DAMAGE TO SOUTHERN MICHIGAN CONIFERS DURING THE WINTER OF 1976-77

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ABSTRACT.--In southern Michigan, the winter of 1976-1977 was marked by unseasonably cold weather in early December, prolonged cold weather in December and January, severe drought at the onset of cold weather, and by higher than average absolute minimum temperatures. Damage, presumably from the early December cold weather, was severe to southern seedlots of ponderosa pine, Austrian pine from the western Mediterranean, Cryptomeria, Spanish origin Scotch pines planted in low-lying areas, and southern seedlots of white fir. Surprisingly, there was little damage to eastern white pine from the southern Appalachians, southwestern white pine from Arizona and New Mexico, baldcypress and Metasequoia. Comparisons between laboratory and field experiments indicate that laboratory experiments can give useful information about the temperatures at which appreciable injury can be expected in the field.

The winter of 1976-77 was the coldest in memory for many parts of the Eastern United States. Southern Michigan was no exception. It seemed desirable to assess the damage caused because there is a good possibility that woody plants which survived that winter will continue to thrive for many years.

HOW SEVERE WAS THE WINTER?

The winter was especially severe as regards average temperature, duration of cold weather, and drought. For Lansing, the average December temperature was 11.5°F below the 40-year average, and December had a

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total of 1,445 degree-days (below 65°F) as compared with normal totals of 1,000-1,100. In Lansing, there was a period of 54 successive days when the temperature did not rise above freezing. Records were also broken in Battle Creek and other southwestern Michigan cities.

On December 3, 1976, there were unseasonably low temperatures. That night the temperature dropped to -7°F at Lansing and Battle Creek and to -15°F at the Kellogg Forest. Absolute minimums later in the winter were not extraordinary, however. At Lansing the lows were -17°F on December 30 and January 9, as compared with a low of -25°F the previous January 18. At Battle Creek the lows were -10° and -9°F, respectively on December 31 and January 28, as compared with a low of -12°F the previous winter.

The winter was also marked by severe drought conditions. Precipitation had been below normal the previous two years. These drought conditions continued into 1977 and by midsummer were so severe that many small ponds disappeared.

WHEN DID THE DAMAGE OCCUR?

Only for ponderosa pine is it possible to estimate the date on which the damage occurred. For other species it is possible only to say that severe damage was evident by the end of February.

In ponderosa pine, one of us (DeHayes) was in the process of making a detailed laboratory study of cold hardiness. This entailed collecting needles and twigs, freezing them at various temperatures in the laboratory, and measuring electrically the resultant cell damage. Needle collections of nonhardy types made shortly after the December 3 cold spell were mottled. Also, laboratory tests made at the same time indicated cell damage similar to that induced by artificial freezing.

NATURE OF THE DAMAGE

Observations on ponderosa pine indicated that the initial injury to a needle could be at any place, from base to tip. If at the tip, only the tip subsequently became brown. If at the base, the entire needle became brown. Generally, there was a strong correlation between the proportion of needles attacked per tree and the amount of damage per needle.

Cambial injury was less common, and was nearly limited to twigs with 100 percent leaf damage. Some pines were completely brown by mid-February but still retained green cambium and produced new growth later in the spring. Mortality was generally limited to trees which had been damaged in previous years or which were in frost pockets subject to extraordinarily low temperatures.

THE MOST SERIOUSLY DAMAGED SPECIES

Ponderosa Pine (Pinus ponderosa)

Damage was most noticeable on the trees of the ponderosa pine range-wide provenance tests established in 1962 at the Kellogg and Russ Forests with O. O. Wells' material. Although these plantations had suffered some damage in previous years, the 1976-77 injury was by far the worst. Damage was nil to the all-interior provenance test established in 1968 with material supplied by the U.S. Forest Service.

In the range-wide tests, trees from California (all parts except the extreme northeast) were hit hardest. Already weakened by cold injury in other years, few seemed likely to survive for more than a year or two. Next worst were trees from Arizona and New Mexico. Most of them seemed destined to survive; their growth rates were already much reduced because of injury in previous years. Trees from the Willamette Valley in western Oregon suffered moderate winter injury (30 to 40 percent of the leaf area brown) in 1976-77 although they had been damaged little in previous years. They had been among the tallest and grew well in 1977 despite their injury.

Ponderosa pines from eastern Oregon, Washington, Idaho and the interior states north of Colorado came through the winter unscathed. According to laboratory tests they had achieved sufficient hardiness even by early December to withstand severe cold.

Another experiment at Kellogg Forest which was a casualty of the cold weather was a plantation of Placerville-produced hybrids which had been planted in the early 1950's. A great number had California ponderosa pine as one parent. Perhaps because they had been planted with better air and soil drainage than found in the provenance test, they had remained thrifty for many years. However, all with California germplasm succumbed after the 1976-77 winter.

In addition to the experimental plantations, Kellogg Forest has four commercial plantations of ponderosa pine which are 35 to 40 years old. They seem to be of Washington or northern interior origin. These were not harmed by the cold although a small percentage of the trees have serious disease problems.

Around the Lansing area and at scattered locations elsewhere, ponderosa pine has been used as an ornamental, and many trees are more than 50 years old. Most of these ornamentals escaped injury.

Austrian Pine (*Pinus nigra*)

Austrian pine has been a favorite for planting along roadsides in southern Michigan because it is resistant to salt. While disease has been a problem on older trees, damage from cold had rarely occurred on trees south of the Bay City-Muskegon line.

Winter injury was very noticeable after the 1976-77 winter, however. In the range-wide provenance test established in 1961 at Kellogg Forest, most trees from Corsica and southern France had 60 to 70 percent of the foliage turn brown. They had been similarly injured in the nursery but had suffered only minor damage in recent years.

Seedlots from Spain, other parts of France, the Greek Islands, and the Greek Peloponnesian Peninsula were damaged on 10 to 30 percent of their foliage. Trees from Austria, Yugoslavia, northern Greece, Turkey, and the Crimean SSR were not hurt.

Many non-experimental roadside trees, most of them thought to be of Austrian origin, were also damaged. It was typical to find heavy injury (50 to 75 percent of the foliage brown) on one or two of a group of 10 trees, with no injury on the remainder. The damaged trees grew normally during 1977.

White Fir (*Abies concolor*)

At both Russ and Kellogg Forests we have provenance tests including seedlots from the Rocky Mountain portion of the range. The Russ plantation, on a low-lying site, was damaged most heavily. In the most sensitive seedlots, 100 percent of the leaf area was injured at Russ as compared with 30 to 40 percent at Kellogg.

There was an interesting contrast in hardiness between two Arizona seedlots originating 1° latitude and 500 ft elevation apart. The most severely damaged seedlot in the experiment was the fastest growing one, No. 2427, from an elevation of 8,100 ft and a latitude of 32° 27'N on Mt. Lemmon in extreme southern Arizona. There was very little damage to moderately fast growing seedlot No. 2423, collected from an elevation of 7,600 ft and a latitude of 33° 20'N. Other seedlots from central Arizona and southcentral New Mexico suffered slight to moderate damage (10 to 30 percent of leaf area injured). Slowly growing trees from farther north suffered no damage.

The California-Oregon provenance test organized by W. J. Libby is also represented by a small plantation at the Kellogg Forest. Practically the entire population from these states exhibits introgression from grand fir (*Abies grandis*), which is a lower elevation and less hardy species of the Pacific Northwest. Trees in this experiment had suffered some winter injury in most previous years, but not to the same extent as in the winter of 1976-77 when they became red-brown.

White fir suffered less permanent damage from the cold than did the pines. The most badly damaged trees from Arizona and New Mexico grew as well in 1977 as in previous years. Even many of the California trees which were red-brown at the end of the winter produced new shoots in the spring.

Eastern White Pine (Pinus strobus)

In southern Michigan, eastern white pine from the southern Appalachian Mountains holds special promise. It has grown rapidly for 18 years and is recommended for commercial planting. We were apprehensive as to the effect of the extreme cold weather on the fast growing seedlots. In three widely separated plantations south of Lansing there was no winter injury, even to trees from northern Georgia. We have not had a chance to re-examine a 10-year-old plantation of southern Appalachian trees located in the northern half of the Lower Peninsula.

The long winter was, however, an extraordinarily hard one for eastern white pines located along roads throughout the Lower Peninsula. Apparently most of the damage is due to blowing salt dust, rather than spray. Where there was considerable open space next to the road, as along a thruway, there was serious needle burn on trees 200 to 300 ft to leeward of the road. In the case of roads bordered by trees, damage was usually limited to within 50 ft of the roadway. Whereas in previous years such damage was usually confined to young trees, some 70-80 ft specimens were brown after the 1976-77 winter. Trees away from roads were not affected, even though in the open.

Southwestern White (Pinus strobiformis) and Limber Pines (P. flexilis)

Southwestern white is a 5-needled pine native to Arizona, New Mexico, and a small part of Texas. It has thick, blue-green foliage, grows at moderate rates, and has been in much demand for Christmas tree planting in recent years. Even the fastest growing seedlots from Texas came through the winter unscathed at both the Russ and Kellogg Forests. Also, older trees in a Battle Creek arboretum were undamaged by the winter.

Limber pine is a slow growing relative from Colorado, Utah, and north. Peculiarly, it suffered apparent winter injury. On a very small number of trees, 30 to 40 percent of the foliage was brown at the end of the winter.

Western White Pine (Pinus monticola)

Western white pines of north Idaho origin were planted at Kellogg Forest and at the Tree Research Center on the MSU campus in East Lansing in 1970. They appeared hardy until the winter of 1976-77 when most of the trees on the MSU campus were severely injured (60 to 90 percent of

the needles brown). At Kellogg Forest, damage was severe for trees planted within 10 ft vertical distance of the bottom of a ravine but slight for trees planted on a hilltop or on upper slopes.

Scotch Pine (Pinus sylvestris)

Interracial hybrids of Scotch pine have been planted on hilly ground at Kellogg Forest since 1970. In the plantations there are 50 ft elevational differences within relatively short distances. There are some low spots without air drainage. Within 1 ft vertical distance of these low spots, some trees died. Trees in other parts of the plantations suffered no injury.

Scotch pine of Spanish origin has been recommended for Christmas tree planting in those parts of the state with an average January temperature of 20°F or above, or roughly in the southern third of the state. These recommendations will have to be changed because even in those areas some plantations suffered severe needle injury during the 1976-77 winter. Damage was most serious in low-lying areas. In some cases nearly 100 percent of the needles were brown and it appeared that mortality would result. We have not had a chance to evaluate the long-term effects of the damage in plantations with less severe injury.

Sugi (Cryptomeria japonica)

Cryptomeria or sugi is a Japanese conifer which is more accustomed to a Tennnessee than a Michigan climate within its native range. Nevertheless, we have two specimens which have lived for more than 40 years on the MSU campus. One, situated about 10 ft from a tall building escaped serious injury. On the other, situated in the open, more than half of the leaf area was dead by the spring of 1977.

SOME SURPRISING ESCAPES

In view of the severity of the winter, we were not surprised as much by the presence of brown trees in some species as by their absence in others. Douglas-fir is a case in point. At Russ and Kellogg Forests there are provenance tests covering the entire interior portion of the range and one seedlot from western Oregon. These tests were planted from 1965 to 1968. Although late spring frosts had killed newly expanded shoots in several years, there had been no previous winter injury. Nor was there any winter injury following the 1976-77 winter, even to fast growing seedlots from southern Arizona and western Oregon.

Metasequoia is a fast growing conifer from a remote part of China. Charleston, South Carolina is the American city having the climate most similar to that prevailing in its native valley. Only unbounded optimism would have caused people to plant it as far north as Michigan in the first place. However, there was only a slight amount of twig dieback--no more

than in previous years--on the several trees which have been planted on the MSU campus. This was true in spite of the fact that all had been planted in exposed situations.

Baldcypress (Taxodium distichum) was another surprise because its native range extends only as far north as southern Illinois and southern Indiana. We have three old trees on the MSU campus, none planted in a particularly favorable spot. They were just as healthy after the 1976-77 winter as in any other year.

First-generation hybrids between Austrian and Japanese red pines (Pinus densiflora) have been planted at several places in southern Michigan during the past 10 years. They did not suffer any noticeable winter injury even though needles turned brown on some Austrian pines similar genetically to the parents of the hybrids.

CONCLUSIONS FROM THE WINTER

The unseasonably cold weather in early December presumably was responsible for most injury suffered by nonhardy types of ponderosa and Austrian pines. For those species the hardening pattern was such that trees could not withstand low temperatures so early in the season although they withstood even lower midwinter temperatures in previous years. The hardening pattern is not the same for all species, however. For example, forsythia, quince, and several rhododendrons flowered profusely in 1977 although their flower buds had been killed by January cold a few years earlier. Thus, the winter of 1976-77 was a good one to test hardiness in some species, and not a good one in others.

Waiting for an abnormally cold winter is a slow way to select trees for cold hardiness. For that reason, laboratory experiments have been undertaken to determine artifically the temperatures at which freezing injury occurs. Three such experiments performed on provenance test material growing at the Kellogg Forest near Battle Creek provide data applicable to southern Michigan. They are the eastern white pine experiment by Maronek and Flint (1974), the unpublished study of black cherry by Sung Gak Hong of the University of Minnesota (now of the Republic of Korea) and the PhD. thesis work on ponderosa pine by one of the present authors (DeHayes). In eastern white pine, needles of the least hardy types were injured severely if subjected to laboratory temperatures of -25° to -44° (-31° to -42C) from November to January; field-grown trees did not experience such low temperatures and suffered no injury. In black cherry, laboratory temperatures of -40°F (-40C) in January caused twig damage to the least hardy types; field-grown trees did not experience such temperatures and suffered no damage. In ponderosa pine, laboratory determined damaging temperatures in early December were much higher for California trees, slightly higher for Arizona-New Mexico trees, and

slightly lower for Washington trees than the actual low temperature of -15°F (-26C) recorded at Kellogg Forest on December 3. Damage was great for California trees, moderate for Arizona-New Mexico trees, and nil for Washington trees.

Thus, it appears that the laboratory tests of hardiness provide useful information about the temperatures at which appreciable field damage can be expected.

LITERATURE CITED

Maronek, D. and H. L. Flint. 1974. Cold hardiness of needles of Pinus strobus as a function of geographic source. Forest Sci. 20:135-141.