Excerpt from "The Status of Temperate North American Forest Genetic Resources. 1996. D.L. Rogers and F.T. Ledig, eds. Report No. 16, University of California Genetic Resources Conservation Program, Davis, CA. 102 p.

North American temperate forests

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North American temperate zone

In trying to place bounds on the temperate forests, we could simply say that they occupy the area between the boreal forest and the tropical forest. However, it is not a simple matter to place limits on those plant associations either. Based on the Holdridge life zone system, the boreal zone lies north of an isotherm of 6°C mean annual temperature (Holdridge 1947). We took the limits of the boreal forest as given by Elliott-Fisk (1988): the southern limit approximates the 18°C July isotherm in eastern and central Canada, but is shifted to cooler, moister climates to the west. Latitude is a poor delimiter; in British Columbia, Canada, temperate and boreal forests intermingle because of the complex topography. Some species typical of the boreal forest, such as white spruce (*Picea glauca* (Moench.) Voss.), lodgepole pine (*Pinus contorta* Dougl.), and quaking aspen (*Populus tremuloides* Michx.) are also components of temperate forest associations, such as the Rocky Mountain forest.

A boundary between tropical or subtropical forests and temperate forests is even more difficult to draw than a northern boundary between boreal and temperate forest. Based on Holdridge life zones, the bounding isotherm would be about 18°C mean annual temperature. The astronomical divide between the temperate zone and the tropics, the Tropic of Cancer, is at 23°30' N latitude, but in Durango, México, spruce species—a genus characteristic of the boreal forests—occur south of the Tropic. Most of highland México is temperate, but subtropical forest extends far north of the Tropic of Cancer in Veracruz (Hartshorn 1988). One set of possible boundaries for the temperate forest is shown in Figure 1.

In the final analysis, the definition of boundaries for temperate forests seemed unimportant. The workshop participants entered discussions with the realization that hard and fast lines were not always possible between temperate, boreal, and tropical forests. In fact, much of the discussion was conducted without regard for the temperate forest boundaries. The discussions and the recommendations that emerged from the discussions often seemed broad enough to encompass boreal, temperate, or tropical species. We recognize that there are many similarities in management of tree species across the three major forest zones, and that genetic resource conservation practices have common themes across forest zones. However, the species most prevalent and most studied and, therefore, those that subconsciously guide our thinking, are monoecious and wind pollinated.

North American forest genetic resources

North America is a continent rich in climatic and topographic diversity and, therefore, rich in biological resources. The genetic resources in North American forests are the basis for plantation forestry in much of the rest of the world. Sitka spruce (*Picea sitchensis* (Bong.) Carr.), loblolly pine (*Pinus taeda* L.), Monterey pine (*Pinus radiata* D. Don.), and oocarpa pine (*Pinus oocarpa* Schiede) are planted on millions of hectares in Africa, Asia, Australia, Europe, and South America (Figure 2).

Of the three countries that coexist in North America, México is the richest in species diversity. The United States and Canada together have about 650 tree species (Little 1979) while México has about 2,000 to 3,000 (J. Rzedowski personal communication, 1989). Of a total 22,000 plant species in México, 11,000 are endemic, and certainly more will be discovered. México's many taxa represent a wealth of genetic diversity. One of México's gifts to the world is maize, of course, but another is pine. México is a center of diversity for pines, being home to about half the world's pine species. Of the (approximately) 50 pine species native to México, 17% are considered endangered (see "Status of Temperate Forest Tree Genetic Resources in North America—México", below).

The gravest danger to the forest resource may be the loss of populations and genetic resources within species—called the "secret extinctions" (Ledig 1993). Loss of forest genetic resources occurs largely as a result of conversion of forest land to other uses, primarily grazing and agriculture. The situation is worst in México. Deforestation in México is proceeding at a rapid rate; conservatively, about 0.65% (over 165,000

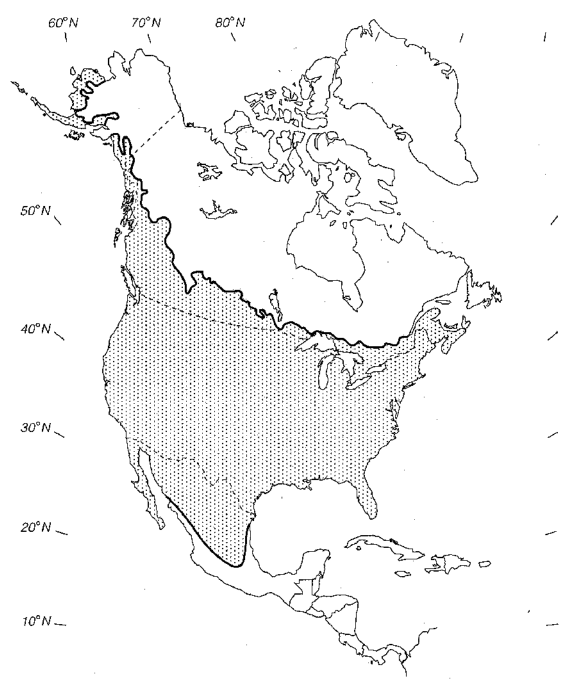

Figure 1. The temperate zone of North America as defined by the boundaries of the boreal forest in the north (after Elliot-Fisk 1988) and the subtropical and tropical forest in the south (after Hartshorn 1988). However, islands of temperate forest occur on high peaks as far south as the Central American republics.

Figure 2. A plantation of Sitka spruce (*Picea sitchensis* (Bong.) Carr.) in Scotland. Sitka spruce is a North American temperate species extensively planted in Europe.

ha) of the temperate forest area is converted annually (Cairns et al. 1995; Anonymous 1992). Conversion results in the elimination of local populations with, perhaps, unique genetic resources.

It is imperative that national leaders understand that a species, like ponderosa pine (*Pinus ponderosa* Laws.) or oocarpa pine, is not one, homogeneous population. A wide-ranging species is usually a collection of genetically distinct populations. Local populations are adapted to their environment, and if those populations were extirpated, or replaced with stock of nonlocal origin, forest productivity would be reduced. For example, if ponderosa pine sites at 825 m elevation in the Sierra Nevada of California had to be replanted with seed from 600 m lower in elevation, the reduction in volume at 50 years of age would be about 5% (see Figure 3). If replanted with seed from 600 m higher in elevation, the reduction would be about 20%. We find similar relationships for planting sites at other elevations. Thus, local genetic resources contribute to forest productivity which, of course, is a basic economic value, and if those resources were lost, it might be difficult or impossible to replace them.

The genetic diversity within individual populations serves other biological and potentially commercial purposes. This diversity provides some evolutionary flexibility, allowing species to respond to changes in the environment such as 'climate change'. Individual populations may be the source of specific adaptations such as resistance to particular diseases or insects, tolerance to certain soil conditions, or other attributes that may be of current or future value in domestic forest tree breeding programs.

Concern for genetic resources in North America should include forest species that we now do not consider as commercial species, because we may discover new uses for them in the future. Pacific yew (*Taxus brevifolia* Nutt.) was valueless ten years ago (see Box 1). But then taxol from bark extracts was found to be highly effective against cancer in tests conducted by the U.S. National Cancer Institute (Douros and Suffness 1980). In a matter of years, yew became so highly sought that conservationists were concerned it would be eliminated from forests in the Pacific Northwest.

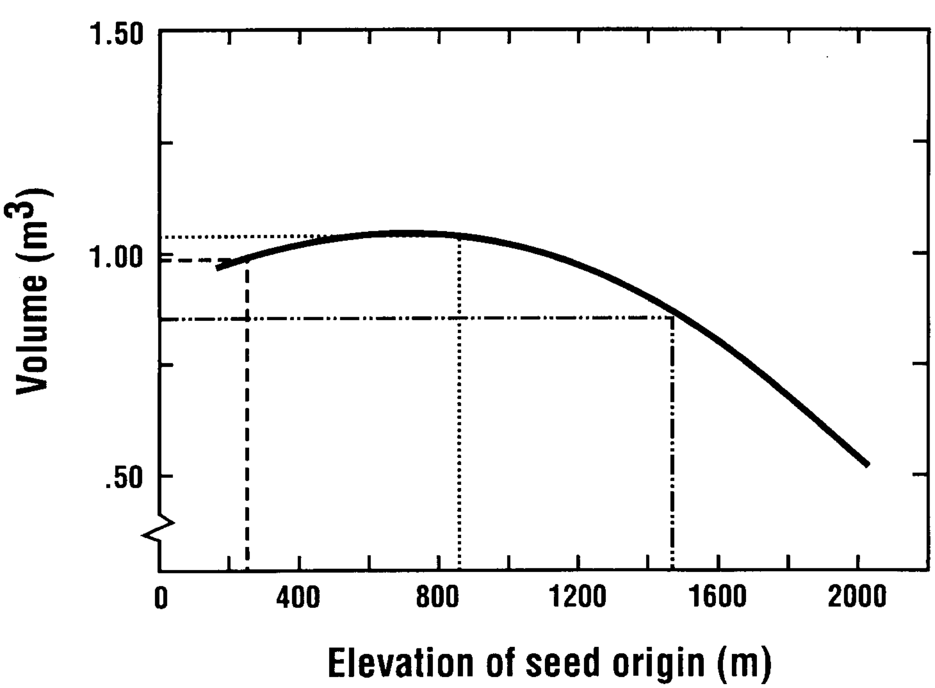

Figure 3. Fifty-year, per tree volume of ponderosa pine (*Pinus ponderosa* Laws.) as a function of elevation of the seed origin. Results are for a plantation at 825 m elevation and mean latitude 39°N in the Sierra Nevada of California. The central set of coordinates represents use of the local seed; the set on the left shows that a 5% reduction in volume is expected if seed originates from 600 m lower in elevation than the planting site; the set on the right shows that a 20% reduction in volume is expected if seed originates from 600 m higher in elevation. (M.T. Conkle, unpublished data).

Box 1

The Pacific yew: Minor species or cancer remedy?

The argument has often been made that biodiversity of our native ecosystems should be conserved to ensure that as-yet-undiscovered but potentially useful plant products are not lost to society. Although such discoveries are relatively infrequent, an outstanding example is that of the Pacific yew (*Taxus brevifolia* Nutt.).

The Pacific yew is a small, long-lived, shade-tolerant, dioecious gymnosperm native to the western United States and Canada. Though the species is widespread geographically, from coastal southeastern Alaska to northern California and as far east as western Montana, it occurs rather sporadically in that range. In the intensively managed, low-elevation forests of the Pacific Northwest, the yew has no doubt diminished in abundance because of its perceived lack of timber value and consequent neglect as the focus of reforestation efforts over the last 100 years.

In the 1960s, tissues of Pacific yew were discovered to contain an active ingredient that arrested cell division in cancerous cell lines. By the late 1980s, the Pacific yew had become the focus of considerable attention by medical and forest management communities because it was identified as the primary source of the compound taxol, a potent chemotherapeutic agent.

For a brief time, the discovery of taxol was feared to be detrimental to the viability of the species because there was a rush to obtain bark for clinical use. This led to the death of a large number of trees that were harvested for their bark alone. However, the discovery may ultimately be viewed as the milestone that galvanized a remarkable series of activities resulting in significant long-term protection for the species. Government agencies instigated immediate harvest and management protocols that limited access on national forests and BLM (Bureau of Land Management) lands. Universities and private companies sought to better understand the genetic diversity of this and related species, to aid in its management and to develop domesticated sources of taxol, cultivated outside the natural forests.

Today, less than five years after Taxol® was approved as a clinical drug, relatively small amounts of the compound are derived from Pacific yew. The majority is derived from a conversion of a related compound taken from domesticated, ornamental yews (semisynthesis). While the Pacific yew remains a minor species in the Pacific Northwest forests, it will no longer be viewed as an inconsequential component of the ecosystem. Furthermore, as a result of the attention given to this minor species, regional land managers appear to have a much deeper appreciation of the need to intelligently manage diversity.

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