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FIRE EFFECTS APPRAISAL:
THE WISCONSIN DNR EXAMPLE

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FIRE EFFECTS APPRAISAL:
THE WISCONSIN DNR EXAMPLE

By

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ABSTRACT

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The goal of this study was to develop a new appraisal system for the Wisconsin DNR. The Fuels and Effects Committee decided that use in court was the overriding need, but the system would also be used in fire management planning. Landowner effects were used when feasible, but internal consistency was also a constraint. The Committee had veto power, as well as frequent input, to assure acceptance. The procedures selected may not be those chosen if theoretical accuracy was the sole criterion, but the needs and constraints of the DNR were met.

Timber volume and values are from the Wisconsin severence tax system, with mortality estimates based on crown or bark scorch. Crops and facilities are assessed at fair market value. Negligible effects were assumed on watershed. For wildlife, value was assumed to be related to populations. The full impact is dependent on timber mortality in important habitats, and expenditures are used for valuation. Recreation use loss is use change times expenditures. Ornamental tree loss depends on tree location, vigor, and size, on species desirability, and on a basal area value. Effects on aesthetics and environmental quality are assessed using descriptive terms, relating fire severity and affected populations.

Nine research topics are described which would improve the system by broadening the data base or testing key assumptions. The final chapter describes several recurring concerns and the steps from Committee approval through expected statewide implementation by the spring of 1982. The approved handbook is in the appendix, although a format change is needed to meet state requirements.

ACKNOWLEDGEMENTS

I would like to express my appreciation for the assistance by the entire staff of the USDA Forest Service, North Central Forest Experiment Station in East Lansing. Thanks go especially to Von Johnson, whose desire for fire effects research prompted him to contact Michigan State University and to provide the funding to study the effects in a particular state. When Von left East Lansing, Dave Baumgartner took over the necessary administration on the project through its completion.

I'd like to thank the Wisconsin DNR for the opportunity to develop a new system for appraising the effects of forest fires. Many people, especially members of the Fuel and Effects Committee, gave their time, expertise, and support that made the new system acceptable. Thanks also go to the professors at Michigan State who provided feedback to make the system the best it could be. And thanks to Maxine Fay for the excellent job of typing and proofreading the manuscript.

Finally, I'd like to thank my wife, Julie, for providing thoughtful review and analysis, but especially for giving me encouragement when the study bogged down.

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CHAPTER 1. SUMMARY AND CONCLUSIONS

The objective of this study was to develop a new fire effects appraisal system for the Wisconsin Department of Natural Resources (DNR). The DNR Fire Management staff created the Fuels and Effects Committee to oversee the development of a replacement for the current appraisal system. The new system had to be as accurate as possible within the contraints identified by the DNR Fuels and Effects Committee. Initially, four constraints were proposed: (1) any college graduate could use the system; (2) the appraisal could be included on the fire report; (3) the time requirements could not be much greater than the time used for the current system; and (4) the system should yield relatively consistent results for different appraisers. In addition to these constraints, the Committee frequently reviewed the system to insure that it would be acceptable to the field personnel as well as to DNR administrators.

The system that was produced by this study is presented in its entirety in Appendix A. Although there are faults with the new system, it is acceptable to, and has been accepted by, the field personnel and the upper echelon of the DNR. This acceptance was demonstrated by the field test in 1980 and the plans to implement the new system throughout Wisconsin by 1982.

The new fire effects appraisal system is not perfect. One reason is that many of the theoretical evaluation models which exist are not usable. For example, the present net value of a timber stand is probably the best measure of its value, but the problems associated with predicting harvest volumes, prices and dates reduce its accuracy.

The problems identified in the existing yield tables and the additional data and computational requirements proved unacceptable to the DNR Committee. Another problem with using some evaluation models is that the necessary data is simply unavailable. In estimating the effects of fire on wildlife, for example, gross expenditures may not be the most desirable measure of value, but it was the only acceptable measure which was available and consistent for all of the species groups and for all sites in Wisconsin. Table 1 identifies the valuation models considered, the method chosen, and the rationale for the selection.

There are also problems associated with the physical effects predictions. Much of the research used for these estimates has been extrapolated beyond the conditions examined in the studies. It has been used because it at least provides a scientifically acceptable methodology on which to build. For example, the hardwood mortality predictors are based on data for an oak-hickory forest in Missouri. It may be acceptable to apply the data to oaks in Wisconsin, but the extrapolation to aspen and maple may be inappropriate. The problem, however, is that there is no data available on the fire-caused mortality of aspen, maple, birch, or other hardwoods. The question was whether to use existing data beyond its relevant range, to use expert opinion when available, or to ignore the effects. The decision was made with support from the DNR Committee that extrapolating the existing data was the most desirable option. Ignoring the effects was rejected as administratively unacceptable and expert opinion was dismissed because of the innate bias (not necessarily intentional) reflecting the "Smokey Bear Syndrome" of fires as unqualified disasters.

Table 1.-- Resource valuation models.

Alternatives	Method Chosen	Rationale
Timber		
1. Present Net Value	Severance Tax Value (merchantable timber)	1. Reduced data requirements
2. Current Value		2. DNR familiarity
3. Severance Tax Value	Present Net Value (immature timber)	3. DNR acceptability
Crops		
1. Market Value	Market Value	-
Facilities		
1. Use Value	Restoration Cost	1. Simplicity
2. Restoration Cost		2. DNR acceptability
Wildlife and Recreation Use		
1. Willingness to Pay	Gross Expenditures	1. DNR acceptability
a. Visitor Survey		2. Data availability
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-	Descriptive Terms	1. DNR acceptability
Ornamental Trees		
1. Timber Value	Evaluation Formula	1. Data availability
2. Property Value		
3. Asset Value		
4. Legal Value		
5. Replacement Cost		
6. Evaluation Formula		

Most of the assumptions and extrapolations used in this study have been identified. Chapter 5 addresses some of the key areas which need additional research. While specific studies are not discussed, nine broad categories are identified as fertile research fields. There is enough information needed that dozens of scientists could spend their entire careers improving the data just for the Wisconsin DNR.

The study was designed for practical application by the Wisconsin DNR. The dominant requirement was to improve credibility as expert witnesses in court, although the results of the system may be used for other purposes. If the only goal of the system had been to improve fire planning and/or to justify and adjust the fire program, a different set of values may have been appropriate. A comparison of the values used in the DNR study with comparable U.S. Forest Service values may serve to illustrate this. The Forest Service values are from the 1980 update of the Resources Planning Act (RPA) program (USDA, 1980); the values are for Region 9, the area from Minnesota to Missouri to Maryland to Maine and the lands in between. In timber, the values are very similar since both systems use stumpage values; stumpage is a market value and is, therefore, used uncritically for all timber valuation. In recreation and wildlife, the values are less similar. The RPA has a value of $3 for a recreation visitor day (RVD) on developed sites, and between $7.25 and $10.50 per RVD for wildlife use. The DNR values for recreation range from nearly $10 to $24 daily per visitor group, while wildlife values are from 53¢ to over $25 per hunter/observer-day. One must be careful comparing these values because the user measurement is different for the two systems. In addition, the values which are measured are quite different. The DNR values are expenditures by users, whereas the RPA values are an estimate of the value to the user in excess of the cost incurred to use the resource. It would be easy to digress into a discussion of which value is more correct or more proper, but such discussions have taken place before and will undoubtedly occur again; a discussion in this paper would have little impact on the debate. Expenditures were chosen because it was more acceptable to the DNR Committee.

In conclusion, the DNR wanted a system which would improve its credibility in appraising fire effects. The new system was designed to meet that desire, and the DNR is comfortable that its needs have been met. Others must be aware of potential problems that can occur if the system and the results are extrapolated beyond their purpose.

CHAPTER 2. INTRODUCTION

Background and Problem Statement

The Wisconsin Department of Natural Resources (DNR) is required by law to protect all state and private unincorporated lands in Wisconsin from fire. This responsibility is limited in some parts of the state, particularly the southern parts, by various mutual-aid agreements or statutory authorities. Included in this protection requirement is the task of assessing the effects of fires. These appraisals are a part of the public record and hence are available to anyone. They have been frequently used in insurance settlements and legal proceedings.

Some DNR personnel have expressed dissatisfaction with the current appraisal system, particularly because of embarrassment in court due to indefensible and unexplainable values. The current procedures were developed in 1938, and reflect the available knowledge and relative resource values of the time. One problem is that immature stands are appraised by applying a current stumpage rate to a dimensionless value, determined from tables which include size class, stand density, site class, and fire severity as variables. The problem is particularly severe for plantations, where calculated losses are often less than half of the original planting cost. A second major problem is that a predetermined loss of one dollar per acre is assumed for recreation and wildlife, and another dollar loss per acre is assessed for site deterioration (Wisconsin DNR, 1976b). These values have caused many problems for the DNR field personnel.

The Fire Management Staff in Madison was aware of the general dissatisfaction and agreed that a new system was needed. The DNR Fuels and Damage Committee (later renamed Fuels and Effects Committee) was formed to address the problem; the members are identified in Appendix B. The first meeting was in March, 1977. After discussing the current system the DNR Committee agreed that they did not have sufficient expertise to develop a new system. Thus they decided to accept an offer from the U.S.D.A. Forest Service, North Central Forest Experiment Station, to fund a study on fire effects appraisal in Wisconsin.

A meeting was arranged for the DNR Committee to discuss the problem with the Forest Service in November, 1977. Two uses of the system were identified: (1) planning and evaluating the fire organization, and (2) the appraisals that are used in court. It was decided that the defensibility in court took precedence, when the two needs were in conflict.

Objective

The objective of this study is to develop a fire effects appraisal system for the Wisconsin DNR that is as accurate and as consistent as possible within the constraints set forth by the DNR Fuels and Effects Committee. Accuracy is assessed by theoretical correctness, with emphasis placed on those resources most affected by fire. The constraints are: (1) it should be simple enough for a college graduate (not necessarily a forester) to use; (2) it should be completed with the fire report (within 30 days of the fire); (3) it should require no more than an hour to complete for an average (1 acre) fire; (4) it should provide results which would be fairly consistent for any given fire, regardless of who made the appraisal.

Approach

Several appraisal techniques have been suggested over the years[1/]. One of the earliest was by Sparhawk (1925). He limited himself to timber losses "not only because of the extreme paucity of data (concerning other values), but also because the existing data indicate that such damage is less than the probable error in estimating damage to timber" (p 737). Craig et al (1945) made the first attempt to assess the effects of fire on all resources. Many systems appraise damages by multiplying a value per acre times the area burned. The Forest Service uses this procedure, with seven rather broad value classes. The primary problem with this type of system is that it permits no variance for fires of different intensities. The most complete guide to fire effects appraisal was developed by Crosby (1977). He sets forth techniques for evaluating the effects on all resources, but the system is very detailed and time-consuming.

The new Wisconsin DNR system was set up to value changes in physical outputs for various resources. Each resource element was addressed independently, under the headings of market and non-market resources. The literature was surveyed to identify fire-caused changes in resource outputs and to specify measurable variables that could be used to predict those output changes. Values for each resource element were then determined from existing information.

1/ For a detailed discussion, see Julie K. Gorte and Ross W. Gorte, Application of Economic Techniques to Fire Management - A Status Review and Evaluation, USDA Forest Service General Technical Report INT-53 (Ogden, UT: 1979), 26 pp.

The valuation methods that are available are discussed for each resource element, followed by a discussion of the procedures selected for use. Appendix A is the appraisal handbook, with the specific procedures and appropriate numbers and tables included; the handbook is presented in its entirety to give the reader a sense of the scope and complexity of the system. Chapter 5 focuses on research needed to improve the data base or to test some of the key assumptions in the system. Chapter 6 addresses the recurrent concerns of the DNR and the steps taken to get the system implemented state-wide.

Valuation

Anything that people want can be said to have value. In an economic sense, value is defined as demand for a good or service being greater than supply at a price of zero dollars (Gibbs, 1977). Although this price is not always a market price, the economic concept of value may still be used. For such non-market goods as wildlife, it is necessary to derive values from the behavior of consumers or through interview techniques.

This assumes that valuing non-market resources is necessary. There may be many reasons for placing a value on these resources but in general all relate to the same need: to know how much the resource is worth relative to other resources so allocation decisions can be made (Coomber & Biswas, 1973). There are many people who are opposed to valuing non-market resources. Their reasons include that personal values defy objective evaluation and that valuing these resources is too complex. Others argue that we should use social values rather than economic values. Schuster (1977) claims that "the term 'social value' is more often incorrectly used ... than it is correctly used", since social values typically describe motivating forces or activities (aesthetic pleasure, peace of mind, hunting) while economic values describe benefits of activities. It is these economic values which should and must be used to allocate resources.

The values affected by a fire depend on the objectives of the evaluation. The change in gross state product may be the important value for state lands, but it may not be relevant for a county or a private citizen. The DNR tentatively identified two uses of the fire effects appraisal: fire planning and court proceedings. The courts use information on the effects on an individual landowner, but this may not be appropriate for fire planning. If a fire, for example, caused some campers to change from one campground to another, there might be no effect on the total camping use in Wisconsin (if excess capacity exists); however, the owner of the burned campground would feel a loss from receiving fewer camping fees.

The DNR Committee decided that the effects on the individual landowner took precedence over effects for planning. Even this did not eliminate all problems. The question arose as to landowner objectives; specifically, did a landowner have a timber loss even if he had no plans or desire to sell timber? After more discussion, the DNR Committee decided on potential landowner effects. Their basic reason was that average landowner tenure is much less than most timber rotation ages and that the landowner would probably experience some effect on his property sale if the timber was burned regardless of his plans or desires for harvesting. The DNR Committee also agreed that consistency in variation was essential; this is particularly true within a resource element, such as a consistent basis for jack pine and oak timber, or for deer hunting and duck hunting. An imputed value for non-market resources should be calculated if possible when market values are available.

CHAPTER 3. MARKET RESOURCES

The marketable natural resources are those which can easily be bought and sold. The markets for these commodities determine prices which then regulate production and consumption. For individual landowners, who are the producers, any reduction in marketability or volume of output resulting from a fire can be an economic loss. Consumption may be unaffected, particularly if excess capacity exists. The courts, however, are only interested in the effects on the individual landowners. This chapter, therefore, focuses on those resources for which the landowner could have an economic loss.

Timber

Methods Available

Any fire which kills trees potentially affects commercial timber values. There are, however, several ways to measure such values, depending on landowner objectives and the relationship among growth, harvest and inventory on the owner's lands. Because of the potential complexity of a system designed to accommodate all these factors, the DNR Fuels and Effects Committee decided that the value change of the burned stand, independent of the surrounding land, was the appropriate measurement. Changes in stumpage values can be used as a proxy for value change since they reflect the relative quality and availability of timber supplies. There are basically three methods which can be used to obtain stumpage value changes in Wisconsin, summarized in Table 2.

Present net value is theoretically the most correct method, but it requires predictions of future harvest date, price and yields. On state lands, the future date can be from timber management plans. Such plans, however, frequently do not exist for private lands, but DNR

Table 2.--Timber valuation models.

Alternatives	Method chosen	Rationale
1. Present Net Value	Severance Tax Value (merchantable timber)	1. Reduced data requirements
2. Current Value	Present Net Value (immature timber)	2. DNR familiarity
3. Severance Tax Value		3. DNR acceptability

rotation ages could be used as a rough guide. Predicting future prices is difficult but assuming constant real prices is a possibility. A real interest rate should be used in discounting, although the DNR uses six percent for all analyses and would consider no alternatives. Future yields can be estimated using the yield tables for Wisconsin (Essex & Hahn, 1976), but the accuracy of the tables has been questioned. DNR estimates show that actual growth is more than double the yield table estimates, primarily because of intermediate harvests[1/]. One administrative problem of using the present net value method is the increase in field measurements which would be required. Site index (age and height measurements) and volume by species are needed, whereas only timber type, diameter class, and volume are presently being recorded.

Current value, although theoretically less correct than present net value, is simpler to apply. It also eliminates the problems associated with predicting harvest date, prices and yields. However, this method does assume no value for immature timber (seedlings and saplings). This is particularly acute in stands that have had site preparation, artificial regeneration, or other silvicultural treatments. The problem of increased field measurements is the same as with the present net value method.

The severance tax is a third alternative available in Wisconsin. It was developed to eliminate the cost of cruising every stand of timber which is offered for sale by any landowner. It is basically the same as the current value method, but the field measurements are

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1/ Personal communication with Harry W. Thorne, Staff Assistant, Forest Management Section, Wisconsin DNR. Madison WI. 11/8/77.

greatly reduced. This method also has the flow of ignoring the potential value of immature timber.

Procedures Developed

The technique selected for appraising the effects of fire on timber is a combination of the severance tax value and the present net value methods. The severance tax value will be used for all merchantable timber, while the present net value will be used for immature timber. Any salvage values which occur will be deducted from the calculated loss.

The severance tax value method was selected primarily because of its simplicity. While this method is theoretically less correct than present net value, the predictions needed for calculating the present net value reduce its accuracy. The present net value of immature timber was used because the severance tax value assumes zero value for such timber, and that assumption was unacceptable to the DNR. It is necessary to estimate the volume and determine the discount period for appraising the effects of fire on immature timber. The present net value method requires estimates of harvest volume and harvest date, but the procedures developed for the Wisconsin DNR differ somewhat. Instead of using harvest volume and date, an estimate is made of the volume and the age of a stand when it becomes merchantable. This estimate is made by using the yield tables to calculate the merchantable volume by age class for each timber type and comparing those volumes to the average sapling density for each type. Average sapling density was estimated using the number of sapling of each species and the average volume of each species in each timber type. The detailed procedures and necessary data are in Appendix C.

The problems of predicting prices and yields still exist but have been reduced. The discount period has been shortened from the rotation age to the time when a stand becomes merchantable, usually less than half the rotation age. This shortened discount period reduces the errors caused by assuming that the real stumpage price remains constant, and it makes the discount rate less important. The problem of underestimating volume by using the yield tables is minimized because most intermediate harvests occur after the stand becomes merchantable. This procedure does require numerous assumptions, and some research is needed to improve the merchantable age predictions, as recommended in Chapter 5.

The effects on merchantable timber will be assessed using the following equation:

$$\text{Loss} = \begin{matrix}\text{Average}\\ \text{Volume}\\ \text{Per Acre}\end{matrix} \times \begin{matrix}\text{Average}\\ \text{Price By}\\ \text{District}\end{matrix} \times \begin{matrix}\text{Predicted}\\ \text{Mortality}\end{matrix} \times \begin{matrix}\text{Acres}\\ \text{Burned}\end{matrix}$$

The procedure for appraising fire effects on immature timber is identical, except that the average volume per acre will be the predicted volume when the stand becomes merchantable and a discount rate will be included.

Christmas trees pose a different problem since volume is not a relevant measure. The following equation will be used to assess the effects of fire on Christmas trees:

$$\text{Loss} = \begin{matrix}\text{Value}\\ \text{Per Tree}\end{matrix} \times \begin{matrix}\text{Trees}\\ \text{Per Acre}\end{matrix} \times \begin{matrix}\text{Acres}\\ \text{Burned}\end{matrix}$$

The field procedure requires a density estimate in trees per acre, rather than volume per acre. "Mortality" is assumed to be 100 percent since almost any damage to the crown of the tree will render it worthless as a Christmas tree.

The descriptions of the various values and the tables for volume and price are in the handbook, Appendix A. The following discussion of timber effects is separated into mortality and regeneration for conifer and hardwood timber types.

Timber Effects

Conifer mortality is predicted in Figure 1, which was determined from two linear regression lines. The equations for the lines are:

Equation 1: $y = 1.386 + .401\,x$ for $x \leq 57$; $r^2 = .66$
Equation 2: $y = -75.826 + 1.758\,x$ for $x > 57$; $r^2 = .73$

where y is estimated mortality in percent and x is the percent of crown scorched. The regressions used the data listed in Table 1, with the equations being developed for scorch of 60 percent or less and for scorch of more than 60 percent.

Two regression equations were used because no regression model provided a mortality estimate of 100 percent for 100 percent crown scorch. While less than 100 percent mortality may be a better reflection of the actual effects, it was unacceptable to the DNR Committee. Linear regression was chosen over other regression models available, including the power model ($y=ax^b$), the logarithmic model ($y=a+b \ln x$), and the exponential model ($y=aw^{bx}$). There are two reasons for selecting the linear model. First, the linear regressions yielded higher coefficients of determination than the other regression models, indicating that the linear model fit the data better than the others. The second reason is the administrative acceptability of the resulting predictor; only the combination of two linear regressions provided an acceptable mortality prediction for 100 percent crown scorch. The data in Table 3 are from Methven (1971), for red and white pine in southern Ontario, and from the Wisconsin DNR for red and jack pine in Wisconsin.

Table 3. -- Conifer scorch and mortality data.

Equation 1		Equation 2	
Scorch (percent)	Mortality (percent)	Scorch (percent)	Mortality (percent)
20	10	72.5	60
37.5	15	77.5	50
40	20	80	50
47.5	15	82.5	88
50	25	87.5	82
57.5	20	92.5	75
60	30	98	98
		100	100

Results similar to those shown in Figure 1 have been reported in Southern pine plantations (Bonninghausen, 1962). However, Figure 1 may overestimate the mortality of the swamp conifer species because they are less susceptible to heat damage than are the pine species (Weetman, 1956). Because relatively few fires occur in the swamp conifer types, due to lower stand densities and higher moisture levels, and because there is a lack of data on fire-caused mortality in swamp conifers, th DNR Committee decided that the pine equations could be extended to all conifer species.

Conifer regeneration is assumed to occur naturally. The following are situations where natural regeneration will generally not occur: (1) red pine stands, (2) jack pine stands under eight years old, and (3) white cedar stands with a hardwood understory or with over 30 percent other swamp conifer species. Regeneration is assumed to be unnecessary in these stands if mortality is less than 50 percent. In those

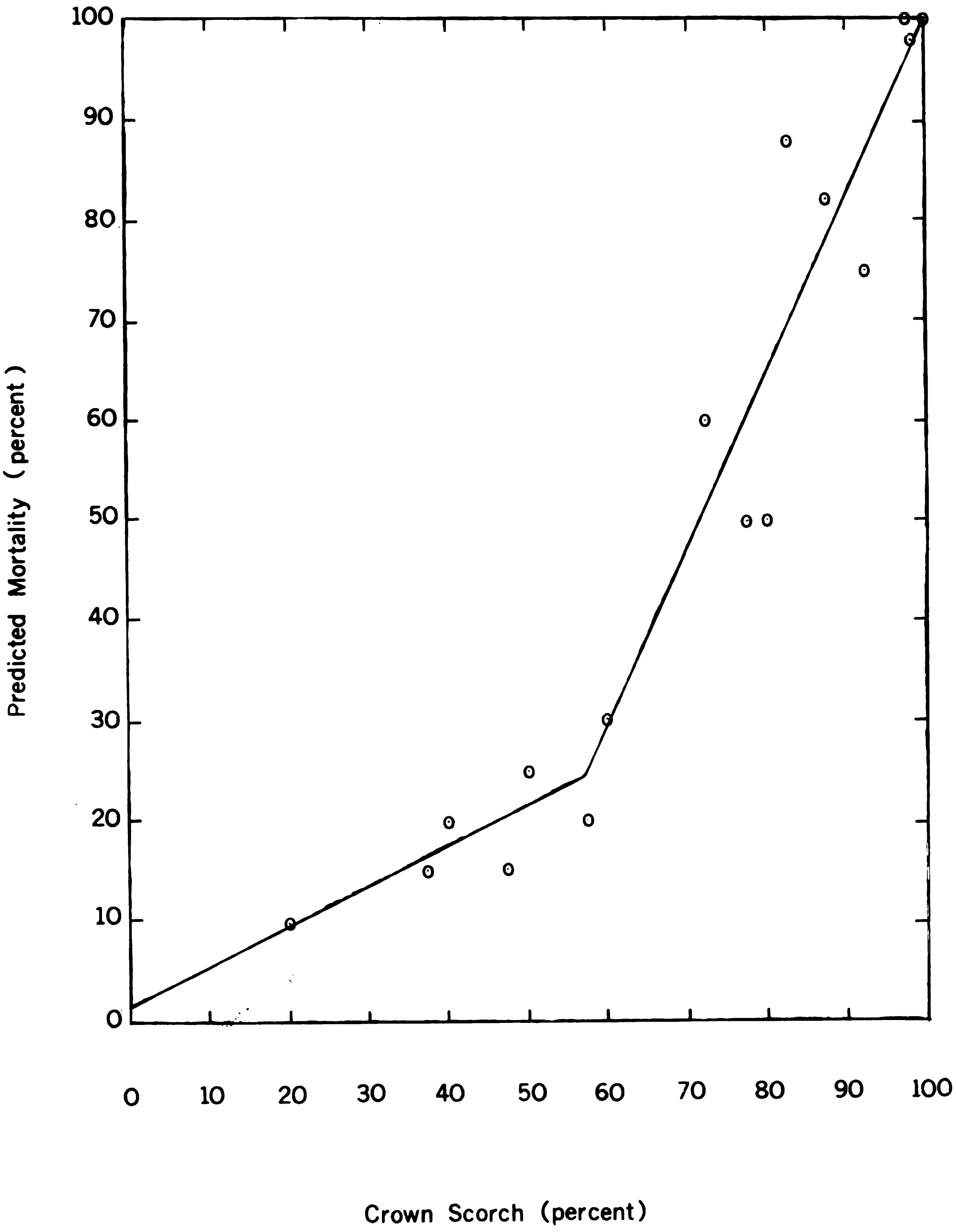

Figure 1.--Conifer mortality estimator and data points.

situations when mortality exceeds 50 percent, a regeneration loss is calculated and the value of the replacement timber type is estimated. The exception to this rule is plantations since they are not the result of natural regeneration.

Red pine is assumed not to regenerate naturally following fire even though fire prepares an adequate seedbed for red pine. This is based on the findings of Van Wagner (1970). Since red pine is often succeeded by open field following fire, the timber value of the replacement type is assumed to be zero.

Jack pine will not regenerate until it is eight years old. Although it is a serotinous species and requires intense heat for regeneration, jack pine usually doesn't bear cones until after its seventh year (Cayford, 1970). Concern was expressed about the replacement of jack pine by aspen following some major fires in Wisconsin[1/]. Since aspen and jack pine often occur on similar sites and aspen is a prolific seeder and sprouter (Horton & Hopkins, 1965), aspen is assumed to be the replacement timber type for jack pine stands which do not regenerate naturally.

White cedar stands generally change to hardwood species if there is a vigorous hardwood understory because most hardwoods sprout rapidly after a fire (Little, 1963). The replacement timber type is the understory timber type. If a white cedar stand which has more than 30 percent other swamp conifer species (balsam fir, spruce, or tamarack) is burned, it will regenerate to the predominant alternative timber type, according to the management prescriptions for white cedar in the

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[1/] Personal communication with Milton E. Reinke, State Forester, Wisconsin DNR. Madison WI. 7/6/78.

Silviculture Handbook (Wisconsin DNR, 1977a). For example, if a burned white cedar stand was 20 percent white cedar, 15 percent black spruce, 12 percent balsam fir, and 9 percent tamarack (36 percent other swamp conifer species), the replacement type is black spruce.

It is assumed that natural regeneration either will occur or is unnecessary in all other situations. The need for regeneration should depend on the density of the residual stand, but 50 percent mortality was assumed to simplify the calculations. Fifty percent was selected arbitrarily, but deemed acceptable by the DNR Committee. The assumption that natural regeneration will occur is supported by research following prescribed burning (e.g. Ahlgren, 1963; Benzie et al, 1973; Gysel et al, 1972), and Ahlgren (1959) reported that all northern conifer species are capable of regenerating after wildfires.

Hardwood mortality is estimated from Figure 2. Since mortality is predicted using bark scorch height, one would expect mortality to vary with diameter. Accordingly, two curves were developed, depending on diameter class; only two classes were used because of a lack of more detailed data. The equations are:

For trees $\geq$ 5" dbh: $y = 49.248 + 4.911\,x;\ r^2 = .69$
For trees $<$ 5" dbh: $y = 11.861 + 5.070\,x;\ r^2 = .75$

where y is estimated mortality in percent and x is bark scorch height in feet. The two regressions used the data in Table 4, from research by Ralph Loomis[1/]. As with conifer mortality, linear regression was chosen over non-linear regression models because the linear model resulted in higher coefficients of determination.

[1/] Personal communication with Ralph M. Loomis, Research Forester, USDA Forest Service. East Lansing, MI. 7/78.

Table 4. -- Hardwood scorch and mortality data.

Scorch	Mortality (percent)		Scorch	Mortality (percent)	
(feet)	=5" dbh	5" dbh	(feet)	=5" dbh	5" dbh
.25	63.6	25.0	7.0	76.9	45.3
1.0	34.8	2.4	8.0	86.6	76.7
2.0	60.5	11.7	9.0	100.0	43.5
3.0	68.8	20.7	10.0	--	60.0
4.0	78.7	34.8	11.0	--	50.0
5.0	64.4	43.5	12.0	--	76.9
6.0	80.4	58.2	13.0+	--	80.0

These regressions were developed using data from an oak-hickory forest in Missouri, and therefore may yield poor mortality estimates for the aspen, white birch, and northern hardwood timber types. However, no other data was available for developing simple predictors. The DNR Committee, recognizing the potential problem, began a study to check predictions with actual mortality to assess the accuracy of the curves, and will prepare new curves for other timber types if necessary.

Live cull was assumed to be negligible. Live cull is damage to trees which results in a reduction in timber quality or volume without causing mortality. Concern about fire-caused live cull has been expressed[1/], but it was found to be relatively minor if the timber was under 90 years old or less than 20 inches in diameter (Berry, 1969), while another researcher found no volume or quality loss in saplings or poletimber if the trees survived (Loomis, 1974).

1/ Personal communication with Gordon L. Landphier, Chief, Fire Control Section, Wisconsin DNR. Madison WI. 6/28/79.

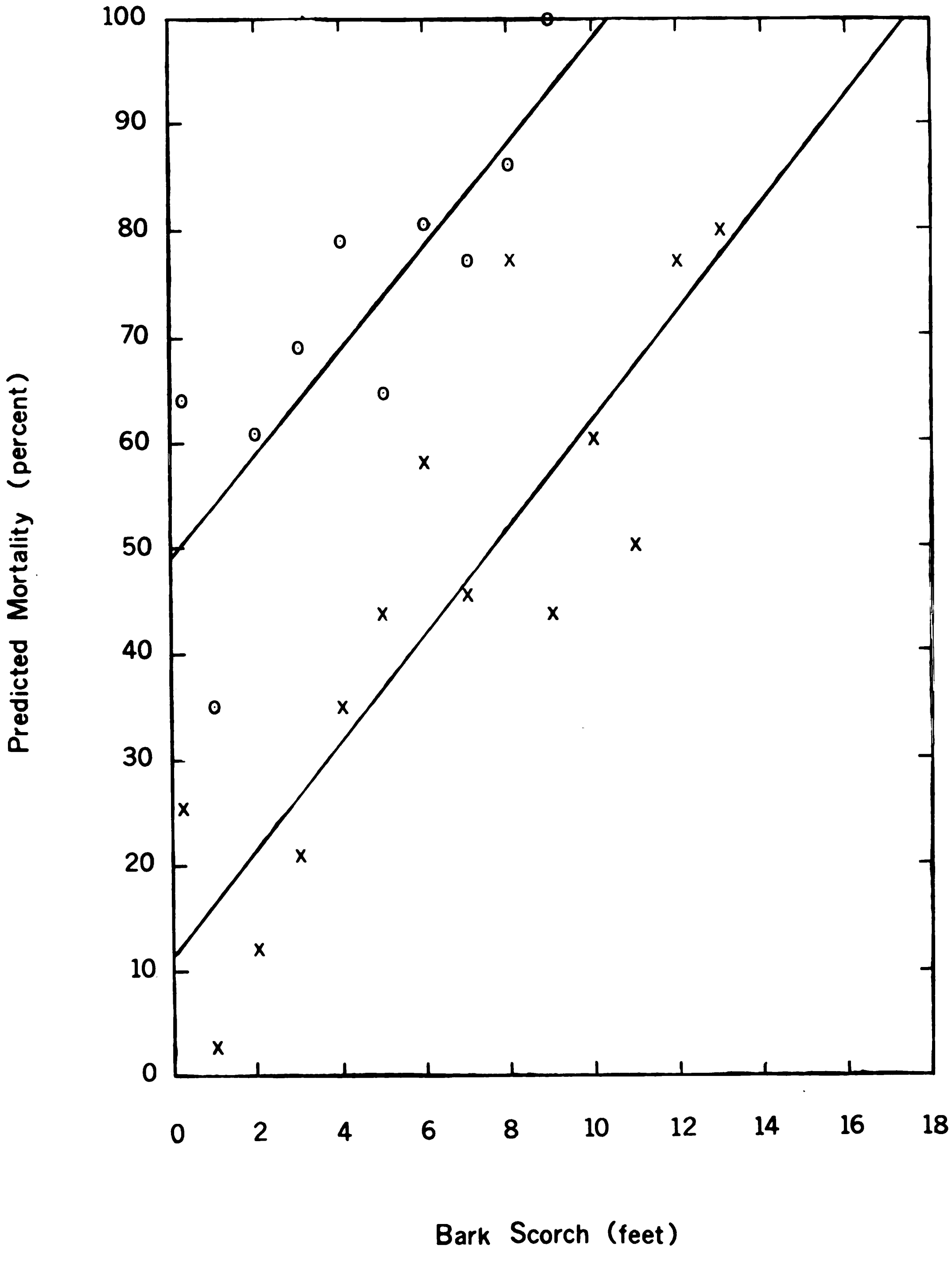

Figure 2.--Hardwood mortality estimator and data points.

Hardwood regeneration is assumed to occur naturally for all hardwood timber types. The predominant hardwood species in Wisconsin are maple, aspen, oak, and paper birch, all of which resprout following fire (Ahlgren, 1959; Fennel & Hutnik; Vogl, 1970). Even the most intense prescribed burns couldn't prevent aspen suckering (Horton & Hopkins, 1965). Yellow birch is the only hardwood species which has been identified as definitely a non-sprouter (Fennel & Hutnik, 1970).

Timber Values

The values proposed are those calculated annually by the Wisconsin DNR Timber Management Staff. The stumpage values are the weighted average for each timber type in each district in Wisconsin. The weighting system used is the average volume of each timber species in the timber type for each district. Local stumpage prices for a particular species will be used in pure stands, like plantations, but not in mixed stands. The additional time needed for estimating volume and mortality by species was considered to be too costly.

Christmas tree values are generally available from county extension agents. These values include expected price and discount rates which are appropriate for such commercial enterprises. By using external values, rather than estimates of costs from the plantation owner, the time required to obtain a present value per tree can be reduced substantially.

Crops

Evaluating the effects of fire on crops and forage is similar to the timber evaluation, since timber is only a special kind of crop. However, several factors combine to greatly simplify the procedure. Most crops are harvested annually, thus eliminating the problem of discounting future values. County agents generally have records available for estimating yields and prices. The problem of predicting mortality is also eliminated since few crops can survive a wildfire.

The method to be used by the Wisconsin DNR is basically a two-pronged approach. If the burned crop can be replanted in the current year, the loss is the sum of the replanting cost and the value of the reduction in the expected yield (the replanted crop would probably have a reduced yield due to a shorter growing season). If the crop is not replantable, the loss is the value of the expected yield.

The first step is to determine if the burned crop has already been harvested. If all crops on the burned site have been harvested, there is no loss. If a crop has not been harvested, then the loss for each burned crop is calculated using the following equation:

$$\text{Crop Loss} = \text{Replanting Cost} \times \text{Acres Burned} + \text{Yield Loss} \times \text{Price} \times \text{Acres Burned}$$

The replanting cost is zero if the crop cannot be replaced in the current year. The yield loss and price information can be determined from the farmer (a potentially biased source) or from the county agent.

Facilities

The value of equipment or improvements generally lies in their value in use. This is not limited to such income-producing equipment as tractors, because the value of a vacation home, for example, lies in its use, or at least its potential use. Fire can quite obviously change the value by either eliminating or altering the use or potential use of the equipment or improvement. Ornamental trees will be discussed in Chapter 4 even though their primary value is as an improvement.

The most common technique for estimating these losses is to calculate the cost to restore or replace the equipment or improvement affected by the fire. While this technique is the simplest to use, it generally overvalues items which are in poorer condition. A more correct technique would be to estimate the value of the use which would be lost as a result of the fire if replacement did not occur. For income-generating items this may be possible, but many improvements are used for recreating. It would, for example, be very difficult to calculate the use value of a vacation home.

The method to be used by the Wisconsin DNR is to estimate the cost to restore the equipment or improvement to its pre-fire condition. In some cases, this will be the additional maintenance required to restore that condition. An example of this would be repainting a barn which was blackened by the soot from a fire. Many cases, however, will require replacement. To reduce the possibility of overvaluing worn equipment and improvements, the replacement value will be restricted by the pre-fire condition of the item. The replacement value for a 1959 pickup truck, for example, is the price of a 1959 pickup in similar condition on a used-car lot, not the price of a 1980 pickup truck. This technique provides an adequate estimate of value change if one assumes that restoration or replacement will occur. If the item is restored or replaced, it is likely that the future use value of the item is more than the cost to restore/replace it. The DNR Fuels and Effects Committee stated that it was administratively unacceptable to determine if an item would, or should, be replaced or restored.

The field procedures require determining the equipment and improvements which require added maintenance and then the items which need to be replaced. An estimate of the pre-fire condition (excellent, very good, good, fair, poor) is also made. In the office, the cost of the required maintenance or the replacement is determined. Contractors and used equipment dealers are useful sources, but professional judgement will also be needed. Equipment loss is the sum of the costs to replace or repair the burned items.

CHAPTER 4. NON-MARKET RESOURCES

Non-market resources are those which are not regularly traded in established markets. The value of these resources generally cannot be captured by individual landowners because of their inability to control the use, like with sightseeing, or because the service is provided free by the public landowners, like hiking. Since the courts are interested primarily in the effects of fire on individual landowners, the value of non-market resources is not relevant. However, because there can be a fire-caused change in non-market values, such changes are relevant for fire management planning. The new appraisal system will be used for both court proceedings and fire planning, and therefore values for non-market resources must be included but explicitly distinguished from landowner effects; steps have been taken by the DNR to make this distinction on their new appraisal reporting forms.

Fire effects on watersheds have been assumed to be negligible in Wisconsin. A detailed literature review by Wells *et al* (1979) examined the effects of fire on erosion and on water quality and quantity. Their report indicated that the effects are only significant for very intense fires on steep slopes with highly erodible soils. A USDA Soil Conservation Service soil type map for the state showed that the necessary combination of highly erodible soils on steep slopes was virtually non-existant in Wisconsin.

Wildlife

Wildlife value is actually a catch-all term which includes several values. People use wildlife in different ways and value it for a number of reasons. One of the most obvious of the wildlife values is activity value (Brookshire *et al*, 1978). Activity value is associated with firsthand use of the resource. It can be further subdivided into consumptive and nonconsumptive use. Consumptive use means actually taking wildlife out of the environment, as fishermen and hunters do. Nonconsumptive users are those who engage in wildlife observation, birdwatching, wildlife photography, and nature study. They do not harvest animals.

A second type of wildlife value is option value (Brookshire et al, 1976). This category does not include users of the wildlife resource, but those who value it because they may wish to use it in the future, or wish to preserve it for the use of their children. In other words, they value the option to use the resource, though they do not actually use it at present.

Existence value is another wildlife value which, though simple to conceptually separate from option value, is difficult to measure separately. Existence value is derived from people enjoying the resource simply because it is there. They neither use wildlife nor plan to use it, but value its continued existence.

Methods Available

According to neoclassical economics, the value of any good or service is the product of price times the quantity purchased at that price. The market, the interaction between producers and consumers, determines the price and quantity purchased. It allocates goods and services to those who are willing to pay the price (Gibbs, 1977). Unfortunately, the market for the wildlife resource doesn't work perfectly. The reasons for this include: wildlife is usually considered common property, belonging to the state and hence to all the people; and wildlife is a "public good" where the uses of the resource are not mutually exclusive. For example, the same area can be used for deer hunting and birdwatching (Davidson et al, 1966).

Several approaches have been taken in attempting to evaluate non-market resources. Most of the research has been directed toward recreation, especially for valuation of developed sites, but it is equally applicable to wildlife since the activity and option values of wildlife are in reality recreation values. The approaches are identified in Table 5, along with the selected method and the rationale

for the selection. Willingness to pay is the approach that has had the most attention. It is the amount that people would pay in order to use (or to have the option to use or merely to have) the wildlife resource. Most of the discussion has focused on how to measure the willingness to pay. One technique suggested is to conduct a visitor survey to directly ask the visitors how much the recreation activity is worth (Hammack & Brown, 1974). The primary problems with this approach are the potential for bias in the structure and administration of the questionnaire/interview and the questionable relationship between how much people say they will pay and how much they actually will pay (Beardsley, 1971; O'Connell, 1977). One study in Wisconsin has shown that the amount for which people said they would sell their use rights was twice as much as the actual amount necessary to purchase their use rights[1/]. While this study dealt with the willingness of people to sell their use rights (rather than willingness to purchase the rights), it does illustrate the problems

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1/ Study conducted by Richard Bishop and Tom Heberlein of the University of Wisconsin, Madison; reported by David Pritchard, "$5.2-Million Value Put on Horicon Hunt," Madison (WI) Capital Times, Wednesday, November 15, 1978.

Table 5. -- Wildlife and recreation use valuation models.

Alternatives	Method Chosen	Rationale
1. Willingness to Pay	Gross Expenditures	1. DNR acceptability
a. Visitor Survey		2. Data availability
b. Travel Cost		
c. Consumers' Surplus		
2. Alternatives		
a. Market Value		
b. Opportunity Cost		
c. Alternative Sites		
3. Expenditures		
a. Gross Expenditures		
b. Investment Cost		
c. Market Value of Fish		
d. GNP Effects		
4. Other Methods		
a. Value Added		
b. Willingness to Sell		
c. Value per User Day		

inherent in such questionnaire or interview studies. Other researchers have attempted to reduce this problem by instituting bidding for the use rights (Brookshire _et al_, 1978).

Another technique for measuring willingness to pay has been called the travel cost method. Originally suggested by Hotelling (1949), and first applied by Trice and Wood (1958), this method requires determining how much users pay in travel costs, and relating that to the number of users. The value, then, is the product of the quantity of use (number of users) times the difference between the amount people would pay and the actual amount paid. Trice and Wood assumed that people would pay as much as the top ten percent of the actual amounts paid (i.e. the 90th percentile). This assumption has been severely criticized. The other primary criticism focuses on the assumption of a homogeneous population (Coomber & Biswas, 1973).

The third technique for estimating willingness to pay involves the use of consumers' surplus. Consumers' surplus is the value (benefits received) in excess of the amount paid. Usually consumers' surplus is considered to be the total value over the amount paid, while monopolist revenue is the maximum potential revenue that a nondiscriminating monopolist could receive (Coomber & Biswas, 1973). For either measure, a demand curve is necessary. The two basic ways to estimate demand curves are virtually identical to the direct measures of willingness to pay. The first way is to estimate changes in use resulting from changes in cost, using a survey or a bidding-type game (Randall, 1977; Brookshire et al, 1978). This, however, has the problems mentioned earlier about the accuracy of survey methods. The other way, known as the Clawson method, is to estimate demand by examining travel costs for different geographical regions. The major problem with this method is the assumption that differences in participation rates are the result of difference in travel costs, i.e. the population has homogeneous tastes and preferences (Clawson & Knetsch, 1966). Others have suggested using all transfer costs rather than just travel costs (Brown et al, 1973). An additional problem with the Clawson method is that it usually is more costly to apply (O'Connell, 1977).

The basic problem with using consumers' surplus, or any measure of willingness to pay, is the noncomparability with other measures. When comparing two investments, it is imperative to be comparing apples with apples. A comparison with the benefits of one alternative measured by consumers' surplus and the benefits of another measured in market values could result in less-than-optimal resource allocation (Beardsley, 1971; O'Connell, 1977).

The alternatives approach is the second one that is frequently used. One technique is to determine the market value of the resource in question. In theory, this technique is acceptable, but the need for either selling the resource or observing the sale of a comparable resource makes it very difficult to use (Coomber & Biswas, 1973; Knetsch & Davis, 1966). Another problem is that many non-marketed uses have no analogy in the private sector.

Another technique for estimating the alternative value of the resource is to identify its opportunity costs. The potential value of the resource in other uses may, however, be a severe underestimate of value, especially for unique resources. It is a measure of what is given up, rather than what is received. The use of this technique for the wildlife resource is more difficult, in general, because many wildlife uses are compatible with and secondary to other uses on the same site.

A third way to estimate the alternative value is to estimate the costs of using alternative sites. However, this requires an accurate assessment of the resources on the site being valued and on alternative sites. By identifying the change in resources available on one site, it is possible to estimate changes in use on all sites. This can be valued by estimating changes in user costs (Talhelm, 1973).

Expenditures is a third basic approach to the valuation of non-market resources. The most common technique is to measure gross expenditures. One advantage in this technique is that it is an expressed willingness to pay, and therefore is more similar to market price than any other measure (Coomber & Biswas, 1973). Another advantage is the relative ease to apply this technique. There are, however, many problems with this method. The gross expenditure method includes all transfer costs. It does not measure benefits to the owners or to the users, nor is it a measure of net or site benefits. It also includes many secondary benefits (Coomber & Biswas, 1973; Knetsch & Davis, 1966; O'Connell, 1977). Finally it is a measure of the maximum dollar amount that could be redirected, rather than a measure of people's willingness to pay (Stevens, 1966a).

Another expenditure technique is to assume that the value of an investment is equal to the cost to provide the recreational opportunity. Under this assumption, all potential investments are good, and the most desirable ones are the most costly (Trice & Wood, 1958; Stevens, 1966a). In spite of its inherent inadequacy, cost can be used if a cost/use ratio is used as an allocative criterion (O"Connell, 1977), but allocation decisions among different resources may be impossible.

A third technique which is frequently mentioned but seldom used is called the market value of fish. This asserts that the value of the use is equal to the market value of the outputs produced for consumptive use. However, as Stevens (1966a) points out, the output is often the activity rather than the physical commodity (fishing, not fish).

A fourth technique which can be included in the expenditures approach is the GNP effect. This assumes that the value of a day in recreation is the same as the value of the output of a day of work; i.e. value per user day equals GNP per capita per day. This assumes that all days are perfectly substitutable, and the problems with this are obvious.

Several other approaches have been proposed. One is to use value added by use of the resource, rather than gross expenditures, leading determine the willingness to accept compensation (to sell). This is the same as willingness to pay, except that a different set of property right is assumed (Randall, 1977). A third approach is to use a value per user day, preferably from the fee at a comparable private site (O'Connell, 1977). This can also be adjusted for political and social pressures, and may therefore be a more acceptable measure of value (Coomber & Biswas, 1973).

Procedures Developed

Of the possible techniques described above, the one selected for use by the Wisconsin DNR is the gross expenditure method. There are two reasons for using this technique. The first is that the values which are derived using this technique are institutionally acceptable. The DNR Fuels and Effects Committee agreed that the values determined using expenditures are acceptable to the Wisconsin DNR. The other reason for using expenditures is that it is the only measure of value which is available for several different types of wildlife across the state. Several studies have been conducted on the value of a specific species or area (e.g. the geese on Horicon Marsh), but the only measure available which is consistent for all wildlife types affected by fire is expenditures.

Expenditures is not necessarily the correct measure of value, but it does provide a consistent basis for analysis, and consistent values are necessary for management planning (Schuster, 1977). It is necessary to prevent comparing these measures with the marketable values from timber and crops, but these precautions have been incorporated on the appraisal form. In addition, wildlife values have been identified in Chapter 5 as an area needing more research.

The technique proposed for evaluation of the effects of fire on wildlife is based on changes in use and the relative success for various wildlife uses on the burned site. The following equation will be used to assess the effects of fire on each group of species affected:

Loss or Benefit	=	Full Effect	x	Success Index	x	Use Change	x	Wildlife Value

The specific equations and the appropriate tables and values for each wildlife species group are in Appendix A, the appraisal handbook.

The success index is, in general, a ratio of use per acre in a county relative to the average use per acre in Wisconsin. The success index for each species group in each county was calculated by dividing the use per acre by the average in Wisconsin for that species group. Thus, a success index of one indicates average use, while a two indicates double the average and a point five is half of the average use. For game species, the percentage of total harvest in each county was used as a proxy for hunter use, while nature study participations was used for non-game species use. The data used for developing the indices and maps showing the distributions are included in Appendix D.

This evaluation method assumes that wildlife values are related to the quantity of use on a given site and the probability of success in that use. Intuitively, the quantity of use will depend on the probability of success if success is desired. This assumption has been questioned in the literature. Wennergren <u>et al</u> (1977) found that hunter success was a primary determinant of site quality for big game in Utah, but less than half of the backcountry fishermen in Washington fished for reasons related to the catch (Hendee <u>et al</u>, 1977). Potter <u>et al</u> (1973) found that nature, escapism and compansionship were the primary reasons for hunting, but satisfaction related to hunting success (e.g. harvest and trophy display) did add to the value of the hunting experience. In examining anticipated success, Stevens (1966b) found a significant positive correlation between changes in anticipated success and changes in fishing effort.

Another major assumption is that use and probability of success are directly proportional to animal populations. This is neither supported nor refuted in the literature, although it is intuitively reasonable. One would expect an increase in a deer herd to result in a higher probability for shooting a deer.

A third assumption is that probability of success on a burned site is not related to the probability of success on nearby, substitute sites. Intuitively, there is some population regeneration response to changes in habitat conditions, but there is also probably a relocation response, especially in the first year. There is no literature available to help in distinguishing these responses. Stevens (1966b) did find that a change in anticipated success at a substitute site did not affect salmon fishing at the site he examined. While there was obviously no relocation of the salmon, his study does suggest that the use of alternative sites is unaffected by use on the burned site. In a DNR Committee meeting, a DNR wildlife biologist stated that his research has shown there is little or no relocation response in deer[1/].
Still, this assumption may result in a substantial overestimate of the effects of fire on wildlife. These assumptions are very important in the valuation of the effects of fire on wildlife, and research is recommended in Chapter 5 to address this area.

1/ Personal communication with Keith McCaffery, Wildlife Biologist, Wisconsin DNR, Rhinelander WI. 7/26/79.

Wildlife Effects

The full effect of fire on wildlife use is the net change in use per acre for a fire with 100 percent mortality of the trees. This is the total expected change in animal populations (in percent) times the average use per acre for Wisconsin. Table 6 shows the use of each wildlife species group (National Analysts, 1975) and the average use per acre.

Table 6. -- Wildlife use in Wisconsin.

Species Group	Total Use (thousands)	Average Use Per Acre
Deer	6,034	.175
Rabbit	3,781	.110
Grouse	2,146	.062
Pheasant	2,825	.082
Waterfowl	3,339	.097
Non-Game	38,761	1.124
Area in Wisconsin:	34,483,200 acres	

The total expected change in animal populations is the expected change by year, determined from the literature, discounted to the present at six percent. The correct procedure for determining the present value of future effects is to discount the value of those future effects. If, for example, a fire causes the animal population to increase to 200 percent over the pre-fire population in the first year, to 125 percent over the pre-fire level in the second year, to 50 percent over the pre-fire level in the third year, and return to the pre-fire level in the fourth year, the present value of the increases is the sum of the value of the use times the increase in each year and discounted to the present.

Mathematically, letting V be the value of the use and using an interest rate of 6 percent, this is:

$$PNV = \frac{2.00\ V}{(1.06)} + \frac{1.25\ V}{(1.06)} + \frac{0.50\ V}{(1.06)} = V\left[\frac{2.00}{(1.06)} + \frac{1.25}{(1.06)} + \frac{0.50}{(1.06)}\right]$$

The advantage of the second equation is that the value of each use can be updated annually to adjust for inflation, and can be changed when new information becomes available. These are separated into value and full effect in the appraisal equations so that the values can be changed when appropriate.

There is no evidence in Wisconsin to support or refute the assumption of constant values, but real values are probably increasing with the general trend in increasing recreational participation nationwide. If real values are increasing in Wisconsin, the results of the appraisal will underestimate the actual effects.

The use change in the equation is a measure of acres burned at 100 percent mortality in the appropriate timber types. Since the full effect is for 100 percent mortality, it must be reduced for fires of lower intensity. It is assumed that the relationship between effects and intensity is linear. This is unsupported in the literature, although it is intuitively reasonable to expect a positive relationship between timber mortality and the food and cover available for wildlife. The function is assumed to be linear because it simplifies the calculation and because there is no evidence to the contrary.

White-tailed deer is the predominant big game species in Wisconsin. Moose are beginning to return to the state, but they are still relatively rare. Since the effects of fire are generally beneficial to moose, the assumption of no effect will probably cause a slight underestimate of the benefits resulting from fire 1/.

The full effect of fire on deer is an increase of 3.86 hunter-days per acre. This is the present net worth of a 3-fold increase in deer populations for 10 years, multiplied by the average use of .175 hunter-days per acre per year. The change in deer use is based on information from a DNR wildlife biologist[2/]. This estimate is generally supported in the literature, although some sources report higher population increases. Vogl and Beck (1970) found deer use to be 2.8 times higher on the site eight years after a fire in northern Wisconsin. In a study in oak in Pennsylvania, Ribinski (1970) reported that a constant percent of available browse was consumed, regardless of the amount of browse available. The burned sites showed a 16-fold increase in browse and a 16-fold increase in browse consumed. Loomis (1977) reported similar increases in available browse in his study of an oak-hickory forest in Missouri. However, Dills (1970) found increases in browse available of only three to six times the pre-fire levels.

The use change associated with the full effect is limited to red and jack pine plantations and to northern hardwoods and white birch. Although aspen is the most important deer browse species (Vogl, 1967), the use of aspen stands is unrelated to the age of the stand[3/]. The increase in forage is related to crown openings, which is directly proportional to mortality in pine plantations. The hardwood stands,

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1/ For more detailed information on the effects of fire on moose, see David L. Spencer and John B. Hakala, "Moose and Fire on the Kenai," Tall Timbers Fire Ecology Conference Proceedings No. 3 (Tallahassee, FL: 1964), pp 11-33.

2/ Personal communication with Keith McCaffery. 7/26/79.

3/ Ibid.

however, show little change in crown openings until mortality is at least 50 percent[1/]. A linear relationship between no effect at 50 percent mortality and full effect at 100 percent mortality was, therefore, assumed for northern hardwoods and white birch, while the pine plantations have an assumed linear relationship from no effect at zero mortality to full effect at 100 percent mortality. The use change was assumed to be negligible in all other types except the swamp conifers, as discussed below.

There is also a size effect on deer populations. McCaffery and Creed (1969) found that deer use in forest openings in northern Wisconsin decreases as the size of the openings increases. Since their regression is based on openings and only very intense fires cause openings (timber mortality of 100 percent), the size relationship must be tempered. The area change, calculated by summing mortality times acres burned for the appropriate timber types, is a more appropriate measure to use than fire size[2/].

A loss of deer habitat occurs if a conifer swamp is burned, since cover is more restrictive than browse in winter habitat and conifer swamps provide the most desirable cover (Wetzel et al, 1975). Most deer yarding occurs in these conifer swamps (Kabat et al, 1953), so the full effect of a fire in a swamp would be the temporary elimination of deer use. The temporary period is 25 years if one assumes that stands provide adequate cover when the trees reach about half of their merchantable age.

1/ Personal communication with Keith McCaffery. 7/26/79.

2/ Personal communication with Leslie W. Gysel, Professor, Department of Fisheries and Wildlife, Michigan State University, East Lansing MI. 3/12/79.

Small game includes rabbits and upland game birds. These species were grouped together to increase institutional acceptability, rather than because of similarities in response to fire. Hence, the full effect varies with the timber type (habitat) affected. Appendix A shows the system before this change was made; separate effects for rabbits, grouse, and pheasants are calculated in the handbook.

Table 7 shows the estimated changes in animal populations and the discounted sum. Grange (1965) reported that the snowshoe rabbit population cycle in Minnesota followed the successional changes in the forest. The population peaked at 1.5 to 800 times above mature forest populations for the second through the fifth years of the cycle. On severely burned sites in Alberta, a one-year disappearance of rabbits was reported (Keith & Surrendi, 1971). Jack pine, black spruce, aspen, and white birch have been identified as the types which comprise the predominant habitat for snowshoe rabbits (Grange, 1965).

Table 7. -- Small game population changes.

Years Since Fire	Rabbit Estimate	Discounted	Upland Bird Estimate	Discounted
1	- 1.0	- .94	+ 3.04	+ 2.87
2	+ 1.5	+ 1.33	+ 3.04	+ 2.71
3	+ 1.5	+ 1.26		
4	+ 1.5	+ 1.19		
5	+ 1.5	+ 1.12		
Total		+ 3.96		+ 5.58

Grouse includes sharptailed and ruffed grouse and Hungarian and Chukar partridges because they have similar habitat requirements. Quail have been included under pheasants. The increase of 304 percent in the average of the increases in sharp-tailed grouse broods reported by Kirsch and Kruse (1972). Two years has been identified as the duration of fire-caused habitat improvement for prairie chickens, a similar species (Chamrad & Dodd, 1972). Jack pine and aspen have been identified as important in grouse habitat (Cayford, 1970) [1/], while numerous authors have discussed the beneficial effects of fire in open fields for upland bird species, including pheasants and quail (e.g. Hamerstrom, 1963; Komarek, 1971; Miller, 1963).

The full effect for the various timber types is the sum of the animal population change times the hunter use for each species group. Thus, open fields have an increase of .45 hunter-days per acre, resulting from a 558 percent increase in pheasant popoulations times .082 hunter-days per acre for pheasant and quail. Black spruce and white birch have a full effect of .43 hunter-days per acre, from the 396 percent net increase in rabbit populations times .110 rabbit hunter-days per acre. The full effect for jack pine and aspen is .77 hunter-days per acre. This is the sum of the .43 rabbit hunter-days per acre increase and .34 grouse hunter-days per acre, resulting from a 558 percent increase in the .062 hunter-days per acre for grouse.

The use change for small game is the product of mortality times acres burned in the appropriate timber type. This is to reduce the full effect for fires with less than 100 percent timber mortality. It has been arbitrarily assumed that the relationship between timber

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1/ Aspen was added by the Wisconsin DNR Committee. Rhinelander WI. 11/7/78.

mortality and effect is linear.

Waterfowl in Wisconsin includes geese, ducks, rails, coots, and gallinules. The effects of fire on waterfowl is an increase of .30 hunter- days per acre. This is from the 315 percent increase in the average use of .097 hunter-days per acre for waterfowl. Table 8 shows the estimates and the discounted estimates for waterfowl. The increase of 118 percent is a combination of increased nesting success and increased numbers of nests. Kirsch and Kruse (1972) found a 58 percent increase in nesting success on burned sites, and an increase in the number of nests on the same site of 59.3 percent after the fire. The

Table 8. -- Estimated changes in waterfowl populations.

Years Since Fire	Population Estimate	Discounted
1	1.18	1.11
2	1.18	1.05
3	1.18	.99
Total		3.15

increase in the number of nests was reduced to 38.5 percent because adjacent unburned sites also showed an increase in the number of nests, possibly indicating population increases from causes other than the fire. The three-year period for the predicted effects is arbitrary. While numerous authors have discussed the beneficial effects of fire on desirable food plants (e.g. Givens, 1962; Bendell, 1974), none have addressed the question of how long the effects last. The use change is limited to open types within one mile of open water, because most waterfowl nest in open fields and marshes, and feed primarily in water-related ecosystems.

A loss to waterfowl occurs if the nests are burned. The full effect is a one-year loss of the harvest of juvenile waterfowl, i.e. birds born the preceding summer. In Wisconsin, 63.6 percent of the annual harvest is juveniles (Jahn & Hunt, 1964). Thus, the full effect is a loss of .06 hunter-days per acre (63.6 percent of .097 waterfowl hunter-days per acre). A nesting index is needed to account for the presence or absence of nests. Ward (1968) indicates that all waterfowl nest from mid-May to the end of July, but mallards and pin-tails begin nesting by mid-April. Since these two species total 47.3 percent of the ducks which nest in Wisconsin (March et al, 1973), and since ducks account for 69.6 percent of all waterfowl use (Wisconsin DNR, q), the nesting index is .33 between mid-April and mid-May. From mid-May to the end of July, the index is 1.00, and it is .00 the rest of the year. The use change is again limited to marshes and open fields within one mile of open water.

Non-game species include all animals which are not hunted. For this study, non-game effects are limited to the effects of fire on non-game birds for two reasons: most wildlife observation is birdwatching, and the literature has contradictory reports concerning small mammals. Specifically, two recent studies (Buech et al, 1977; Coble et al, 1976) have shown significant short-term reductions in small mammal populations following fires, but other authors reported short-term increase to such populations (Ahlgren, 1966; White, 1960).

The full effect of fire on non-game birds is an increase of .20 observer-days per acre. The total effect is an 18 percent increase in birds for one year. This is the average of increases reported by Bock and Lynch (1970), a 28.6 percent increase in number of species present, and Bendell (1974), only a 7.4 percent increase. Ahlgren (1963) found such increases to last only one year following prescribed burning.

Rare, endangered and threatened species listed for Wisconsin include many predatory species and several aquatic species of amphibians and reptiles (Wisconsin DNR, 1975). The effects of fire has been assumed to be negligible unless a particular species can be identified as being directly affected. This was the limit that the DNR Committee would accept. Generally, the assumption of negligible effect is true. The aquatic species are unaffected, since water quality is assumed to be unaffected by fire. The predators are either unaffected or benefitted due to the generally beneficial effects of fire on game and non-game species. Threatened gallinaceous birds, including the prairie chicken, the yellow rails and the piping plover, are also generally benefitted since they respond much like the upland game birds. Kirtland's warblers have been identified in Wisconsin, but sighting are very rare and scattered. It is unlikely that there is a native population in Wisconsin.

Fish are assumed to be unaffected by fire. Fire-caused pollution could influence fish populations by affecting other biota (Komarek, 1965), but such pollution has been assumed to be negligible in Wisconsin, as previously discussed. In addition, stream temperature changes have been reported as too small to affect trout populations (Helvey et al, 1974).

Wildlife Values

The values used in assessing the effects of fire on wildlife are listed in Table 9. The values are the expenditures made in Wisconsin in 1975 for various types of hunting and for wildlife observation

(National Analysts, 1975), inflated to 1978 dollars using the Consumer Price Index.

Table 9. -- Wildlife use, expenditures, and values.

Activity or Species Group	Days of Use	Expenditures 1975 Dollars	Expenditures 1978 Dollars	1978 Value Per User Day
	-millions-			
Deer	6.03	121.71	158.19	25.39
Small Game	8.67	52.82	66.48	7.67
Waterfowl	2.61	28.51	35.89	13.75
Observations	38.76	16.34	20.56	.53

Recreation

Most resources affected by fire can be associated with a single purpose, like timber or water. Recreation is different, however, because it includes many uses, ranging from hunting to hiking, from boating to sightseeing. Some of these uses are mutually exclusive at a particular time, like hiking and boating, but others, like camping and hunting, can be complementary. Other chapters have covered some of the aspects of recreation use. Evaluation of the effects of fire on wildlife-associated recreation is discussed earlier. The aspects which will be covered in this section are the change in recreation use, other than the use associated with wildlife, and the change in long-term visual quality or aesthetics. The effects of fire on ornamental trees is also covered, although they are really property improvements, not unlike a fence or a picnic table. The DNR Committee decided that ornamentals should be included as a part of recreation.

Aesthetics

That beauty has value in our society is obvious when one examines the prices paid for some paintings and sculptures. The value of an aesthetically pleasing view is shown by the crowds of visitors to such beautiful parks as Yosemite and Yellowstone. While there is no concrete evidence that a burned site is less desirable than an unburned site, the usual reaction to Smokey Bear advertisements suggests that fire, and the resulting burned site is undesirable. For a marketable commodity, like timber, this undesirable condition would be reflected in the price and the quantity purchased, but price and quantity are not relevant measures for aesthetic quality.

The technique selected for the DNR is to use a descriptive term to identify the relative effect of the fire. It was decided that no dollar value would be estimated for two reasons. First, because "beauty is in the eye of the beholder," standardization of the value might be impossible. The second and more important reason is that the DNR Committee decided that any value would be unacceptable to the "powers that be."

Several variables influence the relative effect of a fire on aesthetics. The variables which will be used include the size of the area burned, the aesthetic importance of the area, and the intensity and duration of the effect. The size of the area burned is measured in acres, using six arbitrary classes so that tables with discrete categorizations of the relative effects could be developed.

Five recreation use classes were identified to rate the relative aesthetic importance of the burned area. One criterion for selecting the use class is the type of road from which the burned site can be seen; the highest category is a site visible from a four-lane highway, while the lowest category is a site which cannot be seen from any road. The second criterion is the general recreational use of an area from which the fire site is visible. Lakes with public access and developed sites like campgrounds and picnic areas rate the highest category. The middle class includes burned sites seen from any lake or lakeshore, from moderately used trails or pathways, and from streams with moderate fishing or heavy to moderate canoeing. The lowest category is used for burned areas which cannot be seen from any road, trail, lake, or stream.

The third variable considered is the intensity and duration of the fire's effect. This will be measured by the average timber mortality, using four arbitrary categories. If the fire is only in non-timber types, the effect will probably be short-lived, as grasses and most shrubs come back vigorously following fires. The effect was, therefore, assumed to be negligible for fires with less than 19 percent average mortality. Although numerous authors have discussed the beneficial effects of low-intensity fires on aesthetics (e.g. Fox, 1969; Papenfus, 1971; Perkins, 1971), the DNR Committee decided that any assessment of aesthetic benefits to low-intensity fires would be administratively unacceptable.

The aesthetic effects range from extreme damage to very heavy, heavy, moderate, and light damage and to negligible effect, as shown in the handbook, Appendix A. The effect for each combination of average mortality, acres burned, and recreation use class was determined arbitrarily by the author with adjustment by the DNR Committee.

Ornamental Trees

As described previously, ornamental trees are really improvements which enhance the visual quality of a site. On developed recreation sites, they should result in increased use, just like any other improvements. However, ornamentals can affect the property value of a vacation home, for example, and thus have value which is not strictly limited to affecting income.

There are numerous methods available to calculate the value of an ornamental tree, identified in Table 10[1/]. One method is to estimate the timber value of the ornamental, but selling timber is not the reason (usually) for having ornamentals. Another technique is to

Table 10. -- Ornamental tree valuation models

Alternatives	Method Chosen	Rationale
1. Timber Value	Evaluation Formula	1. Data availability
2. Property Value		2. DNR abilities
3. Asset Value		
4. Legal Value		
5. Replacement Cost		
6. Evaluation Formula		

determine the property value change resulting from having (or losing) an ornamental tree; the problem here is the need for an accurate appraisal of the market value of the property. A third way is to estimate the asset value, usually done by municipalities by capitalizing the annual maintenance costs; this, however, assumed the ornamental is worth whatever is spent to keep it alive. The next technique is the legal value, as defined by the courts, by the Internal Revenue Service, or even by insurance companies; unfortunately, there

[1/] This discussion is based on Michael T. Lambur, Economic Values of Urban Trees (unpublished manuscript, Michigan State University, Department of Forestry).

is very little useful information available about these valuations. Another method is to estimate the replacement cost, but it is nearly impossible to replace burned ornamental with a tree identical to the ornamental before it was burned, especially as the diameter increases. The final method is the use of an evaluation formula. Several formulae are available, with the basic value usually related to circumference, diameter or basal area. The most widely used formula was developed by the International Shade Tree Conference (ISTC) in 1969. This formula includes a basic value per square inch of basal area, a species factor to account for the hardiness and desirability of the species, and a condition factor to assess the health and desirability of the affected ornamentals. It has been suggested that a location factor is also important in determining the value of a specific tree (MF&PA, 1978).

The technique selected for the Wisconsin DNR is the ISTC evaluation formula. Theoretically, the most correct technique would be to estimate property value changes, but this requires accurate property value appraisals. The DNR Committee rejected this as more than the field personnel could handle. The ISTC formula appears to be as accurate as the other techniques available, and it is widely used in arboriculture and urban forestry. One additional advantage is that it is simple to implement.

Ornamental loss is calculated by multiplying the cost by the condition class and the location class for each ornamental which is killed. The condition class is a relative rating, between zero and one, of the health, form, and vigor of the affected ornamental. Location class is an assessment of the importance of the ornamental in the landscape, from one for lone trees on an important site to zero for trees that aren't ornamentals.

Replacement costs for shrubs and small trees are generally available from nearby nurseries. Cost for larger trees is calculated by multiplying the basic value by the basal area and the species factor. The species factor for the various trees in Wisconsin was determined as the average values for Michigan and Wisconsin (MF&PA, 1978; Wisconsin b) and is shown in Appendix A.

The base value used in Wisconsin is $16.77 per square inch of basal area. This is from the $9 per squre inch determined at the International Shade Tree Conference in 1969, inflated to 1978 dollars using the Consumer Index. This is the only value reported in the literature surveyed.

Recreation Use

There are basically three values associated with recreation, as described in the wildlife section. They include activity value, option value, and existence value. Activity value is the value of a particular site for recreating, while option value is associated with the desire to maintain the possibility of recreating in a certain way on a particular site. Existence value is the value of knowing that a certain type of recreation on a specific site is available even with no current or expected participation (Brookshire et al, 1978).

Recreation is considered a non-market service, because camping is generally the only activity provided by the private sector. This is at least partly because of the area needed for much recreation and many private lands are too small to provide adequate facilities. Another factor is that some important uses, like sightseeing, are virtually impossible for a landowner to control or prevent.

There are several ways to measure the value of a non-market commodity. Willingness to pay, measured by surveys or travel costs or consumers' surplus, is one technique. Another is to calculate the cost of alternatives, either the opportunity costs of the existing site or the additional cost to use a different site. The third technique frequently suggested is to use expenditures, measured in one of several possible ways.

The gross expenditures method is the technique selected for the Wisconsin DNR. One reason is that the DNR Fuels and Effects Committee felt that the values derived using this method were administratively acceptable. Another reason is that gross expenditures is the only measure which is available for many types of recreation. As discussed earlier, consistency is very important in planning (Schuster, 1977). Precautions have been taken on the appraisal reporting form to prevent comparisons of recreation values with other values estimated in the fire appraisal.

The valuation method is fairly simple and straightforward. Since the available values are measured by user groups per day, it is necessary to estimate the number of user groups lost and the length of time affected. The user groups lost can generally be determined from the records of the owner or manager. Only developed recreation sites were assumed to be significantly affected by fires. There is obviously some judgement involved, but the DNR Committee felt that this was acceptable due to the relatively rare occurrence of such circumstances. Judgement is also involved in selecting the most appropriate use category of those available. Only use lost during the current season is included since recreational equipment and improvements are assumed to be replaced or restored.

The values to be used in calculating the fire effects on recreation use are listed in Appendix A. The values are the expenditures made in Wisconsin in 1969 (Wisconsin DNR, 1969), inflated to 1978 dollars using the Consumer Price Index.

Environmental Quality

There are many aspects of the environment which can be affected by fire. These include water quality, soil stability, air quality and life and limb. Most aspects, like water and personal property, have been discussed previously. Human life won't be covered because death is a rare occurrence in forest fires in Wisconsin, as well as the reluctance of the DNR to placing a specific value on a human life.

The air quality values which can be influenced are related to the desire for clean air. Since the primary pollutants are carbon dioxide and particulates, there is little health risk attributed to forest fires (Cooper, 1971; Hall, 1972). However, the particulates can cause problems such as soiling clothes and dirtying windows. Smoke can also cause the "Smokey Bear Syndrome", the fear associated with fires (Papenfus, 1971).

The technique selected for the DNR is to use a descriptive term to identify the relative effect of the fire. It was decided that no dollar value would be determined for two reasons. First, the ability of the field personnel to estimate changes in visibility, costs associated with the soot, and increases in fear is severely limited. Second, and more important, the DNR Committee felt that the arbitrary nature of any value attached to such effects would obscure any meaning the relative descriptions would have in their planning.

Several variables are to be determined in the field. One important variable is atmospheric stability, since this is the primary influence on the time needed for smoke dispersal (Schroeder & Buck, 1970). Another is the volume of smoke produced. Based on the experience of the DNR Committee, smoke volume depends mostly on the size of the fire and on the duration of smoke production. Thus, a peat fire with a relatively small size may produce a large volume of smoke whereas a large grass fire may produce much less. The smoke index, an ordinal measure of smoke volume, is the product of fire size and smoke duration.

The third variable considered is the population which is affected by the smoke. Five population use classes were identified to rate the relative importance of the use areas affected by the smoke. These classes generally depend on the size of the city or town in which the smoke can be detected, although highway size and recreation importance can also influence the classification.

The effects range from extreme damage to severe, heavy, moderate, and light damage and to negligible effect, as shown in Appendix A. The effect for each combination of smoke index, population use class, and atmospheric condition was determined artibrarily by the author with adjustment by the DNR Committee.

CHAPTER 5. RESEARCH NEEDED

Many assumptions have been made in the development of the DNR Fire Effects Appraisal Handbook. Some are extrapolations from existing research beyond the relevant ranges of the studies. Other assumptions have been based on field experience or intuitive logic, without explicit analysis. Research is needed to test the key assumptions and to provide information which can be used to improve the accuracy of the system. The following discussion of research topics is separated into market and non-market resources.

Market Resources

Timber Mortality and Cull

This may be the most important research topic. Mortality estimates affect non-market resource values, specifically aesthetics and wildlife, as well as timber values. The data used to develop the conifer mortality predictors are from prescribed fires in red and white pine stands in southern Ontario and from wildfires in red and jack pine stands in Wisconsin. There is insufficient data available to determine if the various conifer species are affected differently, or if tree size (height or diameter) has an affect on the mortality predictions. There is the implicit assumption that crown scorch is the best predictor of mortality. The hardwood mortality curves were derived from an oak-hickory forest in Missouri. Research is needed to determine if the curves are appropriate for oaks in Wisconsin and whether the predictions are applicable to other hardwood timber types. Bark scorch has been assumed to be an adequate predictor, since it is the measure used in the Missouri oak-hickory study. Live cull, damage to volume or value without mortality, has been assumed to be negligible, while this assumption is based on existing research, there is literature to the contrary (e.g. Burns, 1955; Kuenzel, 1936).

Immature Stand Valuation

Many assumptions were made in the procedure used for valuing immature timber. Most involve data derived from research on the Wisconsin timber supply (Essex & Hahn, 1976; Spencer & Thorne, 1972). Several adjustments were needed to balance with the field experience of the DNR Committee members. Research is needed to provide an empirical basis for predicting volume and the age at which that volume is reached.

Timber Stand Regeneration

There are two questions on this topic which need to be addressed. The first is whether the effects of fire on regeneration need to be assessed. The effects on plantations were assumed to be zero, since natural regeneration and timber plantations are mutually exclusive; however, wildfire could cause an increase in the costs of site preparation and the increase would be attributable to the fire. In addition, preliminary estimates indicate that the values involved in natural regeneration are usually less than one-tenth, and often less than one percent, of the damage to the existing stand. Since the procedures for estimating regeneration loss and replacement value are rather lengthy and complicated, it may not be worthwhile to appraise these effects.

The second question for regeneration research is when regeneration is needed and what type of regeneration occurs. This research is only important if the values involved are significant enough to be appraised. The procedures developed for the Wisconsin DNR assume that regeneration will occur when it is needed except for fires in red pine stands, young jack pine stands, and some white cedar stands. Regeneration is assumed to be necessary, but with a timber type change, in these stands with over fifty percent mortality. Research is needed to determine the conditions in all timber types when regeneration becomes necessary. Research is also needed to establish the timber type and the density of the regeneration. The new system assumed that regeneration is usually the same timber type (with the exceptions noted) and the same density as the existing stand.

Non-Market Resources

Wildlife Valuation

The major assumption in the wildlife appraisal section is that human use, and therefore value, varies proportionally with changes in wildlife use of the burned site. Research has suggested that there is a positive correlation between wildlife populations and human value, but the specific relationship has not been identified for any animal species or for any particular site. Another important assumption is that wildlife use of the burned site is unrelated to use on adjacent sites. While there would seem to be some relocation in use patterns, it was stated that the effect was negligible for deer[1/], the species one would expect to show the greatest change in use patterns. This is obviously an area which needs to be examined.

Even if research indicates that human use is directly proportional to wildlife populations and that there is no relocation effect, there are still several assumptions upon which the appraisal system is based.

1/ Personal communication with Keith McCaffery. 7/26/79.

One is that all population responses identified in the literature are for very intense fires (100 percent timber mortality) for the "average" site in Wisconsin. Another assumption is that there is a linear relationship between no effect at zero timber mortality and full effect at 100 percent mortality (except for deer in northern hardwoods and white birch). A third assumption is that the identified habitat (timber) types are affected identically, and there is no effect on any other cover type. Research is needed either to verify the relationship between timber mortality and population response to fire in various cover types or to establish some other measurable independent variable.

Recreation Use

It was assumed that changes in use at developed recreation sites could be determined, while changes in dispersed recreation use would be negligible. The method for estimating use change at developed sites may be adequate, especially since fires at developed sites are relatively rare (none in the two years of testing). Research is needed, however, to assess the changes in dispersed use. Intuitively, some uses are unaffected, like sailing and canoeing, while many uses like hiking may be damaged and others, blueberry picking for example, may be benefitted.

Non-Market Values

Expenditures was the value measure used in Wisconsin because it met the needs of the DNR: it was a consistent measure for several types of use that varied by type of use affected. The studies used for determining wildlife and recreation expenditures, however, were conducted by different groups for different purposes, and therefore may not be comparable. Also, as discussed earlier, expenditures may not be a desirable measure of value. Research is needed to establish a consistent basis for valuing all non-market resources.

Ornamental Trees

There are at least three areas needing research for ornamental assessment. One is to determine the value of an ornamental tree; the ISTC value is acceptable, but the rationale for the base value was not discussed in the literature surveyed. Another research topic is in defining ornamental trees; the description used was determined arbitrarily, although it satisfied the DNR Committee. A third area is determining the probability of an ornamental being killed or losing some of its value as an ornamental. The assumption used is that a tree will die if the timber mortality predictors indicate over a fifty percent expected mortality in a timber stand; if the tree is not expected to die, there is no effect on its ornamental value.

Aesthetics and Air Quality

The table for rating the relative effect of wildfires on aesthetics and environmental quality were developed in an arbitrary manner. The classes used for fire size, mortality, use, and smoke volume were determined arbitrarily. The descriptions of the effect were also arbitrary, although they correspond with the categories used in the National Fire Danger Rating System. Research is needed to provide a more consistent and objective basis for evaluating the effects, and preferably to determine value changes which at least correspond with the recreation and wildlife values.

CHAPTER 6. IMPLEMENTATION

There were several concerns which arose during the development of the system that had to be considered. The most important concern throughout the development centered on resource values, especially the relative sizes of timber and wildlife values. There was a general awareness that a distinction between market and non-market goods was necessary, but it was not discussed explicitly in the first few meetings. However, after several discussions, the DNR Committee unanimously agreed that a statement concerning the non-comparability of values must accompany any and all benefit and loss estimates. In addition, some training of DNR personnel was considered necessry to help them understand the difference.

Another concern was the potential loss resulting from fire-induced type conversions, particularly in relation to the change from jack pine to aspen following one large fire in central Wisconsin. The concern was satisfied by including the regeneration loss and replacement value for certain stand conditions. The DNR Fuels and Effects Committee had found that the values involved probably did not justify the effort expended to calculate them, but concluded that they would only be able to eliminate the procedure when they could prove the insignificance of the values.

A third question which was raised more than once was the occurrence of cull in hardwoods. Research has shown that fires can cause scars without killing the trees, but some evidence indicates that multiple fires are necessary for significant scarring. The DNR Committee decided to accept the assumption of negligible cull while initiating a study to analyze this assumption.

The effect of fires on rare and endangered species was discussed at several Committee meetings. There was a desire to at least consider such effects. After discussing a proposal for appraising such effects, the DNR Committee decided to exclude the specific approach. The general feeling was that any specific statements would be indefensible, unless the individual were a wildlife expert, and that it could be argued that rare and endangered species were a part of the non-game species.

The fire effects appraisal system was approved by the DNR Committee at a meeting on August 29 and 30, 1979. During the meeting, two major tasks were assigned to help get the system instituted. The first task was to get the approval of the state forester and the fire control staff for a test of the system during the 1980 fire season. This test was to include about a dozen people, selected so as to cover the entire range of timber types and experience in Wisconsin. Other factors in the selection were the ability of persons to handle the added work of applying both systems and their willingness to critically analyze the system. Preliminary selections were made at the August meeting. The participants are listed in Appendix B. The second task was to present the proposed system at the annual staff meeting in Madison in late October. This step was deemed necessary to head off opposition.

Several more meetings were arranged during that August session. The DNR Committee agreed to meet in early November to prepare the training program for the dozen participants. The topics for instruction were divided among the Committee members. Another meeting was set for late January for a dry run of the training program with the training scheduled for late February.

The training meeting was held in Tomahawk, Wisconsin, on March 4 through 6, 1980. The meeting opened with a background and history of the development, followed by the presentation of the new system. There were a lot of questions, but none that had not been raised by the DNR Committee during the development. On the final day, a comparison of the expected timber effects using the old and new systems was made. Finally, the rules for testing the system were specified. Each participant was to use both systems for the 1980 fire season. At least 30 days after the fire, each was to return to the fire site to check the mortality prediction. Lastly, each person was asked to critically evaluate the system, and be prepared to discuss changes and improvements at the planned autumn meeting.

The DNR Committee meeting for reviewing the system took place on November 5 and 6, 1980[1/]. The focus of the meeting was the wildlife section. There was some dissatisfaction with this section, although there were few specific suggestions for improvement. One change which was prepared too late for inclusion in the test was the replacement of the rabbit, grouse, and pheasant effects by the small game effect, as presented in this paper. While the change in calculations is minor, the DNR Committee felt it would increase the administrative acceptability of this section. One specific problem which was raised is that the pheasant effects may be grossly overestimated; apparently a substantial portion of the pheasant harvest

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[1/] The observations on this meeting are from personal communication with Gene Miller, Wisconsin DNR Fuels & Effects Committee member. 11/12/80 is from a "put-and-take" operation. The proposed solution is to reduce the full effect by the percent of the harvest which is from the native population.

One major complaint was the amount of time required on the wildlife effects. The primary example was that the non-game effect was less than one dollar for every fire in the test. The DNR Committee responded that some calculations may be eliminated when there is enough evidence to suggest that the effect is negligible, and the non-game effect appears to be negligible. In addition, the Committee decided to substantially rewrite the handbook to simplify the procedures and to meet Wisconsin printing requirements.

Another criticism focused on the size of the calculated benefits. Part of this problem was related to pheasants, as noted above, but much of it resulted from the selection of the participants. About 80 percent of the fires in the test were in the southern half of the Wisconsin although most of the fires that the DNR suppresses are in the northern half, which has much lower waterfowl and pheasant success indices. The Committee has suggested that the commitment to a fair and reasonable wildlife appraisal could be improved by increasing field-level cooperation with the Wildlife Division. Contact would be made by a Committee member early in 1981.

There were two complaints about the timber effects section. One, particularly from the southern areas, was that the system seemed to ignore timber quality losses for surviving trees. The Fuels and Effects Committee responded with the existing state-of-the-arts information on live cull, and promised further study, but no specific tasks or responsibilities were identified. The other complaint was the valuation of immature plantations. Several participants asked if replacement costs could be used, even after being shown that replacement costs were often lower than the calculated loss. One suggestion was to include both on the fire report, but this will undoubtedly lead to summing them, and therefore, to substantially overstating timber losses. The response to this request was left open. The question of site clearing costs was also raised. I had earlier told the DNR Committee that any costs which exceeded normal site preparation costs were legitimate fire-caused losses, but no consistent method for estimating this exists. The DNR Committee decided to look further into the possibility of estimate site clearing costs.

There was some dissatisfaction with the "adjective values" used in aesthetics and environmental quality. Following the discussion, the DNR Committee decided to continue with that structure. The participants agreed that was probably the best alternative available, even though it was not particularly satisfying to them.

The Committee was pleased with the overall response to the new system. Their major concerns were the acceptability of the system and the accuracy of the mortality predictors. Though there was some dissatisfaction with the system, most agreed that it was an improvement over the existing system and should be implemented. The mortality checks conducted by the group appear to be reasonably close to the predictors. The new data will be added to the existing data and new curves will be drawn, but the feeling is that the changes would be minor. One problem is fire running up the bark of white birch trees; this causes very high bark scorch without a correspondingly high mortality rate. Further research on this problem, and on all the mortality estimates, is planned.

The handbook will be substantially rewritten from the form presented in Appendix A. The handbook and the necessary forms will be finalized by October, 1981, so that they can be printed and distributed during the winter. Training sessions will probably be conducted throughout Wisconsin prior to the 1982 spring fire season, when the new fire effects appraisal system will be implemented state-wide.

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APPENDIX A

Table of Contents

(Cont'd)

Fire Effects Appraisal Handbook

Wisconsin Department of Natural Resources

Field Measurements - Chapter 10

Equipment Needs

The following equipment is needed to make field measurements for this appraisal system. These items should be stored in the ranger's truck.

1. Tatum
2. Handbook
3. Supply of field worksheets
4. Bitterlick stick or prism
5. Cloth tape
6. Diameter tape
7. Ax or fin saw
8. Increment borer

Step 1. Identify overstory cover types on the burned area.

A. For each type, select the appropriate symbol from column 2 of Cover Type, Table 1 in Appendix A, and record it under Cover Type. If more than one species occurs, select the dominant one, using the definitions listed in Cover Type Table 1.

B. Record the size class and density class for each overstory timber type, using the categories in Size-Density Table 2 in Appendix A.

NOTE:

1. Use the lower size class whenever an overstory stand is composed of more than one size class, unless over 75 percent of the trees are in the higher class.

2. If the stand is a plantation, mark a "P" in front of the timber type. If it is a Christmas tree plantation, mark "CP".

3. Plantations in immature size class (0-5") are in density class 4 unless poorly stocked; then use class 3.

4. Christmas tree plantations must be recorded by tree species, average tree age, and number of trees per acre. Record trees per acre under Density Class.

C. Enter the acres burned for each type under Acres Burned.

Step 2. Identify understory cover types on the burned area. If there is an understory present, record timber type, size class, density class, and acres burned as for overstory types. Record each understory timber type on the line directly below the overstory type it is associated with and draw loop connecting the two lines.

Step 3. Determine scorch for each burned timber type. Scorch is very important in determining timber loss. Additional time should be spent obtaining this figure for high value timber, large acreages, or when other circumstances warrant a more accurate figure. Trees estimated should be in the same diameter class as the cover type. If an understory is present, determine a separate estimate for those trees. If one portion of the cover type sustained a higher amount of scorch than the remainder, consider treating the two portions as separate timber types.

A. For each conifer stand, estimate the average percent of crown scorch and record under Scorch. Crown scorch is the amount of needles discolored. Estimate at least 4 representative trees separately and average together. If scorch varies drastically, estimate more than 4 trees. Trees with all needles consumed are 100 percent.

Step 3. (Cont'd)

B. For each hardwood type, estimate the maximum height of bark scorch in feet. Bark scorch is the amount of bark that is discolored; at least 4 representative trees should be measured and their maximum heights should be averaged. Record under Scorch.

Step 4. For each immature stand (0-5"), determine the average age of the trees in the stand; round to the nearest 5 years. Record under Age.

Step 5. For each merchantable stand in density class 4, estimate the volume per acre and record under Volume.

NON-TIMBER

Step 1. Identify each non-timber type on the burned area, according to the definitions in Cover Type Table 1 in Appendix A. Select the appropriate symbol and record it under Cover Type; record the acres burned under Acres Burned.

Step 2. Add the total non-timber acres burned and the total timber acres burned, and record under Total Acres Burned.

CROP

Step 1. Identify each crop type on the burned area. Record each under Crop and enter area burned for each crop under Acres Burned.

Step 2. Determine if each of the burned crops has been harvested in the current growing season. If the crop has been harvested, record a "yes" under Harvested. Examine nearby unburned crops or ask the farmer or a neighbor to determine if the crop has been harvested.

EQUIPMENT

Step 1. Determine all equipment and improvements which require replacement or additional maintenance. Was the equipment/improvement insured? By what company? What was the cost when new? List each with an estimate of its condition before the fire. The general condition should be determined from the condition of other nearby pieces of the same type of equipment, with adjustment based on the knowledge of the owner or manager. If the piece was unique on the site, or if all such pieces burned, the estimate should be based on the judgment of the owner or manager.

The following condition classes should be used:

Excellent = virtually brand new
Very Good = fairly new, but with some evidence of wear
Good = worn, but still working well
Fair = well worn, but still working
Poor = still working, but obviously needing replacement

If the item is basically junk/scrap metal, about how much does it weigh? Finally, devote effort commensurate with values; i.e., if values are high, do a lot of digging. If low—not too much.

RECREATION

Step 1. Determine which Recreation Use Class is affected by the fire. Select the highest class in which the fire can be classified. Record under Use Class.

Recreation Use Class

A: Fire site can be seen from a 4-lane highway, OR from a lake with a public assess, OR from a developed recreation site (campground, public beach, picnic ground, etc.).

B: Fire site can be seen from any state or federal highway, OR from any lake with boating access, OR from heavily fished streams, OR from heavily used trails or pathways.

C: Fire site can be seen from any paved road, OR from any lakeshore (where the lake is at least 1 acre), OR from any stream with a moderate amount of fishing or with heavy or moderate canoe use, OR from any moderately used trail or pathway.

D: Fire site can be seen from any road or trail OR from any permanent stream.

E: Fire site cannot be seen from any road, trail, lake or stream.

Step 2. Determine all ornamental trees which are killed (all hardwoods less than 5"; hardwoods 5" or more with scorch height of 8' or more; conifers with crown scorch of more than 70 percent).

A. The condition of each tree should be estimated, using the knowledge of the owner or manager. The following condition classes should be used:

Condition Class

1.00 = A well formed tree, with no visible defects.

0.75 = An aesthetically pleasing tree, with some visible defects (like dead branches), but in very good health.

0.50 = A nice looking tree, with visible defects (like dead branches or basal scars) and adequate health.

0.25 = An acceptable tree, but in rather poor health.

Record the appropriate value under Condition Class.

B. The location of each burned ornamental tree should be recorded using the following location classes:

Location Class

1.00 = A tree which is standing alone on a lakeshore, OR in a developed recreation site (campground, public beach, etc.), OR in the front yard of a home.

0.75 = A tree which is standing in a small group on a lakeshore, OR in a developed site, OR near a home.

0.50 = A tree which is standing near the forest edge around a lake, OR a developed recreation site, OR a home; it must be within 100 yards of the lake, site, or home and within 10 feet of the forest edge.

0.25 = A tree which is visible from a lake, a developed recreation site, or a home, but which is definitely a part of the forest (along the edge); it must be within 100 yards of the lake, home, or recreation site.

Record the appropriate value under Location Class.

C. Determine the diameter (at breast height, if possible) and record under Diameter.

Step 3. For each developed recreation site, estimate the number of visitor groups which would have used the burned site during the remainder of the season (from the time of the fire until December 31). This should be related to the number of campsites, picnic sites, trails, etc. which will be closed to use. The use of each site can be determined from the records of the owner or manager. Record the estimate under Visitor Groups Lost.

ENVIRONMENTAL QUALITY

Step 1. Determine if the atmosphere is in a stable or unstable condition. Record under Atmospheric Condition.

A. Stable - The clouds, if any, are flat and tend to be thin and wispy (cirrus); smoke columns flatten out and tend not to rise very far; if there are any winds or precipitation, it is steady; visibility is poor (hazy conditions).

B. Unstable - The clouds are very puffy like thunderheads (cumulus); smoke columns rise very high and dissipate; winds and precipitation tend to be strong and gusty (showery); if it is clear, the visibility is very good (no haze or fog).

Step 2. Determine the length of time in hours (or fraction of hour if less than one hour) that the fire is producing a significant amount of smoke in the Population Use Class you have chosen for the fire. Times from the fire report can be used to assist this estimate. Record under Smoke Duration.

Step 3. Determine the Population Use Class which is affected by the fire. Select the highest class possible. Record under Population Use Class.

Population Use Class

A: Smoke can be detected (seen or smelled) within a city of more than 100,000 people.

B: Smoke can be detected (seen or smelled) within a city of more than 10,000 people.

C: Smoke can be detected (seen or smelled) within a city or town of more than 1,000 people, OR on a 4-lane highway, OR at a developed recreation site (campground, boat launch, picnic area, etc.).

D. Smoke can be detected (seen or smelled) within a town of at least 100 people, OR on any paved road, OR at any moderately used recreation site (fishing streams, lakes, trails, etc.).

E: Smoke cannot be detected (seen or smelled) within any town of 100 people or more, NOR from any paved road, NOR at any moderately used recreation site.

Fire Effects Appraisal Handbook

Wisconsin Department of Natural Resources

Office Calculations - Chapter 20

WILDFIRE EFFECTS ON TIMBER

Step 1. Effects on Merchantable Conifers (except Christmas trees).

A. Determine Current Loss for each conifer timber type. Use the formula:

Current Loss = Volume (1) x Price (2) x Mortality (3) x Acres Burned (4)

Calculate using numbered definitions of terms below and record under Current Loss. For natural PR stands with mortality exceeding .50, see part B. below. For C stand with mortality exceeding .50 and either a hardwood understory or more than 30 percent of the stand in other swamp conifers, see part C. below. For all other cases, Regeneration Loss = 0 and Replacement Value = 0. Calculate Loss and record under Loss, using the formula:

Loss = Current Loss + Regeneration Loss - Replacement Value

1. Volume is from the table below using the size class and density class recorded in the field. If volume was measured directly in the field, that volume may be used if it represents the stand better.

Size Class	Units	Density Class ''''	'''	''	'	0
5-9"	Cords	a/	16.5	10.0	5.0	0.0
9-15"	MBF	a/	6.7	3.7	1.8	0.0
15"+	MBF	a/	10.2	6.4	2.8	0.0

a/ Volume was estimated in the field.

2. Price for each timber type is listed by district in Stumpage Values, Table 1 in Appendix C. For each plantation or pure species stand with considerable loss, contact the Area-Forester for the current market price for the species. If there are explicit restrictions on timber harvesting (like wilderness areas or developed campgrounds), then the price is $0.00.

3. Mortality is determined from Conifer Mortality, Figure 1, Appendix B. Round off to 2 decimal places and record under Mortality.

4. Acres Burned was recorded in the field.

B. Red Pine (PR) Regeneration Loss and Replacement Value.

1. Regeneration Loss = Volume (a) x Price (b) x Periodic Rate (c) x Acres Burned (d)

(a) Volume is from the table above using size class 15"+ and the density class recorded in the field (if the stand was density class 4, the volume is 13.7 MBF).

(b) Price for PR sawtimber is listed by district in Stumpage Values, Table 1 in Appendix C.

(c) Periodic Rate is .00069 - the rate which corresponds with the rotation age of natural red pine (130 years).

(d) Acres Burned was recorded in the field.

2. Replacement Value = $0.00.

NOTE: Return to where you were Page 20-1 for merchantable conifers and Page 20-3 for immature conifers.

C. White Cedar (C) Regeneration Loss and Replacement Value.

1. Regeneration Loss = Volume (a) x Price (b) x Periodic Rate (c) x Acres Burned (d)

(a) Volume is from the table below using the density class from the field.

Units	Density Class				
	''''	'''	''	'	0
MBF	9.7	6.7	3.7	1.8	0.0

(b) Price for C sawtimber is listed by district in Stumpage Values, Table 1 in Appendix C.

(c) Periodic Rate is .003 - the rate which corresponds with the average rotation age of white cedar (100 years).

(d) Acres Burned was recorded in the field.

2. Replacement Value = Volume (a) x Price (b) x Periodic Rate (c) x Acres Burned (d)

(a) Volume is from the following table using the size class which is appropriate for the replacement timber type.

(1) Replacement Timber Type: If the stand is more than 30 percent other swamp conifer species, the replacement timber type will correspond to the predominant species. For example, if the stand has 15 percent black spruce, 12 percent balsam fir, and 9 percent tamarack, the replacement timber type will be black spruce (BS). If the stand is less than 30 percent other swamp conifer species, then replacement type will be the same as the understory type.

(2) Size Class is 5-9" for all conifer replacement timber types and 5-11" for all hardwood types except NH, O, and SH. For these, the size class is 15"+.

	Size Class	
	5-9" or 5-11"	15"+
Volume	10.0	6.4
Units	Cords	MBF

(b) Price for the replacement timber type is listed by district in Stumpage Values, Table 1 in Appendix C.

(c) Periodic Rate is the rate from the table below which corresponds with the rotation age of the replacement type. Each type is listed next to its average rotation age. This value can be used if the correct rotation age for the site is unknown.

Species	Rotation Age	Periodic Rate	Species	Rotation Age	Periodic Rate
	30	.211	T,SH	100	.0030
A	35	.150		110	.0016
	40	.108		120	.00092
	45	.078		125	.00069
FB	50	.057	PW	130	.00051
	55	.042		140	.00029
BW	60	.031		150	.00016
	70	.017		160	.000089
	80	.0095		175	.000037
SB, SW	90	.0053		200	.0000087

(d) Acres Burned was recorded in the field.

NOTE: Return to where you were (Page 20-1 for merchantable conifers and below for immature conifers).

Step 2. Effects on Immature Conifers (except Christmas trees).

A. Determine Current Loss for each coniferous timber type. Use the formula:

Current Loss = (1) Volume x (2) Price x (3) Mortality x (4) Acres Burned x (5) Discount Rate

Calculate using numbered definitions of terms below and record under Current Loss. For natural PR stands with mortality exceeding .50, see Step 1, Part B. on Page 20-1 . For C stand with mortality exceeding .50 and either a hardwood understory or more than 30 percent of the stand in other swamp conifers, see Step 1, Part C. on page 20-2. For natural PJ stand with mortality exceeding .50 and an age of less than 7 years, see Part B following. For all other cases, Regeneration Loss = 0, and Replacement Value = 0. Calculate loss and record under Loss. Use the formula:

Loss = Current Loss + Regeneration Loss - Replacement Value.

1. Volume is the predicted volume from the table following which corresponds to the timber type and density class.

Timber Type	Density Class	Predicted Volume	Merchantable Age
Plantations	4	23.0	20
	3	16.5	20
PR & PJ	3	16.5	25
	2	10.0	25
	1	5.0	25
PW	3	16.5	35
	2	10.0	35
	1	5.0	35
FS & C	3	10.0	35
	2	5.0	35
	1	5.0	65
SB & T	3	10.0	65
	2	5.0	65
	1	0.0	--

2. Price for the burned trees is listed in Stumpage Values, Table 1 in Appendix C. For plantations or pure species stands with considerable loss, contact the Area Forester for the market price of the burned species. If there are explicit restrictions on timber harvesting (like wilderness areas or developed campgrounds), then the price is $0.00.

3. Mortality is determined from Conifer Mortality, Figure 1, Appendix B. Round off to 2 decimal places and record under Mortality.

4. Acres Burned was recorded in the field.

5. Discount Rate is the rate from the table following which corresponds to the discount period.

   a. Discount Period = Merchantable Age - Current Age. If the discount period is negative, Discount Rate = 1.0.
   b. Merchantable age is listed in the table above.
   c. Current age was recorded in the field

Discount Period	Discount Rate	Discount Period	Discount Rate
0	1.00	35	.13
5	.75	40	.10
10	.56	45	.07
15	.42	50	.05
20	.31	55	.04
25	.23	60	.03
30	.17	65	.02

B. Jack Pine Regeneration Loss and Replacement Value.

1. Regeneration Loss = Volume (a) x Price (b) x Periodic Rate (c) x Acres Burned (d)

   a. Volume is from the table below using the density class recorded in the field.

Units	Density Class				
	''''	'''	''	'	0
Cords	23.0	16.5	10.0	5.0	0.0

   b. Price for PJ is listed by district in Stumpage Values, Table 1 in Appendix C.

   c. Periodic Rate is .042 - the rate which corresponds with the average rotation age of jack pine (55 years).

   d. Acres Burned was recorded in the field.

2. Replacement Value = 10.0 x Price (a) x Periodic Rate (b) x Acres Burned (c)

   a. Price for Aspen (replacement timber type) is listed by district in Stumpage Values, Table 1 in Appendix C.

   b. Periodic Rate is .150 - the rate from the table below which corresponds with the average rotation age for aspen on sandy soils (35 years).

   c. Acres Burned was recorded in the field.

Step 3. Effects on Christmas Trees

A. Determine Current Loss for each Christmas tree plantation. Use the formula:

Current Loss = Value (1) x Trees per Acre (2) x Acres Burned (3)

Record under Current Loss and under Loss for each species.

1. Value per tree can be determined from an external source, such as a claims office of an insurance company or a county extension agent. Usually only tree species and age will be necessary. Record under Price.

2. Trees Per Acre was recorded in the field under Density Class. Record under volume on office worksheet.

3. Acres Burned was recorded in the field.

Step 4. Effects on Merchantable Hardwoods.

A. Determine Current Loss for each hardwood timber type. Record under Current Loss and under Loss for all timber types. Use the formula:

Current Loss = Volume (1) x Price (2) x Mortality (3) x Acres Burned (4)

1. Volume is from the table below using the size class and density class recorded in the field. If volume was measured directly in the field, that volume may be used if it represents the stand better.

Size Class	Units	Density Class ''''	'''	''	'	0
5-11"	Cords	a/	16.5	10.0	5.0	0.0
11-15"	MBF	a/	6.7	3.7	1.8	0.0
15"+	MBF	a/	10.2	6.4	2.8	0.0

a/ Volume was estimated in the field

2. Price is listed in Stumpage Values, Table 1 in Appendix C by district. If there are explicit restrictions on harvesting (like wilderness areas or developed campgrounds), then the price is $0.00.

3. Mortality is determined from Hardwood Mortality, Figure 2 in Appendix B. Round to 2 decimal places and record under Mortality.

4. Acres Burned was recorded in the field.

Step 5. Effects on Immature Hardwoods.

A. Determine Current Loss for each hardwood timber type. Record under Current Loss and under Loss for all timber types. Use the formula:

Current Loss = (1) Volume x (2) Price x (3) Mortality x (4) Acres Burned x (5) Discount Rate

1. Volume is the predicted volume in the table below using the density class recorded in the field.

Timber Type	Density Class	Predicted Volume	Merchantable Age
NH, O, A, & BW	3	16.5	25
	2	10.0	25
	1	5.0	25
SH	3	16.5	35
	2	10.0	35
	1	5.0	35

2. Price for each timber type is listed in Stumpage Values, Table 1 in Appendix C by district. If there are explicit regulations restricting harvest (like wilderness areas or developed campgrounds), then the price is $0.00.

3. Mortality is determined from Hardwood Mortality, Figure 2, Appendix B. Round to 2 decimal places and record under Mortality.

4. Acres Burned was recorded in the field.

5. Discount Rate is the rate from the table below which corresponds to the discount period.

   a. Discount Period = Merchantable Age - Current Age. If the discount period is negative, Discount Rate = ~~0~~ 1.0

   b. Merchantable Age is listed by timber type in the table above.

   c. Current Age was recorded in the field.

Discount Period	Discount Rate	Discount Period	Discount Rate
0	1.00	20	.31
5	.75	25	.23
10	.56	30	.17
15	.42	35	.13

Step 6. Total Wildfire Effects on Timber.

A. Sum the columns listed below for all cover types and record in the Total row under the appropriate heading.

1. Acres Burned. NOTE: Only for the Overstory types.
2. Current Loss.
3. Regeneration Loss.
4. Replacement Value.
5. Loss.

B. Determine Average Mortality and record under Average Mortality. Use the formula:

Average Mortality = Total Mortality (1) / Total Timber Acres Burned (2)

1. Total Mortality is the sum of Acres Burned times Mortality for each overstory timber type.

2. Total Timber Acres Burned was recorded under Acres Burned in the total row.

WILDFIRE EFFECTS ON CROPS

Step 1. Effects on Crops.

A. Determine Crop Loss for each crop, using the formula:

Crop Loss = (Replanting Cost (1) x Acres Burned (4)) + (Yield Loss (2) x Price (3) x Acres Burned (4))

If there is a "yes" under Harvested, eliminate part A. and proceed with part B. Record crop loss under Crop Loss.

1. Replanting Cost: Determine from the farmer or a neighboring farmer if the crop is replantable this year. If it is replantable, then determine the replanting cost per acre from the farmer or his neighbor. If it is not replantable, then replanting cost is $0.00. Record the replanting cost under Replanting Cost.

2. Yield Loss: Determine the yield loss per acre from the farmer, a neighboring farmer, or an external source such as a county extension agent or a local insurance company, and record under Yield Loss. The yield loss will be the expected yield per acre if the crop is not replantable this year, or the difference between expected yield for the burned crop and for the replanted crop, if the crop can be replanted.

3. Price can be determined from one of the sources mentioned above. Record under Price.

4. Acres Burned was recorded in the field.

B. If there is a "yes" under harvested, then Crop Loss is $0.00.

WILDFIRE EFFECTS ON EQUIPMENT AND IMPROVEMENTS

Step 1. Effects on Equipment and Improvements.

A. Determine Equipment Loss, using the formula:

Equipment Loss = the sum of Cost

Record under Equipment Loss.

1. Cost: For each piece of equipment which is affected by the fire, as listed in the field, determine the Cost associated with it. For those requiring only additional maintenance, Cost is the cost of the additional maintenance (like the cost of repainting a shed). If the equipment was destroyed, use the insurance value whenever possible. When such are unavailable, use the market price of a similar piece of equipment in similar condition. If used equipment of that type is not regularly bought and sold, use the market price for a new piece. Multiply the price for the new piece by the condition value, listed below:

Condition	Condition Value
Excellent	1.00
Very Good	.80
Good	.60
Fair	.40
Poor	.20

Record the cost for each affected piece of equipment under Cost.

Forest products should be included in this section.

WILDFIRE EFFECTS ON WILDLIFE

Step 1. Effects on Deer Habitat

A. Determine Benefit and record under Deer Benefits. Use the formula:

Benefit = Full Effect (3.86) x Success Index x Use Change x Expenditures ($25.39)

1. Success Index is listed by county for deer in Success Index, Table 2 in Appendix C.

2. Use Change = Area Change x Size Effect

   a. Area Change is the sum of Area Index times Acres Burned for the timber types listed below. Area Index is from Figure 3, at right. NOTE: This applies to overstory timber types from field sheets only.

      (1) BW - White Birch

      (2) NH - Northern Hardwoods

      (3) PJ - Jack Pine - plantations only

      (4) PR - Red Pine - plantations only

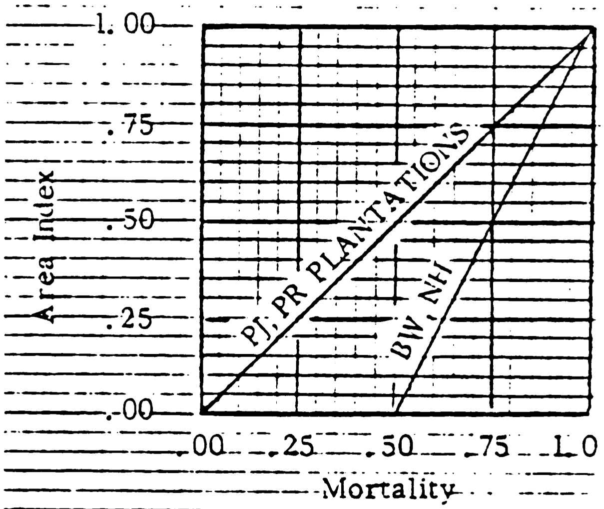


Figure 3. Area Index

   b. Size Effect is from the table below, using Affected Area.

      Affected Area = Average Mortality x Total Timber Acres Burned

      Round off to 1 decimal place.

Affected Area - Acres	Size Effect	Affected Area - Acres	Size Effect
0.0 - 1.9	1.00	10.0 - 14.9	.34
2.0 - 2.9	.77	15.0 - 19.9	.25
3.0 - 3.9	.68	20.0 - 24.9	.19
4.0 - 4.9	.61	25.0 - 34.9	.11
5.0 - 5.9	.56	35.0 - 44.9	.04
6.0 - 7.9	.49	45.0+	.00
8.0 - 9.0	.43		

B. Determine Loss and record under Deer Losses. Use the formula:

Loss = Full Effect (2.24) x Success Index x Use Change x Expenditures ($25.39).

1. Success Index is listed by county in Success Index, Table 2, Appendix C.

2. Use Change is the sum of Acres Burned times Mortality for each of the types listed below. NOTE: This applies to overstory timber types only.

a. FS - Fir-Spruce c. T - Tamarack
b. SB - Black Spruce d. C - White Cedar

Step 2. Effects on Rabbit Habitat.

A. Determine Benefit and record under Rabbit Benefits. Use the formula:

Benefit = Full Effect (.43) x Success Index (1) x Use Change (2) x Expenditures ($7.67)

1. Success Index for rabbits is listed in Success Index, Table 2, Appendix C.

2. Use Change is the sum of Acres Burned times Mortality for each burned stand of the types listed below. NOTE: This applies to overstory timber types from field sheets only.

a. SB - Black Spruce c. A - Aspen
b. PJ - Jack Pine d. BW - White Birch

Step 3. Effects on Grouse Habitat.

A. Determine Benefit and record under Grouse Benefits. Use the formula:

Benefit = Full Effect (.34) x Success Index x Use Change x Expenditures ($7.67).

1. Success Index is listed for grouse by county in Success Index, Table 2, Appendix C.

2. Use Change is the sum of Acres Burned times Mortality for each burned stand of the types listed below. NOTE: This applies to overstory timber types from field sheets only.

a. A - Aspen b. PJ - Jack Pine

Step 4. Effects on Pheasant Habitat.

A. Determine Benefit and record under Pheasant Benefits. Use the formula:

Benefit = Full Effect (.45) x Success Index (1) x Use Change (2) x Expenditures ($7.67)

1. Success Index is listed for pheasants by county in Success Index, Table 2, Appendix C.

2. Use Change is the Acres Burned for all FO (Open Fields).

Step 5. Effects on Waterfowl Habitat.

A. Determine Benefit and record under Waterfowl Benefits. Only calculate a benefit if fire occurs on open fields within one mile of a lake or stream. Use the formula:

Benefit = Full Effect (.30) x Success Index x Use Change x Expenditures ($13.75).

1. Success Index for waterfowl is listed by county in Success Index, Table 2, Appendix C.

2. Use Change is the sum of Acres Burned in the cover types listed below.

a. FO - Open Fields   b. M - Marsh

B. Determine Loss and record under Waterfowl Losses. Only calculate a loss if a fire occurs on open fields within one mile of a lake or stream.

Loss = Full Effect (.06) x Success Index (1) x Nest Index (2) x Use Change (3) x Expenditures ($13.75).

1. Success Index is listed for waterfowl in Success Index, Table 2, Appendix C.

2. Nest Index is listed below by date:

From	To	Nest Index
January 1	April 14	0.00
April 15	May 14	0.33
May 15	July 31	1.00
August 1	December 31	0.00

3. Use Change is the sum of Acres Burned in the cover types listed below.

a. FO - Open Field   b. M - Marsh

Step 6. Effects on Non-Game Birds.

A. Determine Benefit and record under Non-Game Benefits. Only consider acres burned in timber when calculating benefits to non-game species. Use the formula:

Benefit = Full Effect (.20) x Success Index (1) x Use Change (2) x Expenditures ($0.53)

1. Success Index for non-game birds is listed by county in Success Index, Table 2, Appendix C.

2. Use Change = Average Mortality x Total Acres Burned in timber types.

Step 7. Total Wildfire Effects on Wildlife

A. Add the benefits calculated above, and deduct any losses. Record under Total Wildlife Effect.

WILDFIRE EFFECTS ON RECREATION

Step 1. Effects on Aesthetics.

A. From Aesthetics, Table 3, Appendix C, determine Effect on aesthetics. Record under Aesthetics Effect.

1. Average Mortality was recorded in the Timber Effects Section. NOTE: If average mortality is less than .18, record "negligible effect" under Aesthetics Effect. For fires in non-timber cover types (FO, FC, M), record "negligible effect" under Aesthetics Effect.

2. Acres Burned was recorded under Acres Burned in the Total row of the Timber Effects Section.

3. Use Class was recorded in the field.

B. Determine Ornamental Loss and record under Ornamental Loss. Use the formula:

Ornamental Loss = sum of Tree Loss

1. Tree Loss = Condition Class x Location Class x Cost.

Record next to each burned ornamental under Tree Loss. NOTE: If more than one tree of that species, size, condition, and location was burned, multiply Tree Loss by the number of such trees.

a. Condition Class was recorded in the field.

b. Location Class was recorded in the field.

c. Cost: For all shrubs and evergreens, determine the replacement cost of each dead bush; these costs are generally available from nurseries, claims offices of insurance companies, and the like. For all trees, use the formula:

Cost = .79 x Species Factor x $(\text{Diameter})^2$ x \$16.77

(1) Species Factor is from Species Factor, Table 4, Appendix C. Tree species are listed alphabetically by scientific names; all conifers are listed first.

(2) Diameter was recorded in the field.

Step 2. Effects on Use of Developed Recreation Sites.

A. Determine Use Loss and record under Use Loss. Use the formula:

Use Loss = Visitor Groups Lost x Value

1. Visitor Groups Lost was recorded in the field based on the records or judgment of the owner or manager.

2. Value is from the following table, using the Use Category which is most appropriate for the recreation site.

Use Category	Value
Sightseeing	$23.79
Camping	22.64
Fishing	21.14
Picnicing	17.31
Boating	14.29
Hiking	13.71
Swimming	9.63

WILDFIRE EFFECTS ON ENVIRONMENTAL QUALITY

Step 1. Effects on Environmental Quality.

A. From Environmental Table 5, Appendix C, determine Effect on environmental quality. Record under Environmental Quality Effect.

1. Atmospheric Condition was recorded in the field.

2. Smoke Index = Total Acres Burned x Smoke Duration. Round to one decimal place.

   a. Total Acres Burned was recorded on the field worksheet under the Timber Effects Section.

   b. Smoke Duration was recorded in the field.

3. Population Use Class was recorded in the field.

SUMMARY

Landowner Losses:	Social Effects:
Timber	Wildlife
Crops	Recreation Use
Equipment	Aesthetics Effects
Ornamental Trees	Environmental Quality Effects

APPENDIX

APPENDIX A

TABLE 1. COVER TYPES IN WISCONSIN

Timber Type	Symbol	Definition
White Pine	PW	More than 50% pine with more white pine than red or jack pine.
Red Pine	PR	More than 50% pine with more red pine than white or jack pine.
Jack Pine	PJ	More than 50% pine with more jack pine than white or red pine.
Fir-Spruce	FS	Swamp border or upland types with predominantly balsam fir or spruce.
Black Spruce	SB	More than 50% swamp conifers with more black spruce than other species.
Tamarack	T	More than 50% swamp conifers with more tamarack than other species.
White Cedar	C	More than 50% swamp conifers with more white cedar than other species.
Aspen	A	More than 50% aspen.
White Birch	BW	More than 50% white birch.
Oak	O	Dominated by red, white, or black oak and associated species.
Swamp Hardwoods	SH	More than 50% swamp hardwood species; ash, red maple, American elm, etc.
Northern Hardwoods	NH	More than 50% northern hardwood species; sugar maple, yellow birch, beach, etc.
Open Field	FO	Non-timbered grasslands, pastures and upland brush.
Cultivated Field	FC	Non-timbered cropland.
Marsh	M	Non-timbered marsh, bog, muskeg or lowland brush.

APPENDIX A

TABLE 2. SIZE AND DENSITY CLASSES FOR WISCONSIN TIMBER TYPES

Size Class	Diameter Hardwood	Diameter Conifer
Seedling & Sapling	0-5"	0-5"
Poletimber	5-11" a/	5-9" b/
Small Sawtimber	11-15" a/	9-15" b/
Large Sawtimber	15"+ a/	15"+ b/

NOTE: Use the lower size class whenever a stand is composed of more than one size class unless at least 75 percent of the trees are in the higher size class.

a/ Sawtimber size classes are for only NH, O, SH; for all other hardwood types, poletimber diameter is 5"+.

b/ Sawtimber size classes are for only PW, PR, C; for all other conifer types, poletimber diameter is 5"+.

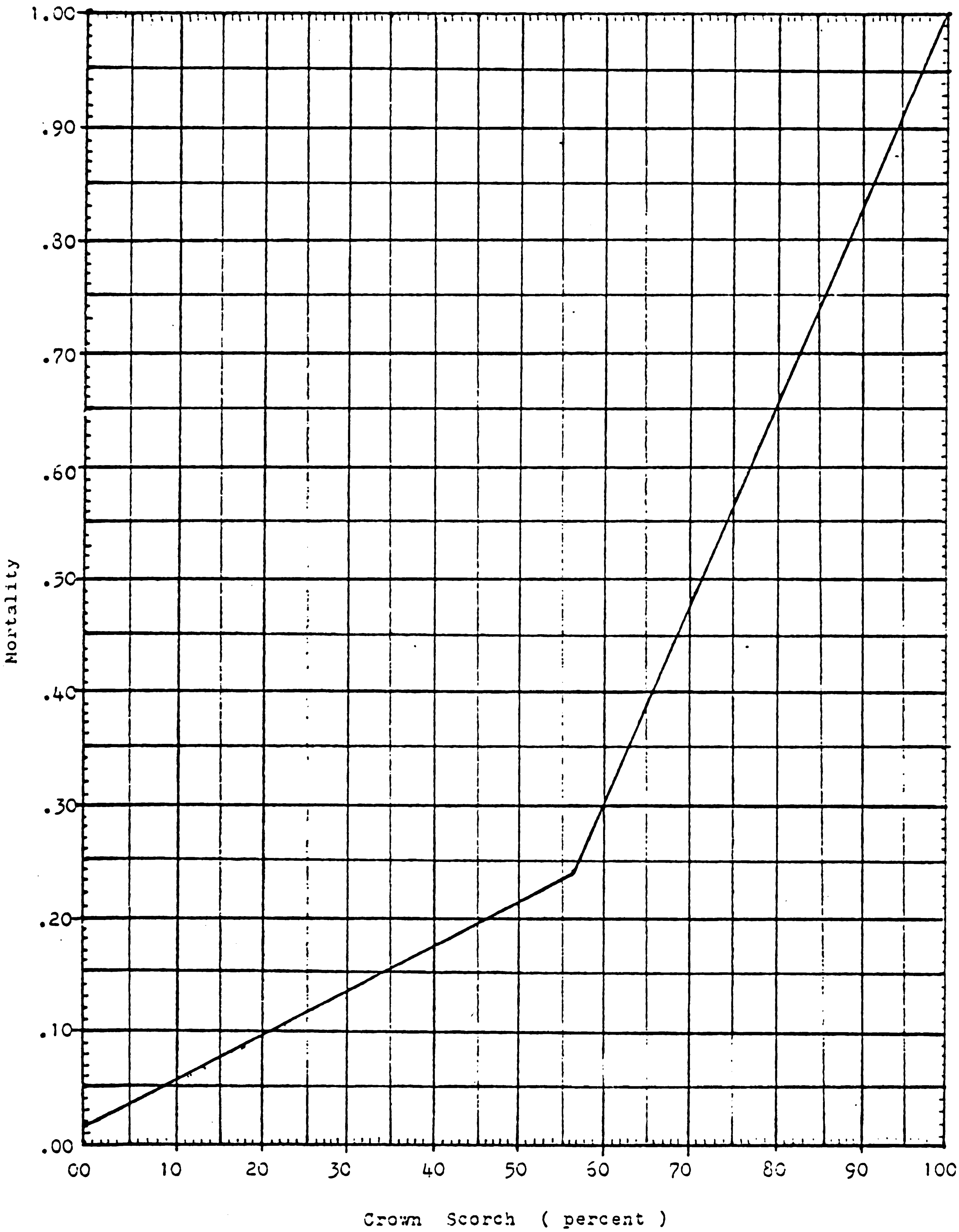
Size Class	Units per Acre	''''	'''	''	'	0
0-5"	Trees	c/	700+	400-699	100-399	0.0-99
5-9" d/	Cords	20.0+	13.1-19.9	7.0-13.0	3.1-6.9	0.0-3.0
9-15" d/	MBF	8.5+	5.0-8.4	2.5-4.9	1.2-2.4	0.0-1.1
15"+	MBF	12.0+	8.5-11.9	4.4-8.4	1.3-4.3	0.0-1.2
---	BA	150+	86-150	51-85	21-50	0-20

c/ This density class is to be used for plantations only.

d/ For hardwood stands, these size classes are 5-11" and 11-15".

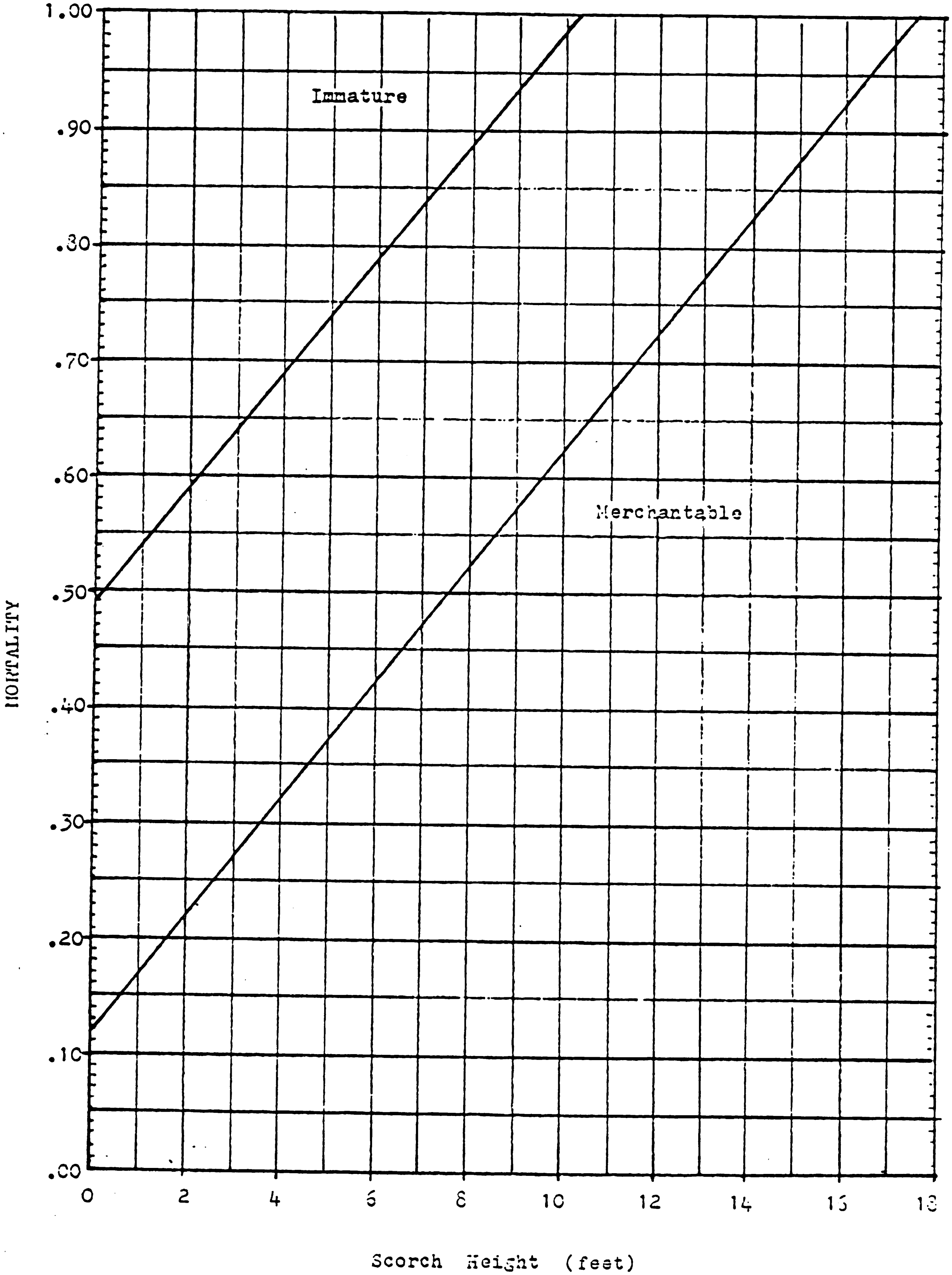
APPENDIX B

FIGURE 1. CONIFER MORTALITY.



APPENDIX B

FIGURE 2. HARDWOOD MORTALITY.



APPENDIX C.

TABLE 1. STUMPAGE VALUES (from Forest Crop Law Withdrawal Data (1979-80)

Forest Type	NC	NW	WC	LM	S & SE
	POLETIMBER STANDS-AVERAGE VALUE PER CORD ([illegible])				
PW	5.98	5.58	5.19	6.55	4.57
PR	7.84	7.35	7.09	9.00	6.01
PJ	10.63	11.78	12.35	12.66	9.23
FS	4.77	3.77	3.80	5.26	3.65
SB	6.36	5.08	5.21	7.10	4.84
T	4.59	4.31	4.31	4.91	4.19
C	4.12	3.65	3.70	4.28	3.63
NH	3.46	2.19	2.77	3.87	2.81
O	3.35	2.70	3.02	4.18	2.62
OX	3.20	2.65	2.94	3.99	2.51
SH	3.51	2.33	2.86	3.84	2.91
A	4.42	3.05	3.14	5.88	3.11
BW	3.56	2.59	2.79	4.32	2.59
	SAWTIMBER STANDS-AVERAGE VALUE PER MBF ([illegible])				
PW	54.14	43.11	43.13	43.03	54.44
PR	52.23	42.83	40.91	38.35	52.35
C	26.85	25.73	25.46	26.62	26.74
NH	49.43	36.36	42.72	48.96	45.54
O	51.85	43.91	54.23	62.67	60.72
SH	38.69	32.71	34.74	38.96	38.55

APPENDIX C

TABLE 2. SUCCESS INDEX BY COUNTY.

	Deer	Rabbit	Grouse	Pheasant	Waterfowl	Non-Game
Northwest						
Ashland	.48	.00	1.23	.00	.20	.36
Barron	.48	.25	1.80	.24	.65	1.24
Bayfield	.75	.00	.70	.00	.20	1.24
Burnett	1.17	.00	1.80	.00	1.08	1.24
Douglas	.16	.00	1.80	.00	.20	1.24
Iron	.16	.00	.19	.00	.20	2.49
Polk	1.17	.25	1.80	.24	.65	2.49
Price	.75	.00	.70	.00	.20	1.24
Rusk	.75	.25	.19	.00	.20	.08
Sawyer	.48	.00	1.23	.00	.20	4.28
Taylor	.48	.00	.70	.00	.20	.08
Washburn	.75	.00	.19	.00	.20	4.28
West Central						
Buffalo	2.52	.25	.70	.24	1.74	.08
Chippewa	.48	.25	1.80	.24	.20	.08
Clark	1.17	.25	.70	.24	.20	.08
Crawford	1.17	.25	1.80	.24	3.01	.65
Dunn	.48	.25	.70	.64	.65	.65
Eau Claire	1.17	.25	1.23	.64	.20	.08
Jackson	2.52	.63	3.23	.64	.20	.36
La Crosse	1.17	.63	1.80	.64	3.01	1.24
Monroe	1.17	.25	1.23	.24	.20	.08
Pepin	1.17	.63	.19	.24	1.08	.08
Pierce	.48	.25	1.23	1.62	.65	.36
St. Croix	.16	.25	1.23	1.62	.65	.36
Trempealeau	1.75	.25	1.80	1.62	.20	.36
Vernon	1.17	.63	1.23	.24	1.74	.08
North Central						
Adams	2.52	1.61	1.80	.00	.65	.36
Forest	.48	.00	3.23	.00	.20	1.24
Juneau	1.75	.25	1.23	.24	1.74	.65
Langlade	.75	.25	.70	.00	.20	.36
Lincoln	1.17	.25	3.23	.00	.20	.36
Marathon	1.17	1.61	1.80	.24	.65	.08
Oneida	1.17	.00	1.80	.00	.65	2.49
Portage	1.75	.63	1.80	.24	.65	.08
Vilas	.75	.00	1.80	.00	.65	4.28
Wood	2.52	.63	1.80	.00	1.08	.08

APPENDIX C

TABLE 2. SUCCESS INDEX BY COUNTY (CON'D).

	Deer	Rabbit	Grouse	Pheasant	Waterfowl	Non-Game
Lake Michigan						
Brown	.16	3.03	.19	.64	1.08	.65
Calumet	.48	3.03	.00	1.62	1.74	.08
Door	.75	.25	.00	1.62	.20	4.23
Florence	.48	.00	.70	.00	.20	2.49
Keewaunee	.75	1.61	.19	1.62	.65	.08
Manitowoc	.75	1.61	.00	1.62	1.08	.36
Marinette	1.17	1.61	.70	1.62	.20	1.24
Menominee	1.17	.25	.70	.64	.65	.08
Oconto	1.17	.00	.70	1.62	.65	.65
Outagamie	1.17	3.03	.00	.64	.65	.36
Shawano	1.17	.63	1.80	.64	.65	.36
Waupaca	2.52	1.61	.70	.64	.65	.65
Waushara	2.52	.63	1.80	.64	.65	.36
Winnebago	.48	3.03	.00	2.83	3.01	.65
Southern						
Columbia	2.52	.63	.19	2.83	3.01	2.49
Dane	.48	1.61	.00	1.62	1.08	1.24
Dodge	.16	3.03	.00	5.72	7.13	.08
Fond du Lac	.48	3.03	.00	5.72	7.13	.08
Grant	.16	.25	.19	.24	.65	.36
Green	.16	3.03	.00	5.72	.20	.08
Green Lake	2.52	1.61	.00	5.72	7.13	1.24
Iowa	1.75	.25	.70	.64	.65	.65
Jefferson	.16	1.61	.00	2.83	7.13	.36
Lafayette	.16	3.03	.00	2.83	.20	.36
Marquette	2.52	.25	.19	1.62	3.01	1.24
Richland	1.17	1.61	1.23	.00	.20	.08
Rock	.16	6.18	.00	5.72	1.08	.36
Sauk	1.75	1.61	.19	.64	.65	2.49
Southeast						
Kenosha	.16	6.18	.00	1.62	1.08	4.23
Ozaukee	.16	.63	.00	5.72	1.08	.65
Racine	.16	6.18	.00	1.62	1.74	1.24
Sheboygan	.48	1.61	.19	5.72	1.08	.65
Walworth	.16	6.18	.00	1.62	1.08	4.23
Washington	.48	1.61	.19	2.83	.65	.36
Waukesha	.16	6.18	.00	2.83	.65	.65

APPENDIX C

TABLE 3. DAMAGE EFFECT ON AESTHETICS

Part A. Fire with Average Mortality between .00 and .18

For all Use Classes and all fire sizes, the effect is Negligible.

Part B. Fire with Average Mortality between .72 and 1.00

	Use Class				
Acres	A	B	C	D	E
0.0-1.0	High	High	High	Moderate	Moderate
1.1-5.0	High	High	High	High	Moderate
5.1-20.0	Very High	Very High	High	High	Moderate
20.1-100.0	Extreme	Very High	Very High	High	High
100.1-500.0	Extreme	Extreme	Very High	Very High	High
500.1+	Extreme	Extreme	Extreme	Very High	Very High

Part C. Fire with Average Mortality between .43 and .71

	Use Class				
Acres	A	B	C	D	D
0.0-1.0	Moderate	Moderate	Moderate	Low	Low
1.1-5.0	High	Moderate	Moderate	Moderate	Low
5.1-20.0	High	High	Moderate	Moderate	Low
20.1-100.0	Very High	High	High	Moderate	Moderate
100.1-500.0	Very High	Very High	High	High	Moderate
500.1+	Extreme	Very High	Very High	High	Moderate

Part D. Fire with Average Mortality between .19 and .42

	Use Class				
Acres	A	B	C	D	E
0.0-1.0	Low	Low	Low	Negligible Effect	Negligible Effect
1.1-5.0	Moderate	Low	Low	Low	Negligible Effect
5.1-20.0	Moderate	Moderate	Low	Low	Negligible Effect
20.1-100.0	High	Moderate	Moderate	Low	Low
100.1-500.0	High	High	Moderate	Moderate	Low
500.1+	High	High	High	Moderate	Low

APPENDIX C

TABLE 4. SPECIES FACTORS FOR ORNAMENTAL TREES.

Part A. Conifers

Common Name	Scientific Name	Species Factor
Balsam Fir	Abies balsamea	.50
Other Firs	Abies spp.	.75
Eastern Red Cedar	Juniperus virginiana	.50
Larch; Tamarack	Larix spp.	.75
Spruce	Picea spp.	.75
Eastern White Pine	Pinus strobus	1.00
Scotch (Scots) Pine	P. sylvestris	1.00
Red Pine	P. resinosa	.75
Jack Pine	P. banksiana	.50
Austrian Pine	P. nigra	.50
Ponderosa Pine	P. ponderosa	.50
Douglas-fir	Pseudotsuga menziesii	.75
Cedar	Thuja spp.	.75
Hemlock	Tsuga spp.	1.00

Part B. Hardwoods

Common Name	Scientific Name	Species Factor
Maples:	Acer spp.	
Suger Maple	A. saccharum	1.00
Black Maple	A. nigrum	1.00
Special varieties of red & Norway maples		1.00
Small tree maples (like Amur maple, hedge maple, etc.)		1.00
Red Maple	A. rubrum	.75
Norway Maple	A. platanoides	.75
Japanese Maple	A. palmatum	.75
Paperbark Maple	A. griseum	.50
Sycamore Maple	A. pseudoplatanus	.50
Silver Maple	A. saccharinum	.25
Boxelder	A. negundo	.25
Horsechestnut; Buckeye	Aesculus spp.	.50
Tree-of-Heaven; Ailanthus	Ailanthus altissima	.25
European Alser	Alnus glutinosa	.50
Serviceberry; Shadblow	Amelanchier spp.	1.00
Birch	Betula spp.	.75
Hornbeam	Carpinus spp.	1.00

APPENDIX C

TABLE 4. SPECIES FACTORS FOR ORNAMENTAL TREES.

Part B. Hardwoods (Con'd).

Common Name	Scientific Name	Species Factor
Hickory	Carya spp.	.75
Catalpa	Catalpa spp.	.25
Hackberry	Celtis spp.	.75
Eastern Redbud	Cercis canadensis	.75
American Yellow-wood	Cladrastis lutea	1.00
Dogwood	Cornus spp.	.75
Turkish Hazelnut	Corylus colurna	.75
Hawthorn	Crataegus spp.	.75
Special Varieties		1.00
Russian Olive	Elaeagnus angustifolia	.75
Beech	Fagus spp.	1.00
Ash	Fraxinus spp.	.75
Special Varieties		1.00
Gingko	Gingko biloba - male	1.00
	- female	.50
Honeylocust	Gleditsia triacanthos	.25
Thornless Honeylocust		.50
Special Varieties		.75
Kentucky Coffeetree	Gymnocladus	.50
Walnut	Juglans spp.	.75
Panicled Goldenrain Tree	Koelreuteria paniculata	.50
American Sweetgum	Liquidambar styraciflua	.75
Tuliptree	Liriodendron tulipifera	.75
Osage-orange	Maclura pomifera	.25
Magnolia	Magnolia spp.	.75
Apple; Crabapple	Malus spp.	.75
Special Varieties (like Flowering Crabapple)		1.00
Mulberry	Morus spp.	.25
Black Tupelo	Nyssa sylvatica	.50

APPENDIX C

TABLE 4. SPECIES FACTORS FOR ORNAMENTAL TREES.

Part B. Hardwoods (Con'd).

Common Name	Scientific Name	Species Factor
American Hophornbeam	Ostrya virginiana	1.00
Sourwood	Oxydendrum arboreum	.50
Corktree	Phellodendron spp.	.75
Planetree; Sycamore	Platanus spp.	.50
Poplar	Populus	.25
Cherry:	Prunus spp.	
Black Cherry	P. serotina	.50
Pincherry	P. pennsylvanica	.50
Special Varieties		.75
Other Cherries		.25
Pear	Pyrus spp.	.50
Oak	Quercus spp.	1.00
Locust	Robinia spp.	.25
Willow	Salix spp.	.25
Sassafras	Sassafras albidum	.75
Japanese Pagoda Tree	Sophora japonica	.50
Mountain Ash	Sorbus spp.	.50
Japanese Lilac Tree	Syringa amurensis japonica	.75
Linden	Tilia spp.	.75
Basswood	T. americana	.50
Elm	Ulmus spp.	.50
Japanese Zelkova	Zelkova serrata	.25

APPENDIX C

TABLE 5.. DAMAGE EFFECT ON ENVIRONMENTAL QUALITY

Part A. Atmospheric Condition is Stable

Smoke Index	Population Use Class				
	A	B	C	D	E
0.0-1.0	Very High	High	Moderate	Low	Negligible Effect
1.1-10.0	Very High	High	High	Moderate	Negligible Effect
10.1-100.0	Very High	Very High	High	Moderate	Low
100.1-1000.0	Extreme	Very High	High	Moderate	Low
1000.1-10,000.0	Extreme	Very High	High	High	Low
10,000.1+	Extreme	Extreme	Very High	High	Moderate

Part B. Atmospheric Condition is Unstable

Smoke Index	Population Use Class				
	A	B	C	D	E
0.0-1.0	High	Moderate	Low	Negligible Effect	Negligible Effect
1.1-10.0	High	Moderate	Low	Low	Negligible Effect
10.1-100.0	Very High	High	Moderate	Low	Negligible Effect
100.1-1000.0	Very High	High	Moderate	Low	Negligible Effect
1000.1-10,000.0	Very High	Very High	High	Moderate	Negligible Effect
10,000.1+	Extreme	Very High	High	Moderate	Low

FIRE EFFECTS APPRAISAL HANDBOOK
FLOW CHART

Start with the first line and complete all calculations before proceeding to the next.

CHAPTER 10 - FIELD MEASUREMENTS
CHAPTER 20 - OFFICE CALCULATIONS

I. TIMBER

Merchantable Conifers? If yes, do Step 1, Page 20-1.

Immature Conifers? If yes, do Step 2, Page 20-3.

Christmas Trees? If yes, do Step 3, Page 20-5.

~~Immature~~ Merchantable Hardwoods? If yes, do Step 4, Page 20-6.

~~Merchantable~~ Immature Hardwoods? If yes, do Step 5, Page 20-6.

Timber Types? If yes, do Step 6, Page 20-7.

II. CROPS?

If yes, do Page 20-8.

III. EQUIPMENT?

If yes, do Page 20-9.

IV. WILDLIFE (For Timber Types Use Overstory ONLY!!)

NH, BW, PR or PJ plantation? If yes, do Step 1-a, Deer Benefits, Page 20-10.

FS, SB, T, C? If yes, do Step 1-b, Deer Losses, Page 20-10.

SB, PJ, A, BW? If yes, do Step 2, Rabbit Benefits, Page 20-11.

A, PJ? If yes, do Step 3, Grouse Benefits, Page 20-11.

FO? If yes, do Step 4, Pheasant Benefits, Page 20-11.

FO, M? If yes, do Step 5, Waterfowl Benefits and Losses, Page 20-12.

Step 6 - Non-Game Benefits, Page 20-12. Overstory Timber Types only.

Step 7 - Wildlife Total, Page 20-13.

V. RECREATION

Step 1 - Aesthetics Effect, Page 20-13.

Ornamental Trees? If yes, do Step 1-b, Page 20-13.

Developed Recreation? If yes, do Step 2, Page 20-14.

VI. ENVIRONMENTAL QUALITY

Step 1 - Page 20-15.

FIELD MEASUREMENTS WORKSHEET

FIRE # ____________________ DATE ____________________ COUNTY ____________________

TIMBER - List understory, if present, on line directly under overstory. (Page 10-2)

Timber Type	Overst. (yes/no)	Plant. (yes/no)	Size Class	Dens. Class	Acres Burned	Scorch (ft. or %)	Age*	Volume**

NON-TIMBER - Open Fields (FO) or Marsh (M) (Page 10-3)

Cover Type	Acres Burned

TOTAL ACRES BURNED ____________________
(Overstory Timber + Non-Timber + Crop)

CROP - Cultivated Fields (FC) (Page 10-3)

Crop	Acres Burned	Harv.? (yes/no)	Replant. Cost	Yield Loss	Price

EQUIPMENT (Page 10-3)

Type of Equipment	No.	Condition	Price

RECREATION (Page 10-5)

Ornamental Trees	No.	Diameter	Cond. Class	Loc. Class

Recreation Use Class ____________________

Visitor Groups Lost ____________________

ENVIRONMENTAL QUALITY (Page 10-6)

Atmospheric Condition ____________________ Smoke Duration ____________________ Population Use Class ____________________

* Note: Age for immature (0-5) trees only.

**Required for merchantable density class 4 only, or if measured for other merchantable stands.

Rev. 1/80

FIRE EFFECTS APPRAISAL HANDBOOK - OFFICE CALCULATIONS WORKSHEET

FIRE # ____________ DATE ____________ COUNTY ____________

I. TIMBER (Immature Stands Only)

Timber Type	Volume x	Price x	Mortality x	Acres Burned x	Disc. Rate =	Current Loss +	Regen. Loss -	Replace. Value	= Loss
		OVERSTORY TOTAL			TOTALS				

AVERAGE MORTALITY ____________

REGENERATION LOSS

Timber Type	Vol. x	Price x	Per. Rate x	Acres Burned =	Regen. Loss

REPLACEMENT VALUE

Vol. x	Price x	Per. Rate x	Acres Burned =	Replace. Value

II. CROPS

Crop	(Replant. Cost	x Acres Burned) +	(Yield Loss	x Price	x Acres Burned)	= Loss
					TOTAL	

III. EQUIPMENT

Item	No. x	Cost =	Loss

IV. WILDLIFE

	Constant x	Success Index x	Use Change x	Constant =	Benefit (+) or Loss (-)
Deer Benefits	3.86			$ 25.39	
Deer Losses	2.24			25.39	
Rabbit Benefits	.43			2.67	
Grouse Benefits	.34			2.67	
Pheasant Benefits	.45			2.67	
Waterfowl Benefits	.30			13.75	
Waterfowl Losses	.06			13.75	
Non-Game Benefits	.20			.53	
			Nest Index	TOTAL	

V. RECREATION

Timber Type	Acres Burned x	Area Index =	
		TOTAL	

Area Change x	Size Effect x	Use Change

Aesthetics Effect [ ]

Ornamental Trees

Const. x	Spec. Fact. x	Dia.² x	Const. =	Cost
.29			$ 16.77	
.29			16.77	
.29			16.77	

Species	No. x	Cond. Class x	Loc. Class x	Cost =	Loss
				TOTAL	

Visitor Groups Lost ____________ x Value ____________ = Recreation Use Loss [ ]

VI. ENVIRONMENTAL QUALITY

Atmospheric Condition ____________

Smoke Duration ____________

Smoke Index ____________

Population Use Class ____________

Environmental Quality Effect [ ]

FIRE EFFECTS - GLOSSARY

AFFECTED AREA	(For deer benefits only) The effective size of the opening created by fire.
AREA CHANGE	(For deer benefits only) The effective area of habitat which receives the full increase in deer use.
AREA INDEX	(For deer benefits only) An index that relates timber mortality to timber types that affect deer.
ATMOSPHERIC CONDITION	An estimate of the relative stability of the atmosphere.
AVERAGE MORTALITY	The average percent of trees killed by the fire in all stands weighted by the acreage in each stand.
BARK SCORCH	The amount of bark that is discolored by fire. Measured as a maximum height in feet from the ground to the top of the bark scorch.
CONDITION VALUE	An estimate of the percent of useful life remaining in the affected piece of equipment or improvement.
COVER TYPE	A tract of land characterized by the predominance of one or more key plant species. Cover types include timber and nontimber types as well as crops.
CROP LOSS	A combination of replanting costs and yield losses; depending on the circumstances, may be both or one of the two.
CROWN SCORCH	The amount of needles discolored fy fire. Measured as a percent of the total needles present before the fire.
CURRENT LOSS	The current value of the trees killed by the fire.
DISCOUNT RATE	The factor which discounts the expectedvalue of a currently immature stand from the merchantable age to the present.
EQUIPMENT CONDITION VALUE	An estimate of the percent of useful life remaining in the affected piece of equipment.

EQUIPMENT LOSS — The sum of the cost of each affected piece of equipment, or improvement.

FULL EFFECT — The net change in use per acre if resource is completely distroyed. A constant for each year.

LOCATION CLASS — A rating of the relative importance of the tree in the landscape; this defines whether a tree is ornamental or not.

MERCHANTABLE AGE — The age at which the majority of the average stand of that timber type will be greater than 5" dbh.

MORTALITY — The amount of cover type killed by the fire. Measured as a decimal fraction of the total type in the fire.

NEST INDEX — A number that indicates what percentage of waterfowl are nesting during a period of the year.

OVERSTORY — The timber species or group of species which constitutes the uper crown canopy of a forest.

PERIODIC RATE — The factor which discounts all future timber harvests.

POPULATION USE CLASS — A relative rating of the number of people affected by the smoke from a fire.

PRESENT NET WORTH (PNW) — Discounted future value or value today of all future income.

RECREATION USE CLASS — A relative rating of the visibility (amount of use) of the burned site.

REGENERATION LOSS — The present net worth (PNW) of all future timber harvests of the burned timber type.

REPLACEMENT TIMBER TYPE — The timber type which will regenerate on the burned site, if the initial type does not regenerate itself.

REPLACEMENT VALUE — The present net worth (PNW) of all future timber harvests of the replacement timber type.

REPLANTING COSTS — The costs necessary to reestablish a crop.

SMOKE INDEX — A relative rating of the ~~quality~~ QUANTITY of smoke produced by the fire.

SMOKE DURATION	The length of time that a fire produces a significant amount of smoke.
STUMPAGE VALUE	The value of timber standing in the woods to the landowner if he sold it for harvest. Values in Table 1 of Appendix A are adjusted to reflect presence of other timber species in the timber type.
SUCCESS INDEX	Recent hunting success in a particular county as compared to the whole state, sightings are used for non-game species. A constant for each year by county by species.
TIMBER TYPES	A tract of land characterized by the predominance of one or more key tree species.
TOTAL MORTALITY	As used in Timber section - the sum of acres burned times mortality for each overstory timber type in the fire..
TREE CONDITION CLASS	A relative assessment of the form and vigor of the ornamental tree.
UNDERSTORY	The timber species or group of species which is distinct from and below the overstory.
USE CHANGE	The change in use of the habitat by species.
YIELD LOSS	The quantity of crop that can't be harvested because of the fire; the expected yield/acre if the crop can't be replanted durin the current year.

APPENDIX B

PERSONS INVOLVED IN DEVELOPMENT

DNR Fuels & Effects Committee Members

1. Fred Axelrod, Chairman, Wausaukee
2. Duane Dupor, Liaison, Madison
3. John Grosman, Woodruff (left committee 7/79)
4. Lon LaBumbard, Spooner (left committee 4/79)
5. Gene Miller, Barnes (joined committee 11/78)

Associated DNR Personnel

1. Milt Reinke, State Forester, Madison
2. Gordon Landphier, Chief, Fire Control Section, Madison
3. Bill Martini, Fire Suppression Specialist, Tomahawk
4. Chuck Mueller, Forest Inventory Supervisor, Tomahawk

Non-DNR Personnel

1. Van Johnson, Project Leader, US Forest Service (until 11/78)
2. Dave Baumgartner, Economist, US Forest Service (since 2/79)
3. Al Simard, Project Leader, US Forest Service (since 4/79)

PERSONS INVOLVED IN IMPLEMENTATION

DNR Committee (Training Instructors)

1. Fred Axelrod, Wausaukee
2. Gene Miller, Barnes
3. Duane Dupor, Madison
4. Larry Forden, Bowler

DNR Implementation Test Participants

1. Terry Gordon, Wausaukee
2. Walt Gyllander, Florence
3. D. Jerabek, Spooner
4. Robert Oxnem, Wisc. Dells
5. Paul Pendowski, Wisc. Rapids
6. Tom Roberts, Green Bay
7. Marshall Ruegger, Dodgeville
8. Lawrence Schmitt, Boscobel
9. Michael Sohasky, Summit Lake
10. Barry Stanek, Gordon
11. Richard Thorbjornson, Spooner
12. Richard Wojciak, Poynette

APPENDIX C

VOLUME PREDICTION AND DISCOUNT PERIOD DETERMINATION

It is necessary to estimate the volume and determine the discount period for appraising the effects of fire on immature timber. Most procedures require estimates of harvest volume and harvest date, as discussed under the present net value method. The procedures which follow are somewhat different. The predicted volume is the volume when the stand becomes merchantable, and the discount period is the difference between the current age and the age when the stand becomes merchantable. The following describes the information and procedures used to develop the estimates.

For each age class in each timber type described in Appendix A, the cubic volume in the existing yield tables (Essex & Hahn, 1976) was converted to cords per acre by dividing the cubic volume by 80 cubic feet per cord (see the assumptions discussed below). For example, the jack pine type has a total of 381.36 cubic feet in the 21-30 age class, this was converted to 4.8 cords per acre (381.36/80). The volume was classified according to Table 11 and recorded in Table 12.

Table 11. -- Density classification system.

		Density Class				
Size	Units	''''	'''	''	'	0
Merchantable	Cords	20.0+	13.1-19.9	7.0-13.0	3.1-6.9	0-3.0
Saplings	Trees	-	700+	400-699	100-399	0-99

The percent of each tree species which occurs in each timber type was calculated by dividing the cubic volume in each type by the total cubic volume for that species in all types; Table 13 shows these percentages. As an example, 76.8 percent of all jack pine saplings occurred in the jack pine type; this was calculated by dividing the cubic feet of jack pine in the jack pine type (490.96 cubic feet) by the total volume of jack pine in all timber types (639.58 cubic feet). In the red pine type, there was a 8.6 percent of all jack pine saplings, calculated by dividing the volume of jack pine in the red pine type (55.26 cubic feet) by the total jack pine volume (639.58 cubic feet).1/

1/ These are the sum of the jack pine volume per acre for the three youngest age classes (0-10, 11-20, and 21-30) in the jack pine type, all 12 types, and the red pine type, respectively (Essex & Hahn, 1976).

Table 12. -- Density classes by age class for each timber type.

Age Class	Timber Types					
	PJ	PR	PW	FS	SB	C
0-10	0	0	0	0	0	0
11-20	0	0	'	'	0	'
21-30	'	' '	'	'	0	0
31-40	' '	' '	' '	' '	0	' '
41-50	' '	' ' '	' '	' '	0	' '
51-60	' ' '	' ' ' '	' ' '	' '	'	' '
61-70	' '	' ' ' '	' ' ' '	' ' '	' '	' '
71-80	-1/	' ' ' '	' ' '	' '	'	' '
81-90	-	' ' ' '	' ' '	' ' '	0	' ' '
91-100	-	' ' ' '	' ' ' '	' ' '	0	' ' '
101-120	-	-	' ' ' '	' '	'	' ' '
121+	-	-	' ' ' '	'	'	' ' ' '
Saplings	'	' ' '	' '	' ' '	' ' '	' ' '

Age Class	Timber Types					
	PJ	PR	PW	FS	SB	C
0-10	0	0	0	0	0	0
11-20	0	0	0	'	'	0
21-30	'	'	'	'	'	
31-40	'	' '	' '	' '	' '	' '
41-50	'	' '	' '	' '	' ' '	' '
51-60	' '	' '	' '	' ' '	' ' '	' ' '
61-70	'	' '	' '	' ' '	' ' '	' ' ' '
71-80	' '	' '	' ' '	' ' '	' ' '	' '
81-90	' '	' '	' ' '	' ' '	' ' '	' ' '
91-100	'	' ' '	' ' '	' ' '	'	-
101-120	-	' '	' ' '	' ' '	-	' '
121+	-	' ' '	' ' '	' ' ' '	' '	'
Saplings	' '	'	' '	' '	'	' ' '

1/ A dash means there were no sample plots in this age class.

Table 13. -- Percentage of saplings occurring in each type.

Tree Species	No. of Saplings [1]	Timber Type PJ	PR	PW	FS	SB	C	T	O	SH	NH	A	BW
White Pine	73.6	1	9	65	6	2	1	2	1	3	7	2	1
Red Pine	107.3	4	76	13	[2] *	3	-	-	1	1	*	2	
Jack Pine	266.1	77	9	2	1	-	-	*	6	1	*	4	*
White Spruce	39.0	-	6	-	75	-	4	-	-	7	1	7	-
Black Spruce	176.1	-	1	-	17	51	12	15	-	1	-	1	2
Balsam Fir	522.3	-	1	-	68	3	7	2	-	5	6	4	4
Hemlock	31.0	-	-	-	35	-	-	4	-	5	38	3	15
Tamarack	96.8	-	-	-	2	32	5	51	*	5	-	2	3
White Cedar	192.2	-	-	2	10	1	80	-	-	2	1	1	3
White Oak	127.1	*	-	-	-	-	-	-	72	3	5	6	14
Select Red Oak	121.1	2	5	-	1	-	-	-	53	1	20	6	12
Other Red Oak	157.5	14	12	-	-	-	-	-	61	*	0	5	2
Hickory	65.5	-	-	-	-	-	-	-	75	1	14	2	8
Butternut	5.3	-	-	-	-	-	-	-	60	-	22	2	17
Ash	319.8	-	-	-	13	-	-	-	1	62	16	5	3
Balsam Poplar	10.0	-	-	-	29	-	-	-	-	12	14	24	21
Cottonwood	0.7	-	-	-	-	-	-	-	24	76	-	-	-
Black Walnut	1.1	*	1	2	3	-	9	-	6	39	32	4	3
Yellow Birch	91.4	-	-	-	24	-	-	-	-	19	36	4	17
Hard Maple	1038.9	-	4	-	15	-	-	-	-	8	66	6	1
Soft Maple	894.7	-	1	-	9	7	-	2	8	25	35	6	7
Beech	14.7	-	-	-	-	-	-	-	-	-	100	-	-
Basswood	319.8	-	-	-	-	-	-	-	11	3	78	4	3
Paper Birch	385.8	1	1	1	8	2	19	3	5	4	10	7	38
Bigtooth Aspen	140.7	3	-	-	-	23	-	-	23	5	11	27	8
Quaking Aspen	921.5	2	6	3	10	5	3	3	3	5	13	42	5

1/ Number of saplings in millions (Spencer & Thorne, 1972).

2/ An asterisk denotes less than .5 percent.

Table 14. Number of saplings in each timber type.

Species	Timber Type											
	PJ	PR	PW	FS	SB	C	T	O	SH	NH	A	BW
Wh. Pine	1 1/	7	47	4	1	* 2/	2	1	2	5	2	1
Red Pine	5	81	14	*	3	*	-	1	1	*	2	1
Pine	204	23	5	3	-	-	1	15	2	*	11	1
W. Spruce	-	2	-	29	-	2	-	-	3	1	3	-
B. Spruce	-	2	-	30	89	21	27	-	1	-	2	4
Hemlock	-	-	-	11	-	-	1	-	2	12	1	5
Tamarack	-	-	-	2	31	5	50	*	4	-	2	3
W. Cedar	-	-	4	19	2	155	-	-	3	2	1	5
B. Fir	-	2	-	357	14	34	9	-	29	30	23	24
White Oak	1	-	-	-	-	-	-	91	4	6	7	18
Select RO	3	6	-	1	-	-	-	64	1	24	7	15
Other RO	22	19	-	-	-	-	-	95	*	9	7	3
Hickory	-	-	-	-	-	-	-	49	1	9	1	5
Butternut	-	-	-	-	-	-	-	3	-	1	-	1
Ash	-	-	-	40	-	-	-	5	197	52	15	10
B. Poplar	-	-	-	3	-	-	-	-	1	1	2	2
Cottonwood	-	-	-	-	-	-	-	*	1	-	-	-
B. Walnut	-	-	-	-	-	*	-	-	*	*	-	-
Y. Birch	-	-	-	22	-	-	-	-	17	33	4	16
H. Maple	-	37	-	153	-	-	-	-	83	689	61	16
S. Maple	-	55	-	81	62	-	21	70	222	309	57	64
Beech	-	-	-	-	-	-	-	-	-	15	-	-
Basswood	-	-	-	1	-	-	-	18	5	125	7	5
P. Birch	3	5	4	31	8	71	12	20	16	39	28	147
B. Aspen	4	-	-	-	32	-	-	32	7	16	38	11
Q. Aspen	20	54	26	92	45	24	32	28	49	125	386	42
TOTAL	263	243	100	879	287	312	155	492	651	1503	667	398
Area 3/	728	310	178	628	236	302	222	2665	1558	3522	366	554
Trees/Ac.	361	784	562	1400	1216	1033	698	185	562	427	182	718

1/ Number of saplings in millions, except for trees per acre.

2/ An asterisk denotes between 100,000 and 500,000 trees.

3/ Thousand acres in the timber type (Spencer & Thorne, 1972).

The number of saplings of each species in each timber type was then calculated by multiplying the percent of each species in each timber type by the number of saplings of each species. Table 14 lists the calculated number of saplings in each timber type. The number of trees in each timber type were summed to get the total number of saplings by timber type.

The average number of trees per acre was calculated by dividing the total number of saplings in each timber type by the total acres in that type. This is shown in the last row of Table 14. An example of this calculation is the average trees per acre for the jack pine type (361), calculated by dividing the total of 263 million saplings in the jack pine type by the 728 thousand acres in the type. The number of trees per acre was classified according to Table 11 and recorded in Table 12. The youngest age class at which the sapling density class is the same as the merchantable density class was identified and listed in Table 15. For example, the jack pine type has a sapling density class of ' (one-prime); the youngest age class in which the merchantable density class is ' is the 21-30 age class.

Table 15. -- Age class of merchantability.

Timber	Age Class	Adjusted Age Class	Timber Type	Age Class	Adjusted Age Class
PJ	21 - 30	21 - 30	T	51 - 60	61 - 70
PR	41 - 50	21 - 30	O	21 - 30	21 - 30
PW	31 - 40	31 - 40	SH	31 - 40	31 - 40
FS	61 - 70	61 - 70	NH	31 - 40	21 - 30
SB	- - -	61 - 70	A	11 - 20	21 - 30
C	81 - 90	61 - 70	BW	51 - 60	21 - 30

Some of the merchantable age classes were judged to need adjustment. Some of the density classes for the merchantable and sapling age classes were very close to the cutoff between classes. Based on the experiences of the DNR Committee members[1/], the merchantable age class for aspen (A) was lengthened. Similarily, northern hardwoods (NH) is more like oak (O) than indicated, and hence the merchantable age class was shortened. Other adjustments made were to shorten the merchantable age in white birch (BW), white cedar (C), and red pine (PR), and to ignore the predictions for tamarack (T). Tamarack was assumed to be the same as black spruce (SB).

Another adjustment was needed because black spruce, and hence tamarack, does not become merchantable. To adjust for this, the expected density class was reduced and a merchantable age class identified. Another adjustment which was made was to reduce the density class and shorten the merchantable age, when possible, for the two other swamp conifer types, fir-spruce (FS) and white cedar. Due to the slow growth of these types, this adjustment will result in a higher loss estimate, and thus was deemed desirable by the Committee.

Finally, an adjustment was needed to handle plantations because the growth rate and densities in plantations differ substantially from natural stands. The predicted volume, 23 cords per acre, is from the average for density class '''' (four-prime). The merchantable age of 20 was selected because it was deemed reasonable by the DNR Committee, and it resulted in a present net value which roughly corresponds with reported costs for planting and site preparation in the Northeast, as reported by Benzie et al (1973).

1/ Meeting of the Wisconsin DNR Fuels and Effects Committee. Rhinelander, WI. 7/24/78.

There are several assumptions which are necessary for this procedure. The first is that there are 80 cubic feet of pulpwood per cord. In Wisconsin, softwood pulpwood roundwood products averaged 78.9 cubic feet per cord in 1967, while hardwood pulpwood roundwood products averaged 79.0 cubic feet per cord (Spencer & Thorne, 1972).

The second assumption is that the percent of saplings of a given species is directly proportional to the cubic volume per acre in the three youngest age classes. Restated, this assumes that the average cubic volume per tree for an aspen sapling in the jack pine type is the same as the average cubic volume per tree for an aspen sapling in the oak and the aspen types. This does not assume that each species grows equally well in each timber type, but only that the volume is proportional to the number of stems in the type.

A third assumption is that the number of saplings in a given timber type divided by the acres in that type yields an average density for a sapling stand in that type. This assumption is probably the weakest step in the procedure, and at least one of the reasons that the adjustment were needed.

Another assumption is that the earliest merchantable density class is acceptable. The accuracy of these tables has been questioned (see present net value), and it was suggested that one of the sources of error was intermediate harvests. By using the earliest merchantable age class, this source of inaccuracy may be substantially reduced. The problem of stand density is solved by using only the average for Wisconsin. This, however, brings up the problem of extrapolating from the average stand. It has been assumed that stands of different densities react similiarly. For example, Table 12 shows that a jack pine stand in density class ' will be a merchantable jack pine stand of density class ' when it is 21 to 30 years old. It is assumed that a density class '' sapling stand will become a density class '' merchantable stand when it is between 21 and 30 years old.

APPENDIX D

SUCCESS INDEX CALCULATION

It is necessary to calculate a success index for each wildlife species group in each county. Since there is no data on hunter use by county for the game species, the success index for each species group is based on the percent of the total animal harvest in each county[1/], from the Wildlife Division of the DNR. The non-game group is based on weekend nature study participations in each county, estimated by the DNR Recreation Division. The following steps describe the procedures used to develop the success index for each species in each county[2/].

For each county, the percent of the species group harvested (number of weekend participations in nature study) was divided by the number of acres in the county, from Table 16. The result was divided by the average percent harvest (nature study participations) per acre for the state, 2.90×10^{-6} per acre (3.756 per acre), and recorded in Table 17.

The success index for each county was averaged with other counties of similar success indices. The grouping was done by an arbitrary selection, using observed breaks in the distribution for each wildlife group. Table 18 gives the number of counties in each group (Frequency), the weighted average index (Index), and range (Low to High). Figure 3 shows the site distribution of the index for each

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1/ No hunter success data were available for Menominee County, so the success indices were determined using the indices from the neighboring counties (Oconto, Shawano, Langlade). If 2 counties had the same index, Menominee's index was the same. If all 3 were different, Menominee's was the median index.

2/ Where the procedures for non-game species differ from the procedures for the game species, the differences are noted in parentheses.

species group. The counties were grouped together in order to have data from more than one observation. The DNR Committee plans to recalculate the success indices as more data becomes available from the Wildlife Division.

The success index for each group (Index in Table 18) is the weighted average for each group. It was calculated by summing the harvest percent (nature study participations) for each county in the group, dividing by the area in all of the counties in the group, and then dividing by the statewide average of 2.90×10^{-6} per acre (3.756 per acre).

Table 16. -- Acres, harvest, and nature study by county.

County	Acres (000)	Percent of Harvest: Deer	Rabbit	Grouse	Phea-sant	Water-fowl	Nature Study Days
Northwest							
Ashland	664	.76	.00	2.28	.00	.55	1065
Barron	553	.89	.18	2.62	.42	.65	2303
Bayfield	934	1.95	.00	2.12	.00	.88	6174
Burnett	538	1.95	.00	2.76	.00	1.76	2824
Douglas	835	2.19	.00	3.92	.00	.81	3124
Iron	478	.31	.00	.40	.00	.19	5037
Polk	596	1.72	.38	3.31	.11	1.30	4583
Price	806	1.68	.00	1.16	.00	.15	2787
Rusk	580	1.20	.05	.54	.00	.34	0
Sawyer	806	1.24	.00	3.11	.00	.65	10294
Taylor	624	1.06	.00	1.35	.00	.44	188
Washburn	523	1.33	.00	.23	.00	.01	6280
West Central							
Buffalo	455	2.85	.12	1.10	.38	2.56	143
Chippewa	652	.62	.16	3.19	.51	.40	366
Clark	781	3.00	.73	1.41	.42	.15	281
Crawford	364	1.26	.43	2.24	.21	3.63	997
Dunn	546	.77	.62	1.31	.75	1.00	1486
Eau Claire	414	1.35	.40	1.41	.76	.36	200
Jackson	639	5.29	1.34	6.44	1.00	.41	661
La Crosse	289	1.03	.45	1.61	.34	1.98	1408
Monroe	586	2.13	.36	1.94	.57	.28	13
Pepin	150	.50	.41	.06	.06	.44	0
Pierce	378	.64	.26	1.40	1.40	.61	597
St. Croix	470	.32	.22	1.86	1.86	1.12	757
Trempealeau	470	2.24	.59	2.27	2.27	.43	604
Vernon	513	1.42	.91	1.88	.15	2.52	225
North Central							
Adams	413	2.80	1.40	2.72	.00	.74	678
Forest	644	.90	.00	6.19	.00	.50	2488
Juneau	495	2.73	.48	1.66	.50	2.48	1190
Langdale	548	1.22	.20	.82	.00	.54	768
Lincoln	571	2.13	.62	4.74	.00	.37	829
Marathon	1015	3.04	3.96	5.22	.51	2.32	430
Oneida	712	2.12	.00	3.34	.00	.92	5667
Portage	516	2.42	1.33	2.54	.51	.86	0
Vilas	555	1.38	.00	3.71	.00	1.20	9213
Wood	516	3.28	.78	3.14	.00	1.57	335

Table 16. (Continued).

County	Acres (000)	Percent of Harvest: Deer	Rabbit	Grouse	Phea-sant	Water-fowl	Nature Study Days
Lake Michigan							
Brown	335	.25	2.83	.16	.70	1.06	737
Calumet	212	.30	2.37	.00	1.26	1.04	0
Door	315	.59	.25	.00	1.18	.10	7521
Florence	312	.47	.00	.67	.00	.00	2819
Keewaunee	211	.47	.93	.03	.91	.44	44
Manitowoc	378	.74	2.40	.00	1.58	1.27	411
Marinette	882	3.41	3.19	1.74	3.13	.05	4013
Menominee 1/	230						132
Oconto	641	2.05	.00	1.62	2.37	.93	1271
Outagamie	406	1.23	3.41	.00	.65	.79	456
Shawano	588	2.62	.90	2.74	.86	1.48	778
Waupaca	481	3.48	2.98	.87	1.14	1.04	1093
Waushara	401	2.82	.65	1.84	.55	.65	527
Winnebago	287	.42	2.70	.00	2.33	3.03	675
Southern							
Columbia	497	3.74	.77	.23	3.92	4.19	5159
Dane	767	.97	5.15	.00	3.74	2.69	3105
Dodge	569	.48	4.60	.00	8.04	12.23	0
Fond du Lac	464	.59	4.17	.00	6.41	8.93	269
Grant	734	.35	.87	.52	.73	1.54	747
Green	374	.12	2.96	.00	5.46	.22	128
Green Lake	227	1.44	1.01	.00	5.52	5.10	904
Iowa	488	2.60	.59	.99	1.24	1.11	1317
Jefferson	361	.31	1.16	.00	3.52	7.36	552
Lafayette	412	.14	3.81	.00	3.20	.05	524
Marquette	291	2.98	.01	.13	1.60	2.22	1301
Richland	373	1.56	2.00	1.22	.00	.21	0
Rock	461	.18	7.12	.00	8.41	1.24	726
Sauk	538	2.72	1.88	.30	1.29	.64	5856
Southeast							
Kenosha	174	.04	5.58	.00	1.04	.64	2489
Ozaukee	151	.10	.29	.00	1.89	.51	499
Racine	216	.04	4.29	.00	1.17	.95	932
Sheboygan	323	.52	1.68	.10	6.88	.91	635
Walworth	356	.14	4.96	.00	1.57	.96	7759
Washington	275	.26	.90	.01	2.00	.62	406
Waukesha	355	.20	6.03	.00	2.95	.65	849

1/ No hunter success data are available for Menominee county.

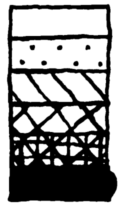
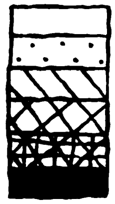
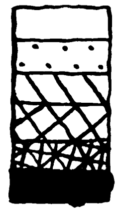
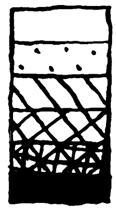
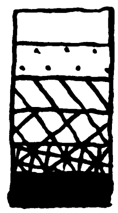
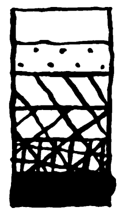
Table 17. -- Calculated success index and map identification number.

County	Map ID #	Deer	Small Game PJ,A	Small Game BW,SB	Small Game FO	Water-fowl	Non-Game
Northwest							
Ashland	1	.394	.428	.000	.000	.285	.430
Barron	2	.555	.663	.112	.262	.403	1.553
Bayfield	3	.720	.283	.000	.000	.326	1.772
Burnett	4	1.251	.641	.000	.000	1.129	1.409
Douglas	5	.904	.586	.000	.000	.334	1.003
Iron	6	.224	.104	.000	.000	.136	2.825
Polk	7	.995	.834	.220	.064	.753	2.063
Price	8	.718	.180	.000	.000	.062	.927
Rusk	9	.714	.135	.030	.000	.203	.000
Sawyer	10	.531	.482	.000	.000	.280	3.426
Taylor	11	.586	.270	.000	.000	.242	.081
Washburn	12	.877	.055	.000	.000	.009	3.221
West Central							
Buffalo	13	2.160	.360	.091	.288	1.941	.084
Chippewa	14	.328	.665	.085	.270	.210	.151
Clark	15	1.322	.431	.322	.188	.065	.096
Crawford	16	1.195	1.030	.408	.199	3.446	.735
Dunn	17	.486	.550	.392	.474	.628	.730
Eau Claire	18	1.124	.638	.333	.633	.304	.129
Jackson	19	2.853	1.719	.723	.539	.221	.277
La Crosse	20	1.230	1.039	.538	.406	2.370	1.308
Monroe	21	1.254	.549	.212	.335	.168	.006
Pepin	22	1.146	.650	.940	.138	1.009	.000
Pierce	23	.584	.615	.238	1.279	.559	.424
St. Croix	24	.235	.597	.161	1.365	.822	.432
Trempealeau	25	1.642	.878	.432	1.664	.312	.344
Vernon	26	.954	.847	.611	.101	1.693	.118
North Central							
Adams	27	2.335	1.566	1.167	.000	.621	.440
Forest	28	.482	1.199	.000	.000	.268	1.035
Juneau	29	1.900	.621	.334	.348	1.728	.644
Langdale	30	.768	.267	.126	.000	.337	.376
Lincoln	31	1.286	1.275	.374	.000	.223	.389
Marathon	32	1.033	1.500	1.345	.173	.787	.114
Oneida	33	1.027	.586	.000	.000	.445	2.135
Portage	34	1.618	1.182	.889	.341	.572	.000
Vilas	35	.858	.835	.000	.000	.748	4.452
Wood	36	2.190	1.091	.521	.000	1.051	.174

Table 17. (Continued).

County	Map ID #	Deer	Small Game PJ,A	Small Game BW,SB	Small Game FO	Water-fowl	Non-Game
Lake Michigan							
Brown	37	.257	1.916	2.910	.720	1.094	.589
Calumet	38	.487	2.543	3.846	2.045	1.694	.000
Door	39	.646	.175	.274	1.292	.106	6.405
Florence	40	.520	.268	.000	.000	.000	2.426
Keewaunee	41	.767	.986	1.518	1.486	.726	.056
Manitowoc	42	.676	1.398	2.192	1.443	1.156	.292
Marinette	43	1.333	1.042	1.247	1.224	.019	1.220
Menominee	44						
Oconto	45	1.103	.316	.000	1.275	.498	.532
Outagamie	46	1.045	1.849	2.898	.552	.668	.301
Shawano	47	1.536	.918	.528	.504	.869	.355
Waupaca	48	2.496	1.590	2.138	.818	.744	.610
Waushara	49	2.423	.929	.559	.473	.562	.352
Winnebago	50	.505	2.071	3.247	2.802	3.640	.631
Southern							
Columbia	51	2.597	.399	.534	2.722	2.907	2.786
Dane	52	.436	1.477	2.316	1.682	1.208	1.086
Dodge	53	.291	1.779	2.788	4.872	7.349	.000
Fon du Lac	54	.438	1.977	3.099	4.763	6.638	.155
Grant	55	.164	.349	.409	.343	.722	.273
Green	56	.111	1.739	2.724	5.028	.205	.092
Green Lake	57	2.192	.980	1.537	8.401	7.759	1.070
Iowa	58	1.838	.519	.417	.877	.788	.724
Jefferson	59	.296	.981	1.538	3.362	7.029	.410
Lafayette	60	.117	2.036	3.192	2.681	.041	.341
Marquette	61	3.529	.063	.012	1.895	2.631	1.198
Richland	62	1.442	1.587	1.848	.000	.193	.000
Rock	63	.135	3.394	5.320	6.284	.928	.422
Sauk	64	1.742	.838	1.204	.826	.410	2.917
Southeast							
Kenosha	65	.079	7.050	11.052	2.060	1.268	3.834
Ozaukee	66	.228	.422	.662	4.314	1.171	.886
Racine	67	.064	4.375	6.858	1.871	1.516	1.159
Sheboygan	68	.555	1.182	1.792	7.340	.969	.527
Walworth	69	.135	3.061	4.798	1.518	.931	5.837
Washington	70	.327	.726	1.130	2.512	.779	.396
Waukesha	71	.194	3.741	5.864	2.869	.636	.642

Table 18. -- Success index group statistics.

Group	Index	Frequency	Range Low	Range High	Symbol
Deer					
	.16	14	.064	.296	
	.48	15	.327	.586	
	.75	9	.646	.877	
	1.17	19	.904	1.536	
	1.75	5	1.618	1.900	
	2.52	9	2.160	3.529	
Small Game: PJ,A					
	.27	18	.055	.431	
	.59	15	.482	.726	
	.94	14	.834	1.091	
	1.40	10	1.182	1.590	
	1.90	9	1.719	2.453	
	3.94	5	3.061	7.050	
Small Game: BW,SB					
	.00	14	.000	.000	
	.25	20	.012	.432	
	.63	11	.521	.940	
	1.61	13	1.130	2.316	
	3.03	8	2.726	3.846	
	6.18	5	4.798	11.092	
Small Game: FO					
	.00	19	.000	.000	
	.24	13	.064	.348	
	.64	12	.406	.877	
	1.62	14	1.224	2.060	
	2.83	6	2.512	3.362	
	5.72	7	4.314	8.401	
Waterfowl					
	.20	24	.009	.337	
	.65	22	.403	.869	
	1.08	11	.928	1.268	
	1.74	5	1.516	1.941	
	3.01	5	2.370	3.640	
	7.13	4	6.638	7.759	
Non-Game					
	.08	19	.000	.174	
	.36	17	.273	.440	
	.65	11	.527	.886	
	1.24	12	.927	1.772	
	2.49	6	2.063	2.917	
	4.28	6	3.221	6.405	

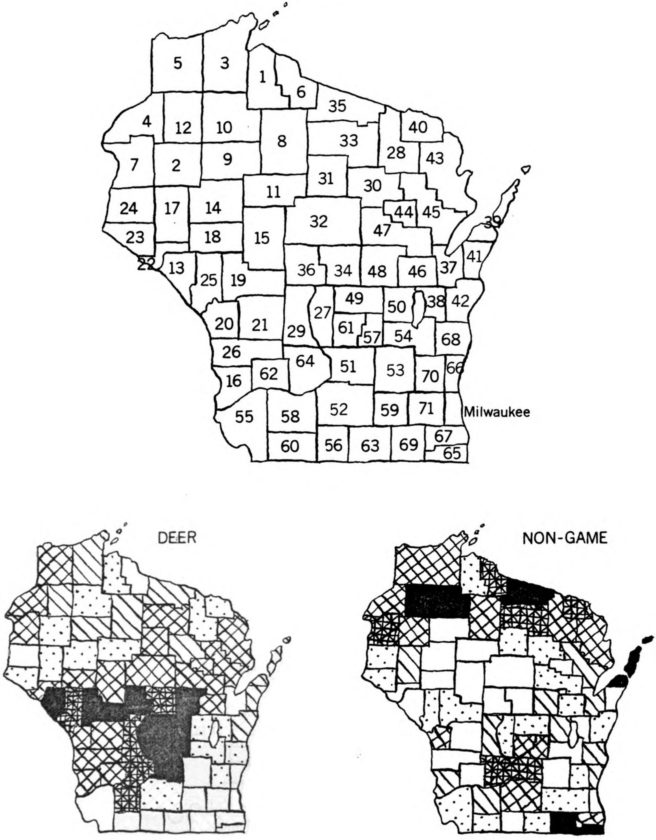


Figure 3.-- Maps of success indices.

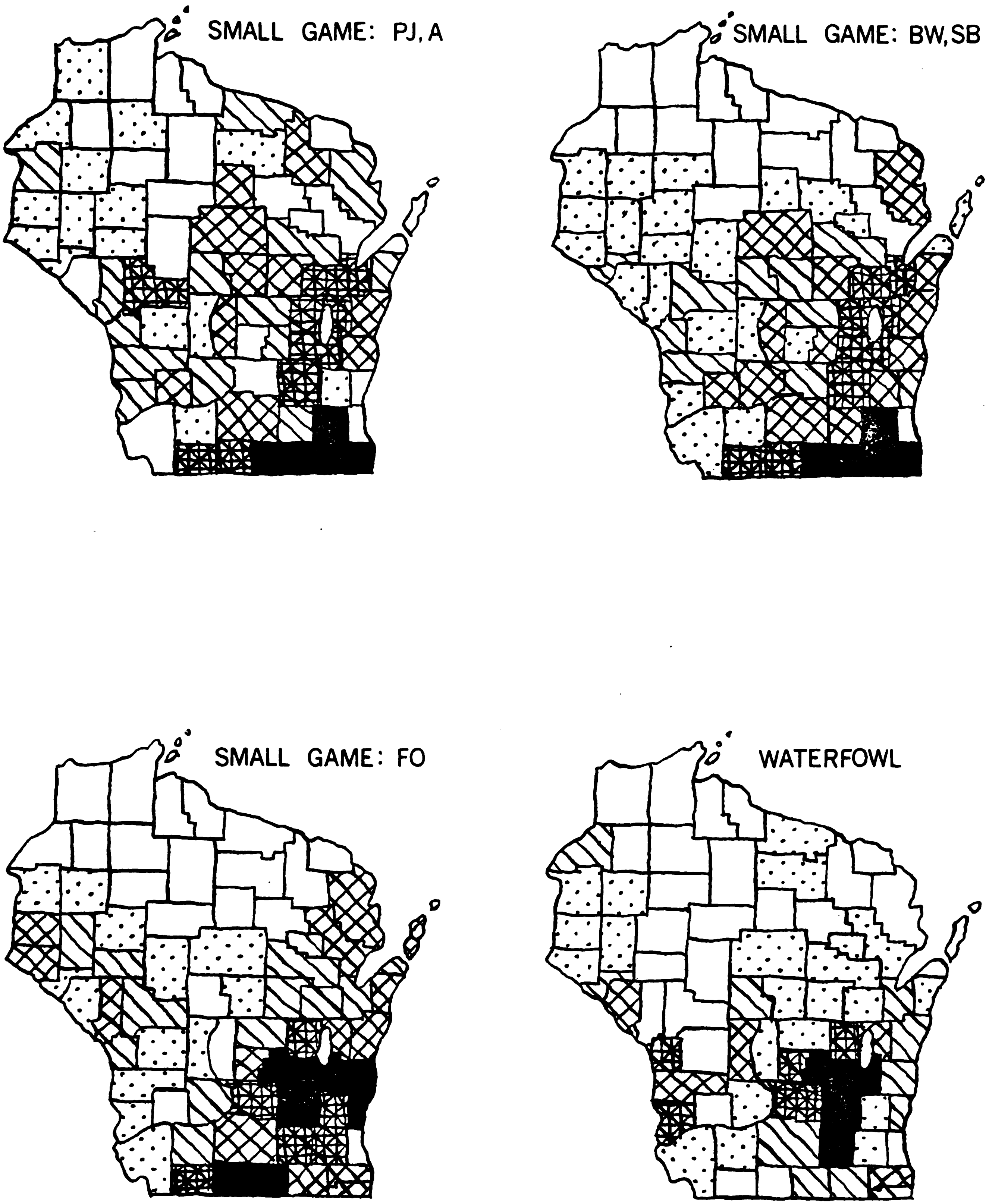


Figure 3.-- (Continued).