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EFFECTS OF A SEVERE FREEZE ON NATIVE WOODY PLANTS IN THE LOWER RIO GRANDE VALLEY, TEXAS

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ABSTRACT.—The effects of a severe freeze in December, 1983 on the native plants of the lower Rio Grande Valley, Texas were determined for 75 species. Damage was initially assessed by examining leaves, apical meristems, and cambial tissues of stems. Initial assessments were confirmed by surveys in the spring when new leaves were present. Forty-three species were either undamaged or had only minor leaf damage. Twenty-two species with damaged leaves had intact apical meristems or showed evidence of damage for less than 10 cm below the apical meristem. Three species, *Leucaena pulverulenta*, *Cordia boissieri*, and *Karwinskia humboldtiana*, had more extensive damage, i.e., 10 cm - 40 cm below the apex, but showed evidence of recovery by the presence of undamaged cambial and phloem tissues below the apex. Eight species, *Avicennia germinans*, *Capsicum annuum* var. *glabriusculum*, *Cereus pentagonus*, *Chiococca alba*, *Citharexylum berlandieri*, *Erythrina herbacea*, *Iresine palmeri* (male plants), and *Petiveria alliacea*, were seriously damaged. Temperatures lower than those occurring in December, 1983, or similar temperatures for much longer periods of time, would be necessary to kill most of the native species in the lower Rio Grande Valley, Texas.

At 3:00 a.m., 24 December 1983, a cold front moved through the Rio Grande Valley of southern Texas dropping air temperature to a minimum of −8.8°C. The temperature was −3.9°C during the following day (Edinburg Daily Review, 1984). In Edinburg, Texas, 53-55 consecutive hours of freezing or below freezing temperatures were reported. During that time, temperatures of −6.7°C or below were recorded for six hours. The effects of freeze damage on the economy of the lower Rio Grande Valley, Texas, was estimated at $510 million, with at least $200 million in damages to agricultural interests including citrus and vegetable production (Fikac, 1984). Extensive damage to introduced, relatively hardy, tropical, ornamental plants was noted. For example, numerous specimens of *Washingtonia filifera* (Washington palm), *W. robusta* (Washington palm), *Phoenix canariensis* (ornamental date palm), *P. dactylifera* (date palm), *Eucalyptus camaldulensis* (eucalyptus), and *Opuntia ficus-indica* (Indian fig) were killed.

Although there have been numerous studies on the physiological effects of freezing temperatures on woody plants in temperate zones (Parker, 1963; Weiser, 1970; Burke et al., 1976), there have been few assessments of freeze damage of native woody plants in subtropical areas. Defoliation, destruction of apical meristems, splitting of bark, and large limb death were reported for southern California shade and ornamental trees after a period of freezing temperatures by Skinner (1938), but he did not present species lists or quantitative data. Kinnison (1979) described leaf, twig and stem freeze damage of native and introduced species in central Arizona. Jones (1979) visually surveyed freeze damage of native plants in Sonora, Mexico, but he concentrated on woody species with ornamental value and did not quantify the data. Thus, previous studies have been incomplete surveys, i.e., all of the native woody species in an area have not been systematically examined. Furthermore, data have not been quantified so that comparisons could be made.

We examined the effects of a severe freeze on the native woody plants of the lower Rio Grande Valley, Texas. This study provides basic information that will allow resource managers to compare the cold-hardiness of these native woody plants.

STUDY AREAS.—Four study sites were located in Hidalgo and Cameron Counties in the lower Rio Grande Valley, Texas (Fig. 1). Site 1 is located on the Valverde Ranch approximately 32 km northwest of Edinburg in a "brush-grassland" vegetation zone (Lonard et al., in press). The plant community was stratified with the overstory containing *Prosopis glandulosa* (honey mesquite), *Pithecellobium flexicaule* (Texas ebony), *Cordia boissieri* (Mexican olive), *Bumelia celastrina* (la coma), and *Parkinsonia texana* var. *macrum* (paloverde). A diverse assemblage of woody species comprises an almost impenetrable understory. These include *Karwinskia humboldtiana* (coyotillo), *Leucophyllum frutescens* (cenizo), *Celtis pallida* (spiny hackberry), *Acacia berlandieri* (guajillo), *A. rigidula* (blackbrush), *Zanthoxylum fagara* (colima), *Koeberlinia spinosa* (allthorn), *Opuntia leptocaulis* (tasajillo), *O. lindheimeri* (Texas prickly pear) and numerous other less abundant species. Scattered grasses include *Bouteloua trifida* (red grama), *Aristida roemeriana* (three-awn) and the introduced *Cenchrus ciliaris* (buffelgrass).

Site 2 is located 15 km south of Mission in the Rio Grande Floodplain (Fig. 1). Common floodplain trees include *Ulmus crassifolia* (cedar elm), *Celtis laevigata* (hackberry), *P. flexicaule*, *Leucaena pulverulenta* (tepeguaje), *Ehretia anacua* (anacua), and *Fraxinus berlandieriana* (Mexican ash). Understory shrubs include *Forestiera angustifolia* (desert olive), *C. pallida*, *Heimia salicifolia* (hachinal), *Diospyros texana* (Texas persimmon), *Parkinsonia aculeata* (retama) and *Acacia smallii* (huisache). On higher terraces *P. glandulosa*, *P. texana* var. *macrum* and *K. spinosa* are common.

Site 3, also in the Rio Grande Floodplain, is located approximately 16 km southeast of Brownsville (Fig. 1). This site includes a native palm grove of *Sabal texana* (Texas palmetto). Other common trees include *P. flexicaule*, *C. laevigata*, *C. pallida* and *L. pulverulenta*. The presence of *Iresine palmeri* (Palmer's bloodleaf), *Chiococca alba* (David's milkberry) and *Xylosma flexuosa* (brush-holly) add to the tropical aspect of this site (Lonard et al., in press).

Site 4 is located in the "clay dunes" (Clover, 1937; Johnston, 1955) or "lomas" (Auffenberg and Weaver, 1969) 12 km east of Brownsville adjacent to the ship channel. Dominant woody species include *P. glandulosa*, *Ziziphus obtusifolia* (lotebush), *Yucca treculeana* (Spanish dagger), *Citharexylum berlandieri* (fiddlewood) and *Z. fagara*. On the margins of the ship channel, *Maytenus texana* (leatherleaf), *Monanthochloe littoralis* (shoregrass), *Avicennia germinans* (black-mangrove) and other halophytes are common.

MATERIALS AND METHODS.—At each study site a random sample of three to five individuals of each native woody species was scored as follows: undamaged leaves (0), minor frost damage to leaves (1), leaf death and undamaged apical meristems (2), leaf death and twig damage 1.0-10.0 cm below the apical meristem (3), leaf death and twig damage 11-20 cm below the apical meristem (4), leaf death and twig damage 21-40 cm below the apical meristem (5), or twig damage to the base of the plant or to 50 cm above the base (6). From this data, a composite freeze damage index value was determined for each species by summing values for each of the damage classes listed above at all study sites and determining the mean.

Frost damage to leaves was assessed visually. If the lamina was dry and brown, it was scored as a dead leaf (Demos et al., 1973). Minor leaf damage was noted if only leaf margins and leaf apices were brown.

Twigs bearing dead leaves were examined visually for frost damage. Blackening of the bark at the tips of branches was used as evidence of damage (Smithberg and Weiser, 1968). In addition, hand-prepared cross sections of twigs were made in the field. If cross sections of the apical meristem and adjacent embryonic zones revealed green tissue, we assumed that subsequent primary growth was not adversely affected.

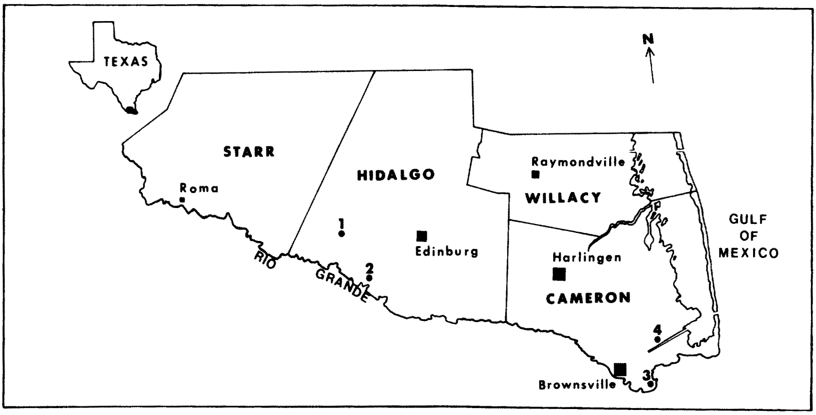

FIG. 1.—Map of the lower Rio Grande Valley, Texas showing the locations of four freeze assessment study sites.

Evaluations of twig damage at different distances below the twig apex were made visually by examining hand-prepared cross sections of the cambial region and adjacent phloem tissue (Weiser, 1970). We used the condition of brown, brittle, and desiccated tissue as evidence of twig damage.

Woody species at site 1 were evaluated for freeze damage 11 January 1984. Species at site 2 were scored 21 January 1984, and plants at sites 3 and 4 were examined 28 January 1984. We revisited site 1, 14 March 1984, sites 3 and 4, 24 March 1984, and site 2, 25 April 1984, to check the accuracy of our initial assessment.

Thirty-five native woody species were examined and scored at site 1, 42 species at site 2, 35 species at site 3, and 27 species at site 4. Seventy-five different species were evaluated for freeze damage (50 with 5 individuals per site and 25 with fewer than 5 individuals per site). Scientific nomenclature followed Kartesz and Kartesz (1980).

RESULTS.—Thirty-one native woody species were undamaged by the 24 December 1983 freeze (Damage Index = 0) (Table 1). We had previously determined that all of these were leafy during winter months with exceptions of the Cactaceae (*Echinocereus enneacanthus*, *O. leptocaulis*, and *O. lindheimeri*) and the leafless *K. spinosa* and *E. antisyphilitica* (personal observations).

Minor frost damage to leaves was evident in 12 species (Damage Index = 0.5-1.5) (Table 1). Leaves of these species were discolored at the apex or at the margins. Large individuals of *U. crassifolia* at site 2 were deciduous prior to freezing conditions. Juvenile leafy individuals in protected locations showed evidence of minor frost damage. The native palm, *Sabal texana* (Texas palmetto), was damaged only slightly at site 3.

Dead leaves but undamaged apical meristems characterized 12 species (Damage Index = 2-2.5) (Table 1). Some individuals of these species are often deciduous during winter or during drought conditions and include *C. pallida*, *E. anacua*, *Jatropha dioica* (leatherstem), *P. glandulosa*, *Sapindus drummondii* (Western soapberry), and *Z. obtusifolia*. However, all of the above except *J. dioica* had brown or blackened leaves.

Damaged leaves and twig damage 1.0-10.0 cm below the apex were noted in nine species (Damage Index = 3-3.3) (Table 1). Stem types were brittle and discolored, but chlorophyllous tissue was present near stem apices.

TABLE 1.—*Assessment of freeze damage to native woody plants of the lower Rio Grande Valley, Texas. Damage index values were scored as: 0 = undamaged leaves; 1 = minor leaf damage; 2 = leaves dead, apical meristems undamaged; 3 = leaves dead and twigs dead 1.0-10.0 cm below the apical meristem; 4 = leaves dead and twigs dead 11-20 cm below the apical meristem; 5 = leaves dead and twigs dead 21-40 cm below the apical meristem; 6 = leaves dead and twigs dead to 50 cm above base or to base of the plant. Index values are summed for all individuals of a species and the mean reported.*

Species	Damage Index Value	Species	Damage Index Value
Avicennia germinans	6	*Sabal texana*	1
Capsicum annuum var.		*Ulmus crassifolia*	1
glabriusculum	6	*Aloysia gratissima*	0.7
Cereus pentagonus	6	*Condalia hookeri*	0.5
Chiococca alba	6	*Schaefferia cuneifolia*	0.5
Citharexylum berlandieri	6	*Zanthoxylum fagara*	0.5
Erythrina herbacea	6	*Amyris madrensis*	0
Iresine palmeri (male)	6	*A. texana*	0
Petiveria alliacea	6	*Aster spinosus*	0
Leucaena pulverulenta	4.5	*Atriplex acanthocarpa*	0
Karwinskia humboldtiana	4.3	*Baccharis neglecta*	0
Cordia boissieri	4	*B. salicifolia*	0
Croton torreyanus	3.3	*Castela texana*	0
Acacia berlandieri	3	*Clematis drummondii*	0
A. rigidula	3	*Cocculus diversifolius*	0
A. smallii	3	*Diospyros texana*	0
Celtis laevigata	3	*Echinocereus enneacanthus*	0
Heimia salicifolia	3	*Ephedra antisyphilitica*	0
Mimosa malacophylla	3	*Ericameria austrotexana*	0
Parkinsonia texana var. *macrum*	3	*Forestiera angustifolia*	0
Pithecellobium pallens	3	*Guaiacum angustifolium*	0
Sapindus drummondii	2.5	*Iresine palmeri* (female)	0
Celtis pallida	2.3	*Koeberlinia spinosa*	0
Ehretia anacua	2.3	*Leucophyllum frutescens*	0
Acacia greggii	2	*Lycium berlandieri*	0
A. schaffneri	2	*Maytenus texana*	0
Coursetia axillaris	2	*Opuntia leptocaulis*	0
Fraxinus berlandieriana	2	*O. lindheimeri*	0
Jatropha dioica	2	*Phoradendron tomentosum*	0
Parkinsonia aculeata	2	*Prosopis reptans* var.	
Pithecellobium flexicaule	2	*cinerascens*	0
Prosopis glandulosa	2	*Rivina humilus*	0
Ziziphus obtusifolia	2	*Salicornia virginica*	0
Hibiscus cardiophyllus	1.5	*Smilax bona-nox*	0
Randia rhagocarpa	1.5	*Solanum triquetrum*	0
Bumelia celastrina	1	*Viguiera stenoloba*	0
Malpighia glabra	1	*Xylosma flexuosa*	0
Phaulothamnus spinescens	1	*Yucca treculeana*	0
Rubus trivialis	1		

More extensive damage was noted in *L. pulverulenta* at sites 2 and 3, where leaf death and twig damage was noted 21-40 cm and 11-20 cm below the apical meristem. At site 1, *C. boissieri* was damaged 21-40 cm below the apical meristem.

Eight native woody species, *Avicennia germinans*, *Capsicum annuum* var. *glabriusculum* (bird pepper), *Cereus pentagonus* (barbed-wire cactus), *Chiococca alba*, *Citharexylum berlandieri*, *Erythrina herbacea* (coral bean), *Iresine palmeri* (male plants) and *Petiveria alliacea* (garlic-weed) were damaged extensively (Damage Index = 6) (Table 1). All *C. pentagonus* plants examined were killed. Severely damaged individuals of the other species resumed growth from the base of the plants or from subterranean perennating structures the following spring. *Avicennia germinans* shrubs less than 1.0 m tall had dead leaves but undamaged apical meristems.

Native members of the Rutaceae, i.e., *Amyris madrensis* (chapotillo), *A. texana*, and *Z. fagara* were undamaged, or in the case of the latter, exhibited only minor frost damage to leaves. This was in contrast to the introduced members of the family that include *Citrus sinensis* (orange) and *C. paradisica* (grapefruit). We observed extensive damage to orange and grapefruit trees that included leaf-kill, fruit damage and trunk splitting. None of the native species that we sampled had evidence of ruptured bark or freeze-cracked trunks.

All introduced palms including *W. filifera*, *W. robusta*, *P. canariensis*, *P. dactylifera* and *Arecastrum romanzoffianum* (cocos plumosa) showed extensive leaf damage or were killed. *Sabal texana*, on the other hand, had only minor frost damage at leaf apices, and many individuals were apparently undamaged.

Bumelia celastrina, *C. pallida*, *Condalia hookeri* (brasil), *Guaiacum angustifolium* (guayacan), *O. lindheimeri*, *Phaulothamnus spinescens* (snake-eyes), *P. flexicaule* and *Z. fagara* were common to all study sites. *Bumelia celastrina*, *G. angustifolium*, *P. spinescens* and *P. flexicaule* were damaged at site 1, but were undamaged at sites 3 and 4.

Discussion.—Shreve (1914) reported that winter minimum temperatures effectively limit the northern distribution of southwestern desert plants and Parker (1963) concluded that drought and cold temperatures are the two most important factors limiting plant distribution. The use of minimum temperatures alone is a poor index of cold severity. Duration of sub-freezing temperatures provides better information but is no substitute for direct information on freeze damage to plants.

Chilling injury of plants occurs periodically in subtropical and tropical climates (Lyons, 1973). Eighty-seven percent (N = 179) of the native woody species in the lower Rio Grande Valley, Texas have humid tropical or southwestern desert phytogeographic affinities (Lonard and Judd, in press). Approximately 40 percent of the woody species reach their northern limits of distribution in southern Texas. Sub-freezing temperatures of 53-55 hours duration in the lower Rio Grande Valley, Texas in December, 1983 had little detrimental effect on most of the native woody species. Only eight (< 5%) species were killed or seriously damaged. Furthermore, two of these species, *Capsicum annuum* var. *glabriusculum* and *Petiveria alliacea* produce large numbers of viable seeds so that their continued presence appears likely. All the severely damaged species, with the possible exception of *Erythrina herbacea*, have Tropical Caribbean or West Indian phytogeographic affinities.

Resistance to injury by sub-freezing temperatures by woody plants in the lower Rio Grande Valley, Texas may reflect physiological adaptation to low temperature. For example, McMillan (1975, 1979) and Sherrod and McMillan (1981) have shown that populations of *Avicennia germinans*, *Thalassia testudinum*, *Syringodium filiforme* and *Halodule wrightii* from the southern Gulf of Mexico and Caribbean regions show less tolerance to chilling conditions than populations from coastal Texas. They concluded that the differentiation of response to chilling among the populations is based on inherited properties.

The dioecious scandent vine, *Iresine palmeri*, exhibited an interesting phenomenon of sexual dimorphic response to freezing conditions. Male plants were frozen to the base, but female plants located only several meters distant were undamaged and bore flowers and fruit. We are unable to provide an explanation for this observation.

Freezing temperature occurs at regular intervals (slightly less than annually) in the lower Rio Grande Valley of Texas and apparently serves as a major selective factor in determining those species that are best adapted to the subtropical, semi-arid environment of southern Texas. However, it is apparent that temperatures lower than those occurring on 24 December 1983 and/or similar temperatures for much longer periods of time, would be necessary to kill most of the native woody species in this area.

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