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THE CARE AND HANDLING OF THE FOREST GENE POOL

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What must be the world's most magnificent pool of forest genes has timbered our Pacific slopes.

Why else do the tallest firs, pines, spruces, hemlocks, redwoods, and larches all rise along the Pacific Coast of North America? Does their hugeness simply thrust up from our deep soils and mild, rainy climate? From a vantage point of three decades in forest research, I believe the key to this wealth of timber is more than a matter of soil and moisture.

Taken together, the genes of our 22 commercial western conifers seem to me to constitute our vital basic resource. And unless we recognize the magnificent quality of this gene pool, we may needlessly risk pauperizing or destroying it as man begins to alter it along the lines of his customary philosophy of genetic improvement.

Consider some evidence bearing out the rarity of this vast gene pool. In combination with the rest of the forest plant community, our conifers utilize what actually are rather ordinary soils and surprisingly droughty climate to produce remarkable growth. Our climate, for instance, is mild, but can hardly be considered superior. It is characterized by severe summer drought—even in the Douglas fir region west of the Cascades there can be from one to four months of moisture deficiency between May and October of any year—whereas the forest climates of the eastern US, Europe, China, Japan, and New Zealand generally have rain better distributed throughout the growing season. Our soils, although good, must undergo the severe leaching of three to eight feet of rain between fall and spring.

But if climate and soils in our region are not superior, the growth rate of our conifers clearly is. When appropriate strains of our world-record species are planted in other temperate forest zones of the world, they usually outgrow native trees by wide margins. When we try the best species from other forest regions here, as we have for over 60 years, our own species outgrow **them** by wide margins, and few among them would even come close to meeting our timber needs if our native trees were unavailable.

Pacific conifers are the best in the world, in spite of ordinary soils and regular drought.

How could this bonanza of remarkable growth rates and the presence of the world's tallest trees in each of 10 major genera have uniquely happened in western North America? Across tens of millions of years, three strokes of fortune occurred:

—The climate of this region became cooler and droughtier as the Cascades rose and the ocean currents cooled. Earlier warm-climate species in our lowlands—palm, oak, acacia, cinnamon, pecan, magnolia—gave way perhaps ten million years ago to the more valuable conifers of today.

—About a million years ago there appeared the Douglas fir, the remarkable evolutionary success that has become our most valuable tree. With its heavy armor of bark to assure its survival in the fire-prone West, and durable wood that gave it long life between major fires, the Douglas fir came to dominate the best sites of the West.

—The third stroke of fortune, and perhaps the most crucial, was geographical. The north-to-south orientation of the mountains of North America furnished a high escape route, virtually all the way to the subtropics, which appears to have saved our migrating forest complex intact from the ice ages. This was not the case on the Eurasian land mass, where mountains and seas are oriented east to west; there the oncoming ice must have trapped many fast-growing, cold-sensitive species and strains against the crosswise geographical barriers and eliminated them.

Besides this set of remarkable circumstances, there was the rare good fortune that Western man did not arrive here early enough to inflict upon the forest gene pool the drastic disruption that characterized other temperate zones. Even when the course of settlement came to the Pacific Northwest, several trends wove together to minimize man's impact on the great gene pool. Until early in this century, the nation's lumber needs were met mostly by logging in the Lake States and the South. Then between 1920 and World War II, the per capita demand for wood slacked off; less wood going into housing and industry meant less cutting in our forests. At about the same time, the national forests, which in a unique quirk of history had been set aside a few decades earlier, began to receive good protection. Federal ownership made up half the forest land in Oregon and Washington; until after World War II, relatively insignificant cutting occurred on that protected acreage.

Meanwhile, the concept of sustained yield of timber was gradually accepted, first on the public lands and then more and more on private lands, as owners began to find that there were no new timberlands to buy and that nurturing the existing forest to produce future timber crops made economic good sense.

Along with these major trends went a customary reliance on natural seeding whenever timber was cut. Most of our cutover land was being reforested by windborne seed which came from the edge of the uncut stand or from single cull trees left standing amid clearcuts. This method too helped to carry on the gene pool mostly intact. Natural seeding accomplished something else only now being scientifically

documented: the vital preservation of the gene pool in every locality. Recent research shows that genetic makeup can be different in natural stands only a few miles apart—a complex selection response among multitudinous traits, species by species and niche by niche, to fit the varied environmental changes in our broken topography.

Taken together, these trends prolonged much of the region's natural forests until after World War II. To find **any** cultivated plant with virtually any intact gene pool is not the rule, for the impacts of man on the plant resources of the world are severe and in many cases tragic. Yet about three decades ago our phenomenal gene pool was miraculously intact, saved by the series of unique human and geological events; and

Until the end of World War II, natural seeding kept our timber gene pool mostly intact.

reliance on natural seeding meanwhile assured that degradation of the conifer genes would be slow, if it happened at all.

Much has changed since then. The two most significant tendencies are those from natural regeneration of forests to planting, and toward increased investment in genetic improvement of timber species. Both have strong economic justifications, and both have the potential of altering our basic resource, the gene pool.

Planting alters it in a somewhat random but slow process. Genetic improvement alters it deliberately and rapidly. We should direct our concern for this alteration in our gene pool resource as soberly as if we were talking about protecting the very soil itself.

Just as the factors preserving the gene pool have been complex, so are those trending toward its alteration. One came about with the renewed demand for wood in the building boom which followed World War II. As the cutting to meet this demand advanced southward from the earlier logging areas of Puget Sound and the Columbia

Increased demand for wood has made nature's regeneration period economically unacceptable. Planting has replaced natural reseeding, quickly altering the gene pool.

River, and into higher elevations which previously had not been touched, the percentage of land that would not regenerate easily by natural means increased. The reason was a combination of browsing by animals, extreme competition from brush, and too-severe exposure. Where regeneration failed over an extensive area, any replacement growth would be a somewhat different gene pool.

An even larger alteration was developing unnoticed on our best timber sites. This was the replacement of conifers by broadleafs in the man-made succession. Although the early forestry researchers of this area were generally correct in assuming a cutover patch would regrow in a natural succession starting with annual plants, then perennial plants, then broadleaf brush, then conifer trees, this did not always occur. Instead, brush species quickly dominated many sites and have persisted for most of a century. On about 30% of the acreage—usually the best 30% for growth—the succession through the broadleaf brush stage lengthened to represent a lasting change. Three million acres, or nearly 5000 square miles, of the Coast and northern Cascade Ranges today are occupied by alders, maples, and lesser brushy broadleaf species instead of the fast-growing coniferous forests worth five to ten times as much.

Simultaneously, as log prices rose, it became uneconomical in logging to leave cull trees as the natural seed source. By 1960, virtually every conifer of a chosen stand was being felled for its merchantable wood. This meant that on private timberlands, where large clearcuttings were the rule, planting had to be generally substituted for natural reseeding.

On public forest lands, although clearcuts were smaller, a similar change from natural reseeding to planting was being encouraged by the "regeneration period" concept. This is the assumed time after cutting until a new stand is naturally regenerated. Economists could show that even a 5-year regeneration period without growth was financially intolerable. Removal of every conifer tree became a contract specification for cutting on public lands as well as the custom on the large private timber tracts.

Thus, where relatively little planting was done for reforestation before World War II, planting is now the primary regeneration method. But to replace the natural gene pool while using planted stock is difficult to do. There is no way in the seed collection methods, whether by climbing trees or robbing the caches of cone-cutting squirrels, to avoid a different selection of seed than would drift down from the natural stand itself. Nursery programs assure a different selection too. A high percentage of nursery seed become plants in the forest, whereas a natural stand may start with a million seed per acre and only a few hundred will survive. Difficulties of scheduling the seed collection, nursery, and cutting operations assure that much non-local seed is represented in planting.

The change from natural seeding to planting, then, has represented the first large-scale alteration of the Northwest's unique gene pool. Now we come to the final trend—the introduction of genetic improvement to forest trees.

A few decades back, foresters began trying to copy from Europe and the eastern US a practical program intended to produce genetically superior tree stock for reforestation. About 600 acres in western North America became devoted to what we call seed orchards. There cuttings taken from expensively selected trees in the forest were grafted onto seedlings planted orchard-like on farm land. As the grafts grew, they would interpollinate and the seed would be used in reforestation. The program had worked satisfactorily in the pines of the eastern U.S. But for the species of main interest here, the Douglas fir, there began to be problems.

Studies demonstrated that very high levels of "outside" pollen were contaminating the seed orchards. Also, orchards were expensive because of the specialists needed and the price of cultivated land. The most dramatic problem, however, was graft incompatibility in the Douglas fir. A rejection of tissue was occurring between the seedling understock and the graft, much like the problem in human heart transplants.

Although mostly resolved by now, these disturbing problems, plus the fact that the Douglas fir was found to be discouragingly slow and cyclic in its production of seed, began to suggest there should be a search for some approach besides the seed orchards. A genetic program I had earlier proposed for the region's Christmas tree growers had proven successful. Stripped to its basics, the notion had been that good genetic gains could come about by planting wind-pollinated seed from trees growing naturally in the forest, if one kept track of their progeny value and used seed of only the best one-quarter or less of parents for reforestation. This "non-seed orchard" approach began to find adherents. By 1971, what has come to be called the "progressive program" was in use on two million acres; it now encompasses much of the forest land in western Oregon and Washington.

Even though so simple a program was never envisioned as the dominant beginning genetics program, it has proved to have practical advantages. No seed orchard investment is needed, no new expertise by forestry staffs. It has permitted rapid advance into more sophisticated programs involving cross-pollinations. More important, the program was economical enough so that about 20,000 parent trees will be tested—and hence has been more effective than programs used in other forest regions in terms of preserving the gene pool of each locality.

But so extensive have become the two

significant trends — from the natural regeneration of forests to planting, and toward increased investment in genetic improvement of the timber species—that we must ask where they may be taking us. Right now, some investment in tree improvement programs of one kind or another has been made in seven out of every ten acres of commercial forest land in the Pacific Northwest. The history of man's effects on other gene pools is a warning to us that once begun, any alteration tends to become more and more extensive.

If we look broadly at the path of all genetic improvement, we find really only one philosophy or model. There are strong parallels in it to mining. One prospects the gene pool for the richest sources of the desired genes, refines them into as pure a state as possible, then spreads the product as broadly as the competitive market permits. Everything except the pure product goes into the waste heap. (Admittedly, many genetic programs do carry along sufficient genetic diversity in their product to prevent loss of vigor or to protect against pests or environment. The essential point remains that the genetic goal is to have as refined a product as conditions will permit.)

Reflecting on the "mining" philosophy, one can see that only certain parts of it have large consequences for the gene pool. Prospecting and purifying are in themselves relatively innocuous. It is the replacement of the original gene pool with a more "profitable" one which wreaks the great consequence.

The history of plant improvement is that we usually have been thorough in replacing the original gene pool with an "improved" strain. For example, by the time of Columbus, corn had been so altered by selection done by the Indians that the original wild corn plant was extinct, and corn's future was entirely dependent upon man: it could not persist in the wild. The history of improvement in wheat similarly has been the refining of the gene pool into one strain after another, none of which could exist without man; each, in turn, was wiped out by a pest. Fortunately, a new improved strain was always in the wings, arising from some resistance gleaned out of the shrinking original gene pool. Today the original gene pool of wheat is reduced to a few small acreages in the "fertile crescent" of the Mediterranean area.

Replacing the original gene pool with an "improved" strain can turn out—a lifetime later—to be a mistake.

To follow this "mining" model is by far the most likely path for our forest gene pool. Exploitation and quick gains have always prevailed in our resource management.

Picture the landowner's choice of alternatives in reforestation if some forest geneticist should produce a refined strain that promises to give a 50% gain in production. Will that landowner have any long-range concern for his present forest gene pool? Can he compete if he resists using the new strain?

Yet the already existing strain, genetically tuned to its own local land form and ecosystem and probably growing at the rate that long-term extremes of the environment will permit, may well be superior in most ways. And much is at stake whenever we thoughtlessly discard a local adapted, well-buffered, multi-species gene pool. In forestry the crop is long-lived, and it may take the length of human lifetime just for any mistakes in the altered gene balance to show up.

Historically, however, we can see that with both economics and established philosophies so well served by simply mining our gene pool, it would take a miracle to keep intact this unique forest resource. What would this miracle involve? A different genetic philosophy.

It would mean, first, the patient acceptance by the forest landowner that this most magnificent gene pool is not yet understood, and that ample amounts should be preserved by natural seeding with natural selection in every locality until it is understood for its total worth, adaptation, buffering, and other qualities.

Secondly, it would call for acceptance of a different kind of breeding in our forest species, in which the geneticist begins by assuming that the local strain already has been bred for most of the adaptation and buffering that is wanted, and he need change that strain only to the extent necessary to incorporate genes for safe enhancement of growth.

In the short run, this might sacrifice quick gains by not breeding for a purer genetic product, but in the long run it might maximize gains by avoiding costly environmental and pest losses. The details of such a philosophy remain to be worked out, but it is highly important that geneticists give it a try. It is more a change in goals than in techniques.

Once we fully realize that our forest genes are a more valuable and critical source of wealth than the soil itself, perhaps the Northwest gene pool will again be saved intact by one more unique historic event—a cautionary approach by man.

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