USE OF SOIL TESTING TO PREDICT FERTILIZER RESPONSE

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ABSTRACT

Assessments of nitrogen fertilization in Pacific Northwest forests indicate a wide range of responses. If response could be predicted, in some manner, stands could be fertilized relative to their economic return. Soil tests have promise as a predictive tool, but the techniques are new and have not been fully field tested for forest crops. Therefore their use involves a measure of uncertainty. Knowledge today indicates relative response can be predicted in some stands, but the prediction of absolute response is not a practical use of soil tests in forestry. Additional work will be needed before soil tests can be used to assist managers in even a yes or no decision for the addition of nitrogen fertilizer.

INTRODUCTION

Nitrogen fertilizer applications in Pacific Northwest Douglas-fir stands have increased substantially in the past decade. Increased demand for wood and wood products and sounder estimates of the gains that can be achieved from N applications to forest stands have contributed to this increase. The change in the ratio of average log price per thousand board feet to cost of applying 200 lb N/acre illustrates how the demand for wood has made fertilizer a better investment today than it was a decade ago. In 1969 this ratio was slightly over two to one; today the ratio has increased to approximately six to one (Washington State Department of Natural Resources, Division of Forest Land Management, unpublished data 1978).

The risk associated with investing in forest fertilization has been reduced further because additional comprehensive growth response data have become available in the past 10 yr. The Regional Forest Nutrition Research Project alone has contributed approximately 1450 plots to the data base (University of Washington 1979). This added information has boosted confidence in average response estimates.

The expanded data base suggests that not all stands respond to N fertilizer. As fertilizer prices increase, these stands become more of a financial liability. It has been estimated that average response per acre, on site index II and III lands, could be increased by one-third if the lowest responding stands (lowest 25%) were identified and fertilizer applications eliminated (Shumway and Atkinson 1978). Soil testing is one method that may prove useful in identifying some of these nonresponding stands and aid foresters in assigning a risk factor to potentially fertilizable stands.

RISK ASSESSMENT

Since limited information on soil fertility exists in forestry, initial work in developing and using soil testing will center on an assessment of whether or not to fertilize. This requires that a "decision point" or benchmark nutrient level be determined. When a soil test level is above the benchmark the likelihood or magnitude of response is too low to justify additional fertilizer. Stands growing on soils with levels below the benchmark would be suitable for fertilizer applications. Estimation of the decision point requires that two factors be known: (1) The point where growth response becomes unprofitable, and (2) the correlation between soil test level and response.

BREAK-EVEN YIELD

The level of yield increase required to break even depends on management objectives; however, general estimates are possible. Using current plot techniques it is difficult to detect statistically significant differences between treated and control plots when control plot growth is greater than 80% of treated plot growth (relative yield = 80%). This point could be used as a conservative estimate of the lowest acceptable response; however, yield increases that are not statistically significant can be economically beneficial. On the other hand, economic benefits are certainly poor in instances where fertilized and unfertilized stands grow at the same rate (relative yield = 100%). In agricultural crops the decision point is generally reached at relative yields of 90% or 95%. This yield level is probably a reasonable starting point for forest crops.

DECISION POINT DETERMINATION

The data in Figure 1 illustrate how any index of available soil N could be used in deciding whether or not to apply 200 lb N/acre to Douglas-fir stands.

In this instance, 95% relative yield is attained when soil test N is approximately 50 ppm. This level of N then would constitute an estimated decision point. In stands where the N level is greater than 50 ppm, fertilizer would not applied. The decision point implies that stands above this level will not respond economically to fertilizer and stands below this level will. Soil tests are seldom, if ever, this precise.

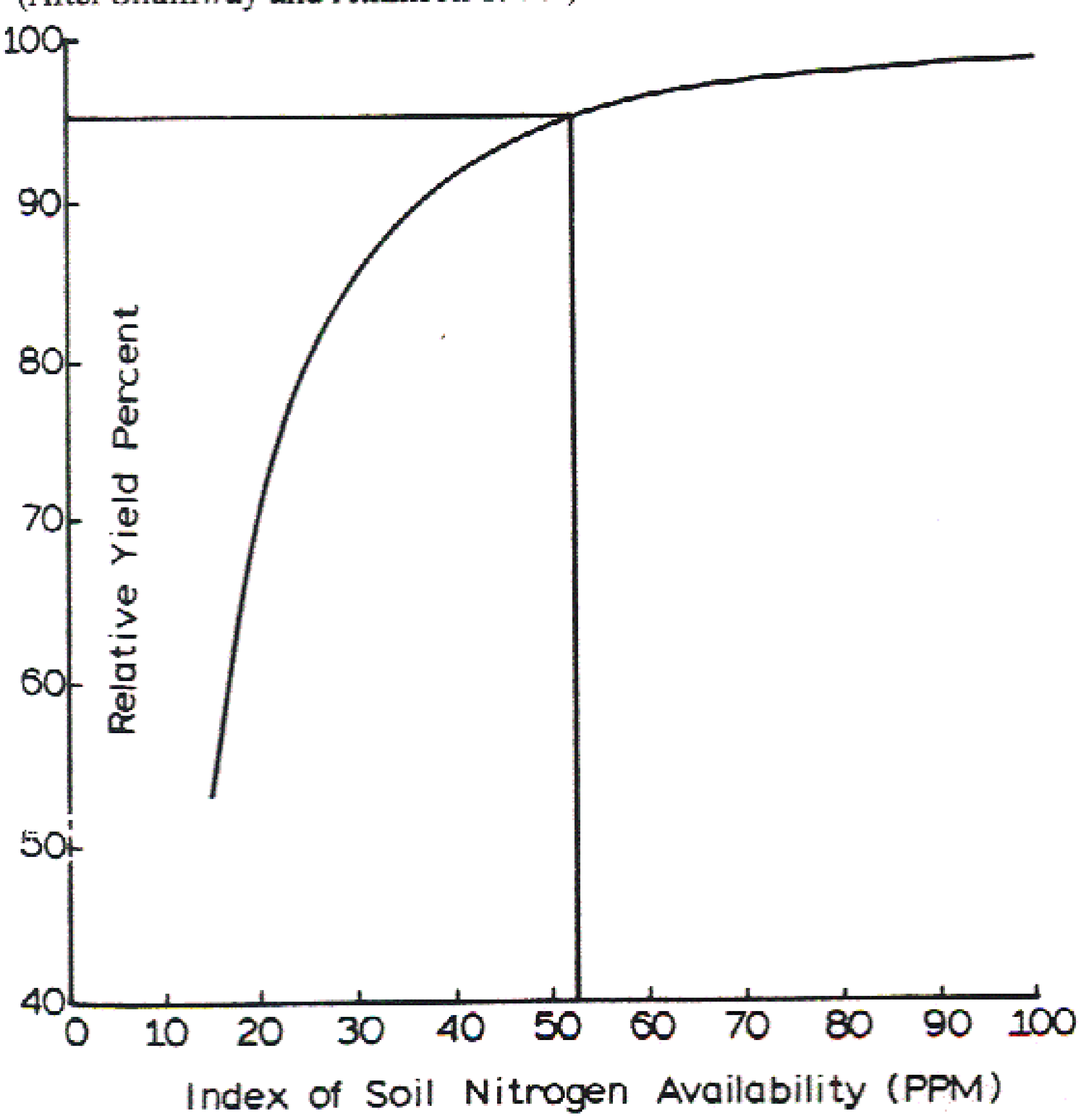
LIMITATIONS

Soil sampling and response variation within a series of plots at a single location form an obvious source that contributes to imprecision. More fundamental differences such as climate, stand structure, and levels of other nutrients are more serious sources of error. These factors can influence the level of response independently of any measure of soil N availability.

The use of relative yield as a measure of response reduces variation in data collected from plots distributed over a wide range of soil, site, and stand conditions. This measure has limitations in field application, however. As with any relative measure its meaning changes. On highly productive sites a 95% relative yield can mean a larger absolute response than the same yield level on a site of low productivity.

Soil testing techniques that examine the levels of only one essential element reduce precision since levels of other nutrients can in some cases limit response to N additions.

Figure 1. The effect of soil test N on relative yield of Douglas-fir. (After Shumway and Atkinson 1978.)



When other elements are more limiting than N (e.g., S and K), soil tests for N fail to predict accurately even when soil N is also low. If soil testing is used, its limitations must be kept in mind when interpreting the results.

PRESENT AND FUTURE USE

Soil tests that predict the need for fertilizer in forest crops of the Pacific Northwest are not currently available, but work to develop them is in progress. One test for N availability does look promising and is being examined by several individuals in Washington, Oregon, and California. This test measures potentially mineralizable N in soils and was developed for agricultural crops (Waring and Brenner 1964). This index correlates well with diameter growth response of selected Douglas-fir trees to the addition of 200 lb N/acre (Shumway and Atkinson 1978). Thus there is reason to believe that soil tests can be a useful tool in forestry.

Even if a soil test is developed for prediction of N response, its application in forest crops will be a challenge. This is particularly true where response estimates must be made on large tracts of land covering a wide range of soil conditions. The cost of annual sampling under these conditions could be prohibitively expensive.

One possible alternative to annual sampling is to develop an average index of N availability for a soil mapping unit and use this to estimate response wherever this mapping unit occurs. To be useful this technique requires that soils be reasonably uniform in N availability. There are some indications that this may be true for some soils. In a study of the response of western hemlock to N additions it was found that similar soil mapping units had similar levels of potentially mineralizable N even though they were separated geographically by up to 20 mi in one instance (Strand, Crown Zellerbach Co., pers. commun. 1979).

If potentially mineralizable N does prove to be a good index of N availability and is shown to be reasonably consistent within a given soil series or phase, it could provide at least an estimate of whether a given soil on average is above or below the decision point.

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CORPORATE STRATEGIES FOR FOREST FERTILIZATION

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ABSTRACT

Before embarking on a forest fertilization program, corporations should develop a strategy. Such a strategy includes making value choices as well as selecting alternatives. Making decisions about alternatives requires information. Research provides this information. Consequently research is part of a dynamic strategy for a process such as forest fertilization.

INTRODUCTION

Forest-based corporations which consider fertilization as a means of increasing productivity will get better results if a strategy is developed first. A strategy is the direction and specific ends desired plus acceptable means for getting there. Fertilization requires a fairly specific set of alternatives which only make sense in the context of desired results from forest management. Important components of a strategy are (1) value choices, (2) processes for making decisions (or choices), and (3) information needs.

VALUE CHOICES

The objectives of a fertilization strategy may appear obvious. Typically a corporation has a measure for evaluating increments in forest asset value. Present net value, internal rate of return or benefit/cost ratios are common measures. Establishing a guiding rate of interest or cut-off rate of return used by a corporation is a strategic decision. While a variety of economic arguments can be made for objectively estimating this rate, this decision varies in virtually all corporate settings. This rate determines the character, productivity, and raw material product matrix of a given forest type.

High rates lead to shorter rotations, small logs and more concern with fiber, chip, and reconstituted wood-based products. Low rates lead to longer rotations, larger logs, and more concern with lumber and veneer products. Consequently, the interest rate must be compatible with the basic strategy of a forest-based corporation or the forest assets will not be compatible with finance, production, and marketing.

The practice of forestry in an industrial setting is always a balancing act between today and tomorrow. As one corporate executive succinctly puts it, "If there ain't no today, there won't be no tomorrow." Even-flow volume constraints in the public sector have been discussed vigorously in recent years. While even-flow volume constraints are not common in corporations, cash flow usually is.

A simple method to analyze value choices is to list the criteria which are important; e.g., cash flow requirements, expected timber yield, present net worth, environmental factors, etc. These can be restructured if they are too narrow or too broad, and then ranked in terms of current importance. Criteria are listed as one dimension of a matrix and alternatives become the other dimension as shown in Figure 1.

Figure 1. A format for analyzing fertilizating decisions.

	ALTERNATIVE			
Criteria	A	B	C	D
Cash demand	X	X	X	0
Net present value	X	X	0	0
Environmental factors	X	0	X	0
Growth response/when	X	X	0	0

The "X's" represent known factors which are objective in the sense of being testable information about a given alternative. The "O's" represent information or facts which are not known. Before the trade-offs between alternatives can be evaluated and decisions made, this information is needed.

In cases such as alternative "D," in which all information in the matrix is unknown, the process of designing this alternative; i.e., specifying values for each criteria, becomes important. One approach to designing an alternative would be to assign values to the alternative which are equal to or better than the current best alternative in that criteria. For example, if alternative "B" was best in terms of *Net Present Value*, then this value would be assigned to alternative "D." Estimating unknown values for other alternatives; i.e., estimating a value for *Environmental Factors* for alternative "B,' will further enhance the creative process of designing alternative "D."

A final set of strategic choices includes who sets the strategy and how they do this. A strategy is a complex creation and its success in a corporate setting ultimately depends on the cooperative actions of many people. Consequently, a strategy set by one person, at minimum, has to be sold to other key managers. In many cases the final strategy selected will be superior and its execution will be according to plan if a broad group is responsible for its development. This leads us to the processes for making decisions.

PROCESSES FOR MAKING DECISIONS

Complex processes for making decisions exist in most corporations. These processes often develop empirically and usually can be improved. Forest fertilization and other silvicultural choices are merely examples for questioning whether current processes are efficient, effective, and creative.

There are several questions which can be asked about a decision process.

1. Who participates in decisions? How?
2. Who sets objectives? Constraints? Criteria? Goals? How?
3. Who designs alternatives? How?
4. Who evaluates alternatives? How?
5. Who implements decisions? How?
6. Who tracks implementation? How?
7. Who analyzes feedback? How?

Note that any comprehensive process which involves several people requires a lot of communication. Usually some thought is necessary to improve communication. Foor communication can be improved by exposure to better techniques, especially more verbal and visual methods. But poor communication often is a symptom of more serious difficulties. An open atmosphere is necessary for good communication. Correction of such fundamental difficulties is not easy, but is possible (although well beyond the topics of this discussion).

INFORMATION NEEDS

Three contexts exist with regard to available information: (1) complete, (2) almost none, and (3) partial.

Given the many papers of this Alderbrook Conference, most readers would agree that "partial information" characterizes the environment for forest fertilization. Before deciding on a strategy the following is needed: (1) What is known? (2) What is not known? (3) What may be known soon? (4) What difference will new information make?

If new information is unlikely for some time, a strategy has to be set in a context of greater uncertainty than is desired. The value of new information may be low, however, which indicates that uncertainty is inherent in the decision-making groups as opposed to being caused by a lack of information.

Research is a means of acquiring information. Forestry in North America is a public activity and much of the research is performed by public agencies and universities. So one alternative is to use outside research sources entirely. A corporation which uses this alternative needs staff members who can critically review research results and translate these into operational terms.

Another alternative is to rely on internal research. This presumes that the complexity of forestry is such that each corporate setting is uniquely different. There is a danger of isolation from the scientific community; a danger which is enhanced if a corporate research group presumes itself in some sense superior to others. This alternative is expensive per unit of new information, which is its greatest drawback.

Cooperatives are an increasingly popular method for conducting research which benefits corporations. The simplest type of cooperative involves multiple corporate sponsors giving grant-in-aid funds to a university for specific studies. More complex co-ops involve sharing data, field tests on cooperator lands, and/or close interactions of personnel. Because public agencies often have essentially the same silvicultural problems, they often are members of co-ops with industrial firms.

Mixed research strategies have much to recommend them. First, most corporations need a small research group at minimum to solve internal problems and interpret external results for internal use. Second, both cooperatives and close monitoring of external groups reduces the cost of information and increases the robustness of internal information. The particular scale selected is peculiar to a given corporation and reflects the view of its future as well as the size of its resource base.

There are also a number of ways of mixing research with operations. Basically, all operational implementation can be viewed as a learning experience. With some forethought regarding design and measurement, operational experiences can become feedback information which can be evaluated by research. Given the complexity and dynamic nature of forestry, this strategy greatly reduces the cost of gathering information. Some information, especially time-series data, is extraordinarily expensive to gather in a strict research context.

Further, a mix of cross-sectional and time-series data provides a base for eliminating bias in most silvicultural growth-response estimates.

COMMENTS AND SUMMARY

The range of corporate strategies on forest fertilization is similar to those facing public agencies. In both cases, objective information is important, and facts should be separated from values. The role of objective information, indeed, is set by several critical value choices. Perhaps the most critical choices concern the processes by which these choices are made. Who makes the decisions? How are the decisions made?

Industrial forest fertilization only makes sense in terms of corporate strategies. All strategies have risks. Better strategies are not risk-avoiding, but instead are based upon learning. What is a high risk today will become better known and a lower risk over time, whether by acceptance and experience or by rejection. But new risks will enter the picture in a learning strategy because learning always probes the boundaries of "what is" and "what might be."

Research is a means of generating new information which, in a sense, reduces uncertainty. But research also creates new boundaries and uncovers new ideas which in turn increase uncertainty. The future depends upon how many new options are created and exploited.