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# Injury to Plants from Rapidly Dropping Temperature in Washington and Northern Idaho

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In nearly 70 years of recorded weather history, Washington and northern Idaho have on three occasions experienced exceptionally sharp freezes in late autumn or early winter that caused considerable damage to plants. A brief review of these events is warranted since the records are consistent enough to permit the drawing of significant conclusions.

### Freeze of December 1924

Aside from the actual records of daily maximal and minimal temperatures for the freeze of December 1924, two publications have referred to its effects on plant life. The monthly weather summary for Washington (*7*) indicated damage to crops over a wide area, stating that there was suspected injury to winter wheat, truck crops, and peach spurs. On the west side of the Cascades in Washington it is possible that even native taxa were damaged, for the summary also states: "Shrubbery in the Puget Sound country is reported as damaged by the cold." Unfortunately the brevity of this comment robs it of most of its fundamental biologic significance, for there is no indication as to whether or not the damage was confined to exotic "shrubbery."

In the period 1911-1917 a series of plantings of different geographic races of *Pinus ponderosa* were made at the Priest River Experimental Forest in Bonner County, Idaho (*12*). Included were populations obtained from the Siskiyou and Shasta National Forests which are situated in the mild oceanic climates of southwestern Oregon and north central California, respectively. The sudden drop in temperature (Fig. 1, upper part) on December 15, 1924, when the

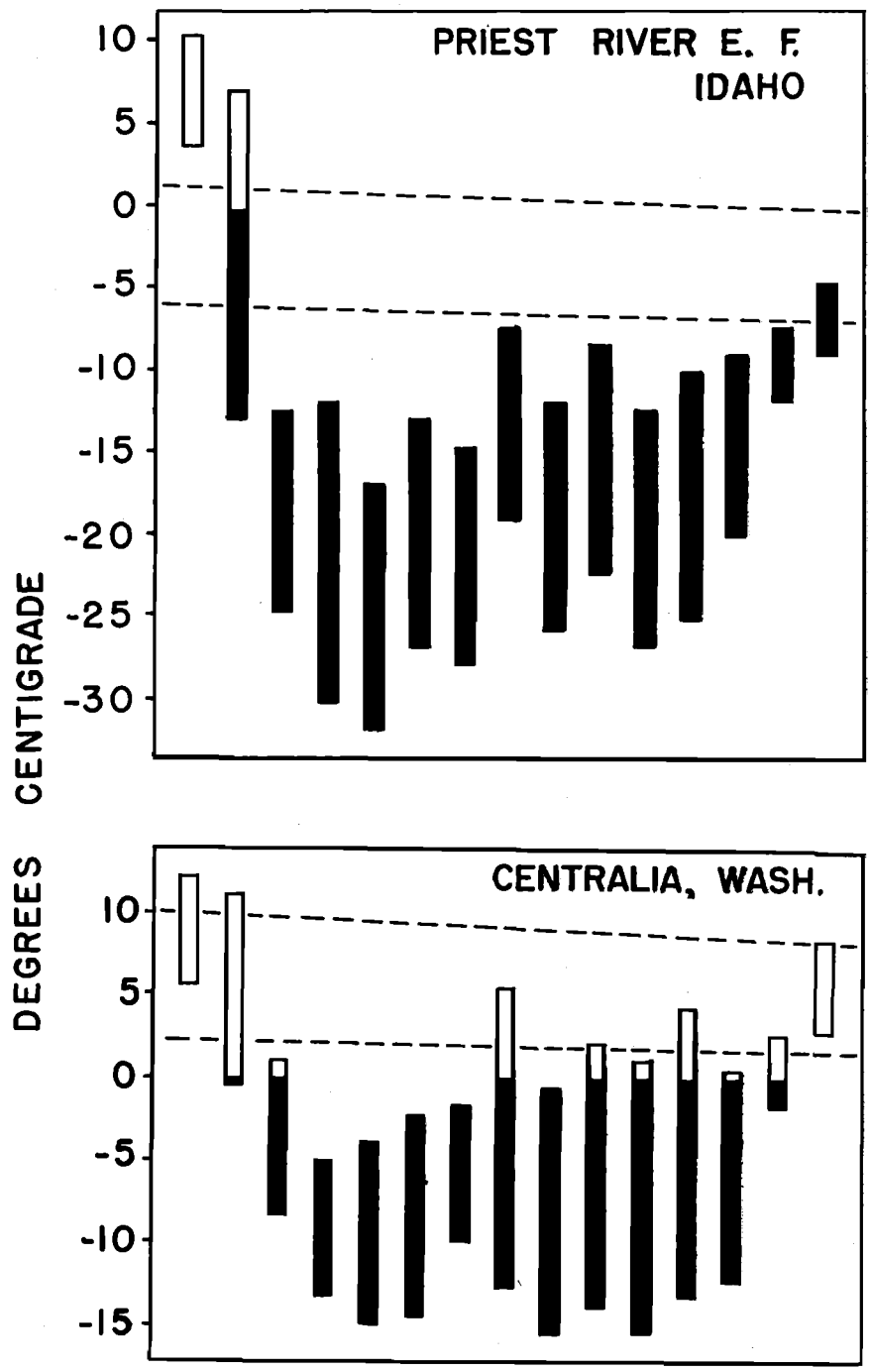


Fig. 1.—Diurnal ranges of temperature during the unseasonal cold weather of December 14-28, 1924. Dashes represent smoothed trend lines based on monthly means, intended to approximate the average ranges of diurnal temperatures at this time of year. Shading of columns indicates temperatures below the freezing point of water.

Siskiyou planting was eight years old and the Shasta nine years old, proved disastrous. Most trees of the Siskiyou planting were killed, and the Shasta planting was completely destroyed. Races from other regions, all with more continental climates but from places as remote from the test location as Arizona and South Dakota, withstood the temperature drop without evident injury. A curious feaure of this cold wave that is also characteristic of most others discussed in this report is that immediately prior to the invasion of cold air there was a brief period of abnormally high temperatures which served to accentuate the extent of the subsequent precipitous drop.

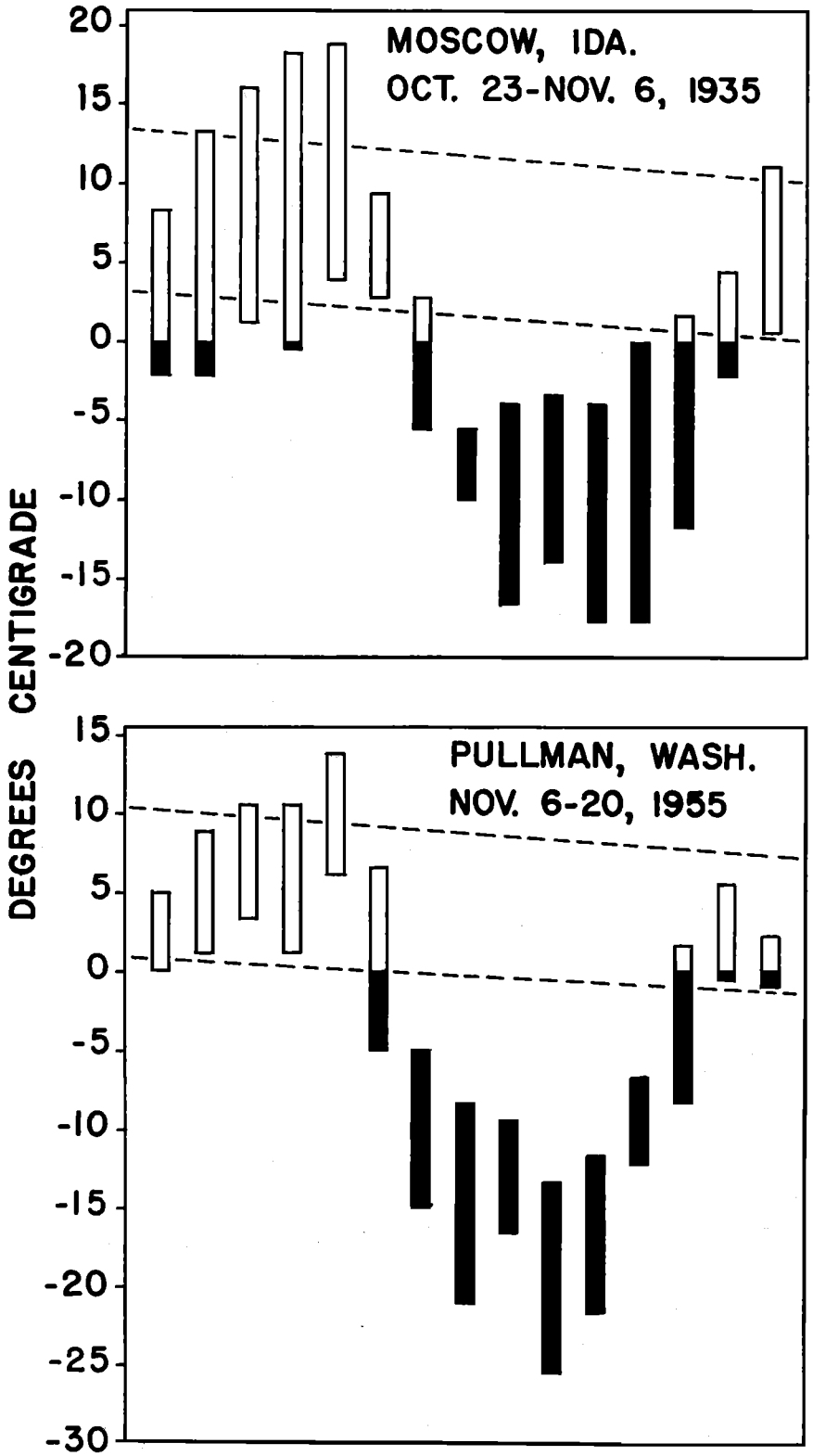


FIG. 2.—Comparison of damaging cold waves for the same area at intervals of 20 years. Moscow and Pullman are located about 10 miles apart on similar topography.

Comparison of the actual temperatures with norms for the season (Fig. 1) does not suggest greater abnormality for the coastal region (as exemplified by Centralia) than for the inland station; yet if native plants sustained damage, it was confined to the coastal region.

**Freeze of October-November 1935**

In the autumn of 1935, temperatures prior to October 17 had not dropped lower than 30°F. in the Weather Bureau instrument shelter at Moscow, Idaho (Fig. 2, upper part). On the 25th, and especially on the 26th and 27th, daily maximal temperatures rose well in excess of the average, then on the 28th a mass of cold air began to invade the area and temperatures dropped rapidly. For a period of five consecutive days temperatures were so abnormally low that daily maximal remained below the normal minimal values for this season, resulting in a condition of about equal intensity but shorter duration than that which destroyed pines at the Priest River Experimental Forest 11 years earlier (compare Fig. 1, upper half, and Fig. 2, upper half).

Comments published in the then-current issues of *Climatological Data* (*8*) recognized this as "unusually cold weather for so early in the season," resulting in the coldest November temperature since 1893. Elsewhere (*9*) it was stated that "damage from the early November freeze was considerable" also in Washington, especially to "pears in the Kennewick section, sweet cherry, apricot, and English walnut trees." In the memory of the writer, damage to sweet cherries (probably mostly the Lambert variety) proved so extensive in the Pullman-Moscow area that many trees were cut down the following summer.

**Freeze of November 1955**

Almost exactly 20 years later than the episode described above, the weather phenomenon was repeated. Both the maximal and minimal temperatures were well above normal the day before an influx of polar air brought on rapid freezing. For six consecutive days even the maxima remained below the normal minima at Pullman, Washington.[1] The depression was greater and more enduring than 20 years earlier, but the pattern was strikingly similar, as was the time of year (Fig. 2, lower half). The 1955 cold wave was the more severe, as the depression of maxima below the normal minima was greater, and this phenomenon continued for six consecutive days.

According to the U. S. Weather Bureau (*11*) "new minimum temperature records for November were set in many areas during this freeze; the entire State had the coldest weather of record for so early in the season, and it was the longest period of severe cold ever noted in the 66 years of record."

At the writer's home located about one mile west of Pullman, Washington, 52 species or varieties of woody plants were damaged, in degrees ranging from slight to complete killing. Injured patches of bark appeared to die at varying times spread over a number of months, these sometimes completely girdling and thereby killing the distal portions of axes or branches. Frequently the girdled stems put out new leaves at the usual time the following spring, these crops of leaves dying at varying intervals over the summer.

By no means were all the exotics damaged. Many showed no detrimental effects, e.g., pears (Bartlett, Winter Nellis, Sheldon), sour cherries (Lake Duke), *Picea abies*, *Thuja occidentalis*, *Kolkwitzia amabilis*, and *Spiraea vanhoutei*. Black raspberries (Cumberland), oddly enough, gave exceptional yields the following summer. Strawberries bore normally.

[1]No temperature records had been made in Pullman in 1935; this station is 10 miles from the one at Moscow, Idaho, so that the data are closely comparable.

There appeared to be a correlation between the degree of injury and degree of age of plant and seasonal maturity of leaves. A young apricot tree (budded to Tilton and Royal varieties) was killed while an established tree (Wenatchee Moorpark) suffered negligible damage. Young *Robinia pseudoacacia* that were exceptionally vigorous as a consequence of fertilization of the soil were heavily injured, whereas others that had been forced into seasonal maturity by drouth and low fertility survived. A well-established tree of the early-maturing Redhaven peach escaped damage while the later-maturing Rochester succumbed. Leaves of many ornamental trees that were still green were frozen without an abscisss layer forming, so that they hung on the trees through the winter. In fact, a tree of *Quercus* (*coccinea?*) located at the south edge of Pullman retained its full complement of dead 1955 leaves throughout the summer of 1956, along with the new crop.

Native plants at the site west of Pullman completely escaped injury. This also applies to plants that had been transplanted here on the grassland from their native homes in the relatively cool and moist coniferous forests of the mountains a few miles to the east: *Acer glabrum* var. *douglasii*, *Berberis nervosa*, *Betula papyrifera*, *Larix occidentalis*, *Pachistima myrsinites*, *Pinus ponderosa*, *Pseudotsuga menziesii* (Mirb.) Franco, *Sorbus scopulina*. However, all three of the "natives" that had been transplanted upslope from drier climates (*Artemisia rigida*, *A. tridentata*, and *Chrysothamnus nauseosus* var. *albicaulis*), were included in the group of plants completely killed.

Microclimates in the small town of Pullman were sufficiently different from those of the surrounding countryside that damage to exotics in the town were relatively light.

West of the Cascades, "minimum temperatures . . . prior to this storm . . . had remained above freezing in many of the . . . areas;" then when the cold air moved in "maximum temperatures remained below freezing for approximately four days or longer. This was as many days with a maximum temperature below freezing as is usually recorded during an entire winter." It was immediately reported that "losses of strawberries, raspberries, blackberries, etc., and small fruits appear to be very high. Roses, shrubs, and many ornamental trees appear to have been killed. Nurseries suffered heavy losses of plants. Indications are that some orchards may have been damaged in both divisions of the State." This latter proved to be an underestimate. "There was an unusually heavy drop of needles from evergreen trees" (native? exotic?) "after temperatures began to moderate." A preliminary estimate of freeze damage to crops was that it "may reach 11 million dollars" (*11*). A year later the loss was reappraised at 66 million dollars.

Although the cold wave of November 1955 caused no apparent damage to native plants in eastern Washington and northern Idaho, Taxa native to the seaward side of the Cascades were extensively damaged (*2*). Injury to native evergreen trees there was not uniform. It was lighter on the windward side of the Olympic Peninsula than elsewhere, lighter below an overstory of taller trees; lighter on northerly rather than on southerly slopes, lighter in the centers of timber tracts rather than along their margins, lighter where snow covered seedlings rather than having been blown off. *Tsuga heterophylla* was more severely damaged than was *Thuja plicata*, with *Pseudotsuga menziesii* least damaged of the three. The evergreen *Arbutus menziesii* and the deciduous *Alnus rubra* were extensively killed. The evergreen shrubs *Vaccinium ovatum* and *Gaultheria shallon* were also heavily damaged.

Severe damage or killing of many exotic trees and shrubs as well as a few natives (*Alnus rubra*, *Cornus nuttallii*, and *Tsuga heterophylla*) was also reported at the University of Washington Arbore-

tum, at Seattle (*5*). It was noted that young and actively growing saplings of *Cornus nuttallii* were more susceptible than seedlings or old trees (*13*). Also, injury to the stem "six to eighteen inches above the ground line" was especially fatal (*13*).

It is interesting to compare conditions in northern Idaho and on the west side of the Cascades for this period, since a pair of stations can be selected both of which are surrounded by forests containing much *Tsuga heterophylla, Thuja plicata,* and *Pseudotsuga menziesii.* Only the *Pseudotsuga* has been recognized as taxonomically distinct in the areas, *P. menziesii* var. *menziesii* to the west of the Cascades and *P. m.* var. *glauca* to the east. The length of the period of below-average temperatures (Fig. 3) and the degree of depression appear of about equal magnitudes. Since damage was sustained only by the coastal ecotypes, one might conclude that the ecotypes of the oceanic climate are genetically less adapted to endure deviations from average temperature ranges than are ecotypes of the quasi-continental climate. Stated in another way, the inland ecotypes are better adapted to their climate than are the coastal races. Since Duffield (*2*) remarks on variation in damage sustained by individuals exposed to the same microclimate, it may be postulated that the coastal populations contain genotypes that are fairly tolerant of unusual cold conditions, but have not been rigorously purged of the sensitive genotypes as appears to be the case inland.

The hypothesis as to the distinct difference in cold tolerance between oceanic and quasi-continental ecotypes, suggested by the circumstances described above, is strengthened by two further observations. In a nursery located on the campus of the University of British Columbia at Vancouver, B. C., about a hundred feet above sea level and a few hundred yards from the sea, 2-year-old seedlings of *Pseudotsuga menziesii* representing both oceanic and continental ecotypes had grown for two years under oceanic climate at the time of the 1955 freeze. Subsequent tallies of damage showed a distinct tendency toward greater damage to those plants representing oceanic races (*4*). Also at La Grande, on the seaward side of the Cascades in Washington, only oceanic ecotypes of *Pinus ponderosa* from Washington and Oregon were damaged severely, whereas trees representing continental ecotypes were damaged lightly or not affected (*3*). The latter circumstance is complementary to the racial test of *Pinus ponderosa* which is located in Idaho and provided information described earlier.

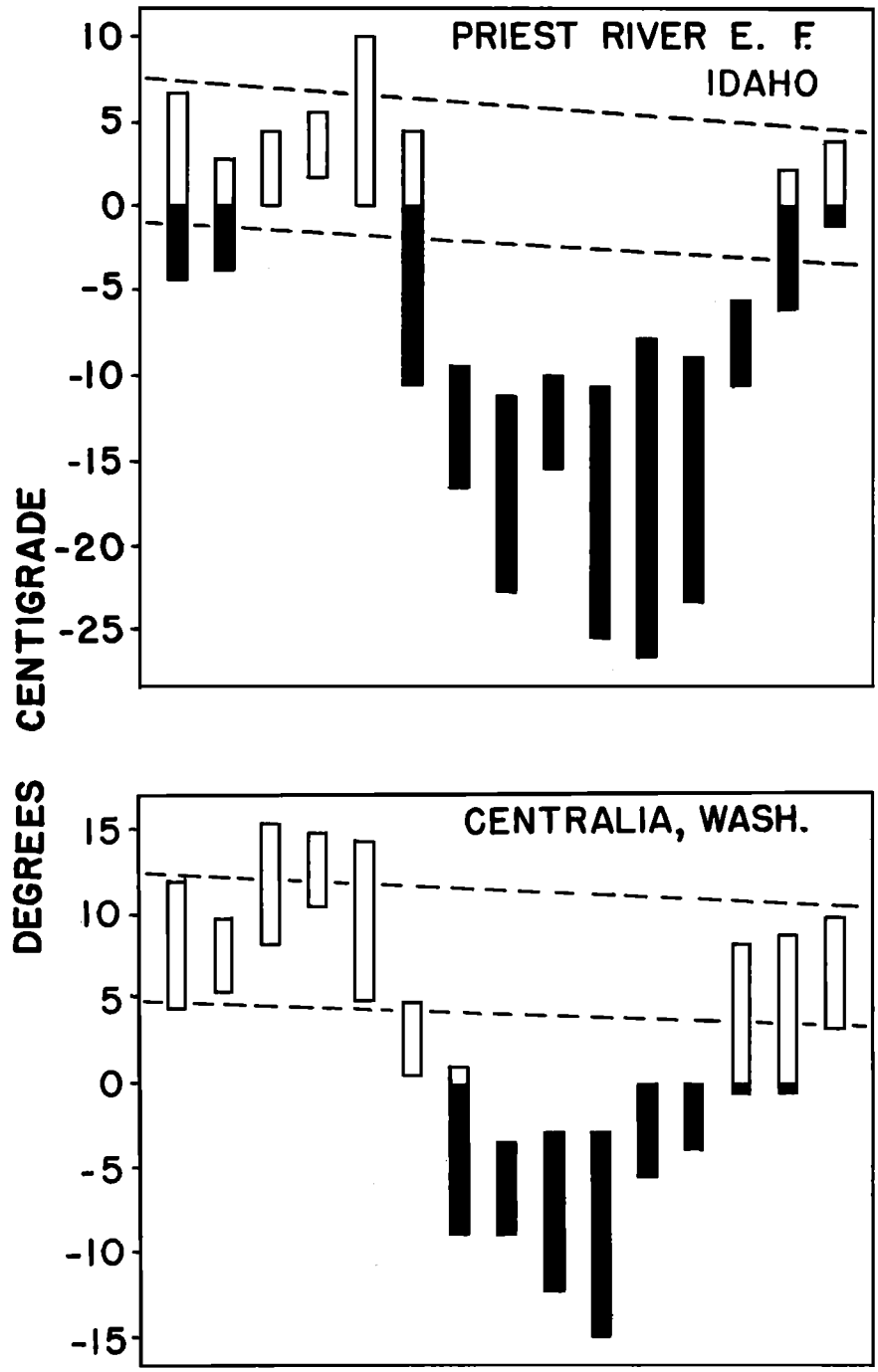


FIG. 3.—Comparison of the character of one cold period, November 6-20, 1955, as recorded 50 miles from the ocean at Centralia, Washington, and 300 miles from the ocean at Pullman, Washington. Both areas are in forests where *Tsuga heterophylla, Thuja plicata,* and *Pseudotsuga menziesii* are comon trees, but these trees were damaged only near the coast.

## Discussion

A conclusion that the shoots of oceanic ecotypes are damaged by sudden drops in temperature in late autumn or early winter, whereas ecotypes from quasi-continental climates are little if at all damaged, seems well supported by the observations reported above. It rests upon the divergent responses of unintentional but nevertheless fully satisfactory reciprocal transplants of *Pinus ponderosa* races grown in both climatic types, upon the divergent responses of diverse races of *Pseudotsuga menziesii* grown in oceanic climate, and upon the differences in damage sustained by native vegetation in two regions where the degree of severity of freezing appears equivalent.

One practical application of this conclusion is suggested. There is a growing industry in the vicinity of large metropolitan districts near the coast based upon growing small trees of *Pseudotsuga menziesii* that are harvested in a short rotation and sold for decorations at the Christmas season. Since only symmetrical and healthy trees are salable, and sudden drops in temperature may be expected to cause severe economic damage to the plantations at intervals of perhaps only a few rotations, the risk involved in using coastal ecotypes might be avoided through the use of inland ecotypes instead. The feasability of this practice would, of course, hinge upon finding at least one inland ecotype with growth rate, susceptibility to disease, or other characteristics that did not nullify the advantage of superior cold tolerance.

The freeze phenomena also have a bearing upon ecologic plant geography. An hypothesis has been advanced that the limits of plant ranges may be set by climatic extremes, but this has been recently reviewed in detail and challenged in part by pointing out the complete lack of any factual support for areas regularly subjected to freezing weather in winter (*1*). Severe as they were, the botanical consequences of the three extreme freezes reported above show that for the region and time span concerned, temperature extremes would have to be much more violent to cause enough disruption of life cycles to become a key factor determining plant ranges. Heavy damage or even death of exotics is not valid evidence for the hypothesis, since exotics are planted well beyond their natural ranges. Critical support for the hypothesis must consist of depopulation of at least a sector of at least a thin peripheral belt about a plant's range, and although many native plants are at the margins of their ranges in Washington and northern Idaho, none of these is known to have suffered any damage to their aerial parts that cannot be completely repaired by one or two near-normal seasons.

## Summary

Abrupt invasions of abnormally cold air masses in late autumn or early winter have been recorded in Washington and northern Idaho in 1924, 1935, and 1955. Exotic plants were damaged and sometimes completely killed during each of these cold waves. In one garden at Pullman, Washington, all (eight) woody plants transplanted here from wetter climates immediately to the east survived without injury, whereas all (three) woody plants that had been transplanted here from drier climates immediately to the west were killed completely. Native plants in the quasi-continental climate of eastern Washington and northern Idaho appear not to have been damaged, but in the oceanic climate to the west of the Cascades there was extensive damage to natives in 1955 and possibly also in 1935. Since the relative abnormality of the cold waves appears to be the same on both sides of the Cascades, it may be concluded that the coastal ecotypes of shrubs and trees are less well adapted to their climate than are the inland ecotypes. This conclusion is borne out by divergent behavior of inland and coastal races planted together in both climatic regions. It would appear that on account of their hardiness, the use of inland ecotypes might be less risky in coastal plantations producing Christmas trees. Despite the conspicuous damage and great economic loss resulting from these three cold waves, there is no evidence in the 67 years of weather records in this area that low temperature extremes have any influence in determining the ranges of native plants.

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