonmethane hydrocarbons (NMHC), total particulate matter (PM), and particulate matter with diameters less than 2.5 micrometers (PM2.5). These emissions are considered important for visibility and human health standards, and can be arrayed against levels of fuel treatment as well.

Currently, we believe that equation (1) can be used to transform the x-axis in Figure 1 from reductions in area burned to reductions in total emissions by wild and prescribed fires. Using the program RXCOST, we also can transform the y-axis in Figure 1, resulting in a graph of treatment costs vs. emission reductions. This would provide a tool to managers for assessing the cost-effectiveness of fuel treatments for reducing overall emissions. We envision a similar framework can be developed for assessing treatment costs vs. effects on nonmarket resources.

Objective: Expand applicability of the prototype simulator to suitable DOI units

We anticipate that the simulator will be most applicable to areas like Sequoia-Kings Canyon NP, with actual or contemplated large-scale prescribed burn programs. Likely candidates include other national parks with high levels of fire activity (wildfire, prescribed fire, and wildland fire for resource benefit). Other candidate areas could include large refuges or wilderness areas with active fire programs.

Eventually, the prototype might prove useful for evaluating fuel management schemes for areas with extensive fuelbreak systems, especially where prescribed fire is the preferred treatment for reducing fuel hazards between fuelbreak segments. In such landscapes, fuelbreak system layout would need to be included as a GIS theme, including dates for construction and maintenance, for incorporation into the cost-effectiveness analysis.

Pending successful outcomes of phase 2, a transfer workshop or conference may be planned for disseminating results from our efforts. Other potential products include non-technical user guides for the simulator and several scientific publications.

Objective: Revise and update program RXCOST

Efforts are currently underway to update the RXCOST program, using fire records archived since construction of the original program. Efforts to date have involved data retrieval, preliminary analysis, and contemplation of the 'look and feel' of the revised system. We anticipate that the revised systems will distinguish between proposed and actual costs while featuring several different screens than the original version.

So far, we have collected all the data needed for RXCOST. We were able to collect not only project requests but also the matching actual project costs. Additional guidance will be required from NPS-NIFC regarding the impact of the new roving crews (modules) on individual fire costs. To date, we have been unable to collect the cost per field area of these roving crews.

Some preliminary regression analysis has been completed. We have not yet identified all variables and relationships impacting expected project costs. Primary impacts do appear to remain the same as previously found: acres treated, NFDRS fuel model treatment/project type, field area. The regression analysis should be finished by mid-February.

Management Implications

This project will improve the ability of DOI managers to implement cost effective prescribed fire programs, based on foundations established on previous projects, including Phase 1 of the current project. We anticipate that managers will gain improved perspectives for assessing impacts large scale prescribed fire programs, including reductions in suppression costs but also incorporating nonmarketed values and smoke impacts.

The cost-effectiveness frontier generated by the simulator enables managers to select the most effective size of the prescribed fire program subject to the available budget, as well as assessing tradeoffs between different budgetary levels. Transforming simulator inputs and outputs can assess additional tradeoffs. The improved processor also will allow agencies to be more accountable and responsive to mandates contained in GPRA.

Conclusions

Phase 2 of this project will considerably enhance decision-making capabilities for assessing DOI prescribed fire programs. Although we feel we are on the right track, progress to date has been impeded with the departure of the part-time graduate research assistant prior to summer, 1998. This situation should improve with the anticipated hire of a full-time Research Associate during January 1999.

Although this project will improve decision-making capabilities, substantial work remains in terms of assessing and evaluating DOI prescribed fire programs. A spatially-explicit tool for assessing the benefits and costs of large scale fuel treatments is an ambitious undertaking that will require periodic refinements and updates, especially in response to technological improvements and changing policy environments. Our prototype represents a first attempt aimed at incorporating economic criteria in such a tool. As such, the estimates are admittedly crude for projected burned area, suppression cost savings, or other derived estimates for emissions and impacts on values-at-risk (including nonmarket resources). Managers will be able to rely on the prototype for guidance but not leadership in making cost-effective decisions.

Areas of Future Research

The current prototype's focus on smoke emissions may require additional refinement. Smoke impacts per incident may be more important than the total emissions currently under consideration. A single episode that "smokes in" a local community may nullify years of successful prescribed burning projects in an area.

Prototype application to other DOI units will require consideration of the unique features and values at risk in each study area. Perhaps more important will be the extent to which fuels have been treated in the area. Areas in which fire has been excluded for decades will require a different perspective than areas in which fire has been restored in recent years.

Our analyses in Phase 1 and currently under refinement in Phase 2 will assist managers in justifying a cost-effective prescribed fire management program subject to alternative budgetary constraints. However, the optimal budget level for a management unit or DOI bureau is another issue that is determined elsewhere.

Additional refinements that might be contemplated in the future include extension to areas where treatments other than prescribed fire are contemplated. For example, the analysis system might be used in areas possessing an installed fuelbreak network, with fuelbreak segments serving as anchors for rotational applications of large scale prescribed fire. Alternatively, the system might be modified to facilitate comparisons between prescribed fire and mechanical thinning alternatives.

Once fire has been successfully restored in an area, additional prototype refinements might facilitate establishment of seasonally adjusted goals for prescribed fire maintenance treatments. For example, the size of annual prescribed fire treatments might need to be adjusted depending on climatic influences, fire danger variations, and area burned by wild and prescribed fires to date.

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