THE FOREST GENETICS PROGRAM FOR THE NORTHERN REGION

USDA, Forest Service
Missoula, Montana

By

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APPROVAL SHEET

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Date

PREFACE

Forest genetics comes of age. It is no longer regarded solely as the science of breeding super trees. Tree breeders have learned that evolution has created remarkable adaptive mechanisms often disrupted by Man's manipulations. In the Northern Rockies, some adaptability may have been lost already in resource management practices. In preventing these losses in the future we will leave a precious inheritance - literally - to our children and grandchildren. It will be an inheritance of the full range of biological options that 400 million years of terrestial plant evolution has created. It will be an inheritance willed by competent forest biologists working together and using the tools of understanding. Society's demands will be met through practices dictated by the natural history of an area, and not by the current demands of the consumer.

The Forest Genetics Program for the Northern Region is a statement of our intent to manage -- not simply manipulate -- plant gene resources in our National Forests. It represents a synthesis of current genetic concepts and principles applied to resource management in the Northern Rockies. This document is, in effect, the will and testament for 17 million acres of forests. The science of genetics, broadly applied, will help assure that these forests are passed on as adaptable as they were received.

Regional Forester

ABSTRACT

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by

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The principles of genetics are applicable to all resource management functions. Man's manipulations of vegetation in all major resource management activities in the Northern Rockies effect evolutionary change. Chapter I identifies the genetic implications of:

1. Artificial and natural reforestation.
2. Fire and fuel management.
3. Insect and disease control.
4. Timber stand improvement, including the application of synthesized chemicals.
5. The loss of plant populations to construction projects, industrial pollution, and natural catastrophies.
6. Rehabilitation.
7. Tree improvement projects.

A more thorough discussion of genetic principles and their implications for resource management in the Northern Rockies appears in Appendix 1. The current conduct of these activities suggests that resource managers in the Northern Rockies are not entering genetic planning into their management prescriptions. The deficiency results from inadequate genetic education.

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¶ Chapter II focuses on the application of genetic principles and breeding technology to increasing tree fiber volume yields on lands managed for timber production. Costs dictate that the Tree Improvement program be designed for highly productive lands only. Thus, the demands for improved trees are developed by determining future planting needs on Productivity Class (PC) 1 and 2 lands. It is assumed that the benefits of tree improvement will increase planting demands in the future.

Project priorities are developed from computations of need for improved seed, modified by:

1. The relative amounts of fundamental genetic knowledge available for different species, and

2. The potential for cooperation from other agencies and organizations.

The priorities, in descending order are:

1. Douglas-fir, western white pine, ponderosa pine for appropriate PC 1 and 2 lands west of the Continental Divide.

2. Lodgepole pine for all appropriate PC1 and 2 lands; western larch for appropriate PC 1 and 2 lands west of the Continental Divide.

3. Engelmann [and white] spruce for all appropriate PC 1 and 2 lands; Douglas-fir for appropriate East Side PC 1 and 2 lands;

(;) grand fir

for appropriate West Side PC 1 lands.

4. Subalpine fir for all appropriate PC 1 and 2 lands.

A tree improvement flow chart shows the procedures for sampling, evaluation, selection, breeding, and mass seed production. Most projects are started with low-intensity-selection, high-volume sampling of wild populations, followed by establishment of uniform-environment, multiple-plantation progeny evaluation. Relative performance of groups in these evaluation plantations will permit reliable selection of superior genotypes. Earmarked evaluation plantations will then be rogued - on the basis of group performance - into seed orchards, where crossing of superior genotypes and mass seed production will proceed. In the meantime, parental wild stands tentatively identified as superior (from early progeny evaluation data) will be thinned to produce seed perhaps 2- to 3-percent improved.

Two elementary economic analyses of tree improvement in the Northern Rockies are presented. Both show the undertaking to be economically viable. Yet, tree improvement is not to be justified solely on its internal rate of return or current net worth, for there are many other compelling benefits not easily quantified by economists. Ten are listed.

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The first commercial plantings of genetically improved seedlings-- rust-resistant western white pine--will be in 1974. These plantations should be ready for commercial thinning in 2004. Two percent improved Douglas-fir and ponderosa pine seed will be available in 1980 or earlier to meet a portion of the planting needs of National Forests and cooperators. Small amounts of improved grand fir seed may be available by 1975. Dollar returns from 1980 plantations should commence in 2010.

Plans are laid also for the acquisition of unimproved seed so as to control seed source tightly. By 2020 most unimproved seed is to be gathered in multiple-species seed production areas. Establishment of these areas is to commence in the decade of the 70's.

Chapter III identifies and plans for specific educational needs of National Forest and Regional Office personnel for meeting their responsibilities as custodians of gene resources. The first is to build a thorough genetic foundation for Forest and District personnel making resource management prescriptions; the second is to provide specific skills to those implementing tree improvement projects; the third is to develop support for the Forest Genetics Program from the Regional Forester's Staff and Forest Supervisors. The Northern Region's Program for Continuing Education in Forest Ecology and Silviculture meets part of the first need. The program will be supplemented by a multi-media packaged course of instruction. Training for tree improvement projects, too, will be accomplished through a multi-media training package. To meet the third need, the Regional Geneticist will prepare a multi-media explanation of the Forest Genetics program for his presentation at Staff and Supervisors' meetings.

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Finally, Chapter III plans for genetic inputs into the Northern Region's Native Shrub Program. The objectives are very different from those for timber. Consequently, the genetic considerations differ also. These considerations are discussed and a procedure for making and implementing genetic recommendations is detailed.

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CHAPTER I

GENETICS IN THE MANAGEMENT OF FORESTED LANDS IN THE NORTHERN REGION

INTRODUCTION

Like Nature, man's impacts on ecosystems have as their final consequence changes in the genetic constitution of living organisms. The wisdom of current land management activities will be measured by the quality of the genes in future generations of forest plant and animal communities.

Forest genetics in Northern Region (fig. 1) forestry has evolved from breeding super trees to the broad perspective of applying genetic principles to all resource management activities. Gene frequencies of plant populations are changed not only by our Tree Improvement Program, but also by our regular reforestation practices, fire and fuel management, insect and disease control programs, cultural practices, and by construction and industrial processing. The Forest Genetics Program, based on biological principles (Appendix 1), is a start at building into the consciousness of our resource managers a custodianship of gene resources.

Figure 1.--Map of Region 1 National Forests.

This expanded perspective of forest genetics in no way devalues the need for the Tree Improvement Program. Its potential was formally recognized in a document drafted in 1965 and revised in 1968 and again in 1970 (Wellner et al.). This earlier document emphasized white pine

Figure 1.--Map of Region 1 National Forests

blister rust resistance breeding.

The current document is the next stage in the evolution. The "selection pressures" have changed. Biologically we're more knowledgeable. Study of the genetic control of blister rust resistance shows that natural selection is increasing resistance of the white pine in some areas faster than we would have predicted. Our understanding of forest ecology discourages practicing monoculture in most of our timber types. Natural regeneration on many highly productive sites is more efficient than planting. The increasing demand for forest products from a diminishing available commercial forest land base (Anon., 1972a; Anon., 1972b) makes it imperative that we increase the volume yield of timber growing on the acres remaining. These concepts were not principal considerations in the earlier Tree Improvement Program plan. The foregoing factors demand equitable attention to all commercially important species in developing the Tree Improvement Program to meet current and future needs.

ACTIVITIES NEEDING GENETIC PLANNING

Forest managers must recognize and plan for the genetic consequences of their actions. Genetically-informed action can optimize genetic quality and biological diversity. For example, understanding the genetic control of blister rust resistance in western white pine will help in writing marking guides for a harvest operation in northern Idaho. The prescription will require that rust-infected but surviving mature trees in long-infected stands be left to regenerate openings, along with some of the disease-free white pines. Likewise, the silviculturist who recognizes the respective roles of environment and genes on variation in low-heritability traits finds more options in marking a natural regeneration harvest cut.

These same managers will relate the natural history of the Northern Rockies to evolution--the changes in gene frequencies over generations, leading to adaptation to local environmental conditions. They will be wary of initiating or continuing treatments which do not parallel natural environmental influences. The genetically-informed manager will refuse to use inadequately-tested, nonlocal seed for his artificial revegetation projects. He will assess the value of genes to be lost to major construction projects or industrial processing before they are initiated, and he will bank those genes potentially useful.

He will recognize the roles of natural wildfire in shaping plant and animal populations. Has genetic drift played a more important evolutionary role in the Northern Rockies than in other North Temperate regions? How strongly inherited are fire-adaptive traits? How rapidly will they be lost with fire exclusion? Do we have native insect or disease pests that have been so dominantly controlled by wildfire that hosts have never built genetic resistances? What will be the genetic response of a tree species to an exotic insect or disease pest?

Two influences introduced by man -- slash and blister rust mortality -- in northern Idaho are building fuel at rates seldom equal ed in the natural history of the area. What will be the genetic consequences of the conflagration certain to come in time if foresters do nothing to reverse the fuel buildup? How does prescribed burning differ from wildfire burns through evolutionary time, and what are the consequences? The informed manager will require answers to these questions before planning protection and cultural activities.

Thinning also has the potential of changing gene frequencies. The silviculturist must be able to predict the genetic worth of leave trees if some are to serve as parents for the next generation.

Artificial forestation, too, can make rapid changes in gene frequencies of forest tree populations. The changes can be made desirable or undesirable, or they can be avoided. An understanding of evolution is required of the forester enforcing cone collection standards, the nurseryman identifying and tracing seed and seedlings, and the planting officer checking the stock or seed identification in the field. The nurseryman has an added responsibility: his cultural treatments and culling practices impose early and often stringent selection pressures which may or may not enhance later adaptability or productivity.

The same kind of understanding is needed for revegetation with subarboreal plants. However, the objectives for establishing plant communities, the severity of land disturbances, and the plant life cycles are likely to be different from those for tree reforestation, and the manager must adjust his genetic inputs accordingly.

WHAT KINDS OF GENETIC CONSIDERATIONS ARE NEEDED?

Land management agencies in the Northern Rockies conduct many practices paralleling natural events. These probably have no dysgenic consequences. Other practices are undertaken in ignorance of the genetic consequences. Sometimes resource managers have consciously applied possibly dysgenic practices for short-term benefits at the sacrifice of long-term genetic quality. The following sections discuss the most serious problems.

Planting and Direct Seeding

For many years yet, the seed for most stands harvested in Region 1 will be from genetically unevaluated sources (fig. 2). It should be assumed that seed from local sources is best adapted to local conditions unless data show otherwise. The Northern Region has developed a system for identifying seed by elevational zone, geographic area, and habitat type (Daubenmire & Daubenmire, 1968; Pfister et al., 1972; Pfister et al., 1973) so that plant material can be used in the area from which it originated. The system is only partially successful. Two questions remain unanswered:

Figure 2.--Regenerating a harvested area by planting. Is the seed source appropriate?

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(1) Where are the genetic populational boundaries?

(2) How can we be assured of using only local material until the first question is answered?

Other questions in artificial reforestation are:

(1) What is the probable genetic quality of trees providing seed for artificial reforestation?

(2) What is the consequence of the various artificial selections to which seed or seedlings are subjected between tree of origin and the establishment of a forest stand?

(3) Can the above potential problems be partially solved by the Tree Improvement Program?

Answers to these questions are provided in Chapters II and III.

Often, planting or direct seeding of a cutover area is partially justified on the assumption that suppressed or poorly-formed trees produce genetically inferior seed if left to naturally regenerate an area. This assumption is invalid for many North Temperate conifers

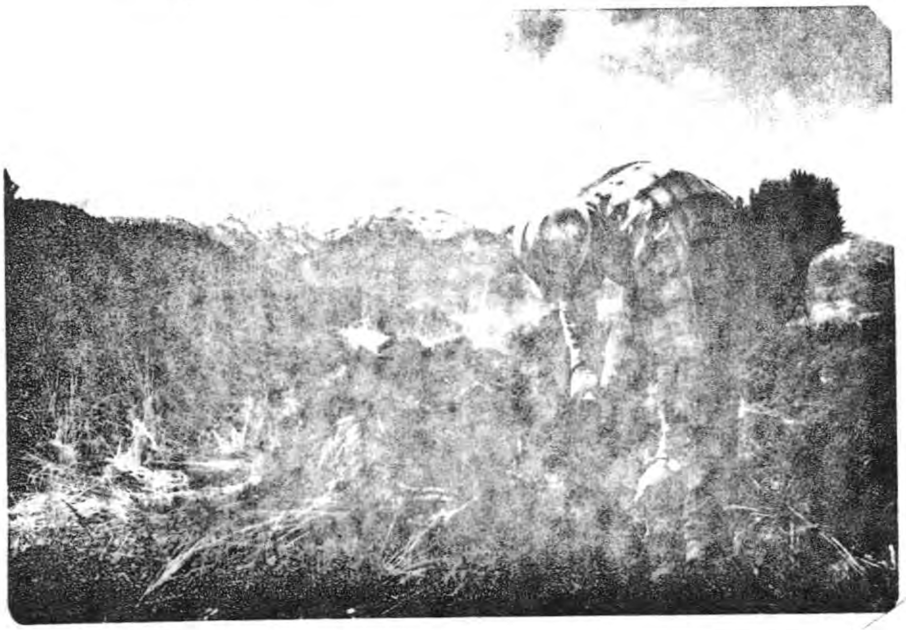


Figure 2.--Regenerating a harvested area by planting. Is the seed source appropriate?

(Howe, 1971; Kral, 1967; Rolmeder, 1961; Vins, 1966) if the suppression or poor form is not due to disease or insect activity (which might indicate genetic susceptibility to the pest). Genetic variation in growth traits among trees in a stand is usually masked by the variation induced by environmental influences (fig. 3). This masking is probably especially marked in the Northern Rockies where there are enormous and abrupt environmental gradients.

Figure 3

Undoubtedly the most dramatic change in the future of artificial reforestation will be the production of eugenic seed improved for traits important to people who use forests and forest products. Tree improvement programs, while offering much potential, must be undertaken with caution. Severe narrowing of the gene pool base must be avoided, as well as the use of inadequately tested nonlocal sources. The tree breeder must recognize that natural selection has built remarkable balance mechanisms among competing biological and environmental systems. Gene combinations developed for other systems can be inappropriate for local conditions, and lead to disease, insect, growth, or mortality problems not presently serious in native populations.

Natural Regeneration

In the past, forestry agencies have been too little concerned about the genetic quality of parents for natural regeneration (fig. 3a). There is evidence that some current practices are dysgenic, particularly with regard to insect and disease susceptibility(Appendix I). Current public pressures to improve the appearance of logged-over areas have prompted some National Forests to leave esthetically pleasing trees--three to seven live cull trees per acre which would normally be felled following

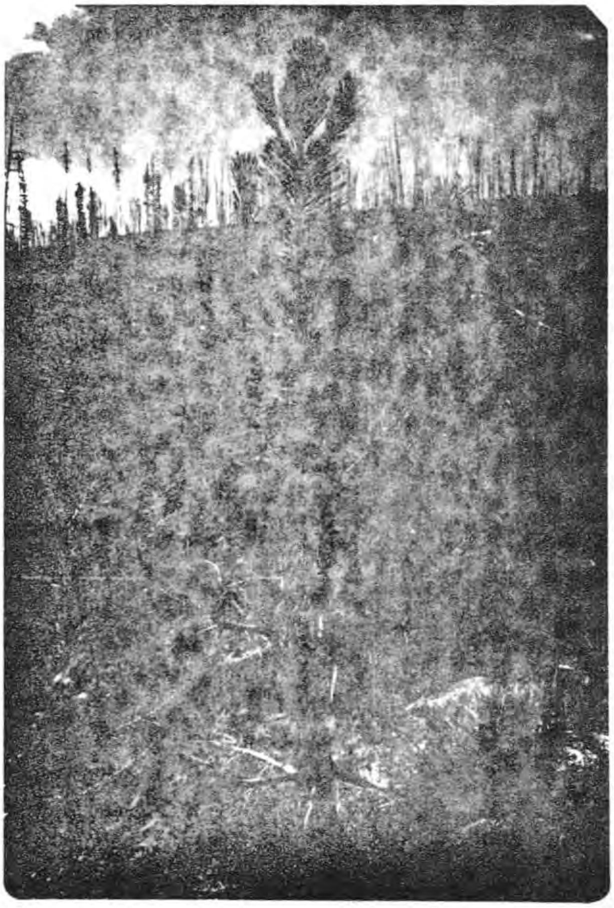


Figure 3. What is the relative importance of genes and environment? Although the two ponderosa pine trees appear to be the same age and growing under similar conditions, the difference in height probably is determined more by environment than genes. (Additional discussion in text, page 7 and Appendix I.)

clearcut logging--to enhance the landscape. These trees are frequently full of disease or insects, yet are contributing to the regeneration of the sites. This practice, and similar unconcern for the potential genetic quality of leave trees in partial cutting, may be an effective selection for disease or insect susceptibility in the regeneration (See Appendix I).

Figure 3a. --Alternative partial cuts. What is the comparative genetic quality of the parents of the regeneration?

Another area of concern is the genetic quality in growth traits of trees to be left for regeneration in partial cuts. As noted earlier, we frequently do not have the ability to recognize the genetic quality in growth traits of trees growing in a wild stand. It follows, if this is true, that suppressed and poorly-formed trees, if they are healthy, may be left for regeneration without fear of deteriorating genetic quality.

Timber Stand Improvement

Thinning

In stands entered for thinning, the silviculturist already should have planned his regeneration harvest cutting method. If it is to be a shelterwood or seed tree cut, he must recognize that some of the trees he leaves now will be the parents of the next stand. What is their probable genetic quality? How strongly is this quality inherited? Will the genetic considerations suggest compromises in selecting leave trees principally on economic projections? That is, will some of the trees which will "pay their way" if removed in thinning be trees that ought

Figure 3a.-- Alternative partial cuts. What is the comparative genetic quality of the parents of the regeneration?

to be left for genetic reasons, while subeconomic trees are taken instead?

Other Cultural Treatments

What is genotype X environment interaction? Until the resource manager understands this phenomenon, he will be unsympathetic with the tree breeder's demand that future cultural treatments be planned today. Cultural conditions will determine which genetic lines are valuable. A genetic line which performs well under low-intensity culture may not perform as well under high-intensity culture.

In short-generation agronomic crops, the breeder can adjust to changing cultural practices by quickly producing new lines. Forest tree breeders are much less able to adjust in this way. Silviculturists must plan now for 21st Century cultural practices and tree breeders must evaluate their plant material under those conditions. This means careful considerations of planting techniques, site preparation, weed and pest control, species composition, spacing, thinning, pruning, and fertilization. The best way to make reliable predictions is to plan future silviculture now.

Fire and Fuel Management

What Has Been The Probable Evolutionary Role of Fire?

Wildfire has molded life in the Northern Rockies for at least 10,000 years. Because it superimposes itself on nearly all other factors of the environment, fire has been second only to climate in dominant environmental influences operating in the evolution of Northern Rocky Mountain plant species.

Yet the fire and fuel management practices in the Northern Rockies have developed to meet the needs of modern man rather than to parallel the natural history of the area. The evolutionary role of wildfire is not generally appreciated. For example, fire and fuel managers often cannot recognize the possible genetic consequences of fire exclusion (if it were possible), or unnatural patterns of burning because they are uneducated in genetics and evolutionary mechanisms.

An understanding of evolution permits prediction of the genetic consequences of fire management actions. The rapid shift from serotiny to nonserotiny (probably simply inherited; Lotan, 1971; Rudolph et al., 1959) in closed-cone pines results from fire exclusion. The processes creating fire adaptive traits e.g., insulative bark and light seeds, are affected by fire and fuel management practices. Fire may have precluded the development of genetic resistance to certain pests in some tree species (fig. 4). Finally, genetic drift influences the genetic variation of a population, and major fires may have created suitable conditions for genetic drift.

Figure 4

Genetic understanding will support new fire-related policies evolving in the Northern Rockies, where fire and fuel management are being substituted for fire suppression (Moore, 1971). However, these practices attempt to avoid major conflagrations, such as the 1910 fire or the 1967 Sundance burn. Yet, these catastrophic events have played an evolutionary role in plant species, too (fig.4a). The elimination of such fires surely must be a goal in populated areas, but land managers must recognize that there will be genetic consequences to the plant communities.

Figure 4a --Small islands of live trees on the distant mountainsides were centers of population spread. These "bottlenecks" may have been ideal conditions for genetic drift--the nondirected fixation of gene combinations.

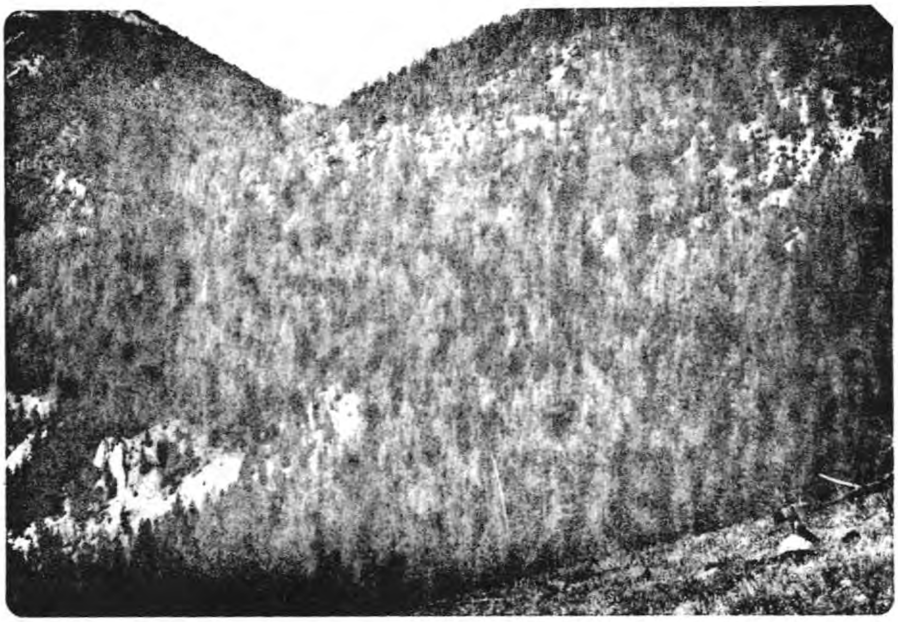


Figure 4. Western spruce budworm epidemics historically may have been controlled by fire. Has fire's control inhibited the development of genetic resistance to the pest in the hose?

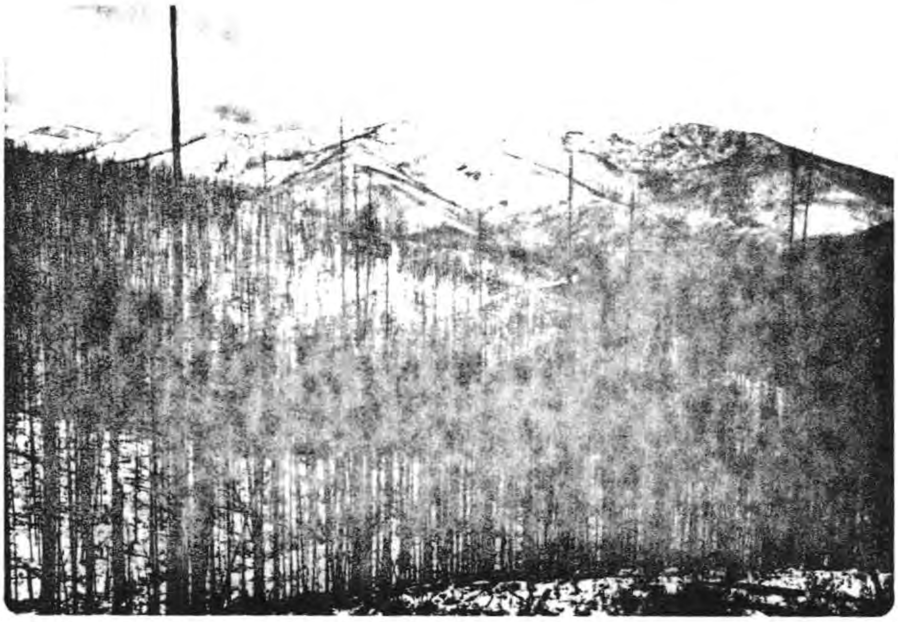


Figure 4a.--Small islands of live trees on the distant mountainsides were centers of population spread. These "bottlenecks" may have been ideal conditions for genetic drift--the nondirected fixation of gene combinations.

Insects and Diseases

Murphy's Law states, "If it can go wrong, it will." Regarding exotic insects and diseases, it seems appropriate to paraphrase, "If it hasn't been introduced, it will be." In our highly mobile world contamination is almost inevitable. Examples of introduced pests are the Dutch elm disease (transmitted by an introduced insect), chestnut blight, white pine blister rust, and larch casebearer. Host populations have no well-developed natural resistance or balance mechanisms permitting both organisms to survive together because the hosts have not "evolved" with the pests.

Resource managers are faced with serious problems from native, as well as exotic pests. The spruce bark beetle epidemic of the mid-50's is a past example. A serious western spruce budworm epidemic is currently damaging forests in Montana and Idaho.

Often the forest manager turns to the tree breeder for help with pest problems. Occasionally a breeding program can succeed in combating a pest problem, as the western white pine blister rust breeding program has (Bingham et al., 1971). But such programs, because they are long term, may become obsolescent with the development of an efficient, safe, biotic or chemical control, or may be bypassed by a mutant form of the pest. The manager should look first to these latter control areas for help, and to cultural treatments to level off the natural cycles of native pests.

Nevertheless, the Tree Improvement Program will provide opportunities for assessing the potential for resistance breeding for defoliating insects and diseases attacking at an early age. This is discussed in Chapter II.

Major Population Removals

Many activities in the Northern Rockies have the consequence of removing large segments of plant populations from breeding. Air pollution, urban sprawl, dam projects, strip mining, recreational developments, monoculture, and highway and right-of-way clearing are examples. All may have the effect of eliminating plants over wide areas (fig. 5) or of disrupting reproductive processes (fig. 6).

Figure 5.--Color print of Kellogg area from air.

Figure 6.--Color print of dying trees at Columbia Falls, Mont.

One consequence is that the possibility of revegetating with completely local seed may be denied. Moreover, without a genetical evaluation of the plant material to be lost, potentially valuable gene combinations may be discarded.

The manager facing decisions about major plant population removals should enter these genetic considerations into his assessments. At least he should know what kinds of genetic evaluations are needed and obtain help from specialists.

GOALS OF THE FOREST GENETICS PROGRAM

The foregoing discussion suggests two distinct goals for the Northern Region's Forest Genetics Program:

(1) Increase the yield of forest products through a tree improvement program.

(2) Raise the level of understanding in resource managers so that they recognize the probable genetic consequences on plant populations of all their management decisions.

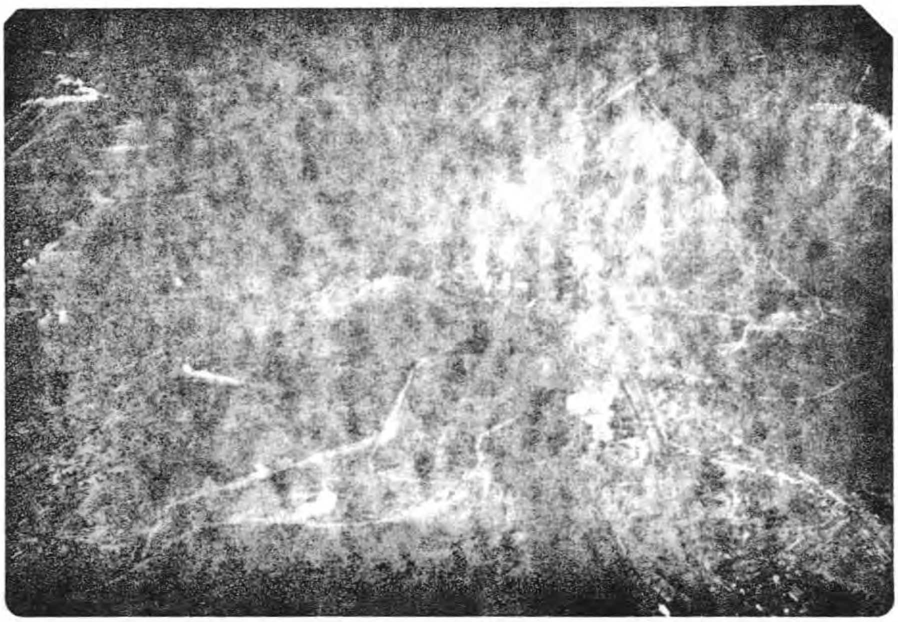


Figure 5.--Color print of Kellogg, Idaho area from air.

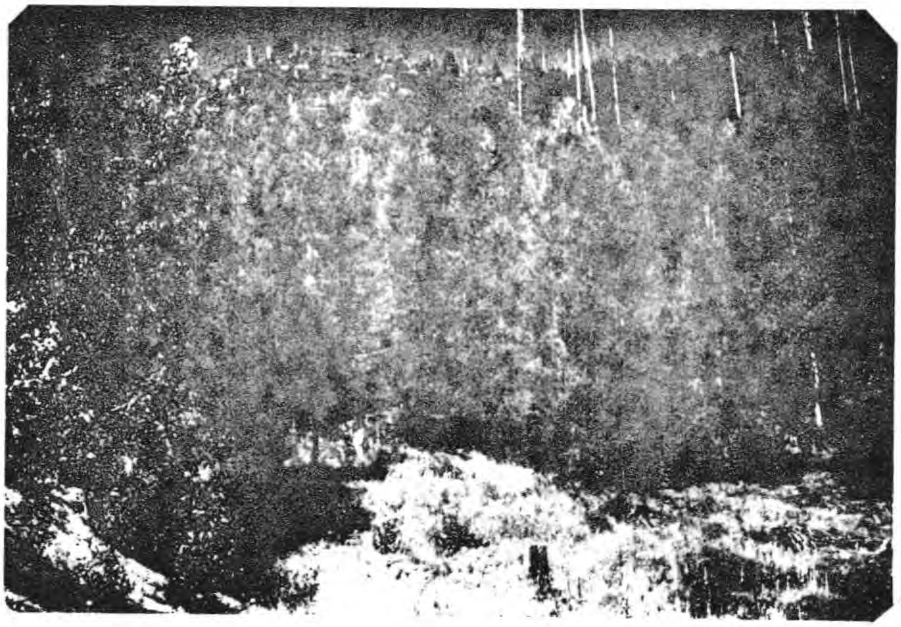


Figure 6.--Color print of dying trees at Columbia Falls, Montana.

Our principal emphasis in the Tree Improvement Program (Chapter 2) will be on fiber volume yield increase. A reasonable expectation is 12.5 percent genetic gain per generation, for all species (based on predicted gains in programs elsewhere in North Temperate conifers, including western white pine (Steinhoff and Hoff, 1971). Chapter 2 also develops the rationale for designing the Tree Improvement Program for the Region's most productive lands only.

In assessing the need for raising genetic consciousness, (Chapter 3), the urgency of an educational program was underscored recently by the first group of students in the Northern Region's Program for Continuing Education in Forest Ecology and Silviculture (see Appendix 2). We learned that none of 25 students had formerly had a course in genetics of any kind. Yet these 25 were the "cream of the crop" of three Federal agencies, selected from more than 39 applicants on the basis of outstanding academic records and work histories. The program outlined in Chapter III is our start at making these men and others like them truly custodians of the gene resources.

CHAPTER II

THE TREE IMPROVEMENT PROGRAM

The most spectacular rewards of tree improvement in forest trees in the U.S. have been to increase timber yields in the southern pines (Zobel, 1971). Similar achievements are accruing in western conifers--particularly Douglas-fir--and in ornamental and Christmas trees. Many tree improvement programs follow the breeding pattern established by agronomic crop breeders, and they are apparently reaping many of the same rewards. We expect the same.

A thoughtful Tree Improvement Program will provide the following added benefits:

(1) By proper selection of wild sources, the breeder may include portions of his collections in gene banks to later reconstruct wild populations.

(2) Tree improvement programs provide plant material whose source--often to the individual parents--is identified. This material will be of value to research organizations for the study of genetic variation patterns and inheritance mechanisms.

(3) By improved growth rates and disease and insect resistance, the production of forest products may be concentrated on fewer acres, freeing other forest land for the other uses.

(4) Esthetic devaluation and fire hazards in forest stands can be reduced by using planting stock with rapid juvenile growth rate (accelerated recovery of logged areas) and insect and disease resistance (fewer pest-killed trees).

(5) By preventing the loss of a disease- or insect-threatened species, tree improvement can maintain the full complement of species alternatives for the land manager.

(6) Tree improvement programs may control insect and disease pests when other controls are environmentally unacceptable.

(7) As byproducts, variants may be recovered which will be useful for special purposes, such as ornamental planting or disturbed area rehabilitation.

(8) Tree improvement creates an awareness in local resource managers of the role of genes in the biology of forest communities.

(9) Increased yields from tree improvement may remove the need for intensive cultural treatments (e.g., fertilization) in areas where they might be environmentally undesirable.

(10) Tree improvement usually induces improved culture of forest stands.

THE CURRENT ARTIFICIAL REFORESTATION PROGRAM

Planting

The Northern Region's planting programs increased from 2652 M seedlings planted on 5475 acres in 1960 to 14,814 M seedlings planted on 37,478 acres in 1969, our peak year. In part, the late 60's planting programs reflected the rehabilitation efforts on the Sundance Burn of northern Idaho.

Since 1969, planting has declined to 9048 M seedlings on 31,711 acres in FY 1972 (fig. 7). The FY 1973 program is 10,115 M[1/] seedlings.

[1/] An additional 3,239 M seedlings are being supplied by the Coeur d'Alene Nursery to customers other than R-1 National Forests.

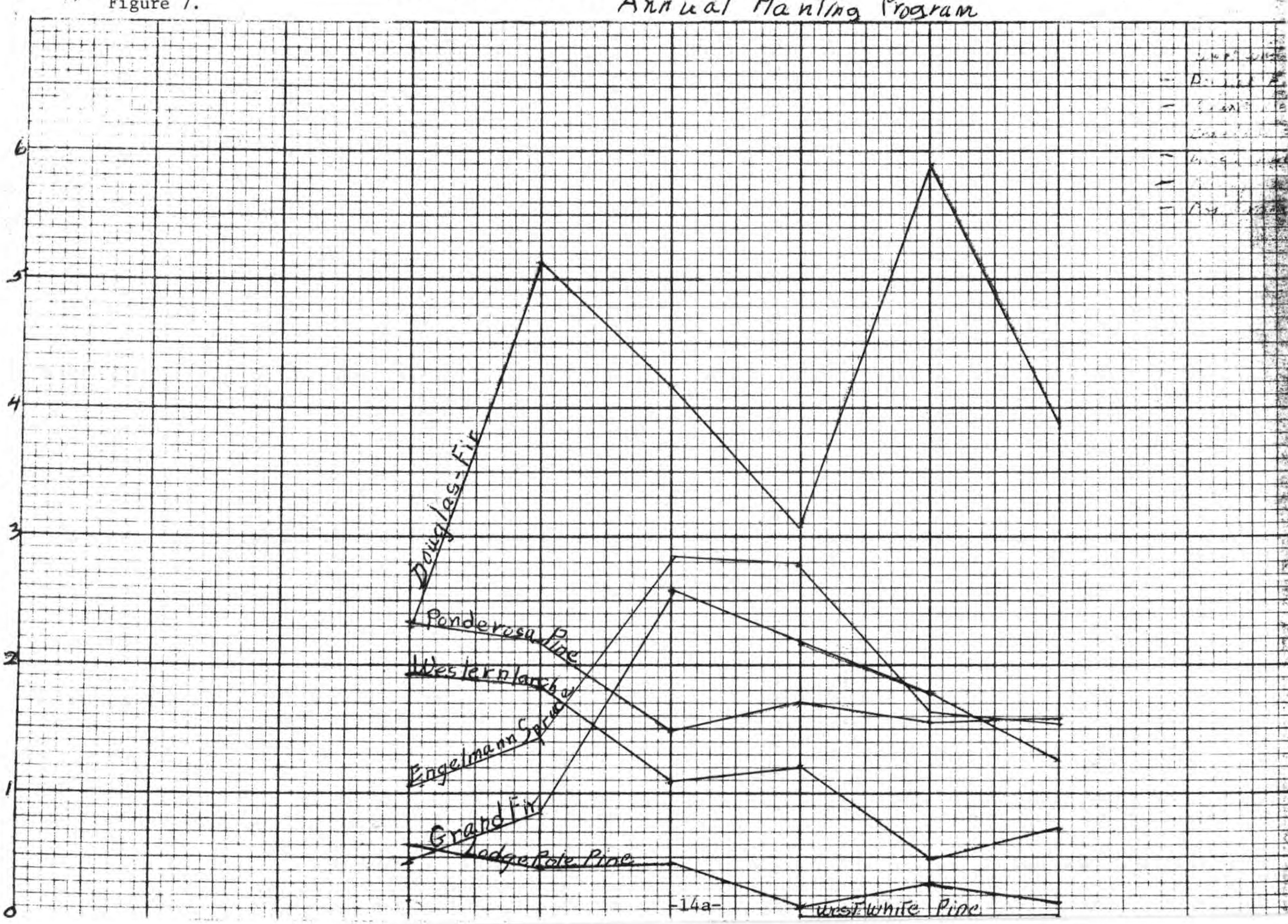
National Forest plans show additional reductions in the next 4 to 5 years to a level of about 8 million seedlings annually, as natural regeneration is more widely employed as a silvicultural practice.

Douglas-fir continues as the Region's most-planted species (fig. 7). Grand fir and western larch have increased in planting, due to the need for multispecies plantations and the decreasing stumpage price differentials between species.

Figure 7.--Graph of R-1 Annual Planting Program, by species, FY 1965 through FY 1972.

Western white pine has been planted in the Region since 1966 only in experimental plantations established cooperatively with the disease resistance breeding project of Intermountain Forest & Range Experiment Station. However, in the spring of 1972 the Nursery received sowing orders

Figure 7.



Annual Planting Program
Number of Seedlings (MM)
0
1
2
3
4
5
6
Douglas-Fir
Ponderosa Pine
Western larch
Engelmann Spruce
Grand Fir
Lodge Pole Pine
West White Pine

for 190,000 rust-resistant WWP seedlings to be planted on National Forests as 2-0 stock in 1974. Orders from five National Forests for sowing for an additional 339,000 seedlings are expected in Spring, 1973. This white pine material is predicted to exhibit 50 to 60 percent survival to rotation age under field conditions (Bingham et al., 1973). It is to be planted in mixture with other species at a [rate] (ratio) of no more than 33 percent white pine.

Direct Seeding

An average of six National Forests in Region 1 annually carried out direct seeding projects in fiscal years 1967, 1968, 1969, 1971, and 1972. The principal species was western larch; a total of 264,880 M larch seeds were dispersed. Other species were Douglas-fir, grand fir, ponderosa pine, Engelmann spruce and lodgepole pine.

Results have been mixed and success predictability [is] low. Direct seeding would be an inefficient means of establishing forest stands from expensive genetically improved seed.

SEED PROCUREMENT

The Regular Program

Seed for artificial reforestation is collected principally by local citizens from squirrel caches in wild stands (except western white pine, summarized later). Cone collections are made from geographic areas established on the following criteria (as of 9/1/72):

1. National Forest (zone)
2. Ranger District within National Forest (subzone)
3. 1000-foot elevational band within District
4. Habitat type[2/] within elevational band

2/ After Daubenmire & Daubenmire (1968) for northern Idaho & eastern Washington; after Pfister, et al, 1972, and Pfister, et al., 1973, for Montana.

Seed is labeled with the above source information and kept identified from the field through the seed handling and storage, the nursery raising, and back to the field for planting of seedlings, or the shipping of seed for direct seeding projects.

Sufficient inventories will be built in all lots by 1976 to avoid using any material not collected within the local area. Currently, Regional guides permit the use of material collected in certain adjacent areas.

As specific planting needs are anticipated on Forests, sowing requisitions are placed with the Coeur d'Alene Nursery, by seed identification, as read by Forest personnel from the Seed Inventory Printout (fig. 8). The Nursery honors only sowing requisitions which do not violate the limits of Regional guides for the use of nonlocal seed or stock.

Figure 8.--Photo reduction of one page of the Seed Inventory ADP output.

Unless requested otherwise, the Nursery grows 2-0 bare-root stock in all species except western larch and ponderosa pine, in which 1-0 bare-root stock is grown. The nursery will also provide a limited output of container-grown stock in FY 1974 and thereafter. ¶Selection is imposed at several points in seed procurement and nursery processes. The first is the selection of cones in squirrel caches. What kind of a genotypic sample is represented in squirrel caches? Research is needed to provide the answer here. The next major selection probably is in seed germination in the nursery beds, which may permit survival of many genotypes which would not survive in the wild. Another selection is on the sorting table where the "runts" are discarded. The net effect

Fig. 8

SEED INVENTORY

SEED LOT NO.	* * *SEED IDENTIFICATION* * * FOR.	DIST	SPEC	ELEV	SUB ZONE	YEAR COLL	HAR. TYPE	GEN. TEST	* * * SEED DESCRIPTION * * * / - - - INITIAL TEST - - - MO.	YR.	BEST GERM.	% PUR.	NO. OF SEEDS/LB. (HUN.)	-LATEST TEST- MO.	YR.	BEST GERM.	CURRENT POUNDS OF SEED	VIABLE SEED (M) PER LB.	TREE EQUIV. (M) PER LB.	DESIRED LBS. OF SEED	CONE NEEDS (BU.)
0216	17	7	2[illegible]2	3	0	70	00	0	02	71	.91	.93	39.1	02	71	.91	5	33.0	14.1		
0794	17	7	2[illegible]2	4	0	66	00	0	03	67	.75	.94	37.5	07	69	.87	8	30.6	13.1		
0783	17	7	2[illegible]2	4	0	70	00	0	02	71	.83	.90	37.4	02	71	.83	12	27.9	11.9		
0788	17	7	2[illegible]2	5	0	70	00	0	02	71	.79	.93	37.5	02	71	.79	5	27.5	11.8		
0790	17	7	2[illegible]2	6	0	71	00	0	02	72	.77	.90	39.0	02	72	.77	2	27.0	11.6		
0801	17	7	2[illegible]2	6	0	71	00	0	02	72	.73	.97	42.4	02	72	.73	5	30.0	12.9		

SPECIES TOTALS 232.9 37

DISTRICT TOTALS 232.9 37

of these nursery selections may be that the field receives some seedlings poorly adapted to the planting site. If so, planting should be done at a higher than desired density.

Controlling seed source is a problem in the seed procurement program. The press of business in the fall often denies adequate field inspection of collectors and of cones at the buying station. Part of the problem results from a shortage of adequately trained cone procurement officers. This deficiency is to be treated through training programs outlined in Chapter 3. The establishment of seed production areas will also help, as outlined in a later section of this chapter.

The costs of the regular seed procurement program and nursery operations are recovered by the sale of seed and stock through a revolving Working Capital Fund (WCF). The seed procurement program cost $55,900 in FY 1972, which was 2.54 percent of the total artificial reforestation program in that year (exclusive of Tree Improvement).

Genetically Improved Seed

Seventy-five pounds of [30 percent] rust-resistant western white pine seed were produced in two seed orchards in 1970 through 1972. This was about 2.1 MM seeds. It was produced by manual, mass pollination with pollen from known rust-resistant genotypes provided by the Intermountain Forest & Range Experiment Station [Project INT-1451], Moscow, Idaho. It is used below 3500 feet elevation on white pine sites in northern Idaho and eastern Washington.

The two seed orchards are the Intermountain Forest & Range Experiment Station Breeding Arboretum at Moscow, Idaho and the Sandpoint (Idaho) Seed Orchard of the Kaniksu National Forest. The cost of the improved seed, which is borne by WCF, is $54.00/lb.

When this seed is received by the Nursery it is coded in the column of the Seed Inventory entitled "Genetically Tested" (fig. 8). This references genetically improved material back to its seed orchard (or other production source) and accession record (description of the seed's "pedigree"). A copy of this latter record is retained in the Regional Office. Plantations established from this material will retain the "Seed Identification Number."

Other Tree Improvement Projects

The Region has ten other tree improvement projects in four species underway (table 5 , Appendix 3). Four of these are cooperative research or administrative studies to provide basic information for efficiently designing future projects. The rest are designed to produce genetically improved seed.

There are five projects in western white pine, one in ponderosa pine, three in Douglas-fir, one in Engelmann and blue spruce, and one multiple-species project. These are summarized in table 5 , Appendix 3, and in a later section of this chapter.

The Native Shrub Program

The Coeur d'Alene Nursery produces bare-root stock of 17 native shrub species plus cuttings of *Salix spp*. for use on severely disturbed sites and for other nontimber objectives requiring subarboreal plants. The seed procurement and nursery production costs are being covered by WCF, effective July 1, 1973. These 18 groups of plants are ordered, shipped and handled by Forests the same as tree stock. An additional 20 species are currently under administrative study to determine where and how they can be planted.

The principal genetic need of the Native Shrub Program is to identify seed zones. The Intermountain Forest & Range Experiment Station has been asked to help, and to consider other research needs for broadening the Program. The Station is currently determining its level of participation.

THE FUTURE ARTIFICIAL REFORESTATION PROGRAM

Tree breeding is a long-time endeavor. Meeting artificial reforestation needs with a tree improvement program requires some crystal-ball gazing. On which lands will we be growing timber 7, 50 and 100 years from now? On which of those will we have artificial reforestation needs? Should a tree improvement program try to provide seed for all of those lands, or if not, which? This section attempts to answer these questions in defining the needs for improved and unimproved seed in 1980, 2020, and 2080. The following broad assumptions are made:

1. There will be a continued increasing demand for timber in North A merica through 2080 (Anon, 1972a; Anon, 1972b).

2. There will be a decreasing available forest land base through 1980.

3. The Northern Region will be managing timber stands to maximize volume on 90 to 150 stems per acre [3/].

[3/] One of the assumptions for developing the 1972 Office of Management and Budget (OMB) Timber Issue Report. If the management changes, seed needs may change.

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4. Stumpage price differentials between species per unit volume will be nearly zero.

5. On a per acre basis, the tree improvement dollar is much better spent for a high productivity site than a low productivity site.

6. Tree improvement, because of its high costs, should not attempt to provide seed for direct seeding in the Northern Rockies.

Each of these assumptions is quantified in the development of the next section.

Planting Needs and Tree Improvement

Land Productivity

The Northern Region currently has about 15.5 MM acres of land available for commercial timber production (Commercial Forest Land--CFL) in National Forests in five states. By 1980 as much as 2.5 MM acres may be withdrawn for other uses (table 6 , Appendix 4). Although there may be additional withdrawals by 2020 or 2080, we have no basis now for predicting them.

Predicted withdrawals are lands currently reserved and deferred for study for possible nontimber uses. After the withdrawals, we expect to be left with 3.79 MM acres in Productivity Class [4/] (PC)1, 4.56 MM in PC2, 3.19 MM in PC3, and 1.52 MM in PC4 (table 6, Appendix 4).

Growth and yield data developed by the Northern Region and the Intermountain Forest & Range Experiment Station [5/] project that intensively

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4/ Culmination of normal yield tables. Assimilated by Intermountain Forest & Range Experiment Station personnel and described by Brickell (1970).

5/ Op . Cit. OMB Timber Issue, 1972. Based principally on unpublished IFRES data used in the R-1 Guide for the Management of Western Larch.

managed stands can average 12,000, 9450, 7000, and 4000 cu. ft. per acre yield at rotation in PC1 through 4, respectively, without tree improvement (these yields converted to growth in fig. 9.) If using genetically improved stock were to increase yields by 12.5 percent, the increases would amount to 1500, 1190, 875, and 500 cu. ft. per acre for PC1 through 4, respectively.

Figure 9.--Growth/Potential Related to Site Index, Productivity Class, and Habitat Type (From 1972 OMB Timber Issue).

If 500 cu. ft. (for PC4) is defined as a 1-unit return on the tree improvement investment, then the returns for PC3, 2, and 1 are 1.75, 2.38, and 3.00, respectively. Actual returns on dollar investments would be further differentiated by the necessity of compounding interest for 75-, 90-, 115-, and 130-year rotations for PC1 through 4, respectively. This weighting may be computed by assigning the values 1, 1.20, 1.53, and 1.73 to rotation ages and multiplying the reciprocal of each value times the unit return (above). The resulting values are 3.00, 2.28, 1.16, and 0.58 for PC1 through 4, respectively. Concluding from this analysis, tree improvement for PC1 lands is more than a five-fold better investment than for PC4 lands, on a per-acre basis, and more than 2-1/2 times better than for PC3 lands, but only about one-third better than for PC2 lands. An investment in PC2 lands would be nearly four times better than in PC4 and almost twice that for PC3 lands.

Economic Analysis of Tree Improvement for Timber Production

By 2080 Northern Region National Forests will yield genetically improved timber from 12.618 M acres of PC1 and 20.270 M acres of PC2 lands annually (table 7, Appendix 4). The increased yield due

Figure 9

Belongs Here.

exclusively to tree improvement will be 18920 M cu. ft. on PC1 lands and 24120 M cu. ft. on PC2 lands. Now, the following assumptions are made:

1. 1 cu. ft. = 5 board feet (1973 average R-1 conversion).

2. Average value of timber in May, 1973, dollars is $75/M bd. ft. stumpage.

3. The first annual return on the tree improvement investment will come in 2080.

4. The total investment to bring that first annual return will be made in 1973.

The first annual return on the tree improvement investment will be $16,140,000 (in 1973 dollars). Discounting this back to 1973 at 6 percent compound interest shows that an investment of $24,000 could be made in 1973.

This analysis ignores that final harvest returns will begin to accrue in the tree improvement program by 2049, the first harvesting of genetically improved stands. Ignored, too, are benefits prior to final harvest, such as rapid recovery of logged-over areas, higher commercial thinning yields, and reduced pest damage. The possibility of higher value of timber relative to other consumer items is also not considered. On the other hand, the Northern Region has been investing in tree improvement almost annually for 23 years (Wellner et al, 1970) with no prospect of return from final harvest until the mid-21st Century.

The cooperative Inland Empire Ponderosa Pine Tree Improvement Committee project (fig. 14 and table 5, Appendix 3) serves well as a specific example of costs and returns in a tree improvement program in the Northern Rockies. Using actual and projected costs and projected returns (table 1), the internal rate of return (using the computer program INVEST III, Dyrland, 1971) is 5.87 percent, and the net present worth is $341, 608.30 at 4.88 percent.

These assessments of tree improvement as an economic investment for timber production in the Northern Region suggest that it will provide an acceptable rate of return. Nevertheless, we do not justify the Tree Improvement Program on economics alone, for there are many intangible benefits accrued, to which economists are unable to assign meaningful dollar values.

Developing Priorities

Productivity classes 1 and 2 lands are 64 percent (8.35 MM acres) of the commercial forest land in Region 1 (table 6, Appendix 4). The magnitude and proportion of this acreage, coupled with the foregoing comparison of investments in different productivity classes, suggest that the Tree Improvement Program be designed for PC1 and 2 lands only.

Where, then, are the PC1 and 2 lands? Forty-nine percent of them are in eastern Washington and northern Idaho, and another 36.5 percent of them lie in western Montana (table 6, Appendix 4). Thus, the Program is designed first for PC1 and 2 lands in eastern Washington, northern Idaho, and western Montana and second for those east of the Continental Divide in Montana. The latter lands are clearly in a different ecologic and probably genetic biological unit, as shown in succeeding paragraphs.

The planting needs now must be quantified, species by species. For 1980 it was assumed that 0.8 percent of the total Commercial Forest Land will require regenerating annually, about equally distributed to the four

Table 1

Assumptions and Values for Computing Ponderosa Pine Tree Improvement Committee Economic Analysis

Assumptions:

1. Planted PP will occupy 827.01 M[1/] acres on cooperators' lands, principally Productivity Class 2.

2. Rotation = 85 years, so $\frac{827.01\ M}{85}$ = 9.73 M acres planted (or treated) annually.

3. Two commercial thinnings prior to final harvest.

4. Two percent genetic gain seed available by 1980 from superior parent stands to fill 1/3 of cooperators' annual planting needs.

5. Seed orchards produce 12.5 genetic gain seed to fill additional 1/10 of cooperators' annual planting needs by 1990.

6. Seed orchards produce 12.5 percent genetic gain seed to fill 100 percent of cooperators' annual planting needs by 2000.

7. Values used:

1/ Acreage in forest type from 1970 IFRES Timber Appraisal reduced by planting proportion--- .35 for NF and .80 for other owners.

Tree Impr. Annual Costs		-Returns-							
Year	$$	Treatment	Begins in year	Through year	Yield 4/ WO/TI	Value	Annual Acres	Added value from 2% gain	12.5% gain
					Mbft/ A/yr.	$$/Mbft	M	$$/yr	$$/yr
1970	22255 2/	45-yr Comm. Thin	2025	2084	3.5	40	3.24	9072	
'71	18321 2/	65-yr Comm. Thin.	2045	2084	12.7	55	3.24	45263	
1972	17160 2/	85-yr Harvest	2065	2084	24.0	70	3.24	108864	
'73	16000 3/	45-yr Comm. Thin.	2035	2084	3.5	40	.973		17028
1974	20000 3/	65-yr Comm. Thin.	2055	2084	12.7	55	.973		84955
'75-79	5000 3/	85-yr Harvest	2075	2084	24.0	70	.973		204330
'80-85	7000 3/	45-yr Comm. Thin.	2045	2130	3.5	40	9.73		170275
'86-87	18000 3/	65-yr Comm. Thin.	2065	2150	12.7	55	9.73		849551
'88-2170	9000 3/	85-yr Harvest	2085	2170	24.0	70	9.73		2043300

2/ Actual costs

3/ Estimated Costs

4/ From 1972 Office of Management and Budget Timber Issue.

productivity classes (table 6, Appendix 4). Of those, 10 percent of the PC1 and 43 percent of each of the other three productivity class lands will require planting.[6/]

[6/] Rationale for this paragraph described below table 6, Appendix 4.

Optimum species mixtures on West Side Forests were estimated by relating Daubenmire (Brown & Pfister, 1971) or Pfister (Pfister et al., 1972) Habitat Type to productivity class (fig. 9) and determining from the graph the relative proportions of species in productivity classes in (a) northern Idaho and eastern Washington, and (b) western Montana (proportions listed in table 8, Appendix 4).

For central and eastern Montana, Pfister's habitat typing (Pfister et al., 1973) showed no Productivity Class 1 or 2 lands (fig. 9)[7/].

[7/] Pfister's Measured trees were vigorous open-grown trees in unmanaged rather than [plots] [were] ~~in~~ [climax, usually old] [stands not well suited for measuring productivity potential of young,] intensively managed stands.

Available Northern Region Inventory data suggest that there are more than 1.3 MM acres of land in these two Productivity Classes on East Side Forests. These data suggest that these productive lands are almost entirely high elevation basins of spruce or subalpine fir climax habitat types. Pfister et al., (1973) found two spruce and one subalpine fir habitat types to be the most productive of the East Side types (fig. 9). So, species mixtures for PC1 and 2 lands in this area (table 6, Appendix 4) were estimated from the tree species presence tabulation provided by Pfister et al. (1973) for those three most productive habitat types. Species mixtures for PC3 and 4 lands were determined as detailed in the preceding paragraph from the graph for central and eastern Montana habitat types (fig. 9).

The final computation for planting needs for 1980 was calculated by multiplying species proportion by planting density (per acre) by number of acres in each productivity class in each area. These values (table 9, Appendix 4) were the basis for developing the Tree Improvement Program (and other seed procurement) for 1980.

Comparable values for 2020 and 2080 were similarly computed [8/] (table 9 , Appendix 4), except with different assumptions. By 2020 all CFL will be under intensive management and higher productivity lands will be on a shorter rotation than lower productivity lands. Thus, higher proportions of the former will be regenerated annually. Also, planting needs are likely to be greater on PC1 lands in 2020 and 2080 than in 1980 because planting--even underplanting--with genetically improved stock can be justified on lands regenerated by natural seed fall in 1980.

Seed quantities (table 2) were computed by inflating planting needs by losses expected between seed extraction and planting. These losses will be less than currently, because of improved nursery practices; e.g., the container growing of stock (Mason, 1973).

Modifying the Priorities

Two factors not previously considered helped establish priorities for the Tree Improvement Program:

8/ Planting densities are shown below table 9 , Appendix 4. If utilization of smaller trees is realized, planting densities may increase to 450 to 600 trees/acre, and seed needs will increase accordingly.

Table 2

R-1 Average Annual Seed Needs (M Seeds)

for 1980

Species	E. Wash. & N. Idaho PC1	PC2	PC3	PC4	Total	W. Montana PC1	PC2	PC3	PC4	Total	E. Montana & S. Dak. PC1	PC2	PC3	PC4	Total
WWP	574	841	0	0	1415	149	1013	537	327	2026	0	0	0	0	0
DF	361	1290	691	0	2342	129	1290	899	410	2728	32	1052	1817	823	3724
GF	783	0	0	0	783	140	1382	649	356	2527	0	0	0	0	0
ES	251	2697	1441	0	4389	196	1201	717	429	2543	135	2201	1441	834	4611
WL	1230	1800	1170	0	4200	490	4160	1900	840	7390	0	0	0	0	0
LPP	0	1820	1645	777	4242	154	2569	1435	637	4795	77	2513	2842	1288	6720
PP	92	766	0	1001	1859	50	716	560	236	1562	0	0	1154	457	1611
SAF	0	1928	2517	0	4445	471	3149	1724	900	6244	54	3845	3438	1767	9104
TOTALS	3291	11142	7464	1778	23675	1779	15480	8421	4135	29815	298	9611	10692	5169	25770
							for 2020 & 2080								
WWP	1196	723	0	0	1919	322	887	453	359	2021	0	0	0	0	0
DF	750	1110	574	0	2434	270	1110	750	451	2581	67	908	1515	908	3398
GF	1630	0	0	0	1630	293	1210	541	395	2439	0	0	0	0	0
ES	521	2323	1215	0	4059	423	1036	595	472	2526	141	1900	1202	920	4163
WL	2560	1550	980	0	5090	1140	3580	1580	930	7230	0	0	0	0	0
LPP	0	1568	1372	861	3801	322	2212	1197	700	4431	161	2170	2366	1421	6118
PP	191	504	0	1107	1802	104	617	468	261	1450	0	0	963	506	1469
SAF	0	1660	2099	0	3759	945	2709	1435	996	6085	118	3320	2860	1949	8247
TOTALS	6848	9438	6240	1968	24494	3819	13361	7019	4564	28763	487	8298	8906	5704	23395

1. The genetic knowledge foundation for the different species.

2. Potential cooperative inputs.

Sound information on the pattern and nature of genetic variation in a species helps the tree breeder to more efficiently design tree improvement projects. Data show the existence and pattern of genetic variation in western white pine, Douglas-fir, ponderosa pine, and lodgepole pine. Fewer data are available for Engelmann spruce, grand fir and western larch, and none for subalpine fir.

A measure of potential cooperative input is the level of participation by Northern Rocky Mountain forestry agencies in current tree improvement projects. Eighteen cooperators, including ten nongovernmental participants, have started a tree improvement project in ponderosa pine in the Inland Empire west of the Continental Divide. The group is named the Inland Empire Ponderosa Pine Tree Improvement Committee. Encouragement of this program can lead to the development of similar efforts in other species.

Cooperatives have been highly effective in tree improvement elsewhere; e.g., the Southeastern U. S. Perhaps the greatest asset of cooperative tree improvement is the potential inclusion in one program of all the sources of genetic variation in the region for which the program is designed. Another is the spreading of costs over several organizations.

Most of the projects outlined here may be designed to be modified, executed, and the improved seed utilized by cooperators in the Northern Rockies. Interested potential cooperators are invited to provide inputs.

Several of the cooperators in the Ponderosa Pine Tree Improvement Committee have expressed interest in starting a cooperative tree improvement project in western larch. U. S. Plywood, the Bureau of Land Management, and the University of Idaho have already started small projects. The Forest Service has the capability and obligation to provide technical leadership in cooperative tree improvement projects, such as in larch.

Interior Douglas-fir (as well as white pine) genetics research is underway at the Intermountain Station Laboratory at Moscow. A needed expansion of the present IFRES research efforts (discussed elsewhere in this document) will be aided by cooperation between IFRES and Region 1. This cooperation will provide tree improvement project planning data and serve as a source of plant material for applied tree improvement.

The net effect of these modifying considerations has been to increase the emphasis on western white pine and ponderosa pine above that suggested by planting needs alone. Blister rust breeding is providing the manager with a second or third or fourth species option in his planting program. He was effectively without this option for nearly two decades. This is biologically valuable but difficult to quantify economically, although it is the major justification for the years of blister rust control work, including the white pine breeding program. ¶ The foregoing discussion suggests that a summarization of priorities as follows, in descending order of importance:

1. Douglas-fir, western white pine, ponderosa pine for appropriate PC1 and 2 lands west of the Continental Divide.

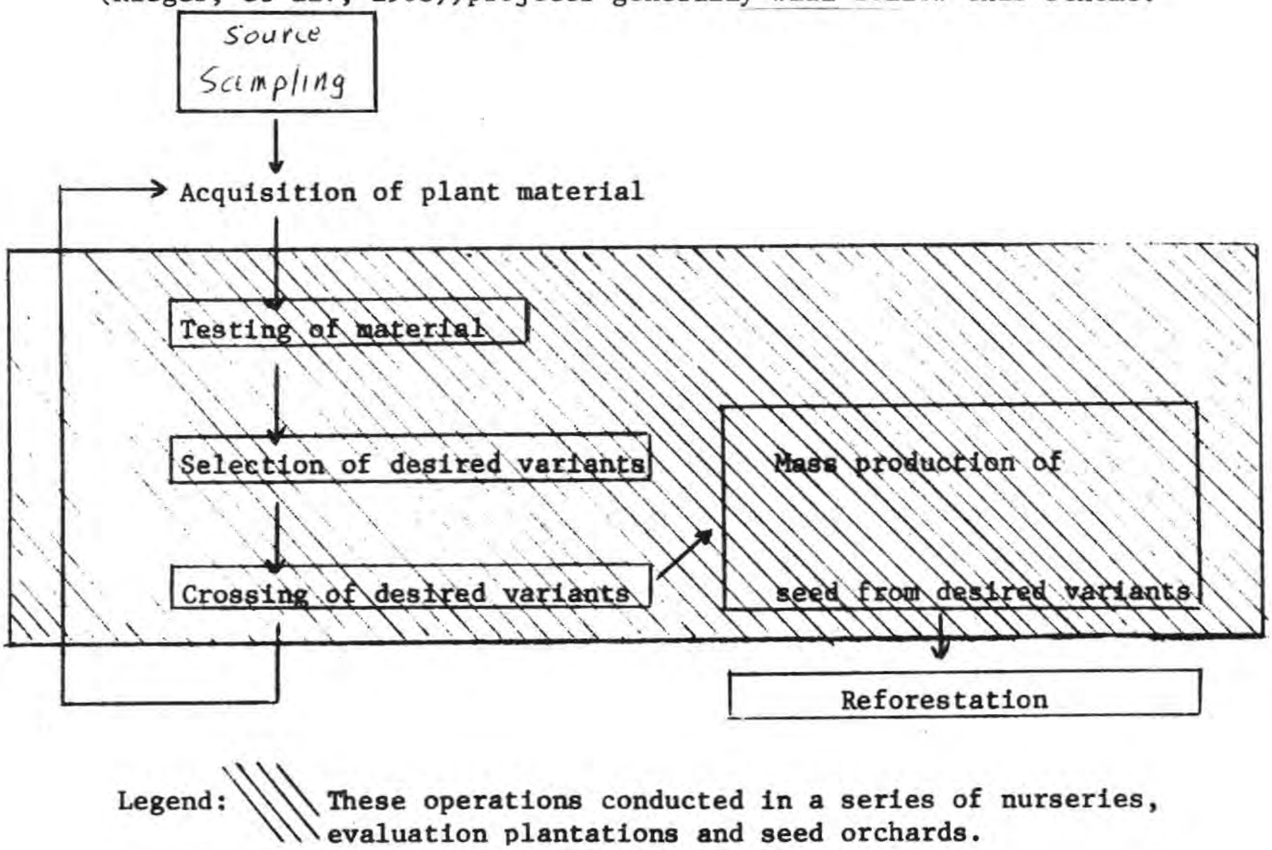
2. Lodgepole pine for all appropriate PC1 and 2 lands, western larch for appropriate PC1 and 2 land west of the Continental Divide.

3. Spruce for all appropriate PC1 and 2 lands, Douglas-fir for appropriate East Side PC1 & 2 lands, grand fir for appropriate West Side PC1 lands.

4. Subalpine fir for all appropriate PC1 and 2 lands.

The Eugenics Cycle

Individual eugenics (improvement of the genetic endowment of a population (Rieger, et al., 1903))projects generally will follow this scheme:



The cycle can be repeated ad infinitum; the sources for the acquisition of plant material will change gradually from wild parents to seed orchard parents.

Plant material (usually seed) will be collected and put into a series of evaluation plantations. Here the plants will be raised under uniform, replicated conditions. The performances (in specific traits) of different groups and families (representing different sources of potential genetic variation) will be compared. The majority of the evaluation plantations will be designed so that all groups may be carried to rotation age in the first cycle. The remaining evaluation plantations will be designed so that the poorest performing groups may be removed (rogued) from the breeding population at some point in the first cycle. This roguing will create seed orchards wherein seed for reforesting planting zones identified by the progeny evaluation will be produced. The evaluation plantations may be retained as gene banks.

Subsequent cycles are begun with seed from (1) a previous cycle, and (2) external sources, often wild. The same groups may be evaluated in subsequent cycles if environmental conditions did not adequately evaluate the plant material (e.g., the once-in-a-hundred years winter on nonlocal sources).

Except for white pine seed orchards, all seed orchards will be created from plantations initially providing progeny evaluation. These data will be used to thin the earmarked plantations into seed orchards, i.e., the poorest performing groups will be rogued out to permit only the best groups to cross pollinate. Thus, the size and design of seed orchards will be initially determined primarily by considerations of experimental design and proposed selection differentials (i.e., what percent of the groups to rogue out). Some limitations will be imposed upon those plantations earmarked to become seed orchards:

(1) Plots of the same family should not be adjacent to one another in different replicates.

(2) There must be a minimum limit to the number of trees represented in the orchard based on estimates of seed needs in the planting zone to be supplied by the orchard. Almost invariably, the requirements of adequate evaluation plantation experimental design will exceed this minimum.

(3) A seed orchard should retain only the groups specific to a planting zone so that seed may be mass produced by wind pollination, insofar as possible.

All field evaluation of plant material will be in several plantations (Appendix 5). Only by multiplantation evaluation can the geneticist:

(1) recommend genotypes for all potential planting sites, or

(2) recommend genotypes for specific environmental conditions,

if genotype X environment interactions are absent or explainable.

In selecting sites for test plantations and seed orchards (Appendix 5) in the ponderosa pine cooperative project (diagrammed in fig. 14) each was considered for its potential as a representative planting site for more than one species. It is more efficient to have several species grouped together, both for site preparation and measurement and maintenance of the plantations.

MEETING SEED NEEDS THROUGH TREE IMPROVEMENT AND OTHER SEED PROCUREMENT

Tree improvement projects are designed to meet the seed needs for planting PC1 and 2 lands. Improved seed cannot be available for all of those lands in 1980. So a seed procurement program, including collection of seed from unevaluated seed production areas, will be needed for many PC1 and 2 lands, as well as for PC3 and 4 lands (table 3). The following sections summarize projects underway or planned for the current decade and which will require P&M[9] financing. Individual projects are detailed in work plans of the projects listed in Appendix 3. They are on file in the Division of Timber Management, Regional Office. Cooperators have copies of cooperative project work plans.

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[9] P&M = Protection and Management. Dollars appropriated annually by Congress.

Table 3

Meeting R-1 Average Annual Seed Needs

Source of Seed for N. Idaho & E. Wash.

Species	Yr	Superior Stands M Seeds	Superior Stands % Gain	Orchards M Seeds	Orchards % Gain	Seed Prod. Areas --M Seeds--	Other --M Seeds--
WWP	1980	0	-	425	15[1]	743	247
	2020	0	-	1919	15[1]+	-	-
	2080	0	-	1919	28[2]	-	-
DF[3]	1980	1156	4	0	-	1186	0
	2020	0	-	1919	10	574	0
	2080	0	-	1919	25	574	0
GF[3]	1980	313	4	0	-	94	376
	2020	326	4	1304	12.5	-	-
	2080	0	-	1630	25	-	-
ES[3]	1980	0	-	0	-	0	4389
	2020	1138	4	1706	12.5	1215	0
	2080	0	-	2844	25	1215	0
WL[3]	1980	909	3	0	-	2633	658
	2020	0	-	4110	12.5	980	0
	2080	0	-	4110	25	980	0
LPP[3]	1980	1456	2	0	-	2786	0
	2020	0	-	1568	15	2233	0
	2080	0	-	1568	35	2233	0
PP[3]	1980	686	4	0	-	587	587
	2020	0	-	695	12.5	1107	0
	2080	0	-	695	25	1107	0
SAF[3]	1980	0	-	0	-	0	4445
	2020	498	4	1162	12.5	2099	0
	2080	0	-	1660	25	2099	0

Source of Seed for W. Montana

Species	Yr	Superior Stands M Seeds	Superior Stands % Gain	Orchards M Seeds	Orchards % Gain	Seed Prod. Areas --M Seeds--	Other --M Seeds--
WWP	1980	0	-	0	-	0	0
	2020	0	-	1209	15[1]+	0	0
	2080	0	-	1209	28[2]	0	0
DF[3]	1980	993	4	0	-	1735	0
	2020	0	-	1380	12.5	1201	0
	2080	0	-	1380	25	1201	0
GF[3]	1980	0	-	0	-	0	2527
	2020	301	4	1202	12.5	936	0
	2080	0	-	1505	25	936	0
ES[3]	1980	0	-	0	-	0	2543
	2020	584	4	875	12.5	1067	0
	2080	0	-	1449	25	1067	0
WL[3]	1980	1395	3	0	-	4634	1158
	2020	0	-	4720	12.5	2510	0
	2080	0	-	4720	25	2510	0
LPP[3]	1980	2645	2	0	-	3069	767
	2020	0	-	2534	15	1897	0
	2080	0	-	2534	35	1897	0
PP[3]	1980	613	4	0	-	664	285
	2020	0	-	721	12.5	729	0
	2080	0	-	721	25	729	0
SAF[3]	1980	0	-	0	-	0	6244
	2020	1096	4	2558	12.5	2431	0
	2080	0	-	3654	25	2431	0

Source of Seed for E. Montana & S.D.

Species	Yr	Superior Stands M Seeds	Superior Stands % Gain	Orchards M Seeds	Orchards % Gain	Seed Prod. Areas --M Seeds--	Other --M Seeds--
WWP	1980	-	-	-	-	-	-
	2020	-	-	-	-	-	-
	2080	-	-	-	-	-	-
DF[3]	1980	0	-	0	-	0	3723
	2020	0	-	975	12.5	2422	0
	2080	0	-	975	825	2422	0
GF[3]	1980	-	-	-	-	-	-
	2020	-	-	-	-	-	-
	2080	-	-	-	-	-	-
ES[3]	1980	0	-	0	-	0	4611
	2020	0	-	0	-	4163	-
	2080	0	-	0	-	4163	-
WL[3]	1980	-	-	-	-	-	-
	2020	-	-	-	-	-	-
	2080	-	-	-	-	-	-
LPP[3]	1980	2331	2	0	-	4389	0
	2020	0	-	2331	15	3787	0
	2080	0	-	2331	35	3787	0
PP[3]	1980	0	-	0	-	0	1611
	2020	0	-	0	12.5	1469	0
	2080	0	-	0	25	1469	0
SAF[3]	1980	0	-	0	-	0	9104
	2020	1031	4	2407	12.5	4809	0
	2080	0	-	3438	25	4809	0

1 Gain in rust resistance
2 Gain in rust resistance. Another 10 to 12 % gain predicted for volume.
3 Predicted gains in volume.

The Douglas-fir Program

Eugenics Projects of the 1970's

The planned Douglas-fir projects detailed in Appendix 3 are summarized in flowcharts (figs. 10 and 11). These are projects either currently underway or planned for the current decade.

Fig. 10
Fig. 11

Seed Production Areas

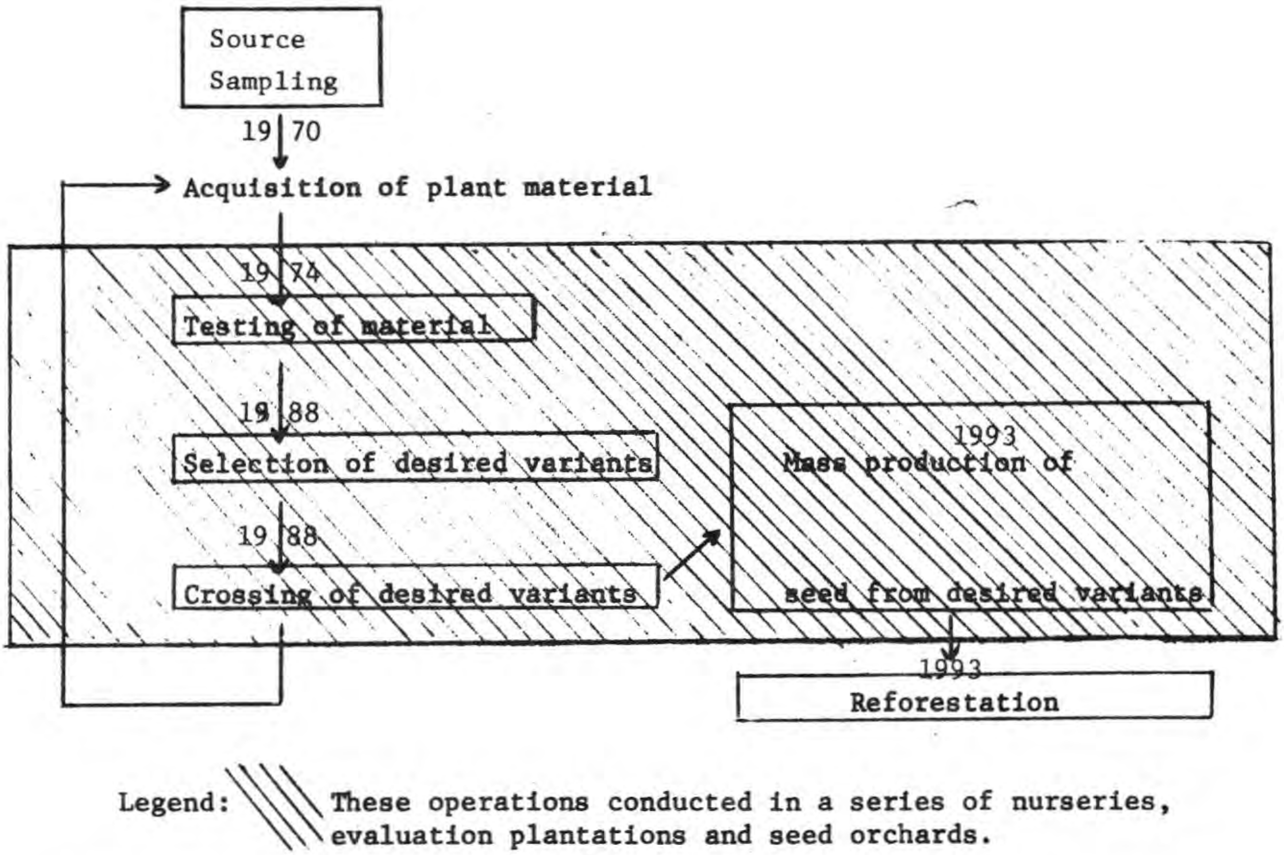
All Douglas-fir seed for planting will still come from wild stands in 1980. A portion of it will come from seed production areas which are parent stands for the Geographic Variation Project (fig. 10 and Appendix 3). Nursery performance and 5-year outplanting performance results will be used to tentatively identify genetically superior stands. These will be thinned to seed production areas in 1979. Six to eight such stands are anticipated.

Additional seed production areas will be established in FY 1975 on the Coeur d'Alene, Clearwater, and St. Joe National Forests as outlined by Hoff and Howe (Appendix 3). The principal objective will be to determine the feasibility of multiple species seed production areas (to include WWP). This will set a pattern for the development of seed production areas throughout the area during 1976-1979 to meet the 1980 seed needs. By 1980 there should be four seed production areas per Forest on each of 10 eastern Washington, northern Idaho, and western Montana National Forests.

The Expanded Program

By the early-to-mid-80's, enough information will have accrued from Douglas-fir projects of the 70's to start an expanded program to meet 21st Century needs of western and eastern Montana (table 3). Sampling will be concentrated in those areas, and will also include sources used in current projects.

Figure 10. Flow Chart of Douglas-fir Geographic Variation Project (Cooperative with Intermountain Forest & Range Experiment Station).



Objective: Assess pattern of genetic variation across broad environmental gradients. Establish outplantings to be rougued to seed orchards.

Sampling: 168 wind-pollinated 1/2 sib families from 24 stands in western Montana and northern Idaho.

Nursery: Replicated sowing at Coeur d'Alene Nursery in May 1972.

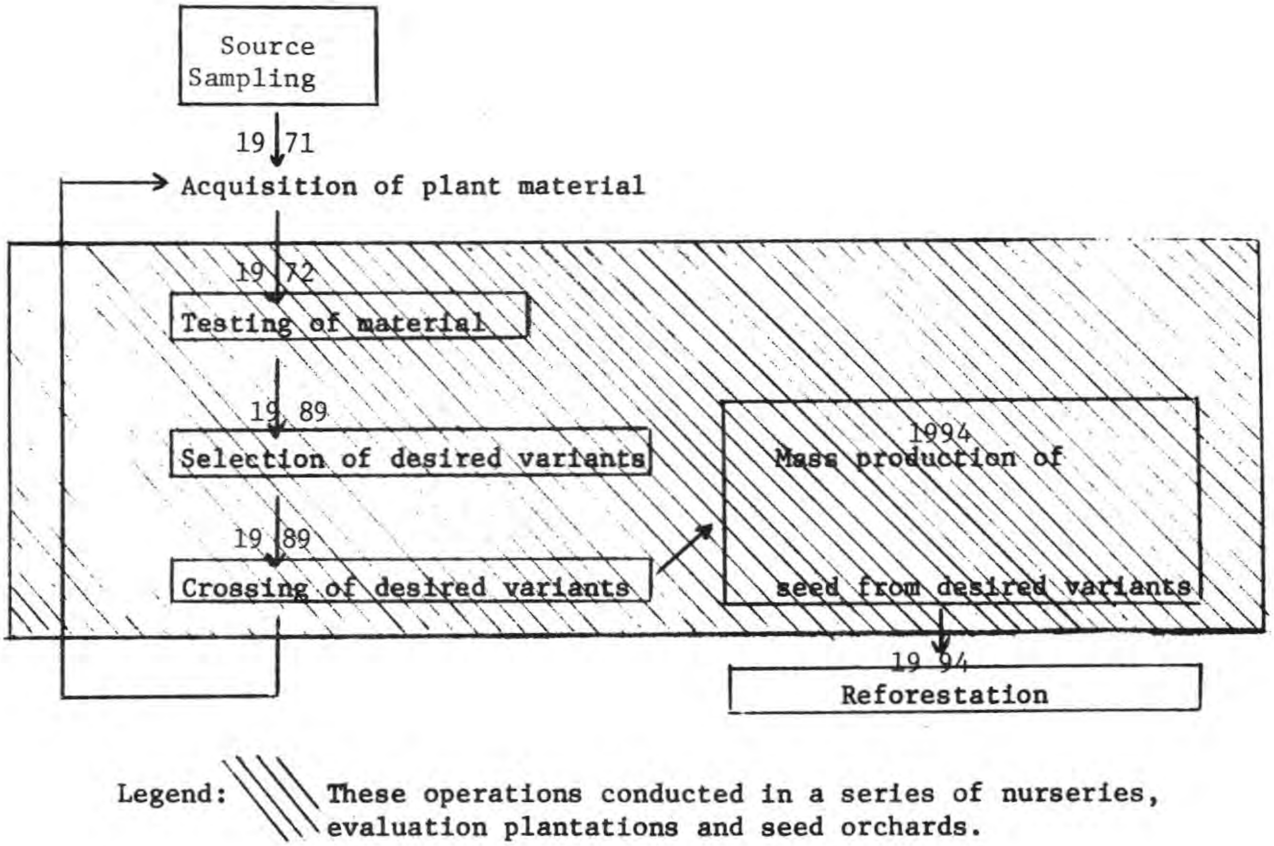
Outplantings: In Spring, 1974, at six sites in western Montana and

northern Idaho--Lone Mountain, Priest River Exp. Forest, Condon, Savenac, Meadow Creek, St. Joe NF.

Potential Seed Orchards: Lone Mountain, Condon, Savenac, Meadow Creek.

Figure .11--Flowchart of Douglas-fir Interracial Hybrids Project

(Cooperative with Intermountain Forest & Range Experiment Station)



Objective: Assess potential for incorporating coastal growth rate into interior race. Establish plantation for roguing into seed orchard.

Sampling: One hundred control-pollinated families from two stands in northern Idaho. Male parents were 25 trees in three stands in Oregon and one stand in British Columbia.

Outplantings: In Spring 1974, at two sites in northern Idaho--Lone Mountain and St. Joe National Forest

Potential Seed Orchard: Lone Mountain.

The Western White Pine Program

Eugenics Projects

The projects planned or underway for the 70's are diagrammed in figures 12 and 13.

Figure 12.--Flowchart of WWP Phase 1
F_2 Seed Orchards (Cooperative with IFRES)

Figure 13.--Flowchart of WWP Phase 2, 3100-tree Evaluation (Cooperative with Intermountain Forest & Range Experiment Station).

Seed Production Areas

Areas on the Coeur d'Alene, Clearwater, and St. Joe National Forests will be established to determine the feasibility and costs of multi-species seed production areas. Most will be combined with Douglas-fir or grand fir (Hoff & Howe, Appendix 3). Another objective will be to determine the rate that natural selection is raising rust resistance and the feasibility of establishing naturally regenerated, natural selection, rust-resistant "seed orchards." Additional seed production areas will be established on the white pine Forests if this technique is satisfactory.

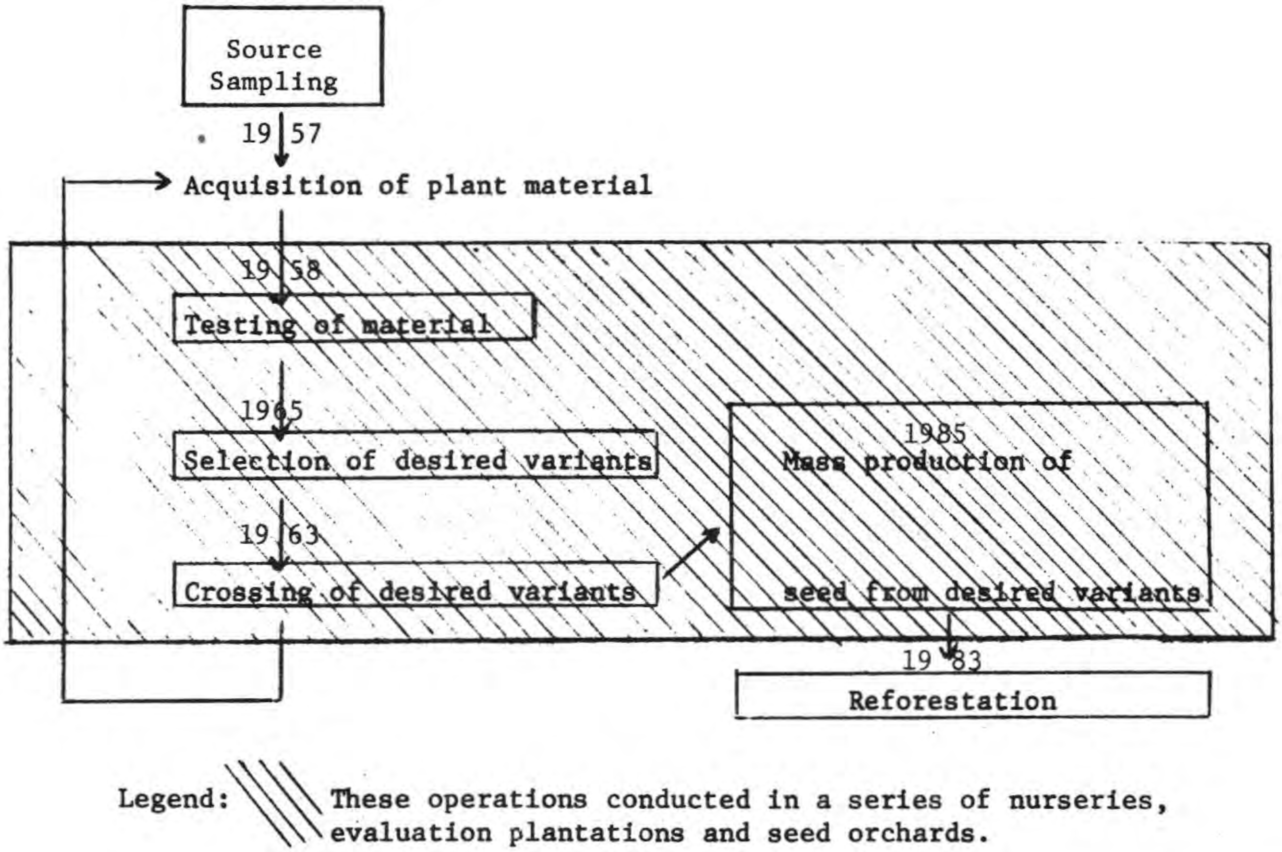
The Ponderosa Pine Program

The Eugenics Project for the 70's

Diagramed in figure 14 is the Inland Empire Ponderosa Pine Tree Improvement Committee project, expected to begin filling R-1 and other participants' seed needs by 1980 (table 3). Eighteen cooperators are participating in this venture; eight of which are nongovernmental agencies.

Figure 14.--Flowchart of the Cooperative Ponderosa Pine Project Eighteen participants.

Figure 12. Flow Chart of WWP Phase 1
F_2 Seed Orchards (Cooperative with IFRES)

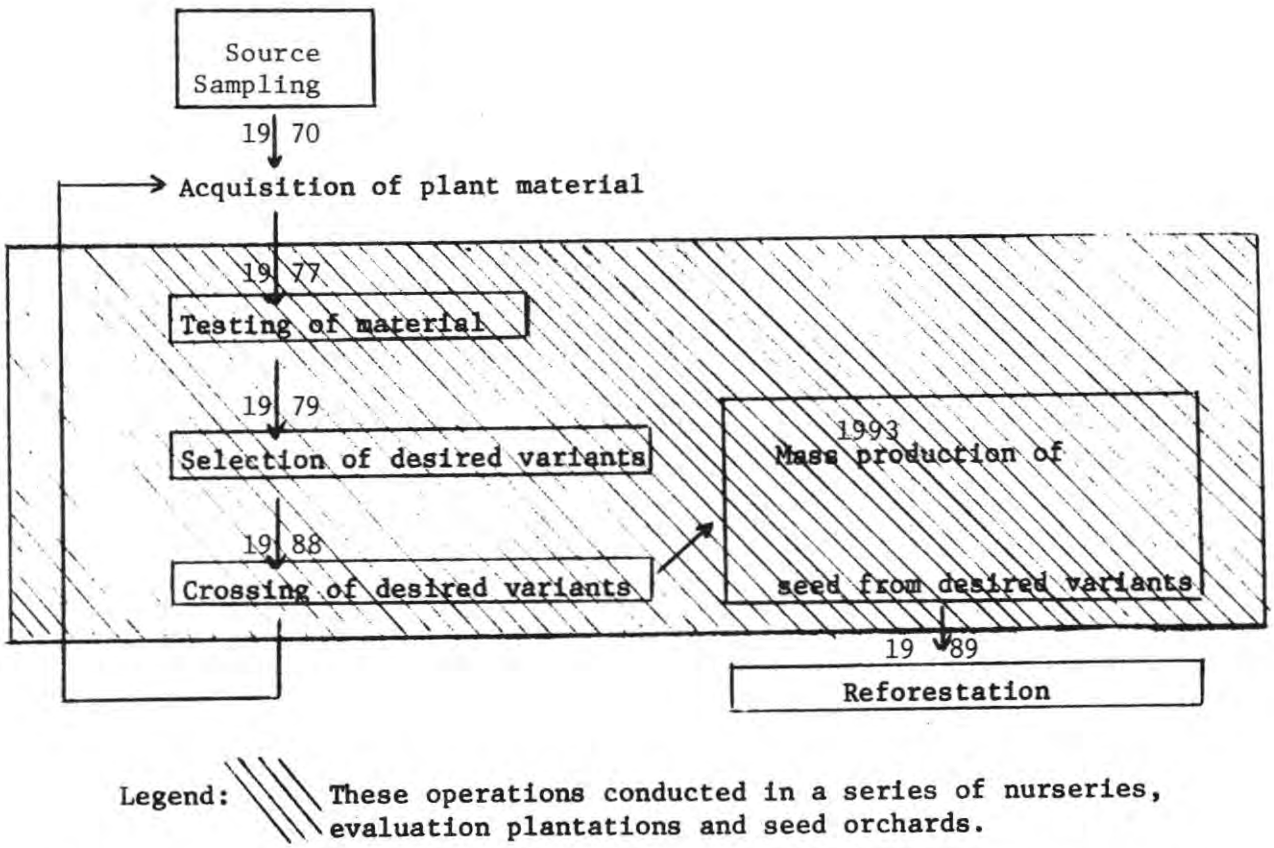


Objective: Produce rust-resistant seed for high-, mid-, and low-elevation planting in northern Idaho, eastern Washington, and western Montana.

Sampling: 12 full-sib families for each elevation band orchard. Parents of know rust resistance.

Orchards: Two at Lone Mountain, one at Coeur d'Alene Nursery. Planting completed in Spring, 1974.

Figure 13. Flowchart of WWP Phase 2 3100-tree Evaluation (Cooperative with Intermountain Forest & Range Experiment Station)



Objective: Produce highly adapted seed for all planting sites in eastern Washington, northern Idaho, and PC1 & 2 in western Montana, improved in rust resistance and growth rate.

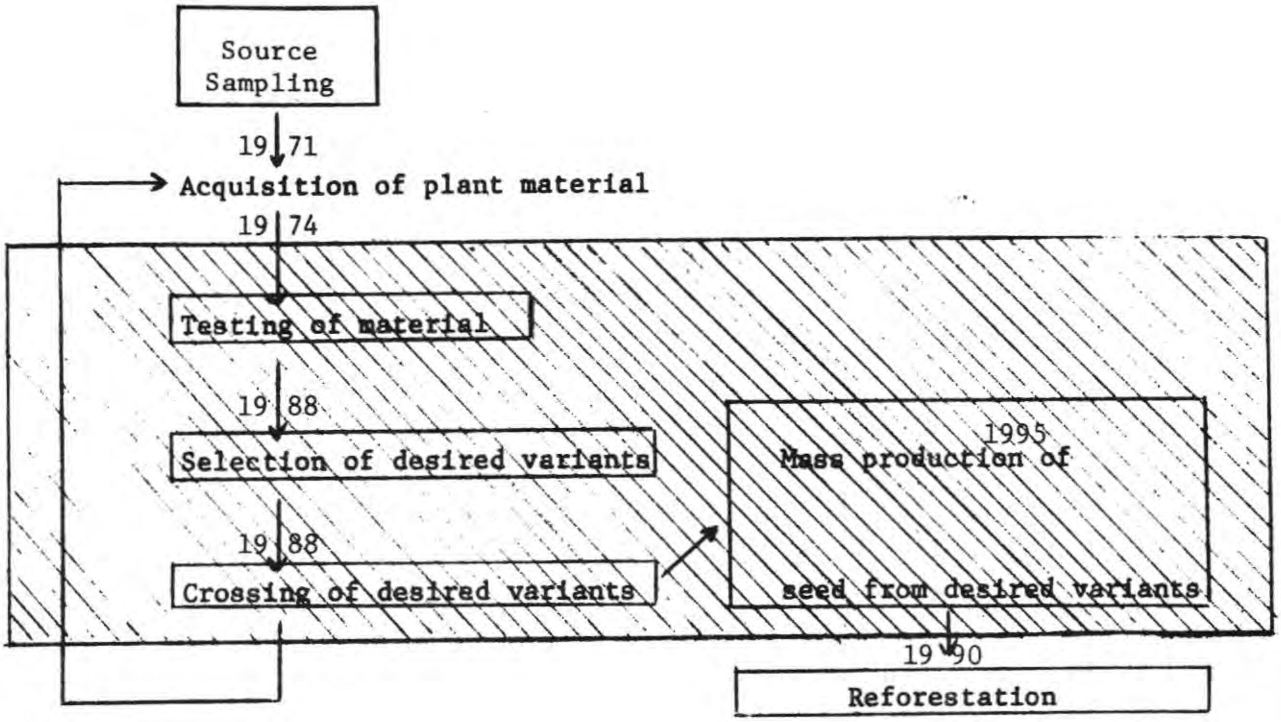
Sampling: Up to 3100 wild putatively resistant trees in area provide control-pollinated or half-sib (CP) families for evaluation. Male parents of CP's have known level of resistance, as well as 400 of female parents.

Testing: Blister rust innoculation to begin in Cd'A Nursery beds in 1976.

Outplanting: Survivors to be outplanted. Begin in 1978 or 1979 at least six sites to be determined. Lone Mountain to be one of them.

Potential Seed Orchards: At least four. Lone Mountain to be one.

Figure 14 Flow Chart of the Cooperative Ponderosa Pine Project
(Eighteen participants)



Legend: These operations conducted in a series of nurseries, evaluation plantations and seed orchards.

Objectives: Produce genetically improved seed (for volume) for planting in Inland Empire west of Continental Divide.

Sampling: Five half-sib (OP) families from each of 90 stands, plus bulk sample from each stand. Weak to mild plus-tree selection.

Outplantings: Nine. Three on NF lands--Long Mountain, Condon, Meadow Creek. Planted in Spring, 1974.

Potential Seed Orchards: Six, including the three NF plantations.

Seed Production Areas

About 30 percent of the parent stands can be thinned by 1980 to serve as seed production areas for genetically superior seed (table 3) as tentatively judged from early progeny test results in the cooperative eugenics project. Forests east of the Continental Divide will establish unevaluated seed production areas to fill about one-half of their needs (table 3). Two to three areas per Forest will be required. Additional seed may be acquired from possibly superior stands sampled in the Southern Idaho Project (Hudson, 1971) or reported by LaFarge (1971).

The Expanded Program

By the second half of the decade of the 80's, a second round of sampling will begin in the eugenics project. This sampling will utilize information and material of the first sampling to further concentrate genes for increased volume.

The Western Larch Program

The Eugenics Project for the 70's

One of the outstanding needs is in western larch (table 2), for which no project has been started. One is to be initiated in the Fall of 1974 by the Northern Region (fig. 15). Information and tentatively superior sources from University of Montana and U.S. Plywood projects may be incorporated.

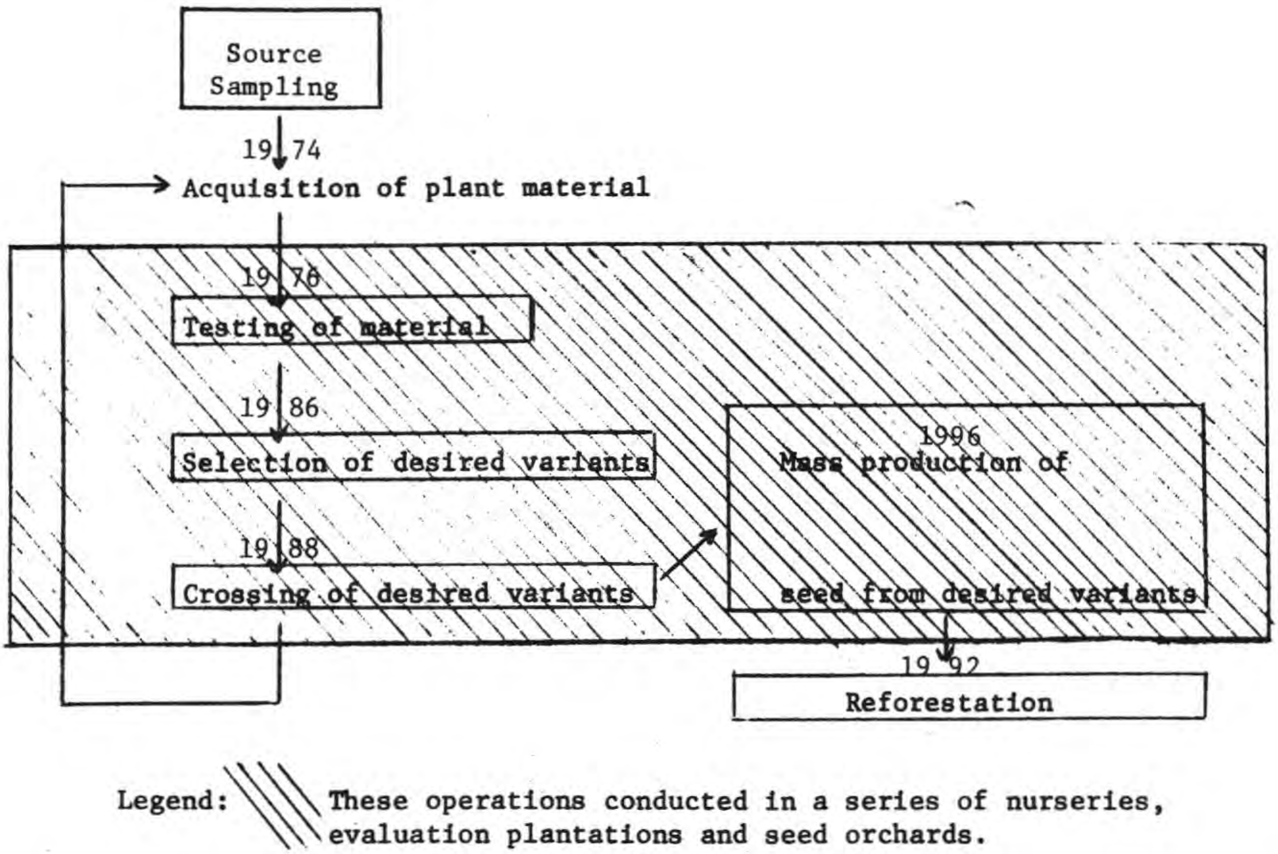
Figure 15.--Flowchart of Western Larch Project

Seed Production Areas

By 1980 enough tentative information will be accrued in the project to permit identifying some parent stands as genetically improved seed production areas. A portion of the seed needs (table 3) will be met from these stands which will number as many as 15.

The eleven WL Forests will develop at least one additional seed production area each, to satisfy the balance of their seed needs.

Figure 15. Flow Chart of Western Larch Project



Objectives: Determine pattern of genetic variation. Determine best local sources. Establish orchards to produce improved seed. Assess potential of nonlocal sources.

Sampling: Ten half-sib (OP) families from each of 5 stands on each of the eleven WL Forests, plus a bulk sample from each stand. Sampling may be enlarged to include cooperators.

Outplantings: Minimum of ten. Each to include local half-sibs only, plus all bulks. Four will be Lone Mountain, Savenac, Condon, Meadow Creek. Other six to be determined.

Potential Seed Orchards: Minimum of five. Lone Mountain, Savenac, Condon to be three--Meadow Creek a possible fourth.

The Lodgepole Pine Program

The Eugenics Project for the 70's

The lodgepole pine project will resemble the larch project in many ways, except that it will be designed to fill the PC1 and 2 needs for all 16 Forests in the Region (fig. 16).

Figure 16.--Flowchart of the Lodgepole Pine Project

Seed Production Areas

A large portion of the needed seed in 1980 can come from parent stands of the eugenics project (table 3) tentatively identified from early progeny test results as genetically superior. The remaining seed will come from one to two additional seed production areas developed by 1980 on each Forest.

The Engelmann Spruce Program

The Eugenics Project of the 70's

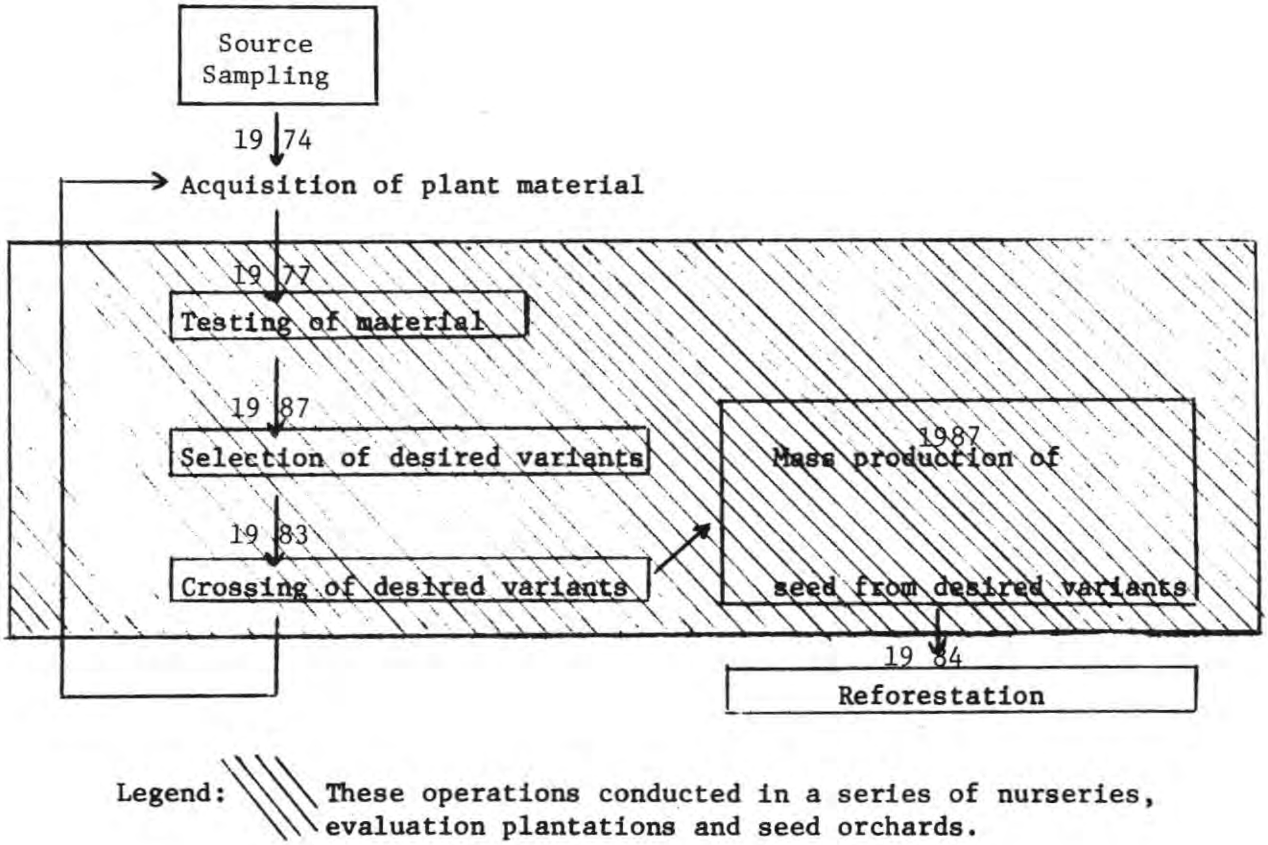
A project in Engelmann and blue spruce was started in 1972, as shown in figure 17.

Figure 17.--Flowchart of Engelmann-blue Spruce Geographic Variation Project (Cooperative with Michigan State University)

The Expanded Program

Information and sources for the current project will be used in developing a project in the early 80's to establish seed orchards to fill the 21st Century needs for spruce.

Figure 16. Flowchart of the Lodgepole Pine Project



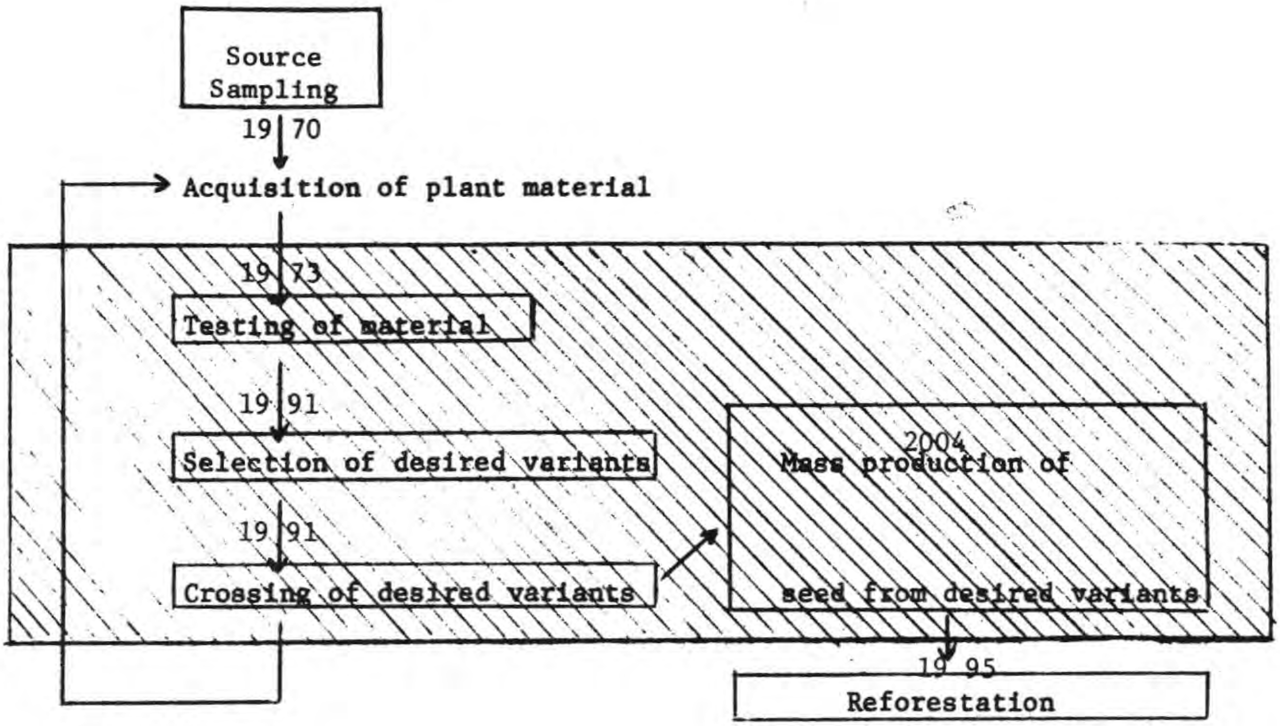
Objectives: Determine pattern of genetic variation. Determine best local sources. Establish orchards to produce improved seed. Assess potential of nonlocal sources.

Sampling: Ten half-sib (OP) families from each of five stands on each Forest, plus a bulk sample from each stand. Sampling may be enlarged to include cooperators.

Outplantings: Minimum of 13. Each to include local half-sibs only, plus all bulks. Four will be Lone Mountain, Savenac, Condon, Meadow Creek. Other ten to be determined.

Potential Seed Orchards: Minimum of eight. Lone Mountain, Condon, Savenac to be three.

Figure 17 Flow Chart of Engelmann-blue Spruce Geographic Variation Project (Cooperative with Mich. St. Univ.)



Legend: These operations conducted in a series of nurseries, evaluation plantations and seed orchards.

Objective: Assess pattern of genetic variation in Engelmann-blue spruce complex. Establish possible seed orchard for Montana plantings.

Sampling: Half-sib and bulk lots from 62 stands in central and Northern Rockies. Many putative hybrids.

Outplantings: Twelve or 13 throughout contiguous U.S. One is at Savenac. Planted, Fall, 1972.

Potential Seed Orchards: Savenac. Others perhaps.

The Grand Fir Program

A portion of the seed for the PC1 and 2 needs of the nine grand fir Forests will come from thinned (FY 1975) parent stands tentatively identified as superior from early progeny test data from Christmas tree plantations on the coast (Douglass, 1970). Information from Douglass' work and, hopefully, from IFRES research work soon to begin, will be used to design a eugenics project in the early 1980's. Additional seed (table 3) will come from multispecies seed production areas established along with white pine and/or Douglas-fir (Appendix 3, Hoff & Howe).

The Subalpine Fir Program

During the 80's a eugenics project will be designed to meet 2020 and 2080 seed needs for PC1 and 2 lands on all R-1 National Forests. In the meantime, research organizations will be encouraged to begin learning about the genetics of the species.

IMPLEMENTING THE EUGENICS PROJECTS

Overall planning for all tree improvement projects in Region 1 will remain with the Regional Forester. The Regional Geneticist will plan for species, size, design, location and care of seed orchards and evaluation plantations, when, where and how to sample populations, interpretation of results and seed source recommendations. Forests will be responsible for providing the manpower and equipment to implement the plans. A written plan for each project will be reviewed by Forest Supervisors and District Rangers and revised, then approved by each participant before funding is given to the respective participant. There will be no projects undertaken in Region 1 without these kinds of controls; tree improvement projects will always be Regionwide or botanical-range-wide in perspective.

The key to success of Regional tree improvement programs in Regions 4 and 6 has been maximum Forest and District involvement. This emphasis also follows the direction set by the Northern Region Regional Forester.

MEASUREMENTS, RECORDKEEPING, AND ANALYSES

The traits which will be measured will be the commercially important traits plus all other rapidly measurable traits which careful observation indicates are variable. Research cooperators may wish to measure additional traits. Some measurements may require destructive sampling, so this sampling must be planned for.

Data will be manually recorded in the field on sheets designed for direct keypunching. The data will be key punched into computer cards or directly onto magnetic tape for storage. Data storage, retrieval, and summary programs are already written to handle data collected in the white pine Phase 2 3100-tree Evaluation project. The data sheet and data card formats (Appendix 6) are usable for any other tree species. The programs, too, are easily convertible for use for other species.

In general, data will be entered into a data matrix and subjected to the multivariate extension of the analysis of variance. This technique will permit assessment of family, group, and provenance performance ranking, and will permit the extraction of the components of variance necessary for computation of heritabilities.

An associated need is to develop a system for tracing plant material from seed through plantation. Genetically improved material will be identified so that its "pedigree" can be located in the accession record in the Regional Office. This is to be completed in FY 1974 by the Regional Geneticist.

RESEARCH NEEDS

Cooperative projects between the Northern Region and research agencies:

(1) Benefit directly and substantially current management practices.

(2) Define clearly the feasibility of proposed management practices. Cooperative tree improvement projects undertaken are those which contribute either: (1) plant material for genetically improved seed production, or (2) information to increase the efficiency of eugenics projects.

The projects outlined in this document have been planned so that interested research organizations can utilize the material for research. The experimental designs are appropriate for the tree improvement needs of Region 1 and for research needs, present and anticipated.

Preceding discussions permit a priority listing of research needs for R-1 tree improvement:

(1) Criteria for developing gene banks.

(2) The nature, pattern and extent of genetic variation, including disease and insect resistance in western white pine, interior Douglas-fir, ponderosa pine, and lodgepole pine.

(3) Improved efficiency for breeding for blister-rust resistance in western white pine.

(4) Biological or chemical control of seed and cone insects.

(5) The nature, pattern, and extent of genetic variation in western larch, Engelmann spruce and grand fir.

(6) The feasibility of breeding for budworm resistance in Douglas-fir and for casebearer resistance in western larch.

(7) Genetics research in other Northern Rocky Mountain species, especially subalpine fir.

Usable genetic variation exists in western white pine, Douglas-fir, ponderosa pine and lodgepole pine, and is assumed in Engelmann spruce, western larch, and grand fir. Projects cannot be planned efficiently in ignorance of these questions. Cooperative research concurrent with R-1 projects using extensive population samples will provide the answers when they are needed for seed orchard establishment, roguing, and resampling. Ten to 15 percent of the R-1 tree improvement budget annually will be devoted to cooperative research projects to answer these questions.

ESTIMATED COST SUMMARY THROUGH 1980

Summarized in table 4 are actual costs of the R-1 Tree Improvement Program, FY 1971 through FY 1973, and estimated costs FY 1974 through 1980.

Table 4 R-1 Tree Improvement Program Costs[1/]

Fiscal Year

Unit	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Total
	- - - - - - - - M Dollars - - - - - - - - - - - - - -										
Forests	36.6	199.1	142	138.5	187.5	249	278	303	328	366	2227.7
IFRES [2/]	48	48	24	24	0	0	0	0	0	0	144
RO Technical Direction	10	20	20	20	20	21	22	22	22	24	201
TOTAL	94.6	267.1	186	182.5	207.5	270	300	325	350	390	2572.7

1/ Includes all P&M financing for eugenics projects and seed production area establishment. Does not include WCF-financed seed orchard operation or regular seed procurement.

2/ Payments to IFRES for cooperative developmental work.

CHAPTER III

OTHER GENETIC CONSIDERATIONS

Two other areas discussed in Chapter I require genetic considerations. The first is the educational and training needs of R-1 personnel, from administrative people to Forest and District personnel making on-the-ground resource management recommendations and decisions. The second area is providing guidelines to the Forest for the technical genetic aspects of the program for revegetation for nontimber objectives on National Forest lands (the so-called "Native Shrub Program").

EDUCATION AND TRAINING

In raising the level of genetic consciousness, there are three distinct needs. The first is to build a genetic foundation for those making resource management prescriptions at the District and Forest level. The second is to build specific skills in personnel implementing TI Program projects. Third, an understanding of and commitment to the Forest Genetics Program must be developed at the Regional Forester's Staff and Forest Supervisor level.

Building Genetic Competence in Forest and District Resource Managers

The Program for Continuing Education in Forest Ecology and Silviculture (CEFES)

This program was initiated in 1973 in response to a deficiency in biological understanding in our Forest and District personnel making resource management (principally silvicultural) prescriptions. The program is a 3-month, highly intensive, graduate-level course of study. It builds from a consideration of the biology of individuals in forest communities, to the biology of populations, to the functioning of biological systems (see Prospectus and Outline, Appendix 2). The genetics portion deals with mitosis, meiosis and Mendelian genetics, and population and quantitative genetics, and their application to tree and shrub improvement and the genetic impacts of all resource management on populations of plants and animals.

This integrated approach to forest ecology will permit these specialists to put genetic considerations into the perspective of the overall biological needs of an area. These people will be prepared to recognize the genetic consequences of their actions, be they in timber harvesting, recreation development, or supervising a portion of a Tree Improvement Program project. The CEFES cost $60,000 for 25 students plus the time of the students in the first year of its operation. Fourteen percent of the instruction contact hours were in genetics.

<u>Genetic Principles, Packaged</u>

Genetic knowledge among resource managers in R-1 is lacking. The CEFES cannot meet this deficiency within a few years. Consequently, a multi-media "packaged" genetics education program will be developed for these personnel. It will be designed so that the program can be completed at the Official Station.

The program will cover the same areas and specialists covered in CEFES, and will be developed by the Regional Geneticist, with cooperation from CEFES genetics instructors. This package is to be completed during FY 1975 at an estimated cost of $6,000 plus the time of students.

<u>Building Skills for Tree Improvement Projects and Seed Procurement</u>

Specific skills such as how to space planted seedlings precisely, how to measure trees rapidly in evaluation plantations, how to mass pollinate, how to replicate, how to evaluate cone quality, etc., must be built into technicians and supervisory foresters implementing tree improvement projects and seed procurement. Each skill will be introduced by a multi-media training package, to be followed by supervised practice of the skill. All personnel involved in these functions will be required to satisfactorily complete the appropriate training beforehand. It is estimated that the development of these packages will cost $5,000 to $6,000 initially (FY 1975) and $500 annually thereafter.

Building Understanding in Administrative Officers

The Regional Geneticist will develop a multi-media presentation of the Forest Genetics Program for presentation to the Regional Forester's Staff and Forest Supervisors. This will be a 30-minute summary of the needs, goals, reasonable expectations, mileposts, and costs of the Program. The presentation will help these administrative officers to view in perspective forest genetics and tree improvement in the total Regional and Forests' programs.

This presentation will be completed in FY 1974. The Regional Geneticist will give the presentation and answer questions in Regional Forester's Staff and Forest Supervisors' meetings in FY 1974.

GENETIC INPUTS INTO THE NATIVE SHRUB PROGRAM

Northern Rocky Mountain National Forests annually revegetate lands for nontimber objectives. The principal reasons are:

1. Burned area rehabilitation and fire and fuel management.
2. Wildlife habitat improvement.

3. Roadway cut and fill slope stabilization (current backlog of 12,250 acres; additional accumulation of 2,450 acres annually).
4. Campgrounds and other recreation area enhancement.
5. Rehabilitation of air pollution-killed areas.
6. Mining area reclamation.

In all cases, production of a harvestable plant product is unimportant. Establishment, survival and maximum occupation of a site are the principal objectives. Genotypes well adapted to specialized environmental conditions are required. With help from IFRES, the major environmental factors accounting for success and failure of plants will be defined. Then genotypes suited to those conditions may be selected and recommended. As an interim step, guidelines for seed and cutting collection are being provided in the revision of the R-1 Seed Handbook, to be completed in FY 1974.

LITERATURE CITED

Anonymous. 1972[a] Potential programs of softwood intensified timber management in the United States. USDA Forest Service Nov. 15, 1972 Revised Draft.

Anonymous. 1972[b] The outlook for timber in the United States- A report of the findings of the 1970 timber review. USDA Forest Service Dec. 5, 1972 Review Draft.

Beaufait, Wm. R. 1971. Fire and smoke in Montana Forests. In: Weddle, Richard M. (ed.) Forest Land Use and the Environment, Montana Forest & Cons. Expt. Sta., Missoula, 1971. 150 pp.

Beaufait, Wm. R. 1972. Personal communication. USDA Forest Service Missoula, Montana.

Bingham, R. T., R. J. Hoff and G. I. McDonald. 1971. Disease resistance in forest trees. Ann. Rev. Phytopath. 9: 433-452.

Bingham, R. T., R. J. Hoff, and G. I. McDonald. 1973. Breeding blister rust resistant Western White Pine VI. First results from field testing of resistant planting stock. USDA Forest Service. Res. Note INT (in press)

Brickell, James E. 1970. Equations and computer subroutines for estimating site quality of eight Rocky Mountain species. USDA Forest Service. Res. Pap. INT-75. 22 pp.

Brown, C. and R. Pfister. 1971. Management implications - timber productivity. In: Identification and management implications of Daubenmire's habitat types training; Coeur d'Alene, Idaho. USDA Forest Service, Region 1.

Callaham, R. Z. 1960. Geographic variation in growth responses of ponderosa pine. Proc. Soc. Amer. Foresters 1959: 38.

Campbell, Robert K. 1963. Phenotypic correlation among branch and upperstem attributes in Douglas-fir. Forest Sci. 9(4): 444-451.

Carlson, Clinton E. and Jerald E. Dewey. 1971. Environmental pollution by fluorides in Flathead National Forest and Glacier National Park. USDA Forest Service, Missoula, Montana. 57 pp.

Critchfield, W.B. 1957. Geographic variation in Pinus contorta. Maria Moors Cabot Foundation. Pub. No. 3. 118 pp.

Daubenmire, R. and Jean R. Daubenmire. 1968. Forest vegetation of eastern Washington and northern Idaho. Wash. Agri. Expt. Sta. Tech. Bul. 60. 104 pp.

Douglas, Bernard S. 1970. Preliminary evaluation of grand fir provenance tests to rate Christmas tree characteristics. USDA Forest Service, Region 6.

Dyrland, Dick. 1971. Program analysis III and the resource manager. USDA Forest Service, Region 5.

Falconer, D. S. 1960. Introduction to quantitative genetics. Ronald Press, NY. 365 pp.

Ford-Robertson, F. C. (ed). 1971. Terminology of forest science, technology, practice and products. Soc. Am. Foresters, Wash., D.C. 349 pp.

Fowler, D. P. and C. C. Heimburger. 1969. Genetic improvement of red pine and eastern white pine. Forest Chron. 45(6): 414-420.

Gerhold, H.D. 1966. Growth and winter injury of Douglas-fir in a 3-year provenance demonstration. Northeast. Forest Tree Impr. Conf. Proc. 13: 50-52.

Haller, J. R. 1965. The role of 2-needle fascicles in the adaptation and evolution of ponderosa pine. Brittonia 17(4): 358-382.

Hanover, James W. and Burton V. Harnes. 1969. Heritability of height growth in western white pine seedlings. Silvae Genet. 18(3): 80-82.

Heimburger C. 1962. Breeding for resistance in forest trees. Forest Chron. 38(3): 356-362.

Heinselman, Miron L. 1971. The natural role of fire in northern conifer forests. In: Slaughter, C.W., Richard J. Barney, and G.M. Hansen (ed.). Fire in the northern environment--a symposium. USDA Forest Service. PNW Sta. 61-72.

Hoff, Raymond J. and Geral I. McDonald. 1972. Stem rusts of conifers and the balance of nature. In: Biology of rust resistance in forest trees. NATO-IUFRO Adv. Study Inst. 1969. 525-536.

Howe, George E. 1971. Assessment of genetic variation in a multi-plantation test of half-sib families of Scotch pine. PH.D Thesis, Mich. St. Univ. 83 pp.

Hudson, Russell. 1971. Personal communication. St. Regis Paper Co., Libby, Montana.

Illingworth, K. 1971. Geographic variation in Pinus contorta. Commit. Forest Tree Brdg. in Canada. Proc. 13 (in press).

Kinloch, Bohun B., Jr., Gaylord K. Parks and Carl W. Fowler. 1970. White pine blister rust: Simply inherited resistance in sugar pine. Science (Washington) 167(3915): 193-195.

Kral, Friedrich. 1967. Inter- und intrapopulationsgenetische Frühtestuntersuchungen on Douglasien-Provenienzen. Cent. Gesamte Forstwessen 84(2-6): 182-206.

LaFarge, Timothy. 1971. Inheritance and evolution of stem form in three northern pine species. PH.D. Thesis. Mich. St. Univ. E. Lansing.

Lester, D. T. and G. R. Barr. 1965. Provenance and progeny tests in red pine. Forest Sci. 11(3): 327-340.

Lotan, James. 1971. Personal communication. USDA Forest Service, INT Forest & Range Experiment Sta., Bozeman, Montana.

Mason, Lee M. 1973. Personal communication. USDA Forest Service, Coeur d'Alene National Forest Nursery, Coeur d'Alene, Idaho.

McDonald, G. I. and R. J. Hoff. 1970. Resistance to Cronartium ribicola in Pinus monticola: Early shedding of infected needles. USDA Forest Service. Res. Note INT-124.

McKimmy, M. D. 1966. A variation and heritability study of wood specific gravity in 46-year old Douglas-fir from known seed sources. TAPPI J. Tech. Ass. Pulp PAP. Ind. 49(12): 542-549.

Moore, William R. 1971. Personal communication. USDA Forest Service Northern Region, Missoula, Montana.

Mutch, Robert W. 1970. Wildland fires and ecosystems--a hypothesis. Ecol. 51(6): 1046-1051.

Ogilvie, R. T. and E. von Rudloff. 1968. Chemosystematic studies in the genus Picea (pinaceae). IV. The introgression of white and Engelmann spruce as found along the Bow River. Can. J. Bot. 46(7): 901-108.

Painter, Reginald H. 1951. Insect resistance in crop plants. The Univ. Press of Kansas. Lawrence. 520 pp.

Patterson, D. N. 1969. Further studies in wood quality, wood quantity, wood value and rotations from wood core analysis. East Afr. Agr. Forest J. 35(1): 33-44. Abstracted in: Biol. Abst. 51:51889.

Pfister, Robert D., Stephen F. Arno, Bernard L. Kovalchik, and Richard C. Presby. 1973. Preliminary forest habitat types of central and eastern Montana. USDA Forest Service In't. Forest & Range Experiment Sta. and Region 1, Missoula, Montana.

Pfister, Robert D., Stephen F. Arno, Richard C. Presby, and Bernard L. Kovalchick. 1972. Preliminary forest habitat types of western Montana. USDA Forest Service, In't. Forest & Range Experiment Sta. and Region 1, Missoula, Montana. 80 pp.

Philpot, Charles. 1972. Personal Communication. USDA Forest Service. Northern Forest Fire Lab., Missoula, Montana.

Rehfeldt, G. E. and R. J. Steinhoff. 1970. Height growth in western white pine progenies. USDA Forest Service Res. Note Int.-123.

Rieger, R., A. Michaelis and M. M. Green. 1968. A glossary of genetics and cytogenetics. Springer-Verlag. New York. 507 pp.

Roche, L., M. J. Holst and A. H. Teich. 1969. Genetic variation and its exploitation in white and Engelmann spruce. Forest Chron. 45(6): 445-448.

Rolmeder, E. 1961. Das Problem der Erkennbarkeit Über Durchsohnittlicher Wuchsveranlagung am Phänotyp der Mutterbäume. Forstwissenshaftl. Centralbl. 80(11/12): 321-343.

Rudolph, T. D., R. E. Schoenike, and T. Schantz-Hansen. 1959. Results of one-parent progeny tests relating to the inheritance of open and closed cones in jack pine. Univ. Minnesota Forestry Notes No. 78.

Silen, Roy R. 1966. A simple progressive tree improvement program for Douglas-fir. USDA Forest Service. Res. Note PNW-45. 13pp.

Silen, Roy R. 1972. Personal communication. USDA Forest Service. PNW Forest & Range Experiment Sta., Corvallis, Oregon.

Steinhoff, R. J. 1972. Personal communication. USDA Forest Service. Int. Forest & Range Experiment Station, Moscow, Idaho.

Steinhoff, R. J. and R. J. Hoff. 1971. Estimates of heritability of height growth in western white pine based on parent-progeny relationships. Silvae Genet. 20:141-143.

Squillace, A. E., R. T. Bingham, Gene Namkoong and H. F. Robinson. 1967. Heritability of juvenile growth rate and expected gain from selection in western white pine. Silvae Genet. 16(1): 1-6.

Vins, Bohuslav. 1966. Prispevek k vyzkumu promenlivosti jedle (Abies alba Mill.) [A contribution to the variability of silver fir (Abies alba Mill.)] Rozpr Cesk Akad Ved Rada Mat Prir Ved 76(15): 5-88 Abstracted in: Biol Absts. 50:66860.

Wellner, C. A., S. S. Evans, R. T. Bingham, G. E. Rehfeldt, and R. J. Steinhoff. 1970. Genetic tree improvement program - Northern Region. USDA Forest Service, Northern Region, Missoula, Montana.

Wells, Osborn Oliver. 1963. Geographic variation in ponderosa pine (Pinus ponderosa Dougl. ex Laws.) PH.D. Thesis, Mich. St. Univ.

White, Richard. 1973. Personal communication. University of Idaho, Moscow, Idaho.

Wright, J. W. 1970. Mich. St. Univ. Forestry Dept. Personal communication. E. Lansing.

Wright, J. W., F. H. Kung, R. A. Read, W. A. Lemmien, and J. N. Bright. 1971. Genetic variation in Rocky Mountain Douglas-fir. Silvae Genet. 20(3): 54-59.

Yeatman, C. W. 1967. Biogeography of jack pine. Can. J. Bot. 45(11): 2201-2211.

Yeatman, C. W., and A. H. Teich. 1969. Genetics and breeding of jack and lodgepole pines in Canada. Forest Chron. 45(6): 428-433.

Zobel, Bruce J. 1971. The genetic improvement of the southern pines. Sci. Amer. 225(5): 95-103.

APPENDIX I

GENETIC PRINCIPLES AND INFERENCES FOR THE FOREST GENETICS PROGRAM

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POSSIBLE IMPACTS OF MAN'S ACTIVITIES ON GENE RESOURCES

Natural and human impacts on the environment which influence survival or reproductive behavior ~~has~~ have as their ultimate consequence changes in gene frequency in populations of plants and animals. That is, the number of individuals carrying a particular gene (or combination of genes) changes from generation to generation. This is evolution. Any man-induced change in gene frequency which makes a population poorly adapted to the environment in which it must function must be judged undesirable. In following sections are obvious examples of undesirable man-induced changes in gene frequencies in tree populations. Other of man's activities are viewed in light of their possible genetic consequences. Much of the ensuing is speculative.

Tree Improvement Projects

Size and Distribution of the Gene Pool

The size of the gene pool in an improvement program is a function of the sampling intensity in the populations providing plant material for the program. Wild populations may be randomly or non-randomly sampled. Non-ramdom sampling, e.g., plus-tree (phenotypic) selection, may be very efficient if the trait (or traits) selected for have high heritabilities. However, genotypically non-random selection provides the improvement program with genetically unrepresentative plant material, at least in some genes and gene combinations. Furthermore, non-random selection in wild populations often commits to search and measurement many dollars [of] [time and money] which might be better spent for progeny evaluation [testing]. The effort also restricts the size of the sample included in the program. Skewed and restricted sampling can produce genetically "improved" populations which are suited to a narrow range of environmental conditions. Reforestation in the Northern Rockies--with their immense ecological amplitudes--cannot tolerate these genetic restrictions.

Low-intensity phenotypic selection of plant material in wild populations may permit sample sizes three to four times those of classical plus-tree selection programs, for the same cost, and reduces skewness. Increasing sample size increases the probability of selecting genetically superior individuals, compared to plus-tree selection, if it turns out that the trait in question is under stronger environmental than genetic control (i.e., its genetic potential cannot be recognized in wild trees).

However, quadrupling the sample size can quadruple the size of the testing program that follows. The magnitude of the testing program argues for inter-agency cooperation to spread the cost over several organizations. Other shortcuts, too, can be used to reduce the enormity of the task.

The genetic base must not be seriously restricted or skewed in our Tree Improvement Program. Ultimately, all seed used for reforestation in the Northern Rockies may come from seed orchards. To help assure adequate sampling, the Tree Improvement Program emphasizes low intensity phenotypic selection and large sample size in wild populations.

Capital for Gene Banks

Regardless of how the seed is acquired, man's artificial reforestation practices reduce the number of sources of seed. He cannot collect from every potential parent. Thus both natural and artificial reforestation, even in the absence of tree improvement, has the potential of reducing the gene pool. Eugenics projects, based on adequate extensive sampling, will provide collections from wild populations to be maintained in perpetuity in gene banks.

Controlling Introduced Insects and Diseases

Man has inadvertently introduced some serious insect and disease pests into populations of North American trees. Where resistance genes to exotic pests have been present in a host, breeding programs have been spectacular in rapidly building genetic resistance, without concurrent deterioration of other genetic characteristics. Insect and disease resistance is frequently under strong genetic control (Bingham et al., 1971; Heimburger, 1962; Kinloch, et al., 1970; McDonald and Hoff, 1970; Painter, 1951). Resistance is often conditioned by a few dominance- or epistatic-effect genes. Genetic linkage of pest resistances with other traits is likely to be weaker than among traits controlled by numerous additive-effect genes. Thus, strong selection for pest resistance may be nearly random selection for other genes in the population. Consequently, plus-tree selection for pest resistance may be both highly effective and relatively free of selection bias for other traits.

Local Versus Non-local Sources

The tree breeder's toughest problem is how to balance the benefits of local adaptation against the exploitation of genetic variation, the greatest sources of which are geographic. No genetic improvement is possible in a population having no genetic variation (unless variation is synethesized), and the greater the variation present, the greater the potential improvement. The breeder searches for genetic variation. In most species the greatest amounts are region-to-region, and the breeder wishes to exploit these by provenance (inter-regional) selection.

However, the reason these genetic differences exist is because environmental influences in different regions have been different for many thousands of years; natural selection has adapted local populations to local conditions. Local populations are almost always well adapted to local conditions, but it does not necessarily follow that non-local sources are not adapted to local conditions. Only thorough testing can determine the adaptability of non-local sources; we will not recommend the wide scale use of non-local sources which are not adequately tested.

Introduction of Exotics

The introduction of exotics has proven to be the most valuable tool for tree improvement in Australia, Argentina, and Brazil. In the United States the most important cultivated Christmas tree species, Scotch pine, is an exotic.

The tree improvement picture is not complete without considering the introduction of exotics. These considerations will be based on:

(1) the performance of exotics already introduced into Region 1, and

(2) the performance of species in native habitats similar to Region 1 habitats.

Because of more immediate and urgent needs, and numerous past failures of exotics in Region 1 (Beaufait, 1972), the introduction of exotics assumes low priority. No projects are planned in this document.

Fire and Fuel Management

Some tree and shrub species cannot assume their natural ecological roles in the absence of fire, because of mechanisms which have developed in response to the selection pressure of fire. Obvious adaptive mechanisms are:

(1) Cone serotiny in lodgepole pine.

(2) Seed transportability in western larch and Douglas-fir.

(3) Insulative bark of ponderosa pine, western larch, and Douglas-fir.

Other less obvious but possible adaptive mechanisms are:

(1) New variation created by genetic drift; populations develop out of small patches of fire survivors.

(2) Control of native insect and disease pests (Heinselman, 1971), preventing the development of strong genetic resistance in the trees. That is, fire may have consistently removed the selection pressure of an insect or disease pest before enough tree generations were exposed to it to build genetic resistance.

(3) Heat-induced mutations in surviving trees.

(4) Development and maintenance of allelopathy (Philpot, 1972).

(5) Intraspecific variation in shade tolerance.

(6) Development and maintenance of flammability (Mutch, 1970).

What Could Fire Exclusion Do?

Fire exclusion from lodgepole pine stands for one generation could convert them from predominantly serotinous-coned trees to mostly open-coned. This is because cone serotiny is apparently controlled by a single gene pair in lodgepole pine (Lotan, 1971) as in jack pine (Rudolph et al, 1959). Lodgepole pine has an extremely short generation cycle, so removing the selection pressure of fire and the effectiveness of the alternative selection on a simply inherited trait could effect evolutionary rapid change.

The change would create a regeneration problem for the lodgepole pine manager. Stands would no longer be adequately naturally regenerated by clearcutting and slashing. This technique depends upon seed stored in serotinous cones. But slash from nonserotinous trees would have no seed stored in its cones.

More importantly, non-serotiny would prevent a stand from regenerating adequately following a wildfire, which will be highly probable (Beaufait, 1971) until most forests are under management. Man's attempts at removing a natural selection pressure will have made some populations poorly adapted to the environment in which they must function.

Fire suppression practices over 50 years have had little effect on quantitative adaptive fire traits. One generation of mild selection for numerous additive-effect genes is unlikely to change gene frequency measurably. All of the traits listed in the preceding section, except lodgepole pine cone serotiny, probably are controlled by these kinds of genes, and have been little altered by wildfire suppression activities.

Synthesized Chemicals in the Environment

Los Angeles smog kills trees in the Angeles National Forest. Fluoride in the air near Columbia Falls, Montana, alters plant reproduction and kills trees in the Flathead National Forest. Fluoride pollution near Garrison, Montana, has similar results. These are examples of unplanned biological consequences of industrial processes. Man also uses chemicals for the planned control of biological process. What may be some of the genetic consequences of synthesized chemicals in the environment?

Air and Water Pollution

Three possible genetic consequences of air and water pollution are:

(1) Killing of most trees over very wide areas will prevent rehabilitation with local seed sources. This is exemplified in the Kellogg, Idaho, area (Figure 5)

(2) Selective killing and genotypically non-random disturbance of reproduction may be a selection for resistance to the pollutant.

(3) The chemical, particularly if it becomes systemic, may induce mutations.

Herbicides, Silvicides and Pesticides

The short-term consequences of chemical "biocides" balanced against the destruction wrought by unchecked pests has often weighed in favor of the use of the chemicals. Long-term consequences sometimes reversed the scale. DDT was a well-known example.

Yet, balance mechanisms operating in wild populations of plants and their pests may be lost entirely when the plants are brought under cultivation. Chemical weed and pest controls will continue to be needed in agriculture and forestry until man develops effective alternatives. We must use them, but we must first know their action and then administer them safely, to prevent dysgenic consequences.

The Tree Improvement Program will use chemical weed control. Genetic tests demonstrate that weed competition introduces the greatest source of uncontrolled variation--statistical inprecision--into nursery and plantation evaluations. The uncontrolled variation, which includes genotypically non-random mortality, often masks genetic differences between groups evaluated. Chemical treatments have been shown to be the most efficient control of weed competition.

Other Impacts on Environment

Listed here are activities whose ecological and economic consequences are recognized. Their genetic implications are largely unknown. There probably are genetic consequences of these activities, and we should learn what they are.

Monoculture

Multiple-species stands are replaced in reforestation by a single species of a single age class over a wide geographic area. Genes formerly represented in now-absent species are lost from the gene pool.

Economic Selection

This is a timber harvest regime where all merchantable trees are cut and no investment is made in post-cutting regeneration costs. Natural regeneration might be hoped for, but with no conscious assistance from the forester. The regime is not used on R-1 National Forests, but is employed on other timbered lands in the Northern Rockies. This frequently has the consequence of leaving live cull trees for seed, a possibly dysgenic action, as already discussed.

Slides, Flooding, Wind Damage

Man's construction and flood control and hydroelectric projects often destroy large populations of plants. These parallel natural phenomena, but on a larger scale. Some types of partial cutting may approximate the results of wind damage, another sometimes catastrophic event.

Heavy Recreational and Grazing Use

Camping, hiking, skiing, snowmobiling, horseback riding, littering, wildlife and domestic grazing, etc., create unusual and genetically unmeasured impacts on the land and its resources.

SOURCES OF GENETIC VARIATION

Genetic improvement is based on genetic variation. It is not necessarily true that usable genetic variation exists in a species, even over an entire botanical range, as demonstrated by red pine (Fowler and Heimburger, 1969; Lester and Barr, 1965; Wright, 1970). A tree improvement program should be based upon confirmed knowledge of genetic variation in the population to be dealt with. This information is available for Region 1 populations of western white pine (Hanover and Barnes, 1969; Rehfeldt and Steinhoff, 1970; Steinhoff, 1972; Steinoff and Hoff, 1971; Squillace et al, 1971), Douglas-fir (Gerhold, 1966; Wright, et al. 1971), and ponderosa pine (Haller, 1965; Wells, 1963) for some traits. Data show that usable genetic variation is present inter-regionally in lodgepole pine (Critchfield, 1957; Illingworth, 1971; Kinloch et al, 1970; Yeatman, 1967; Yeatman and Teich, 1969), and Engelmann spruce (Ogilvie and Von Rudloff, 1968; Roche et al, 1969). Since this provenance variation must have originated with tree-to-tree variation, it can be inferred that local variation does exist. But the magnitude of local variation, and thus its usefulness, is not known.

Few genetic data are available for western larch, grand fir, western hemlock, western red cedar, and subalpine fir. Extrapolating from other north temperate conifers, the following assumptions can be made:

(A) Species occupying the greatest ranges of environmental variation will display the greatest amounts of genetic variation. In the diverse environments of the Rockies, ecological amplitude is probably the best measure of environmental variation. Daubenmire [and Daubenmire] and Daubenmire (1968) rank the five species listed above in the following descending order by ecological amplitude: (1) western larch, (2) subalpine fir, (3) grand fir, (4) western red cedar, and (5) western hemlock.

(B) Geographic factors being comparable, a species whose population structure is small, isolated populations, is likely to have more total genetic variation than a species whose structure is large, continous populations (Falconer, 1960). Western red cedar and western hemlock appear to follow the former pattern, while larch and subalpine fir may tend to follow the latter.

(C) In the absence of data to the contrary, the greatest sources of genetic variation are geographic (provenance), and elevational, followed in order by stand-to-stand and tree-to-tree. Western white pine appears to be an exception; tree-to-tree variation may be as large as provenance (Steinhoff, 1972).

(D) Local sources will not necessarily perform best locally. There are examples to the contrary in most thoroughly evaluated tree species. Because of changes in climate or other environmental factors more rapid than a tree species' capacity to adapt, a non-local source may be as well adapted to present local conditions as a local source. Only thorough evaluation can determine this.

The Tree Improvement Program for these five species, then, emphasizes, first, thorough provenance and stand evaluation, and, second, individual tree evaluation. Information gleaned from the first evaluations may suggest later changes in emphasis.

USING THE GENE RESOURCES SO AS TO AVOID DYSGENIC CONSEQUENCES

The procedures used for tree improvement will vary with the species, mode of inheritance, and heritability of the traits dealt with. However, there are a few generalizations which can be made, based on research already cited.

GROWTH TRAITS CONTROLLED BY NUMEROUS ADDITIVE-EFFECT GENES

All variation is the result exclusively of environmental and genetic influences operating together. Variation that is not genetically controlled is environmentally controlled or it is the result of genotype x environment interaction. Variation under strong genetic control has a small environmental component; variation which is largely environmentally-caused has a small genetic component. Most growth traits are under weak genetic control, and subject to high environmentally-caused variation (Howe, 1971; Kral, 1967; Rolmeder, 1961; Vins, 1966).

Implications for Acquiring Plant Material

The genetic variation of traits having a small genetic component (i.e., low heritability) is often masked by the environmental variation when a genotype is unreplicated or the environmental influences are uncontrolled. This is the situation for many growth traits (under weak genetic control) of most tree species growing in wild stands (Howe, 1971; Kral, 1967; Rolmeder, 1961; Vins, 1966). A genotype is represented only once (i.e., the individual tree itself). More important, there is little uniformity in the environment. This masking of genetic variation makes it virtually impossible to assess the genetic potential for growth traits of individual trees growing in wild stands. Based on this analysis, intensive plus-tree selection for traits having low heritability is an inefficient (and very expensive) means of acquiring superior variants.

Secondly, in the absence of data to the contrary, it should be assumed that the greatest source of genetic variation in a species is provenance, the second greatest is stand-to-stand within provenance and the last is tree-to-tree within stand. Thus, when dollars or manpower are limited, the emphasis should be placed on provenance and stand testing and selection.

However, in an applied tree improvement program, seed collections should also include seedlots from individual trees so that heritabilities and combining abilities may be estimated. These estimates must be based upon data from evaluating offspring one or both of whose parents are known. Heritability estimates are needed for predicting genetic gains, upon which forecasts of financial returns are based.

The kinds of traits which typically have low heritability and are controlled by numerous additive-effect genes are growth traits such as height and diameter growth rate, branch number, sweep, taper, and self-pruning (Howe, 1971; Kral, 1967; Rolmeder, 1961; Vins, 1966). Little or no attempt should be made to acquire plant material by intensive plus-tree selection for these kinds of traits. Effort should be concentrated on collecting large, representative samples from stands. The identity of only a very few, low-intensity-selected single-tree seedlots need be maintained. If the first cycle of progeny evaluation shows substantial tree-to-tree variation, then more intensive single-tree collections can be emphasized in subsequent cycles.

Wind pollination among desired variants will be the cheapest way to mass produce superior seed in Northern Rocky Mountain conifers. We will seek female parents producing superior offspring when pollinated by all males (general combining ability (GCA)). We will use GCA in breeding for the growth traits discussed. Thus, seed orchards for improvement of these traits will be designed for wind-pollination, insofar as possible.

INSECT AND DISEASE RESISTANCE MAY BE UNDER STRONGER CONTROL

Other kinds of traits are typically under strong genetic control, e.g., disease resistance (Bingham, et al, 1971; Heimburger, 1962; Kinloch, et al, 1970; McDonald and Hoff, 1970; Hoff and McDonald, 1972), branch angle and crown form in some species (Callaham, 1960; Campbell, 1963; Patterson, 1969), specific gravity of wood in the southern pines (Howe, 1971) (but apparently not in Douglas-fir (McKimmy, 1966)), and insect resistance in some agronomic crops (Painter, 1951). In conifers, where large amounts of pollen can be collected and stored, controlled pollination among plus-selected trees in the wild is often a rational undertaking, for one or both of the following reasons:

(1) The higher probability of choosing genetically resistant parents increases the probability that the added gain (at a given sample size) achievable by full-sib breeding will justify the added costs of controlled pollination, either in the wild or in seed orchards.

(2) These traits may be controlled largely by epistatic- or dominance-effect genes, in which case it is likely that only specific crosses will produce genetically highly superior offspring. This is utilizing specific combining ability (SCA).

However, plus-tree selection for resistance to important insects in Northern Rocky Mountain conifers will seldom be efficient, because there are too many non-genetic reasons for trees escaping infestation in the wild. Therefore, a practical improvement program for insect resistance should follow the scheme diagrammed in Figures 10-17, with the possibility of control-pollinating to mass-produce seed if SCA is to be utilized.

Plus-tree selection for bacterial, viral, or fungal disease resistance can be effective in areas of high infection incidence, i.e., where the chance of escape for non-genetic reasons is low. This effectiveness has been demonstrated in western white pine blister rust resistance (Bingham, et al, 1971) and in many agronomic crop disease resistances (Bingham, et al, 1971). The original acquisition of seed for disease resistance evaluation and selection may be from controlled pollinations among wild trees in heavily infected stands. The original parents should be preserved for additional test crossing as more is learned about inheritance patterns, and for the potential production of commercial seed.

VEGETATIVE PROPAGATION

There have been numerous grafted or rooted seed orchards and progeny evaluations established in North Temperate tree species. A vegetatively-propagated progeny evaluation is a rational operation if the species is normally vegetatively propagated in artificial reforestation. Vegetative orchards for mass-producing vegetative material and for continued improvement breeding likewise are reasonable for vegetatively-propagated species. The Northern Rockies have no coniferous species which are likely to be vegetatively propagated in artificial reforestation.

Grafted seed orchards for seed-propagated species have been established on the following assumptions:

(1) Phenotypically superior wild trees are also genetypically superior, so grafting these individuals into an orchard is an "instant" assimilation of genetically superior individuals. This has been demonstrated untrue for most of the traits important to us in North Temperate conifers.

(2) Grafted trees flower many years earlier than seedlings established at the same time. There are few data available from evaluations of grafted and seedling material treated comparably to support this contention. Undoubtedly, there are large differences between species, but observations in many species indicate that the flowering age differential between grafted and seedling material is not substantial.

(3) A graft union, once established, will be permanently compatible. Graft union incompatibilities, on a large scale, have shown up after 10 years or more in nearly all North American conifers extensively grafted. The problems threaten many expensive grafted seed orchards, including the Region 1 western white pine orchard at Sandpoint, Idaho.

Finally, grafted orchards put the tree breeder one generation behind. That is, the first cycle seed orchard, if grafted, contains the original parents, whereas the first cycle seedling seed orchard contains the offspring of the original parents. The grafted orchard, futhermore, may be several times more expensive to establish than the seedling orchard. For seed-propagated species, as we are dealing with here, grafted orchards and grafted progeny evaluations will not be utilized.

APPENDIX 2

PROSPECTUS and CONTENT
for the
PROGRAM FOR CONTINUING EDUCATION
IN FOREST ECOLOGY AND SILVICULTURE

CONTENTS

PROSPECTUS 73

A PROGRAM FOR CONTINUING EDUCATION AND CERTIFICATION IN FOREST ECOLOGY AND SILVICULTURE IN THE NORTHERN REGION 73

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W.R. Beaufait
April 24, 1972

PROSPECTUS

"The end of education . . . is more education." (John Dewey)

A Program for Continuing Education and Certification in Forest Ecology and Silviculture in the Northern Region

What is a Silviculturist?

The latest Terminology of Forest Science (Society of American Foresters, 1971) defines silviculture as "...the science and art of cultivating forest crops based on a knowledge of silvics." More particularly, it is "...the theory and practice of controlling the establishment, composition, constitution, and growth of forests." Silvics is "...the study of the life history and general characteristics of forest trees and stands with particular reference to locality factors."

These formal definitions aside, silviculture simply means growing trees in a forest setting. A silviculturist is a kind of forest gardener with background in, and a deep respect for, the biology of life, growth, and reproduction. He combines this knowledge with an appreciation for Man's creature needs from the forest.

A silviculturist is a forester who, through specialized education and experience has become a practicing forest ecologist. He differs from other members of his profession in that he requires a strong biological foundation in plant and animal ecology, plant physiology, soil productivity, and the basic energy systems which fuel forest communities. Most forest management decisions involving land treatment, access, harvest and cultural methods, and forest production are based on silvicultural tenets.

Selection of Silviculturists

At present, Northern Region foresters are assigned to the jobs of District or Forest Silviculturist without consideration for two facts. First, silviculture is a specialty requiring academic foundations in plant ecology and forest biology not always available to baccalaureate graduates of forestry schools. For that matter, current and projected forestry curricula no longer require the scientific foundation and exposure to biological principles necessary to make sound management prescriptions.

Second, the reservoir of biological understanding has expanded greatly within the last decade. Many of these concepts have not found their way into professional training at the undergraduate level. For example, new perspectives in plant succession, mineral nutrient cycling, energy exchange and their interactions in forest communities are imperfectly understood by both recent graduates and those who have been practicing forestry for some years. These disciplines, with their tap roots in physical and biological science, are essential to forest land managers who hope to avoid serious errors in land use and treatment.

The Forest Service has depended upon the classical 4-year forestry education to fill its need for silviculturists. However, a graduate forester is not qualified as a silviculturist because he has had one or two courses in the subject any more than he is as a wildlife biologist or a soil scientist. He usually has had one or two courses in these subjects as well. Moreover, some foresters are now graduating without academic exposure to forest ecology and silviculture.

Why a Program Now?

The specialities of silviculture are: Forest ecology, reforestation methods, forest genetics, stand improvement, and harvest systems. All require significant education beyond the baccalaureate. At present, there are no systematic programs to provide the necessary background within the Forest Service. At the same time, the Chief's "Framework for the Future", the Northern Region's "Management Direction" and "Program Emphasis", and recent Task Force Reports on "Forest Management in Wyoming" and "Management Practices on the Bitterroot National Forest" provide a mandate for advanced, high-quality practice of these skills.

The same credentials are required of silviculturists whether they are prescribing for wildlife habitat enhancement, watershed protection, scenic vistas, or timber production. For that matter, the growing and tending of forest vegetation is an underlying mechanism for serving all of these resources. Training, in the conventional sense, simply cannot achieve the needed competence, background in fundamentals, and flexibility in application of silvicultural principles. However, professionally trained foresters are the logical raw material for the District, Forest and Regional staff positions in silviculture.

The Program Outline

The Division of Timber Management offers to Supervisors and Rangers a proposed Program of Continuing Education in Forest Ecology and Silviculture designed to meet the pressing needs for quality management. It involves a liaison between three area universities and the Northern Region to achieve a payoff in 20 "qualified" individuals within about 2 years; then 20 more each year after that (one for each Forest plus 4 in the Regional

Office). Similar programs could be initiated simultaneously elsewhere in the Service.

The basic plan is as follows:

1. Foresters with at least one year of timber management experience are selected for the Continuing Education Program based upon their academic and employment records, and their desire to devote some of their career to staff work in Forest Ecology and Silviculture.

2. These men will be enrolled for three one-month sessions over a period of one year in the three forest schools in the Northern Region (University of Montana, University of Idaho, and Washington State University), or others in the Pacific Northwest.

3. The three intensive, live-in, one-month sessions would be structured as below:

Prospectus

	Institution	Subject Matter Courses
Session 1	University of Montana (Individuals)	Forest Autecology: genetics, physiology, physical geology, climatology, measurements (Statistics)
Session 2	Washington State University (Populations)	Forest Synecology: soils ecological classification systems, animal & plant population dynamics, measurements (computer programming)
Session 3	University of Idaho (Systems)	Silvicultural Systems: watershed, regional silviculture, tree and shrub improvement, measurements (systems), economics.

4. The two periods between sessions would be planned (with the employee's supervisor) for work as closely related to the educational experience as feasible.

5. Upon completion of the Program, accompanied by rigorous testing and evaluation by faculty and supervisors, graduates would be certified to write silvicultural prescriptions in the Northern Region National Forests.

6. The Program will be administered by a three-man Forest Service steering committee consisting of representatives from Timber Management, Personnel Management and a designated Line Officer. This group will evaluate the faculty qualifications and course outlines submitted by each forestry school for its phase of the Program. The Division of Operation would negotiate contracts with the institutions. The committee will monitor quality of instruction, testing, student performance and ultimately, certification. Control of the Program will remain at all times with the Forest Service.

7. Refresher courses will be scheduled at about 3-year intervals for Program graduates who remain professionally active in the field.

Additional Benefits

This entire Program gains strength from the use of qualified, scientifically-oriented academic personnel for instruction. Yet it retains strong guidance by the Steering Committee to ensure practical application of the continuing education experience. In other words, teachers do the teaching in an academic atmosphere with all attending educational advantages. However, the Program's applied orientation is maintained by active Agency participation in selection of faculty, course outlines and testing procedures.

There are some subjects in the Prospectus for which the local institutions do not have the best qualified faculty. Under these circumstances, the university involved would make arrangements for "in residence" services of specific faculty from other universities or agencies, including the Forest Service.

The intensive, month-long sessions are planned to make full use of advanced teaching methods and all waking hours of participants. Program benefits will begin to be available immediately. Upon completion of the first month's session, the students will return to their Forests to apply what they have learned.

Students who wished to do so would be encouraged to complete, on their own, necessary requirements for a Master of Forestry or Master of Science degree from any of the three institutions involved. The level and amount of course content will be such as to require some additional academic credit, in addition to a professional paper or thesis, to fulfill all requirements for a graduate degree.

Standards of knowledge can be set at the Program's testing level. Supervisors will have access to objective criteria for evaluating the biological quality of management recommendations. New applicants can be tested for their knowledge as forest ecologists and silviculturists. These features will also help publicize the Agency's concern for quality forest management, but more important will demonstrate that we are doing something about it.

Finally, the Program could serve as a pilot for similar efforts in continuing education within the Northern Region and the Forest Service. The Forest Service must demonstrate both its credentials and progressiveness in growing and safely harvesting trees to retain public confidence in its stewardship.

Projected Costs

The direct costs to the Government, exclusive of salaries, can be extrapolated from present experience, as follows:

1.	Tuition for 20 contact days	$ 400.00
2.	Per diem	400.00
3.	Total per student	800.00
4.	Total for 20 students per session	16,000.00
5.	Total for 20 students for entire program	$48,000.00

Thus, for $48,000 the Northern Region will academically qualify at least one man on each Forest in Forest Ecology and Silviculture. These men will have credentials nearly equivalent to a Master degree. The total cost is easily less than the money spent to rectify a single, serious land management error.

CONTENT

Graduate-level classes in:

TOPIC	SESSION I. Autecology	II. Synecology	III. Silvicultural Systems
A. Earth Science	Review Geology Geomorphology Climatology	Meteorology Soils	Hydrology Watershed Management Landscape Architecture
B. Biological Sciences	Systematics Anatomy Physiology Silvics Genetics of Individuals	Population Dynamics Genetics of Populations Ecological Classification	Tree and Shrub Improvement Regional Silviculture
C. Measurements	Statistics Sampling Mensuration	Mensurational ADP Growth and Yield	Systems Analysis Economics

Graduate credit will be available for the course by individual arrangement with the universities involved.

APPENDIX 3

SUMMARY OF TREE IMPROVEMENT PROJECTS FOR THE 1970's

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Table 5. Summary of Tree Improvement Projects. 79

TABLE 5 SUMMARY OF TREE IMPROVEMENT PROJECTS

ABBREVIATED TITLE	PROPOSED OUT R-1 COOPERATORS	WORK PLAN APPROVED YES	WORK PLAN APPROVED NO	COOP. NO.	OBJECTIVES	BRIEF DESCRIPTION	PROJECT STARTED	SEED ORCH. & PLANTATIONS ESTABLISHED	FIRST COMM. SEED ORCH. SEED (YR)	MAX. COMM. SEED ORCH. SEED BEGINS (YR)	EST. DURATION FIRST CYCLE (YRS)	WORK PLAN AUTH
PONDEROSA PINE COOPERATIVE TREE IMPROVEMENT	PPTIC	X			GENETICALLY IMPROVE GROWTH TRAITS IN INLAND EMPIRE. DEFINE POPULATIONAL BOUNDARIES IN TERMS OF H.T., LAT., LONG., ELEV., SLOPE, ASPECT.	5 OP 1/2-SIB COLLECTIONS FROM PLUS TREES IN 100 STANDS PLUS BULK COLLECTIONS. LOCAL 1/2 SIBS PLUS BULKS FROM ALL STANDS TESTED AT EACH OF 10 SITES. SIX PLANTATIONS CONVERTIBLE TO SEED ORCHARDS.	1970	1974	1988	1995	80	C.W. WAN
3100 TREE TEST	INT		X		IMPROVE BLISTER RUST RESISTANCE AND GROWTH TRAITS FOR 6 WWP FORESTS. DEFINE POPULATIONAL BOUNDARIES AS ABOVE.	3100 CP FULL-SIB FAMILIES FROM PLUS TREES FOR RESISTANCE IN N. IDAHO & W. MONT. TESTED FIRST FOR RESISTANCE, THEN FOR GROWTH TRAITS. SIX OUTPLANTINGS	1968	1980	1994	2000	80	R.J. HOF G.I. McDONAL
DOUGLAS-FIR GEOGRAPHIC VARIATION	INT	X		FS-INT 1401-550	DETERMINE PATTERN OF GENETIC VARIATION OVER WIDE AREA. DEFINE POPULATION BOUNDARIES AS ABOVE.	1/2 SIB OP FAMILIES FROM 7 TREES IN EACH OF 4 STANDS IN EACH OF 6 H.T.'S IN MONT. & N. IDAHO, W. OF CONTINENTAL DIVIDE. SIX OUTPLANTINGS.		1974	1989	2001	80	G.E. REHFELDT
PHASE I WWP F_2 SEED ORCHARDS	INT	X			PRODUCE RUST RESISTANT SEED FOR LOW-MID-& HIGH ELEVATION PLANTING.	12 CP F_2 FULL SIB FAMILIES FOR EACH ELEVATION-BAND ORCHARD. 3 ORCHARDS.	1970	1971-1974	1988	1994	25-30	R.T. BINGHAM
FIELD-LEVEL RESIS. WWP PHASE I	INT	X		FS-INT	DETERMINE FIELD LEVEL OF RESISTANCE OF F_1, B_1, F_1 SELECTIONS.	TEST ACCUMULATED BREEDING MATERIAL ON HIGH-INFECTION SITES ON 3 FORESTS.	1970-1972				17	R.T. BINGHAM
DOUGLAS-FIR LOCAL VARIATION	INT	X		FS-INT 1401-549	DETERMINE PATTERN OF GENETIC VARIATION OVER NARROW & ABRUPT ENVIRONMENTAL GRADIENTS. ESTABLISH MAGNITUDE OF SEED ZONING PROBLEM.	INTRA- & INTERPOPULATIONAL CROSSES BETWEEN POPULATIONS ON 2 ASPECTS AT 3 ELEVATIONS IN EACH OF 2 DRAINAGES. ENVIRON. PRECONDITIONING IN NURSERY AND OUTPLANTING ON 3 ADJACENT SITES.	1970	1974	-	-	80	G.E. REHFELDT & R. STEINHOF

TABLE 5 SUMMARY OF TREE IMPROVEMENT PROJECTS (CONT.)

ABBREVIATED TITLE	PROPOSED OUT R-1 COOPERATORS	WORK PLAN APPROVED YES	WORK PLAN APPROVED NO	COOP. NO.	OBJECTIVES	BRIEF DESCRIPTION	PROJECT STARTED	SEED ORCH. & PLANTATIONS ESTABLISHED	FIRST COMM. SEED ORCH. SEED (YR)	MAX. COMM. SEED ORCH. SEED BEGINS (YR)	EST. DURATION FIRST CYCLE (YRS)	WORK PLAN AUTH
LODGEPOLE PINE RANGE-WIDE T.I. SAMPLING	BLM, PPTIC INT, R-4, R-5, R-6, R-2, R-4, R-3, B.C. ALBERTA, INT		X		DETERMINE PATTERN OF GENETIC VARIATION. DETERMINE AND USE BEST LOCAL SOURCES (GROWTH TRAITS). ASSESS POTENTIAL OF NONLOCAL SOURCES. DEFINE POPULATION BOUNDARIES IN TERMS OF H.T., LAT, LONG., ELEV., SLOPE, ASPECT.	200 RANDOM BULKED STAND OP SEED COLLECTIONS FROM COOPERATORS OUTSIDE R-1 PLUS 1/2-SIB OP FAMILIES FROM 10 RANDOMLY CHOSEN TREES IN EACH OF 50 R-1 STANDS. MINIMUM OF 16 TEST SITES EACH TESTING LOCAL 1/2 SIBS AND ALL 250 STAND PROGENIES IN ADJACENT PLANTINGS.	1973	1976	1983	1988	40	R. STEINHOF
WESTERN LARCH RANGE-WIDE T.I. SAMPLING	PPTIC, R-6, R-4, B.C. ALBERTA, INT		X		DETERMINE PATTERN OF GENETIC VARIATION. DETERMINE AND USE BEST LOCAL SOURCES (GROWTH TRAITS). ASSESS POTENTIAL OF NONLOCAL SOURCES. DEFINE POPULATION BOUNDARIES IN TERMS OF H.T., LAT., LONG., ELEV., SLOPE, ASPECT.	SAME AS FOR LPP ABOVE, EXCEPT 80 BULKED STAND SAMPLES FROM OUTSIDE R-1. SEVEN 1/2 SIB OP FAMILIES PLUS BULK FROM EACH OF 45 R-1 STANDS. MINIMUM OF 11 TEST SITES.	1974	1976	1989	1996	80	G.E. REHFELDT
DOUGLAS-FIR INTERRACIAL HYBRIDS PROJECT	INT	X			INCORPORATE COSTAL DOUGLAS-FIR GROWTH ATTRIBUTES INTO INLAND DOUGLAS-FIR AND RETAIN WINTER HARDINESS.	POLLEN COLLECTED AND APPLIED TO FEMALE FLOWERS OF TREES NEAR MOSCOW WITH BACK CROSSING. PROGENY TEST IN 2 OR MORE PLANTATIONS	1970	1974	1989	1994	80	G.E. REHFELDT
ENGELMANN SPRUCE BLUE SPRUCE GEOGRAPHIC VARIATION	MICH. ST. UNIV.	X			DETERMINE PATTERN OF GENETIC VARIATION IN BLUE SPRUCE/ENGELMANN SPRUCE COMPLEX. ASSESS LOCAL & NONLOCAL SOURCES.	BULK AND 1/2-SIB COLLECTIONS FROM 49 STANDS OUTSIDE AND 8 IN R-1. ONE R-1 TEST AND 11 ELSEWHERE.	1970	1973	1990	2000	80	J. HANOVER
WESTERN WHITE PINE LOCAL VARIATION	--------------------SAME AS DF LOCAL VARIATION ABOVE--------------------											G.E. REHFELDT & R. STEINHO

ABBREVIATED TITLE	PROPOSED OUT R-1 COOPERATORS	WORK PLAN APPROVED YES	WORK PLAN APPROVED NO	COOP. NO.	OBJECTIVES	BRIEF DESCRIPTION	PROJECT STARTED	SEED ORCH. & PLANTATIONS ESTABLISHED	FIRST COMM. SEED ORCH. SEED (YR)	MAX. COMM. SEED ORCH. SEED BEGINS (YR)	EST. DURATION FIRST CYCLE (YRS)	WORK PLAN AUTH
SANDPOINT $F_{1.5}$ SEED ORCH. WWP PHASE 1	INT	X			PRODUCE RUST RESISTANT $F_{1/2}$ SEED UNTIL LATER GENERATION ORCHARDS PRODUCE.	ANNUAL HAND OP OF GRAFTED TREES IN 17-ACRE SANDPOINT, IDAHO R-1 (KANIKSU NF) SEED ORCHARD.	1952	1957	1968	1979	30	R.T. BINGHAM
NATURAL SELECTION FOR RUST RESISTANCE WWP PHASE 2	INT		X		ASSESS ADMINISTRATIVE & SILVICULTURAL PROBLEMS OF PREPARING A SITE FOR NATURAL REGENERATION OF POSSIBLY RESISTANT WWP. DETERMINE POTENTIAL FOR SEED PRODUCTION AREA.	REMOVE ALL TREES EXCEPT WWP FROM 3 ADJACENT SITES. SCARIFY. ASSESS REGENERATION RESULTS. PLANT RIBES SP. TO ASSURE NATURAL INNOCULATION. SCORE RESISTANCE IN SEEDLINGS.	1973	-	1977	1977	40	R. J. HOF[illegible] & G.E. HO[illegible]
MULTI-SPECIES PLANTING SURVIVAL TEST FOR LONE MTN.			X		DETERMINE SURVIVAL POTENTIAL OF R-1 SPECIES WITHOUT IRRIGATION AT LONE MTN.	PLANT "MILL-RUN" DF, WL, ES, PP, LPP, GF AT LONE MTN. SCORE 1 & 2-YR. SURVIVAL AND HEIGHT GROWTH	1971	1971	-	-	2	G.E. HOWE

APPENDIX 4

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Region 1 Planting Program for 1980 (Acres)

State	National Forest	(1) Acres Under Management for Timber Production (CFL) PC1	PC2	PC3	PC4	(2) Acres Regenerated Annually (.80% of column 1) (a) PC1	(b) PC2	(c) PC3	(d) PC4	(3) Acres Planted Annually 2a x .10 PC1	2b x .43 PC2	2c x .43 PC3	2d x .43 PC4
		M ACRES											
	Colville	276.2	234.8	110.5	69.1	2.210	1.878	.884	.553	.221	.808	.380	.238
WASH.	Kaniksu	173.4	54.5	7.1	2.4	1.387	.436	.057	.019	.139	.187	.025	.008
WASH. TOTAL		449.6	289.3	117.6	71.5	3.597	2.314	.941	.572	.360	.995	.405	.246
		(11.9%)*	(6.3%)	(3.7%)	(4.7%)								
	Kaniksu	519.0	163.4	21.3	7.1	4.152	1.307	.170	.057	.415	.562	.025	.025
	C d'A	382.1	222.3	76.4	13.9	3.057	1.778	.611	.111	.306	.765	.263	.048
IDAHO	Clw.	511.0	352.8	219.0	133.8	4.088	2.822	1.752	1.070	.409	1.213	.753	.460
	St. Joe	303.7	161.5	116.3	64.6	2.430	1.292	.930	.517	.243	.556	.400	.222
	Nezperce	269.9	359.8	179.9	90.0	2.159	2.878	1.439	.720	.216	1.238	.619	.310
IDAHO TOTAL		1985.7	1259.8	612.9	309.4	15.886	10.078	4.903	2.475	1.589	4.334	2.108	1.064
		(52.5%)	(27.6%)	(19.1%)	(20.3%)								
	Kaniksu	218.3	68.9	9.0	3.0	1.746	.551	.072	.024	.175	.237	.031	.010
	Flathead	196.2	400.3	141.3	47.1	1.570	3.202	1.130	.377	.157	1.377	.486	.162
W.	Lolo	123.0	765.1	314.2	163.9	.984	6.121	2.514	1.311	.098	2.632	1.081	.564
MONT.	Btr.	78.1	222.4	198.4	102.2	.625	1.779	1.587	.818	.063	.765	.682	.352
	Koot.	528.2	440.2	337.5	161.4	4.226	3.522	2.700	1.291	.423	1.514	1.161	.555
W. MONT. TOTAL		1143.8	1896.9	1000.4	477.6	9.151	15.175	8.003	3.821	.915	6.525	3.441	1.643
		(30.2%)	(41.6%)	(31.3%)	(31.4%)								
	Helena	73.7	191.0	119.9	39.0	.590	1.528	.959	.312	.059	.657	.412	.134
E.	Deerlodge	59.6	506.5	163.9	14.9	.477	4.052	1.311	.119	.048	1.742	.564	.051
MONT	Custer	0.0	13.3	119.7	88.7	–	.106	.958	.710	–	.046	.412	.305
&	Bvhd.	9.6	86.3	671.4	191.8	.077	.690	5.371	1.534	.008	.297	2.310	.660
S. DAK.	Gallatin	12.9	115.9	103.0	25.8	.103	.927	.824	.206	.010	.399	.354	.089
	L & C	50.4	201.5	285.4	302.2	.403	1.612	2.283	2.418	.040	.693	.982	1.040
E.MT & S.D. TOTAL		206.2	1114.5	1463.3	662.4	1.650	8.916	11.706	5.299	.166	3.834	5.034	2.279
		(5.4%)	(24.5%)	(45.9%)	(43.6%)								
PC TOTALS		3785.3	4560.5	3194.2	1520.9	30.284	36.484	25.554	12.167	.303	15.689	10.988	5.232
GRAND TOTAL		13060.9				104.489				32.212			

* Percentage of Region 1 acres of this PC.

Table 7. Region 1 Planting Program for 2020 and 2080 (Acres)

State	National Forest	(1) Acres Under Management for Timber Production (a) PC1	(b) PC2	(c) PC3	(d) PC4	(2) Acres Regenerated Annually (a) 1(a)÷ 75 PC1	(b) 1(b)÷90 PC2	(c) 1(c)÷115 PC3	(d) 1(d)÷130 PC4	(3) Acres Planted Annually 2ax.25 PC1	2b x .40 PC2	2c x.40 PC3	2d x .60 PC4
		M ACRES											
WASH.	Colville	276.2	234.8	110.5	69.1	3.683	2.609	.961	.532	.921	1.044	.384	.319
	Kaniksu	173.4	54.5	7.1	2.4	2.312	.606	.062	.018	.578	.242	.025	.011
WASH. TOTAL		449.6 (11.9%)*	289.3 (6.3%)	117.6 (3.7%)	71.5 (4.7%)	5.995	3.215	1.023	.550	1.499	1.286	.409	.330
IDAHO	Kaniksu	519.0	163.4	21.3	7.1	6.920	1.816	.195	.055	1.730	.726	.078	.053
	C d'A	382.1	222.3	76.4	13.9	5.095	2.470	.664	.107	1.274	.988	.266	.064
	Clw.	511.0	352.8	219.0	133.8	6.813	3.920	1.904	1.029	1.703	1.568	.762	.617
	St. Joe	303.7	161.5	116.3	64.6	4.049	1.794	1.011	.497	1.012	.718	.404	.298
	Nezperce	269.9	359.8	179.9	90.0	3.599	3.998	1.564	.692	.900	1.599	.626	.415
IDAHO TOTAL		1985.7 (52.5%)	1259.8 (27.6%)	612.9 (19.1%)	309.4 (20.3%)	26.476	13.998	5.338	2.380	6.619	5.600	2.136	1.428
W. MONT.	Kaniksu	218.3	68.9	9.0	3.0	2.911	.766	.078	.023	.728	.306	.031	.014
	Flathead	196.2	400.3	141.3	47.1	2.616	4.448	1.229	.362	.654	1.779	.492	.217
	Lolo	123.0	765.1	314.2	163.9	1.640	8.501	2.732	1.261	.410	3.400	1.093	.757
	Btr.	78.1	222.4	198.4	102.2	1.041	2.471	1.725	.786	.260	.988	.690	.472
	Kootenai	528.2	440.2	337.5	161.4	7.043	4.891	2.935	1.242	1.761	1.956	1.174	.745
W. MONT. TOTAL		1143.8 (30.2%)	1896.9 (41.6%)	1000.4 (31.3%)	477.6 (31.4%)	15.251	21.077	8.699	3.674	3.813	8.431	3.480	2.205
E. MONT. & S. DAK.	Helena	73.7	191.0	119.9	39.0	.983	2.122	1.043	.300	.246	.849	.417	.180
	Deerlodge	59.6	506.5	163.9	14.9	.795	5.628	1.425	.115	.199	2.251	.570	.068
	Custer	0.0	13.3	119.7	88.7	-	.148	1.041	.682	-	.059	.416	.409
	Bvhd.	9.6	86.3	671.4	191.8	.128	.959	5.838	1.475	.032	.384	2.335	.885
	Gallatin	12.9	115.9	103.0	25.8	.172	1.288	.896	.198	.043	.515	.358	.119
	L & C	50.4	201.5	285.4	302.2	.672	2.239	2.482	2.325	.168	.896	.993	1.395
E. MT & S.D. TOTAL		206.2 (5.4%)	1114.5 (24.5%)	1463.3 (45.9%)	662.4 (43.6%)	2.750	12.384	12.725	5.094	.688	4.954	5.090	3.056
PC TOTALS		3785.3	4560.5	3194.2	1520.9	50.472	50.674	27.775	11.699	12.618	20.270	11.110	7.019
GRAND TOTAL				13060.9			140.620				51.017		

* Percentage of Region 1 acres of this PC.

Table 8. Species Composition of Planted Stands[1]

		WWP	D-F	GF	ES	WL	LPP	PP	SAF
					Proportion				
E. Wash.	PC1	.21	.21	.21	.07	.21	0	.07	0
&	PC2	.09	.22	0	.22	.09	.13	.17	.09
N. Idaho	PC3	0	.22	0	.22	.11	.22	0	.22
	PC4	0	0	0	0	0	.20	.80	0
	PC1	.12	.16	.08	.12	.20	.08	.08	.16
W.	PC2	.09	.18	.09	.08	.17	.15	.13	.12
Mont.	PC3	.08	.21	.07	.08	.13	.14	.17	.11
	PC4	.10	.20	.08	.10	.12	.13	.15	.12
E. Mont.	PC1	0	.22	0	.44	0	.22	0	.11
&	PC2	0	.25	0	.25	0	.25	0	.25
	PC3	0	.29	0	.11	0	.19	.24	.15
S. Dak.	PC4	0	.29	0	.14	0	.19	.21	.17

[1] Eastern Washington and northern Idaho calculated by determining the distribution of habitat types in Productivity Classes (fig. 9), then looking up species composition in Brown's and Pfister's (1971) Management Implications. If, for example, a species appeared in three habitat types out of a total number of appearances for all species of 20, then it would have a proportion of .15.

Western and eastern Montana calculated the same way from figure 9.

Table 9. Region 1 Average Annual Planting Stock Needs for 1980 1/

M Seedlings

Species	E. Wash & N. Idaho PC1	PC2	PC3	PC4	Total	W. Montana PC1	PC2	PC3	PC4	Total	E. Mont. & So. Dakota PC1	PC2	PC3	PC4	Total
WWP	123	180	0	0	303	032	217	117	070	436	0	0	0	0	0
D-F	123	440	235	0	921	044	440	307	140	931	011	359	620	281	1271
GF	123	0	0	0	123	022	217	102	056	397	0	0	0	0	0
ES	041	440	235	0	716	032	196	117	070	415	022	359	235	136	752
WL	123	180	117	0	420	049	416	190	084	739	0	0	0	0	0
LPP	0	260	235	111	606	022	367	205	091	685	011	359	406	184	856
PP	041	340	0	445	826	022	318	249	105	694	0	0	513	203	716
SAF	0	180	235	0	415	044	294	161	084	583	005	359	321	165	850
TOTAL	574	2020	1057	556	4207	267	2465	1448	700	4880	049	1436	2095	969	4445

1/ Calculated by multiplying acres (table 6, col. 3) by proportions in table 8 by 300 trees/acre for PC1; 375 for PC2; 425 for PC3, and PC4

Region 1 Average Annual Planting Stock Needs for 2020 and 2080 2/

M Seedlings

Species	E. Wash. & N. Idaho PC1	PC2	PC3	PC4	Total	W. Montana PC1	PC2	PC3	PC4	Total	E. Mont. & So. Dakota PC1	PC2	PC3	PC4	Total
WWP	256	155	0	0	411	069	190	097	077	433	0	0	0	0	0
D-F	256	379	196	0	831	092	379	256	154	881	023	310	517	310	1160
GF	256	0	0	0	256	046	190	085	062	383	0	0	0	0	0
ES	085	379	196	0	660	069	169	097	077	412	045	310	196	150	701
WL	256	155	098	0	509	114	358	158	093	723	0	0	0	0	0
LPP	0	224	196	123	543	046	316	171	100	633	023	310	338	203	874
PP	085	293	0	492	870	046	274	207	116	643	0	0	428	225	653
SAF	0	155	196	0	351	092	253	134	093	572	011	310	267	182	770
TOTAL	1194	1740	882	615	4431	574	2129	1205	772	4680	102	1240	1746	1070	4158

2/ Calculated by multiplying acres (table 7, col. 3) by proportions in table 8 by 150 trees/acre for PC1; by 250 for PC2; and by 350 for PC3 and 4.

Table 10. Estimated Annual Per Tree Cone and Seed Productions of Northern Rocky Mountain Species

Species	Immature Age (Yrs.)	Immature No. Sound Seeds Per Year	Mature - Open-grown No. Sound Seeds Per Year
WWP	14	747 1/	37,361 2/
D-F	15	26,400 3/	66,000 4/
GF	20	1,000 8/	4,060 5/
ES or WS	20	41,500 8/	166,100
WL	20	2,800 8/	22,000 5/
LPP	10	20,000 8/	40,000 5/
PP	20	2,000 8/	9,000 6/
SAF	20	1,875 8/	7,500 7/

1/ Actual production of Sandpoint (Idaho) Seed Orchard in 1970

2/ Barnes, 1969. Three-year average in a 40-year old plantation; 30-foot spacing.

3/ Actual production of Denny Awl Seed Orchard (USFS Pacific Northwest Region) in early 70's.

4/ Woody Plants Seed Manual and USFS Northern Region Seed Handbook

5/ USDA, FS, 1965 and Northern Region Seed Handbook.

6/ Fowler (1963) and USFS Northern Region Seed Handbook.

Projection is for 20- to 40-year old trees.

7/ Personal observation of author and Northern Region Seed Handbook.

8/ Estimate of author.

APPENDIX 5

Description of Tree Improvement Areas and Seed Orchards

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Coeur d'Alene Nursery White Pine Seed Orchard 88

Condon Tree Improvement Area 88

Meadow Creek Test Plantations 89

Bechtel Butte and Emerald Creek Test Plantations 90

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Merry Creek Test Plantation 93

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Table 11. Ponderosa Pine Tree Improvement Committee Approved Test Plantation and Seed Orchard Sites 94

Lone Mountain Tree Improvement Area. This is a 320-acre level site on the Rathdrum Prairie 20 miles north of Coeur d'Alene, Idaho, on the Coeur d'Alene National Forest. It lies at about 2,000 feet elevation. Approximately 180 acres are currently being developed for seed orchard/ evaluation plantations. The projects underway or planned through F.Y. 1976 are summarized.

Project(s)	Completed in F.Y.
Preparation and planting of cooperative ponderosa pine test plantation/seed orchard (16 acres). Predicted duration 80 years.	1974
Preparation and planting of 2 WWP Phase I rust resistant seed orchards (19 acres). Predicted duration 30 years.	1974
Preparation and planting of DF Geographic Variation cooperative project with IFRES (9 acres). Predicted duration 80 years.	1974
Deer-proof fence around 180 acres, irrigation system, administrative facilities on 9.5 acres.	1974

Preparation and planting of LPP evaluation plantation/seed orchard (19 acres). Predicted duration 60 years.	1977
Preparation and planting of WL evaluation plantation/seed orchard (6.5 acres). Predicted duration 60 years.	1976

Coeur d'Alene Nursery White Pine Seed Orchard

Nine acres at the Coeur d'Alene National Forest Nursery are devoted to a Phase 1 rust-resistant white pine orchard to produce seed for low elevation planting. This orchard will be completed in F.Y. 1974. The predicted duration is 30 years.

Condon Tree Improvement Area. This 40-acre tract is located on the Condon District of the Flathead National Forest. It is in the Swan Valley, at 3,100 feet elevation, and is about 1/4 mile east of the District Ranger Station. About 35 acres are being developed for seed orchard/evaluation plantations.

Project(s)	Completed in F.Y.
Preparation and planting of cooperative ponderosa pine project (16 acres). Predicted duration 80 years.	1974
Deer-proof fence around 38 acres.	1974
Preparation and planting of DF Geographic Variation cooperative project with IFRES (9 acres). Predicted duration 80 years.	1974
Preparation and planting of WL evaluation plantation/seed orchard (6.5 acres). Predicted duration 60 years.	1976
Irrigation system	1976

Meadow Creek Test Plantations. This 110-acre tract lies west of Meadow Creek near the confluence of Orchard Creek on the Clearwater District of the Nezperce National Forest. About 70 acres of it are reserved for genetic evaluation plantations in the decade of the 70's.

Project(s)	Completed in F.Y.
Cattle-proof fence around 25 acres.	1974
Preparation and planting of cooperative PP project (16 acres). Predicted duration 80 years.	1974
Preparation and planting of DF Geographic Variation cooperative project with IFRES (9 acres). Predicted duration 80 years.	1974
Preparation and planting of LPP evaluation plantation (19 acres). Predicted duration 60 years.	1977
Preparation and planting of WL evaluation plantation (6.5 acres). Predicted duration 60 years.	1976

Bechtel Butte and Emerald Creek Test Plantations. These four tracts located on the Clarkia District of the St. Joe National Forest total 9 acres.

They were prepared for planting the Local Variation study in Douglas-fir (cooperative with the Intermountain Station):

Project(s)	Completed in F.Y.
Prepare sites, spray brush plant DF Local Variation cooperative study with INT (9 acres). Expected duration 80 years.	1973
Average annual measurements and maintenance.	Through 1976

Savenac Tree Improvement Area. The former Savenac Nursery site at Haugen, Montana, on the Superior District of the Lolo National Forest was approved by the WO for abandonment as a Forest Service-operated nursery in January 1972. About 140 acres are under irrigation and will be suitable for evaluation plantations for many species and seed orchards for a few:

Project(s)	Completed in F.Y.
Site preparation, service irrigation system, cattle-proof fence, plant ES/Blue spruce provenance project (8 acres Savenac Creek side). Predicted duration 80 years.	1973

Project(s)	Completed in F.Y.
Site preparation, service irrigation system, deer-proof fence around 60± acres, plant DF Geographic Variation cooperative study with IFRES (9 acres). Predicted duration 80 years.	1974
Site preparation and planting of LPP (19 acres). Duration 60 years.	1977
Site preparation and planting of WL (6.5 acres). Duration 60 years.	1976

Sandpoint Seed Orchard. This 17-acre western white pine seed orchard to produce partially rust-resistant seed is located next to the Sandpoint District Ranger Station on the Kaniksu National Forest. Manual mass pollination of the 15-year-old grafted trees produces about 50 bushels of cones annually. The trees are planted at a 20' x 20' spacing. Seed from this orchard and from the Moscow Arboretum (Intermountain Station) is being used in the regular reforestation program of the Region.

Boulder Creek Natural Seeding Area. This 15-acre test of natural selection for rust resistance will be prepared in the fall of 1973. It will be scarified to provide a suitable seedbed for white pine trees left after logging, which will be completed in summer 1973. Site preparation will be covered by slash and K-V collections.

Merry Creek Test Plantation. This 36-acre F_2 white pine rust-resistant evaluation plantation was planted in 1970 at Merry Creek on the Clarkia District on the St. Joe National Forest. Maintenance and inspection are performed cooperatively by Intermountain Station and St. Joe personnel.

Gletty Creek Test Plantation. This 36-acre plantation, established in 1971, is part of the same study as the Merry Creek plantation. It is located on Gletty Creek of the Newport District, Kaniksu National Forest.

Jaype Test Plantation. This is the third and final evaluation plantation in the same study in which the Merry Creek and Gletty Creek plantations were established. This 20-acre site is across the road from the Jaype mill on the Pierce District of the Clearwater National Forest.

Miscellaneous. White pine provenance plantations and graft plots are located on Teepee Creek of the Coeur d'Alene, Elk River and Fernwood of the St. Joe and Randolph Creek of the Lolo National Forests. All are covered by special use permits issued to the Intermountain Station and are measured and maintained by the Station. Other white pine evaluation plantations are maintained and measured by the Intermountain Station on the Priest River and Deception Creek Experimental Forests.

Table 11

Ponderosa Pine Tree Improvement Committee

Approved Test Plantation and Seed Orchard Sites

Name	Nearest Town	Legal Description	Owner	Recommended For: Test Pltn. Only	Recommended For: Test Pltn. &/or Seed Orchard	Species Suitability
Meadow Cr.	Grangeville, Id.	SW 1/4, sec. 26 T30N, R4E	USFS	X		LPP, PP, WL, DF, GF
Tensed	Tensed, Id.	NW 1/4, NW 1/4, sec. 16, T44N, R4W	Idaho		X	PP, DF, WWP
Lone Mtn.	Coeur d'Alene	N 1/2, sec. 27, T53N, R4W	USFS		X	LPP, DF, PP, WL, GF WWP
Wolf Cr.	Libby	W 1/2, NW 1/4, sec. 8, T29N, R26W	St. Regis		X	PP, DF, WL, LPP
Condon	Condon, Mt.	NW 1/4, NE 1/4, sec. 36, T21N, R17W	USFS		X	PP, DF, SAF, WL, LPP, ES
Lubrecht	Clearwater, Mt.	NE 1/4, NE 1/4, sec. 15, T13N, R15W	Univ. of Montana		X	PP, DF, WL, LPP
Mont. St. Nursery	Missoula	NW 1/4, NE 1/4, sec. 30, T13N, R19W	Montana		X	PP, DF
Rye Cr.	Darby, Mt.	Sec. 23, T3N, R19W	B.N.	X		PP, DF, LPP

APPENDIX 6

ADP FORMS USED IN WWP PHASE 2 3100-tree EVALUATION PROJECT

CONTENTS

R-1 Tree Improvement ADP Handbook by Gerald Franc, Clearwater NF

R-1

TREE IMPROVEMENT ADP HANDBOOK

by

Gerald Franc

USDA Forest Service
Clearwater National Forest

April 1973

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I. Candidate Identification

Columns one through twelve of the tree improvement ADP program identify the individual candidate tree. This information is repeated on both Card No. 1, "Tree Data" and Card No. 2, "Pollination Data," and on any or all subsequent data cards which may be added to this program.

Columns 1 and 2 - Forest (2 digit)

Ref: T.M. Control Handbook 2409.21e - Chapter 121--4

Use the standard Forest codes for Region One forests:

Code

02 - Beaverhead
03 - Bitterroot
05 - Clearwater
06 - Coeur d'Alene
07 - Colville
08 - Custer
09 - Deerlodge
10 - Flathead
11 - Gallatin
12 - Helena
13 - Kaniksu
14 - Kootenai
15 - Lewis and Clark
16 - Lolo
17 - Nezperce
18 - St. Joe

Columns 3 to 5 - Species (3 digit)

Ref: Compartment Prescription Handbook 2409.21 - Chapter 323--1

Use the national code to identify the particular tree species.

Code

017 - Grand fir
019 - Subalpine fir
060 - Juniper
073 - Western larch
093 - Engelmann spruce
101 - Whitebark and limber pine
108 - Lodgepole pine
119 - Western white pine
122 - Ponderosa pine

202 - Douglas-fir
231 - Pacific yew
242 - Western redcedar
263 - Western hemlock
264 - Mountain hemlock

Columns 6 to 9 - Tree Number (4 digit)

Use the number of the individual tree for which the data is being submitted.

Columns 10 and 11 - Year Found (2 digit)

Enter here the last two digits of the calendar year in which the candidate tree was found.

Code	
67	1967
68	1968
etc.	

Column 12 - Code Class (1 digit)

Ref: T.M. Control Handbook 2409.21e - Chapter 121--1

Indicate if the information being submitted is new unrecorded data, changes in already submitted data, additions to data already submitted or a deletion of data already submitted.

Code	
1	New, unrecorded data
2	Deletion
3	Change or addition

II. Card No. 1 - Tree Data

Column 13 - Card Identification (1 digit)

Identify the particular data card for which the entry is being made.

Code	
1	Tree data (This code is pre-printed in Column 13 of the Card No. 1 portion of the tree improvement field sheet)

A. Selection Area

Columns 14 to 16 - Compartment (3 digit)

Ref: T.M. Control Handbook 2409.21e - Chapter 121--4, 5, and 6.

Use the established compartment identification number for the compartment in which the tree stands.

Column 17 - Quarter Sections (1 digit)

Identify the quarter section in which the individual tree is located.

Code	
1	Northeast
2	Northwest
3	Southwest
4	Southeast

Columns 18 and 19 - Section (2 digit)

Enter the number of the Section in which the individual tree is located.

Columns 20 to 22 - Township (3 digit)

Enter the township number in which the individual tree is located in the first two columns. In the third column, indicate whether the township is north or south of the principal State meridian using the following code:

Code	
N	North
S	South

Columns 23 to 25 - Range (3 digit)

Enter the range number in which the individual tree is located in the first two columns. In the third column, indicate whether the range is east or west of the principal State meridian using the following code:

Code	
E	East
W	West

Columns 26 to 29 - Road Number (4 digit)

Enter either Forest Service or fire protection road number depending upon whether the tree is on National Forest or State and Private land.

Columns 30 and 31 - Ownership (2 digit)

Ref: T.M. Plan Handbook 2411.1 - Chapter 511.3

Use the standard ownership code to indicate the ownership of the land on which the tree is located.

Code	
01	National Forest
13	State of Idaho
37	PFI
33	Burlington Northern
39	Diamond International
41	Small Private
etc.	

B. Tree Information

Column 32 - Tree Origin (1 digit)

Indicate whether the tree is planted or natural.

Code	
1	Natural
2	Planted

Columns 33 and 34 - Date of Origin (2 digit)

Enter the last two digits of the calendar year in which the tree germinated. (To determine the actual age of the tree simply subtract the date of origin from the current year.)

Columns 35 to 37 - Height (3 digit)

Enter the actual height of the tree to the nearest foot.

Columns 30 to 40 - Diameter Breast High (3 digit)

Enter the diameter of the tree to the nearest tenth of an inch. This measurement is to be taken at 4 1/2 feet above the ground.

Column 41 - Crown Class (1 digit)

Ref: Compartment Prescription Handbook 2409.21 - Chapter 322--3.

Record the crown class of the tree according to the following code:

Code

1 Isolated
2 Dominant
3 Codominant
4 Intermediate
5 Over-Topped

Columns 42 and 43 - Growth (2 digit)

Ref: Compartment Prescription Handbook 2409.21 - Chapter 322-3

From an increment core bored at D.B.H., measure and record to the nearest 1/20 of an inch the length of the most recent 10 growing rings.

Code

07 7/20 inch or .7 inch in 10 years
13 13/20 inch or 1.3 inches in 10 years
23 23/20 inch or 2.3 inches in 10 years
etc.

C. Site Description

Columns 44 and 45 - Elevation (2 digit)

Ref: T.M. Control Handbook 2409.21e - Chapter 122--4

Enter the elevation above sea level of site on which the tree grows. Record to the nearest one-hundred feet.

Code

02 200 foot elevation
21 2100 foot elevation
35 3500 foot elevation
etc.

Column 46 - Aspect (1 digit)

Ref: T.M. Control Handbook 2409.21e - Chapter 122--4

Enter the aspect of the site upon which the tree grows.

Code

1 North
2 Northeast
3 East
4 Southeast
5 South
6 Southwest
7 West
8 Northwest
9 Level or rolling

Column 47 - Physiographic Site (1 digit)

Ref: T.M. Control Handbook 2409.21e - Chapter 122--4

Enter the physiography of the site where the tree is growing.

Code

1 Ridge Top
2 Dry Slope
3 Moist Slope
4 Stream Bottom
5 Flat Bench
6 Other

Column 48 - Open (1 digit)

The data originally intended for this column is not being taken. This column will be reserved for future use.

Columns 49 and 50 - Habitat type (2 digit)

Ref: T.M. Control Handbook 2409.21c - Chapter 122-2, and 3.

Enter the habitat type of the site upon which the tree is growing.

Code

10 Ponderosa pine/wheatgrass
11 Ponderosa pine/Idaho fescue
12 Ponderosa pine/bitterbrush
13 Ponderosa pine/lemmon needlegrass
14 Ponderosa pine/snowberry

15	Ponderosa pine/mallow ninebark
20	Douglas-fir/wheatgrass
21	Douglas-fir/mallow ninebark
22	Douglas-fir/snowberry
23	Douglas-fir/pinegrass
31	Grand fir/myrtle pachistima
32	Subalpine fir/myrtle pachistima
33	Subalpine fir/common beargrass
34	Subalpine fir/rusty menziesia
35	Subalpine fir/whortleberry
41	Western redcedar/myrtle pachistima
42	Western redcedar/ladyfern
43	Western redcedar/devilsclub
51	Western hemlock/myrtle pachistima
54	Mountain hemlock/common beargrass
55	Mountain hemlock/rusty menziesia
61	Alpine fir/grouse whortleberry (huckleberry)

D. Disease Information

Column 51 - Canker Number (1 digit)

Ref: Notes on Field Selection of Blister Rust Resistant Western White Pine, R.T. Bingham.

Enter the actual number of blister rust cankers on the candidate tree:

Code	
0	None
1	One
2	Two
etc.	Up to five

Column 52 - Infection Rate (1 digit)

Ref: Notes on Field Selection of Blister Rust Resistant Western White Pine, R.T. Bingham.

Enter the blister rust infection rate for other white pine trees in the stand with the candidate tree. Cankers are counted on a minimum of three other randomly selected trees in the site and the average number per tree determined.

Code	
0	10-20 cankers/tree

1 21-40 cankers/tree
2 41-75 cankers/tree
3 76-160 cankers/tree
4 151 + cankers/tree

(Columns 51 and 52 apply only to the white pine tree improvement program. These columns may be used for something else for other species.)

E. Flowering Data

Columns 53 to 55 - Female Flowers (3 digit)

Enter the actual number of female flowers observed at the time the tree was located. Large numbers may be estimated.

Columns 56 to 58 - Current Year Cones (3 digit)

Enter the actual number of current year cones on the tree at the time it was located.

Columns 59 to 61 - Persistent Cones (3 digit)

Enter the actual number of previous year cones still persisting on the tree at the time it was located. (These cones will be open and many or most will have fallen off. They will be an indication of the flowering habits of the tree.)

Column 62 - Male Strobili (1 digit)

Record the presence of male strobili on the tree.

Code

0 None
1 Light
2 Moderate
3 Heavy

Columns 63 and 64 - Tree Status (2 digit)

The program will use specific information on cards 1 and 2 to determine the status of the candidate tree up to and including code 20, "Sufficient Seed on Hand." Additional data card codes will be prepared in the future to cover progeny testing, out planting, etc. The program will eventually determine tree status up to and including code 90, "Tree Dropped from Program." The current status of each tree will be printed automatically on the most recent "TrIm" list.

Occasionally a tree may be dropped from the program for reasons not covered by the ADP program (i. e., windfall). Losses which are outside the scope of the program must be entered on the field sheet by hand. Codes 91 through 99 inclusive are the only codes which should be entered in columns 63 and 64.

Code	
00	Tree unpollinated
10	Additional pollination required
20	Sufficient seed on hand
30	Seed sown
40	Progeny established
50	Progeny inoculated
60	Survival measured
70	Vigor quality test installed
80	Out planted
90	Tree dropped from program - below program standards
91	Tree dropped - excessive blister rust
92	Tree dropped - inadequate flowering
93	Tree dropped - too difficult to climb
94	Tree dropped - unable to relocate tree
95	Tree dropped - killed by fire, windfall, etc.
96	Tree dropped - insect or disease killed
97	Tree dropped - animal damage
98	Tree dropped - felled by man
99	Tree dropped - other causes

III. Card No. 2 - Pollination Data

Column 13 - Card Identification (1 digit)

Identify the particular card for which the entry is being made.

Code		
2	Pollination Data	(This code is pre-printed in column 13 of the Card No. 2 portion of the tree improvement field sheet.)

A. Controlled Pollination

Column 14 - Pollination Number (1 digit)

Number each subsequent pollination beginning with No. 1.

Columns 15 and 16 - Year Pollinated (2 digit)

Enter the last two digits of the calendar year in which the particular controlled pollination is accomplished.

Columns 17 to 19 - Date Bagged (3 digit)

Enter the day of the year on which the pollination bags were placed in the tree. Use the consecutive number; i. e., 1 to 365.

Column 20 - Bud Development (1 digit)

Indicate the female flower bud length to the nearest 1/20 inch (one randomly chosen bud).

Code	
1	Bud small - less than 5/20
2	Bud medium - 5/20 to 10/20
3	Bud large - 10/20 or more

Columns 21 to 23 - Buds Bagged (3 digit)

Enter the actual number of buds bagged.

Columns 24 to 26 - Date Pollinated (3 digit)

Enter the day of the year by consecutive number (i. e., 1 to 365) on which the controlled pollination was accomplished.

Column 27 - Flower Development (1 digit)

Indicate the flower development at the time of pollination according to the following code:

Code	
1	Not opened
2	Partly opened
3	Maximum
4	Partly closed
5	Closed

Columns 28 to 31 - Pollen Number (4 digit)

Enter the number given to the particular tester pollen used. In cases of controlled crosses between two trees in the program, enter the number of the tree from which the pollen was obtained.

Columns 32 to 34 - Flowers Pollinated (3 digit)

Enter the actual number of flowers pollinated.

Column 35 - Loss Code (1 digit)

If the number of flowers pollinated (col. 32-34) is less than the number of buds bagged (col. 21-23), determine the reason and enter the appropriate code:

Code	
1	Development stopped
2	Bag loose, damaged or missing
3	Heat damage - sun scorch
4	Stem damaged or broken
5	Insect damage
6	Animal damage
7	Other

Columns 36 to 38 - Date Disbagged (3 digit)

Enter the day of the year on which the pollination bags were removed from the tree.

Columns 39 to 41 - Conelets (3 digit)

Enter the actual number of successful conelets at the time of disbagging.

Column 42 - Loss Code (1 digit)

If the number of conelets (col. 37-38) is less than the number of flowers pollinated (col. 31-32) determine the reason and enter the appropriate code.

Code	
1	Development stopped
2	Bag loose, damaged or missing
3	Heat damage - sun scorch
4	Stem damaged or broken
5	Insect damage
6	Animal damage
7	Other

Columns 43 to 45 - Date Squirrel Bagged (3 digit)

Enter the day of the year by consecutive number (i. e., 1 to 365) on which the squirrel bagging was accomplished.

Columns 46 to 48 - Cones Bagged (3 digit)

Enter the actual number of cones bagged.

Columns 49 to 51 - Date Cones Collected (3 digit)

Enter the day of the year by consecutive number (i. e., 1 to 365) in which the cones were collected.

Columns 52 to 54 - Cones Collected (3 digit)

Enter the actual number of cones collected.

Column 55 - Loss Code (1 digit)

If the number of cones collected (col. 52 to 54) is less than the number of cones bagged (col. 46 to 48) determine the reason and enter the appropriate code.

Code	
1	Development stopped
2	Bag loose, damaged or missing
3	Heat damage - sun scorch
4	Stem damaged or broken
5	Insect damage
6	Animal damage
7	Other

Columns 56 to 59 - Seed extracted (4 digit)

Enter the actual number of seed extracted from the cones.

Columns 60 to 62 - Seed per Cone (3 digit)

Enter the calculated seeds per cone from the controlled pollination.

Columns 63 to 65 - Average Weight per Seed (3 digit)

Enter the calculated average weight per seed in milligrams to the nearest tenth.

B. Pollen Collection

Columns 66 and 67 - Pollen Collection No. (2 digit)

Number each subsequent pollen collection beginning with No. 01.

Columns 68 and 69 - Year Collected (2 digit)

Enter the last two digits of the calendar year in which the pollen is collected.

Columns 70 to 72 - Date (3 digit)

Enter the day of the year by consecutive number (i. e., 1 to 365) on which the pollen is collected.

Columns 73 to 75 - Male Strobili (3 digit)

Enter the male strobili production on the tree at the time of controlled pollination or pollen collection.

Code

001	Light	(This code is revised from a pervious, 3
002	Moderate	digit code. The first two digits may
003	Heavy	eventually be used for some other data.)

Column 76 - Strobili Development (1 digit)

Record the development of the male strobili at the time of collection.

Code

1	Scales closed
2	Buds green
3	Buds yellow-green
4	Pollen ready to fly
5	Pollen flying
6	Mostly shed
7	All shed

Column 77 to 79 - Pollen Separated (3 digit)

Enter to the nearest tenth, the ounces (liquid measure) of pollen separated from the male strobili.

USDA-FOREST SERVICE

TREE IMPROVEMENT

FOREST (1-2)	SPECIES (3-5)	TREE NO. (6-9)	YEAR (10-11)	CODE CLASS (12)

CARD NO. 1 (COLS. 13-64)		
CARD CODE	(13)	1
COMPARTMENT	(14-16)	
QUARTER SECTION	(17)	
SECTION	(18-19)	
TOWNSHIP	(20-22)	
RANGE	(23-25)	
ROAD NUMBER	(26-29)	
OWNERSHIP	(30-31)	
ORIGIN	(32)	
DATE OF ORIGIN	(33-34)	
HEIGHT	(35-37)	
D.B.H.	(38-40)	
CROWN CLASS	(41)	
GROWTH RATE	(42-43)	
ELEVATION	(44-45)	
ASPECT	(46)	
PHYSIOGRAPHIC SITE	(47)	
HABITAT TYPE	(49-50)	
CANKER NO.	(51)	
INFECTION RATE	(52)	
FEMALE FLOWERS	(53-55)	
CURRENT CONES (O.P.)	(56-58)	
PERSISTENT CONES (O.P.)	(59-61)	
MALE FLOWERS	(62)	
TREE STATUS	(63-64)	

CARD NO. 2 (COLS. 13-79)		
CARD CODE	(13)	2
POLLINATION NUMBER	(14)	
YEAR POLLINATED	(15-16)	
DATE BAGGED	(17-19)	
BUD DEVELOPEMENT	(20)	
BUDS BAGGED	(21-23)	
DATE POLLINATED	(24-26)	
FLOWER DEVELOPMENT	(27)	
POLLEN NUMBER	(28-31)	
FLOWERS POLLINATED	(32-34)	
LOSS CODE	(35)	
DATE DISBAGGED	(36-38)	
CONELETS	(39-41)	
LOSS CODE	(42)	
DATE SQUIRREL BAGGED	(43-45)	
CONES BAGGED	(46-48)	
DATE CONES COLLECTED	(49-51)	
NO. CONES COLLECTED	(52-54)	
LOSS CODE	(55)	
SEED EXTRACTED	(56-59)	
SEEDS/CONE	(60-62)	
AVE. WEIGHT/SEED	(63-65)	
COLLECTION NUMBER	(66-67)	
YEAR	(68-69)	
DATE	(70-72)	
MALE STROBILI	(73-75)	
STROBILI DEVELOPMENT	(76)	
OUNCES POLLEN SEPARATED	(77-79)	