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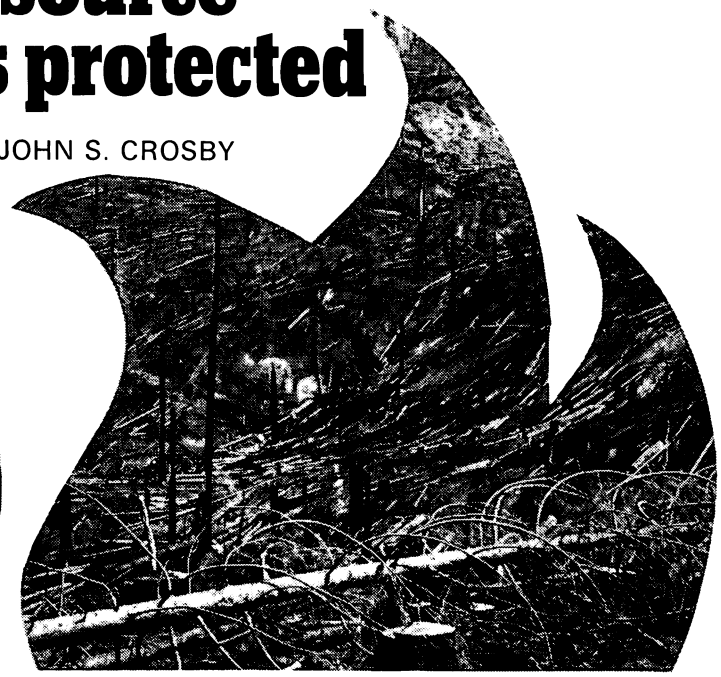
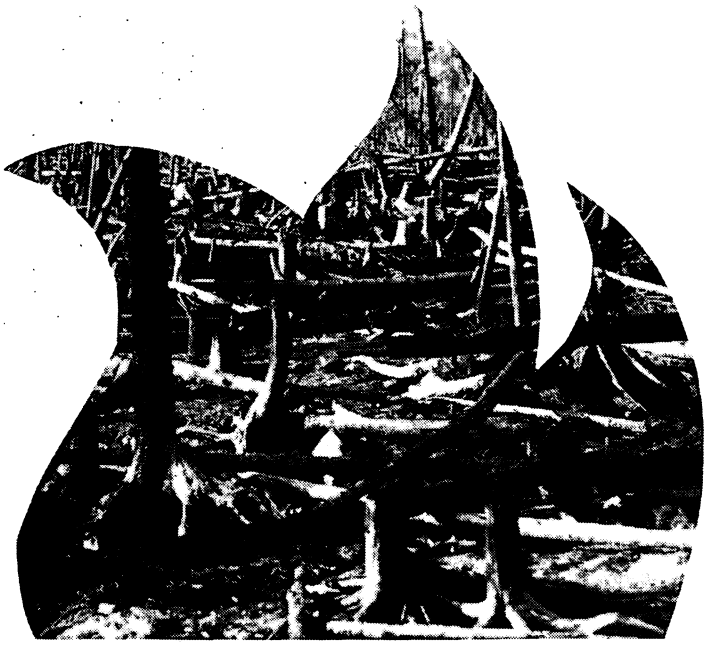
A GUIDE TO THE APPRAISAL OF: wildfire damages, benefits, and resource values protected

JOHN S. CROSBY





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A GUIDE TO THE APPRAISAL OF WILDFIRE DAMAGES, BENEFITS, AND RESOURCE VALUES PROTECTED

John S. Crosby

INTRODUCTION

The purpose of this paper is to present concepts and methods for appraising damages and benefits resulting from wildfire and wildland resource values protected that will be more useful than present appraisal methods for making fire prevention, presuppression, and suppression decisions. The same concepts and methods may serve the needs for appraising damage for trespass claims as well as for planning.

Wildland fire control is an expensive necessity to conserve natural resources and property and to ensure public safety. More than $100 million, mainly tax revenues, is spent annually on wildland fire control in the United States. Although progress has been made in fire prevention, there is an irreducible risk of wildland fires starting, spreading, and doing damage so that fire control efforts will be needed indefinitely.

Rising costs of fire control coupled with increasing values of resources in recent years has caused much concern among the Congress, State legislatures, fire control administrators, and the public about the allocation of funds for fire control. Although adequate fire control is difficult to define, it must satisfy the needs for controlling fire and it must be carried out efficiently within limited budgets.

Guiding policy has been couched in general terms. For example, a goal of the USDA Forest Service is to provide "control of fires commensurate with values protected". Another often-used but more specific objective is to provide protection at the "least-cost-plus-loss". Both objectives require sound damage and value protected information in order to measure achievement.

Theoretically, an economic analysis should provide sound guides to both adequate and efficient fire control, but in practice there have been many difficulties. One serious problem is that the quality of information on fire damages, benefits, values protected from fire, and even resource values has been very poor. As a result it has been nearly impossible to satisfactorily analyze fire control needs and accomplishments on an economic basis. Such an analysis would be invaluable to guide decisions in planning, budgeting, and in actual fire suppression.

Costs can be obtained accurately by bookkeeping. Most appraisals of wildland fire damage have been based largely on property, timber, and range resource losses that lend themselves reasonably well to accepted valuation techniques. But appraisal of losses is inadequate for the more subjectively valued resources such as watersheds, recreation, wildlife, and the environment. The increasing importance of these later resources in todays society makes it necessary to appraise them more realistically.

The biological, economic, and psychological impacts of forest fires are complex. Imperfect biological prediction and economic models hamper sound appraisal. Owing to traditional and sometimes illogical concepts, the lack of definitive valuation methods, and to the diversity of opinion on these items, it appeared at the outset of this study that attention was needed to develop logical valuation concepts as well as to formulate some methods for their application. Unless agreement can be reached on concepts and method, appraisal will continue to frustrate resource managers.

A major thesis presented here is that appraisals are needed as tools for fire control planning and management. All too often "damage" has been treated as a statistical item required to complete a fire report. The objective of providing a tool for the decisionmaker as planner, administrator, or as fire suppression officer, however, sets the purpose of appraisal in a different context and should give new direction to the appraisal process.

Because fire control decisions are made throughout the line of authority

from policy making to suppression of active fires, it is essential that the same concepts and methods be recognized and understood by all the people making these decisions.

HOW VALUES-AT-RISK RELATE TO RESOURCE APPRAISAL

Forests and other wildlands contain widely different combinations of vegetation, soils, animals, climate, configuration, and ecological interactions. Any part or all of a particular combination may satisfy human needs. Values-at-risk indicate any or all of the useful resources jeopardized when a fire occurs.

Forest and other wildlands are valuable because they serve human needs. Value is thus a cultural characteristic of wildland resources rather than an intrinsic property. Regardless of the functions served by wildlands, value derives from the supply of products and services and the demand for them.

Value for our purposes thus evolves from the use of and plans for use of the wildland products and services. Moreover values will change when objectives of use change. It follows that forest and wildland fire control is carried on to permit the achievement of certain social and economic resource-related goals. Fire control is successful if it keeps fire from preventing goal achievement and unsuccessful if goal achievement is hindered or prevented.

Damage or benefits occur only if the achievement of goals is altered unfavorably or favorably, respectively, by fire-caused physical changes. Moreover, because the physical fire effects must be evaluated in terms of goal achievement, the socioeconomic effects of fires uniquely determine the significant physical changes that must be identified and measured for damage appraisal.

"Value protected" is conceived here to include only the partial resource value subject to fire damage. This is a meaningful value representation for fire-control planning and decisionmaking because it is possible for certain resources to be relatively immune to fire damages and, in some cases, some fires may produce benefits.

Neither appraised damage from a given fire nor value protected may be greater than the prefire resource value. Benefits, however, may accrue to prefire resource values. The following statements about these relations can be made if it is assumed the area appraised is some given unit of resource management and losses are based on a given size and intensity of fire:

(1) Resource value $\geq$ value protected = maximum potential damage $\geq$ appraised damage.

(2) Fire benefits = appraised values added = postfire resource value *less* prefire resource value (when result is +).

Obviously *value protected* is limited by the *value of the resource*. However, *value protected* may be much *less* than *resource value* depending upon the susceptibility of the resource to physical fire-caused changes that affect goal achievement. Moreover, the *damage* caused by a given fire may vary from 0 to 100 percent of *value protected*. The *damage* as a portion of *value protected* varies with the severity of the fire, the susceptibility of the resource to destruction, and, in some instances, to the area burned.

DEFINITIONS

Damage: The unfavorable effect of fire-caused changes in the resource base on the attainment of organization goals.

Benefits: The favorable effect of fire-caused changes in the resource base on the attainment of organization goals.

Value protected: The maximum potential resource value that can be destroyed by fire on a resource management unit. This would reflect the maximum potential fire-caused reduction in goal attainment.

Resource value: The full value of the resource, including maximum damagable value (value protected) and remaining nondamagable value.

Because damage and value protected are goal oriented, it is essential to know and understand the goals of the wildland managing organizations for which appraisals are being made. For example, achievement of 4 of the 11 goals found in the USDA Forest Service "Framework for the Future" are affected by forest fires. These goals can be translated into general objectives as follows:

1. To ensure that forest fires do not significantly interrupt or reduce the continued supply of products or services and productive capacity of wildland resources needed for the physical and economic needs of society.

2. To prevent destruction of real and personal property and improvements by forest fires.

3. To ensure minimum fire-risks to the safety, health, and survival of the people in and near the forest and wildlands.

4. To protect, maintain, and/or improve the quality of the environment.

These objectives imply that values-at-risk are diverse. They involve measurable products or services, each supported or created from different sets of wildland components and/or attributes (table 1).

Values-at-risk can be categorized as (1) forest or wildland resource values--values derived from forest resources and forest resource products; (2) nonforest resource values--values independent of forest values but influenced by fires; and (3) environmental values-at-risk--values related to the environment that overlap both of the foregoing.

The *resource* group includes timber, range, watershed, recreation, and wildlife resources. The *nonforest group* includes values such as human life, health, physical and economic well-being, real and personal property, and conservation of "energy".

Damage to nonforest values is directly caused by the flames, heat, and/or smoke per se; there are few after effects. Most benefits of fire control to the nonforest group accrue from total fire prevention. In these instances the wildland provides a fuel hazard threatening nonforest values,

Table 1.--*Kind of resource value protected, composition, product and product use, and measure appropriate for fire-damage appraisal purposes*

Values-at-risk	Resource composition	Resource product	Physical product measure
FOREST RESOURCES			
Timber supply	Merchantable or potentially merchantable trees and soil productivity.	Wood and related products.	Wood volume--present or future.
Range	Grasses, herbs, browse plants, and soil productivity.	Forage	Tons/acre - AMU.
Watershed service	Live and dead organic soil cover, growing conditions, soil characteristics, topography, and stream channels regulating water storage and runoff and soil erosion.	Service: water processing and storage, stream flow regulation, and soil stabilization.	Change in watershed behavior and associated economic and social effects.
Recreation opportunity	Any wildland feature, substance, or situation providing an opportunity for recreation activities (uniquely determined by the activity).	Human satisfaction from experiencing recreation activities. Product is also a user- or visitor-day.	No direct measure. Indirect measure--change in use of site, i.e., visitor days.
Wildlife and wildlife habitat	Wildlife populations and habitat.	Food, fur, recreation, and environmental enjoyment, satisfaction or service.	Pounds, number, quality, recreation-day, relative quality of environment as affected by changes in animal populations.
NONFOREST RESOURCES			
Public safety	People protected.	Personal health (physical and mental well being).	Injuries, sickness, and deaths and/or economic consequences.
Property	Real and personal property, improvements. Commercial facilities.	Services (shelter, manufactured products, comforts, safety, conveniences, etc.).	Property description and significance.
ENVIRONMENTAL VALUES			
Life functions and visual and sensory preception.	Vegetation, soil, water, air, surface configuration, animals, and certain interrelations as climate, ecological states.	Environmental quality within acceptable limits in support of plant and animal life processes; and sensory preceptions.	Measures of: land, air water, and other preceptive quality (parts/million, etc.) and personal responses to change in quality.

whereas in the forest resource group, the forest itself is a resource value-at-risk and many complex after effects may result.

Environmental values are a mixture of the two former types and are categorized separately. Certain local environmental conditions may be created or strongly influenced by wildland, such as air and water quality or scenic quality. While the wildland is burning, environmental changes occur "downstream" (smoke effects) although other onsite effects may persist (ugliness). Whether transient or persisting, such effects may evoke strong responses from residents and often from nonresidents.

Subjective, environmental values can outrank the forest resource values in priority for protection. Thus, they must be accounted for in some value scale.

These distinctions have more than academic importance if for no other reason than they direct the purpose, priority, and technology of fire-control planning and execution. Organizations oriented towards *resource* protection *only* may be unprepared, underfinanced, or even unauthorized for the different methods and demands imposed on them by the extension of protection to the nonforest and environmental values. For example, a high level of fire control might be required by the public for the safety of people living in a flammable semiwildland setting regardless of the *forest resource* values protected. Or, the current interest in "environmental quality" may force fire-control organizations to protect *environmental values* per se, irrespective of any *forest or nonforest resource values*.

VALUATION METHODS

One approach to estimating effects of fire-caused changes on the attainment of objectives is the measurement of the reduction of National, State, or regional income caused by wildfires. Estimates should be made using the most appropriate method, which Streeby listed as follows: market price, conversion return, discounted net value, discounted conversion return, replacement costs, and user cost. A narrative statement of the significance of physical fire-caused changes should be used as a last resort. "Relative value", which is useful to designate differences among levels of value of the same resource has use in some planning techniques.

Values-at-risk protected from fire vary in the nature and marketability of their products. Some, such as wood products, enter well-developed markets in which prices are established. Others, such as recreation products, environmental values, and wilderness, are subjective in nature (nonmarket) and do not enter formal markets where prices for products or services are established. Nevertheless, these products are subject to forces of supply and demand that determine their value. Because of the variability in nature of products, and markets, all of the methods are useful in making wildland appraisals.

If the measure of damage is to be "reduction in income", it is necessary to specify for a given appraisal and resource the level of income being considered--National, State, regional, community, or individual. However, discretion is needed. For example, a fire that destroys the local income from a recreation attraction may not be a loss to the regional income if other attractions are available nearby. Thus, the recreationist can simply transfer his spending to another location within the same region.

Dollars make the ideal common denominator for comparing and combining individual resource values. However, dollars are not necessarily a more valid value judgment than any other value statement about a resource, especially when no firm market exists. A scenic area cannot be adequately assigned a market value because scenery is not a product traded in market. However, scenery does have value, and estimates of its dollar value can be made even though not definitive. Moreover, we can analyze many of the value criterion involved to make comparative statements about scenic values in relation to other areas. Thus strict adherence to dollars is not a necessity to obtain values for planning purposes, even though dollars are needed for a strict financial analysis.

The Resource Appraisal Unit

Few, if any, wildland values are independent of the land area on which they occur. Except for very high-value individual trees, such as a large, high-quality walnut tree, most trees are merchantable as timber only when they occur in numbers sufficient to make harvesting an economic

venture. Recreation opportunities require some minimum areas for use or management. For appraising value protected an appraisal unit of management size peculiar to each resource use must be designated.

In areas managed for multiple use, the appraisal unit for each individual resource may vary in size being bounded by different kinds of limits. For example, a timber resource appraisal unit may or may not correspond with a watershed unit boundary, or a recreation unit boundary. It might be practical to appraise values protected per acre as the average of the particular unit of management for each value-at-risk, so that the sum of all values-at-risk for any one particular parcel of land can be combined to show the total resource value protected. Thus, it would be practical to let appraisal units correspond to functional management units.

Problems may arise where there is no specific plan of management for given areas, either public or private. However, all lands perform some watershed function, form a habitat, and contribute toward the environment. Therefore, some status for appraisal purposes could be assumed. Although timber, watershed, range, or recreation potential may be the best alternatives, other potential values-at-risk should not be overlooked.

Size and Intensity of Fires

High-intensity fires usually cause more and a greater degree of physical changes than do low-intensity fires. Thus, to the extent that damage is related to number and degree of physical changes, damage per acre increases with the intensity of fires. As a fire grows in size, it tends to jeopardize a broader range of objectives. Moreover size and intensity may increase simultaneously to magnify both degree and number of effects.

A fire may influence the achievement of objectives on adjacent or downstream lands. This "spilling over" effect on unburned areas increases the per acre damage on the burned areas. Suppression costs usually increase with fire size and intensity, some times drastically. The total of these costs plus damages tends to increase the value per acre protected as fires increase in size and intensity, even though the costs of suppression per acre burned tends to decrease as fire size increases.

Consequently, size and intensity of fires are important planning factors. It is especially important that some probable maximum size and intensity of potential fires be assumed when estimating the value protected.

FOREST AND WILDLAND RECREATION RESOURCE

Concept

Recreation resources are the natural features that provide an opportunity for forest and wildland recreation activities. Natural features such as openings, trees, and other vegetation, soil, rocks, water, weather, historical events, wildlife, topography, geologic formations, scenery, and other amenities provide most opportunities. The *value of recreation resources, therefore, is the value of the recreation opportunities.*

Recreation *activities* have different requirements for successful and satisfying accomplishment, so the *recreation activity uniquely defines the recreation resource for that activity.* Any appraisal of a recreation opportunity, therefore, must be made in terms of specific activities or groups of activities. The opportunity must be appraised in terms of the *required or essential features* making the activity possible and the *environmental features* that make the location for the activity an attractive place.

Environmental amenities have a stronger relation to recreation use than to any other of the multiple forest and wildland uses. Because it is necessary to relate amenities to some form of demand, they are included with recreation resources in this paper.

The *product* of the recreation resource is human satisfaction from recreation activities. This product is difficult to evaluate directly in dollars because there is no measurable unit of human satisfaction. The best expression of value of recreation opportunities is the amount people will be willing to spend to participate.

Some agencies estimate the number of recreation-days (visitor days) and assign a research-determined or arbitrary value per day to estimate recreation benefits.

Much of the recreationists dollar is spent for travel opportunities and occasions. This complicates the assessment of the value of individual public recreation opportunities. Moreover, much outdoor recreation is offered free or at nominal cost on the recreation site.

Appraisal

Recreation resource values are of two kinds: (1) the value of the resource opportunity itself; and (2) the values associated with recreation improvements. If the management objective is to provide some level and quality of recreation opportunities, and a fire destroys all or part of an opportunity, damage has occurred in the sense that goal achievement is reduced.

Because recreationists are mobile, they often find another opportunity as a substitute for the one that is lost with little or no change in their spending habits affecting National income. But if we try to maintain the same or an increasing level of opportunities in a fixed area, the part of the budget diverted to restoration, relocation, or replacement of changed opportunities may well account for part of the damage from forest fires.

From a purely monetary viewpoint, such costs may serve the need for damage appraisal. Although the urgency of demand for rehabilitation would indicate something about the demand for the opportunity, restoration costs do not tell much about the importance of the opportunity. For example, historic trees or buildings destroyed by fire could be replaced, but they would not have the same significance the originals had. The replacement cost would only be a token of some greater or smaller social loss. Some form of opportunity evaluation seems necessary. However, it is probably true that a strict financial analysis of many recreation resources falls short of a satisfactory guide to fire-control priority.

Recreation improvements represent values-at-risk--and can be considered resources. However, they are usually provided to: (1) help manage people; (2) increase the capacity for use; (3) protect the site; or (4) increase availability and use of opportunities, notable exceptions to the latter are swimming pools or impoundments. Improvements usually *enhance* the opportunity, rather than *make* the opportunity for outdoor recreation. Improvements may be costly, but they have usefulness only as long as the opportunity is viable.

If the opportunity itself is destroyed or rendered unusable for a long time (10 years), appraised damage will be the value of the lost opportunity, or the cost of its relocation, or the depreciated capital value of the improvements. *If the opportunity is still viable after a fire or its use is only temporarily reduced,* appraised damages will be the costs to restore the opportunity and the improvements if the opportunity is still needed, plus any reduction in opportunity value.

A decision on the destructability of the opportunity is critical to the appraisal. The appraiser must define the activities involved and determine the necessary resource elements for their successful accomplishment. If these elements are destroyed, the activity is no longer possible. If they are only reduced in quality, the activity may still be practiced though rehabilitation might be required.

Appraisal of the opportunity value is complex, but damages appraised, as cost of restoration, replacement, or relocation, are comparatively easy and reliable to estimate.

Fire-caused recreation benefits are possible and care must be excercised to account for them in appraisals. Improved game habitat might increase hunting success. Burned areas may provide points of interest. Fires can increase the variety of vegetation or produce new crops of berries--or openings in large areas of monotypes. Recent burns are good bird- and game-watching areas. A burn may also change the kind of activity an area may support without loss of use.

Many features that provide recreation opportunities can't be destroyed by fire. For example, lakes, beaches, geological features, mountain-climbing areas, and trails. Other features, such as groves of trees or rare plants, can be destroyed. Many activities can still be carried on after a fire, however, they may lose much of their charm because of environmental changes. Thus, the quality of environmental

features are often reduced but the essential features for the activity survive. Complications occur when a fire simply changes the activities possible but doesn't prohibit use of the area for other activities.

Evaluation of Recreational Opportunities

Private land offering recreational opportunities can often be evaluated through open-market exchanges. A reduction in value because of fire is equal to damage. This is a sound method of evaluation, but seldom is usable for public land.

A method often proposed, but seldom used for other than major recreation developments, involves preparation of a schedule of the amount of use with changing costs to participate (Clawson and Knetsch 1967). Opportunity values are actually determined by the amount people are willing to pay or forego in order to participate in activities. If these costs can be established and the number of persons who would participate at various cost levels determined, the value of the opportunity can be obtained. This information is difficult to acquire, but represents the truest expression of value because the method accounts for variation in elasticity of demand (Knetsch 1971). Clawson and Knetsch (1967) illustrated this method using travel distance as the cost variable.

Another system determines the average cost-per-day-per-person to participate in a recreation activity at a particular site. The opportunity is then valued as the product of the average cost-per-person and the number of persons participating per year, or a capitalization of the annual net costs. If realistic net-per-capita data can be found for each activity, the method is useful. Such information is not readily available and the method may severely underestimate the value for scarce high-quality opportunities (Knetsch 1971). However, a set of per-capita rates have been used in certain government estimates. For example, a useful set of per-capita rates was used in "A model for the determination of wildland resource values" (USDA Forest Service 1971a).

Because valuation of opportunities cannot be precisely made, a *relative value of recreation opportunities* might be determined for some opportunities. When dollar values are essential, approximate relative values must be assigned a dollar value using one of the above methods.

Opportunity cost is a method that can be used to find at least a minimum value. This method is logically applied to areas withdrawn from multiple use and limited to a single recreational use. Thus, the value of the sum of the most valuable compatible uses given up to supply recreation use represents at least a minimum value of the recreation opportunity. For example, if timber values of $500 per acre are prohibited because an area has been restricted to recreation use, the recreation opportunity value would be at least $500 per acre. The recreation value, however, may be much greater than the opportunity value.

The method proposed for determining the indicated relative value of recreational opportunities involves combining three value factors: quality, substitutability, and use.

Quality is expressed as an *opportunity index* derived from the essential features and the attractions of the opportunity. *Physical and social substitutability* are combined into an index that together with the opportunity index rates the *uniqueness of the opportunity*. Uniqueness combined with use provides the *indicated relative value*. Use, however, is a combination of capacity for use and the percent of capacity actually used as illustrated in figure 1.

Opportunity Index

The concept of a recreation opportunity index (see box) assumes that the basic unit of recreation is an activity: what the recreationist does--his participation at a given place. Participation involves two sets of conditions: essential features and attractions. There are certain features or objects that must be present to permit successful participation in an activity. These can be called the *essential features*. For fishing, there must be water stocked with fish and access to the water although fishing success may vary. If the recreationist is satisfied to fish simply because he wants to catch fish, these are the only conditions he requires. Most people, however, like to participate recreationally in a pleasant place and probably be able to do other things, so the

			Number or code		Index		Value	
			Pre-fire	Post-fire	Pre-fire	Post-fire	Pre-fire	Post-fire
1. Essential feature rating								
a. Diversity (average rating)	Pre-fire	Post-fire						
2. Attractions:								
a. environment								
b. climate								
c. *wildlife*								
d. *geology*								
e. *biology*								
f. *landscape & scenery*								
Sum								
Average								
3. Opportunity Index								
1. Physical substitutability								
2. Social substitutability								
3. Substitutability Index								
UNIQUENESS INDEX								
1. Capacity class								
2. Percent of capacity used								
3. Use index								
VALUE CLASS AND ESTIMATED DOLLARS							$	$
INDICATED RELATIVE VALUE PROTECTED CLASS AND ESTIMATED VALUE							$	$

Figure 1.--*Sample form to determine indicated relative value and value protected for a recreation resource.*

attractions at a fishing site are usually deciding factors in *where* he participates. Thus the *attractions*, in addition to the *essential features*, strongly influence the choice of both activity and location.

By combining these factors, we can obtain an index of the quality of the opportunity. These factors can be objectively identified and rated so the index is relatively free from personal bias.

When rating an area for a given activity, it is possible that the quality of the essential features is not sufficiently good to ensure success, but there are many fine attractions. For such a situation, the point on the chart in the box would fall below the diagonal line (point B, for example). This would alert the appraiser to the fact that perhaps some other activity or group of activities might be better served than the activity at first selected. The area can probably support a diversity of activities. The further towards the upper right corner the point falls on the chart the more desirable the site for recreation. It probably means that it would be a popular place. In private ownership it would command a high price. In public ownership such an area would likely be heavily used, and would present many problems in administration to prevent conflicts of use, overcrowding, vandalism, and even public controversy over use. This estimate is then one expression of value.

When several activities[1] are possible on an area, it is logical to rate the site

[1]*One should be guided by what people do. The activity may be floating down a stream on an inner tube, collecting mushrooms, resting, climbing trees, watching hawks soar, throwing stones, catching frogs, hunting treasure, or making sand candles.*

Estimating Recreation Opportunity Index

Essential Feature Rating

1. Set down the essential features for the activity to be rated. Associated activities for a given attraction may be averaged giving a within-group rating.
2. On a scale of 1 to 5 (vertical scale) estimate the success the average participant could expect to realize from the given feature quality on the rating site. To do this use Appendix 1.--Rating essential features of recreational activity.

Attraction Rating

3. List the attractions for the site and nearby areas. Include environment and use at least five attractions if possible. If some are not present, this is not a concern. Exclude attraction most nearly corresponding to the activity being rated. This attraction should be rated as an essential feature.
4. Rate each attraction on a scale of five using Appendix 1.--Rating essential features of recreational activity.
5. Find the average rating of attractions (horizontal).

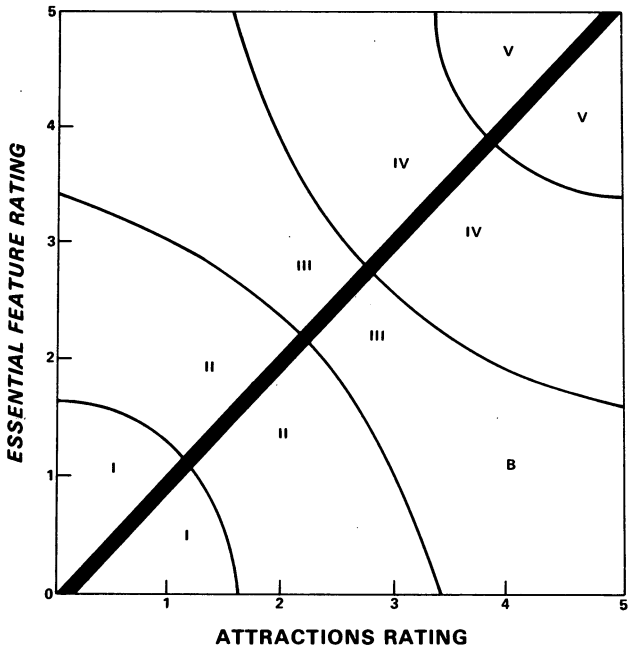
Diversity Rating

1. Rate attractions as above.
2. Use at least five recreation activities from two or more different kinds of attractions, but average the success rating for the vertical entry.

Opportunity Index

Find where lines produced from the calculated vertical and horizontal values cross. The roman numerals I through V rate the opportunity. I is poorest; V is best.

on the basis of its diversity. In this case, several attractions would be rated. Instead of rating the essentials for a single opportunity, however, the average of the success ratings for several possible activities would be used for the vertical scale entry to the chart in the box. Whenever a site rating falls beneath the diagonal line in rating a particular activity, therefore, it is well to consider the possibility of rating diversity.



Diversity is also the best way to rate unfamiliar areas, areas for inventory, and most campgrounds.

Diversity of recreation opportunities is of two kinds: (1) diversity of activities within a common attraction, and (2) diversity of activities among different attractions. For example: water attractions may support swimming and bathing, beach sports, boating, fishing, scuba diving, and outdoor living. Another site may have water, geological and biological attractions that will support water sports, spelunking, rock collecting, ecology study, bird watching, hunting, walking, and photography as well.

Recreationists form in general interest groups so the more successful the opportunities within a common attraction, more people of the group are attracted to the site. The greater the diversity of kinds of attractions, the greater the number of people from different interest groups will be attracted. Only the hard core of an interest group, however, need or want highly specialized essential features. Most recreationists have broad interests so they may even fall into more than one general interest group. The result is that increasing diversity is likely associated with a large increase in people served and attracted to the site with consequent chances for conflicts of interest and associated management problems.

In rating diversity, the essentials rating should include at least five activities from at least two different kinds of attractions. This lower limit to numbers of activities rated must be made or only the best would be rated, which would decrease the sensitivity of the index.

Most campgrounds have been developed around one or more attractions that provide opportunity for activities. Campground popularity and use will usually be some function of the successful activities that are possible on the site or adjacent to it. Thus campgrounds should be evaluated in respect to the activities that can be pursued on the site.

If a facility has been established specifically as a place for outdoor living, it should be rated for the activity *outdoor living*. If many activities are possible, rate diversity including outdoor living.

Substitutability Index

If a large number of different recreation areas and activities are available, the loss of one may not be critical. People will probably spend the same amount of time or money at another place or on another activity, and the loss to income is negligible. However, if the opportunities are very few in number and of high quality, the loss of one may be important because people may be prohibited from participating, or alternate opportunities may be overused. Substitutions or their absence are a strong factor in value determination (Knetsch 1971).

Social substitutability also seems to be a requirement in the appraisal because relatively low-quality recreation opportunities often serve an important need in a community and increases the value of the opportunity above the amount its quality normally would command. This is especially true for sites serving people unable to afford travel to better-quality opportunities further away.

Physical and social substitutability for the opportunity have been combined to broaden and strengthen the concept. A method for determining the suitability is given in the box.

Substitutability Index

Physical substitutability for opportunity (code)	Social substitutability (code)				
1	1	2	3	4	5
1	I	II	II	III	IV
2	II	II	III	III	IV
3	III	III	IV	IV	V
4	IV	IV	IV	V	V
5	V	V	V	V	V

Criteria

Physical Substitutability Code

1. Many equal or similar opportunities locally and nationally for a single activity or for related or different activities. Some form is found in most all areas. Few, if any, limits to access or availability.

2. Equal or similar opportunity and range of activity common but poorly distributed locally, regionally, or nationally. Access and availability occasionally a problem, but not a significant limitation.

3. Equal or similar opportunity and range not common, but are well distributed locally and nationally. Access and availability may be a restriction to use.

4. Equal opportunity and range somewhat restricted locally but more common in some other regions. Access and availability may be a severe restriction.

5. Equal quality is very rare in any forested region. Maybe only one of a kind. Visitors come from far off. Unless in public ownership generally closed to public use.

Social Substitutability Code

1. Serves only a minor and incidental or unimportant local need. Nonessential.

2. Serves local population only, but not considered very essential. Loss would not be serious.

(Continued on page 11

(Continued from page 10)

3. Serves local needs very well and is needed here, but is only casually used by outsiders. Loss would be hard on some groups who use extensively but could not afford similar recreation at greater distances.

4. Important local need served. Loss would mean a severe restriction of opportunities in all groups. Frequently used by outsiders serving regional needs.

5. Highly essential to serve recreation needs locally, regionally, and/or nationally.

Uniqueness Index

The combination of Opportunity index (see box) with Substitutability index forms a further evaluation of the opportunity. Uniqueness indicates the supply or frequency of opportunities of different quality. If high quality is also very scarce, the opportunity commands a high value (Class V). If low-quality opportunities are plentiful, they are comparatively cheap (Class I). Other combinations are intermediate in value (Classes II to IV).

Uniqueness Index

Opportunity index	Substitutability index: I	II	III	IV	V
I	I	II	II	II	II
II	I	II	III	III	III
III	II	III	III	IV	IV
IV	II	III	IV	IV	V
V	III	III	IV	V	V

Use Index

Use of an area for recreation confirms that a recreation opportunity exists and that the features constitute a recreation opportunity. However, we must also recognize that some unused areas have potential for recreation use. For damage appraisal, present use takes precedence over potential use. For planning, potential use and need must be recognized. For estimating value protected, therefore, potential use and value are logical considerations.

The Use Index combines capacity for use and percent of capacity used (see box). Carrying capacity is a concept that is difficult to express in precise numbers (Wagar 1964, Lime 1972) and no formulae to compute such numbers exists.

Carrying capacity is based on the capacity of the site to withstand use without degredation and the tolerance of people to crowding. Whichever limit is reached first establishes the capacity.

Paths, roads, and sanitary facilities, for example, all tend to increase capacity of a site to withstand use. But capacity can also be increased if users will tolerate lower standards of quality. Group activities have a higher tolerance to crowding than do individual activities. Thus, a swimming beach has a higher capacity per acre than wilderness use, hunting areas, or birdwatching.

When estimating Use index, highest ratings are given to areas carrying nearly full capacity use for the activity being considered. As use increases or decreases from full capacity use, the value rating decreases. Classes of capacity change in

Use Index

Capacity used (percent)	Capacity--annual visits: < 500	500 to 5,000	5,000 to 50,000	50,000 to 500,000	500,000+
	Number				
40	I	I	I	II	III
41 to 80	I	I	II	III	IV
81 to 120	I	II	III	IV	V
121 to 160	I	I	II	III	IV
161+	I	I	I	II	III

multiples of 10; thus, the class ranges should be as precise as possible.

Actually, the value of an opportunity increases up to full capacity use. Thus, up to full capacity each user receives full enjoyment from the opportunity, the more users at full enjoyment the greater the total enjoyment--value of the opportunity. If the use exceeds capacity, however, the amount of enjoyment per person begins to decrease: consequently total value decreases, or increases very slowly, depending upon the rate of decrease in enjoyment.

Indicated Relative Value Class

The Indicated Relative Value class is obtained by combining the Uniqueness index with the Use index: class I is the lowest value; class V is the highest value.

Indicated Relative Value Class

Use index	Uniqueness index I	II	III	IV	V
I	I	II	II	III	III
II	II	II	III	III	IV
III	II	III	III	IV	IV
IV	III	III	IV	IV	V
V	III	IV	IV	V	V

Relative Value Protected Class

The Relative Recreation Resource Value Protected class (see box) is obtained from a dual rating of the opportunity: a prefire rating (before any fire occurs) and a potential rating which assumes that a fire causing maximum effects has occurred. The fire may not be of maximum intensity, but it must have caused a maximum effect on the resource.

Damage may not be larger than the prefire value rating. If, as may be the case for wildlife habitat, the postfire Indicated Value is greater than the prefire value class, benefits have occurred and the value protected is zero, or perhaps prescribed fire should be used.

A dollar appraisal may be made by simply applying a price per use-day multiplied by the number of users. The value per day suggested in "A Model for Determining Wildland Resource Values" (USDA Forest Service 1971a) is suitable but would be appropriate to use a range of values--a low figure for class I and increasing values for the classes II to V.

Relative Value Protected Class

Prefire class	Potential class I	II	III	IV	V
I	I*	**			
II	II	I			
III	III	II	I		
IV	IV	III	II	I	
V	V***	IV	III	II	I

*When no change in relative value results from burning, value protected is minimal.

**Blank cells represent fire benefit and hence no value protected.

***When the greatest loss can occur; hence, the relative value protected is greatest.

WILDLIFE RESOURCE

Concept

Conflicts in evaluating wildlife and wildlife habitat result from the complexity of biological and economic factors. The unresolved problems have often led to oversimplification in which some arbitrary amount of per acre damage has been claimed for every fire.

Although the relations between wildlife and value or damage most commonly have involved "game" animals and fish, these constitute only the more visable, sporty, or edible of the wildlife species that may be present. However, it is not reasonable to confine appraisal to "game" animals because (1) the maintenance of game animals in a habitat is so intimately related to food chains and the quality of the site to provide covers, and (2) both relate to the environmental considerations.

An animal habitat is an area combining water and food supply with cover for protection against weather and predators, and for resting, breeding, nesting, and playing. For most species, all these conditions must be found within an area that individuals of a species normally claim as their range. A proper balance of these conditions is needed for optimum habitat.

The natural animal component of any ecosystem is a unique product of the kind, size, density, and distribution of plants and other animals on an area modified by the climate and topography. The animal compliment is expected to change as the plant composition changes. Regardless of the existing type of plant community, however, compatible animal population can be expected to occupy the site. Disturbance on the site brings with it a probable adjustment in the character of habitat and a corresponding adjustment in the abundance and diversity of the animal population.

Fire is one such disturbance. Some animals may be killed or injured by fire, particularly the young and those species having limited mobility although whole populations are seldom if ever decimated by fires. Burning may also cause an abrupt and radical change in the vegetative character and the microclimate with a corresponding change in the animal compliment or a change in the vigor and abundance of the prefire animal population.

Temporarily, a freshly burned area may seem to be a biological desert. In some, new vegetation may be slow to develop, but almost immediately the animal compliment begins to adjust. A new balance of species, abundance, and vigor is established with the development of new vegetative situations. Because the vegetative state may also change rapidly in the first years following fire; the animal complement also can be expected to change but this change may lag the changes in food and cover.

The amount of fire-caused change in wildlife will depend in large measure upon the size and severity of the fire and the associated weather and climate. Regardless of the amount of change, however, the site still constitutes a habitat. Some animals can be expected to be compatible with the new habitat continuously trending towards a new balance. Moreover, some animals occupy all areas from which they are not artificially excluded.

Wildlife habitat resources differ from other wildland resources only because the primary product is different--wildlife is mobile and timber, forage, or watershed, for example, are not. Wildlands only become a habitat when they are stocked with compatible wildlife. *Thus the wildlife resource is a combination of habitat and wildlife breeding stock.* The ultimate economic product must be considered to be hunting, fishing, photographic activity, ecologic function, or the enjoyment and dependence on a quality environment, rather than deer, trout, or animals per se.

Specific objectives of local wildlife management together with desires of the people for wildlife as a part of the environment are needed to define the role of fires in respect to damage appraisal. These goals may vary.

Indigenous wildlife is legally the property and responsibility of the States while certain migratory wildlife has become a federal or international responsibility. *Wildlife* is thus *public* rather than *private* in nature and is managed for the public good, yet much *habitat is privately owned.* Public objectives for wildlife may or may not be coincident with private objectives of land (habitat) management. The opportunity for full wildlife management is best on public land, but broad public policy towards wildlife must be applicable to all ownerships because wildlife know no ownership boundaries and inhabit all kinds of land.

Most management has been aimed at manipulating ecosystems and regulating hunting, fishing, and predation for the purpose of favoring or discouraging game populations. Many kinds of nongame manipulations are also carried on to control pests or predators, although these are not generally considered to be "wildlife management". Moreover, marketing of most wild animals is illegal except for certain fish and furbearers. Thus, wildlife management unfortunately has become popularly identified with sport fishing and hunting objectives, which are distinctly recreational in nature.

However, some agencies now conceive the purpose of wildlife management to be that of maintaining a diverse population of animals. Expenditures are even made to maintain endangered species. This expands recreation uses from hunting and fishing alone to include nature study, birdwatching, photography, painting, and other forms of wildlife enjoyment and recognize the environmental values of wildlife.

For monetary evaluations, we are strictly concerned with the effects of

fire-caused changes in wildlife and habitat on human goals. When we recognize the existence of animals in the environment for the sake of the benefits humans derive from a "whole" environment, the existence of certain animals and, thus, of their habitats, has economic significance.

Unfortunately, there are few good guides to wildlife habitat quality or to the expected carrying capacity of different habitats. Some agencies have tentatively set up standards of desirable balance of vegetation types to meet certain wildlife objectives. Using these, the effects of fire can be judged beneficial or detrimental depending upon whether the fire moves habitat conditions towards or away from defined optimum balances. If the postfire trend is toward a poorer balance, damage has occurred and may be measured by the costs to rehabilitate the habitat. Precise statements cannot be made, but the following can be used as a guide. When a change of 20 percent or more in type conditions by area occurs in a habitat-range, the case should be carefully studied for either benefits or damages. Thus, to be of significance the size of fires may range from 1 to 2 acres for rabbits, to 200 to 300 acres for deer and turkey, and larger for some other species and many predators. For most purposes, fires of less than 10 acres could generally be ignored in wildlife damage appraisal.

Because the boundaries of a habitat cannot be accurately drawn and the size of animal range units varies widely, it is probably sensible to relate wildlife habitat appraisal units to timber management units. Timber management, moreover, usually has more influence on habitat than any other form of planned forest resource management. This means that wildlife appraisal units could be defined as ranging from 500 to 2,000 acres.

Appraisal

Because wildlife does not exist naturally independent of its habitat, it is not logical to evaluate wildlife apart from habitat. Attempts have been made to find the value of game and fish taken by sportsmen. On the premise that the game is worth at least as much as sportsmen are willing to spend to take the game, value figures have been derived by dividing estimates of the total amount spent by hunters or fishermen by the numbers of game taken. An estimate of the value of habitat as a producer of *game* could be made by capitalizing the total amount spent if the annual take and costs remained about the same from year to year. An estimate of capital value per acre of habitat could be obtained by dividing this capitalized value by the acres from which the game was taken. Such figures obviously only represent an *average* value per acre or per animal taken on the total area sampled. The estimate of *damage* would represent the decrease in capital value per acre.

On a Statewide basis, unless an extremely large amount of habitat were burned and the habitat greatly reduced in productivity, the computation would be unlikely to show significant decreases in value of wildlife and habitat. Gathering adequate information for small areas would be difficult and expensive. Moreover, it would be illogical to claim the capital value per acre as a loss from fire because the habitat is not often destroyed but only changed in quality. This change could be either for better or for worse, depending upon the human goals for its use.

When it is necessary to claim a value loss for animals destroyed by fire, the above process may produce the most reasonable value obtainable. However, it should be pointed out that the value derived from this process applies to the game *harvested*, not to the value of any individual animal. Any one animal could have a much smaller value because usually only the increase in a population is harvested in any year, and the animals killed by fire may or may not have been harvestable. Moreover, the value is further inflated because it does not account for costs involved in producing the game (the costs of operating a game management division, law enforcement, and related activities).

Basically, a claim for damage to wildlife and habitat must relate to a decrease in breeding stock and/or habitat quality that reduces the capability of the burned area to serve the human objective for wildlife use and enjoyment.

The appraiser must first determine how attainment of the human goals have been altered and, if they have been changed, determine the value of the damage or benefit.

As with recreation resources, damage to wildlife and habitat relates to: (1) the amount of decrease in opportunity to participate in wildlife use and enjoyment, (2) demand for the opportunity, and (3) the cost to restore the habitat and wildlife population to its former or equal status. Opportunity loss should be handled as described on pages 8-10.

With respect to (3), the sample list shown in figure 2 might prove helpful. Damage may be estimated to include (1) any costs to restore the habitat and restock the breeding population if it has been critically reduced by a fire; (2) temporary cost to maintain wildlife, and (3) increased management costs less any benefits. The justification for this expenditure will depend largely on public demand as well as technical considerations. If the change affects environmental quality only, methods suggested on pages 17-18 should be applied.

Habitat restoration is not often undertaken following fires. When such measures are not taken, certain conclusions can be inferred: (1) the damage to wildlife and habitat may be insignificant or beneficial; (2) the change in wildlife and habitat has not affected human goals; (3) there is no wildlife objective or policy for the burned land, which indicates that wildlife is not important to management; (4) the costs of rehabilitation are greater than the expected benefits; (5) there is no way to restore the former habitat although the new habitat can serve a different purpose very well; or (6) there are no funds available for rehabilitation even though it is needed.

Restoration costs should not be claimed as damage unless the restoration is to be done. If, however, there is expected to be a significant reduction in recreation opportunity relating to the fire, damage may be estimated in terms of appropriate recreation opportunity lost.

Damages claimed by individuals or others must relate to loss of income resulting from the reduction in wildlife numbers or diversity. Such loss may be properly charged as a local loss of income although there may be no loss in National income because the same amount would normally be spent by sportsmen in other areas.

Value protected will be the amount of such costs on area in which unfavorable fire effects can be expected. If fires can be expected to cause little change in the habitat quality, or to improve it, little or no value protected can be assigned.

Relative value of the wildlife supported recreation opportunities may be

Effects of fire on:

(Estimate)	Immediate effects (0-5 years)			Long-range effects (5 years+)		
	Adverse	No chg.	Favorable	Adverse	No chg.	Favorable
a. food						
b. cover						
c. breeding and nesting						
d. change in cover distribution						
e. change in recreation use						
f. overall effect						

g. predominant effect: Immediate _____ or long range _____
favorable _____ or unfavorable _____

Costs to restore habitat to an adequate level (if desirable):
a. treatment costs:
b. population maintenance costs:
c. animal restocking costs:
d. estimated number of animals killed and value/unit _____

Figure 2.--*Sample form to use as a reminder list for appraising wildlife habitat damage.*

estimated by means of the system on page 12. A change in relative value owing to fire may also be indicated by means of a before and after fire estimate.

Lacking any other means to appraise wildlife habitat value protected, a simple statement of urgency may be as useful as any evaluation. Such a statement must include: (1) the objective of wildlife habitat management, (2) the importance of meeting this objective, (3) how fire could cause failure to meet the objective, and (4) the relative urgency to control fire in the habitat so that the objective can be achieved together with an estimate of the size of permissible fire.

On areas for which there is no objective, the appraiser must assume some broad objective to make an appraisal. This will usually be in terms of public good related to the presence and maintenance of wildlife and wildlife diversity.

NONFOREST VALUES-AT-RISK

Concept

Nonforest values-at-risk refers to those values that are independent of forest resource values. Generally this means values that have been introduced into the wildland setting and not derived from it. Among the more obvious are buildings of all kinds from homes to factories, and such improvements as bridges, roads, powerlines, and fences. Another set of values relates to people, especially to residents and their activities--human safety and health; discomforts and inconveniences; traffic hazards and delays; energy consumption; and increases in crime.

Appraisal

Damage to property and improvements is logically appraised by current market prices, by repair or replacement costs, or, if unneeded in the future, by depreciated capital values. There may be cases where an item of property is unwanted and unneeded and its destruction is desired, in which case the fire may have performed a service. In such cases, cause and effect should be carefully studied to be sure the wildfire was not caused by intentionally burning the property.

There is no appropriate way to directly estimate the value of a human being, his safety, or health as such. However, approximations, based on such tangibles as loss of income, medical and hospital expenses, may be used to estimate damages.

Wildfires may cause numerous temporary discomforts and inconveniences to residents and travelers. It may result in cost due to traffic hazards and delays, heavy smoke on highways and airfields that may result in accidents, rescheduling of common carriers, as well as local traffic. At times heavy smoke over settled areas and cities has resulted in an increased demand for electric power for lights, water pumping, and other energy uses during fires. Where people must be evacuated from endangered homes, the prospects of vandalism and theft may require special police or the National Guard.

When any of these effects occur, the costs generated are logical inclusions for damage appraisal. Some of these costs are relatively straightforward, such as the cost of additional police officers, or accidents resulting from smoke-caused reduced visibility. Others are difficult to estimate, such as the increased amount of energy used or the cost to airlines to reroute or reschedule commercial flights. Probably only the most clearcut items would be included in a claim for damages in a trespass case, but consideration should be given to the others in any statistical compilation of damages and in planning.

The value protected for nonforest values-at-risk would be the estimated costs and losses that may be incurred as a result of some major fire situation affecting a given community. Estimates of the value of endangered property and improvements would undoubtedly comprise the most realistic part of the appraisal in dollars, and the assumption could well be made that the full value of the property is subject to loss.

In respect to public safety, the estimate should probably not be made in dollars, but rather in terms of potential risks involved. This may include consideration of numbers of people threatened, the capacities for warning and evacuation, the possibilities for entrapment, the nature and frequency of possible fires,

and the occurrence of weather conditions conducive to disastrous conflagrations. In some instances, ensuring public safety may be so overriding in importance that it becomes the major task confronting the fire-control personnel. If this is the case, all other values-at-risk are of secondary importance and regardless of the high values that may be involved they only contribute to the urgency, rather than create it.

ENVIRONMENTAL VALUES-AT-RISK

Concept

Environmental values are complex and require special analysis. Despite the somewhat vague references often made today to "environmental" deterioration, an appraisal of damage to the environment must be more specific. The purpose is to find out how fire-caused changes in the environment affect human objectives, well being, and financial status. The transitory effects on people while a fire is burning would best be appraised by methods described in the chapter on Nonforest Values-At-Risk.

Environments, for our purposes, can be described in terms of air, climate, soil, water, vegetation, and wildlife, and to some extent the interactions among these such as ecological status and scenery. Like watersheds, which are everywhere over land areas, every place has an environment.

Natural or seminatural acceptable environments differ in composition and quality. Generally, natural states are favorable and form some standard of quality. Reduction in quality is caused by degredation in such forms as visual, atmospheric, water, thermal, or chemical pollution. Efforts are now being made to set acceptable limits to air, water, and noise pollution. These are related to objective animal, vegetative, or even industrial tolerances, but visual pollution is subjective and affects individuals differently.

Moreover, different environments are conducive to characteristic life styles, whether woodsman, farmer, or urbanite. Each group has adapted to a different environment although each environment is life sustaining and presumably satisfies its indigenous group. Each group would resist abrupt changes in its particular environment and groups placed in another environment would likely be displeased. Thus, abrupt changes in environments, caused by forest fires may cause unfavorable reactions and produce pollution in view of some groups, especially residents.

A fire, even a large one, rarely renders the environment completely hostile to human habitation except temporarily in close proximity to and during active combustion. But fire-caused changes may have important effects on human responses to the environment including even mental health problems. Visual changes possibly may dominate, but odors become different and objects dirty. Objects take on grotesque or ugly arrangements, diurnal air and soil temperature ranges increase, wind blows stronger, frost penetrates deeper, snow depth is greater, and snow melt occurs earlier.

Appraisal

Rehabilitation costs are inadequate as a base expression of environmental resource value. However, they do provide a useful dollar approximation of the value protected if one will recognize that the *environmental resource value* itself may be much greater. A direct comparison of resource value and value protected is impossible because meaningful dollar values can't be placed on the environmental resource and mixed value units are not comparable. Where rehabilitation costs are used, they are intended to express an opportunity cost value of the environment. Use of rehabilitation costs says that we must value the prefire environment at least as much as the cost to restore it. It may also mean that we consider it essential to maintain the quality of the environment, shortening the time of its incapacity and is worth anything spent to correct it. As a drain on the budget, it is a meaningful representation of reduction in National income.

Several methods have been proposed to rate the relative quality of scenery (Sargent 1967, Litton 1968, Twiss and Litton 1966). Rating pre- and postfire quality using such methods can be helpful in appraising the change in scenic quality. Moreover, where some forms of income depend upon visual quality, a loss of income from reduction in visual quality is one measure of damage. Another is restoration or relocation costs.

Subjective, nonmarket values are probably best judged by social and political expressions. These expressions take the form of public opinion, protest, and controversy. The objective of such tactics is to influence individuals, officials, or legislators and to express values. The final result is often a new law. Judicial decisions sought through civil suits are also being used to direct decisionmaking.

These pressures may be aimed at many objectives--increased protection, changes in policy, or more efficiency to conserve certain values-at-risk. Public clamor for more or better protection from fire to produce environmental benefits is an expression that these values are considered higher by some people than obviously valued by legislators or administrators. Thus some values are formed in nonmonetary terms in a political or public opinion "market".

The following questions may be suggestive of other considerations that may apply to a particular case in question. What are the local and regional attitudes toward the environment? Will *any* fires be tolerated? Are the critical effects of fires temporary, irreversible, or persisting? What special features are present?

Dollars are the most convenient measure for economic analysis and should be used as far as possible. But when dollars are meaningless and otherwise fail to fulfill the need to justify fire-control action, the appraiser should not hesitate to use narrative statements as value judgments.

Size and intensity of fires affect damage to the nonforest and environmental values-at-risk, but many conflicting factors are involved so that such statements as to the effect of size intensity cannot be confidently made. Property and human life losses may be high with even a small fire, whereas some large fires may not jeopardize much property or human safety. Environment will probably be little changed by a small fire, whereas the significance of the effects may grow rapidly with increasing size. High-intensity large fires distribute a large quantity of smoke over a large area, but may loft the smoke high enough to be only a minor irritant while smoke from a small, low-intensity fire may be more irritating.

Visual pollution following the fire can be annoying to residents and tourists, but much depends on the location of burned area. A large burn in a remote area may go unnoticed whereas a small burn along a highway or close to a village can be upsetting. Vegetation may respond quickly after a low-intensity fire in central hardwoods so the scars are well hidden by midgrowing season while a moderate-intensity fire in young pine leaves visual reminders for several years.

Thus the value-protected appraiser must estimate the kind and size of fire most likely to cause the most damage to the specific set of values-at-risk being appraised. Consideration should also be given to estimating the fire size and intensity thresholds at which damages begin.

Measures of damage for appraising changes in other environmental values are as follows:

Fire-caused damage to environmental values

A. Air pollution, visibility obstruction, chemical effects

   1. Increase in health costs
   2. Cost of traffic accidents
   3. Cleanup costs
   4. Increased cost of undiscovered fires
   5. Loss of vegetation and crops
   6. Increased cost of fire control

B. Water pollution

   1. Costs to restore pure water at prefire level

C. Soil change

   1. Loss of productivity of soil evaluated through loss of income
   2. Costs of restoring soil condition to prefire status

D. Climate change (usually microclimate)

   1. Restoration cost

E. Ecological state (natural balance of plants, animals, and soil)

   1. Costs to restore the site
   2. Losses owing to fire-caused change in environment

F. Human inhabitability

1. Cost to relocate people
2. Loss to community through voluntary removals, recreationists, etc.

WATERSHED RESOURCE

Concepts

A watershed has value owing to its ability to regulate the rate, timing, and quality of water delivered to streamflow and storage, and to regulate soil erosion. The watershed only receives precipitation and disposes of it through evaporation, transpiration, storage, and streamflow. The watershed, therefore, is a *water processing unit*. The watershed does *not* "produce" water, but it does affect water yield as well as ground water recharge and values related to soil erosion. Watershed behavior is responsive in varying degrees to fire-induced changes in vegetation, soil cover, and soil permeability. Fire-caused *changes* in watershed performance and their impact on people and budgets are of concern in estimating *damage* and *values protected*. We are not concerned directly with *water* resources, only with watershed performance. Watershed consideration must be given in every appraisal of fire damage and value protected even though it is inconsequential.

Every watershed exhibits a characteristic behavior. People living on it or downstream learn something about its behavior. They learn, for example, how high runoff peaks have been; how low the flow may be in drought; the quality of water and its complement of fish; and the amount and effects of soil erosion taking place. They learn to live with and depend on this behavior or they may learn to correct some undesirable aspects. We may assume that certain costs and losses are usually associated with this expected behavior.

Should a wildfire occur on the watershed, the damage it causes will be the amount of the *increase* in costs if any, above the prefire average, any unexpected rehabilitation costs, plus any increase in losses of crops, property, and improvements, recreation opportunities, etc., but these must be in excess of the normally expected costs and losses before the disturbance to qualify as damage.

Critical factors in appraisal of watershed damage are:

1. *Watershed essentiality*.--This is a demand factor. The essentiality of demands for water and watershed services can be graded from absolutely essential to desirable. A dependable supply of good quality potable water is an *absolute necessity* to support a population. The normal water quality from a given watershed is essential to sustain established fish life. A suitable watershed condition is often essential to control soil erosion. Stable water levels are *needed* for commerce, and stable water quality is *needed* for many industrial uses. Water is *desirable* for recreation purposes and amenities, but not absolutely essential.

Almost any increase in demand for water or for watershed services creates an increase in dependency on water yield or for the watershed to maintain a new level of population, crop security, public safety, fish life, or amenities. *Watershed essentiality* is used here in the sense of expressing an *inflexible or increasing demand for watershed services*.

2. *Susceptability of watersheds to change in behavior when burned*.--The watershed stability (capacity of watersheds to maintain normal behavior in spite of disturbance) varies widely--from very stable to very unstable.

A fire may kill vegetation and destroy the soil cover. This affects the capacity of the soil to absorb precipitation and resist soil erosion. The amount of precipitation reaching the soil is increased by a reduction in interception by vegetation cover and the capacity to hold added water is reduced because less of the precipitation received is removed by transpiration. These changes affect the rate and timing of runoff and increase soil movement permitting some soil to be carried into streams and deposited in reservoirs or spill over into lowlands in floods. The amount of change is further influenced by the size of the area burned and by the capacity of the stream channel to carry an increased flow of water and soil.

Susceptibility of a watershed to change in quality of function relates directly to the cost of supplying the watershed services if some constant or increasing requirements are assumed. Thus, to maintain a given quality of services may cost more if the quality of watershed performance is reduced. When attributed to fire, this additional cost can be construed to represent one aspect of the damage.

Effects of changes in watershed behavior on essential watershed services.--Appraisal of damages amounts to an evaluation of the effects of changes in watershed behavior on the plans, objectives, activities, safety, and budgets of institutions and individuals that depend upon the watershed behavior. Thus, there are three categories of watershed damages (assuming a constant demand and essentiality):

A. Costs to restore and rehabilitate the watershed to prefire performance levels, or to provide temporary or permanent substitutes for prefire watershed performance.

   1. Land treatment costs (revegetation, soil stabilization, channel repair, bank stabilization, etc.).

   2. New construction costs to compensate for loss of watershed functions. (Water-treating facilities, reservoirs, dams, flumes, etc.)

B. The *increase* of costs and losses resulting from loss of watershed function: increases in costs of domestic water, road and bridge maintenance, repair or replacement of facilities and improvements, repair of equipment, supplies, and property caused by a change in watershed behavior.

C. Value of property, recreation opportunities, or business income lost or destroyed.

Any of these losses may accumulate over the period during which the watershed function is subnormal.

Other services, such as suitable fish habitat, navigation waters, lake shore, involve so many property owners or so large an area that they must be managed by common consent and objectives, a function that is typically political and governmental.

The *essentiality* and *stability* of the thousands of watersheds is highly variable. These two factors are very important in estimating damage and values protected. At one extreme are highly essential watersheds that are very unstable; at the other extreme are stable watersheds whose service if of little consequence.

Rehabilitation measures are routine in some areas but not in others. The absence of rehabilitation must indicate some value judgment. Either the watershed function is not changed materially by fires or the effects are ignored or not understood.

Appraisal

A comprehensive list of costs and losses is given in the sample form shown in figure 3. If such costs can be estimated directly from information about the burned watershed, no other process is needed to obtain damages.

Damages and value protected should be estimated using the same type of information. In appraising damage, only increased costs and losses made necessary because of an *actual* burn should be included. In appraising value protected, estimates are needed of the costs that would be necessary if the watershed would be burned by a fire that caused maximum loss of benefits to the appraisal unit.

Some costs or losses may affect other resources, such as recreation and wildlife. They may be included where most applicable, but should not be counted twice.

Probable maximum damage must be estimated for the entire watershed unit and divided by the acres to obtain the mean value protected per acre. Therefore, it is necessary to define the watershed unit area under appraisal and the probable size and intensity of the largest fire or the fire causing maximum damage.

Value protected per acre is not constant for all fires in a unit because (1) as the fire increases in size, its effects involve areas downstream from the burn; and (2) the accelerating effects generated by increased areas of reduced watershed capacity.

	No. Units	Cost/Unit	Total Increased Cost
A. WATERSHED RESTORATION COST			
1. *Land Treatment Costs:*			
a. Cost of revegetation.	A.	$	$
b. Cost of mechanical soil stabilization	A.		
c. Cost of restoring fish habitat	Mi.		
d. Cost of bank stabilization (rip-rap etc.)	Mi.		
e. Other			
2. *New Construction Costs:* To compensate for loss of watershed properties			
a. Water filtration & treating equipment & installation			
b. Reservoirs to compensate for irregular flow			
c. Dams, flumes, etc.			
d. Other			
B. INCREASED COSTS			
1. *Increased or New Maintenance Costs:*			
a. Cost of road repair & maintenance	Mi.		
b. Cost of buildings, & bridge maintenance	No.		
c. Cost to maintain damaged equipment	No.		
d. Other			
2. *Replacement or Repair Cost (any purpose items):*			
a. Personal Property			
b. Equipment & supplies			
c. Building, bridges, crossings, etc.			
d. Fish planting			
e. Irrigation facilities			
f. Other			
C. LOSS OF OPPORTUNITY, PROPERTY, & INCOME			
1. *Loss of Income & Property:*			
a. Temporary business income loss			
b. Permanent business income loss			
c. Crop loss (investment plus profit)			
d. Other			
e. Property			
2. *Opportunity Loss:*			
a. Recreation opportunity loss (including amenities, fish, bathing, boating, etc.)			
b. Living space environment loss			
c. Business opportunity			
d. Other			
(Describe loss & estimate cost if possible otherwise give relative value class when possible.)			
Total Loss and Cost			$
Average VP/A Protected			

Indicated value from sample form, figure 6._____

Figure 3.--*Sample form for estimating watershed damage or value protected.*

Watershed damage per acre varies with the size and intensity of the burn. For example, the damage per acre and total damage on a 20,000-acre watershed might vary as follows:

Fire size (Acres)	*Damage/acre* (Dollars)	*Total damage* (Dollars)
10	10	100
100	15	1,500
1,000	100	100,000
10,000	150	1,500,000
20,000	140	2,800,000

The $140 estimate is useful for comparison or combination with value-protected estimates for other resources on the same unit. It would not be representative of damage per acre on small fires, only of potential loss on large hot fires for which planning is needed and it would help to fix the objective of suppression for the unit. This is the value that is protected.

Selecting Watershed Unit Size and Size of Fire

There are no firm rules for delineating unit watersheds or for determining maximum fire size and intensity for appraising watershed value protected. Much depends upon past experience and on the status of management.

Management of watersheds to produce or maintain benefits is ordinarily a response to a need to preserve or enhance watershed performance. The intensity or level of management is predicated on stability of watershed performance and the essentiality of service. The level of management in practice may be a good guide to value protected as well as a help in defining the watershed unit for appraisal because it is probably more intensive on important watersheds that lack stability.

For example, management levels 1 and 2 in table 2 involve little or no recognition of watershed problems and provide only incidental unplanned attention to them. The exception might be that the extensive protection shown in level 2 may be specifically for watershed protection. Although serious watershed problems may be ignored, the principle fire-control planning problem is at the higher levels of planning and policymaking where decisions are made whether or not to protect these lands.

Management levels 3 or 4 are found on the bulk of wildlands both public and private. Watershed management tends to be passive--prevention of watershed deterioration is desired, but little or no manipulation is done to accelerate watershed benefits. There may be no watershed management program other than the incidental benefits accruing from fire control and

Table 2.--*Levels of watershed management*

Level of management	Land use objective	Protection	Regulation of land uses	Usual restoration after disturbance
1	None or speculation	None or very extensive	None	None
2	Vague or general	Extensive fire control	None or minor	None
3	Multiple or specific watershed function recognized but no active watershed management program	Intensive fire control; no distinction among watershed	Vague, may include rural zoning though not specific for watershed	Rare, only in special cases
4	Watershed management through multiple-use planning only	Intensive fire control; specifically recognizing watershed value protected	Other uses planned and regulated to protect watershed	Not routine but done when needed
5	Extensive watershed management at least a secondary objective and may be a primary	Intensive fire control	Regulated in favor of watershed	Definately routine but extensive
6	Watershed a primary or single use	Intensive fire control; perhaps even to trespassing	Strict regulation or exclusion of potentially harmful activities, vegetation may be manipulated to favor water yield or protection	Routine and thorough

management of other land uses structured to prevent watershed deterioration. However, a broad range of watershed stability, essential services, and uses is included so that some discrimination among areas is needed to guide modern fire-control planning.

Management levels 5 and 6 pertain where active watershed management programs are in operation to maintain or improve watershed benefits. Such lands may be located anywhere but will usually be found where watershed problems are somewhat critical, such as on rough topography, in dry climates, or where soils are highly erosive. Extensive or intensive management programs may be followed.

Where management levels 5 or 6 are in effect, watershed units are most likely already defined and qualified managers having good knowledge of the behavior of the watersheds are employed. Although values protected may not have been appraised, the managers should be in a strong position to make such estimates.

The principle problems of unit definition occur with lands under management levels 3 and 4, and with those management level 1 and 2 lands that may be considered for fire-control districts in the future.

Problems in unit definition arise because of the wide range of conditions found on land under management levels 1, 2, 3, and 4. Watershed management is seldom a major priority in land management on such lands, which indicates either that watershed problems are not serious or are not recognized. Nevertheless, there is a need to examine areas to determine relative values protected because of the wide range of soils, topography, land ownerships and uses, watershed dependency, the likelihood of patchwork protection boundaries with parallel agencies having fire protection responsibilities--perhaps on the same drainage. Fire control may be the only approach to watershed benefit production. It is important at least to single out those watersheds on which expenditures for fire control will return highest benefits even on a relative scale.

The first step would be to draw the drainage boundaries of a protection unit on a map. A simple classification of drainages could be developed from general knowledge of the drainages. The classification should be based upon the essentiality of the watershed function and the uses supported, and the topographic features of slope and length of slopes, soil and cover stability affecting the susceptibility to loss of watershed quality by fire[2].

From this classification of drainages, three groups can be set up (1) drainages having high essentiality and high susceptibility to loss of function; (2) drainages having low essentiality and dependence and high stability; and (3) drainages having intermediate characteristics. Because there are no apparent serious problems involved in the low essentiality, high stability drainages, these can be grouped into one large class of lands for which little or no special appraisal or protection is needed. These would be the lowest value-protected watersheds. The medium class may need some special protection efforts, but the high essentiality, low stability group needs to be examined in more detail. These will be the highest in "value protected" of the watersheds on the district and may require special efforts in planning for fire control.

A district might be all of the same class, for example, all plains with deep sandy soils, where the watershed characteristics might not be changed appreciably by fire. But another district might contain a variety of soil types, topographic characteristics, and dependence on the watershed.

The size of watershed units can be established especially for the higher relative value-protected drainages by combining small drainages into large logical units having as homogeneous characteristics as possible. However, the units should preferably not be more than twice the size of the largest major fire occurring during the past 20 to 30 years. Preferably, units should be limited to less than 30,000 acres.

This analysis should be carried out as far down the line of values protected as needed to ensure meeting protection objectives.

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[2]*Some administration units already have methods for classification.*

When the units are delineated, an appraisal should be made of maximum probable damage for maximum destructive fire size on the unit. The total estimate should then be divided by the area of the unit in acres to obtain a value protected per acre in dollars.

Costs to restore watershed functions and services and probable loss of benefits vary over the thousands of small watersheds. Costs are related to specific watersheds, the work that would be needed to restore them if burned, variations in costs of doing specific jobs, and to the urgency for making repairs. So, there is very little opportunity to develop general correlations among fire size and severity, rehabilitation costs, and losses in dollars for large areas. Therefore, valuations should be made on the ground for specific watersheds.

Estimating Relative Value Protected for Watersheds

Use the sample form shown in figure 4. If the computation is an estimate of damage from a given fire, information is recorded in the first set of columns headed DAMAGE. If the computation is an estimate of value protected, use the appropriate columns headed VALUE PROTECTED.

Estimates for the potential type of protection served by the watershed and for the potential type of property and investment value per watershed can be derived

ITEM	DAMAGE		VALUE PROTECTED		INDEX	
	Pre-fire rating	Post-fire rating	Pre-fire rating	Post-fire rating	Damage	Value protected
1. Type of service (Code)					XX	XX
2. Property value (Code)					XX	XX
3. Watershed Essentiality	XX	XX	XX	XX		
4. Hydrologic soil group (Name_____)					XX	XX
5. Storm precipitation					XX	XX
6. Soil cover class					XX	XX
7. Increase in runoff (table 4)	XX	XX	XX	XX		
8. Soil texture					XX	XX
9. Natural protection code					XX	XX
10. Soil permeability					XX	XX
11. Basic erosion factor (table 7)	XX	XX	XX	XX		
12. Land slope (percent)					XX	XX
13. Relative increase in erosion (table 5)	XX	XX	XX	XX		
14. Years to recover					XX	XX
15. Est. of total relative change in watershed behavior (table 8)	XX	XX	XX	XX		
16. Indicated value (table 9)	XX	XX	XX	XX		

Adjustments:
17. Channel capacity: Poor _____ Average _____ Good _____
18. Percent of watershed burned: _____
19. Location in respect to channel: >2 chains: _____ Adjacent: _____

Figure 4.--*Sample form for computing estimated indicated watershed damage and/or value protected.*

using table 3. The values given to the five classes of potential protection served (I-V) are selected in the order in which people would be likely to give up the service. The security of human life, for example, is more important than economic security. The current emphasis on amenities could cause some problem: if a choice had to be made between economic security and amenities, however, the pragmatic choice would likely be in favor of economic security and safety even though amenities might have a high value.

The potential property resource and/or investment value represents values that could be affected by a change in hydrologic behavior of the watershed. Property on or close to flood plain limits, fishing waters, crop lands, and improvements are examples of property and activities that may be affected. Here we are only interested in the *increase* in value jeopardized by a breakdown in watershed function. For example, of 100 percent of value on the watershed unit, 5 percent normally is subject to losses when the watershed is undisturbed. After a fire, the value jeopardized may increase to 8 percent. The increase in value jeopardized is 3 percent as a result of fire.

Table 3.--*Watershed essentiality (potential uses, security on the watershed or within downstream influence)*

Type of service provided (see code below)	Property value code 1	2	3	4	5
1	I	II	III	IV	V
2	II	II	III	IV	V
3	III	III	IV	IV	V
4	IV	IV	IV	IV	V
5	V	V	V	V	V

Type of service provided code:	Increased value of property resource and/or investment per watershed unit jeopardized by fire (in dollars):
1. Little or no security involved.	1. 0 to 1,000
2. Site productivity protected only.	2. 1,001 to 10,000
3. Protection of amenities: scenic and aesthetic values--non-contact water recreation such as boating, and some wildlife water.	3. 10,001 to 100,000
4. Economic security: industry and irrigation water, fisheries, and navigation, disposal water, water power, farms.	4. 100,001 to 1,000,000
5. Security of human life and health: domestic water, ecosystem maintenance, body contact recreation, flood protection.	5. 1,000,000 plus

Entries 4 through 15 of figure 4 relate to the susceptibility of the watershed to changes in hydrologic behavior if it is burned. It provides an estimate of the relative susceptibility of different watersheds to produce an increase in direct runoff (table 4) and soil erosion (table 5).

The estimated relative change (increase) of runoff is developed from the hydrologic soil groups[3], expected storm precipitation (2-year 24 hour storm), and change in soil cover class (table 6). The soil erosion increase estimate is developed from soil texture, natural soil protection, soil permeability, land slope, and cover change (tables 5 and 7).

Time to recover is used in combination with the maximum rating of either table 4 or 5 to obtain the total estimated relative change in watershed behavior (table 8).

Entry 16 in figure 4 is obtained by combining the watershed essentiality rating with the susceptibility to change in hydrologic behavior (table 9).

Limitations

The estimate is relative--not absolute. Actual damage and/or value protected must still be determined from restoration cost and property loss estimates made for the watershed. The main purposes of the relative watershed rating are (1) to direct the analysis of the situation, (2) to determine the relative justification for undertaking restoration costs, and (3) to guide planning. The ratings should be useful for planning protection to find the relative urgency for protection among different watersheds.

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[3]*USDA Soil Conservation Service. 1964. Soil names and hydrologic classification. USDA Soil Conserv. Serv. Nat. Eng. Handb., Sect. 4 Hydrol., Part 1 Watershed Plan.*

Table 4.--*Relative increase in direct runoff from burned areas*[1]

Fire-caused change in soil cover class[2]		Hydrologic soil group[3]															
		A				B				C				D			
		Storm precipitation (inches)															
From	To	1	2	4	6	1	2	4	6	1	2	4	6	1	2	3	6
II	I	L	L	M	M	L	L	M	M	L	L	L	L	L	L	L	L
III	II	L	L	M	M	L	L	L	M	L	L	M	M	L	M	M	M
III	I	L	L	H	VH	L	M	H	H	L	M	H	H	L	M	M	M
IV	III	L	L	L	M	L	L	M	M	L	L	L	M	L	L	L	L
IV	II	L	L	M	VH	L	M	H	H	L	M	H	H	L	M	M	H
IV	I	L	L	VH	E	L	M	VH	E	M	H	VH	VH	M	M	H	H

[1]Approximate value of entries: L = low increase in runoff--0.49 inch. M = medium increase--0.50 to 0.99 inch. H = high increase--1.00 to 1.49 inches. VH = very high--1.50 to 1.99 inches. E = extreme--more than 2.00 inches increase. NOTE: Direct runoff includes overland flow. The proportion of overland flow will increase in progressing form A to D soil groups, it is likely that relatively small amounts would be noted as overland flow whereas a larger part of the smaller increase would be overland flow with C and D soil groups. The relatively smaller increase in C and D soil is because these already have higher rate of yield and the soil exposure does not cause a large increase.

[2]See cover class descriptions and specifications, IV is best condition, I is poorest.

[3]Refer to soils classification.

[4]Obtain amount of storm precipitation from climatological summary for a given locality.

Table 5.--*Relative increase in soil erosion on burned forest watershed areas*

Basic erosion factor	Soil cover condition change		Land slope (percent)								
	From	To	10	20	30	40	50	60	70	80	90
1	II	I	L	L	L	L	LM	M	M	M	M
	III	II	L	L	L	L	M	H	H	H	H
	III	I	L	L	M	M	H	H	H	VH	VH
	IV	III	L	L	L	L	L	L	L	L	L
	IV	II	L	L	L	M	M	H	H	H	H
	IV	I	L	L	M	H	H	H	H	VH	VH
2	II	I	L	L	L	M	M	H	H	H	H
	III	II	L	M	M	H	H	H	VH	VH	VH
	III	I	L	M	H	H	VH	VH	VH	E	E
	IV	III	L	L	L	L	L	L	L	L	L
	IV	II	L	M	M	H	H	VH	VH	VH	VH
	IV	I	L	M	H	H	VH	VH	VH	E	E
3	II	I	L	L	M	M	H	H	H	VH	VH
	III	II	L	M	H	H	H	VH	VH	E	E
	III	I	L	H	H	VH	VH	E	E	E	E
	IV	III	L	L	L	L	L	L	L	L	L
	IV	II	L	M	M	H	H	VH	VH	E	E
	IV	I	L	H	H	VH	VH	E	E	E	E
4	II	I	L	L	M	M	H	H	VH	VH	E
	III	II	L	H	H	VH	VH	VH	E	E	E
	III	I	M	H	VH	VH	VH	E	E	E	E
	IV	III	L	L	L	L	L	L	M	M	M
	IV	II	L	H	H	VH	VH	VH	E	E	E
	IV	I	M	H	VH	VH	VH	E	E	E	E

[1]L = low, least amount of change in soil erosion; M = medium amount of change; H = high amount of change; VH = very high amount of change; and E = extreme amount of change.

Table 6.--*Summary of hydrologic cover condition criteria and classes*

Criteria	Prefire condition				Postfire condition			
Hydrologic condition	I	II	III	IV	I	II	III	IV
Bare exposed soil (percent) (F and H less than 1/4 inch)	>70	35 to 70	10 to 35	<10	90	40 to 70	10 to 40	<10
Litter cover:								
Depth (inches)	Thin	Thin	1 to 2	2+	All burned			
Coverage (percent)	<40	40 to 75	75 to 90	90	30	30 to 60	60 to 90	90
F and H:								
Depth (inches)	Very thin	Thin	1/2-1	1+	Mostly Burned		Part-burned	Intact
Coverage	<30	30-60	60-90	90	<30	30-60	60-90	90
A_1 horizon Depth if present (inches)	<1/4	1/4 to 1/2	1/2 to 1	1+	Little immediate change			
Forest floor weight (tons/acre)	<1	1 to 4	5 to 8	8+	<1	1 to 3	4 to 6	6+
Live vegetation cover	Thin	Moderate to well stocked	Moderate to well stocked	Well stocked	More than 80 percent dead or top-killed all sizes	Most saplings and poles dead or top-killed	Most saplings top-killed	Only smaller vegetation killed or top-killed
					>90 percent exposure	60 to 90 percent exposure	40 to 60 percent exposure	>40 percent exposure
					Annual and perennial herbs mostly all top-killed and some dead. Any fire.			

Table 7.--*Basic soil erosion factor estimate*

Soil permeability[1]	Soil texture[2]								
	Coarse			Fine			Medium		
	Natural soil protection[3]								
	2	1	0	2	1	0	2	1	0
Rapid (A)	[4]1	1	1	1	1	2	2	3	3
Medium (B)	1	1	2	1	2	3	2	3	4
Slow (C)	1	2	2	2	2	3	3	3	4
Very slow (D)	2	2	3	2	3	4	3	4	4

[1]If no better approximation of permeability is available, use the hydrologic soil group estimates A, B, C, and D.

[2]Soil texture: coarse = sand, gravel, sandy loam, loamy sand, sandy clay, sandy clay loam; fine = clay, clay loam, silty clay; and medium = fine sandy loam, silt loam, silt, loam, silty clay.

[3]Natural protection: 2 = site has 2 or 3 of the following characteristics: rocky surface (more than 50 percent rock cover); above average surface roughness, strong stable soil structure; 1 = site has only 1 of above characteristics; and 0 = none of the above characteristics present.

[4]Approximate factor values:
1 = soil loss less than 25 tons/acre/year; K = less than 0.25. 2 = soil loss 26 to 60 tons/acre/year; K = 0.26 to 0.35. 3 = soil loss 61 to 100 tons/acre/year; K = 0.36 to 0.45. 4 = soil loss more than 100 tons/acre/year; K = more than 0.45.

Table 8.--*Estimate of total relative change in watershed behavior*

Highest rating either increased runoff or erosion	Years to recover former watershed function			
	0 to 3	4 to 8	9 to 14	15+
Low	L	M	H	E
Moderate	M	H	VH	E
High	H	VH	E	E
Very high	VH	E	E	E
Extreme	E	E	E	E

Several local interpretations are needed, however, to narrow down the significance of the estimates. Damages will be affected by the area burned and how it is located. Area burned will affect both total effect and total damage. In estimating value protected, however, a burn covering enough of the watershed to cause approximately the maximum damage must be considered.

Table 9.--*Indicated relative value protected*[1]

Susceptibility estimate of total relative change in watershed behavior	Essentiality				
	I	II	III	IV	V
L	I	I	II	II	III
M	I	II	III	III	IV
H	I	II	III	IV	IV
VH	II	II	III	IV	V
E	III	III	IV	V	V

[1]Rankings are devised for stream channels having average characteristics. If channel is less than average or poor in carrying capacity, advance rank one class. If channel has much better than average characteristics to carry additional loads, rank may be decreased one class.

Indicated value-protected class	*Interpretation*
Class I	Little if any restoration costs justified and little property damage possible.
Class II	If susceptibility is high, essentiality is low and vice versa. Only small costs are justified and other losses light. Below average in value protected.
Class III	Same as II but at a higher level of essentiality or susceptiblity. Some restoration is justified but usually not done. Other losses only moderate.
Class IV	Occurs only on Essentiality Class III, IV, or V watersheds. Extra effort cost is justified. Many different items of cost class are indicated.
Class V	Both essential and susceptible. All useful measures should be taken to restore the watershed. Property losses may be high and all types of costs are possible and justified as needed. Highest value-protected class.

On steep watersheds with shallow soil and narrow, shallow channels, flash floods could occur with minor increases in runoff. On broad, flat watersheds with deep soil and adequate channels to carry flow, the same increase in runoff might hardly be noticeable--and would be expected over a longer period of time.

If the fire leaves a strip of unburned area along the stream, it is likely that much of the eroded material will be trapped in this strip and not pollute the stream. If the burn extends along the streambanks, the chance of stream pollution is greater. Moreover, if the streamside vegetation is killed, the chance of increased stream temperature is greater, which could change the fish habitat.

This relative value could be useful as a guide for (1) estimating lost benefits and justifiable restoration costs when estimating damage for specific fires, and (2) for a first estimate of value protected for inventory and fire-planning purposes. Approximate dollar estimates could be made by classifying watersheds into their respective relative indicated value classes and dollar estimates made for sample watersheds representing the classes. Actually, on a given forest or even section of the State, there should be some similarity in hydrologic behavior among watersheds of a given nature. The large differences will be caused by different physiographic and climatic conditions occurring between regions and in benefits or savings produced. The procedure would be most applicable to management levels 3, 4, and possibly 5 (table 2). Much better information should already be available for management class 6.

Unfortunately, there are no generally applicable precise formulae available from which the effects of forest fires on watershed behavior can be predicted. The variables are numerous and complex, joint effects are common and are not well documented (Settergren 1967). Moreover, the effect of watershed changes on the activities and values varies among watersheds.

TIMBER AND RELATED RESOURCES

Concepts

The timber resource is identified as those forest stands included in calculating allowable cut on managed forests or on unmanaged public and private forests. It does not include stands currently and potentially nonmarketable; those reserved from cutting by law, regulation, zoning, or withdrawn for other purposes; and stands physically inaccessable by acceptable standards for the coming rotation.

Stands permanently withdrawn from timber use are excluded from the timber resource (allowable cut base) although National emergencies could force a change in status: National Parks, some forest preserves, and wilderness areas. If timber loss must be estimated for these areas, possible future returns must be discounted for long periods of time resulting in very low loss. If salvage of fire-killed timber is done on such areas, the income must be considered as an unexpected increase in income rather than a loss. In most instances, no timber loss should be claimed.

Other losses, however, such as those for recreation that depend on the trees, may be claimed.

Timber related resource cover items depending on the value of the timber resource but not usually considered in appraising the timber resource alone: real and personal property, primary forest products destroyed (pulp pile, logs, etc.), and community values to labor, business, and residents.

Physical Measures Needed for Estimates

To estimate timber loss, determine fire-caused mortality as well as growth loss from all fire-related causes, which together are known as *growth impact* (USDA Forest Service 1958).

Fire effects on timber resources may include: killed or top-killed trees, bark and outside wood charring, injuries to surviving trees that could cause degrade and volume loss in later years from disease and insect attacks and increased branching due to stocking level reduction, soil exposure with possible effects on physical soil characteristics affecting seedbed and site characteristics, undesirable changes in species composition in future natural stands, and failure to restock to desirable species requiring treatments to reestablish growing stock.

Timber survey methods are well known to practicing foresters and need not be elaborated here. Any system that will develop information on the mortality of merchantable trees and growing stock and show the effects of fire on young growth and future volumes and quality should provide the needed information.

Perhaps the most comprehensive method for obtaining field data and computations of fire-caused timber volume loss was devised by the USDA Forest Service Survey Section. Detailed instructions are contained in *3152.42 Handbook on the Appraisal of Fire Damage to Timber on Protected State and Privately Owned Commercial Timber Lands*.

The principal challenges in making the physical survey are (1) to identify soon after a fire potential future volume and quality reduction in surviving trees, and (2) to predict the ensuing stand and its merchantable volume during the coming rotation. Unfortunately, few foresters have opportunities to develop the experience to do this and must rely on available research and/or local experienced people. A list of appropriate references is included in Appendix II.

Predicting the stand expected to follow a fire is difficult. Successful natural regeneration varies with species, soils, climate, and especially macro- and microclimate variation immediately folowing the fire. In some localities, regeneration is fairly certain; in others, it is very unlikely. The general probabilities should be fairly well known in a locality. Appraisers should make it a point to learn how forests in the area respond and how this response varies with fire intensity.

Site deterioration is an aspect of fire damage about which too little is known. It is also likely to be overrated. There are glaring examples of site deterioration such as the loss of organic soils on which vegetation has survived. Perhaps fires on coarse soils where the organic materials are not plentiful or rapidly recycled and vegetation is slow to reestablish represent situations where fires may reduce site quality mainly through the loss of nitrogen and nutrient necessary to start a new cycle of vegetation.

The most probable effects of fire on site quality relate to changes in soil nutrients, soil physics, including moisture relations, and microclimatic effects. Such effects as the release of minerals held in deep mor humus in cold climates have been shown to be beneficial. Moreover, there is little proof that fires in general reduce site quality.

Injured Stands

Injury is perhaps a greater cause of damage in hardwood than in conifer stands. Typical fires in hardwood stands are lower in intensity and less apt to burn in the crowns than fires in conifer stands. The result is that injury is high in hardwoods and mortality is high in conifers.

On medium sites, the critical period for hardwoods is when the trees are 30 to 60 years old, while they are in the large pole and small sawtimber sizes. At an

earlier age, while the trees are of seedling and sapling size, injured trees will often outgrow wounds and produce little degrade in quality of logs (Loomis 1973).

Older and larger trees are less vulnerable to injury, and have salvage value. Moreover, if salvaged before wood rotting has begun or while confined to the sapwood,[4] little loss will occur because injured wood will be slabbed off in the waste. Principal losses will be due to harvesting smaller-size timber, which may reduce stumpage price as well as volume. It may be necessary, however, to hold the injured trees until they can regenerate a new stand particularly if regeneration is dependent upon seed.

Economic Measures of Damage

Timber damage and value protected can usually be appraised more accurately than other forest resource damages because of better market and product measures, although there are uncertainties to consider. Loss of income is the difference between the present value of the expected net pre- and postfire returns from sale of stumpage where salvage is included in postfire returns. The methods of appraisal may be direct market value, conversion return, discounted net value of future returns or conversion returns, and, in some instances, replacement cost.

Other items that may be appraised in estimating timber and timber related damages are as follows:

1. Costs or increase in costs as a result of fire to:

    a. Reestablish stands that would not have been required without fire.

    b. Sanitize burned stands to control insect and disease outbreaks.

    c. Other timber stand improvement to remove unmerchantable fire-caused cull and potential cull and to increase desirable species and growth that would have been unnecessary without the fire.

    d. Reduce fuel hazard increased by the fire.

    e. Increased administrative costs to revise and carry out the management plans.

2. Loss of primary forest products destroyed by fire such as pulpwood, logs, bolts, posts, and poles[5].

3. Loss of timber-related improvements and equipment used in timber harvesting.

4. Community losses, including loss of jobs that cannot be replaced or income of suppliers and service industries.

Streeby outlined the major constraints and suggested methods for estimating timber damage in each case. The major constraints are marketability of timber, planned cutting date, and kind of management.

Streeby designated market conditions as *full allowable cut sold,* and *full allowable cut not sold.* Full allowable cut sold is described as an approximate balance between stumpage supply and demand, or as an excess of demand over supply. This does not assume temporarily depressed markets or cyclic situations, but rather situations where competition for the supply has been and is expected to continue strong. The case is usually characterized by bid prices higher than minimum acceptable appraised prices of stumpage. It also applies to areas of young timber of desirable species and quality that are expected to have good markets when they reach merchantable size. Markets for species may vary on the same areas, but it should not be difficult to designate areas and species on any protection area filling these qualifications. Probably the bulk of all timbered areas in the United States fall in this cagegory.

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[4] *The time available for salvage with minimum loss from degrade varies with species, climate, and infection opportunities. Wood rotting tends to develop faster in warm, moist climates and is slower in cool, dry climates. Insect attacks that kill and weaken trees may begin very quickly. Local considerations will govern the decision.*

[5] *Ownership in items 3 and 4 must be considered in estimating* who *loses, but for planning purposes it is immaterial who loses if the values are at risk.*

Where this condition applies, timber stands injured or destroyed by fire can be valued by using market price. Young stands below merchantable size, however, should be appraised by discounting future returns, or by replacement value. In any case, the value of salvaged material should not be claimed as damage. Moreover, if the next rotation harvest is advanced or brought closer to the present because of the fire, an adjustment should be made for the changed timing of the next harvest cut and returns. In many cases, the effect on the appraisal is small and could be ignored.

Full allowable cut not sold is characterized by a stumpage supply greater than the demand so that not all the allowable cut is used or sold. Bid price is usually close to or the same as appraised price and competition is weak or nonexistant. Some offerings are not sold and some merchantable-sized stands are not even offered for sale.

Markets are subject to change--sometimes suddenly--because of new technology, shortages in more desirable species, changes in accessability, or entry of new capacity for use.

Damage to such markets should not be large. The two market conditions shown in table 10 are possible: (1) timber sold before being burned or is burned during harvest, and (2) timber is not sold before the fire. If the timber is not sold, it may be salable now at minimum price or it may be merchantable at some future time. If it is never expected to be merchantable, it would not be included in the allowable cut base.

If the timber is sold or in process of harvesting, any damage should be appraised on the basis of the sale price as in the case of full-cut-sold. If timber is plentiful and a less valuable stand is substituted for the burned stand to complete a sale, the difference in value of the two stands is a measure of loss of income.

If a substantial part of a rotation is expected to elapse before the timber is marketable, new growth may replace the trees burned before they are needed, thus, no loss of income would occur. If, however, the timber would become marketable in the future and because of the fire is then not suitable, the discounted expected future net returns would be the base for claiming damage.

At present this case applies mostly to inaccessible stands, stands of low volume and quality, and stands of presently unmerchantable species. Some good site, low-quality stands could benefit by a fire that destroyed the unmerchantable trees if a new stand was established.

Planned or estimated date of cutting distinguished between cuttings planned or contracted for the current year from timber to be cut in the future up to a rotation or more hence. Current year contracted cutting should include the period through the time the contracted price for stumpage is valid.

Damage to timber contracted for sale during the first year of the contract (beginning with sale preparation) can be appraised at market prices. Timber to be cut in the future should be appraised at the discounted value of future net returns. Young timber having merchantable value, however, may be appraised at the present market value even though growth in volume and value may have been expected to make the stands more valuable in the future.

Kind of management must distinguish between even-age, and all-age management because this influences the technique of estimating damage. In even-age managed stands loss of seedlings, saplings, and even pole-size trees that are substantially smaller than the average of the stand does not ordinarily constitute damage. In all-age managed stands, however, each age and size class of trees is needed in the stand at all times, hence the loss of the smaller trees at any time constitutes damage.

It is particularly important to avoid overappraisal of stands for which only a future market exists and to avoid appraising timber loss on forests withdrawn from the market.

Value Protected

The whole timber value that is at risk in the worst fire that may occur determines the value protected, however, a lesser value based on the worst probable

Table 10.--*Methods for appraising damage to timber*[1]

Kind of Stand and Planned Cutting Date	Method: Full allowable cut sold	Method: Full allowable cut not sold
EVEN-AGE STANDS		
1. Seedling-sized plantations	(1) Replacement cost + (2) Loss of growth (years since planting).	(1) Replacement cost if advisable. (Planting may not be a viable option for timber, but may have other values.)
2. Sapling or pole sized but currently unmerchantable sized plantations	(1) Market value of similar stands (transaction evidence) less land value if separated. (2) Discounted future net returns adjusted for timing of rotation. (3) Cost value. (4) Replacement cost.	Same as for Full Allowable Cut Sold except no loss if natural reproduction will form a suitable stand by the time it is needed.
3. Immature and presently less than merchantable size natural stands.	(1) Market value of similar stands (transaction evidence) less land value. (2) Discounted future value of returns with adjustment for timing of rotation.	No loss if stand and growth will likely be replaced naturally before needed. (1) Costs of sanitation, timber stand improvement, and probable hazard reduction.
4. Early merchantability stand. a. pulp stands b. nonpulpwood (no current cutting planned)	(1) Stumpage market value minus salvage with adjustment for earlier next rotation. (1) Stumpage market value minus salvage adjusted for rotation. (2) Discounted future value minus salvage adjusted for rotation. (Use when large growth in value is expected.)	No loss if replacement is expected by time stand would be harvested. Otherwise same as for Full Allowable Cut Sold.
5. Mature or near mature stands. a. to be cut now b. future cutting planned	(1) Stumpage market value minus salvage. (1) Stumpage market value minus salvage. (2) Discounted net future value at planned harvest minus net salvage and adjustment for earlier rotation.	(1) Market value of stumpage minus salvage. (2) Loss from substituting another less valuable stand to protect purchaser. (1) Discounted reduction in net harvest returns minus net salvage. (2) No loss except for sanitation or timber stand improvement if full cut is not expected during this rotation.
ALL-AGE STANDS		
1. Managed and regulated a. full salvage required b. no change in cutting routines	(1) Stumpage market value minus salvage adjusted for irregularity in future returns. (1) Discounted expected returns without fire minus expected with fire returns	(1) Situation unlikely to occur. (1) Same.
2. Unmanaged	(1) Stumpage market value minus salvage.	(1) If marketable now, prefire market value minus salvage only. (2) If marketable only in distant future, discounted without fire minus with fire net future value.

[1]Add the fire-caused costs of management, timber stand improvement, or hazard reduction as appropriate in each case.

fire is sometimes used in planning fire control action.

Value protected can be estimated by using the same methods suggested for damage appraisal to establish the present value of forest stands less salvage following fires. A broad average value per acre for a large protection unit or even a State may be obtained using rough methods. However, such appraisals do not provide the value discrimination among resource units needed for planning protection on small planning units. It could be prohibitively costly to make detailed appraisals for all resource units in a protection area.

If we assume, however, that the value classes ($250 to $500 per acre) being used by the USDA Forest Service reflects approximately the range of value differences that can be correlated with significantly different levels of fire control, it would

not be necessary to appraise differences less than $500 for estimating timber values for resource units in value protected. Because this is not a very sensitive value separation, appraisals can be approximate without loosing significance.

Even-Age Management

For estimating standing immature timber value, discount to the present the expected net stumpage return per acre at maturity as follows:

$$PV = \frac{FV}{1.op^n} = \frac{\text{Expected Future Value (FV)}}{(1 + \text{interest rate})}$$

If fire-killed timber is not salvageable because of the fire or because it is not marketable (too young), the timber loss (value protected) would equal its discounted future value at full maturity. *If the timber is salvageable*, the value would be present value minus salvage (PV-S). For example, merchantable products begin to be produced at age 40, and full salvage of burned timber is carried out. The salvage value increases with age of stand; therefore, the potential value protected is reduced as the stand age increases. At rotation age, the salvage is approximately equal to rotation income and loss approaches zero if salvage value is not reduced below normal market value by the fire.

In general, the value protected for most even-aged stands that can be salvaged is highest during the period just before merchantable products are first produced. If the timber is rendered unsalvageable by the fire, however, the value protected increases throughout the rotation and is greatest if killed at full maturity.

This method of finding value class or the actual approximate value is illustrated in figure 5. The example shows the value protected from a fire that occurred in the 60th year of a stand being managed on a 100-year rotation for which final yield (including intermediate cuts) would have amounted to $1,700 per acre (5 percent present value).

Follow the 40 year vertical line until it intersects the 5 percent present value (PV) line, then follow horizontally to the $1,700 value line (top scale). Thus the value is now Class I. The dollar value of the income would be $1,700 x 0.14 (multiplier in left axes), which equals $239.00. Salvage of $50 per acre is anticipated; therefore, value protected would be $189 per acre ($239 - 50). Addition of values protected for other resources could raise this figure.

If the value protected estimate is made at the beginning of a 10-year planning period, the value at the end of the period should also be estimated. In 10 years, only 30 years would remain till harvest. Therefore, the stand may have increased to a Class II stand unless possible salvage value has also significantly increased. The year during the planning period for which value protected is to be estimated must be decided.

All-Age Management

The value structure for all-age managed stands differs from that for even-age managed stands. A *cutting unit* of a *regulated all-age* forest maintains its present value as shown in figure 6. Any cutting unit of a fully regulated all-age live stand reaches a maximum value just before and a minimum value just after periodic cutting. The range of value varies with price, rotation length, cutting cycle, and interest rate. The value of a fully *regulated all-age forest* where annual cuts are made may remain constant, but the value of any cutting unit fluctuates within the cutting cycle.

A fire in all-age forests may kill trees of all ages, although mortality probably decreases with increasing tree size. Loss of immature trees creates voids of mature trees at some future date that either must be replaced with trees from other sources or by skipping all or part of a harvest cut. In even-aged stands, however, the loss of young understory trees from middle to older age stands is often a benefit because they are not wanted until the new stand is being reestablished.

Thus, managed all-aged forests maintain a relatively constant value and value protected. The value protected varies with vulnerability of the stand to damage (young tree species), volume, stumpage price, and fire intensity. Because cuttings are regular, slash may usually be present although more scattered and never as heavy and hazardous as in the clearcut even-aged stands.

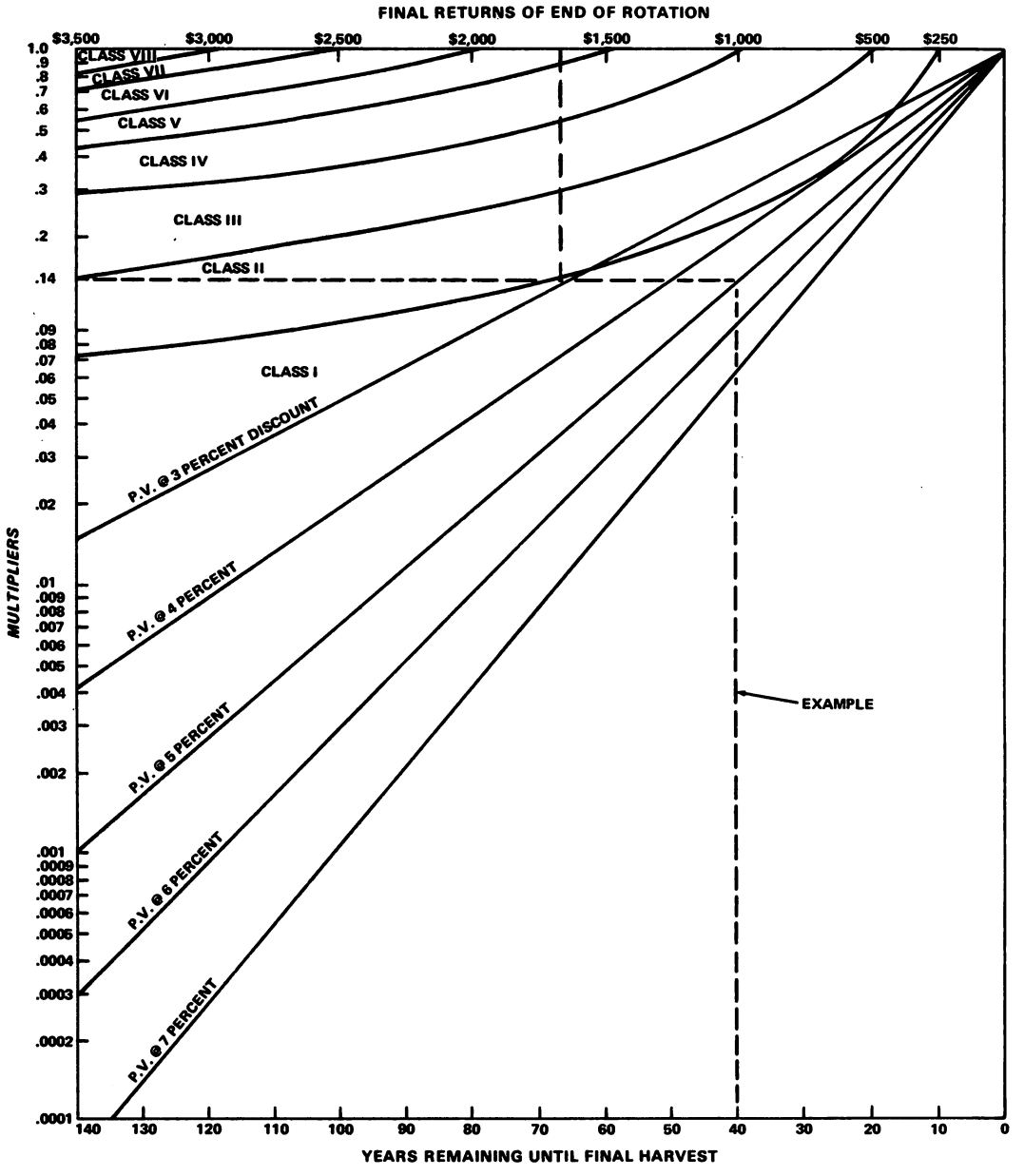

Figure 5.--*Value and value class for estimating value protected even-age management young stands (per acre).*

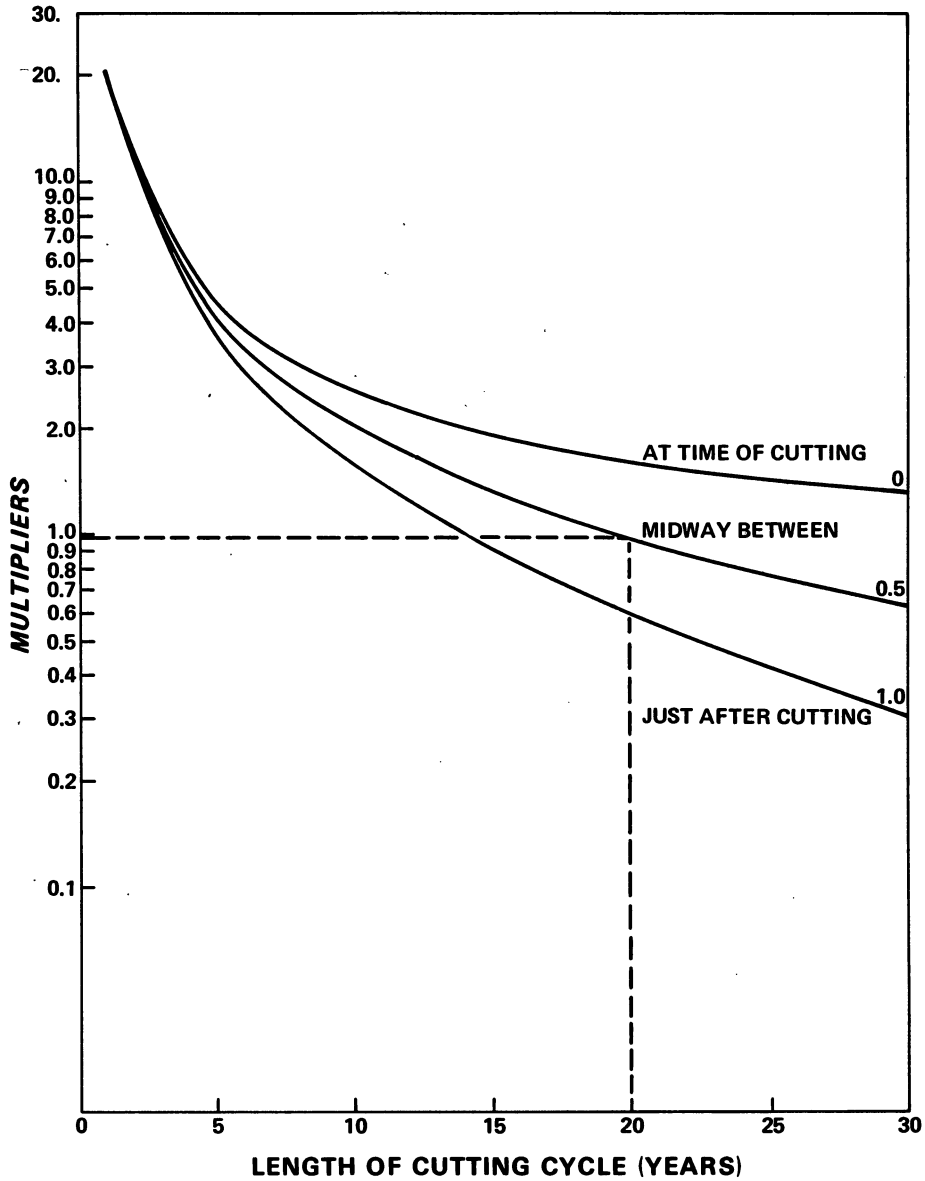

Figure 6.--*Multipliers of expected net income from cutting unit to find present value of an all-age managed cutting unit using a 5 percent discount rate. Example (dashed lines): Each 20 year cutting cycle yields $100 per acre net return from a cutting cycle unit. To find present value (PV) at 1/2 cutting cycle multiply $100 by 0.985, which equals $98.50 per acre.*

Relations illustrated in figure 6 and table 11 can be used to appraise value protected for all-age cutting units. A given periodic net income from a cutting unit and cutting cycle interval (horizontal scale), times the multipliers (vertical axis, fig. 6) will give the present value of future income of the cutting unit at 5 percent interest (Lundgren 1971, table 4). If all the cutting units in the regulated forest are considered, the value of the property would be the capitalized value of 1 year's net income. A fire-control planning period may be less than, equal to, or more than one cutting cycle; therefore, the midpoint value of a cutting unit may be most appropriate for planning use. If the full allowable cut is not expected to be made, the appraisal is made differently.

RANGE RESOURCES

Concepts

Forage--the range product--is essentially an annual crop and for more than most forest resource the effect of fires is seasonally dependent. However, some animals browse in addition to grasses and herbs is utilized and some domesticated animals, especially hogs, utilize mast, fungi, insects, and roots.

Range fires seldom kill all the native grasses and perennial herbs though there may be delicate relations existing among amount of grazing use, species present, and fires and season of burn. Underused range grasses may be benefited by fire or fire may help to decrease woody plant competition and heavy litter accumulation. Prescribed range burning is used as a range management tool in some areas. Hence, careful evaluation is needed to distinguish between benefits and damage. Moreover, a decision must be made as to whether the range will restock naturally, and, if not, for how long a period will it be useless for range whether or not it restocks naturally.

Table 11.--*Multipliers of expected net income from cutting unit to find present value of a cutting unit (all-age management, 5 percent discount rate)*

Portion of cutting cycle left	Years in cutting cycle						
	1	5	10	15	20	25	30
Just before cut	21.000	4.619	2.590	1.927	1.605	1.419	1.301
0.1	20.898	4.508	2.467	1.791	1.456	1.256	1.124
0.2	20.796	4.400	2.349	1.664	1.320	1.112	0.971
0.3	20.695	4.293	2.237	1.547	1.198	0.984	.839
0.4	20.594	4.190	2.131	1.438	1.086	.871	.724
0.5	20.494	4.089	2.029	1.336	0.985	.771	.626
0.6	20.394	3.990	1.933	1.242	.894	.683	.541
0.7	20.295	3.894	1.841	1.154	.811	.604	.467
0.8	20.196	3.800	1.753	1.073	.735	.535	.403
0.9	20.098	3.709	1.670	0.997	.667	.473	.348
1.0 (Immediately after cut)	20.000	3.619	1.590	.927	.605	.419	.301

EXAMPLE: Cutting cycle = 10 years; 0.4 cutting cycle remains before next cut (4 years); net value of periodic cut is $600 per acre; multiple from table (or graph) is 2.131.

Present value of cutting unit is $600 x 2.131 = $1,378.60 per acre. If the timber on the unit is completely killed and no salvage is possible because of the fire, the damage is $1,378 per acre. If salvage is possible, damage = $1,378 - net salvage value per acre.

FORMULA USED: $$PV = \frac{Y}{1.op^{n}} + \frac{Y}{(1.op^{r}-1)\ (1.op^{n})}$$

Where: PV = present capitalized value, Y = net income per acre at end of cutting cycle, r = years in cutting cycle, and n = years left in cutting cycle before next cut.

Some examples of damage and no-damage are:

1. Damage will occur if the current crop of forage is destroyed, just before its planned use.
2. Loss may occur if the fire burned in early spring so that the range had to be protected from use to prevent overgrazing.
3. Loss will occur if the fire kills desirable forage plants that will be replaced by undesirable plants.
4. No loss can be estimated unless use of the forage is planned or in progress.
5. No loss can be estimated if wildfire occurs at the time prescribed burning is planned and the results are comparable.

Damage can be estimated as the net value of the total animal month units (AMU'S) lost to use, or the cost of substitute range if the range will restock naturally. Loss of hay destroyed can be valued at market prices for hay.

Improvements and Livestock:

Loss of improvements and livestock must be considered: fences, stock pens, water installation, feeding racks, gates, and wood cattle guards. Livestock also may be injured or killed.

Losses of improvements will be evaluated at replacement cost if the range will be useful again. If the range will not be restored, either naturally or artificially, the depreciated value of improvements must be charged. Livestock will be valued at the market price of animals injured or killed, reduced by any probable salvage value.

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APPENDIX I.--RATING ESSENTIAL FEATURES OF RECREATIONAL ACTIVITY

Rating	*Criteria*[6]
1	Major deficiencies in essentials mostly not correctable. Chance for successful participation very poor. (This will seldom be used because the activity is usually impossible.)
2	Below average. Major deficiencies in essentials, mostly correctable, but expensive or difficult to correct. Success fair to good if problems are overcome.
3	Average situation. Essentials all present but minor deficiencies are present that generally can be corrected easily or ignored. Average chance of success in activity.
4	Better than average situation. Minor deficiencies keep the opportunity from being topnotch.
5	All essentials present and of good quality. Opportunity to participate successfully is exellent and proven. No deficiencies or with only minor deficiencies corrected.

Examples of Essential Features

Activity	*Essential features*
Brook trout fishing	A. Cold water stream or lake. B. Water stocked with brook trout. C. Reasonable access (implies both physical approachability as well as legal entry). D. Legal to take in season.
Swimming	A. Water (stream, lake, pond, pool, etc.) B. Water temperature 60° at least part of season. C. Secure bottom, preferably sandy. D. Preferably a gradual slope to bottom. E. Water meets sanitary standards. F. Good access.
Deer hunting	A. Large area of favorable habitat. B. Huntable population of deer. C. Access to a large territory. D. Legal to take in season. Camping or other housing facilities or sites.
Mountain climbing	A. Challenging mountain. B. Access.
Outdoor living (one aspect of camping)	A. Flat or nearly flat, well drained open spot for shelter, cooking fire, etc. B. Portable water. C. Fuel supply. D. Protection from elements (desirable). E. Access.
Cross-country hiking	A. Marked trail or path. B. Legality of passage assured. C. Possible campsites. D. Portable water at reasonable intervals. E. Pleasant environment, scenery, interesting sights, vegetation, wildlife, etc.
Birdwatching	A. Almost any place birds are found, few limitations. B. Access.

Rating Attractions

Recreation attractions are features or conditions that support different activities or make up the environment.

The specific attractions individually provide major resources essential for fairly specific groups of activities. Thus in evaluating a site for one activity probably one attraction is rated in terms of essential features. The remaining attractions,

[6] *Do not consider competition from people (crowding) to be a deficiency. This is rated under "Use".*

if any, are used to evaluate the general attractiveness of the site.

The appraiser should try to be objective in his rating. A broad viewpoint is needed comparing a situation with others occurring anywhere. The objective is to see how this opportunity compares with many other opportunities.

Categories for Rating Recreation Attractions

Outdoor environment.--This is the condition of vegetation, soil, air, water, and care that affect the senses. Consider such items as naturalness, sounds, odors, colors, purity. Where Code 1 is poorest and 5 is highest quality, the following descriptions apply.

Code 1 = Polluted, unnatural, offensive odor, noisy, too many signs, unnatural disturbances, dirty, messy, erosion, and unnatural coloration. *Code 2* = Few major, but many minor deficiencies. *Code 3* = Average of natural conditions or a state of being, acceptable level of disarray. *Code 4* = Few minor deficiences. *Code 5* = Pure; natural; sweet, clean odor; quiet or only natural sounds and noises; no signs and distractions; undisturbed; clean; orderly (natural orderliness); uneroded; and natural coloration.

Climate.--The climate of a place is the composite of the means and extremes and distribution of heat and cold, wetness and dryness, and storminess and calmness. Different climates have built-in variations, diurnal, short period, or seasonal that present expected variations within certain limits. None of these conditions is necessarily undesirable for recreation, for the recreationists must expect some risk of change and unfavorable weather. He tends to select the climate or time of year appropriate to his favorite activity. The primary consideration here is the dependableness of the typical variable weather patterns within a climate. For example, one would be disappointed to go to a normally dry area only to find it very wet, or to a normally hot area to find it cold. Thus climate may be rated 1 to 5 on the basis of the probability of drastic changes from the normal ranges. *1* = very undependable, *3* = average dependability, *5* = rarely undependable.

Wildlife and Wildlife habitat.--Consider primarily species representation, abundance, and habitat quality and diversity. *Code 1* = poor. Animal populations and habitats badly out of balance--much above or below the expected capacity of populations. Variety of species very limited, and many expected species not present. *Code 2* = below average. Generally deteriorating. Major defects in habitat or in predation, hunting, etc. Some species over capacity. *Code 3* = average. Most indigenous species present but populations below capacity in numbers. Habitat has some flaws and animal sightings may draw comment. Species representation reasonably normal. *Code 4* = above average. Situation improving and chance of desirable balance soon is very real. Many species represented. *Code 5* = most indigenous species including some that are rare or possibly endangered. Habitat supports healthy near-capacity numbers. Diverse habitat. Sightings not rare. Good balance between prey and predators.

Suggested recreation activities: (1) hunting and fishing, (2) bird and animal watching, (3) wildlife photography, and (4) biology study.

Water and watershed--this doesn't include scenic properties. Consider primarily purity, temperature, depth and/or flow; banks, shores, and bottoms, action; size of water body or stream.

Ratings must consider the amount of departure from the natural state of the water and watershed. The more nearly the water approaches the natural state the better the situation. A completely natural condition rates 5 and a much changed situation, especially if the change is ugly, polluted, or deteriorated, rates 1.

Water attractions however are often altered drastically by stream-channel straightening, and control structures, or by dams to create reservoirs or lakes. The alteration may have been made for recreation purposes, but perhaps more often recreation use is secondary to hydroelectric power, flood control, domestic water supply, or irrigation. Obviously an unnatural situation is created and must be rated as to its simulated naturalness. Thus stump and snags left in the lake are unnatural; shorelines, bottoms, and biological characteristics may be slow to assume true lake characteristics and sometimes develop

undesirable aspects. If the manmade lake or waterway has been well designed and simulates natural situations, it may become an attraction and the dam itself may be an attraction. Artificial lakes generally have very high recreational value in areas where natural lakes and or streams are not common.

Suggested activities: (1) swimming and bathing; (2) boating and canoeing; (3) sailing and motorboating; (4) water skiing; (5) sightseeing; (6) iceskating and boating; (7) photography; (8) painting and art works; (9) fishing; and (10) scuba diving.

Rating a water body can't be done the same for all activities. For example, water suited to fishing may not be suited to swimming and bathing. Canoeing waters are not necessarily good for motorboats or sailboats. Water may be too dirty for body contact recreation but suitable for boating. The purpose of the rating is important in forming the rating as an essential feature for an activity. As an attraction, however, naturalness or simulated naturalness is an important quality and no specific activity need be considered.

Geologic and topographic features.-- Every location is the product of geologic formation and change. The features may be simple and straightforward, or complex and difficult to understand. Although the interpretation of simple geology may be interesting, it is actually the unusual aspects of geology and topography that usually provide a recreation attraction. The features that deserve consideration are variety or uniqueness of display, mineralogy, formations, soil, geologic erosions of unusual character, and the interpretation of these features for the recreationists. These are features that strike the public as interesting. Although recreationists may not understand the features, they are intrigued by them and their curiosity is sparked. Interpretation may significantly increase enjoyment. Categories depend largely on the rarity of occurrence in a locality or among localities and the degree of interpretation.

1. Very common, interesting but monotonous features. Great plains, prairies, vast swamps, sand plains, mountain areas without a focus of attention. Little or no attempt made to inform the recreationist.

2. Features similar to category 1, but with some attempt to interpret for visitors.

3. Average situation, mostly humdrum but accentuated by points of interest such as rare outcrops of rock, small river gorge, abrupt breaks in the common situation such as a cliff, sudden separation from plains to mountain, waterfalls, etc. Some interpretation given.

4. Average sites with excellent interpretation.

5. Rare formations of high interest such as Yellowstone thermals, highest peaks, caves, big springs, rock sculpture from wind or water, shear cliffs of great height, dunes, canyons, glaciers, faults, good interpretation where needed.

Examples of activities: (1) rock and mineral collection, (2) photography, (3) art forms (such as painting), (4) sightseeing, (5) geology study, and (6) viewing scenery.

Biological and ecological features.-- Every area will also have certain biological and ecological features. The general vegetation situation as a macroscale feature should be included under ENVIRONMENT. Here the concern is most likely a microscale phenomenon with biological and ecological conditions as a special attraction, but emphasis is on the illustration and state of biological condition or development rather than on the beauty or amenity aspects. Consider such features as species, either because of outstanding variety or because of rare occurrence; unusual shapes or profuseness of blooms, etc., exceptional groves of trees, or concentrations of animals, state of preservation, age, number and clarity of ecological development stages; effect (good or bad) of disturbances, outliers, heritage remnants, display and arrangement, showiness or subtleness. Interpretation may add to understanding and enjoyment of lay people.

Criteria:

1. Vegetation consisting largely of pioneer stages or possibly of stagnant mature systems of ecological development

with many expected plants missing. Artificially generated vegetation. Monotony of vegetation.

2. Situation much as in 1 but with interpretation of meaning and significance.

3. Average vegetation conditions for an area with illustrations of many different biological processes and species, but so common and unspectacular that it is very commonplace. Interpretation can improve on interest value.

4. Good quality illustrations of natural development with good diversity of species, but with only modest attempt to interest recreationists with interpretation. Some features outstanding enough to attract much attention.

5. Unique examples of species or ecological states, and combining beauty of naturalness, form, development, color, bloom, and persistence. Rare species of importance or well known species of great interest.

Examples of recreation activities: (1) nature study or ecology study; (2) photography and other art forms; (3) sightseeing; (4) hiking, riding, touring; (5) collecting; (6) fruit and berry picking; and (7) natural area study and visiting.

Landscape and scenery.--In this category we are concerned with a focus of interest. Consider variety of scene, the depth of view, focus of interest, arrangement of components, detail, naturalness, and absence of unharmonious detractions.

Criteria:

1. Nearly all nearby detail, little or no depth and distance to scene. Little or no variety of components--monotonous, or with glaring detractions as inappropriate components, messiness.

2. Mostly as in category 1 but with potential for much better if given proper maintenance and development.

3. Average. Perhaps largely foreground and middle-distance views, limited variety, but variety not absent. Moderately or occasionally distracting ugliness or unharmonious components. Only moderately photogenic. Pleasant but not exciting or dramatic.

4. Mostly average but with occasionally much better views, composition, or interest.

5. Full range of depth and variety. Usually has a focus of interest, though this may encompass the total view. Dramatic, photogenic, well arranged components. Or it may be a scene of limited depth but impressive detail, arrangement of variety on a small scale.

Suggested recreation activities: (1) sightseeing; (2) touring, hiking, riding; (3) photography; (4) relaxation; (5) escape; (6) outdoor living; (7) painting (drawing); and (8) scenic drives.

Historic or heritage features.--Historic features are not readily identified on the ground by casual inspection of the site. Historic significance of a site comes about because some event of historic significance took place there. It is a part of our heritage and we must be told that it happened here. It may be a tree under which an Indian Treaty was signed, a building where an important person was born, a battlefield, a place where an important discovery was made, a "first" building.

Significance of the site is more a matter of the significance of an event or person. Events of National or international significance would rank highest; those of strictly local interest and importance lower. Many times historic significance can be developed by research into the history of a place. Most areas have some historic interest feature if they are developed.

The age of the historic event is also a criteria. However, age is apt to be correlated with importance for minor historic events tend to lose interest with time. Important events will hold interest for longer spans. Historic events having to do with beginnings, firsts, one of kind, important changes, or great discoveries may be of great significance. Often if the sites are of great significance, they are now National parks, State parks, or are registered historic places.

The more nearly the site still represents the conditions at the time the event took place the more important the site. Thus some sites of historic importance are useful because they show some past commonplace situation illustrating life style or state of culture. A high

rating is given to a site that has been preserved in much of its original state.

Suggested activities: (1) sightseeing, (2) history study, (3) photography and art forms, (4) recreation of primitive times, (5) ecological study, and (6) hunting for evidence of historic interest.

Anthropological and prehistoric features.--Prehistoric sites are "discovered" and subsequently developed or studied to deduce the significance of the find. Discoveries that become important in tracing the past activities and development of man have considerable importance and consequently interest. Much depends upon the manner and effectiveness of display and interpretation given so that recreationists can understand what they see. The rating should be in terms of the significance and interest in the "find" as well as how it is displayed. "Finds" are not related to specific events or people but rather to the evidence of a culture or stage in the progression of man through the past.

Suggested activities: (1) sightseeing; (2) anthropological study; (3) revelation of man's origins; and (4) exploration and hunting for relics, artifacts, or other evidence. (On known sites, this should be controlled.)

Occupancy.--Occupancy per se by permanent or semipermanent residents is not important. What is of importance, however, is how such occupancy relates to the activities being rated. Thus to find someone living in a wilderness would be inappropriate; it would be equally so to find no residents in a good agricultural area. The critical considerations relate to the appropriateness of the occupancy and somewhat to its density in relation to the activity in question. In general, if interruptions by occupancy impair an activity it is undesirable; if the interruptions do not influence the activity or even improve the opportunity, it is desirable.

Improvements.--Improvements generally have the purpose of increasing capacity, managing people, providing safety and access, or serving needs for essential services. Because the improvements intrude on the site, they should be functional but unobtrusive. They should usually not be a focal point. Thus the appropriateness of the type, design, materials, location, and effectiveness of performing functions are the criteria for rating. Exceptions might be improvements or structures that are themselves the major attraction--for examples, the St. Louis Gateway Arch, a museum, or a lodge.

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ACKNOWLEDGMENTS

Fire effects involve a complex of biological, economic, and management relations. There are diverse opinions on many issues while the core problems have seldom been systematically attacked during the three-quarters century of fire control in the United States. This report is a synthesis of information and ideas from sources too numerous to be cataloged individually although significant ones are referenced in the text.

Some more specific assistance was obtained by Cooperative Aid studies with universities. Among these was an Economic Analysis of Fire Damages made by Larry Streeby while a Doctoral candidate at the University of Wisconsin, under the supervision of Dr. William R. Bentley. Although no formal publication of results has been made to date, Streeby's work has provided the principle economic concept used in this report. Professor Carl Settergren of the University of Missouri studied the effects of fire on watersheds. His Doctoral thesis (University of Colorado) was a fine review of present and past knowledge and problems, highlighting the very complex and difficult nature of this aspect of damage appraisal. Master's candidate Norman H. Fennell, under the supervision of Dr. Russell J. Hutnik, The Pennsylvania State University, provided insight into the ecological effects of fires on eastern hardwood stands.

Robert M. Loomis was associated with the project throughout its life, concentrating on the effects of fires on eastern hardwoods. His work has provided important guidelines for appraising the often puzzling results of the typical moderate intensity fires occurring on these fire-prone and extensive woodlands.

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Crosby, John S.
1977. A guide to the appraisal of wildfire damages, benefits, and resource values protected. USDA For. Serv. Res. Pap. NC-142, 43 p., illus. North Cent. For. Exp. Stn., St. Paul, Minnesota.

A set of value concepts and methods for appraising both values-at-risk and changes in value resulting from wildfire are presented. Emphasis is placed on the effects of forest fires in terms of their affects on human and organizational goal achievement. Fire effects that help achieve goals are beneficial; those that hinder goal achievement are undesirable and create damage.

OXFORD: 435.2:435.3. KEY WORDS: forest fire damage appraisal, forest fire benefits, values-at-risk, forest fire planning.

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