Chapter 21

Fertilization in Western Washington and Oregon: A Checklist for Projects on National Forest Lands

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ABSTRACT. Background information is presented on the past role of fertilization in national forests of the Pacific Northwest and current practices. A specific description is given of the step-by-step process followed at the Gifford Pinchot National Forest, in southwestern Washington State, in planning and carrying out a fertilization project.

The National Forest System in Washington and Oregon got a late start in forest fertilization. One reason for the delay was the backlog of large areas undergoing other, more traditional forms of timber stand improvement (TSI). A second was the lack of usable (understandable) literature. And a third reason was a shortage of actual project experience.

In 1969, the Regional Forest Nutrition Research Project (RFNRP) was established at the University of Washington. In the following years, systematic sampling was done, first for second-growth Douglas-fir (*Pseudotsuga menziesii*) and later for western hemlock (*Tsuga heterophylla*) forests. The RFNRP provided an organized system of information sharing. I believe this single step has contributed more to the practice of fertilization in the Pacific Northwest than any other. The cooperative has members representing both large and small private corporations as well as several state and federal agencies. The change in traditional uses of TSI to include fertilization can be seen in the trends of the last 15 to 20 years. Through 1984, national forests in Washington and Oregon fertilized about 31,400 hectares. In the last six years, about 62,700 hectares were completed, a fourfold increase in the area treated on an annual basis.

In 1988, forest fertilization accounted for 22% of the TSI area treated in the Pacific Northwest. Of the area fertilized in the entire National Forest System, 80% came from this region. Over many years, Forest Service policy in the Pacific Northwest has evolved to the present practices:

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- Forest fertilization may be performed in established stands where research or administrative studies have produced reliable data that predict, with reasonable assurance, gains in volume or value for the species to be fertilized. For example, research has shown that Douglas-fir on the west side of the Cascades will demonstrate an adequate response 70% of the time. However, research has also revealed that coastal western hemlock is quite variable in its response to the addition of nitrogen, while the variety that occurs on the west slopes of the Cascades is much more predictable. East of the Cascade crest, response data from research are not as plentiful, requiring that response data in support of fertilization be from site-specific research or from areas where the soils can be correlated with a similar tested land type that showed acceptable gains in volume or value. The correlated soils should have the same soil moisture and temperature regime, particle size class, and parent material.

- The predicted environmental effects of fertilizing should be included in an environmental analysis report. An environmental impact statement may be needed for fertilization in some municipal watersheds or other sensitive areas. A categorical exclusion may be appropriate in some situations. Projects will be designed to meet applicable water quality standards, and monitoring will be conducted as a routine part of any fertilization program likely to affect lakes or streams. Monitoring to determine growth response will be addressed in the forest plan monitoring process.

- The decision to fertilize a particular stand should be based on a silvicultural prescription containing appropriate supportive information for selection of the fertilization treatment, including stand examination data, an economic evaluation, and multiple-use direction for the site.

- Administrative studies already established should be continued and measured for a minimum of ten years following treatment. Measurements beyond this period will be determined on a case-by-case basis. Plans for installing trials in new areas will be coordinated with the Regional Office. New trials will be installed and established in accordance with existing procedures of the RFNRP for westside forests and the Intermountain Forest Tree Nutrition Cooperative (IFTNC) for eastside forests, and in coordination with the forest plan monitoring process.

In the following pages, I will describe several categories familiar to many readers. My remarks reflect activities and experiences gained on national forest lands in the Douglas-fir region of western Oregon and Washington with particular reference to the Gifford Pinchot National Forest, in southwestern Washington. This information is intended to represent a wide array of conditions and experiences encountered.

Decision Making

One of the largest planning obstacles to overcome is deciding where fertilizer should be applied. Four important approaches are followed on the Gifford Pinchot: identifying responsive soils, selecting suitable stands, predicting response, and doing economic analysis.

The University of Washington (RFNRP) program provided some basic soils information of a regional nature. Those data indicated that most soils were at least somewhat deficient in available nitrogen and that additions of about 224 kg/ha appeared to give the most response for the cost expended. Our forest expanded the data base by installing trials on major soil types covering large areas. Today, soils on about 210,400 hectares, or 40% of the forest, are considered to be deficient in nitrogen. In addition, we have data indicating response duration and magnitude of stand response.

The second consideration is that stand conditions must be similar to those encountered in the fertilizer trials. "Best" qualified stands (1) have crop trees that are mostly Douglas-fir with crown ratios of at least 40%, (2) have stocking level control completed, (3) are 80 to 13 years old, and (4) are on site III (culmination of mean annual increment is 8.4 m^3/ha per year), corresponding

Table 1—Ranking of Douglas-fir stands for fertilization with urea, by stand age, site class, and thinning, Gifford Pinchot National Forest. Highest priority = 1; lowest = 31. Partially adapted from the RFNRP Biennial Report, 1974-76.

Stand Age (yr)	Site Class: Unthinned IV	III	II	I	Thinned IV	III	II	I
25	31	29	28	30	27	25	24	26
35	23	21	20	22	19	13	12	17
45	16	10	14	18	9	4	6	11
55	9	5	8	15	3	1	2	7

Note: Of the first 10 priorities, 6 are site III or lower. Of the first 19 priorities, 6 are in the older age classes.

Table 2—Benefit-cost ratio at two market interest rates.

Project Cost ($/ha)	Benefit-Cost Ratio At 7 1/8%	At 15%
220	13.8	9.7
250	12.4	8.7
270	11.3	7.9
300	10.3	7.2

to average productivity (site I has high and site IV has low productivity). This information can be sorted and arranged into a ranking table for stand selection as displayed in Table 1.

Site-specific stand examination data from the project area are arranged in a format compatible with trial information. Using stand data, a predicted gain is made for the project area according to the appropriate mix of trial information.

Based on anticipated project response and assumptions about the future value of wood, a range of benefit-cost ratios is displayed using different project costs and discount rates. Hence a decision can be made relative to other TSI projects that qualify for the same scarce TSI dollars, as long as assumptions used in the economic analysis are the same for all projects. Table 2 is a sample display of economic analysis. Many other approaches are possible.

An environmental analysis can be incorporated into this decision-making process. This documentation is prepared in advance of the project. Included in the analysis is a description of the action, alternatives considered, an environmental effects summary, and contacts with the public.

Application Monitoring

Uniform application of fertilizer by aircraft in mountainous forest land is difficult to achieve. Two factors can affect the distribution pattern: (1) the amount of fines or dust in the bulk product and (2) the ability of the pilot. We control the first factor by measuring representative samples of fertilizer for dust content; the service contract contains load rejection provisions if fines exceed a specified percentage (currently 10%).

Monitoring the distribution pattern of fertilizer reaching the forest floor requires fast-moving Forest Service ground checkers. These people are usually in contact with the pilots and can advise them on distribution problems, skips between flight lines, and other missed areas.

It is strongly advised that the contract require "calibration flights." This involves flying over containers arranged in a systematic grid. Measurements are made of the swath width and weight of fertilizer in the containers. Visual inspection of this calibration procedure can also provide the field checkers with an idea of how 448 kilograms of urea appears on a hectare.

The project layout sometimes facilitates even distribution. Project boundaries must be visible from the helicopter, and have uniform long, smooth lines. We help by marking boundaries with flags, helium-filled balloons, and flares.

Environmental Monitoring

Although fertilizers are technically not a pesticide, applications receive the same attention as applications of herbicide. A contingency plan is prepared which details procedures for accidental spills and cleanup. Significant spills (needing immediate attention) are described and procedures given for each case. A system for notifying specific individuals is included. The Forest Pesticide-Use Coordinator is the first person to be notified. Because we have never had an incident involving fertilizers, our contingency plans remain untested under actual conditions.

Water quality sampling is conducted to develop natural (as closely as possible) background levels of sediment, chemical content, and temperature. Project area sampling is done to monitor impacts. Fertilization projects are easily coordinated with regular water-monitoring activities. The only difference is increased sampling during the project and shortly thereafter. Eventually, water sampling decreases to pretreatment frequencies.

Fortunately, unlike herbicides and other chemicals used in forestry, fertilizers do not generally raise public concern. However, the consideration given to a fertilization project implies, by design, the same carefulness as for an application of herbicides. We believe the small price required to carefully exclude streams and lakes from project areas and to monitor water quality is justified.

Response Monitoring

The difference between the predicted response (based on a closely measured, carefully applied research or administrative trial) and an actual large-scale operational project is termed "falldown." Our response monitoring plan, developed at the regional level, provides a means of assessing falldown.

The basic steps include: locating and marking paired plots to be used for comparisons, keeping records in a data system for later recall and to provide information for other system users, taking first measurements on the plots, observing treatment application, remeasuring five years later, doing the calculations, and providing the results.

In the overall prediction process, the falldown factor can be incorporated to increase the reliability of the predicted response. In turn, future assessments can be made with a better linkage to typical situations which are not as closely controlled. Several authors have speculated that the falldown factor is from 20 to 40%; results from our monitoring have not been completed.

Project Operations

Because of the logistics of moving and positioning heavy, bulky loads, environmental problems may arise in connection with fertilization projects. In preparing the environmental assessment, project areas are verified in the field. We have found that closely clustered project areas are most efficient because they minimize flying time and bulk-hauling costs. By experience, a project size of at least 400 hectares is most desirable to minimize per hectare costs; larger areas are better. Roads suitable for use by heavy trucks with long trailers are needed in order to access large heliports.

With an approved environmental assessment and field verification, a service contract is prepared for advertisement. The contract provides for the contractor to secure, deliver, and uniformly spread the fertilizer over a specified number of hectares. The contract specifies contractor-furnished property and services as well as government-furnished property and services. Fertilizer specifications are indicated, and minimal weather conditions for work are outlined. Fertilizer is spread in two flights, usually at right angles to each other or in reverse directions. One-half of the fertilizer is applied in each flight to increase uniformity and reduce skips (zebra effect). The application rate is clearly specified.

Control of the project is through application and contract administration. It is up to the contractor to purchase and deliver the fertilizer to the project area, and apply it at the proper rate. Since a variety of equipment is available, it is the contractor's responsibility to tailor the equipment and operation to perform according to the contract. Performance of the contract specifications is ensured by a list of "Do's," as outlined below.

A. PROVIDING EFFECTIVE ADMINISTRATION

1. Have a sufficient number of personnel available.
2. Have pilot, ground crew supervisor, contractor, and Contracting Officer's Representative (COR) attend the pre-work meeting.
3. Have an open line of communication between COR and contractor. Stress the need to have the contractor communicate with his fertilizer supplier. Have the contractor inform his supplier of the Ranger Station telephone number so messages can be relayed to the project COR.
4. Plan how to get fertilizer supply vehicles to the heliport and away from the heliport.
5. Have access roads well signed so truck drivers can locate the project.
6. Have all inspectors well briefed in advance of the project so they know their duties and responsibilities and the location of the project on the ground. They need to know the exact inspection sites, where the water monitoring spots are, the time required to travel to the inspection sites, the chain of command (Who has what authority? With whom do I talk?). Provide everyone with a copy of the Implementation Plan. Meet the night before, so everyone knows where to be the next morning.
7. Post the project area to warn the public of possible delays and also to direct traffic.
8. Have an information person to control the public at the heliports.
9. Stress safety. Everyone needs to know what's going on.
10. Have someone at the ranger district office to act as a runner or supplier (to supply radio batteries, smoke bombs, balloons or gas, etc.).
11. Arrange for someone else to administer other contracts. It's going to be a full-time job for CORs and inspectors to administer and inspect this project.
12. Approve the time required to administer the project (overtime, comp time, over 12-hour days, seven days per week, etc.).
13. Prepare a contingency plan for spills.
14. Gather weather forecasts, both long-range and local predictions, if available.

B. DOCUMENTING THE PROJECT

1. Have everyone on the project keep a daily record or provide the COR with information to prepare a consolidated diary.
2. Record the weights of fertilizer loads.
3. Summarize the test results for "fines."
4. Maintain the flight log.
5. Maintain the radio log.

C. PROVIDING SECURITY

Security on a project is often overlooked. There is always a danger that equipment left in the field could be vandalized or stolen. Certain groups or individuals who are opposed to the application of pesticides may decide that fertilizers are also undesirable. Marijuana growers may try to interfere with the operation to avoid detection of a garden.

It is easy to advise your law enforcement coordinator of the location and time of each project. That person should know who is to be contacted if assistance is needed. If there is suspicion that some overt interference or violent opposition will occur, then the Forest or Zone Special Agent should be advised of the situation, date, and location. The agent will coordinate with the local law enforcement agencies and the Regional Office.

To date, a formal security plan has not been necessary because of the lack of incidents involving fertilizer application projects.

Conclusions

This chapter briefly describes the process from beginning to end for a fertilization project. The items constitute a checklist for project development. Early planning is necessary and may precede an actual project by several years. In contrast, quality control procedures, such as water monitoring, may run several years after a project has been completed.

Questions and Answers

First, are you able to randomize your control plots and fertilized plots in your response monitoring? If not, how do you interpret whether growth response (or lack of it) is treatment related? Second, are the Gifford Pinchot NF monitoring data statistically sound information? If not, is the investment in monitoring at the project level worth it?

Our monitoring for falldown is not intended to be a fully randomized, statistical design. The objective is to provide a generalized quantification of the relationship between carefully controlled studies and extensive project operations.

The plots we establish are a part of a regional perspective and have some randomization built in. The current procedure was designed by a group of researchers and practitioners to give some indication of response to operational fertilization. It is not intended to be research.

Treating fertilizer as a pesticide seems to send a wrong and misleading message to the public. Why not just call it a "nutrient amendment" and set up an appropriate set of protocols accordingly?

We do not call or advertise fertilizer as a pesticide. We have taken the opportunity to use an existing set of procedures rather than to develop a new process. Also in reaction to incidents, a level of common sense prevails.

How does New Forestry enter into fertilization plans and practices, or vice versa?

We do not consider fertilization to be related to New Forestry. Forest fertilization is one of the tools available to the art and science of silviculture. As management objectives change, there may be new opportunities and challenges to apply silvicutural techniques, such as the addition of nutrient amendments.

What would you consider the smallest acreage you would fertilize? Is there a point where hand application becomes more cost efficient?

I do not know. All of my experience has been related to aerial applications, due to steep topography. I prefer to keep projects at the 400 hectare minimum, because this is about a three-day project. The program manager must decide if a smaller project is worthy at that time or if a delay would add area and increase efficiency of operations. Also there is a minimum size/shape relationship for efficient aerial applications. Some equipment configurations will perform better on small units and others will be more suitable for larger units. We highly encourage potential contract bidders to review the areas before submitting a bid. We assume the successful bidder will have considered all conditions pertinent to the conduct of a successful contract, including total project acres and individual unit size and shape.

Do you have seed orchards on the Gifford Pinchot? If so, do you regularly fertilize them; how often and with what type of fertilizer?

We have several seed orchards in existence. However, they are very young and have not, as yet, started producing seed. Several needs could become evident in the future. Exploration of the genotype x fertilizer interaction will become increasingly important, especially as we move into the second growth and plantation harvesting. A second need is the maintenance of seed orchard soil fertility. Depending on tree species and diagnosed nutritional deficiencies, a regime of supplementation will be used. In fact, in some of the older seed orchards on other national forests, trees have grown so fast as to become troublesome to harvest cones.

What has been done with groundwater monitoring at Forest Service sites?

Currently I know of no research that establishes a relationship between forest fertilization activities and effects on groundwater quality in the Pacific Northwest. We continue to be sensitive to the situation and will change as information warrants.

How many acres has the Gifford Pinchot fertilized?

About 23,000 acres (9,300 hectares) have been treated.

Instead of permanent plots in the units of the fertilization project, will not stand examinations three to five years after the project is completed do the same job, especially when compared to the stand exams that were used to identify the units to be fertilized before the project?

Stand examinations could be used but under the following conditions: (1) The prescription exam would have to be conducted under very strict standards and careful measurement techniques, over and above that typically used to develop a silvicultural prescription. (2) We would have to use the same plot centers on the postfertilization examination to minimize within-stand variation.