Incorporating Non-Market Values in Fire Management Planning[1]

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Abstract

The increased importance of non-market values in land management planning means that fire management and planning needs to more directly and effectively incorporate them into the planning and decision-making process. This means developing better understanding of the role of non-market valuation in the context of fire effects in prevention and suppression. It also means better knowledge and systems for including fire effects on non-market values and how they affect optimal fire management decisions. Non-market and especially non-use values can be incorporated into the cost plus net value change (C+NVC) framework for use with current land management planning systems. An innovative coupling of the C+NVC framework with cost effectiveness analysis (CEA) is introduced.

Introduction

Two economically-based decision frameworks are of particular relevance to fire management programs and budgeting. These are benefit cost analysis (BCA) and cost effectiveness analysis (CEA). CEA is a sub-set of BCA and is used where benefits are particularly difficult to quantify for comparison with cost. CEA has particular relevance to the treatment of non-market or non-use values in fire management. Each of these frameworks is explained below, including their relevance to the fire management situation.

To determine if a particular fire management action represents an improvement in social well being, one must be able to measure the net gain in benefits. Benefits of market goods are more straightforward. But many resources occurring on public lands are non-marketed. As shown here, the benefits of these non-market resources can also be measured in dollar terms. All of these benefits plus the cost savings to society from fire prevention policies such as prescribed burns can be added together. These benefits can only be added together if all resources, market and non-market, are measured with a consistent valuation framework and accounting stance.

This paper reviews current approaches to valuing and incorporating non-market values into fire management research and suggests an innovative approach to the treatment of non-market values that may be difficult or infeasible to quantify.

Benefit-Cost Analysis (BCA)

Benefit cost analysis is the practice of comparing the gains and losses of a particular activity or project with the purpose of aiding social decision-making. BCA can be performed *ex ante* or *ex post* (Boardman and others 1996). *Ex ante* BCA is used as a planning and evaluation tool where the analysis is performed before the project is undertaken to aid in the evaluation of alternatives including project scale. *Ex post* BCA is performed after the project is completed so that actual costs and benefits (as opposed to projected) can be compared. Each has relative advantages. *Ex ante* analysis is most often applied in fire management.
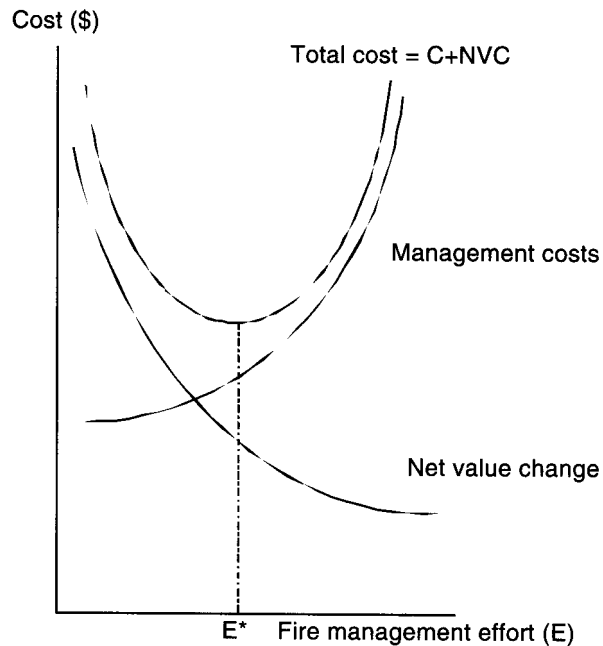
USDA Forest Service Gen. Tech. Rep. PSW-GTR-173. 1999.

217

Figure 1

Generalized fire management model.

Cost ($)

Total cost = C+NVC

Management costs

Net value change

E*   Fire management effort (E)

Benefit Cost Analysis and Cost Plus Net Value Change

Ex ante BCA is appropriate where the benefits and costs of the proposed activity can be identified, quantified, and scheduled. The fire-economics model, C+NVC, is an example of BCA where the cost of suppression and presuppression are compared with net value change (NVC). This overall framework is illustrated in the familiar C+NVC diagram *(fig. 1)*,which shows fire management costs (suppression and presuppression) increasing as more effort is applied (Rideout and Hesseln 1997). Net value change (net damage) declines as fire effort is increased. Together these two effects illustrate a tradeoff in cost where management costs are balanced by fire damage (NVC). The bowl-shaped curve is defined by the vertical sum of management costs and NVC. The minimum of the bowl identifies the cost minimizing amount of fire management effort to apply (E*). Although the cost of fire management activities is conceptually straightforward (practicalities aside) the benefit of fire management (including non-market value effects) can be problematic.

The benefit of fire management is, conceptually, included by reducing the total damage as a result of fire management activities. The total benefit of a particular level of fire management is the difference between NVC with no effort and NVC at the specified level of effort *(fig. 2)*. For example, the total benefit of fire management effort level E is denoted by the distance ($_E$-$_O$) *(fig. 2)*. In the C+NVC model, this benefit is compared with its corresponding costs in suppression and presuppression to form the classic bowl shaped. By locating the minimum point on the bowl, the user of the model is comparing the quantifiable benefits with the quantifiable costs to perform a BCA.

In this way, BCA is consistent with and used in much of the current efforts of fire management and planning. More specifically, this implementation of BCA is intended to be the intellectual foundation of the overall National Fire Management Analysis System (NFMAS) process. A pragmatic difficulty occurs where benefits cannot be adequately scheduled or quantified for inclusion into the BCA process. Some implementations of BCA will treat "non-quantifiable" benefits as items to consider as the quantifiable aspects of BCA are performed.
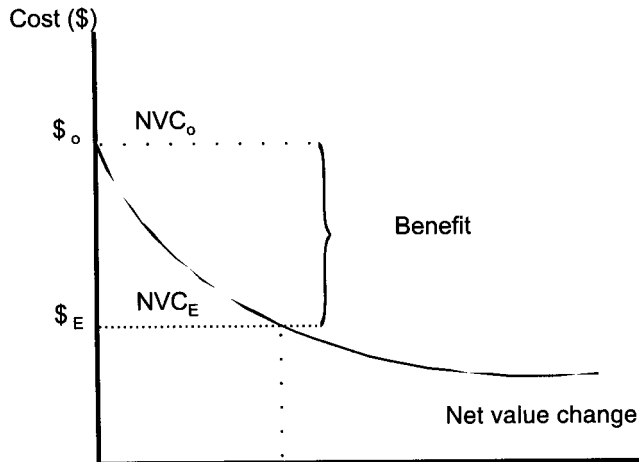
Special Considerations Regarding Benefits

The treatment of benefits is of particular concern and reflects the overall purpose of this project. First, we approach general considerations regarding the treatment of benefits and then address a framework for incorporating non-use values into the C+NVC model using CEA.

Valuation Philosophy and Willingness-to-Pay (Demand)

This report takes the anthropocentric view which states that people (as opposed to natural objects) are the ultimate source of value. Goods and services provide benefits only if an individual or group is benefited. The magnitude of the benefits received is determined by each individual's own judgment of how much better off they are. Thus, economists measure an individual's benefits from fire prevention or fire management as the maximum amount of income they would be willing and able to pay for the program rather than go without. It is important to note that willingness-to-pay in the form of income is simply a proxy for willingness to give up other goods and services to have the resource or project under study. By using monetary measures, we are able to compare the value of various alternatives and incorporate diverse kinds of benefits directly into the analysis. This is known as "monetizing the benefits." Some beneficial effects may be impractical, too expensive or too difficult to accurately monetize. This can be especially applicable to non-use values. Such non-monetized beneficial effects can, under certain conditions, be included into the C+NVC analysis.

The methodology chosen to measure the benefits of resources must allow us to compare marketed resources and nonmarketed resources affected by fire. To obtain consistency in valuation for both marketed and nonmarketed resources, economists rely on values measured from consumer's demand curves and businesses' supply or cost curves to measure net willingness-to-pay. Consumers' willingness-to-pay is measured by consumer surplus, which is defined as the area beneath a consumer's demand curve but above the actual price paid. This area is illustrated as the triangle labeled *Consumer surplus* in the demand curve shown in *figure 3*.

For most goods, consumers receive a surplus or gain in excess of what they pay-this is consumer surplus. For goods and services that are consumable in small units such as hamburgers, cans of soda, etc., it is only the last unit purchased that is worth just what the consumer paid. Because the last unit has a value to the consumer exactly equal to what he or she paid, there is usually no consumer surplus on the last unit bought.

Figure 3

Demand and consumer surplus.
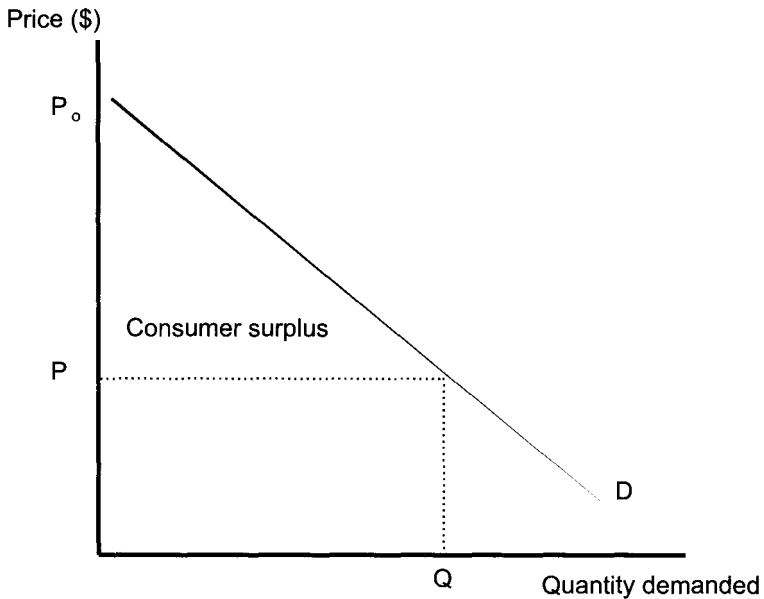
This same logic would hold if the area of public land provided an identical mix of recreational activities (in the same environmental setting) and of the same quality that could be found at other public lands located exactly the same distance from all visitors as this area. Thus, if there were numerous less congested perfect substitute sites available at the same price (distance) and having the same quality (setting, aesthetics, etc.), then a fire at one such recreation area would result in little change in consumer surplus (i.e., people will not be willing to pay anything additional to protect this site from fire). However, it is rare that there are less congested perfectly identical substitute recreation areas located at the same distance to users.

In general, if a catastrophic fire results in a loss of a recreation area, there will be a price increase for consumers who lived closer to that site than any other site providing the same mix of recreation activities and the same setting. That is, these consumers will now have to travel further to obtain that same type of recreation. As such, the price increase translates into a loss in consumers' surplus, just like any other price increase would.

In cases where the substitute sites are so congested that they are rationed by advance reservation or permits, no new visitors can be accommodated and the entire existing consumer surplus would be lost. This situation is typical in East Coast states and a few western states such as California. If the other site does not restrict entry of visitors, the additional visitors may often impose congestion costs on existing visitors to these sites and hence indirectly reduce the quality at the existing sites. Because loss of a recreation site or changes in recreation quality due to fire result in non-marginal changes that do affect prices or quality, there is a change in consumer surplus. This arises in part because recreation is not a homogeneous product traded in national markets. Because of the high travel costs associated with recreation, 80 to 90 percent of visitors travel from within a few hours distance to most recreation sites, i.e., they have localized markets.

There is no inconsistency here in terms of using market price to derive stumpage values for timber and then using consumer surplus for recreation. Both are measures of willingness-to-pay. Price is a measure of gross willingness-to-pay at the margin for one more unit of the good. Thus, all resources affected by fire are compared using the same conceptual measures of value: willingness-to-pay.

Economists are also wary of substitution effects. For example, some fire management programs may enhance one type of resource at the expense of another, such that some public land users lose while others gain. What can be said about an alternative fire policy that makes one person better off but another

worse off? If it is possible to add individual valuations together, it is possible to determine if the sum or total of the valuations is the highest with any alternative. By using the criteria of total benefits, an alternative is preferred if it yields the greatest value of total output.

Accounting Stance

Although benefits are defined from the viewpoint of individuals, often one person's gain is offset by another person's loss. Some resource reallocations do not represent net gains in economic efficiency, but rather simply a transfer of economic activity from one person to another or one location to another. Although this seems very straightforward, if we add one element of realism to this example, we can illustrate a frequent confusion over what constitutes benefits.

For example, assume a policy is proposed to restore fire to the Coeur d'Alene basin in northern Idaho. If the analyst measuring the benefits of this program worked for the State of Idaho and took a state view, then he or she might find that this program resulted in losses to residents living in Idaho. This state viewpoint is one accounting stance. The term "accounting stance" refers to an identifiable group of individuals for which benefits and costs count and for which they do not. Thus, with the State of Idaho or local accounting stance, only benefits received in Idaho and only costs incurred by Idaho residents would count. The state analyst would ignore both benefits and costs occurring outside the region of interest. From a national accounting stance, such a state accounting stance is too narrow to reflect all of the benefits and costs to all people.

A national accounting stance is appropriate for most public land resource actions. This is especially true when dealing with management actions on National Forests, National Parks and National Wildlife Refuges or when dealing with the expenditure of Federal funds. In this case, the national interest is clear: citizens of the United States are all owners of these natural resources and provide the funds to manage them. A state accounting stance in this example would result in failure to incorporate any positive externality of the natural fire into benefit-cost calculations. Because one of the reasons for public ownership of resources is to internalize such externalities into public decision making, it is clear that a national accounting stance is required to ensure that the complete benefits and costs of a resource management action are reflected.

The general guidance to the analyst is to measure benefits and costs "to whomsoever they may accrue." Much like dealing with equity in benefit cost analysis, concerns about which states or nations gain and which lose are best dealt with by displaying the distribution of benefits and costs to each political jurisdiction. This is much better than adopting a narrow accounting stance that results in complete omission of certain state's or nation's benefits and costs.

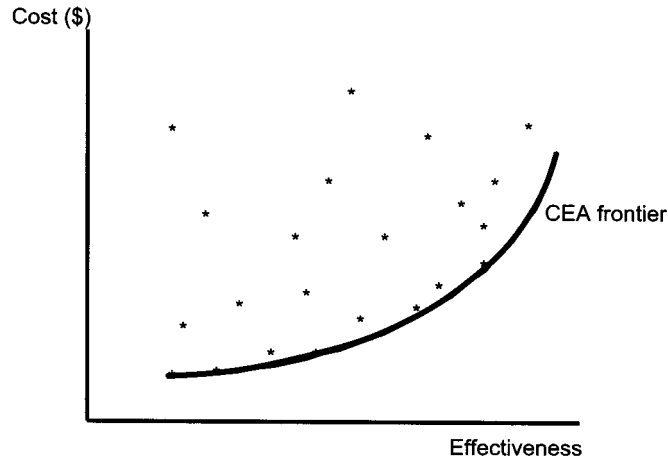### Cost Effectiveness Analysis (CEA)

CEA has particular relevance to non-market issues in fire management and economics. Whereas benefit-cost tools such as NFMAS rely on the quantification of values, values which are difficult or too costly to accurately evaluate can be addressed through the CEA framework adapted for fire management. For example, NFMAS currently only incorporates use-values. Non-use values may be incorporated into the fire management decision making framework by using CEA.

General CEA

CEA was particularly prominent as a technique for addressing the effectiveness of military spending during the cold-war and popularized by then Defense Secretary Robert McNamera. It was defined by William Niskanen (1967) as:

> Cost-effectiveness analysis is specifically directed to problems in which the output cannot be evaluated in market prices, but where inputs can, and where the inputs are, substitutable at an exchange relationship developed in the market.

Figure 4

General result of cost effectiveness analysis (CEA).

It addresses the problem of maximizing effectiveness subject to a generalized resource constraint measured in dollars. Cost-effectiveness analysis is appropriate when (1) there is no market evaluation of alternative outputs, as in the defense sector... and (2) the resource inputs can be appropriately evaluated at market price (p. 18).

The process of CEA depends upon being able to establish physical measures of accomplishment that can be tracked to cost levels. For example, during the cold-war, the Department of Defense was charged with deterrence as an accomplishment. However, directly measuring and evaluating deterrence was not operable so that an effectiveness measure was used instead. The measure of deterrence effectiveness chosen was the capability of armed forces to inflict fatalities on the Soviet Union. A more peaceful example is that of a family contemplating the purchase of a television set. The benefits of a new television are typically very difficult for a family to assess. Instead, for a given set of features, the family may compare cost with picture quality where picture quality would be the measure of effectiveness.

Although there is much to a full CEA, the overall result can be illustrated where cost is plotted against effectiveness to form the CEA frontier *(fig. 4)*. In the illustration particular points (*) are illustrated so as to compare their cost with their effectiveness. Only points on the CEA frontier are cost-effective. Any point on the interior of the frontier could produce more effectiveness at the same level of cost. In this way, points (alternatives) can be compared. In the first stage of comparison, points on the interior of the frontier are identified as inefficient and typically are discarded. In the second stage of analysis, alternatives located along the frontier are considered as to their effectiveness relative to their cost. The choice of alternatives located along the frontier is not directly addressed by CEA, but CEA provides the tool for informed discussions of the cost-effective alternatives. Choices along the frontier are often considered a matter of policy as opposed to scientific investigation.

CEA for Fire Management Systems: Incorporating Non-monetized Values

For values that are impractical or too costly to estimate dollar values (monetize), we can measure physical progress toward accomplishment (effectiveness). For example, preserving or enhancing a measure of bio-diversity could be difficult to reliably monetize. In fuels management problems where the benefits of fuels treatments have been elusive and difficult to measure, effectiveness proxies, such as fuel loading changes provide a measure of effectiveness that can be used in a CEA.

C+NVC ($)

CEA
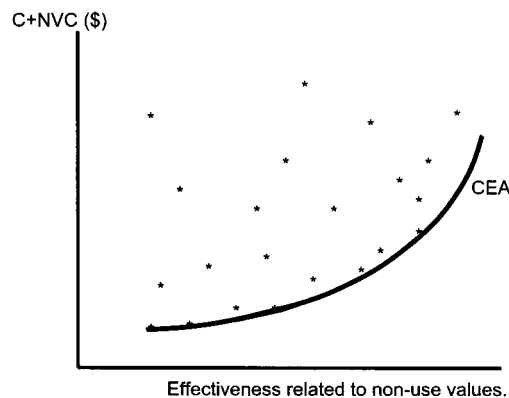
Effectiveness related to non-use values.

In fire planning and management applications where there are identifiable non-monetized values at risk, the C+NVC model as incorporated into NFMAS or other tools can be used to facilitate the CEA. For example, suppose that in fire management planing protecting a particular site from wildfire is associated with preserving a particular non-monetized value. We can incorporate this into the C+NVC like analysis by tracking how much it will cost to provide increasing levels of protection (effectiveness) to the non-monetized resource in question. On one side, through NFMAS or by using some other tool, we can track the amount of cost in terms of C+NVC associated with various protection alternatives. On the other side we will track and associate the corresponding levels of protection or effectiveness for each level of C+NVC provided *(fig. 5)*.

The result of such a CEA process is illustrated in *figure 5*. The interpretation of the illustration is the same as for the generalized CEA, where fire management alternatives (*) on the frontier denote cost-efficient alternatives and alternatives on the interior are inefficient. This allows decision-makers to focus on the cost-effective management strategies and to evaluate the trade-off between fire management costs and the protection of non-monetized value. As currently configured, NFMAS includes the costs of fire management (suppression and presuppression) as well as the cost of resource net damage to use values. The CEA framework for C+NVC, shows how non-monetized values can conceptually be incorporated into the overall analysis for more informed fire management decisions. Improving the measure of non-monetized values poses a trade-off with other fire-management costs and that such improvements will come at increasing cost in C+NVC because of the law of diminishing returns.

Suppose, for example, that we are interested in fire management options at Sequoia, but that we are reluctant to attempt to quantify the benefits of the General Sherman Tree. However, we are very interested in preserving (protecting from wildfire) the tree. To address this issue, we can perform a C+NVC analysis while using fire management alternatives designed to protect this national treasure. The effectiveness of each potential *(ex ante)* treatment can be identified, recorded, and compared with the overall fire management (C+NVC) cost. The CEA will provide decision-makers with the ability to identify cost-efficient options so that informed choices can be made regarding fire management and the level of protection afforded to the tree.

Non-values at risk can be monetized and combined with other resource values as part of the NVC function in the C+NVC models or, in the event that monetization is impractical or unreliable, they can be treated as physical outputs *(fig. 6)*. Such outputs or measures of physical accomplishment can be included as part of the C+NVC/CEA process *(fig. 7)*.

Figure 6

Monetized and non-monetized values as incorporated into the cost plus net value change/cost effectiveness analysis (C+NVC/CEA) framework.
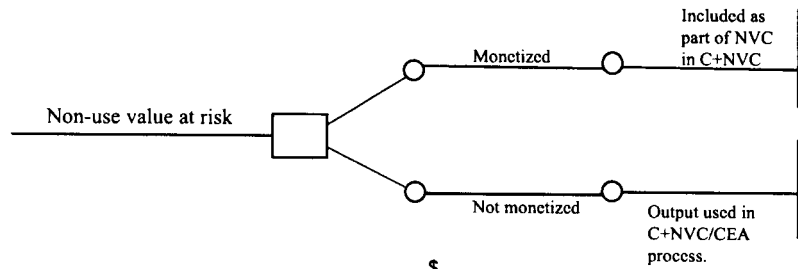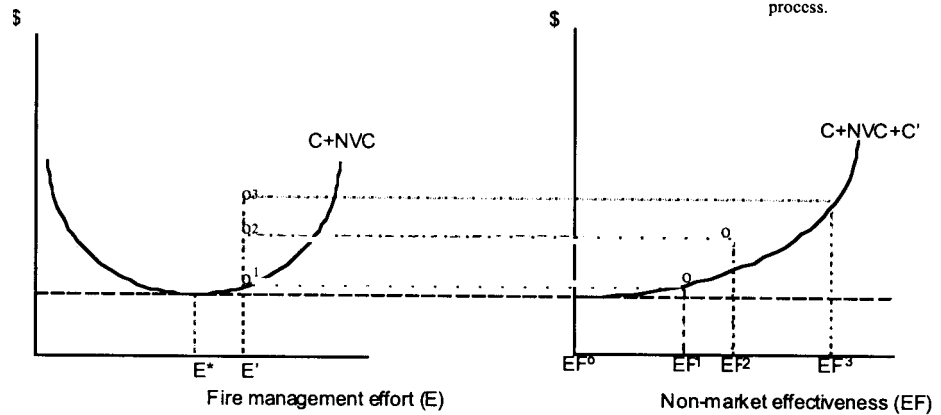

Figure 7

Cost plus net value change (C+NVC) with non-monetized cost effectiveness analysis (CEA).

The analysis illustrated in *figure 7* is valid only under very restrictive conditions; however, it is useful for beginning the discussion on the relationship between C+NVC and CEA analysis. The left panel shows the familiar C+NVC bowl shape with the most efficient level (MEL) of fire management effort at E*. E* corresponds with the MEL where non-use values have not been included in the analysis *(fig. 7)*. As non-monetized values are included at additional cost, the cost of including them will mean increasing total cost above the minimum of the C+NVC bowl. On the right panel, the point corresponding with E* is denoted as EF° and corresponds with a non-use output level for which no additional cost is incurred *(fig. 7)*. Point E' on the left panel denotes an increase in fire management effort and three higher levels of total cost corresponding with three levels of effectiveness in producing the non-monetized benefit. Point one on the left panel corresponds with an increase in total cost and an increase in non-market effectiveness to level EF^1. Holding the level of fire management effort constant at E′ the cost of producing increased effectiveness can be charted for comparison at EF^2, and similarly at greater cost and effectiveness at EF^3. Note that level of effectiveness EF^2 is cost-inefficient because it is on the interior of the frontier. Similarly, alternative levels of fire management effort, beyond E′ can be modeled (left panel) along with increases in total cost aimed at improving overall non-market effectiveness to trace out the cost-effective frontier produced in the right panel (C+NVC+C′). Points along the frontier can then be compared to improve informed decision-making regarding the cost and effectiveness of providing non-monetized benefits. Such comparisons will also be associated with alternative levels of fire management effort as shown in the left panel *(fig. 7)*.

Conclusion

Benefit cost analysis can be used to evaluate fire management alternatives within the C+NVC framework. This framework is currently structured to include market and non-market values as demonstrated by the NFMAS process. Special considerations are often necessary in the incorporation of non-market values in the application of willingness-to-pay measures including the treatment of consumer surplus. Many values (use and non-use) are currently not incorporated

224

A Forest Service Gen. Tech. Rep. PSW-GTR-173. 1999.

into fire management planning because of limitations of planning tools such as NFMAS, difficulties in the measurement of monetized value, and conceptual problems. The C+NVC / CEA process addresses both the monetization issue and the conceptual issue by providing an operationally viable framework for incorporating both monetized and non-monetized benefits into the fire management planning process. CEA is a process developed for addressing the production of objectives that are not practically evaluated in dollar terms. This restricted CEA/C+NVC analysis suggests a potential for advancement in the treatment of non-use values in the evaluation and planning of fire management systems.

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