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ECONOMIC EFFICIENCY VS. LOCAL ECONOMIC IMPACT: A COMPARISON OF NATIONAL FOREST MANAGEMENT PROGRAMS

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ECONOMIC EFFICIENCY VS. LOCAL ECONOMIC IMPACT: A COMPARISON OF NATIONAL FOREST MANAGEMENT PROGRAMS

By

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ABSTRACT

ECONOMIC EFFICIENCY VS. LOCAL ECONOMIC IMPACT:
A COMPARISON OF NATIONAL FOREST MANAGEMENT PROGRAMS

By

Ellen Johnson Hall

The USDA Forest Service has traditionally maintained an interest in the impact of national forest management on local communities. The desire to maintain stable communities has been used as a defense for following less than efficient management policies. Rational policy decisions must be supported by knowledge of the associated costs and benefits. The problem considered in this research is how to measure the impact of forest management policies on a local economy and how to compare that impact to the cost of achieving it. A case study of the Idaho Panhandle National Forests is used to illustrate the method.

The research follows a four step procedure. First, a model is developed defining the conditions which maximize the present value of timber management. Next, the present value maximizing alternative and three other alternatives are developed using the FORPLAN linear programming model. The cost of the three alternate management strategies is identified as the present net value loss compared to the maximum. Third, the impact of each alternative on local employment and income is determined using an input-output model. Finally, losses in the present net value of timber management are compared to gains in the

present net value of local income produced. By using a common unit of measure, the relative costs and benefits of each timber management alternative can be determined.

Major findings include the following:

1. The impact on the local economy of deviating from a model of efficient timber management varies. Policies which push the harvest above the efficient level or increase Forest Service costs are locally advantageous. Policies which keep the harvest below the efficient level or reduce Forest Service costs are locally disadvantageous.

2. Environmental considerations can fall anywhere in the spectrum, adding either to national efficiency or to local economic benefit.

3. In all cases considered in this analysis, local income gains were less than the present net value loss associated with deviation from the efficiency model. All benefit-cost ratios were less than one. Other results might be possible given other management alternatives, a different local economic structure or a different time frame.

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CHAPTER I

INTRODUCTION

The U.S. Forest Service has traditionally maintained an interest in the impact of national forest management on local communities. Until recently, rather less concern has been shown for the economic efficiency of national forest management. The debate over economically efficient forest management centers on the concept of sustained yield, which the Forest Service has interpreted as requiring a nondeclining flow of timber volume from the national forests. Because the concept of local community stability has traditionally been linked with a stable supply of timber, advocates of efficient forest management are suspected of being unsympathetic to local community interests. The rejoinder takes two forms. First, the question is raised whether an even flow of timber is either a necessary or sufficient condition for community stability. Second, even if one could demonstrate that sustained yield does contribute to community stability, a question remains about whether the stability gained is worth the sacrifice in efficiency which usually attends it. This research concerns the latter question.

Research Problem

Local economies dependent on timber resources exist throughout the Pacific Northwest. Many of these areas are also characterized by a predominantly federal land base administered by the U.S. Forest Service.

The entire local economy is therefore closely linked to national forest policies which affect the supply of timber from the national forests. Policies, and policy changes such as departure from the nondeclining even flow concept of sustained yield, can have a direct impact on local communities. That impact is one of many which must be considered in evaluating existing and proposed forest policies.

Another important consideration for any forest management policy is its economic efficiency. Benefits must be weighed against costs, in terms of both cash expenditures and revenue foregone.

The problem considered is how to measure the impact of certain policies on a local economy and how to compare that impact to the cost of achieving it. Whether this impact contributes to a stable community is not at issue, i.e., the concept of community stability provides a general context for this research, but does not constitute the research problem. A case study approach is used: the local economy considered is made up of the five northernmost counties in Idaho. The Idaho Panhandle National Forest (IPNF) is the administrative unit incurring the cost of forest management in the name of, ultimately, the U.S. taxpayer.

Research Objectives

In order to measure policy impacts on the local economy and compare those impacts to their cost, the following research objectives must be achieved:

1. Develop a model which defines the conditions for maximizing the present net value of timber management on the Idaho Panhandle National Forests;

2. Identify the cost, in terms of present net value loss, of following alternate management policies;

3. Measure the impact of each alternative on the local economy; and

4. Develop a common unit of measure by which local economic impacts can be compared directly to changes in the present net value of timber management on the national forest.

In this chapter we will briefly introduce the concept of forest management based on economic efficiency. Efficiency criteria are frequently at odds with traditional volume-oriented forest management policies. We will therefore discuss both the traditional sustained yield - community stability link and the arguments against it as an appropriate land management policy. After demonstrating the problems with current policies, attention can be turned to a more comprehensive discussion of the economic efficiency model and the topic of this research.

Economic Efficiency Criteria in Forest Management

Economic efficiency criteria justify expanding production until the benefits derived from the last unit of output just equal its factor costs. At that point present net value is maximized. In the context of forestry, investments should be made in timber management, silvicultural effort and harvesting only to the point where net timber values just equal costs. There are at least two objections commonly made to this approach on national forest land. First, as a public agency the Forest Service is properly required to practice multiple use management, not to maximize profit. The criteria can therefore be expanded on public forests to include the benefits and costs of multiple use outputs. Evidence from public lands does not support the rationale that nonpriced values and externalities always justify deviation from a strictly market solution (Fight, et al. 1978; Kutay, 1977; Walker, 1974). Justification must be provided on a case by case basis, not as a blanket assumption.

The second objection to the economic efficiency criteria is that it disregards the impact on local communities. The objection implies that current volume-oriented policies are better for local economies. This assumed link between sustained yield policies and community stability is discussed in the remainder of this chapter.

The Sustained Yield-Community Stability Link

Understanding the assumed relationship between sustained yield and community stability first requires an understanding of the terms themselves. The traditional interpretation of sustained yield relates to the maintenance of a flow of harvested timber, and it implies that the harvest should not exceed growth (Waggener, 1978). Smith (1969) contends that the concept of maximum sustained yield was introduced in the mistaken belief that land is more limiting than labor, capital and technology. Under maximum sustained yield, one must therefore promote the greatest possible growth per acre to support the greatest possible harvest per acre.

The concept of maximum sustained yield is closely tied to the model of the normal, or regulated forest. The regulated forest, with normally distributed age classes and productivity growth and a fixed rotation age, is theoretically capable of providing a high, constant level of harvest forever. Most forests are not in a regulated condition. The time needed to reach a regulated condition depends on the rate of harvest in the interim. Achieving the desired age class distribution in the shortest time possible could mean large fluctuations in interim harvest levels. The idea of increasing annual or periodic yields was therefore introduced "as an attempt to encourage stability and to encourage an orderly transition to maximum yields" (Smith, 1969).

The concept of stability is also ambiguous. In a static sense, stability means constancy. In a dynamic sense, stability can relate to the degree of short term variability about a trend (Waggener, 1977) or the rate of change in the trend itself (Jackson, 1980b). Schallau (1974) suggests the term "orderly change," the absence of sudden and unpredictable changes. Beuter and Schallau (1978) expand on that approach and suggest that stability can be achieved whenever both basic and nonbasic sectors of an economy are changing in the same direction and at comparable rates so they remain in balance. The latter definition offers a reasonable approach to a dynamic economy. Instead of managing for maximum sustained yield, forest managers might endeavor to keep the total flow of timber in balance with the rest of the economy. The Forest Service has opted for sustained yield, however, in its strictest form: nondeclining even flow.

The Forest Service has operated under the timber harvest policy of nondeclining even flow since the enactment of Emergency Directive 16 in 1973. Under this policy allowable harvests of timber for each national forest are set at a level which can theoretically be sustained forever. As Josephson (1976) has pointed out, the policy reflects the Forest Service interpretation of legislative requirements contained in the Organic Act of 1897 and the Multiple Use-Sustained Yield Act of 1960. It was reiterated in the Forest and Rangeland Renewable Resources Planning Act of 1974 as amended by the National Forest Management Act of 1976.[1] Josephson states that the even flow policy is believed to represent a means of achieving "stable forest-based communities and long run conservation of resources."

This concern for "stable forest-based communities" has a long history. Schuster (1976) has traced a Forest Service concern for community stability to as early as the 1905 Pinchot letter.[2] Legislation

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[1]Popovich (1977) points out that NFMA Section 13 limits average harvest in any decade to that which can be removed on a sustained yield basis forever. However, some flexibility is added by the caveat that the Secretary of Agriculture may depart from the constraint "in order to meet multiple-use objectives." Walker (1977) has argued that the inclusion of economic criteria in the definition of multiple use would justify departure. The 1974 RPA, as amended by NFMA, also includes several provisions for the cost efficient reduction of timber waste. Zivnuska (1977) suggests waste reduction and efficient use of capital could serve as multiple-use objectives warranting departure. Finally, Zivnuska has pointed out that where private timber stocks have been depleted, departure could serve community stability goals better than nondeclining even flow.

[2]The letter, dated February 1, 1905, was from Secretary of Agriculture James Wilson to Chief Forester Gifford Pinchot. The letter was prepared by Pinchot himself and set down the guides and charter for the new forest agency. The body of the letter is included in Pinchot's Breaking New Ground (Harcourt, Brace and Co., New York, 1947).

linking sustained yield and community stability has been limited, however, to the Sustained Yield Forest Management Act of 1944 and the "O & C" Act of 1937.[3] The Sustained Yield Forest Management Act takes community stability as the raison d'etre for sustained yield forest management. The act states that

> "In order to promote the stability of forest industries, of employment of communities, and of taxable forest wealth, through continuous supplies of timber; in order to provide for a continuous and ample supply of forest products; and in order to secure the benefits of forests in maintenance of water supply, regulation of stream flow, prevention of soil erosion, amelioration of climate, and preservation of wildlife",

the Secretaries of Agriculture and Interior were authorized to form sustained yield forest units. Section 3 of the act also allowed deviations from the usual timber sales procedure if "the maintenance of a stable community or communities primarily dependent upon the sale of timber or other forest products" was at stake. Similarly, the O and C Act stated that the forest was to be managed

> "in conformity with the principle of sustained yield for the purpose of providing a permanent source of timber supply, protecting watershed, regulating streamflow, and contributing to the economic stability of local communities and industries . . ."

Despite the absence of other legislative references to community stability, Jackson (1980b) notes that the Forest Service has interpreted "more frequent reference to even flow as Congressional intent to stabilize communities." Thus the rationale for sustained yield in general and nondeclining even flow in particular has become almost synonomous with the desire for stable communities.

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[3]The O and C Act of 1937 is officially titled the Revested Oregon and California Railroad and Reconveyed Coos Bay Wagon Road Grant Lands Act of 1937.

Critique of the Sustained Yield-Community Stability Link

Waggener (1978) has stated that

> "It is one thing to define worthwhile objectives for public policy and forest policy in particular. It is quite another to assure that the means selected for accomplishing the objectives are actually effective and efficient. Unfortunately, the causal linkage of sustained yield management as the means of accomplishing stability objectives has been one of assertion rather than a careful analysis of actual viability."

The problem is that most of the causes of instability lie elsewhere. The timber industry itself is rather unstable. Unstable markets, the existence of excess timber inventories and the use of forests as a common property resource have all contributed to instability in forestry over the years (Waggener, 1978). Additionally, there is evidence that employment in the forest products industry is declining due to capital substitution, despite relatively even flows of timber (Stevens, 1979; Stier, 1980).

The chief problem with nondeclining even flow is that it is a static policy in a dynamic world. Keeping one factor constant simply shifts the burden of adjustment elsewhere. Waggener (1978) has pointed out that "treating the forestry symptoms of economic instability rather than the underlying causes can be counterproductive." Such policies can inhibit the development of a more diversified economy. Furthermore, stabilizing output from the national forest forces other forest ownerships and mill owners to assume the entire burden of adjustment to changing levels of demand. Jackson's (1980b) study of Montana and northern Idaho provides empirical evidence to support that observation. Jackson examined timber sold, timber harvested, and forest products employment in the study area since 1959. He found the variation in sales and harvest nearly identical, but employment more stable. Other ownerships and purchasers were providing the balance. Price fluctuations are also aggravated by an inelastic timber supply. In addition, because the Forest Service controls sales rather than actual harvest, timber purchasers frequently hold increased inventories of uncut timber to provide flexibility in responding to changing market conditions.

Thompson (1966), Waggener (1969), and Keane (1972) have all pointed out that in a dynamic world, nondeclining even flow cannot guarantee community stability. Indeed, Krutilla and Haigh (1978) have stated that ". . . it is a bit quixotic for the Forest Service to attempt to insure 'community stability' when the means to do so are not available to it."

Others have provided support for Krutilla and Haigh's argument. Bentley (1968) discusses federal sustained yield units, where stability is a primary concern. His findings show stagnation in the local area and a sacrifice of both growth and stability in the region. He further suggests that where the stability goal is achieved, it is the result of performance by firms purchasing national forest timber. In another study, Jackson (1980b) compared employment stability to the proportion of total growing stock under national forest control in 27 states. He found that an increase in the proportion of national forest control is associated with a decrease in employment stability. While this does not prove that national forests cause employment instability, it does raise questions about the ability of the Forest Service to ensure stable communities.

One can agree with Josephson's (1976) comment that boom and bust cycles have great economic and social costs. On the other hand migration and change are a standard part of American economic growth. Improved transportation, technological improvements and economic diversity have all reduced the importance of even flow harvests. Given the preponderance of evidence to the contrary, the burden of proof lies with the Forest Service to show that the sustained yield policy of nondeclining even flow is either necessary or sufficient for community stability.[4]

Given that most of the evidence suggests it is not within the power of the Forest Service to ensure community stability, it becomes doubly important to consider the wisdom of volume-oriented policies. Hyde (1980) summarizes the case against the volume-oriented sustained yield policy as a means of achieving community stability:

> "Since our concern is for human communities, we might expect focus on the human productive resource, labor, and flows of its direct use. Instead, the Forest Service acts to prevent community decline by ensuring periodic harvest flows. For communities maintained by a timber resource from an inefficient land base, this is the same as an extended subsidy for which there is no obvious end and for which someone (the public treasury) must pay. Subsidies imply foregoing other nonsubsidized goods or services which the subsidy dollar could have purchased, and they are inflationary. They may be justified, but justification requires a conscious public policy decision. It is incumbent upon Forest Service managers and others concerned with the community impacts of timber harvests to make the case for such decisions, because there is no guarantee that a subsidized timber flow will succeed in preventing community decline."

In addition to Hyde's concern for subsidies brought about by timber harvests above what could be efficiently supported by the land

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[4]Perhaps in response to this shifting burden of proof, Worthington (1975) has suggested the rationale for nondeclining even flow is moving away from community stability and toward the conservation of resources for future generations.

base, there is an additional concern for harvests lower than what the forest could efficiently provide. A recent study on the Six Rivers National Forest (USDA, 1979) found that a moderate departure from nondeclining even flow would increase the allowable sale quantity, local jobs, revenue to the counties and returns to the U.S. Treasury.

As stated earlier in this chapter, the focus of this research is local economic impact, not community stability *per se*. Many questions have been raised about the meaning of the term community stability and the ability of the Forest Service to affect it. This research concentrates on the measurable impacts of forest management on local income and employment. The procedure developed here can provide information on which a "conscious public policy decision" can be based.

The first set of questions to be answered is "What forest management criterion is best for the local economy?" "Is a policy of maximizing the efficiency of national forest management better or worse for the local economy than a subsidized policy of nondeclining even flow?" Or is some intermediate policy possible? If a policy of subsidy is selected to benefit the local economy, one can join Clawson (1976) in saying that "while subsidies are very common in the national economy, question can always be raised as to the degree of national interest in such local subsidy."

Major Findings

Among the major findings of this study are the following:

1. The impact on the local economy of deviating from a model of efficient timber management depends on "how much" and "in what

direction" the movement occurs. Policies which keep the harvest above efficient levels and management practices which increase Forest Service expenditures are advantageous to the local economy. Policies which keep the harvest below efficient levels and management practices which reduce Forest Service spending are locally disadvantageous.

2. Environmental considerations can fall anywhere in the spectrum with regard to both efficiency and local economic impact. Practices which increase the cost of timber harvest without reducing timber volume can benefit the local economy, but reduce the present net value of timber management. Policies which lead to a reduction in timber harvest to a more efficient level might improve efficiency but have negative impacts on the local economy.

3. In all cases considered in this analysis gains to the local economy were less than the present net value loss which occurred when alternatives to the model of efficient timber management were followed. Comparing local benefits to national costs for each of three alternatives, all three had benefit-cost ratios less than one; one ratio was less than zero. Deviations from the model of efficient timber management for the purpose of promoting local economic benefits did not make a positive net contribution to the national economy. Other results might be possible on other national forests, given different management options and different local economic conditions.

CHAPTER II

PURPOSE, SCOPE AND RESEARCH PROCEDURE

This research will present a method for determining what effect various forest management alternatives are likely to have on a local economy and at what cost that effect is achieved. As Dickerman and Butzer (1975) have pointed out, it is inappropriate to generalize the role of timber industries in local or regional economies. They found that even among regions where direct impacts were similar, indirect impacts might be quite different. In the Pacific Coast region, for example, the forest products industry represents 7 percent of the direct personal income and is associated with 17 percent of total personal income. By way of contrast, western Montana forest products industry accounts for 6 percent of the direct and only 10 percent of the total personal income in the area. Because of the linkages in the Pacific Coast economy, a 20 percent change in timber volume would change the regional economy by 3.0 percent, other things being equal. In western Montana it would take a 30 percent change in timber volume to produce a 3.0 percent impact on the economy. Because local economies differ, their response to alternate forest management programs cannot be simply assumed.

Purpose of the Research

The purpose of this research is to test the hypothesis that adherence to a model of efficient timber management will not only maximize the present net value of the timber but will also maximize the present net value of local economic activity. Conversely, adherence to policies such as nondeclining even flow reduce the present value of local economic activity. In the event the hypothesis proves incorrect, we can determine why less-than-efficient management might be good for the local economy. Using the procedure presented here, we can also determine the amount of subsidy provided the local economy and suggest whether there might be better options for maintaining employment.

Scope of the Research

The research takes the form of a case study of the Idaho Panhandle National Forests. Located in the northernmost part of Idaho, the IPNF is an administrative unit for three designated national forests: the Kaniksu, the Coeur d'Alene and the St. Joe.

The analysis will consider the costs and benefits of four management alternatives for the IPNF. Although the focus will be on timber management alone, inferences can be drawn about the effect of including multiple use management.

The local economic impact area is comprised of five northern Idaho counties: Benewah, Bonner, Boundary, Kootenai and Shoshone. Their borders are roughly coincident with the national forest boundary. The impact of each alternative will be measured in terms of employment and income.

The planning horizon for the management alternatives considered is one hundred thirty years, which is sufficient time for the Forest to reach a fully regulated state. This analysis will concentrate on the first fifty years, capturing most of the present net value of the timber management program and of local economic impacts.

Research Procedure

Subsequent chapters report the research procedure in sequence. In Chapter 3, the theoretical framework for the research is explained. First, an economic efficiency model formulated by William Hyde (1980) is presented. Solution of the model provides an economically optimal timber management regime, i.e., one which maximizes the present net value of management. The solution specifies optimal levels of land allocation, silvicultural effort and timber harvest schedule. The results of Hyde's application of the model are discussed.

In Chapter 4, another version of the efficiency model is presented. It was formulated by the Idaho Panhandle National Forests planning team. The computer model FORPLAN, which is used to solve the efficiency model, is also described. Like Hyde's model, the FORPLAN solution defines an optimal land allocation, level of silvicultural effort and timber harvest schedule.

Chapter 5 first presents three alternatives to the efficiency model. Two of the alternatives produce a higher timber volume in the first decade than the efficiency alternative. In addition, they include several constraints on efficient timber management, including nondeclining even flow, harvest at culmination of mean annual increment and 40 acre maximum clearcut restrictions. Another alternative represents current timber management, and produces a timber volume lower than the efficiency alternative. After all of the alternatives are described, their solutions are compared to the efficiency model solution.

Comparisons are made of the present net value for each alternative, their timber volume and scheduling, land allocation and several silvicultural and production factors which affect costs. The efficiency of national forest management is reflected by the present net value of each alternative.

Chapter 6 turns attention toward the local economic impact area. A profile of the impact area is presented. Then the relationship between the IPNF, the local timber industry and the total economy is described.

The input-output (I-O) model used in this research is described in Chapter 7. First the model formulation is discussed, in the context of forward- and backward-linkage I-O models. The model is used to estimate the impact of the forest management alternatives on local employment and income. The alternatives discussed in Chapters 4 and 5 are then compared for their impact on local economic activity.

Chapter 8 summarizes the results of the analysis and presents conclusions. Joint comparisons are made between the alternatives. The present net value of each alternative is a measure of efficiency. The income produced in the local economy is a measure of the economic benefits which accrue to the community. Both measures are discussed in terms of average annual equivalent values. Conclusions are presented in terms of how movements away from the efficiency model tend to add to or detract from the local economy and how subsidies, where they exist, can be evaluated.

CHAPTER III

DEVELOPMENT AND APPLICATION OF THE EFFICIENCY MODEL

The U.S. Forest Service is the nation's largest timberland manager. Its timber sale policies are guided almost solely by consideration of the volume produced, not its value. As Mead (1966) has pointed out, the objectives of the Forest Service are detached from economic factors. Their objective is to

> "manage each working circle so that it will produce a maximum sustained yield of the products it is best suited to grow. This can be accomplished by selecting a rotation which coincides with the culmination of mean annual increment for the desired products and then regulating the cut so as to achieve, as soon as practicable, the annual or periodic removal of the proper volume."

The allowable cut model therefore spreads the harvest of mature timber over several decades, smoothing out the flow of timber and preventing a "falldown" in future harvestable timber. The nondeclining even flow policy further restricts the harvestable volume in each year. The requirement to harvest at or beyond the culmination of mean annual increment similarly focuses on the volume of timber produced, rather than its value. Clawson (1976) has estimated that these and other departures from efficiency have an annual opportunity cost of six hundred million dollars.

If an adequate economic model exists, the reasons for its preference over volume-maximizing policies are several. Such volume-maximizing policies are, to begin with, probably more restrictive than are legally necessary (Krutilla and Haigh, 1979; Popovich, 1977). Multiple-use purposes might be just as well, if not better, served by a harvest schedule based on efficiency criteria (Hyde, 1980; Kutay, 1977; Calish, et al., 1978). More price stability can be gained when the timber volume offered is price responsive (Waggener, 1969) and recent all-time-high lumber prices have been aggravated by Forest Service volume-oriented policies (Craig and Keane, 1977). Efficiency considerations in management are required by the 1974 Resource Planning Act, as amended by the National Forest Management Act of 1976. Efficient National Forest management is also a concern of the current Presidential Administration (MacCleery, 1982). One question then is: Does an adequate economic model exist?

The Conceptual Efficiency Model

Samuelson (1976) has pointed out that such noted economists as Fisher (1930), Hotelling (1925), and Boulding (1935) tried--and failed--to specify the economic model which correctly predicts "when a tree should be cut." This, despite the fact that Martin Faustmann had in 1849 formed an "essentially correct solution."

Faustmann's (1849) solution was to maximize the present discounted value of net cash receipts, excluding explicit and implicit land rents, calculated over an infinite number of rotations. Samuelson demonstrates that an equivalent formulation maximizes the present discounted value of net receipts for the first rotation only, but with land rent included as a receipt.

More recently, other models have been advanced which build on Faustmann's model. Walker (1971) has proposed the Economic Harvest Optimization Model (ECHO), which generates the timber harvest schedule maximizing the present value of future timber sale income. Berck (1979) has formulated an economic model in which stumpage price is determined endogenously, rather than exogenously as in most models. For the purposes of this analysis, Hyde's (1980) discussion of the economic efficiency model is most useful. After reviewing his presentation of the conceptual model, we will briefly summarize his results with the applied model.

In his Timber Supply, Land Allocation and Economic Efficiency (1980), William Hyde builds on the Faustmann capital theory model. He first presents the conceptual model defining efficient timber production for the competitive firm with a fixed land base. Variable inputs are time, i.e., the length of the production process, and silvicultural effort. At this stage, the conceptual model assumes a homogeneous land base with constant returns to scale for the fixed factor. The conceptual model can be stated as

$$V = \max_{T,E} \left[(p-x)\ Q\ (T,E)\ e^{-rt} - wE\right](1 - e^{-rt})^{-1}$$

Where:

V = present value
T = time; the production period, or rotation age in years
E = silvicultural effort, or all factors of production other than time and land
Q = volume of wood fiber, or harvest volume
p = stumpage value
x = access and logging, or extraction, costs
r = the discount rate
w = the cost of a unit of silvicultural effort

and $(1 - e^{-rt})^{-1}$ transforms all to an infinite series. This is recognizable as the Faustmann formula, and rV is equal to soil expectation value. Hyde uses the conceptual model to demonstrate that

1. If the optimal rotation age T* is held constant, then maximum economic returns occur at the level of silvicultural effort E* where total revenues are in the greatest excess of factor costs, i.e., where decreasing marginal revenue product equals the unit factor cost.

2. If the optimal silvicultural effort E* is held constant, the optimal rotation age T* occurs where the declining marginal revenue product equals the increasing opportunity cost of delaying harvest.

3. When E* and T* are defined, the economically optimum harvest volume Q* is also defined.

To summarize, efficient landowners seek to maximize the present value of timber production rather than maximize timber volume. Optimal timber volume is produced from the combination of inputs and timing which maximizes present value. That combination is found where the cost of the last unit of silvicultural effort equals the value of additional product, and harvest is delayed until that moment when the gains from additional delay are exactly offset by the net additional cost of delay.

Application of the Conceptual Model

Hyde goes on to apply his analytical model in two case studies. The results of his analysis are discussed here for two reasons. First, the results provide some insight into the changes in timber management which result from applying a value-maximizing vs. a volume-maximizing strategy. How do rotation lengths differ? Are fewer acres devoted to timber management? Does silvicultural intensity increase or decrease? Second, Hyde points out the opportunity cost associated with certain public timber management policies. His analysis provides an appropriate background for understanding the implications of this research.

The first case study is a general case for the Douglas-fir region of the Pacific Northwest. Short- and long-run timber supply is an important policy issue in the region. Hyde produces long-run supply projections based on best management practices current in 1975. His factor costs and timber yields vary for six site classes (I+ to V), five levels of silvicultural effort (sequentially more intensive effort from volunteer stands through planting, thinning, fertilizing and using genetically improved seedlings), and three ownership classes (public, industrial and nonindustrial private).

By looking at a vector of expected timber prices, Hyde produces a series of points which together define the annual timber supply for a given site, silvicultural process and ownership. By repeating the process for all five levels of silvicultural effort (for a given site and ownership) and choosing the option with the greatest present value at each price, he produces a long-run supply curve for that site class. To obtain aggregate regional supply he multiplies the annual harvest level at each price times the number of acres in that site class, repeats the process for all site classes and adds them to produce the supply schedule for each ownership. Finally, he accumlates across all ownerships to obtain the regional supply schedule.

Hyde's results from examining the long-run regional supply schedule support his basic production and supply formulations. Some site class, ownership and silvicultural combinations become profitable at very low timber prices. As prices rise, the level of silvicultural intensity and number of profitable timber-producing acres increase. As land quality decreases, the optimal level of silvicultural intensity decreases also. Hyde concludes that it "may be good practice to intensify management on good sites long before poorer sites receive even minimal attention."

Hyde also found that there is a direct relationship between road and logging system access costs and the optimal rotation age, i.e., as the cost of access increases, it becomes profitable to delay harvest longer. An inverse relationship exists between access cost and silvicultural effort. As the cost of access increases, the net value of stumpage can cover only low to moderate silvicultural treatment costs. An important additional conclusion is that access cost can be a particularly important variable on public lands. Since public lands in the West tend to be less accessible than private lands, the optimal level of silvicultural effort on public lands would generally be lower than on private land of the same site class.

Similar conclusions were reached by this author's analysis of the Idaho Panhandle National Forests' management alternatives. Those results will be discussed in Chapter 5.

Completing his analysis of the Douglas-fir region case study, Hyde identifies the average annual harvest in the region as 24-26 million cunits (2.4-2.6 billion cubic feet). Assuming a $140 per cunit price plus his real rate of price increase, Hyde estimates the potential annual long-run harvest is 42 million cunits. The greater potential harvest levels are a function of an assumed increased biomass utilization and widespread conversion from volunteer stands to more

intensive management. In essence, the increase is due to changes in technology and a shift from volume maximization to efficiency maximization, including the more rapid harvest of the region's old growth stands.[4]

Hyde further demonstrates that even if multiple-use considerations preclude all but the least intensive timber management on public land, regional long-run annual harvest could exceed 36 million cunits, a 44 percent increase from the present. This supports his contention that substantial gains in both volume and value are possible by moving to efficiency criteria.

Hyde's second case study is the French Pete Creek drainage on the Williamette National Forest. The drainage is composed of about 19,200 acres, of which 18,600 acres are roadless. The area contains about 700 million board feet of standing timber, most of which is mature timber 100-400 years old. The area also offers unique recreational opportunities and has been considered for backcountry recreation or wilderness designation. Hyde examines the effect of three public timber management constraints--even flow, sustained yield and harvest at culmination of mean annual increment--on the value of standing timber and the value of long-term timber management. His purpose is to draw conclusions about the necessary value of the recreation opportunity in order to justify preemption of timber for recreational use on efficiency grounds.

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[4]The projected harvest is not an expectation of what will actually occur. Instead, the available supply would reduce the market clearing price, or some producers would not find it profitable to adopt efficient production technology. Klemperer (1976) reminds us that strict adherence to the economic model where there are excessive reserves of old-growth could lead to short- and long-run economic, social and environmental dislocations. Those costs would have to be weighed against gains from faster liquidation.

The unconstrained net value of existing timber in the French Pete drainage is estimated at $116-147 million, assuming a 10 percent discount rate and immediate harvest over a period of five years. This is the equivalent of an annual rent of $11.6 to $14.7 million in perpetuity. For French Pete's 18,600 acres, this amounts to a present value of up to $7903 per acre and an equivalent annual rent of $623-790 per acre. This value does not include a cost for reforestation. Since the benefits derived from a regenerated stand would not cover the costs of establishment, present value is maximized by "mining" the timber, i.e., harvesting the existing stand without providing for regeneration.

As Hyde points out, the 1976 National Forest Management Act limits the harvest of standing inventory "for the ostensible purpose of guaranteeing long-term timber supply and ensuring the economic stability of local communities dependent on public timber harvest flows." As applied by the Forest Service, the law emerges as the policy of nondeclining even flow, wherein average annual harvest must be stable or increasing in perpetuity. When applied to French Pete, the policy extends the liquidation period for existing stands to 241 years. Holding the timber for that time reduces the net value to less than zero: -$9.4 million. In effect, the even flow policy absorbs the entire efficiency-derived value of the existing timber.[6] The land would be more efficiently allocated to nontimber uses such as recreation.

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[6]Berck (1979) had somewhat similar results from the application of his model to the Douglas-fir region. Opportunity losses from holding old-growth timber an extra 50 years averaged $6000 per acre, or 45 percent of the total timber value.

Hyde's conclusion is that social welfare might be better served by altering the even-flow policy and harvesting according to efficiency criteria. Exploring this option, two other constraints are considered. First, the option for timber mining is withdrawn. Second, a harvest timing constraint is added.

Timber mining is prohibited by the 1976 National Forest Management Act and violates the intent of the original forest reservation system.[7] Harvest on national forest lands is allowable only when adequate regeneration can be assured. Hyde considers three management alternatives consistent with that philosophy--custodial management, statutory wilderness management and permanent, sustainable timber management. Timber management is justified where net timber values are positive and in excess of other (in this case wilderness recreation) values. His conclusion is that timber management might be justified on 15,146 acres in the drainage. At a market price of $150 per cunit, present value of timber management on regenerated stands is $877,600. The equivalent annual rent at 10 percent is $87,760, or $5.79 per acre per year.[8]

Hyde then analyzes the impact of constraining timber harvest rotations to minimums of 80 and 100 years. Eighty years approximates the volume maximizing age; one hundred years is a more common rotation

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[7]The Organic Administration Act of 1897 (30 Stat. 34, 35, 36) provided for the creation of National Forests and empowered the Secretary of Agriculture to make such rules and regulations as necessary to "preserve the forest thereon from destruction . . ."

[8]The change in present value from the $116-147 million of the existing stand to less than $1 million for perpetual management is not all attributable to the permanent timber management constraint. The value of the existing stand was estimated with regional average costs. The perpetual management option used locally specific costs, which in most cases greatly exceeded the regional average.

for Forest Service managed Douglas-fir. Results indicate that the present value of timber management in French Pete is negative for rotations one hundred years or longer. Under eighty year rotations, 15,146 acres could be managed for a present value of $26,236. The additional opportunity cost of applying the 80 year rotation constraint to the permanent timber management solution is $851,364. Hyde concludes that, with current recreation use at 2000-3000 visits per year and a 2 percent annual growth rate in use, the net recreation value of custodial or wilderness management exceeds the constrained timber value.

Hyde's empirical results from application of the conceptual efficiency model support several conclusions which are relevant to this research. In summary:

1. As prices rise, the level of silvicultural intensity and number of profitable timber-producing acres increases.

2. As land quality decreases, the optimal level of silvicultural intensity decreases.

3. High access costs extend the optimal rotation age and reduce the optimal level of silvicultural effort.

4. Three public timber management constraints--even flow, sustained yield and harvest at culmination of mean annual increment--can significantly reduce or eliminate the positive present net value of timber management, even on productive sites.

In his final remarks concerning the French Pete case study, Hyde states that he finds "no intuitive reason why unspecified community impacts should alter conclusions about allocation of forestland within French Pete." The remainder of this research focuses on another case study--the Idaho Panhandle National Forests. An attempt is made to ascertain whether certain specified community impacts--on employment and income--fare better under volume maximizing or efficiency maximizing management strategies. The harvest schedule under each strategy is developed using the FORPLAN linear programming model.

CHAPTER IV

THE IDAHO PANHANDLE NATIONAL FOREST EFFICIENCY MODEL

Understanding the IPNF formulation of the efficiency model requires an understanding of the computer model used in forest planning. In this section we will look first at the general computer model, then at how it was structured to form the efficiency model. The IPNF uses the linear programming model FORPLAN (Johnson, et al.,1980) to estimate the results of following various management strategies. The objective function may be specified in a number of ways, including maximize present net value, minimize cost or maximize (minimize) some output such as timber, water yield or big game habitat. Right hand side values may be specified for all outputs; constraints may be applied to restrict certain activities and areas, such as the number of acres receiving regeneration harvest in a given period; constraints may be applied to restrict harvest to nondeclining even flow; a sustained yield link is available to assure sustained yield beyond the planning horizon. The FORPLAN model may be run with as few or as many constraints on the solution as desired. Like Hyde's efficiency model, the FORPLAN model may include secular price increases, price variations by diameter, multiple harvests, silvicultural effort subsequent to planting and distinction among site classes.

The FORPLAN Model

The FORPLAN data base consists of management prescriptions of varied emphasis and intensity, analysis areas, economics tables, and yield tables. Each management prescription is a combination of management activities which achieves a desired result on the ground. Analysis areas are homogeneous land areas to which management prescriptions may be applied. Yield tables associated with each output (timber, wildlife, etc.) indicate the results of applying a given prescription to a given analysis area. Economics tables reflect associated costs and benefits.

Management Prescriptions

The IPNF model includes 30 basic prescriptions. For our purposes they fall into four general categories, all of which represent some degree of multiple use.

Timber prescriptions emphasize timber management. Such activities as recreation trail maintenance and transitory grazing are permitted, but do not affect timber volumes or harvest scheduling. For this analysis, the cost of these nontimber activities has been removed from the calculation of present net value.

Compromise prescriptions include some sacrifice of timber, wildlife, visual quality and/or recreation potential. Certain visual/timber prescriptions, for example, require wide road spacings which increase logging costs. In general, the compromise prescriptions are less efficient timber producers than the timber prescriptions.

Nontimber prescriptions do not allow any programmed timber harvest. They include wilderness management; certain administrative, recreation and cultural site management; permanent range; and research forests. They apply to specific areas and are held fixed in the solution.

The maintenance prescription is a special case of the nontimber group. This custodial management prescription applies wherever the marginal costs of management exceed marginal benefits, unless the area is needed to meet right hand side targets for some output.

Management intensity is a function of the management prescription. For timber prescriptions, intensity varies by the number of commercial thinnings permitted (zero to three), the occurance of precommercial thinning, the silvicultural system (clearcut, shelterwood, group selection), and the percentage of the harvested area planted.

Analysis Areas

The IPNF model includes 493 analysis areas. Analysis areas are homogeneous, but not necessarily contiguous, land areas. The unit of measure is acres. Homogeneity is defined by six criteria:

Level 1	Kaniksu, Coeur d'Alene or St. Joe National Forests.
Level 2	Roaded or roadless; RARE II Further Planning Areas; or areas set aside for specific purposes (for example administrative areas and designated Wilderness).
Level 3	Big game winter range; nonwinter range; or riparian areas.
Working Group	Habitat-type groups Cedar/Hemlock/Pachistima; Grand Fir/Pachistima; Alpine Fir/Pachistima; All Other suitable timber types; or Unsuitable timber.
Land Class	Combinations of slope class ($<$ 40% or $>$ 40%) and soil sensitivity (sensitive or nonsensitive).
Condition Class	The condition class represents the average age of the existing stand, or in some cases expresses the average age for trees of a given diameter. Timber age class

divisions include mature sawtimber in need of rehabilitation (age 150 yrs.), mature sawtimber (100 yrs.), immature sawtimber (80 yrs.), poletimber (50 yrs.), stagnated stands (40 yrs.), seedling-saplings (20 yrs.), riparian zones (mixed age), and nonstocked suitable timber land. Noncommercial forest land, unsuitable forest land and nonforest are not available for timber management.

The combination of 30 basic prescriptions and 493 analysis areas yields a total of about 3000 prescriptions to be considered in a FORPLAN solution. Some combinations, such as intensive timber management on unsuitable forest, are not included.

Economics Tables

The economic tables (Hall, 1982a; 1982b) contain the timber costs and benefits associated with each prescription.[9]

Road costs vary from zero to over $900 per acre. They are relatively site specific and depend on the average existing road density of the analysis area, the desired road density for the prescription and the average slope and soil sensitivity of the analysis area. Linear (local) road costs are incurred when the first harvest entry occurs. Nonlinear (arterial and collector) road costs are not a linear function of the number of acres harvested. Substantial costs are incurred as soon as a new area is entered. In order to allocate costs to all acres which eventually benefit from the road, nonlinear road costs are charged against all mature, immature and poletimber stands in the first and second decades and against seedling-sapling stands in the third and fourth decades, regardless of initial entry period.

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[9]In the IPNF model formulaton, nontimber benefits appear in rows and columns appended to the FORPLAN matrix. Nontimber costs are included as an output category and appear on separate yield tables. Neither is

Site preparation costs range from \$147 to \$553 per acre. Methods and costs vary by silvicultural system and land class, and by the requirements of the prescription. The timber prescriptions are generally less expensive than the compromise prescriptions.

Reforestation costs vary by prescription intensity and silvicultural system, from \$40 to \$80 per acre. Site preparation and planting costs for nonstocked lands vary from \$251 per acre on the Kaniksu and Coeur d' Alene to \$642 per acre on the predominantly south slope St. Joe brushfields.

Precommercial thinning for \$136 per acre applies in some prescriptions.

Sale administration and sale preparation combined average \$197 per acre on final harvests; slightly higher for intermediate entries.

All other timber management costs are included in an overhead category and allocated to all forest acres.

Stumpage values appear as dollars per thousand cubic feet (mcf) and vary by habitat type, diameter class and logging system mix, where logging system mix is a function of analysis area land class and the road density required by the prescription. The stumpage value equation is a regression equation based on a procedure suggested by Jackson and McQuillan (1979) and developed for the IPNF by Merzenich (n.d.). It has the form:

$$Y = -287.43 + 0.7743x_1 - 0.5153x_2 - 0.7873x_3 + 80.55x_4$$

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included in the calculation of present value for this analysis, although they are normally part of the FORPLAN objective function.

Where: Y = high bid value
x_1 = weighted average lumber price, lumber tally
x_2 = percent of volume jammer logged
x_3 = percent of volume skyline logged
x_4 = the sum of the natural log of each dbh class times the total net sale volume in each class.

Stumpage values are further refined to reflect predicted real price increases to the year 2030 (Adams and Haynes, 1979). Separate real price trends are applied to timber prices (lumber price, lumber tally) and production costs (all logging and milling costs plus a margin for profit), and an adjustment is made for changes in overrun. The resulting stumpage value change is dependent on the site specific factors affecting the initial lumber price and production cost (Merzenich, n.d.).

Yield Tables

Yield tables provide the link between management prescriptions and outputs. For this analysis, only the timber yield tables are relevant. Timber yields used in the IPNF model are based on projections of Stage's growth prognosis model (Stage, 1973). Projections of average diameter and volume are made by decade for both intermediate and final entries. Yields vary by habitat type and silvicultural system, and are generally higher for regenerated stands than for existing unmanaged stands.

Formulation of the Efficiency Model

The starting point for this analysis is the management alternative which maximizes the economic efficiency of timber management. Like Hyde's efficiency model, it assumes the manager's objective is to maximize the present value of timber production, given variable inputs of land, silvicultural effort and time. The FORPLAN objective function is to maximize present net value; that is, to maximize the excess of discounted benefits over discounted costs. Of the management alternatives evaluated by the IPNF, this one most closely approximates the efficient solution, relatively unconstrained by nontimber considerations and national timber management policies. For the most part, the model is consistent with Hyde's efficiency model, although a few differences exist. Restrictions on the model which cause deviations from the true efficiency model will be noted in this section.

The model uses the 4 percent real discount rate called for by the Forest Service Manual (FSM 1970), whereas Hyde's analysis used 10 percent. The four percent rate approximates the real rate of return on new private capital investment for recent years (USDA, n.d.), and therefore represents the opportunity cost of diverting resources from private use.

The planning horizon is 130 years, or 13 ten year periods. A sustained yield link and ending inventory constraint require sufficient inventory in the 13th period to support sustained yield beyond the planning horizon. The 130 year planning period captures over 98 percent of the present value of timber management and its use should not substantially affect the results. Berck (1979) has used a similar planning horizon in the application of his model.

No right hand side targets are set for any output. No management restrictions are in effect beyond those provided in the standards and guidelines for each prescription. A degree of risk is accepted that all requirements of the NFMA regulations (Fed. Reg., 1979) might not be met. Specifically, water quality might deteriorate in some watersheds, caribou[10] could be adversely affected, and certain old-growth dependent wildlife species might fall below minimum viable populations.

Harvest at or following culmination of mean annual increment (CMAI) is not built-in to this alternative. Although the model is not free to schedule a stand for final harvest in all periods, the range of choice is greater than under other alternatives. Existing stands may be harvested as early as age 60 in most cases. Regenerated stands may not be harvested until age 90. Few of the existing stands were actually scheduled for harvest in their first period of eligibility, but almost all the regenerated stands were harvested at age 90. This suggests that the financial rotation is shorter than 90 years. Present net value of the prescriptions might therefore be underestimated. The underestimation should not be serious. Christopherson and others (1978) have determined optimal rotation ages for various regenerated stands in Idaho. At a five percent real discount rate, many stands maximized Soil Expectation Value (SEV) at over 100 years. Optimal rotations are not as short as the 50-60 year rotations found in the Douglas-fir region.

Long-term timber management is built-in to all prescriptions which harvest timber. The present net value of each prescription is the sum of PNVs for both existing and regenerated stands. Regenerated stands with a negative PNV might therefore be managed for timber production if the value of the existing stand is sufficient to offset the loss. The policy meets the requirements of the 1960 Multiple-Use Sustained-Yield Act and the 1976 NFMA, but violates the assumption that investments

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[10]Caribou are listed by the State of Idaho as a sensitive species. USFS policy is to treat State-designated sensitive species the same as Threatened and Endangered species.

should be undertaken only when marginal benefits exceed marginal costs (Hyde, 1980; O'Toole, 1979). Present net value of each alternative would be higher without this requirement.

As noted earlier, some nontimber prescriptions are fixed in the solution. Designated Research Natural Areas, for example, are not available for timber management. Present net value of each alternative would be slightly higher without this restriction.

All prescriptions included in FORPLAN are multiple-use prescriptions. They include some nontimber costs and benefits. For this analysis, the nontimber costs and benefits have been eliminated from the calculation of present net value. They did, however, affect the original land allocation under each alternative. Any allocation shifts due to nontimber costs and benefits appear to be minor. In most cases where the timber prescription has a positive PNV for timber management alone, it exceeds the PNV of the best timber/nontimber compromise, with or without nontimber costs and benefits included.

The model assumes a horizontal demand curve for timber. The assumption of total price elasticity of demand has been questioned and procedures for developing Forest-specific downward sloping demand curves have been suggested (Connaughton, n.d.; Jackson, 1980a; Walker, 1971). Because the IPNF appears to be operating on the elastic portion of its demand curve (USDA Forest Service, 1982c), and because none of the suggested alternatives can boast a greater degree of statistical reliability, the horizontal demand curve was accepted. This is a comfortable assumption for all harvest levels not far outside the range of current harvest; it becomes less so as harvest levels increase (decrease) dramatically. Effect on present net value is indeterminate, but probably tends to overstate PNV.

Two timber flow constraints were used for this alternative. They are less restrictive than nondeclining even flow, but more confining than applying no restriction. First, a harvest floor at 80 percent of the 1975-1980 average annual sale volume[11] is assumed for all periods. This floor did not constrain the final solution. Second, harvest volume scheduled in each decade must equal between 75 percent and 125 percent of the previous decade's harvest. This allows sequential increases or decreases in harvest volume, but eliminates drastic fluctuations.[12] The effect is to smooth out the harvest somewhat, but also to reduce PNV. The final solution was limited by this constraint in eight of the thirteen periods.

To summarize, the IPNF formulation of the efficiency model has several built-in features which differ from Hyde's model. The discount rate is lower and the planning horizon is shorter than infinity. The allowable age of final harvest probably exceeds financial rotation age in some regenerated stands. Timber mining is prohibited, even though some regenerated stands have a negative present net value. Nontimber benefits and costs may have slightly affected the land allocation. The

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[11]Chargeable offered sale volume is the regulated volume offered for sale, but not necessarily sold. Regulated volume excludes such items as salvage sales, which are also excluded from the FORPLAN model.

[12]An earlier FORPLAN run was made which lacked this restriction. Average annual harvest volume was 97 mmbf in the second decade, 463 mmbf in the third decade and 1853 mmbf in the fourth. While theoretically maximizing PNV, this program does not appear to be implementable. Fluctuations from forty percent of current harvest (245 mmbf) to seven times current harvest strain basic linear programming assumptions, because management costs per unit of output would change. Such fluctuations also raise questions about the assumption of a horizontal demand curve.

model assumes a horizontal demand curve, and a ±25 percent harvest flow constraint was added. The net effect of these features is to produce a lower present net value than an unrestricted efficiency model. If the IPNF model underestimates the true maximum present net value, differences between the true maximum and the other alternative present values will also be understated.

CHAPTER V

ALTERNATIVES TO THE EFFICIENCY MODEL

The Idaho Panhandle National Forest has considered several management alternatives during the forest planning process. Three of those alternatives will be discussed in this chapter. Comparisons will be made between these alternatives and the efficiency model. They differ in their assumptions and constraints, and in their land allocation results.

Alternatives to the Efficiency Model

From among the thirteen management alternatives considered by the IPNF, three were chosen for this analysis. The efficiency model outlined in Chapter 4 will be referred to as Alternative 1. The others are Alternatives 2, 3 and 4. The assumptions and constraints applied to each alternative (USDA, 1982a) are summarized in Table 1.

Alternative 2

This "high market" alternative emphasizes the production of market goods; i.e., timber and range. Because the IPNF already provides surplus range, this is essentially a timber emphasis alternative. A timber harvest target was set at 400 million board feet per year for the first decade, with nondeclining even flow thereafter. Harvest must be at or following culmination of mean annual increment. An ending inventory constraint ensures that the standing volume at the end of the 130

TABLE 1

CONSTRAINTS AND ASSUMPTIONS BY ALTERNATIVE

Assumption/Constraint	Alternative 1	2	3	4	Notes
Objective Function					
Maximize PNV for 13 periods	X	X	X	X	
Timber Constraints					
Harvest constraint					
Nondeclining even flow		X	X	X	
±25% of previous decade	X				Reduces present net value substantially below a completely unconstrained solution.
Ending inventory constraint	X	X	X	X	
Harvest at CMAI		X	X	X	
40 Acre clearcut			X	X	
First decade harvest restriction					
400 mmbf/yr		X	X		
250 mmbf/yr				X	
Land allocation predetermined				X	
Nontimber Constraints					
Caribou habitat management		X	X	X	Reduces present net value below the optimal "timber only" solution.
Elk population target		X	X		No effect on present net value.
Long Canyon to maintenance				X	Reduces present net value below the optimal "timber only" solution.

year planning horizon equals or exceeds the volume that would occur in a regulated forest. Two nontimber constraints were also added. Approximately 89,000 acres were designated as caribou habitat. Timber harvest is allowed in these areas, but restrictions on volumes removed lower the present net value of timber management. The present net value of the alternative is therefore lower than it would be in the absence of the caribou restriction. A second constraint in the FORPLAN model concerned elk production. Minimums were set for elk populations on two of the three designated Forests. These targets became nonbinding in solution; i.e., they were achieved with no reduction in present net value of the alternative.

Alternative 3

This second version of the "high market" emphasis is nearly identical to Alternative 2. It has one additional constraint which simulates the effect of Region 1's 40 acre clearcut policy. Because clearcuts are limited in size and harvested areas need a chance to become reestablished before adjacent areas are harvested, analysis areas exceeding 40 acres cannot be scheduled for harvest in a single decade. Harvest of roadless areas, assumed to have no existing harvest openings, is restricted to 50 percent in each of the first two decades. Roaded areas are assumed to have some harvest openings already. New harvests are limited to one-third harvest in each of the first three periods. The purpose of the restriction is to control the proximity of clearcuts, allowing each unit 10 years to recover before the next is entered.

Alternative 4

This is the Current Management alternative. Although the objective function is to maximize present net value over the 130 year planning horizon, the objective function affects only scheduling, not land allocation. All areas are preallocated to the management prescription which most closely resembles the management required by existing unit plans. FORPLAN's only option is to select the timber harvest schedule which maximizes present net value.

Like Alternatives 2 and 3, Alternative 4 has nondeclining even flow and ending inventory constraints. Harvest is at culmination of mean annual increment or beyond. Caribou areas are designated and the 40 acre clearcut restriction is in effect. An additional restriction concerns Long Canyon, the IPNF's only RARE II Further Planning area. Long Canyon is allocated to the maintenance prescription in this alternative to indicate its deferred decision status. The first decade timber target is 250 million board feet per year.

Some of the restrictions placed on the alternatives cloud the comparisons slightly. The ± 25 percent flow constraint on Alternative 1 leads to underestimation of the maximum present net value. Addition of nontimber constraints for caribou management in Alternatives 2, 3, and 4 and for Long Canyon in Alternative 4 also lead to underestimates of present net value. A detailed analysis of the effects suggests that the underestimate is greatest for Alternative 1 (USDA, 1982a). We can therefore assume that the true differences between the present net values of the alternatives is at least as great as that reported in this analysis.

Comparison of Alternatives

Present Net Value

As the alternatives diverge from the efficiency model, present net value falls. Table 2 compares the present net value of each alternative. This analysis is primarily concerned with the efficiency of the timber management program for the first fifty years of the planning horizon. It is apparent, however, that the relative ranking of the alternatives remains the same for the 130 year planning period. It also remains the same when the nontimber costs and benefits of multiple use are included.

The highest present net value for the first five decades is \$1163 million for Alternative 1. Equivalent annual value is \$54.1 million.[13] The constraints on Alternative 2 reduce present value to \$1088 million, for an equivalent annual opportunity cost of \$3.5 million. Alternative 3 sacrifices an additional \$3.2 million per year. Current management

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[13]The equivalent annual value is the annuity which has the same present net value as the actual income stream of the alternative. The annuity formula is:

$$a = V_0 \frac{[i\ (1 + i)^n]}{(1 + i)^n - 1}$$

Where
a = the amount of a terminating annuity
V_0 = present value of the annual income
i = the discount rate
n = number of periods

This form of the annuity formula is known as an installment payment annuity (Haney and Gunter, n.d.). For the 130 year planning period, the installment payment annuity formula calculates an annual equivalent very close to that found using the perpetual annuity formula:

$$A = V_0 i$$

TABLE 2

COMPARISON OF ALTERNATIVES

	Alternative 1	2	3	4
Present Net Value (MM$--4%)				
Timber Program for 13 Decades	1685	1590	1516	1379
Equivalent Annual Value for 130 years	67.8	64.0	61.0	55.5
Timber Program for 5 Decades	1163	1088	1018	879
Equivalent Annual Value for 50 years	54.1	50.6	47.4	40.9
Multiple Use for 13 Decades	1691	1565	1517	1377
Timber Volume (MMBF/Year)				
Decades 1-13	551	568	570	556
Decades 1-5	556	522	520	483
Land Allocation (M acres)				
Timber Prescriptions	1427	1504	1548	1465
Compromise Prescriptions	285	219	131	335
Timber Total	1712	1723	1679	1800
Nontimber Prescriptions	215	475	346	316
Maintenance	552	281	453	363
Nontimber Total	767	756	799	679
Selected Factors Which Affect Costs				
Harvest on 40% + Slopes (M acres)				
Decade 1	1	15	98	36
Decade 2	168	207	110	104
Decades 3-5	638	535	576	606
Total	807	757	784	745
Commercial Thinning (M acres)				
Decades 1 and 2	-	0.2	1.6	0.9
Decades 3-5	1.2	13.2	17.9	10.4
Nonstocked Acres Stocked (M acres)				
Decade 1	44	51	51	58
Decades 2 and 3	-	12	6	65
Road Cost per mbf (Undiscounted $/mbf)				
Decades 1 and 2	38.06	38.49	39.53	42.60
Decades 3-5	20.18	20.29	20.83	21.64
Percent of Road Costs for 5 Decades				
Decade 1	19	24	25	20
Decade 2	20	23	20	19
Decades 3-5	61	53	55	61

further reduces present value to about 76 percent of the value of Alternative 1.[14]

Timber Volume

The alternatives retain the same ranking when timber harvest volumes for the first fifty years are compared. Alternative 1 averages 556 mmbf per year, followed by Alternative 2 (522 mmbf), Alternative 3 (520 mmbf), and Alternative 4 (483 mmbf). Over the 130 year planning horizon, Alternative 1 drops to last place, reflecting a general emphasis on harvest in the first fifty years rather than over the long term. All four alternatives are substantially above the 245 million board feet sold in 1980.

Average annual timber harvest levels for all thirteen decades are shown in Figure 1. Alternative 1, due to the ±25 percent flow constraint, gradually rises, falls, then rises again. Maximum volume is produced in the fifth decade. Alternatives 2, 3, and 4 display a different pattern. Each reaches its maximum substainable volume in the third or fourth decade and remains there. Due to their high timber

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[14]Hyde's case study of the Douglas-fir region, discussed in Chapter 3, indicated that the addition of nondeclining even flow, harvest at culmination of mean annual increment, and long term timber management constraints reduced the present value of timber management to less than zero. On the IPNF, the 24 percent difference in present value between the maximum and current management might seem surprising. The difference occurs for two reasons. First, much of the difference between an unconstrained maximum present net value and nondeclining even flow also applies to the ±25 percent flow constraint. A separate analysis (USDA, 1982a) estimates the total difference between the two constraints is only about $13 million in present net value. Secondly, the National Forests in the Douglas-fir region are old-growth surplus forests. The difference between optimum financial rotations and nondeclining even flow rotations could be 100-200 years, or even more. The IPNF does not have surplus old-growth. The difference between rotations for mature timber with and without nondeclining even flow is about 20-50 years. Much of the present value is therefore retained.

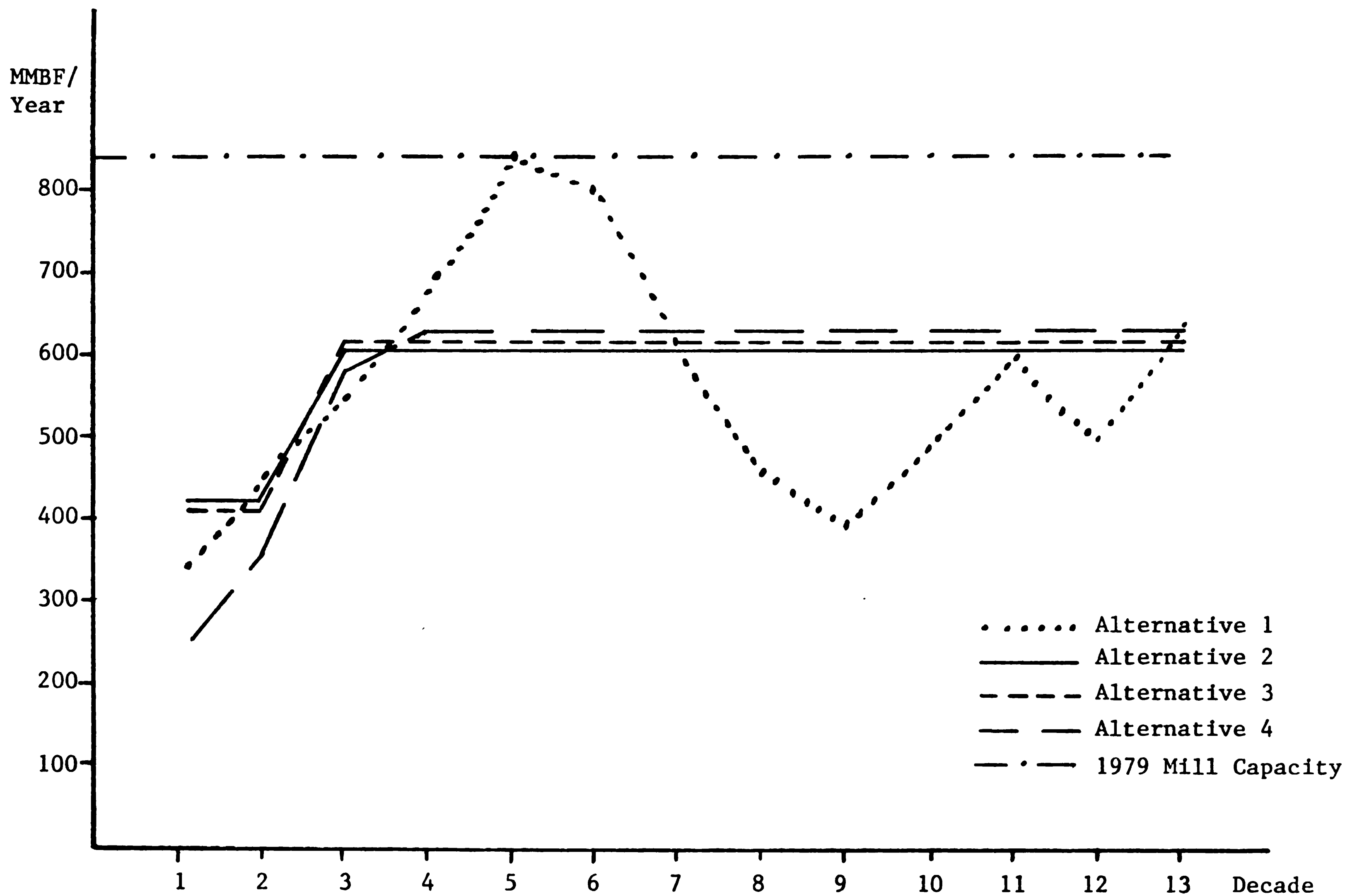

Figure 1. Average Annual Timber Harvest by Alternative

target, Alternatives 2 and 3 produce more timber than Alternative 1 in the first and third periods. That will prove to be important to the local economy, which will be discussed in Chapter 7.

Land Allocation

Alternative 1 allocates the fewest acres to timber prescriptions, appearing to support Hyde's contention that maximizing present net value would concentrate harvest on fewer acres (Hyde, 1980). Alternative 1 also allocates the least land to intensive management, opting instead for extensive management. Because of the allocation of timber/nontimber compromise prescriptions Alternative 3 has the fewest acres under any form of timber management.[15]

Factors Affecting Costs

Movement away from the efficiency model causes costs to rise for several reasons. Among those discussed here are harvesting on steep slopes, commercial thinning, stocking existing nonstocked stands and accessing remote sites.

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[15]The probable reason for this ambiguous result lies in the shelterwood patterns for various prescriptions. The extensive timber management prescription (T3) can be implemented with either a clearcut or shelterwood silvicultural system. Another prescription, one emphasizing both timber and visual quality (V3), is very similar to T3. Their shelterwood patterns differ, however. T3 harvests the overstory two decades following the regeneration harvest; V3 delays until the third. This subtle difference gives FORPLAN added scheduling flexibility. With the ±25 percent flow constraint in effect on Alternative 1, the V3 prescription can sometimes provide additional volume in a period where there is some slack in the constraint rather than in a period where the constraint is already binding. The effect on present net value is not great--often just a few dollars per acre. It does, however, confound the interpretation of land allocations.

Alternative 1 harvests only 1100 acres of greater than 40 percent slopes in the first decade, about one-tenth of 1 percent of its five decade total. Alternative 2 harvests 15,000 acres in the first period, about 2 percent of its total. Alternative 3 was forced into steeper areas sooner because of the 40 acre clearcut constraint. That restriction precludes concentration of a 411 million board foot harvest in the flatter areas. Alternative 4 fared better because of its comparatively low timber target. In the long run, more acres of steep land are harvested under Alternative 1 than any other alternative. Over 40 percent of the impact is delayed until the fifth decade when present value is maximized on those areas.[16]

None of the alternatives do much commercial thinning in the first five decades. Alternative 1 does almost none--1200 acres in the fourth decade. Alternatives 2 and 3 do the most commercial thinning, on 13,400 and 19,500 acres, respectively. Commercial thinning is undertaken to provide volume needed to maintain nondeclining even flow following the high first decade harvest. The lack of commercial thinning is consistent with the results found in a study of Idaho forests by Christopherson and others (1978). Only seven stands of the 117 existing timber stands they examined included commercial thinning as part of the

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[16]There is a definite pattern to the selection of mature stands for harvest under Alternative 1. Period 1 concentrates on stands of high value cedar-hemlock on slopes under 40 percent with low access costs. Period 2 includes more grand fir-alpine fir, higher average access costs and a mix of slopes. Period 3 goes to the lowest valued species on slopes under 40 percent with moderate access costs. Period 4 goes back to high valued cedar-hemlock, but with higher access costs and steeper terrain. The fifth period picks up the lower valued species with high access costs and steeper slopes.

optimal financial management regime. Of those seven, six received additional revenue from an overstory removal, so that only one stand benefited from commercial thinning alone.

The fewest acres are stocked under Alternative 1 and the most under Alternative 4. Alternative 1 immediately restocks those acres having a positive present value for timber management. The areas are exclusively on the Kaniksu and Coeur d'Alene National Forests. The other alternatives stock a few thousand more acres in all three periods to help maintain nondeclining even flow in later years. Alternative 4 stocks 63,100 acres in the third decade. Most of those acres are 70-80 year old brushfields on the St. Joe National Forest. Because of high stocking costs, their present value averages -$189 per acre. These backlog acres are still part of the timber base and therefore must be scheduled for restocking in the Current Management alternative.

In the first two decades, Alternatives 2 and 3 incur road costs about 9 percent higher than the present value maximizing Alternative 1, although the cost per thousand board feet is similar. Alternative 4 has lower absolute costs but higher costs per thousand board feet. The higher cost per thousand is not offset by higher timber values, thereby reducing present net value of current management. The distribution of road costs over the first five decades is also of interest. Alternatives 2 and 3 incur almost half their five period costs in the first two decades. More intensive roading is required to produce higher timber volumes earlier.

In conclusion, a number of observations can be made. Alternatives 2 and 3 sacrifice present net value because of a higher than optimal timber harvest target in the first decade. The higher harvest is bought with earlier road construction, more planting, more thinning and earlier entry on slopes greater than 40 percent. Alternative 4 sacrifices present net value for several reasons. Its first period timber target is lower than optimal, but the alternative would produce more if it could do so efficiently. All acres are preallocated to their current management direction, which is less efficient than what could be achieved. This is particularly true of the St. Joe brushfields, which would be better allocated to maintenance or perhaps elk summer range.

One other alternative was considered for analysis but was not available. The IPNF considered a working circle constraint which would constrain each designated Forest--Kaniksu, Coeur d'Alene, and St. Joe--to a ±20 percent flow constraint, in addition to nondeclining even flow for the IPNF as a whole. The purpose of the constraint would be to reduce harvest fluctuation from one end of the Forest to another. The constraint was finally dropped from consideration even though the harvest by designated Forest changed by as much as 100 percent from one decade to the next.[17] Were the constraint ever applied, it would lower the present value of the alternative. The result would be similar to the existing situation on other National Forests which have overlapping market areas but are administered separately.

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[17]Harvest fluctuations were not as serious when two Forests were combined, e.g. the Kaniksu/Coeur d'Alene and St. Joe/Coeur d'Alene. Since the Coeur d'Alene lies between the other two forests and their log markets overlap, the IPNF planning team chose not to constrain the solution further.

CHAPTER VI

THE ECONOMIC IMPACT AREA

This chapter first presents a profile of the primary impact area for the IPNF. Next, the relationship between the IPNF and the local timber industry is discussed.

Timber Dependency in the Impact Area

The IPNF economic impact area, shown in Figure 2, includes the five northernmost counties of the Idaho panhandle: Boundary, Bonner, Kootenai, Shoshone and Benewah. These five counties incorporate ninety-three percent of the IPNF land area. Virtually all IPNF full time employees and about half the seasonal employees live within the area. Ninety-three percent of the Forest's stumpage is delivered to mills in the area (Hall, 1980).

All five counties are more or less dependent on extractive industries. The 1979 employment figures presented in Table 3 are representative of recent non-recession year employment. The lumber and wood products, government, service and trade sectors are predominant. Kootenai County has the highest population and the highest growth rate. The population in 1980 was 58,759, a 66 percent increase over 1970. Kootenai County also has the most diverse economy. Coeur d'Alene serves as a service center for the area. The lumber and wood products, government, services and trade sectors each account for over ten percent of total employment.

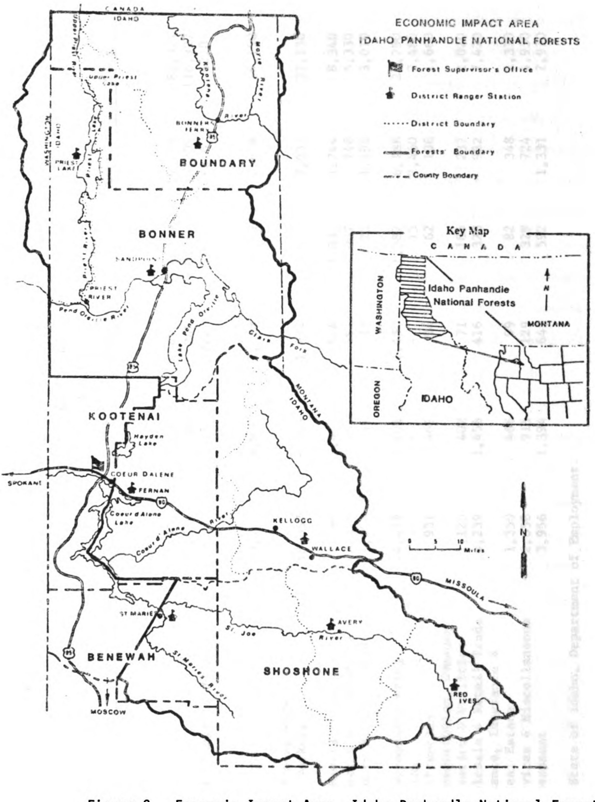

Figure 2. Economic Impact Area, Idaho Panhandle National Forests

TABLE 3

POPULATION AND EMPLOYMENT BY COUNTY,
IPNF ECONOMIC IMPACT AREA

	Kootenai	Bonner	Boundary	Benewah	Shoshone	Total
Population						
1970	35,332	15,560	5,484	6,230	19,718	82,324
1980	58,759	23,449	7,248	8,262	19,209	116,927
Percent Change 1970-80	66.3	50.7	32.2	32.6	-2.6	42.0
Total Employment (1979)	25,481	8,910	2,498	3,299	7,678	46,150
Total Non-ag Wage & Salary Workers	18,057	6,565	1,954	2,617	7,933	37,130
Total Manufacturing	3,598	1,462	504	1,030	1,744	8,340
Lumber & Wood Products	2,314	1,265	491	1,007	248	5,330
Primary Metals & Other	1,284	197	13	23	1,496	3,010
Total Nonmanufacturing	14,459	5,102	1,450	1,587	6,188	28,790
Mining	-	-	-	15	2,460	2,480
Construction	931	467	94	62	106	1,660
Transportation, Communication & Utilities	1,123	402	71	185	237	2,020
Wholesale & Retail Trade	4,239	1,456	416	323	982	7,420
Finance, Insurance & Real Estate	1,350	466	99	82	348	2,370
Services & Miscellaneous	2,858	915	129	329	724	4,930
Government	3,956	1,394	641	592	1,331	7,910

Source: State of Idaho, Department of Employment.

Bonner County is second in population and population growth. The 1980 population was 23,449, a 51 percent change from 1970. Greater concentration of employment in lumber and wood products (14 percent) limits diversity although over ten percent of employment is found in each of three other sectors: government (16 percent), trade (16 percent) and services (10 percent). Boundary County has 63 percent of its employment concentrated in three sectors: government (26 percent), lumber and wood products (20 percent) and trade (17 percent). Benewah County has the highest concentration of employment in the lumber and wood products sector: 31 percent. Some limited diversity is provided by the government (18 percent), trade (10 percent) and service (10 percent) sectors.

Shoshone County has only three percent of its employment in the lumber and wood products sector. Until recently, thirty-one percent of its employment was accounted for in the mining sector and about nineteen percent was in other manufacturing; smelting, in this case. The late-1981 closure of the Bunker Hill mine and smelter has directly eliminated about 2,100 jobs in Shoshone County. The indirect impacts are not yet known. It is likely that the mining and government sectors will now dominate the economy. The government sector includes Forest Service employees at the Wallace, Avery and Red Ives Ranger Districts.

Schuster, Hatch and Koss (1975) have reported other statistics which demonstrate the concentration of the forest products industry in northern Idaho. Tables 4 and 5 summarize their analysis for the IPNF impact area. Table 4 reports location quotients for ten forest products industries. The location quotient is a measure of relative industrial concentration. In this case it compares the concentration of

TABLE 4

LOCATION QUOTIENTS FOR THE FOREST PRODUCTS INDUSTRY, 1973

Industry Class	Benewah	Bonner	Boundary	Kootenai	Shoshone	Total
Timber Tracts	334.3	0.0	0.0	0.0	0.0	22.0
Forest Nurseries	0.0	0.0	0.0	3,302.8	0.0	1,453.5
Miscellaneous Forest Products	0.0	0.0	0.0	0.0	0.0	0.0
Forestry Services	0.0	345.5	0.0	671.4	0.0	345.5
Logging	15,159.1	4,406.9	5,637.5	1,955.3	1,489.9	3,301.4
Sawmills	3,840.3	7,092.2	7,836.5	4,607.2	926.7	4,158.2
Plywood and Veneer	5,441.6	76.1	105.6	1,063.8	0.0	845.4
Wood Containers	0.0	0.0	0.0	355.9	0.0	156.6
Miscellaneous Wood Products	1,147.4	2,783.7	2,168.9	121.3	295.9	796.1
Household Furniture	0.0	7.0	0.0	54.0	0.0	24.9

Source: Schuster, et al. (1975)

employment by sector in each county to the United States average for that sector. The equation for calculating the location quotient is

$$\frac{\text{\% of County Employment in Industry A}}{\text{\% of U. S. Employment in Industry A}} \times 100 = \text{Location Quotient.}$$

The location quotient for sawmills in Kootenai County, for example, is 4607.20. This indicates that sawmill employment is 4,607 percent, or 46 times, as concentrated in Kootenai County as the national average. A location quotient of 100.0 indicates that industry employment in the county is the same as the national average; one less than 100.0 means the industry is underrepresented in the local economy. The magnitude of the location quotient also indicates the degree to which an industry is regarded as a net importer or exporter. Local needs are assumed to be satisfied by an industrial representation equal to the national average. A location quotient greater than 100 therefore indicates a net exporter; less than 100, a net import industry.

Schuster, Hatch and Koss also discuss excess employment in the forest products industry. Excess employment is another measure of employment concentration in excess of the national average. It can be used to determine an industry's importance to the county's <u>pattern</u> of industrial concentration. The authors conclude that "if aggregate excess employment is a measure of overall regional specialization, then the ratio of excess in a specific industry to the aggregate not only reflects the degree to which that industry accounts for specialization but it is also a measure of regional dependency on that industry."

Their results are summarized in Table 5. The first column for each county represents the difference between the percentage occurence of employment by industry in the county and the national average

TABLE 5

EXCESS EMPLOYMENT AND PERCENT OF TOTAL EXCESS EMPLOYMENT
IN FOREST PRODUCES INDUSTRIES, 1973

County	Excess Employment Percent	Percent of Total Excess
Benewah		
Forest Industry Total	49.83	72.86
Total Area	68.39	100.00
Bonner		
Forest Industry Total	32.97	58.66
Total Area	56.20	100.00
Boundary		
Forest Industry Total	36.09	55.89
Total Area	64.57	100.00
Kootenai		
Forest Industry Total	20.68	43.05
Total Area	48.04	100.00
Shoshone		
Forest Industry Total	4.81	6.92
Total Area	69.52	100.00
Total		
Forest Industry Total	21.11	41.09
Total Area	51.36	100.00

Source: Schuster, et al. (1975).

percentage for that industry. Where the difference is positive, there is excess employment. The second column for each county indicates each industry's share of the total excess employment in the county. In Benewah County, for example, total excess employment is 68.39 percent and the forest industry accounts for 72.86 percent of that total. Of the five counties, Benewah is most dependent on forest industry. Shoshone is the least. Using the excess-employment indicator system suggested by Maki, Schallau and Beuter (1968), Benewah County rates as "highly" timber dependent; Bonner, Boundary and Kootenai are "moderately" timber dependent; Shoshone is "slightly" timber dependent.

The area's dependence on the forest products industry causes employment to cycle with the national housing market. Unemployment in the IPNF impact area averaged 9.6 percent in 1981, compared to an Idaho state average of 6.3 percent and national average of 7.6 percent (Idaho Department of Employment, 1982).

IPNF Relationship to Local Forest Industry

Hall (1982c) recently estimated that 19 percent of the local employment is directly or indirectly associated with management of the IPNF. Over half (56 percent) of the impact is through harvesting, hauling and manufacturing timber products. Forest Service employees and contractors account for another 20 percent of the effect. The rest is related to recreation and range management.

Virtually all of the IPNF timber harvest processed within the impact area is received by the plywood, sawmill, utility pole and house log sectors. Total plant capacity in those sectors in 1979 was 833,061 mbf (Keegan, 1982). Total volume of sawtimber received from all sources in that year was 694,603 mbf. Thirty-one percent--217,546 mbf--was harvested on the IPNF. The balance was received from other national forests (6 percent), other public lands (11 percent) and private sources (53 percent). The figures appear to be relatively consistent with earlier log flow studies for 1967 and 1972 (Schuster and Koss, 1979) and 1973 (Godfrey, et al., 1980).[18]

The impact area as a whole qualifies as a dependent community under at least one definition (Federal Register, 1977):

1. primary forest products manufacturing facilities, logging and log transportation account for 10 percent or more of the local community workforce and
2. national forest timber has accounted for at least 30 percent of the timber used in primary wood products manufacturing in the last five years.

Individually, each county but Shoshone meets the same test with regard to national forest timber. Shoshone County does not qualify because less than ten percent of its employment is associated with the forest products industry. Kootenai and Boundary Counties qualify on the basis of their IPNF timber use alone; Bonner and Benewah qualify when purchases from other national forests are included.

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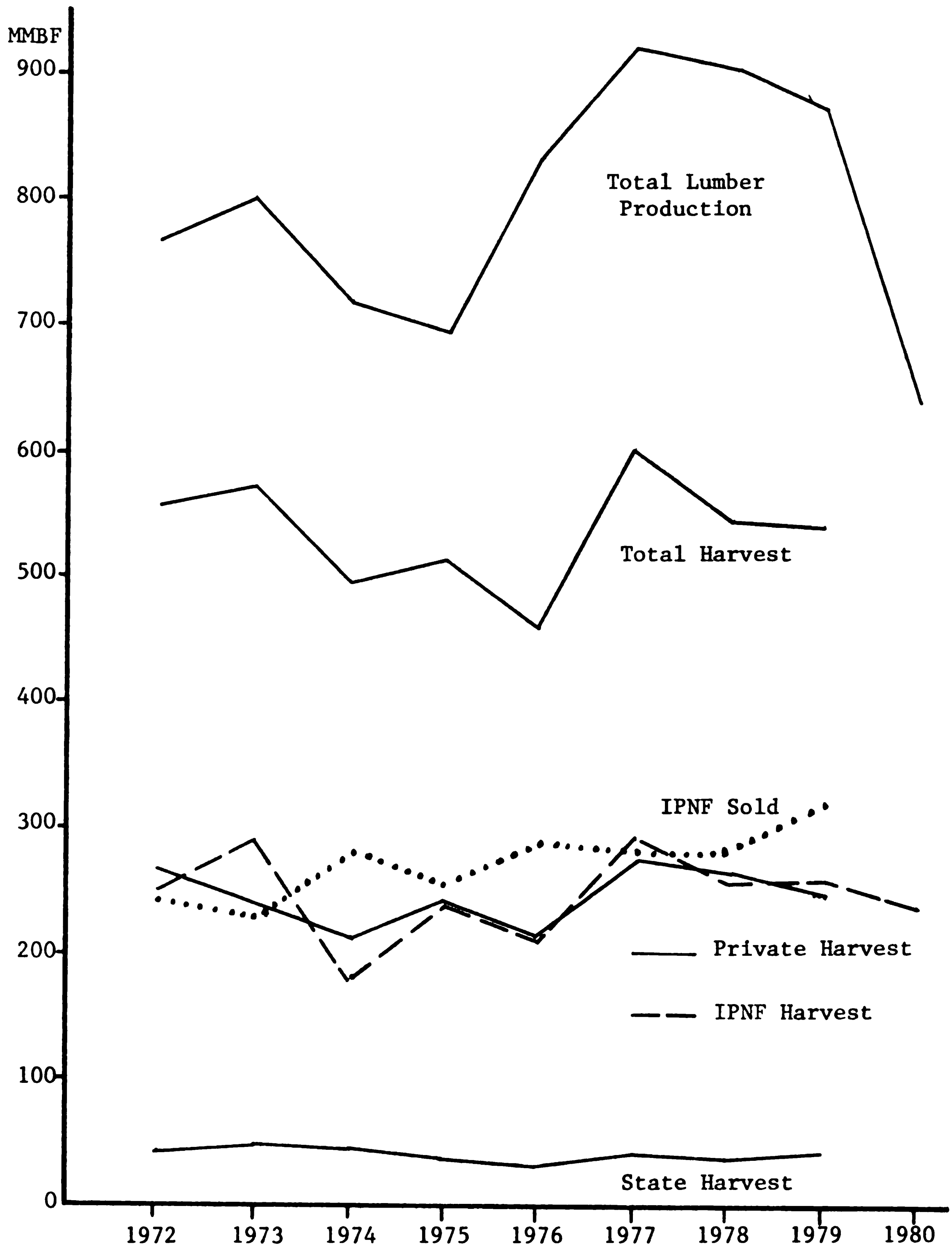
[18]Godfrey, et al. (1980) have noted that the differences in log flow estimates from their study and Koss's (Schuster and Koss, 1979) might be due to the different procedures used. Godfrey, et al. interviewed people who knew destination and estimated origin; Koss's interviewees knew origin and estimated destination. Koss's estimates do not include imports to the State; Godfrey, et al. do not estimate exports to other states. Keegan (1982) surveyed persons knowing destination and estimating origin, and estimates include imports from other states.

Figure 3 illustrates the past relationship of local lumber production to the total local harvest by ownership. Lumber production and employment in the lumber and wood products sector have been a function of lumber markets, not IPNF timber supply. Drops in lumber production correspond to national recessions and the attendant slumps in the housing market. Total harvests follow the general pattern in lumber production. Harvest on the IPNF also appears to follow the general trend in lumber markets. The IPNF harvest averaged 46 percent of total harvest in the area.

The past relationship shows private and other public substitutes for IPNF timber. The future relationship is less certain. One study (Bundy, 1972) indicated that the local private supply would be seriously depleted by the year 2015. Preliminary figures from a 1980 survey of Idaho's state and private forestland (USDA, 1982b), show a 30 percent drop in the impact area's state and private commercial forest acreage and a 31 percent drop in net annual growth since 1964. The annual harvest from 1972 through 1980 averaged 72 percent of the 1980 net annual growth estimate. For the purposes of this research, it is assumed that at least part of any increase in IPNF timber harvest would substitute for private and other public timber. Projections of changes in employment and earnings are therefore greater than what would actually occur. In some cases they will represent "jobs saved" rather than "jobs created."



Figue 3. Lumber Production and Harvest by Ownership, IPNF Impact Area, 1972-1980

CHAPTER VII

IMPACT OF THE ALTERNATIVES ON THE LOCAL ECONOMY

The focus of this study is the impact of Forest Service timber management on the local economy. The relationship of the IPNF to the local timber industry has already been discussed. Timber sold by the IPNF is in most cases harvested and processed by persons living and working in the impact area. Investments made by the Forest Service in road construction, timber stand improvement, planting and other treatments provide employment through local contractors. Forest Service employees are themselves contributors to the local economy. Finally, Forest Service payments to counties--both payments in lieu of taxes and twenty-five percent fund payments[19]--have an impact on the local economy.

Input-Output Model Formulation

An input-output model was used to estimate the impact of each forest management alternative on the local economy. The usefulness of input-output models for forestry has been demonstrated in a number of other studies, including Youmans and others (1973) and Darr and Fight (1974) for Douglas County, Oregon; Terfehr and others (1977) in Mississippi and Miller (1980) for Grant County, Oregon. McKillop (1974) summarizes a number of other forestry related models.

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[19]Twenty-five percent fund payments are based on National Forest receipts and are paid annually. Additional payments, called payments in lieu of taxes, are made only when the twenty-five percent fund payment for the previous year falls below a prescribed amount.

The model used by the IPNF was developed by the Planning, Programming and Budgeting staff in the Region 1 regional office. The procedure is similar to the IMPLAN system currently being used by the Forest Service.[20] The Region 1 system uses economic linkages developed from a national I-O model and adjusted specifically for the multicounty impact area of each national forest in the Region. The following discussion of the I-O model formulation closely follows the summary prepared by Chase (1982).

The Region 1 I-O data base is an adaptation of the 1972 data set compiled by Lofting (n.d.). Lofting used the U.S. Department of Commerce Bureau of Economic Analysis' (BEA) 1972 national input-output model to derive a complete set of economic information for each county. Using independent sources such as the 1974 U.S. Census of Agriculture, Bureau of Labor Statistics, Census of Housing, and industry publications county totals were balanced to state summary totals and state totals were balanced to national totals by Standard Industrial Classification (SIC) code.

Employment and payroll data provided by county, state and national summary files of the 1972 County Business Patterns were used to allocate national gross domestic output first to states and then to counties. Final demand estimates for states were based on the 1963 Multi-Regional Input-Output Model for the United States and updated using the 1972 national final demand as a control total.

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[20]The primary difference between the Region 1 system and IMPLAN is the data base. IMPLAN uses Lofting's new 1977 county data base, which was not complete in time for Region 1's use. The two systems are equivalent in other respects.

The data base for Region 1 was further developed from information on the economic structure of each county in northern Idaho, Montana and North Dakota. The 1972 economic information was updated to 1977 with various sources--County Business Patterns, Statistical Abstracts and Bureau of Economic Analysis reports--used as control totals (Super, 1981). There are 126 industrial sectors in the national data base for each county in each state. In the IPNF five county impact area only 48 of the 126 sectors are present. In order to concentrate analysis on sectors of primary national forest importance and to meet model size constraints the number of sectors was reduced by aggregation to 19. Those sectors most impacted by national forest outputs were left disaggregated, while sectors indirectly impacted were combined. Timber related industrial sectors, for example, were left alone while other manufacturing sectors were aggregated.

Five types of information provided by the I-O model are of importance at the forest level and are defined as follows (McKusick, 1978):

Final demand - That part of an I-O model transactions table containing sectors which represent final or terminal consumers of the output produced by the modeled economy. Final demand is the exogenous sector which determines the level of output of the modeled area's economy since changes in final demand are transmitted through the rest of the economy. In the IPNF model, final demand includes personal consumption expenditures by households outside the local economy, gross private capital formation, inventory accumulation and exports. Local government expenditures are considered part of the processing sector. The model is closed with respect to households, thus personal consumption expenditures by households within the local economy do not constitute part of final demand.

Total gross output - The total value of an I-O sector's output, i.e., its total sales, including additions to inventory.

Employment - The number of full-time equivalent jobs per year. It is generally expressed simply as jobs or as person years of employment.

Income - The amount of income received by employees of the industrial sectors plus income received by proprietors.

Value added - The difference between the value of inputs purchased and the value of outputs sold. It includes wages and salaries, pensions, royalties, annuity payments, business taxes, depreciation, insurance claim payments, dividends, interest, rent and profit or loss. It also includes retained earnings of business and certain transfer payments.

Table 6 displays the original data included in the IPNF model by sector. Table 7 displays the employment, income and value added coefficients by sector. The coefficients are the ratios of employment, income and value added to total gross output. For example, from Table 6 the employment in the logging and sawmill sector (3795.325) divided by total gross output in that sector (235901.049 M$) equals the logging and sawmill employment coefficient (.0161) on Table 7. The interpretation is that each $1,000,000 in total gross output in the logging and sawmill sector requires 16.1 employees. The linear structure

TABLE 6

ORIGINAL DATA FOR INPUT-OUTPUT MODEL,
IPNF IMPACT AREA, 1977 (1978$)

Sector	Final Demand ($1000)	Total Gross Output ($1000)	Employment (Jobs/Year)	Income ($1000)	Value Added ($1000)
Miscellaneous Agriculture	1255.453	9383.519	339.000	2635.831	4183.173
Livestock and Products	7746.111	19769.745	264.739	1283.056	5203.397
Food and Feed Grains	21013.763	29731.429	567.131	5616.267	11556.607
Miscellaneous Mining	18612.045	39859.196	1958.400	34713.374	19566.879
Construction	28469.973	45112.513	1064.794	24482.561	15090.136
Miscellaneous Manufacturing	151205.170	275811.117	2338.283	38337.745	69449.239
Logging and Sawmills	152340.852	235901.049	3795.325	62914.810	94714.271
Other Wood Products	21887.444	23436.999	474.159	6288.147	9276.364
Veneer/Plywood	19446.915	29730.393	441.087	8969.660	11645.395
Transportation, Communication, Utility	39174.239	96442.646	2081.229	30996.667	55329.146
Wholesale Trade	4651.834	20420.571	771.181	10577.856	13808.390
Auto Repair and Service	7456.282	13203.359	891.672	6568.671	10391.044
Eating and Drinking	26615.195	27293.171	1864.244	13676.608	21479.725
Miscellaneous Retail Trade	33186.418	35492.333	2400.349	17678.731	27932.466
Finance, Insurance, and Real Estate	294171.426	367680.352	920.972	21619.605	247412.107
Hotels and Motels	2672.749	4364.790	489.882	2311.593	1707.942
Other Services	10345.715	54150.378	2785.771	28613.060	27670.843
Local, State and Federal Government	194450.641	209542.096	7226.982	62527.361	200678.465
TOTAL	1034702.195	1537325.594	30675.199	379811.586	847095.555

TABLE 7

IMPACT COEFFICIENTS AND TYPE I MULTIPLIERS BY SECTOR,
IPNF ECONOMIC IMPACT AREA (1978$)

Sector	Original Final Demand ($1000)	Original TGO ($1000)	Employment Coefficient (Year/$1000) TGO	Income Coefficient (Income/$1000 TGO)	Value Added Coefficient (VA/$1000 TGO)	Type I Output Multiplier
Miscellaneous Agriculture	1255.453	9383.5	.0361	.2809	.4458	1.4552
Livestock and Products	7746.111	19769.7	.0134	.0649	.2632	2.1842
Food and Feed Grains	21013.763	29731.4	.0191	.1889	.3887	1.6449
Miscellaneous Minning	18612.045	39859.2	.0491	.9809	.4909	1.4925
Construction	28469.973	45112.5	.0236	.5427	.3345	1.5280
Miscellaneous Manufacturing	151205.170	275811.1	.0085	.1390	.2518	2.0801
Logging and Sawmills	152340.852	235901.1	.0161	.2667	.4015	1.6685
Other Wood Products	21887.444	23437.0	.0202	.2683	.3958	1.7087
Veneer/Plywood	19446.915	29730.4	.0148	.3017	.3917	1.8146
Transportation, Communication and Utility	39174.239	96442.7	.0216	.3214	.5737	1.4160
Wholesale Trade	4651.834	20420.6	.0378	.5180	.6762	1.3034
Auto Repair and Service	7456.282	13203.4	.0675	.4975	.7870	1.2380
Eating and Drinking	26615.195	27293.2	.0683	.0501	.7870	1.2380
Miscellaneous Retail Trade	33186.418	35492.3	.0676	.4981	.7870	1.2380
Finance, Insurance and Real Estate	294171.426	367680.4	.0025	.0588	.6729	1.3724
Hotels and Motels	2672.749	4364.8	.1122	.5296	.3913	1.6874
Other Services	10345.715	54150.4	.0514	.5284	.5110	1.4956
Local, State and Federal Government	194450.641	209542.1	.0345	.2984	.9577	1.0431

of the I-O model allows the coefficients to be used to estimate the labor, income and value added for all changes in gross output.

To determine the amount of change brought about by changes in Forest production the direct, indirect, and induced impacts on the local economy are determined. These impacts are defined as follows (Super, 1981):

Direct impacts - Impacts, measured in terms of income and employment, resulting from an initial purchase from a raw material sector. For instance, a change in timber purchased from the Forest Service will cause an immediate and "direct" impact on the logging and sawmill sectors.

Indirect impacts - Impacts resulting from directly impacted sectors buying goods and/or services from other sectors (second and succeeding rounds). For instance, indirect impacts occur in the saw blade manufacturing sector when sawmills (directly impacted sector) buy new saw blades to process National Forest provided timber.

Induced impacts - Impacts that are generated when households composed of the employees of directly and indirectly impacted sectors purchase goods and/or services from other sectors. Food, services, fuel, households, and many other sectors are involved in induced impacts. In order to calculate induced effects households are considered endogenous to the model.

Table 7 also lists Type I multipliers for each sector. A Type I multiplier is the ratio of the change in direct and indirect total gross output to the direct change in output resulting from an increment of change in final demand for a sector. A change in total sales for one sector can be multiplied by the Type I output multiplier to identify the change in total gross output expected to occur as a result of the sales. Households are not included in the Type I multiplier calculation, therefore, induced effects on output are excluded. Induced impacts are considered in the final round of total change by using a Type II multiplier. A Type II multiplier is a ratio expressing the total change (direct + indirect + induced) to the direct change. Although the Type II multiplier is not shown in Table 7, it is used to calculate the total impact of IPNF management on the local ecomony.

The standard caveats (for example, see Richardson, 1972) for interpreting secondary data models apply to the IPNF model. First, linear production functions are assumed; economies of scale and changing technologies are not considered. National level coefficients are assumed to adequately describe local sector relationships. Time is not considered in the production functions; national forest outputs are assumed to be instantaneously consumed and increased levels of forest output are assumed to be instantly available.

Darr and Fight (1974) have noted two sources of local economic impact: those attributable to changes in final demand and those attributable to resource availability. Impacts attributable to final demand are the normal province of the backward-linked input-output model; i.e., impacts are estimated "backward" from the original change in demand to the industries which satisfy that demand. Impacts attributable to resource availability require an assumption of forward-linkages; i.e., impacts which can be estimated "forward" from the resource supply to the industries which process the raw material and sell finished products to final demand. Where the resource supply is declining, one assumes that industries will be able to process less raw material; output and employment will decline. Where the resource supply is increasing, as in the IPNF timber management alternatives, one must assume that the demand for lumber and other wood products exists to absorb the additional supply. Thus, calculated impacts are the maximum that can occur.

For each IPNF timber management alternative, three elements of change are examined for their impact on the local economy: timber volume harvested, Forest Service investment expenditures and Forest Service operating, maintenance and administration expenditures. Payments to counties are included as operating and maintenance expenses.[21] A per unit expenditure matrix (Wilson, 1980) relates changes in each of these elements to assumed final demand changes in the appropriate sectors of the local economy. Each thousand board feet of sawtimber harvested is associated with the following final demand changes: $202.72 in Logging and Sawmills, $106.33 in Other Wood Products and $66.09 in Veneer and Plywood. National Forest System (NFS) investment expenditures are defined to include all road construction, including purchaser built roads and engineering support. Each million dollars of NFS investment has a direct impact of $250,000 on the Construction sector and $630,000 in the Government sector; $120,000 is spent outside the local impact area. Each million dollars in operating, maintenance and administration expenses has a 1 to 1 impact on the Government sector.

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[21]Forest Service payments to counties are frequently assumed to represent substitutes for local tax revenue. In that case they would have no net impact on the local economy and would not be included in the I-O model. A review of local county revenue (Chase, 1982) indicates that this is not the case for northern Idaho counties. Counties do not tend to change their tax collections in response to changes in Forest Service payments. Increased payments mean more disposable income to the receiving districts, but not lower taxes for county residents. Nor do

One drawback to the form of the IPNF input-output model must be noted at this point. The government sector includes local, state and federal government. The result, as shown in Table 7, is a very low Type I output multiplier of 1.0431 for the government sector. By separating county governments and local units of State and federal government from non-local units, a more realistic estimate of impacts due to Forest Service expenditures and payments to counties would have been possible. As currently formulated, the model underestimates the impact of changes in government income and expenditure.

Components of Change in Local Income and Employment

Input for the I-O model consists of changes from the 1980 base for timber volume and Forest Service costs, including payments to counties. Each element of change has a different, sometimes conflicting, impact on final demand and thus on total gross output, income and employment. The best estimate of change is related to income. Changes in income tend to correspond closely to changes in output, while employment/output ratios are less stable. Table 8 displays employment and income changes associated with a one million board foot change in timber volume, a $1,000,000 change in Forest Service capital expenditures and a $1,000,000 change in operating and maintenance expenditures (or payments to counties). A one million board foot increase in timber volume, for example, would create 13.6 additional jobs and $201,718 in additional income for the area. Sixty-eight

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decreases in Forest Service payments result in higher local taxes, at least in the short run. It is therefore assumed that changes in Forest Service payments represent marginal changes in county revenue. The same assumption was made by Darr and Fight (1974) in their study of Douglas County, Oregon.

TABLE 8

EMPLOYMENT AND INCOME CHANGES FOR SELECTED CHANGES
IN FOREST OUTPUT, IPNF IMPACT AREA (1978$)

Sector	Employment (Person Years)			Income (1000 $)		
	1 MMBF Timber	1 MM$ Capital Expense	1 MM$ O & M Expense[1]	1 MMBF Timber	1 MM$ Capital Expense	1 MM$ O & M Expense[1]
Miscellaneous Agriculture	.193	.121	.110	1.501	.942	.853
Livestock and Products	.010	.024	.018	.049	.116	.087
Food and Feed Grains	.022	.029	.025	.215	.285	.245
Miscellaneous Mining	.062	.288	.113	1.093	5.110	1.996
Construction	.097	6.104	.249	2.227	140.353	5.727
Miscellaneous Manufacturing	.165	.550	.299	2.706	9.025	4.903
Logging and Sawmills	5.690	.166	.008	94.319	2.744	.135
Other Wood Products	2.194	.080	.003	29.098	1.064	.045
Veneer/Plywood	1.377	.056	.002	27.994	1.130	.048
Transportation, Communication and Utilities	.762	1.283	1.139	11.356	19.105	16.961
Wholesale Trade	.533	.773	.422	7.310	10.598	5.782
Auto Repair and Service	.368	1.419	.925	2.714	10.454	6.812
Eating and Drinking	.100	.326	.282	.733	2.394	2.066
Miscellaneous Retail Trade	.336	1.098	.948	2.477	8.090	6.984
Finance, Insurance and Real Estate	.094	.203	.200	2.207	4.763	4.700
Hotels and Motels	.088	.231	.251	.413	1.088	1.185
Other Services	1.351	2.923	2.179	13.872	30.018	22.383
Local, State and Federal Government	.166	22.035	34.762	1.436	190.646	300.755
TOTAL	13.607	37.708	41.934	201.718	437.925	381.669

[1]Includes payments to counties.

percent of the employment and seventy-five percent of the income would be generated in the three forest product sectors. Most of the impact of changes in capital expenditures occurs in the construction and government sectors, while operation and maintenance expenditures and payments to counties concentrate impact on the government sector.

Due to the linear nature of the relationships in an input-output model, the components of change in local income and employment can be easily calculated using the information in Table 8. A five million board foot increase in timber volume, for example, would produce 2.67 jobs in the wholesale trade sector (5 X .533 = 2.67). A $5,000,000 decrease in capital expenditures would eliminate 3.87 jobs in wholesale trade (5 X .773 = 3.87). The net effect of a 5 million board foot increase in timber and a $5,000,000 decrease in capital expenditures would be a loss of 1.2 wholesale trade sector jobs.

As a further example, Tables 9 and 10 illustrate the components of change in employment and income respectively for the first decade timber management program under Alternative 1. In 1980, the IPNF produced 245 million board feet, capital expenditures equaled $14,172,000, operating and maintenance expenditures were $13,553,000, stumpage value was $17,412,000 and payments to counties equaled $4,353,000. Compared to the harvest and expenditures in the 1980 base year, Alternative 1's first decade would produce an additional 94 million board feet of timber each year. Capital expenditures would be lower by $13,000 per year, while annual operating and maintenance expenditures would be $1,750,000 lower. Because timber harvest would be concentrated on the most efficient timber producing lands, annual stumpage receipts from 339 million board feet would increase to $42,567,000, an average of $125.57 per

TABLE 9

EMPLOYMENT CHANGES ASSOCIATED WITH FIRST DECADE CHANGES
IN IPNF TIMBER MANAGEMENT, ALTERNATIVE 1

Sector	Total Employment 1980	Annual Employment Change Associated with: Timber +94 MMBF	Capital Expense -.013 MM$	O & M Expense -1.75 MM$	Payments to Counties +6.29 MM$	Total Change	Total Employment 1990
		(Person Years)					
Miscellaneous Agriculture	339.00	18.14	(.002)	(.19)	.69	18.64	357.64
Livestock and Products	264.74	.94	(.000)	(.03)	.11	1.02	265.76
Food and Feed Grains	567.13	2.07	(.000)	(.04)	.16	2.19	569.32
Miscellaneous Mining	1958.40	5.83	(.004)	(.20)	.71	6.34	1964.74
Construction	1064.79	9.12	(.079)	(.44)	1.57	10.17	1074.96
Miscellaneous Manufacturing	2338.28	15.51	(.007)	(.52)	1.88	16.86	2355.14
Logging and Sawmills	3795.33	534.86	(.002)	(.01)	.05	534.90	4330.23
Other Wood Products	474.16	206.24	(.001)	(.01)	.02	206.25	680.41
Veneer/Plywood	441.09	129.44	(.001)	(.00)	.01	129.45	570.54
Transportation, Communication and Utilities	2081.23	71.63	(.017)	(1.99)	7.16	76.78	2158.01
Wholesale Trade	771.18	50.10	(.010)	(.74)	2.65	52.00	823.18
Auto Repair and Service	801.67	34.59	(.018)	(1.62)	5.82	38.77	840.44
Eating and Drinking	1864.24	9.40	(.004)	(.49)	1.77	10.68	1874.92
Miscellaneous Retail Trade	2400.35	31.58	(.014)	(1.66)	5.96	35.87	2436.22
Finance, Insurance and Real Estate	920.97	8.84	(.003)	(.35)	1.26	9.75	930.72
Hotels and Motels	489.88	8.27	(.003)	(.44)	1.58	9.41	499.29
Other Services	2735.77	126.99	(.038)	(3.81)	13.71	136.85	2872.62
Local, State and Federal Government	7226.98	15.60	(.286)	(60.83)	218.65	173.13	7400.11
TOTAL	30675.20	1279.06	(.490)	(73.38)	263.76	1468.95	32144.15

TABLE 10

INCOME CHANGES ASSOCIATED WITH FIRST DECADE CHANGES
IN IPNF TIMBER MANAGEMENT, ALTERNATIVE 1

Sector	Total Income 1980	Annual Income Change Associated with: Timber +94 MMBF	Capital Expense -.013 MM$	O & M Expense -1.75 MM$	Payments to Counties +6.29 MM$	Total Change	Total Income 1990
	(1000 $)						
Miscellaneous Agriculture	2635.83	141.09	(.012)	(1.493)	5.365	144.95	80.78
Livestock and Products	1283.06	4.61	(.002)	(.152)	.547	5.00	1288.06
Food and Feed Grains	5616.27	20.21	(.004)	(.429)	1.541	21.32	5637.59
Miscellaneous Mining	34713.37	102.74	(.066)	(3.493)	12.555	111.74	34825.11
Construction	24482.56	209.34	(1.825)	(10.022)	36.023	233.52	24716.08
Miscellaneous Manufacturing	38337.75	254.36	(.117)	(8.580)	30.840	276.50	38614.25
Logging and Sawmills	62914.81	8865.99	(.036)	(.236)	.849	8866.57	71781.38
Other Wood Products	6288.15	2735.21	(.014)	(1.862)	.283	2733.62	9021.77
Veneer/Plywood	8969.66	2631.44	(.015)	(1.978)	.302	2629.75	11599.41
Transportation, Communication and Utilities	30996.67	1067.46	(.248)	(29.682)	106.685	1144.22	32140.89
Wholesale Trade	10577.86	687.14	(.138)	(10.119)	36.369	713.25	11291.11
Auto Repair and Service	6568.67	255.12	(.136)	(11.921)	42.847	285.91	6854.58
Eating and Drinking	13676.61	68.90	(.031)	(3.616)	12.995	78.25	13754.86
Miscellaneous Retail Trade	17678.73	232.84	(.105)	(12.222)	43.929	264.44	17943.17
Finance, Insurance and Real Estate	21619.61	207.46	(.062)	(8.225)	29.563	228.74	21848.35
Hotels and Motels	2311.59	38.82	(.014)	(2.074)	7.454	44.19	2355.78
Other Services	28613.06	1303.97	(.390)	(39.170)	140.789	1405.20	30018.26
Local, State and Federal Government	62527.36	134.98	(2.478)	(526.321)	1891.749	1497.93	64025.29
TOTAL	379811.59	18961.49	(5.693)	(667.921)	2400.698	20688.57	400500.16

thousand board feet. Of that total 75 percent ($31,925,000) would be returned to the U.S. Treasury. The remaining $10,642,000 would be retained as payments to counties; $6,290,000 more than the payments made in the 1980 base year.

In this example, the increase in timber volume dominates the overall impact. Fifty-nine percent of the employment increase and sixty-nine percent of the income increase occurs in the three forest products sectors. In almost every sector the increase in payments to counties more than compensates for the reduction in direct Forest Service expenditures.

For other time periods and other alternatives, the components of change can be similarly calculated to estimate the distribution of impacts to different sectors. While important, the distributional aspect of employment and income change is beyond the scope of this research.

Results of Applying The I-O Model

As stated earlier, input for the I-O model consists of changes from the 1980 base for timber volume and Forest Service costs, including payments to counties. The input data is summarized in Table 11.

A review of the input data gives an early indication of the variable results of less-than-efficient National Forest management. Compared to the maximum present value Alternative 1, higher timber volumes are produced earlier in Alternatives 2 and 3, at higher cost. Both higher volumes and higher Forest Service expenditures benefit the local economy in the short run. Current management, on the other hand, produces lower than optimal amounts of timber at lower cost. This

TABLE 11

AVERAGE ANNUAL TIMBER HARVEST AND FOREST SERVICE
EXPENDITURES BY ALTERNATIVE
CHANGE FROM 1980 BASE

Alternative	Period	Timber Harvest (MMBF)	NFS Investment (MM$)	O&M (MM$)	Payments to Counties (MM$)
1	1	94	(0.01)	(1.75)	6.29
	2	179	0.71	(1.28)	9.59
	3	285	(3.05)	3.20	20.75
	4	417	2.07	5.38	33.65
	5	582	3.25	12.69	50.31
2	1	166	1.85	(1.15)	8.39
	2	166	1.45	(0.75)	7.28
	3	351	(0.99)	4.40	22.96
	4	351	1.90	5.58	30.75
	5	351	(7.16)	0.78	36.27
3	1	157	3.48	1.46	6.57
	2	157	(0.05)	(1.94)	9.36
	3	355	0.45	8.76	22.00
	4	355	0.15	5.79	32.27
	5	355	(5.53)	9.14	35.96
4	1	5	(1.18)	(2.59)	2.91
	2	106	(1.57)	(2.44)	7.38
	3	359	0.97	12.18	21.87
	4	359	1.32	24.27	33.06
	5	359	(5.58)	10.09	36.54

suggests that current forest management is less beneficial to the local community than efficient management would be.

The results of the input-output model bear this out. As shown in Table 12, Alternatives 2 and 3 provide more jobs in the first decade than Alternative 1. Current management provides fewer. The same relationship holds true for income. Figures 4 and 5 graphically display the impact by alternative on average annual employment and income.

TABLE 12

AVERAGE ANNUAL CHANGE IN EMPLOYMENT AND INCOME
BY ALTERNATIVE

		Employment		Income	
Alternative	Period	Jobs	Gain (Loss) Compared To Alternative 1	MM$	Gain (Loss) Compared To Alternative 1
1	1	1469		20.69	
	2	2805		39.51	
	3	4760		65.19	
	4	7386		99.89	
	5	10687		142.93	
2	1	2633	1166	37.08	16.42
	2	2588	(217)	36.63	(2.88)
	3	5891	1131	80.89	15.70
	4	6376	(1010)	85.57	(14.32)
	5	6065	(4622)	81.89	(61.04)
3	1	2597	1130	36.15	15.49
	2	2438	(367)	34.38	(5.13)
	3	6133	1373	83.49	18.30
	4	6427	(959)	86.14	(13.75)
	5	6509	(4178)	86.35	(56.58)
4	1	156	(1311)	1.87	(18.79)
	2	1590	(1215)	22.58	(16.93)
	3	6449	1689	86.75	21.56
	4	7338	(48)	94.87	(5.02)
	5	6629	(4058)	87.77	(55.16)

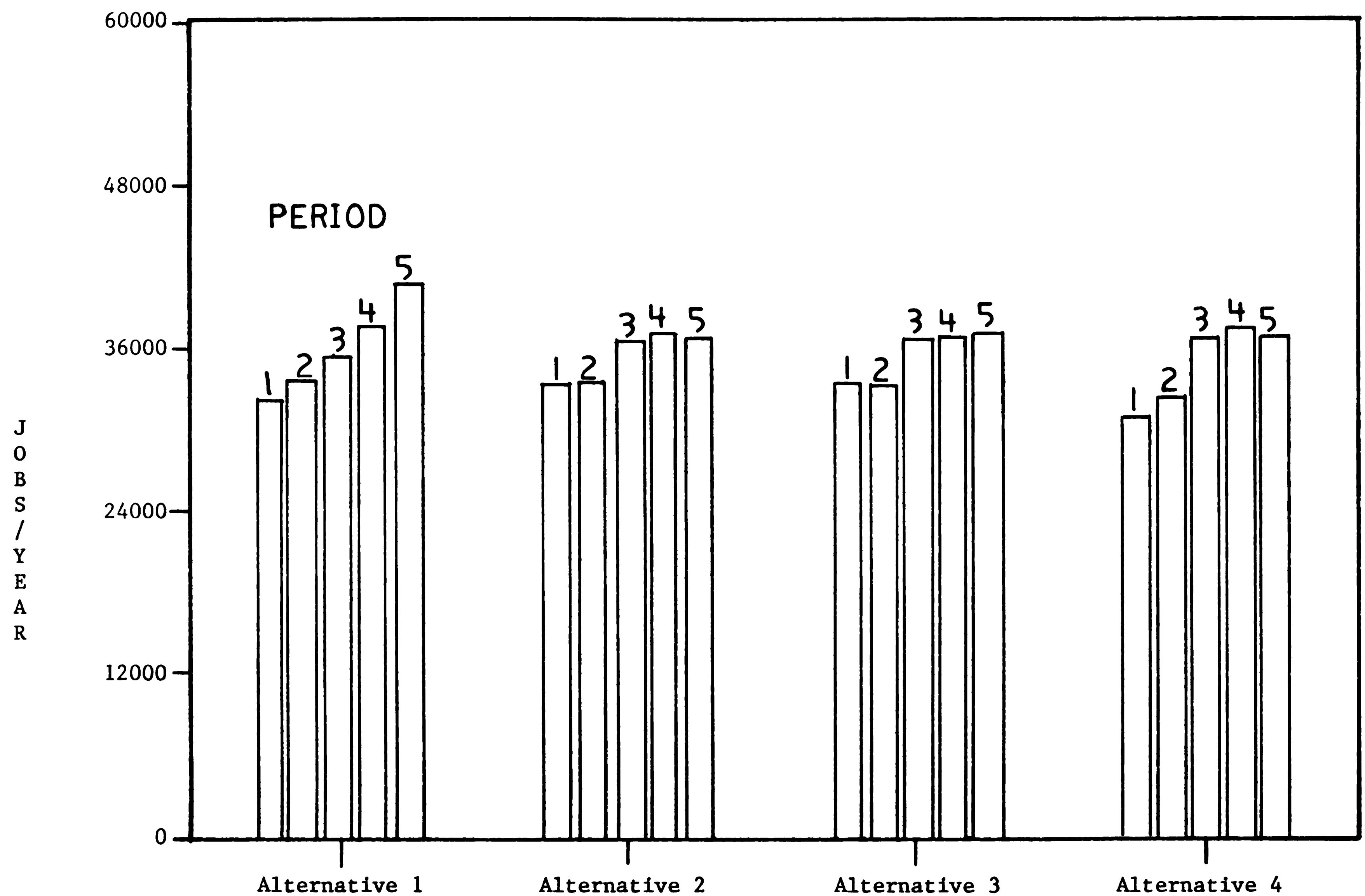

Figure 4. Average Annual Employment by Alternative, IPNF Impact Area

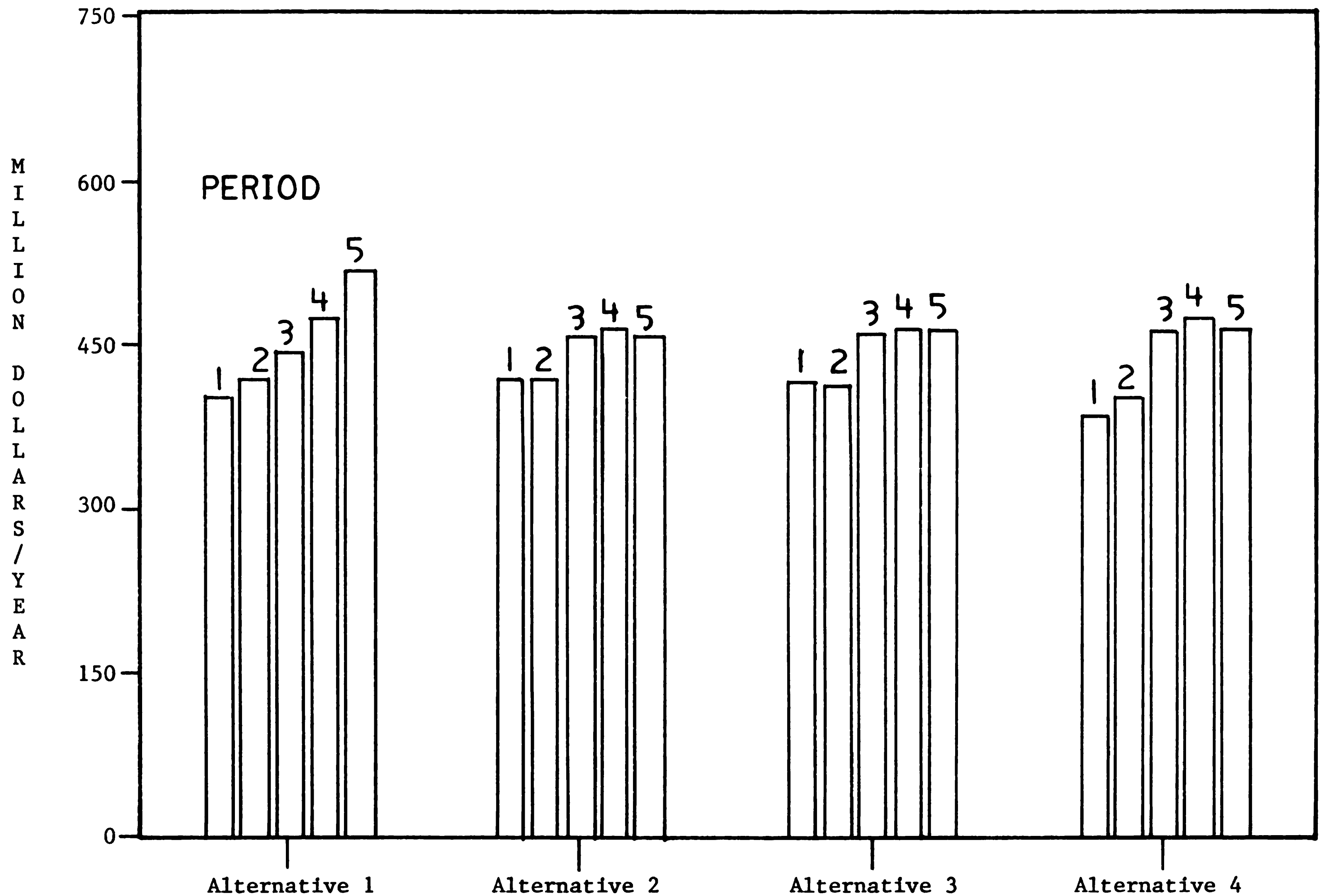

Figure 5. Average Annual Income by Alternative, IPNF Impact Area

CHAPTER VIII

EVALUATING TRADEOFFS BETWEEN EFFICIENCY AND THE LOCAL ECONOMY

In Chapter 5 the relative efficiency of each forest management alternative was discussed in terms of its present net value and equivalent annual value. Alternative 1 had the highest present net value; it is the most efficient management alternative. Alternatives 2, 3, and 4 produced progressively lower present net values, sacrificing efficiency in order to meet other management objectives.

The impact each alternative would have on the local economy was discussed in Chapter 7. Alternative 2 provided the most employment and income in the first decade. It was followed by Alternatives 3, 1, and 4 respectively. At this point the efficiency of each alternative needs to be compared to the effect on the local economy.

Measuring the Tradeoff

In order to relate management efficiency to local economic impacts, each must be expressed in comparable units. The relative efficiency of each alternative has been expressed in terms of its present net value and equivalent annual value. Converting the value of local income to its equivalent annual value provides the comparability desired. The equivalent annual loss in efficiency can then be compared to the equivalent annual gain to the local economy.

Table 13 summarizes the results of comparing the alternatives. Present net values were converted to equivalent annual values for the comparison. The annual figures are for the first fifty years of the planning horizon. Although the absolute values would be larger if we looked at the 130 year planning horizon or an infinite period, the differences between alternatives would remain the same. Focusing on a shorter time period might alter the results, but evaluating long term plans using short term impacts could be misleading.

The equivalent annual value of IPNF timber management under the efficiency model (Alternative 1) is $54.14 million. The value of the other alternatives is lower but still significantly positive. The equivalent annual value of income is higher under Alternatives 2 and 3 than under Alternative 1, largely because of the higher timber volume and higher Forest Service expenditures in the first decade. Average annual employment is higher under Alternative 1, but much of the gain is not realized until the fourth or fifth decade. In every case, the gain in local income is less than the loss in forest management present net value, i.e., the local benefit-national cost ratio for each alternative is less than 1.0.[22]

The comparison of alternatives in Table 13 indicates that the impact on the local economy of deviating from the efficiency model depends on "how much" and "in what direction". Alternative 2 is the best of the group for the local economy. The high timber target in

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[22]If an alternate approach were used and attention were focused on the first decade alone, the benefit-cost ratio for Alternatives 2 and 3 would be positive. This would constitute a long-term national cost to achieve a short-term local benefit.

TABLE 13

COMPARISON OF ALTERNATIVES:
EQUIVALENT ANNUAL VALUE
FOR FIFTY YEARS

	Alternative 1	2	3	4
Equivalent Annual Value of:				
IPNF Timber Management Program (MM$)	54.14	50.64	47.37	40.94
Local Income (MM$)	52.67	54.40	54.34	39.89
Net Change From the Maximum Present Net Value Alternative:				
IPNF Timber Management Program (MM$)		(3.50)	(6.77)	(13.20)
Local Income (MM$)		1.73	1.67	(12.78)
Sum[1]		(1.77)	(5.10)	(25.98)
Local Benefit-National Cost Ratio		.49	.25	-.97

[1]Present net value change in the timber program represents a net national loss. Present net value change in local income represents an income transfer, not a net national impact. The two measures are therefore not normally considered additive, i.e., one cannot add the two together and call the sum "net national change."

the first decade and subsequent nondeclining even flow boost local income $1.73 million above what was achieved under the efficiency alternative.

This was accomplished at a loss to the national economy of $3.5 million per year. That is the equivalent of about $3000 a year for each of the extra 1166 jobs created in the first decade. By the fourth decade the net annual efficiency loss is the same, but there are fewer jobs created than under Alternative 1. On an average annual basis each dollar of subsidy supports a $0.49 increase in local income.

Alternative 3 is also favorable for the local economy, but worse than Alternative 2 from the national perspective. The annual value of local income is $1.67 million greater than under the efficiency alternative. The efficiency loss is $6.77 million per year, or $5,991 per year for each extra job created in the first decade. Each dollar of subsidy supports a $0.25 increase in local income. The nearly double subsidy per unit of impact compared to Alternative 2 is due to maintaining the same timber volume in the first decade while staying within the 40 acre clearcut limit. This considerably increased the cost, particularly access cost, per thousand board feet produced. Earlier reliance on harvesting timber on slopes greater than 40 percent also lowered stumpage values and payments to counties in the first decade.

Alternative 4 shows the effect on the local economy of producing less than the present value maximizing volume, and producing it in an inefficient way. Current management produces both a net loss in national efficiency and a loss to the local economy. This points out at least three problems with current management of the Idaho Panhandle

National Forests. First, the Forests' budget has been inadequate to allow the Forest to operate at its optimal level. Second, current management direction does not make the most efficient use of the available budget. Money allocated to stocking the submarginal St. Joe brushfields, for example, could be used more productively elsewhere if the brushfields were removed from the timber base. The third problem is a remnant of the unit planning process. Former unit plan land allocations were fixed into the current management FORPLAN solution. Since the unit plans were developed in the absence of an integrated, Forest-wide approach and with little regard for economic efficiency, it is not surprising that land allocations are suboptimal.

The results of this analysis cannot be interpreted to mean that the benefits to the local economy in any way "offset" the efficiency loss incurred by the Forest Service. In Alternative 2, for example, the efficiency loss of $3.5 million per year is a net loss to the national economy. It is a subsidy paid by taxpayers to the benefiting residents of the IPNF impact area. The subsidized value of income in the impact area ($1.73 million per year) is not a net contribution to the national economy. It is simply a substitute for the total gross output and income which might have been produced elsewhere in the economy if timber management dollars were efficiently invested elsewhere. Also, the local benefits may not materialize if demand for timber products does not increase as indicated.

The results of this analysis can be interpreted as follows:

1. If the sole decision criterion for the Forest Service is to

maximize national efficiency, the best option is Alternative 1, which maximizes not only the present net value of timber management but also the sum of the present values of timber management and local income. This is the choice dictated by adherence to economic theory.

2. If the sole decision criterion is to maximize the beneficial impact on the local economy, the best option is Alternative 2, which maximizes the present net value of local income.

3. Given the information provided, the tradeoffs between national efficiency and local income are clear. The amount of Hyde's "extended subsidy for which there is no obvious end and for which someone . . . must pay" is clear. The local benefit is also clear, and expressed in comparable terms. If the Forest Service makes a "conscious public policy decision" to subsidize the local economy, adequate information is provided to minimize the resulting inefficiency. If the efficient economic solution is rejected, the best alternative is that which maximizes the positive sum (or minimizes the negative sum) of the national efficiency loss and the local income gain. In this case, Alternative 2 provides the most local gain per dollar of subsidy provided, as expressed in the local benefit-national cost ratio of .49. As pointed out earlier, all benefit-cost ratios are less than 1.0.

Summary and Conclusions

This research has developed a procedure for comparing losses in national forest management efficiency to the associated gains or losses for a local economy. The procedure can be used to answer the questions "What forest management criterion produces the more positive (or less negative) impact on the local economy?" and "At what cost is the criterion followed?"

The procedure involves three basic steps:

1. The present net value and equivalent annual value of each forest management alternative, including a maximum present net value alternative, are calculated using the linear programming model FORPLAN.

2. The effect of each alternative on employment and income is determined. An area-specific input-output model can be used to convert changes in timber output, Forest Service expenditures and payments to counties by alternative into changes in the local economic indicators.

3. The present net value and equivalent annual value of local income is calculated. Both costs and impacts are therefore expressed in comparable terms.

By following this procedure, direct comparisons can be made between alternatives. The subsidy per job created can be determined. The cost per extra dollar of income supported can also be estimated. The value of additional income in the local economy is not a net contribution to the national economy, but a substitute for activity which might have taken place elsewhere.

The results of this research have several implications for national forest land managers. First, some forms of inefficiency are beneficial to a local economy. Policies which keep the harvest above efficient levels and practices which increase Forest Service expenditures can be locally advantageous. The ratio of local gain to national loss depends on the exact combination of forest management activities and outputs involved.

Second, some forms of inefficiency are detrimental to a local economy. Policies which keep the harvest below efficient levels and practices which reduce Forest Service expenditures are locally disadvantageous. Policies which increase purchaser costs, and therefore decrease stumpage value, also have a negative impact on payments to counties. The negative impacts on payments to counties might be offset in the economy by the increase in purchaser spending.

Third, environmental considerations can fall anywhere in the spectrum, having either positive or negative effects on both efficiency and the local economy. For example, the IPNF is considering some alternatives which promote both a higher level of timber harvest and protection of important watersheds. Watershed protection is accomplished by spreading the harvest to more drainages, reducing the impact on each individual watershed. The additional access requirements would require a substantial increase in appropriated funds for road construction. The alternative is favorable for the local economy, but the loss in present net value to the national economy is high.

Hyde (1981), on the other hand, discusses the case of the San Juan National Forest where the current harvest level is higher than that which would maximize present net value. Efficiency and environmental values would both be enhanced by a reduced harvest level, although the local community would be harmed.

Once the cost of subsidizing local employment and production through National Forest management is known, it can be objectively evaluated. Where the subsidy per job is small, it might be considered worthwhile. Or a decision might be made that the goal of promoting stable local communities, even if it is within the power of the Forest Service to do so, is not worth perpetual inefficiency in National Forest management. Hyde (1981) has suggested that other alternatives be considered. A compensatory payment to mill owners and employees, or a gradual reduction in harvest levels could be less burdensome for the national economy, while providing an adjustment period for the local community.

Waggener (1977) has suggested that if the real policy objective is one of income redistribution, that should be acknowledged. Then the objective should be pursued in an efficient way. Continued subsidies through national forest timber management are a redistribution of income not only from the U.S. taxpayer in general but also from the residents of other areas that might have benefited from the efficient investment of timber management dollars.

Waggener goes on to quote the Council of Economic Advisors (1965) "If our economy is to maintain its capacity to grow, government must ease the human adjustments to economic change and assure the redirection of people and capital to new purposes." Such a redirection increases efficiency and eases the transitional burden instead of trying to prevent change in a dynamic economy.

Suggestions For Further Application and Research

Several possibilities exist for further applications and research on this topic.

1. As mentioned in Chapter 5, one other alternative was originally planned for this research but was not available. That alternative would have included a harvest flow constraint on each of the three

designated Forests on the IPNF. It would still be worthwhile to run such an alternative through FORPLAN and perform a comparable analysis. The analysis would be valuable because of the implications it would have for other forests with overlapping market areas. A flow constraint, particularly nondeclining even flow, on each forest could be very costly and entirely superfluous.

2. There is another approach which might be taken on forests with overlapping market areas. Most national forests use both FORPLAN and a standard input-output approach in forest planning. The basic data for applying the procedure developed here is produced as each forest progresses with the planning process. Comparisons could therefore be made not only between alternatives on one forest but also between forests. If the decision were made to sustain the subsidized sale volume available to a given community, there would be a basis for offering that volume from the forest with the lowest tradeoff between efficiency and the value of local income sustained.

3. One option for further research would be the estimation of a production equation which would maximize the sum of the present net value of timber management and local income. The FORPLAN objective function could probably be structured to accomplish this. Such a combination might represent the optimal compromise if local community welfare remains an important Forest Service concern.

4. More research is needed to evaluate the effects of fluctuating national forest timber output over time. Specifically, are there additional transactions costs imposed on both the Forest Service and the timber industry which might reduce the apparent gain in present net value from following the existing efficiency model?

5. This analysis focused on timber management alone. A more thorough investigation of the effect of environmental factors on the national efficiency/local impact relationship would be a useful extension of this work.

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