



The average length of freeze-free season as an index to woody ornamental plant hardiness
by James Lee Murphy

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of
MASTER OF SCIENCE in Horticulture
Montana State University
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Abstract:

This study was undertaken to determine the identity of woody ornamental plants currently grown in Montana. Recommendations for plant adaptability and hardiness zones were based upon this information. Communities selected for this survey included the long freeze-free cities of Billings, Columbus, Miles City, Glendive, Sidney, Glasgow, Great Falls, and Kalispell. Short freeze-free season towns observed were Red Lodge, Lambert, Lindsay, Richey, Scobey, Opheim, Lewistown, Augusta, and Whitefish. Comparisons of the two types of communities revealed that the use of a length of freeze-free season map as a plant hardiness region map was not feasible.

Local floras were established from surveys of all woody plants growing in various blocks of residential areas previously selected in an unbiased fashion from city maps. Resultant data leading to local hardiness designations was used as a basis upon which to suggest changes in the USDA Plant Hardiness Zone Map.

Distribution of species was useful in challenging specific hardiness numbers for several species encountered,

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James Lee Murphy

Date

March 1, 1971

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ABSTRACT

This study was undertaken to determine the identity of woody ornamental plants currently grown in Montana. Recommendations for plant adaptability and hardiness zones were based upon this information.

Communities selected for this survey included the long freeze-free cities of Billings, Columbus, Miles City, Glendive, Sidney, Glasgow, Great Falls, and Kalispell. Short freeze-free season towns observed were Red Lodge, Lambert, Lindsay, Richey, Scobey, Opheim, Lewistown, Augusta, and Whitefish. Comparisons of the two types of communities revealed that the use of a length of freeze-free season map as a plant hardiness region map was not feasible.

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Distribution of species was useful in challenging specific hardiness numbers for several species encountered.

INTRODUCTION AND LITERATURE REVIEW

Winter injury and death of woody ornamental plants has plagued and puzzled home owners, nurserymen and researchers for a long time. Among the proposed explanations of freezing injury to plants is the intracellular ice crystal theory as stated by Levitt (21), Wieser (31), Kenefick (17), Howell and Weiser (16), and Chandler (7). Intercellular ice formation is apparently non-lethal to plants. As ice forms water is drawn from the protoplasts. When a point is reached at which no additional water is available from the cells, ice crystals form within the cells causing their death. Howell and Weiser (16) stated that membrane puncture by ice crystals may be a means of cellular destruction by ice.

Weiser (32) proposed an alternate theory for winter plant mortality through excessive loss of intracellular water. The withdrawal of protoplasmic water by intercellular ice may cause death through several avenues as outlined by Howell and Weiser (16), proteins may be denatured by increased concentration of cytological chemicals as water loss increases, water removal may bring proteins closer together thus allowing for linkage and resultant denatured protein, and some proteins may require a water shell for activity.

Levitt (21), Free (13), Corman (9), and Chandler (7) suggested that the rate of temperature drop is of critical importance in killing of hardy tissues. Gradual temperature decline promotes acclimation; rapid decline results in injury or death. Corman (9) believed that rapid

temperature decline causes sun-scald in woody plants. During the day, the sun warms bark on the southwest side of plant stems to a temperature considerably above air temperature. After sunset the temperature drop of heated tissue is rapid enough to cause injury. Weiser (37) noted that at extremely rapid (experimental) rates of temperature drop the intracellular water does not crystallize but solidifies without crystals through a process called vitrification. Even non-hardy cells can survive vitrification. Weiser (32) concurred with Chandler (7) regarding the inverse relationship between the normal rate of temperature drop and acquired hardiness. Levitt (21) was of the opinion that rapid thawing might also cause injury to plants.

A number of factors affect the ability of cells to develop hardiness. Accumulation of sugars and a decrease in starch tend to increase acclimation according to Levitt (21) and Lapin (20). Weiser (32) expressed the possibility that cellular structures may be disassembled or translocated factors promoting hardiness may form. Levitt (21), Lapin (20) and Kenefick (18) pointed out that membranes may become more permeable and protoplasm more resistant to desiccation, thus allowing free movement of water out of the cells to form intercellular ice and avoid ice crystal formation within cells. Rehder (30) suggested that in general, plants in dry condition can withstand cold because of cellular resistance to desiccation damage. Levitt (21) and Lapin (20) indicated that older plants tend to fare better during winter than

younger ones due to reduced water content. Flint, Boyce, and Beattie (12) were of the opinion that herbaceous species are killed by a single freezing temperature while woody species with more tissues frost kill over a range of temperatures specific for the various tissues. Young woody plants may be affected by cold much as herbaceous species are.

Differentials in growth rhythms related to time of hardening exist between species and among populations of a species. Exotics that could withstand the minimal temperatures of an area are too slow in hardening or too fast in dehardening to survive in that area according to Weiser (32), Flint (11), Lapin (20), and Clark (8). Weiser (32) believed that the initial stimulus to hardening is short days followed by a secondary stage of chilling and a tertiary stage of prolonged cold temperatures. Hardening can be partially inhibited by application of artificial light or periods of warm temperatures.

Many external environmental factors may affect the ability of plants to harden. Wyman (35) cited soil chemistry and physical condition, rainfall, and temperature, especially minimum, as the most influential factors affecting plant hardiness in North America. Soils are often modified by addition of mulch and fertilizer, by leaching, and by removal or burial of topsoil during construction. Rainfall is adequate in most areas of the United States for most ornamentals and is supplemented by irrigation. It has been upon climate, and more specifically temperature, that judgements as to probable hardiness of plant species for given areas have been based.

Montanans have little information available to them regarding the woody plants of potential hardiness in specific areas of the state. Tests currently underway at the Montana Agricultural Experiment Station and its branches may yield useful information in this regard. However, these tests will require years of evaluation, and the number of species potentially desirable for testing may be limited. . .

At present, inquiries regarding plant hardiness must be answered using adaptability information obtained in tests at Bozeman, or based upon staff members' knowledge of plant species found in the locality in question or in analogous sites.

Several hardiness maps have proven useful to Montanans in estimating plant adaptability for given areas. In the Atlas of American Agriculture 1936, the U. S. was divided into 28 growth regions based on homogeneous native species. A revision extended the zonation to 32 regions.

Rehder (30) of the Arnold Arboretum used mean minimum winter temperatures in producing a zone map of most of the United States and southern Canada (Fig. 1d). Species were rated according to the coldest zone in which they were expected to survive with Zone I the coldest and Zone VII the mildest. Ratings were based on trials at the Arnold Arboretum of Harvard University which is located in Zone V. Recommendations for species not tested were deduced from performances under similar European conditions. A later revision by Rehder was followed by a revision to 10 zones by Wyman (34). A 1967 Hardiness Zones of the

