Journal of the Minnesota Academy of Science

Volume 24 | Number 1 Article 5

5-1956

A Basis For Forest Tree Seed Collection Zones in the Lake States

Paul O. Rudolf

past much attention has been directed by forest physiologists, ecologists, and others to the problem of uniform environment development in the laboratory, greenhouse or field. But little concern for the genetic uniformity of the experimental materials has been shown, in spite of the fact that absolute genetic uniformity may be attained directly by the vegetative propagation of an individual (*ortet*) into a clonal line of many genetically identical individuals (*ramets* or *propagules*).

Although clonal lines have been used widely and profitably in many fields of horticultural research, foresters have only in recent years recognized the potential usefulness of such materials. The value of clonal line methods in gum yield studies of the southern pines, one of the first applications of such methods in forestry, has encouraged an ever widening interest in the use of clonal lines in silvical research. Studies of wood density, the vegetative and flowering response to photoperiod, fertilizer effects on growth and flowering and fruiting habits, disease and insect resistance, spacing and thinning, mode of inheritance, adaptation, compatibility, and numerous other special fields of inquiry provide almost limitless opportunity for the utilization of clonal line methods.

One of the currently most active fields of physiological research in forestry is concerned with the problems of vegetative propagation itself, especially the development of practical methods for the rooting and grafting of difficult plants. Recent air-layering and "succulent tissue" grafting studies in the southern pines suggest that development of practical methods of clonal line establishment in other pines, and, indeed, in other "difficult" genera, is not far distant.

With emphasis placed on artificial methods of vegetative propagation there has been a tendency to overlook the fact that naturally occurring clonal lines of trees are common constituents of our forests. The aspens, for example, most frequently occur in clonal clumps of several to several hundred ramets. There is evidence suggestive that certain clones of quaking aspen in the northern part of the state may occupy areas of 10 or more acres and consist of several thousand genetically identical individuals. Such clones provide ideal natural laboratories for the investigation of numerous silvical problems.

A BASIS FOR FOREST TREE SEED COLLECTION ZONES IN THE LAKE STATES

PAUL O. RUDOLF
Lake States Forest Experiment Station [1]

WHY SEED COLLECTION ZONES ARE IMPORTANT

Forest tree species which grow over a wide range of conditions probably have developed races. There is experimental proof for such

[1] Maintained by the Forest Service, U. S. Department of Agriculture, at St. Paul 1, Minnesota, in cooperation with the University of Minnesota.

development for some 25 North American species and observational evidence for several more. In some instances the races differ in morphological features—such as length or color of the leaves, bud shape or color, or bark characteristics—and are easily distinguished. More often, however, the differences are primarily physiological; they may involve resistance to drought, insects, and diseases or adaptability to certain site conditions. Such differences are not visible and usually show up only when stock of two or more races is planted in the same place.

Commonly, trees grown from local seed are best adapted to conditions in that locality. Occasionally, introduced races are superior to local races, but most often the reverse is true. In either event it is important to know whether or not the seed for any plantation originated under conditions comparable to or different from those of the planting site. For this reason it is important to establish homogeneous seed collection zones and to designate as to origin each lot of seed used in reforestation.

ZONES PREVIOUSLY USED OR PROPOSED

Forest tree seed collection zones in a broad sense, have been used in the Lake States for more than 30 years. The state nurseries to a large extent have used seed from their own states, except when exotic species were grown. Sometimes they specified sections of the state in which the seed originated. The U. S. Forest Service has identified its seed collections by the national forest of origin.

Based on studies of seedling cold resistance and intensive observations of the parent stands in the field, C. G. Bates, in 1929, proposed eight seed collection centers for red pine in the Lake States (1, 2). In 1931 Rudolf modified these centers into contiguous zones (fig. 1) characterized by definite but overlapping climatic characteristics (table 1) (3). These zones were used to analyze the results of red pine seed source studies.

In 1939 H. L. Shirley of the Lake States station proposed a series of seed collection zones combining a greater number of factors (table 2). These zones also have some overlapping characteristics. So far they have not been used in practice.

In 1939, the U. S. Department of Agriculture developed the following seed policy: (1) To use only seed of known locality of origin, and nursery stock grown from such seed; (2) To require from the vendor adequate evidence verifying place and year of origin for all lots of seed or nursery stock purchased . . .; (3) To require an accurate record of the origin of all lots of seed and nursery stock used in forest, shelterbelt, and erosion-control planting . . .; (4) To use local seed from natural stands wherever available unless it has been demonstrated that seed from another specific source produces desirable plants for the locality and uses involved (local seed means seed from an area subject to similar climatic influences and may usually be considered as that collected within 100 miles of the planting site and at an

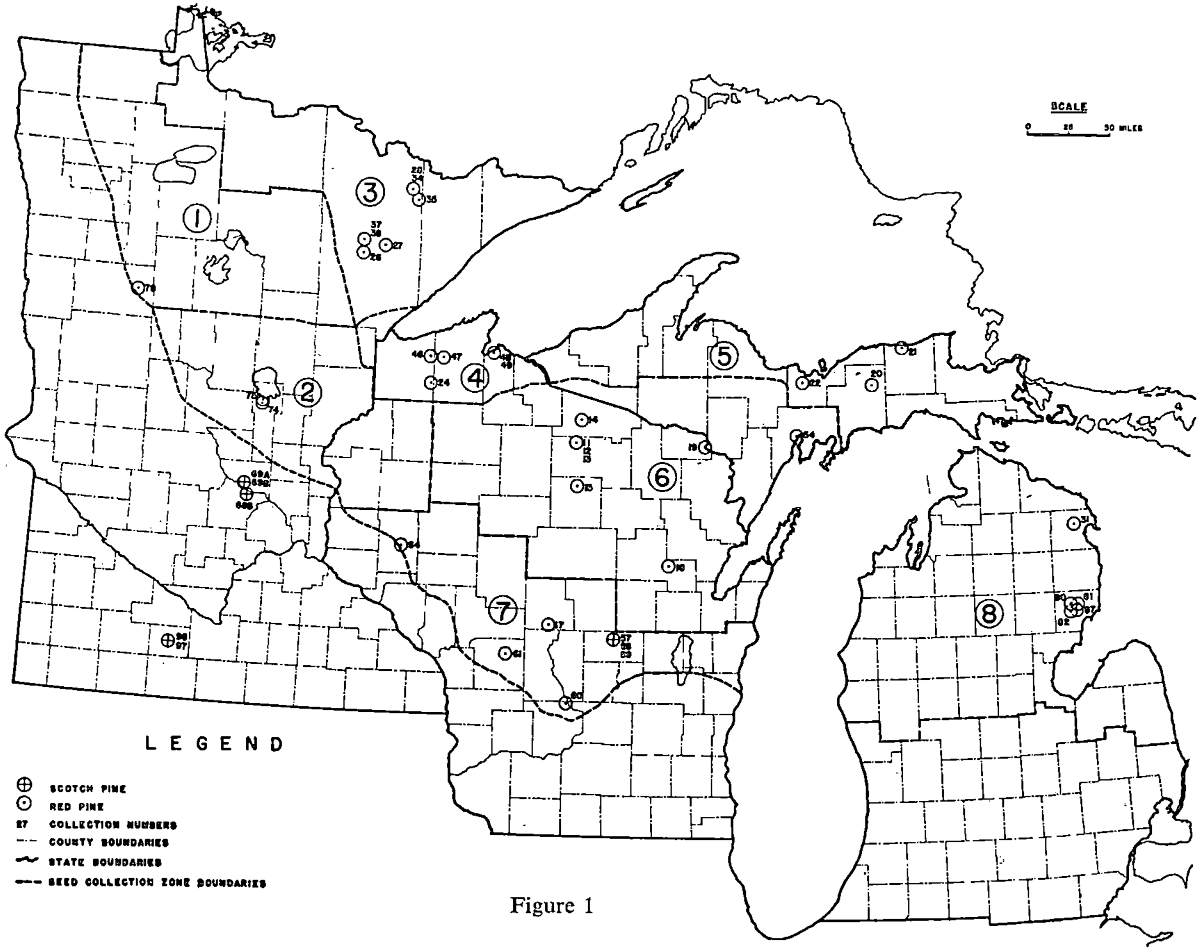
SCALE
0 25 50 MILES
LEGEND
SCOTCH PINE
RED PINE
27 COLLECTION NUMBERS
COUNTY BOUNDARIES
STATE BOUNDARIES
SEED COLLECTION ZONE BOUNDARIES

Figure 1

Figure 1. Forest tree seed collection zones based on seedling response of red pine, developed by Bates and Rudolf.

1. THE NORTHWESTERN MINNESOTA AREA — which includes Roseau, Beltrami, Clearwater, Hubbard, and Itasca Counties; the eastern portions of Marshall, Pennington, Red Lake, Polk, Mahnomen, and Becker Counties; the northern portion of Cass and Aitkin Counties; and the southwestern portion of St. Louis County, all in Minnesota.
2. BRAINERD-CAMERON AREA — which includes Crow Wing, Pine, and Kanabec Counties; the southern portions of Aitkin and Cass Counties; the western portion of Carlton County; the northeastern portions of Todd and Benton Counties; and the greater parts of Wadena, Morrison, Mille Lacs, Isanti, and Chisago Counties in Minnesota; and all of Burnett, Washburn, Polk, and Barron Counties, Wisconsin.
3. THE NORTHEASTERN MINNESOTA AREA — which includes Lake of the Woods, Koochiching, Lake, and Cook Counties, and northern part of St. Louis County, Minnesota.
4. THE HEAD OF THE LAKES AREA — which includes southeastern St. Louis and eastern Carlton counties, Minnesota; Douglas, Bayfield, and northern Ashland and Iron Counties, Wisconsin.
5. THE UPPER PENINSULA AREA — which includes northern Gogebic, and all of Ontonagon, Houghton, Keweenaw, Baraga, northern Marquette, Alger, Schoolcraft, Luce, Mackinac, and Chippewa Counties, Michigan.
6. NORTHEASTERN WISCONSIN — SOUTHERN UPPER PENINSULA AREA — which includes Sawyer, Rusk, Taylor, Price, Vilas, Oneida, Lincoln, Marathon, Waupaca, Shawano, Langlade, Forest, Florence, Marinette, Oconto, Outagamie, Brown, Kewaunee, Door, and southern Ashland and Iron Counties, Wisconsin; and Iron, Dickinson, Menominee, Delta, and southern Gogebic and Marquette Counties, Michigan.
7. CENTRAL WISCONSIN AREA — which includes Chippewa, Eau Claire, Clark, Wood, Juneau, Adams, Marquette, Waushara, Portage, Winnebago, Calumet, and Manitowoc Counties; northeastern St. Croix, Dunn, Pepin, Trempealeau, La Crosse, Monroe, Sauk, and Sheboygan Counties; northwestern Columbia County, and northern Green Lake County, Wisconsin.
8. THE LOWER MICHIGAN AREA — which includes all of the lower peninsula of Michigan north of Oceana, Newaygo, Mecosta, Isabella, Midland, Bay, Tuscola, and Sanilac Counties.

Table 1 — CHARACTERISTICS OF RED PINE SEED COLLECTION ZONES

Zone	Temperature Ranges		Length of Growing Season
	Mean Jan. Degrees F.	Mean July Degrees F.	Days
1. Northwestern Minnesota	0- 6	66-68	100-130
2. Brainerd-Cameron area	4- 8	66-70	110-130
3. Northeastern Minnesota	2-14	60-66	110-140
4. Head of the Lakes	6-12	64-66	120-140
5. Northern Upper Peninsula	12-16	60-66	80-140
6. Northeastern Wisconsin-southern Upper Peninsula	10-18	60-68	80-150
7. Central Wisconsin	12-18	68-70	130-170
8. Lower Michigan	18-24	66-70	90-150

Table 2 — SEED COLLECTION ZONES PROPOSED BY SHIRLEY

No.	Territory	Original Forest Type	Climatic Factors		
			Annual Precipitation Inches	Length of Growing Season Days	Mean Temperature of Growing Season Degrees F.
1.	Keweenaw Peninsula, eastern tip of Upper Peninsula and northern fringe of Lower Peninsula, Michigan.	Spruce-fir and northern hardwood.	25-30	140	60-64
2.	Lower Peninsula of Michigan north of Saginaw Bay.	Northern hardwood, pine.	25-30	120-140	62-66
3.	Lower Michigan south of Saginaw Bay.	Oak-hickory, northern and central hardwoods.	30	140-160	66-70
4.	Upper Peninsula of Michigan and northern Wisconsin.	Northern hardwoods.	30	80-120	60-64
5.	North central Wisconsin.	Northern hardwoods and pine.	30	120-140	64-66
6.	Southeastern Minnesota and southern Wisconsin.	Oak-hickory, northern hardwood, and pine.	25-35	140-160	66-70
7.	Northeastern Minnesota.	Spruce-fir.	20-25	110-120	60-62
8.	Head of the Lakes.	Spruce-fir.	25	120-140	60-62
9.	North central Minnesota.	Pine, spruce-fir, and poor northern hardwoods.	23	120-130	62-64
10.	South central Minnesota.	Pine, oak, and hardwoods.	25	130-140	64-66

elevation differing from it by less than 1,000 feet); (5) When local seed is not available, to use seed from a region having as nearly as possible the same length of growing season, the same mean temperature of the growing season, the same frequencies of summer droughts, the same latitude, and with other similar environment so far as possible; (6) To continue experimentation with indigenous and exotic species, races, and clones to determine their possible usefulness, and to delimit as early as practicable climatic zones within which seed or planting stock of species and their strains may be safely used for forest, shelterbelt, and erosion control; (7) To urge that states, counties, cities, corporations, other organizations, and individuals producing and planting trees for forest, shelterbelt, and erosion-control purposes, the expense of which is borne wholly or in part by the Federal Government, adhere to the policy here outlined. This policy provides a basis for certifying seeds as to origin.

Deficiencies of These Collection Zones

The seed collection zones previously suggested for the Lake States were not based primarily upon climatic factors, and display considerable overlapping of such features. Time may show that they provide valid divisions for certain species, but as knowledge of species behavior accumulates, it should be possible to develop seed collection zones more applicable to individual species. Until that time, however, uniform zones based on some meaningful climatic data, readily available, should be used for all species. This paper describes a basis for such uniform zones.

THE PROPOSED NEW ZONES

An initial attempt to develop seed collection zones on a simple basis involved the use of mean July temperatures. Using an interval of 4° F., three zones were outlined: (1) less than 66°, (2) 66° to 70°, and (3) above 70°.

These zones, however, were rather broad and included quite a range of growing conditions, so a more comprehensive basis was sought. A measure clearly showing the accumulation of warm temperatures seemed most desirable. It was decided, therefore, to use a summation of normal average daily temperatures per year above 50° F. The choice of 50° F. was governed by the fact that physiological activity in many temperate zone plants occurs mostly above that temperature.

The sums of normal average daily temperatures of 50° F. or above (or degree days above 50° F.) were computed for all Lake States localities for which the Weather Bureau reports normal temperatures. These values were entered on a map, and from them zone lines were drawn for each 1,000 degree days (which roughly approximates an average difference of 2° F. during the period in which average daily temperatures are 50° F. or above). For the region, this provided seven zones (the numbered zones in fig. 2), two of them of very limited extent.

To test whether or not these zones had any significance we used data for red pine of 119 Lake States seed sources which had been planted by the Lake States Forest Experiment Station on the Superior National Forest in 1933. Twenty years after planting, values for approximate cubic volume per 100 trees planted (thus combining the effects of survival, height growth, and diameter growth) showed reasonably good agreement with the zonation as follows: 7,000-8,000 degree days, 26.9; 8,000-9,000 degree days, 35.6 (the home locality occurs here); 9,000-10,000 degree days, 28.1; 10,000-11,000 degree days, 19.3; and 11,000-12,000 degree days, 10.4.

However, volumes within a zone definitely tended to decrease with distance away from the home locality. This led to the search for a significant modifying factor. Annual and growing-season precipitations were tried but found unsatisfactory. Average January temperatures, as representing severity of the winters in the localities of seed origin, showed a marked relationship to the average volume per 100 trees planted of the 119 red pine seed sources as follows: 0°-4° F., 50.5 cubic feet; 4°-8° F., 41.5 cubic feet (the home locality is in this belt); 8°-12° F., 36.6 cubic feet; 12°-16° F., 26.0 cubic feet; 16°-20° F., 19.2 cubic feet; and 20°-24° F., 10.6 cubic feet.

A map (fig. 2) was then prepared showing zones based on intervals of 1,000 degree days over 50° F. and 4° F. intervals of mean January temperature. Combined, these two factors produce 28 zones in the Lake States. By states the number of zones is 15 for Minnesota, 15 for Wisconsin, and 13 for Michigan. If we disregard those which occur to a limited extent only, there are 10 for Minnesota, and 8 each for Wisconsin and Michigan.

To simplify delineation of the zones, boundaries were generalized to coincide with county lines (fig. 3). At the present stage of knowledge and practice, such generalizations should cause no serious loss of significance of the zones, and it will simplify zone designation and administration of collections based upon the zones.

PUTTING THE ZONES TO USE

To be effective the zones will have to be used by all agencies collecting and using forest tree seed within the region. However, a number have objected that the proposed zones are too many. Fortunately, some practical concessions can be made.

For use within a state the degree-day zones may be sufficient for many purposes. This would provide six zones for Minnesota, five for Michigan, and four for Wisconsin—the numbered zones on figure 3. It would be desirable to designate collections by both number and letter zones (degree day and January temperature), but the letters could often be ignored for use within a state. For interchange of seed between states, however, the lettered subdivisions of the numbered zones should be included.

WHAT SHOULD COME NEXT?

The use of the seed collection zones will provide a basis for certifying forest tree seed in the Lake States as to origin. That is an important part, but only a part of seed certification. A complete job requires also certification as to quality. Such a procedure is a necessary basis for

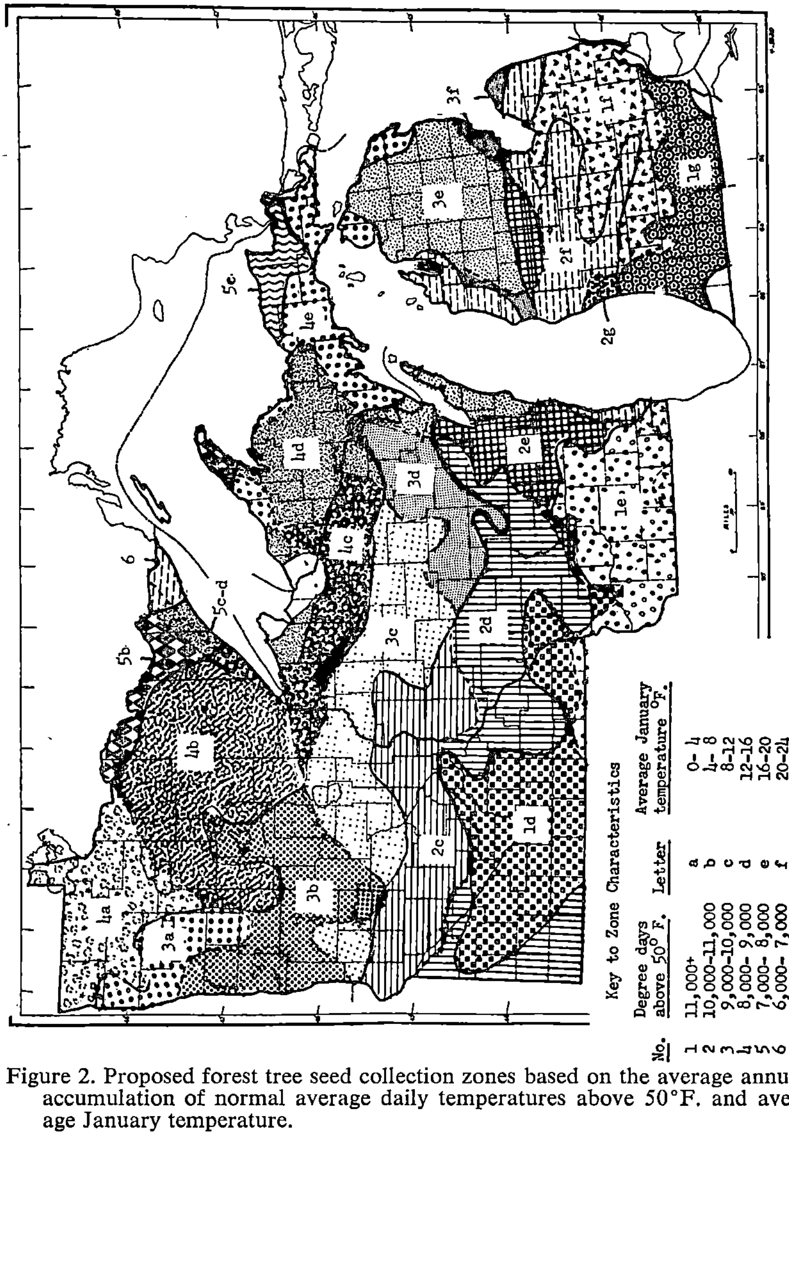

Figure 2. Proposed forest tree seed collection zones based on the average annual accumulation of normal average daily temperatures above 50°F. and average January temperature.

setting a reliable price or value for seed. It requires seed testing, not now generally available for forest tree seeds.

However, the establishment of workable seed collection zones is a necessary first step in seed certification.

SUMMARY

Most forest tree species probably have developed races that differ from one another physiologically rather than morphologically. Often,

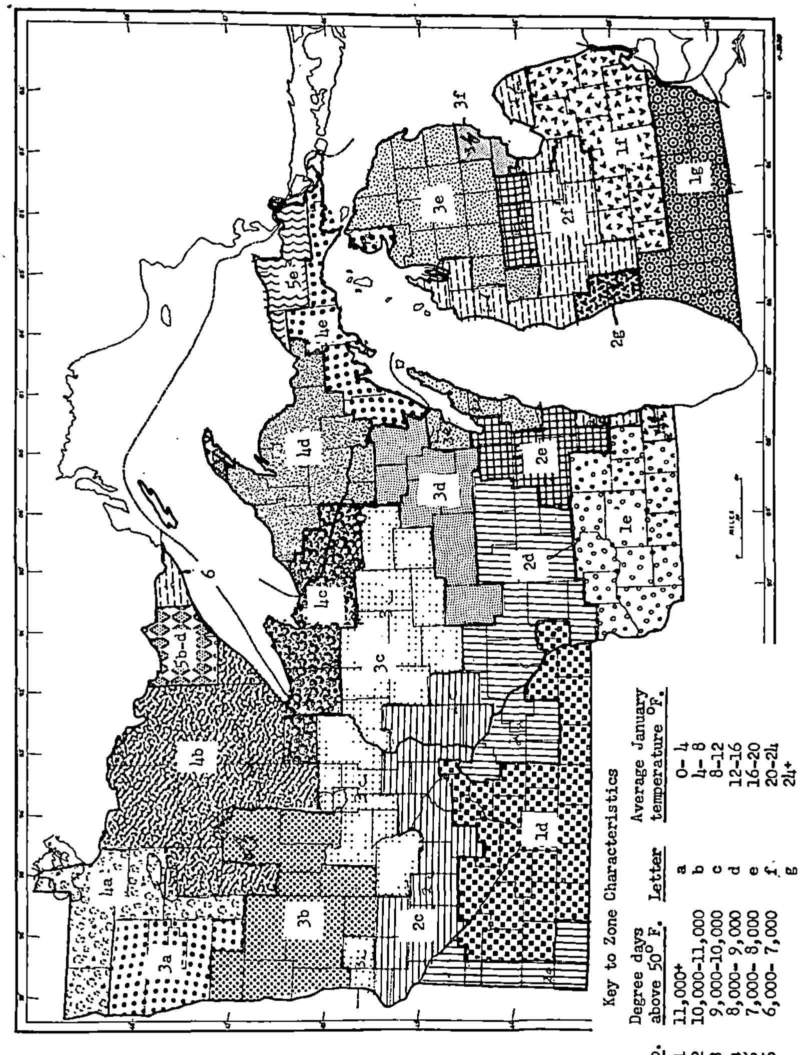

Figure 3. Proposed seed collection zones generalized by county lines.

but not always, the local races are better adapted to the localities of their origin than are other races. For this reason it is important to establish homogeneous seed collection zones and to designate as to origin each lot of seed used in reforestation.

Previously, forest tree seed collections usually have been designated only as to state of origin or, on the national forests, as to forest of origin. In 1929 Bates proposed eight seed collection zones based on response of red pine seedlings. They were modified by Rudolf in 1931. In 1939 Shirley proposed a series of zones combining a number of factors. In that year also the U. S. Department of Agriculture adopted a seed policy stressing use of local or well adapted seed for forestry and related purposes.

All these zones, however, display considerable overlapping of climatic features. There is proposed here, therefore, a series of zones based on two temperature factors: (1) A summation of normal average daily temperatures per year above 50° F., and (2) mean January temperatures. The development of red pine trees of 119 seed sources 20 years after planting showed good relationships to these zones.

The use of seed collection zones will facilitate certification of forest tree seeds as to origin. To certify them also as to quality will require seed testing not now generally available for forest tree seeds. Certification as to origin, however, is a necessary first step in this process.

LITERATURE CITED

1. Bates, C. G. 1930. The frost hardiness of geographic strains of Norway pine. Jour. For. 28: 327-333.
2. Lake States Forest Experiment Station. 1931. Centers for collecting seed of Norway pine. Lakes States For. Exp. Sta. Tech. Note No. 30, 2 pp., illus. (Processed).
3. Rudolf, Paul O. 1948. Importance of red pine seed source. Soc. Am. For. Proc. 1947: 384-398, illus.

VERTICAL MIGRATION OF SPHERICAL AND ASPHERICAL POLLEN IN A SPHAGNUM BOG

JOHN R. ROWLEY
Botany Department, University of Minnesota
and
JOANNE ROWLEY
The Science Museum, St. Paul

ABSTRACT

In an effort to determine the fate of pollen that settles out of the atmosphere, tagged pollen was artificially introduced into the atmosphere immediately above a Sphagnum bog.