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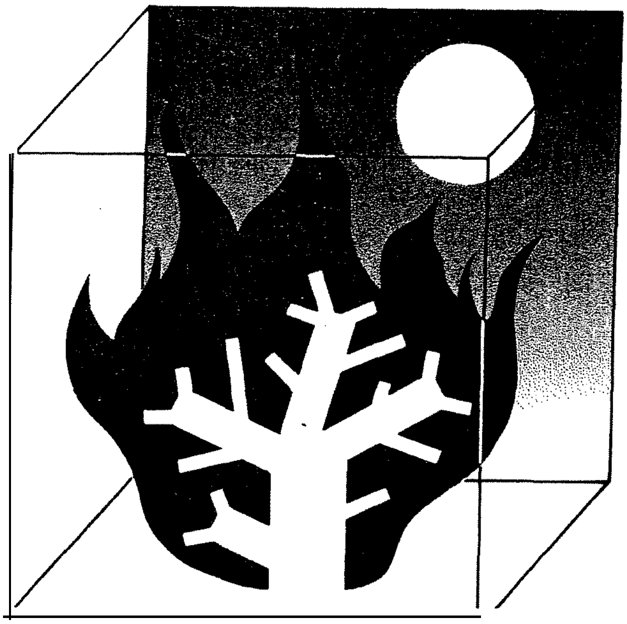
# Fire and the Environment: Ecological and Cultural Perspectives



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# COST-EFFECTIVE WILDERNESS FIRE MANAGEMENT: A CASE STUDY IN SOUTHERN CALIFORNIA

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Abstract-Federal wilderness fire management policies have been scrutinizedsince the catastrophic fires in the Greater Yellowstone Area in 1988. While wilderness tire management objectives are still aimed at recreating natural fire regimes, all USDA Forest Service fire management programs must be cost-effective. Since current Forest Service economic analyses do not fully represent of fire to wilderness, a cost-effectiveness analysis was developed to compare wilderness fire management options. The analytical procedure is briefly reviewed, illustrated through a southern California case study and case study results arc discussed. These results suggest that containment of some tires may be more cost-effective than current control-oriented practices.

Federal wilderness fire management policies have been scrutinized since the catastrophic fires in the Greater Yellowstone Area in 1988. Catastrophic,in this context, is a tire of any size that results in excessive resource damage, excessive suppression costs, excessive damage to private inholdings, or loss of life (Savcland 1986). No lives were lost in Yellowstonc and many have argued the bcnctits, rather than damages, of these fires to the Yellowstone ecosystems, but private lands were damaged and suppression costs were excessive (US Senate 1988). While wilderness fire management objectives are still aimed at recreating natural tire regimes, all Forest Service fire management programs must be cost-effective. If these objectives were difficult to implement in Yellowstone, they will be *even more so in* southern California, where chaparral covered wilderness areas are often surrounded by high valued private property and improvements. The Forest Service's range of options to meet these objectives include the use of appropriate suppression responses and prescribed tire.

Prescribed tires can take two forms: prescribed natural fires and management ignited prescribed fires (USDA Forest Service 1989). All prescribed fires are monitored and managed through the use of detailed bum plans (USDA Forest Service 1989). Theoretically, the only difference between the two forms of prescribed tire is the source of the ignition, but the timing of the fires is also often different. Prescribed natural fires are naturally occurring unplanned ignitions usually caused by infrequent summer or fall lightning storms. Management ignited prescribed *fires* are ignited by Forest Service personnel on their own time schedule when burning conditions and resource availabilities are optimal (usually late fall, winter, or spring in southern California).

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Any fire not classified as a prescribed tire is a wildfire and must receive an appropriate suppression response. These responses range from intensive suppression efforts aimed at keeping the tire as small as possible (a control response) to containment or confinement responses. Containment means surrounding a fire with minimal control lines and utilizing natural barriers to stop its spread. Confinement means limiting a *fire's* spread to a predetermined area principally using natural barriers, preconstructed barriers, or environmental conditions (USDA Forest Service 1989).

A cost-effectiveness analysis has been developed to compare these options for wilderness fire management programs (Childers and Piirto 1989). **In** this analysis, approximating the average annual burned area of the natural fire regime is defined as the objective, fire gaming is used to develop representative fire costs and sizes, and decision trees are used to develop expected annual cost and burned area values for a range of fire management alternatives. This paper briefly reviews the analytical procedure, illustrates the procedure through a southern California case study (two contiguous wilderness areas on Los Padres National Forest, Santa Barbara, CA.), and discusses the case study results.

## THE STUDY AREA

Our case study area comprises 23 1,500 acres of the Dick Smith and San Rafael Wilderness Areas on Los Padres National Forest (fig. 1). The vegetation of this area is predominantly chaparral brush species, including chamise (Adenostoma fasciculatum), assorted ceanothus and manzanita species (Ceanothus spp. and Arctostaphylos spp.), two types of scrub oak (Ouercus dumosa and and several other pyrophytic shrubs. The chaparral intergrades with coast live oak [Ouercus aerifolia) in some riparian areas, big cone Douglas fir (Psuedotsuga and digger pine (Pinus sabiniana) on some north slopes, and a variety of other pines at higher elevations. Fire is a natural component of all of these ecosystems.

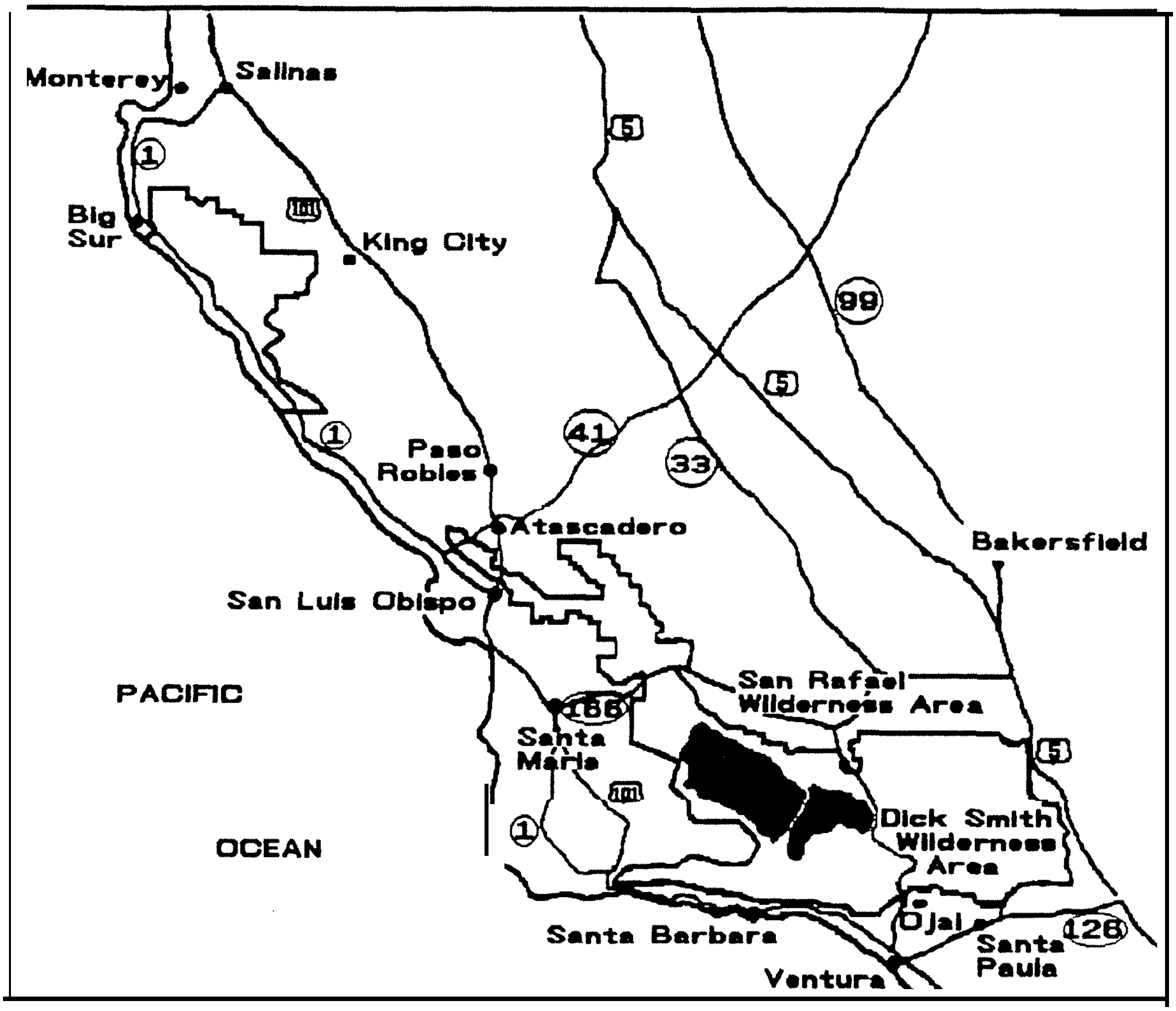


Figure l--Los Padres National Forest, with the Dick Smith and San Rafael Wilderness Areas highlighted

## COST-EFFECTIVENESS ANALYSIS

Most Forest Service economic analyses use cost-benefit models. For example, economic analysis of forest level fire management programs is based on the Cost Plus Net Value Change (C + NVC) model (USDA Forest Service 1987). C + NVC computes the sum of program costs and the quantifiable (in monetary terms) effects of fire on resource values. To be efficient, these cost-benefit analyses must include the effects of fire on all relevant resources. C + NVC models currently include fire effect values for many primary forest resources such as timber, minerals, and forage, and many wilderness outputs such as water, fish and wildlife (measured in numbers of visits by hunters and fishermen), and recreational use (USDA Forest Service 1987). Fire's effects on these resources can be and usually is much different than its effects on a wilderness ecosystem. Since the primary economic value of wilderness remains undefined, fire's effects on wilderness also remain undefined. A cost-benefit analysis which does not include all of the relevant costs and benefits will be incomplete, and often misleading (Williams 1973). Therefore, analyses based solely on C + NVC models are inadequate for wilderness fire management planning.

Saveland (1986) avoided this C + NVC problem in a cost-effectiveness comparison of tire management options for the Frank Church-River of No Return Wilderness Area. In his Analysis, the costs of each alternative were the expected annual suppression costs. "Effectiveness" was the approximation of the average "natural" annual burned ares based on what fire history studies revealed. Saveland (1986) justified this well: Plant communities require a certain amount of fire, just as they require a certain amount of precipitation. ..Altering the average annual burned area would be like altering the average annual rainfall. Though Saveland's analysis involved a different fire regime and setting, his definitions and much of his methodology are appropriate for southern California's chaparral.

Cost-effectiveness analysis (CEA), in its truest form, compares the costs of different alternatives, where each alternative will meet the desired objectives, or have the same effects. A CEA has five key elements: the objective; the alternatives; the costs; the model; and a criterion for ranking the alternatives (Quade 1967).

## The Objective

The most important, and often the most difficult, step in CEA is a clear definition of the goals or the objectives. Public policy usually includes several goals or objectives and these are often conflicting (Quade 1982). Forest Service Policy is no exception. The Forest Service Manual (USDA Forest Service 1986) defines two objectives *for* wilderness *fire* management:

1. (to) permit lightning caused fires to play, as nearly as possible, their natural ecological role in wilderness;

2. (to) reduce to an acceptable level, the risks and consequences of wildfire within wilderness or escaping from wilderness.

The value of fire playing its natural ecological role is currently unquantifiable in monetary terms; thus, it is not included in Forest Service economic evaluations. The consequences of fire are more straight forward. They include resource and property damage and suppression costs. Risk, while also difficult to quantify monetarily, is the probability of a fire resulting in excessive resource damages or suppression costs. Current Los Padres National Forest tire management plans stress the second objective (reducing the risks and consequences); proposed wildfire responses are suppression intensive (control and contain strategies) and no wilderness prescribed fires have been planned. The Forest's current wilderness *fire* management objective might be to respond to and suppress each ignition at minimal cost, regardless of annual burned area. If we are interested in allowing lightning fire to play its natural role, this must be included in the analysis. Our redefined objective might then be to recreate the natural *fire* regime at minimal cost.

To further define this objective, we need to look at the natural fire return interval. By defining the maximum time interval between fires, we can determine the minimal average annual burned area required to recreate the natural fire regime. Research suggests that the area's chaparral historically burned every 30 years (Byrne 1979, Minnich 1983). Los Padres National Forest fire records (1911-1987) suggest that the chaparral bums every 45 years (USDA Forest Service 1988). Forty-five years probably represents the maximum fire return interval since these records were taken while all fires were being actively suppressed. Using the 45-year return interval, an average of over 5,000 acres of the 23 1,500-acre study area would have to bum annually. It is important to note that this 5000-acre average is a long-term objective, not an annual goal. In some years, 20,000-30,000 acres might bum while in other *years* no prescribed fires will be implemented (just as lightning strikes frequently in some years, while no lightning activity occurs in other years).

## The Alternatives

Four alternatives were chosen for the Los Padres CEA.

1. Alternative 1 is the Forest Service's past policy: Control all wildfires regardless of cause, and attempt to meet annual burned area objectives through prescribed burning.

2. Alternative 2 is the fire management strategy proposed in the Los Padres' Land Management Plan: Contain all fires which occur under low intensity and control all moderate to high intensity tires, while pursuing an active prescribed burning program.

3. Alternative 3 (the Confinement Alternative): Confine all low intensity starts, contain moderate to high intensity starts, and control only the starts which occur under extreme tire weather conditions (augmented by prescribed burning as needed).

4. Alternative 4 (the Prescribed Natural Fire Alternative): The same as Alternative 3, with the addition of an approved plan for prescribed natural fire management.

## The Costs

Only the relevant variable costs should be included in a CEA (Quade 1982).

Fixed costs--those that remain the same for each alternative--should not be included. For this analysis, fixed costs include fire suppression equipment, suppression manning levels, and fire management Personnel,, because these forestwide resource level requirements are based on over 100 fires a year and an average of less than two ignitions occur annually in the ease study area. The variable *costs* that must be considered are annual suppression costs, prescribed fire costs, and NVCs for fires originating in the study area.

## The 'Model

A model is a simplified representation of the real world which includes all of the relevant features (Quade 1967). Decision *trees* can be used to evaluate alternative fire management programs in the face of uncertainties about future fire occurrences, weather, behavior, and sizes (Hirsch and others 1981). Decision trees are used to develop expected values. Expected values are probability weighted averages of all possible outcomes. Expected values are not predictions of actual future costs due to the many variables involved in wildland tires; they provide relative values for comparison. For our analysis, decision tree probabilities were derived from fire history records. The range of cost and burned area values were developed through fire gaming since no historic or comparable fire history records were available for containment, confinement, or prescribed natural fire responses (Childers and Piirto 1989).

| Alternative | Representative Location | calm | Weather Pattern | Strategy | Gamed Cost | Expected Value Cost | Gamed s i | Expected Value Size | Gamed Fire NVG | Expected Value NVG |
|---|---|---|---|---|---|---|---|---|---|---|
| Alternative 4 | R.L. 1 0.296 | Lightning a385 | A(.441) | CF(.75) | $3,095 | $117 | 4.0 | a 2 | $44 | $2 |
| | | | | Rx(.25) | $3,689 | $46 | 4.0 | 0.1 | $44 | El |
| | | | B(.118) | CF(.75) | $6,530 | $66 | 450.0 | 4.5 | $1,976 | $20 |
| | | | | Rx(.25) | $6,941 | $23 | 450.0 | 1.5 | $1,976 | s7 |
| | | | C(.147) | CA | $51,730 | $867 | 265.0 | 4.4 | $5,569 | $93 |
| | | | D(.294) | CA | $41,403 | $1,387 | 390.0 | 13.1 | $6,825 | $229 |
| | | Person 0.615 | A(.100) | CF | $3,095 | $56 | 40 | a l | $44 | $1 |
| | | | B(.200) | CF | $6,530 | $238 | 450.0 | 164 | $1,976 | $72 |
| | | | C(.200) | CA | $51,730 | $1,883 | 265.0 | 9.6 | $5,569 | $203 |
| | | | D(.500) | CA | $41,403 | $3,769 | 390.0 | 35.5 | $6,825 | $621 |
| | R L 2 0.25 | Lightning 0.933 | A(.441) | CF(.75) | $2,887 | $223 | 3.0 | a 2 | ($138) | ($11) |
| | | | | Rx(.25) | $47,814 | $1,230 | 740.0 | 19.0 | ($20,736) | ($533) |
| | | | B(.118) | CF(.75) | 5163,384 | $3,373 | 1,950.0 | 48.3 | ($24,608) | ($508) |
| | | | | Rx(.25) | $182,254 | $1,254 | 1,965.0 | 13.5 | ($25,236) | ($174) |
| | | | C(.147) | CA | $93,335 | $3,200 | 780.0 | 267 | ($19,585) | ($672) |
| | | | D(.294) | CA | 3527,336 | S4.416 | 4,200.0 | 35.2 | $240,938 | $16,522 |
| | | Person 0.067 | A(.100) | CF | S2887 | $5 | 3.0 | 0.0 | ($138) | so |
| | | | B(.200) | CF | $163,384 | $547 | 1,950.0 | 6.5 | ($24,608) | ($82) |
| | | | C(.200) | CA | $93,335 | $313 | 788.0 | 26 | ($19,585) | ($66) |
| | | | D(.500) | CA | $527,336 | $36,162 | 4,200.0 | 288.0 | $240,938 | $2,018 |
| | R L 3 a364 | Lightning 0.938 | A(.441) | CF(.75) | $2,525 | $285 | 0.1 | 0.0 | ($3) | $0 |
| | | | | Rx(.25) | $4,821 | $181 | 0.1 | 0.0 | ($3) | $0 |
| | | | B(.118) | CF(.75) | $401 | S12 | 0.1 | 0.0 | ($3) | $0 |
| | | | | Rx(.25) | $110,546 | $1,113 | 833.0 | 8.4 | ($16,435) | ($166) |
| | | | C(.147) | CF(.75) | $17,807 | $670 | 40.0 | 1.5 | ($1,315) | ($50) |
| | | | | Rx(.25) | $88,639 | $1,112 | 835.0 | 10.5 | ($20,544) | ($258) |
| | | | D(.294) | CA | $910,362 | $91,383 | 2,600.0 | 261.0 | $4,847 | $487 |
| | | Person 0.062 | A(.100) | CF | $2,525 | $6 | a l | 0.0 | ($3) | $0 |
| | | | B(.200) | CF | $401 | $2 | a l | 0.0 | ($3) | $0 |
| | | | C(.200) | CA | $17,807 | $80 | 40.0 | a 2 | ($1,315) | ($6) |
| | | | D(.500) | CA | $910,362 | $10,273 | 2,600.0 | 29.3 | $4,847 | $55 |
| | R.L. 4 0.091 | Lightning 1.000 | A(.441) | CF(.75) | S3.475 | $105 | 5.0 | 0.2 | ($116) | ($3) |
| | | | | Rx(.25) | $48,227 | $484 | 748.0 | 7.4 | ($20,734) | ($208) |
| | | | B(.118) | CF(.75) | $167,088 | $1,346 | 1,955.0 | 15.7 | ($24,553) | ($198) |
| | | | | Rx(.25) | $183,371 | $492 | 1,970.0 | 5.3 | ($25,181) | ($68) |
| | | | C(.147) | CA | $98,496 | El.318 | 800.0 | 10.7 | ($18,904) | ($253) |
| | | | D(.294) | CA | 5973,519 | $26,046 | 2,800.0 | 74.9 | $60,638 | $1,622 |
| | | | | | | $194,083 | | 9425 | | $18,697 |
| | | | | Expected Annual Values: | | $341,586 | | 1,658.8 | | $32,907 |

Figure Z-The decision tree for Alternative 4

A decision tree must be complcted for each alternative, using the same probabilities but with different suppression responses and thus different cost and burned area values. The probabilities for each branch of the trees were calculated from the 25-year (I 963-87) fire history of the San Rafael and Dick Smith Wilderness Areas (Childers and Piirto 1989). The decision tree for Alternative 4 of the Los Padres study (fig. 2) illustrates the values and probabilities which were developed for our CEA. Alternative 4's decision tree is presented since it is the most complex decision tree (this is the only alternativc in which strategy is not solcly based on weather pattern).

Fire gaming is the prediction of reprcsentative fire sizes by fire management professionals. Predictions are based on the interactions of estimated tire behavior conditions and given suppression force responses (Harrod and Smith 1983). Our garners included the fire management personnel from the Forest Supervisor's Office and from each of the three ranger districts responsible for the case study area. The "games" consisted of first mapping an overlay of the free-burning fire spread (without any suppression efforts) for a series of time periods. Four weather patterns were mapped at each location and these "fires" were then controlled, contained, confined and managed as prescribed natural tires to develop the cost and burned area values needed to fill in each decision tree. Net Resource Value Changes (NVCs) were calculated using the Forest's 1988 NVC values based on acreage burned by intensity level in each watershed (Childcrs 1991).

Management ignited prescribed fire costs were subjectively estimated at $50 per acre by the garners and by the Santa Barbara Ranger District's Fuels Management Staff. This is more expensive than most recent prescribed fires adjacent to the case study wilderness areas, but initial wilderness prescribed tires will probably be expensive due to the age and continuity of the fuelbeds, remoteness of the fires, and limitations on control lines and the use of mechanized equipment in wildcmess.

### A Criterion

The criterion for ranking alternatives depends on the agency's goals and objectives. Many different rankings are possible. For this analysis, we defined our objective as the recreation of the natural fire regime at minimal cost. Given current budgetary constraints, minimizing costs regardless of burned area might be the agency's actual objective. The sources of proposed expenditures (i.e., forest fire fighting funds vs. program or budgeted dollars) might be important considerations. Risk is also a concern. Finally, the ignition source and timing of the tires might be important to prescribed tire planners. Therefore, all of this information must be provided.

## RESULTS

Four weather patterns were gamed at each of four fire locations: the first set at representative fire location (RL) 1, the second at RL 2, the third at RL 3, and the fourth set under double ignition conditions (two tires occurring simultaneously) using RLs 2 and 4 (Childers 1991). The results of these games are presented in table 1. These values

Table 1--Final size and cost figures for gamed fires.

| | CONTROL | | CONTAIN | | CONFINE | | Rx Natural Fire | |
|---|---|---|---|---|---|---|---|---|
| | Size (acres) | cost (8) | Size (acres) | cost ($) | Size (acres) | cost ($) | Size (acres) | cost ($) |
| Representative Fire Game 1 | | | | | | | | |
| Ueather Pattern A | 0.5 | 7,693 | 0.5 | 5,113 | 4.0 | 3,095 | 4.0 | 3,689 |
| Weather Pattern B | 2.0 | 7,900 | 2.0 | 4,722 | 450.0 | 6,530 | 450.0 | 6,941 |
| Weather Pattern C | 120.0 | 84,592 | 265.0 | 51,730 | (not gamed) | | (not gamed) | |
| Ueather Pattern D | 40.0 | 36,989 | 390.0 | 41,403 | (not gamed) | | (not gamed) | |
| Representative Fire Game 2 | | | | | | | | |
| Weather Pattern A | 0.3 | 3,129 | 0.3 | 2,756 | 3.0 | 2,887 | 740.0 | 47,814 |
| Weather Pattern B | 70.0 | 40,498 | 780.0 | 47,792 | 1,950.0 | 163,384 | 1,965.0 | 182,254 |
| Ueather Pattern C | 145.0 | 86,604 | 780.0 | 93,335 | (not gamed) | | (not gamed) | |
| Weather Pattern D | 1,090.0 | 366,894 | 4,200.0 | 527,336 | (not gamed) | | (not gamed) | |
| Representative Fire Game 3 | | | | | 0.1 | | | |
| Ueather Pattern A | 0.1 | 8,415 | 0.1 | 4,427 | 0.1 | 2,525 | 0.1 | 4,821 |
| Weather Pattern B | 0.1 | 7,541 | 0.1 | 4,896 | | 401 | 833.0 | 110,546 |
| Weather Pattern C | 5.0 | 18,249 | 10.0 | 9,029 | 40.0 | 17,807 | 835.0 | 88,639 |
| Weather Pattern D | 500.0 | 370,193 | 2,600.0 | 910,362 | (not gamed) | | (not gamed) | |
| Representative fire Game 4 | 0.5 | | | | | | | |
| Weather Pattern A | 75.0 | 3,275 | 0.5 | 2,903 | 5.0 | 3,475 | 740.0 | 48,227 |
| Weather Pattern B | [illegible] | 44,518 | 785.0 | 61,549 | 1,955.0 | 167,088 | 1,970.0 | 183,371 |
| Ueather Pattern C | 310.0 | 136,861 | 800.0 | 98,496 | (not gamed) | | (not gamed) | |
| Weather Pattern D | 2.260.0 | 851,674 | 2.800.0 | 973.519 | (not gamed) | | (not gamed) | |

were then run through the appropriate alternatives' decision trees (as per Childers and Piirto 1989) and expected values for average annual suppression costs, burned area, and NVCs were calculated for each decision tree. These results are presented in table 2.

Table 3 includes a breakdown of annual suppression costs and acreage into prescribed fire and forest fire fighting (FFF) costs. Table 3 also illustrates the prescribed bum acreage and costs that would be required to meet our 5,000-acre average annual burned area objective under each alternative. All cost values are presented in 1988 dollars.

## DISCUSSION

One of the most obvious observations from the decision tree results (table 2) and the total cost of implementing each alternative (table 3) is that alternatives 1 and 2 are very similar, as are alternatives 3 and 4. This can be attributed to the similarity of the containment and control responses and the confinement and prescribed natural fire responses as they were used on many of the gamed fires. One gamer concluded that they were still "fighting" the fires, even under the prescribed natural fire responses. For example, the actual dispatch cards of initial attack resources were used to determine who would respond to each fire under both containment and control; thus, many of the same resources were used on both of these strategies. The run cards were heavily modified for confinement and prescribed natural fire responses, but the objectives of these two were often similar. Once these strategies have been implemented, familiarity with appropriate suppression responses and pre-approved prescribed fire bum plans should lead to greater differences in their results. Despite the similarities, these results do provide some valuable information for the decisionmaker.

Table 2--Average annual wildfire and prescribed natural fire cost, cost and San Rafael Wilderness Areas highlighted per acre managed, average annual burned area, and average annual cost per area burned for four alternative fire management programs for the Dick Figure 2--The decision tree for Alternative 4 Smith and San Rafael Uilderness Areas

| | Average annual cost | Cost per acre managed | Average annual burned area (acres) | Average annual cost per burned acre |
|---|---|---|---|---|
| Historical | | | 5000+ | |
| Alternative 1 | 9197,611 | $0.85 | 394.8 | $500.53 |
| Alternative 2 | 9195,474 | SO.84 | 447.2 | $437.11 |
| Alternative 3 | 8334,773 | $1.45 | 1,580.0 | $211.88 |
| Alternative 4 | 8341,586 | $1.48 | 1,658.8 | $205.92 |

Table 3--Breakdown of total average annual suppression/management costs and burned areas by source

| | ALTERNATIVE 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Wildfire Acreage: | 394.8 | 447.2 | 1,580.0 | 1,543.2 |
| Rx Natural Fire Acreage: | 0.0 | 0.0 | 0.0 | 115.6 |
| Mgt Ign Rx Fire Acreage: | 4,605.2 | 4,552.8 | 3,420.0 | 3,341.2 |
| F.F.F. costs: | $197,611 | $195,474 | $334,773 | $331,140 |
| Rx Natural Fire Costs: | 0 | 0 | 0 | $10,446 |
| Mgt Ign Rx Fire Costs: | $230,260 | $227,640 | $171,000 | $167,060 |
| Total Annual Costs: | $427,871 | $423,114 | $505,773 | $508,646 |

If the agency's goal was simply to respond to and suppress or manage each ignition at minimal cost, regardless of annual burned area, alternative 2 would be the most cost-effective. This result is due to the cost-saving advantages of containment over control on most lower intensity tires and the expensive outcomes that can result from trying to confine or manage fires in the decadent fuelbeds.

If, however, the goal is to recreate the natural fire regime (i.e., to meet the 5,000-acre average annual burned area), the decision might be a little more involved. Alternative 2 would still be the least expensive, but alternatives 3 and 4 would require much less program or budgeted dollars to accomplish the objective and result in much more of the acreage burning under natural conditions (natural ignition sources and during the natural fire season).

Containment or confinement strategies can only be used when they are less expensive than controlling a given fire (USDA Forest Service 1989). Table 1 shows that containment cost less than control 56 percent of the times it was used and that confinement cost less or about the ***same*** as control 78 percent of the times it was used. This suggests that containment and confinement are both feasible and cost-effective for our case study ares.

Risk is incorporated into the analysis through the probability of a fire resulting in excessive resource damages or suppression costs (e.g., fire 4D, which cost over $850,000 to suppress regardless of the strategy used). However, none of the confinement or prescribed natural fire responses resulted in a catastrophic fire, and it could be argued that $953,000 (the most expensive gamed fire) is **not** really catastrophic when compared to historic fires like the 1966 Wellman Fire. The Wellman Fire burned 93,600 acres of the case study area and cost over $6.2 million (in 1988 dollars) to suppress. But, since the Wellman Fire occurred under extreme site-specific weather conditions, it would receive a control response under any alternative; and, since it became catastrophic despite control efforts (the only possible response in 1966) it could happen again under any alternative. The risk of another catastrophic fire might seem greater under alternatives 3 and 4, since fires are allowed to get larger, but this is only the short term risk factor. These alternatives would allow ***more*** acres to bum under natural conditions, resulting in cleaner bums than management ignited off-season fires and larger breaks in the decadent fuelbeds, which should help to limit the size of future fires.

## SUMMARY

Developing cost-effective wilderness fire management programs is a dilemma faced by many Forest Service land managers. Wilderness fire management is a requirement, but the value of fire in wilderness remains undefinable in monetary terms so it is excluded from most Forest Service economic analyses. Therefore, cost-effectiveness analysis, using the recreation of the natural fire regime as the objective, can provide important economic information. Decision trees help us predict future fire occurrence potentials, and intensive gaming efforts help us estimate fire sizes and costs associated with the implementation of appropriate suppression responses and prescribed natural fires. Case study results suggest that appropriate suppression responses could provide cost-effective alternatives to current control-oriented practices. Through this extensive and thorough cost-effectiveness analysis we can, hopefully, avoid some of the costly mistakes of past experiences in wilderness fire management.

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