

Summary of the February 2011 Freeze and Effects on Plants in DELEP's Tucson Fields

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The winter of 2010 - 2011 was cold and dry in southern Arizona. A La Niña weather pattern resulted in scant precipitation, especially after the first of the year, exacerbating drought conditions. Three significant freeze events occurred during the winter. A major freeze on four consecutive nights from February 2-6 was the most severe freeze to visit much of southern Arizona since the freeze of December 1978. The February 2011 freeze was the result of an arctic air mass that spread west from the southern Great Plains across Texas and into Arizona. Unusually low temperatures lasting many hours, combined with high winds on the second night of the freeze caused extensive damage to many exotic and some native plants, as well as freezing water pipes. Freezing temperatures extended southward into Sonora and northern Sinaloa, Mexico, damaging native plants and crops. In contrast to the December 1978 freeze which followed a warm, wet autumn with many plants hydrated and not hardened off, the February 2011 freeze was unusually late in the winter. The fall and winter had been quite dry, especially in southern Arizona, and most plants were dormant.

The minimum temperature recorded at The University of Arizona Campus Agriculture Center (CAC), in Tucson, where DELEP's main fields are located was -7.7°C (18°F). Boyce Thompson Arboretum also recorded a low of -7.7°C with lower temperatures in some areas on the grounds. Higher elevation areas in southeastern Arizona and some parts of the Tucson area experienced much lower temperatures. Steady winds on February 2 continued through the night and into February 3. For much of this time winds were sustained between 32 kph (20 mph) and 48 kph (30 mph), with higher gusts. This negated the effects of warm microclimates and drew any warmth from exposed plants and surfaces. Exceptional wind chill readings were experienced in much of the region. Temperatures in Tucson fell below freezing as sunset approached on February 2 and did not rise above freezing until noon the following day, with temperatures remaining below -3.8°C (25°F) for up to twelve hours in many locations. The high temperature on February 3 at the CAC was 3.3°C (38°F) and temperatures again fell below freezing by sunset. Some valley locations in southeastern Arizona remained below freezing for two or more consecutive days. Even more severe conditions prevailed eastward in parts of New Mexico and western Texas.

The February 2011 freeze caused widespread and often severe or fatal damage to many landscape plants as well as some native plants around the region. Succulents were particularly hard hit. Arborecent prickly pears simply collapsed while many aloes

appeared to "melt" into piles of mush. Columnar cacti suffered variable amounts of damage from frozen stem tips to death of most stems or the entire plant. Though temperatures were comparable to the 1978 freeze, damage to native plants was in general, less severe. Minor stem damage was noted on both *Parkinsonia florida* and *P. microphylla* near their upper elevational limits in the Redington Pass area, east of Tucson. In this same area, many plants of *Ferocactus wislizeni* exhibited bleaching of the epidermis of the stem ribs on the east sides of the plants, likely a result of desiccation and freezing due to the persistent strong winds. Some saguaro cacti (*Carnegiea gigantea*) appear to have suffered fatal damage as a result of the freeze and were observed to be rotting in subsequent months. Many smaller saguaros in cold locations and sites near the upper limit of their distribution had blackened stem tips. It is too early to fully assess the damage to saguaro populations but preliminary observations suggest that losses will be minimal. Approximately 25 % of *Mammillaria grahamii* plants were observed to die following the freeze at a location on the east side of Tucson. The minimum temperature recorded at this site was -11.6°C (11°F).

Damage among cultivated woody species around Tucson was variable. In some areas and even within a single hedge, plants of oleander (*Nerium oleander*) ranged from no damage to severe leaf and stem damage; individual eucalypts (*Eucalyptus* species) exhibited extensive leaf burning, while adjacent trees of the same species were essentially unscathed. Many palms exhibited moderate to severe leaf damage, most conspicuously Canary Islands date palm (*Phoenix canariensis*), queen palm (*Syagrus romanzoffianum*) and to a lesser extent Mexican fan palm (*Washingtonia robusta*), while California fan palm (*Washingtonia filifera*), Mediterranean fan palm (*Chamaerops humilis*) and most date palms (*Phoenix dactylifera*) were undamaged. Extensive damage was noted on individual plants of African sumac (*Rhus lancea*) and California pepper (*Schinus molle*). Canary Island pine (*Pinus canariensis*) lost all of their needles but the trees recovered. Citrus fared poorly with the greatest damage exhibited by more tender varieties. A wide variety of shrubs were damaged and in some cases killed. Among the exotic legumes used in landscapes, most of the Australian sennas were extensively damaged or killed, with *Senna artemisioides* subsp. *filifolia* exhibiting the least damage. Only a few individuals of *Acacia stenophylla* showed any foliar damage, however, almost all *Acacia salicina* suffered extensive stem damage and in many cases were killed to the crown. Some individual plants of this species were killed. This is the first time that damage on *Acacia aneura* has been noted, with extensive foliage burn on many plants. *Acacia farnesiana* around Tucson exhibited variable degrees of damage from minor twig damage to entire trees freezing to the base. Most *Parkinsonia praecox* fared well with minor twig damage noted on only a few trees.

Plants at DELEP's Campus Agricultural Center (CAC) and West Campus Agricultural Center (WCAC) fields are planted for a variety of purposes including evaluation for tolerance to ambient temperatures. Both fields are located in areas subject to cold air drainage during typical winters and are among the colder locations in the Tucson basin. During the February 2011 freeze, high winds disrupted the normal settling of cold air in low valley locations, and the temperatures were comparable to those experienced in many areas of Tucson. Many plant species that have exhibited

damage in previous freezes were damaged at least as severely and in some cases more severely than in previous years. Other plants showed less damage than in previous freezes and many plants were undamaged.

The following plants in DELEP's Tucson CAC and WCAC fields exhibited no damage as a result of the February 2011 freeze:

Acacia acuminata

Acacia aneura – one variety, with needle-like phyllodes has never exhibited freeze damage with temperatures down to -9.4° C (15° F). A second variety, with flattened, silvery, curved phyllodes was not damaged at the WCAC field, however, plants that appear to be this variety suffered extensive damage to phyllodes and some stem damage in Tucson landscapes. This may reflect the genetic diversity of the variety across its range with material from some populations exhibiting greater cold-tolerance.

Acacia atramentaria

Acacia brachystachya

Acacia cambagei

Acacia caven

Acacia constricta

Acacia erioloba

Acacia greggii

Acacia haematoxylon

Acacia jennerae

Acacia karroo

Acacia mellifera subsp. *detinens*

Acacia millefolia – no stem damage was noted. This species typically exhibits dieback to stem tips each winter but this does not appear to be related to freeze damage.

Acacia neovernicosa

Acacia nysophylla

Acacia obtecta

Acacia occidentalis

Acacia oswaldii – no freeze damage was apparent, but most stems on this plant have died from undetermined causes and it has low vigor.

Acacia papyrocarpa

Acacia pendula

Acacia prainii

Acacia redolens

Acacia rigidula

Acacia rivalis

Acacia roemeriana

Acacia schaffneri

Acacia schottii

Acacia stenophylla

Acacia victoriae

Acacia wrightii

Amorpha fruticosa

Bauhinia lunarioides

Caesalpinia gilliesii

Caesalpinia paraguariensis

Caesalpinia sessilifolia

Calliandra eriophylla

Colutea istria

Eysenhardtia texana

Geoffroea decorticans

Havardia mexicana

Leucaena retusa

Mimosa aculeaticarpa var. *biuncifera*

Mimosa emoryana

Mimosa farinosa

Mimosa grahamii

Parkinsonia africana

Parkinsonia florida

Parkinsonia microphylla

Parkinsonia praecox subsp. *praecox*

Parkinsonia texana subsp. *macra*

Parkinsonia texana subsp. *texana*

Parkinsonia x 'Desert Museum'

Parkinsonia x *sonorae*

Prosopidastrum globosum

Prosopis chilensis

Prosopis glandulosa var. *glandulosa*

Prosopis glandulosa var. *torreyana*

Prosopis laevigata

Prosopis nigra

Prosopis pubescens

Prosopis reptans var. *cinerascens*

Prosopis velutina

Psorothamnus spinosus

Retama raetam

Senna aphylla

Senna artemisioides subsp. *zygophylla*

Senna wislizeni

Freeze damage was noted on the following plants:

Acacia ampliceps – these plants were frozen to the base with stems to 2.5 cm (1 in) thick and 2 m (6.5 ft) tall killed. This species freezes to the base in most winters and recovers the following season.

Acacia angustissima vars. *angustissima* and *suffrutescens* – plants froze to the crowns with stems to 2.5 cm (1 in) thick killed. These plants typically suffer partial stem die-back from winter freezing each year but recover vigorously the following season.

Acacia aroma – some outer twigs froze back to 15 cm (6 in) from the tips but most stems were undamaged.

Acacia berlandieri – some stems froze back to 30 cm (1 ft) from the tips but overall, damage was negligible.

Acacia borleae – stems were killed to 5 cm (2 in) thick and up to 3 m (10 ft) back from the tips. Both plants are making a vigorous recovery.

Acacia brevispica – the plant froze to the crown with stems to 1 cm thick killed. It is recovering.

Acacia cana – no stem damage was evident and only 10% of the phyllodes were killed. The plant recovered rapidly.

Acacia citrinoviridis – both plants were killed with stems to 2.5 cm (1 in) thick. These previously much larger plants suffered severe damage in the freeze of January 2007 and have exhibited low vigor since.

Acacia coriacea – Plant froze to the base with stems to 1 cm thick killed. This plant has frozen to the ground in most winters and is making a weak recovery.

Acacia craspedocarpa – the tips of 10-20% of the outer phyllodes exhibited minor damage. This is the first time that any freeze damage has been noted on this species at DELEP's Tucson fields.

Acacia crassifolia – the foliage was killed and many stems froze back 2.5-15 cm (1-6 in) from the tips. The plant is recovering.

Acacia difformis – extensive damage to phyllodes and most stems

froze back to 15 cm (6 in) from the tips. The plant had made a full recovery by the end of summer 2011.

Acacia farnesiana – some stems froze back to 30 cm (1 ft) from the tips. It is recovering.

Acacia fasciculifera – plants froze to the base with stems to 2.5 cm (1 in) killed. They are recovering.

Acacia fleckii – stems were frozen to 1 cm thick and up to 1.3 m (4 ft) from the tips. The plant is recovering.

Acacia furcatispina – most outer twigs froze back to 15-45 cm (6-18 in) from the tips.

Acacia galpinii – plant suffered severe damage with the main trunks killed to 20 cm (8 in) thick. It is exhibiting vigorous recovery, but had not previously suffered such extensive damage.

Acacia gerrardii subsp. *negevensis* – many outer twigs froze back to 30 cm (1 ft) from the tips.

Acacia grandicornuta – this plant was killed with stems to 5 cm (2 in) thick and 2 m (6.5 ft) tall frozen. It had suffered severe damage in most previous winters but had recovered vigorously each time.

Acacia grasbyi – the phyllodes were killed and many twigs froze back to 3 cm (1 ft) from the tips. It is exhibiting a healthy recovery.

Acacia harpophylla – most phyllodes were damaged and some twigs froze back to 15 cm (6 in) from the tips. The plant is recovering.

Acacia hebeclada subsp. *hebeclada* – mostly undamaged but some stems appeared to have been killed back to 30 cm (1 ft) from the tips.

Acacia hereroensis – stems to 2.5 cm (1 in) thick and 2 m (6.5 ft) thick were killed. The plants are recovering vigorously.



Acacia hereroensis (K. Coppola)

Acacia kempeana – approximately 20% of the phyllodes had some damage, but the plants were otherwise undamaged.

Acacia kirkii – stems froze back to 2.5 cm (1 in) thick and up to 1.3 m (4 ft) from the tips. The plants are recovering well.

Acacia nebrownii – this plant froze to the crown with stems to 2.5 cm (1 in) thick killed. It is recovering vigorously but suffers substantial freeze damage in most winters at the CAC site.

Acacia permixta – both plants froze to the crown with stems to 5 cm (2 in) thick and up to 4.6 m (15 ft) tall killed. One plant died and the other is slowly regrowing.

Acacia pruinocarpa – three plants at the CAC froze to the base to stems 5 cm (2 in) thick and up to 2 m (6.5 ft) tall. They are recovering. Two larger plants at the WCAC had approximately 20% of the phyllodes damaged with only minor damage to a few twigs that froze back up to 15 cm (6 in) from the tips.



Acacia permixta (K. Coppola)

Acacia pyrifolia – Plant froze to the crown with stems to 3.75 cm (1.5 in) and 1 m (3.3 ft) tall killed. This species freezes to the crown most winters and recovers the following season.

Acacia reficiens – plant exhibited minor damage with only a few twigs frozen back to 15 cm (6 in) from the tips.

Acacia rehmanniana – stems were killed back to 3.75 cm (1.5 in) thick and 1 m (3.3 ft) from the tips. It is recovering well.

Acacia salicina – the plant at the CAC exhibited severe damage with stems to 10 cm (4 in) thick killed. Smaller root sprouts were frozen to the base. Plants are recovering. Plants at the WCAC suffered only minor damage to phyllodes.



Acacia salicina (K. Coppola)

Acacia tetragonophylla – one plant froze to the base with stems to 10 cm (4 in) killed. It is regrowing from the crown. A second plant suffered severe damage with most stems killed to the base, however two trunks survived with some twigs 5 mm thick remaining alive, though all phyllodes were killed.

Acacia viscidula – minor freeze damage to phyllodes only. This plant has gradually died back over several years and may be nearing the end of its normal lifespan. One portion of the plant remains alive but lacks vigor.

Albizia sinaloensis – this species froze to the crown with stems to 2.5 cm (1 in) thick and 1.3 m (4 ft) tall killed. This plant freezes to the ground in most winters but continues to resprout the following year.

Anadenanthera colubrina – stems were killed to 2.5 cm (1 in) thick and 2 m (6.5 ft) from the tips. The plant is recovering vigorously.

Bauhinia carronii – plants defoliated and some twigs were frozen back to 10 cm (4 in) from the tips. This species has not suffered significant freeze damage in over twelve years.

Bauhinia macranthera – minor damage to some twigs which froze back to 10 cm (4 in) from the tips.

Bolusanthus speciosus – plant froze to the base with stems to 2.5 cm (1 in) thick and 1.3 m (4 ft) tall killed. The plant was recovering vigorously during the summer of 2011. This plant freezes to the base in most winters at the cold CAC field site.

Caesalpinia mexicana – stems to 3.75 cm (1.5 in) thick were killed with smaller plants frozen to the base. Recovery was evident.

Caesalpinia palmeri – most stems were undamaged with some stems freezing back up to 15 cm (6 in) from the tips.

Caesalpinia pulcherrima – plant typically freezes to the base in most winters and recovers the following season.

Calliandra californica – plants froze to the base with stems to 0.5 cm thick killed. Plants exhibited rapid recovery.

Coursetia glandulosa – most stems were killed to 2.5 cm (1 in) thick and up to 2.5 m (8 ft) tall. Plants are recovering.

Desmodium cinerascens – this species dies back to the crown with winter freezing each year but recovers the following season.

Havardia pallens – most stems froze back to 30 cm (1 ft) from the tips. Plants recovered well.

Leucaena greggii – plant exhibited minor damage with some twigs freezing back up to 15 cm (6 in) from the tips.

Leucaena pulverulenta – stems to 10 cm (4 in) thick were killed. The plant is making a slow recovery due to limited irrigation and a dry summer in 2011.

Lysiloma watsonii – plants froze to the base with stems to 10 cm (4 in) thick killed. Vigorous recovery occurred in the summer.



Lysiloma watsonii (K. Coppola)

Mimosa asperata – all stems froze to ground level. Plants vigorously resprouted. This cold-sensitive species freezes back substantially even in mild winters.

Mimosa distachya var. *laxiflora* – stems were killed to 3.75 cm (1.5 in) thick. Plants are recovering.

Mimosa dysocarpa – the stems froze back up to 45 cm (1.5 ft) from the tips. Plants recovered rapidly.

Mimosa ephedroides – outer stems froze back to 10 cm (4 in) from the tips but new growth quickly appeared with warm weather.

Mimosa malacophylla – this vine like species freezes to the crown

in colder winters and recovers rapidly the following season.

Mimosa strigillosa – the stems of this trailing plant were undamaged except for some die-back at the tips.

Olneya tesota – the foliage was frozen but no stem damage was apparent.

Peltophorum africanum – stems were killed to 15 cm (6 in) thick and up to 6 m (20 ft) tall. Plants were exhibiting vigorous growth in 2011. Plants were badly damaged during the January 2007 freeze but have otherwise exhibited only minor freeze damage.



Peltophorum africanum (K. Coppola)

Piscidia mollis – plant froze to the base with stems to 10 cm (4 in) thick killed. Vigorous recovery occurred during the summer.

Schotia brachypetala – plant froze to the crown with stems to 1 cm killed. It is recovering well.

Senna artemisioides subsp. *x artemisioides* – most leaves were killed and many stems froze back to 10 cm (4 in) from the tips. Plants recovered well.

Senna artemisioides subsp. *filifolia* – some leaves and flowers on individual stems were damaged, but adjacent leaves and flowers did not show any damage.

Senna artemisioides subsp. *petiolaris* – one plant 2 m (6.6 ft) tall growing in an exposed situation was killed, while two smaller plants growing beneath the canopy of a tree survived with only phyllode damage. These plants have suffered severe freeze damage in previous winters.

Senna costata – plants froze to the base with stems to 1 cm thick and 1.6 m (5 ft) tall killed. They made a healthy recovery. This species freezes back to the base most winters.

Senna hirsuta var. *glaberrima* – the stems froze to the base. This species dies back each winter.

Senna lindheimeriana – the stems froze to near the base but vigorous new growth appeared in the spring of 2011.

Senna pallida – plants froze to the base with stems to 1 cm killed. This is typical in most winters and the plants recover the following season.

Senna polyantha – most stems froze back to 30 cm (1 ft) from the tips. This species is seldom damaged most years and recovers rapidly the following season if it is.

Tephrosia leiocarpa – plants typically freeze to the crown each winter and recover the following year.

Zapoteca formosa var. *schottii* – all stems froze to the base. This species is typically damaged in colder winters. Plants were recovering during the 2011 growing season.