

GREEN ROOF PLANT TRIALS 2011

DENVER BOTANIC GARDENS

HISTORY

The Denver Botanic Gardens Green Roof, built in November 2007, is the first green roof on a city-owned building in Denver. Designed to be publicly accessible, interpretive and educational, it demonstrates the many benefits of green roofs to communities and the environment.

FEATURES

The roof spans approximately 1,180 square feet and faces south. It receives no shade during the day. There is a three-foot high concrete wall surrounding the garden on the east, west and south sides. Another wall, built to separate the patio viewing area from the garden itself, is approximately 18 inches high (see Figure 1).



FIGURE 1

BACKGROUND

Data is collected annually (since 2009) on most of the species on the Green Roof. This annual data collection is for the express purpose of determining the suitability of a wide variety of species for green roof use in this climate. Of the 112 species currently growing on the roof, 50 species were original to the design and were planted in November 2007. Fifteen more species were added in the spring of 2008, 4 species in autumn 2009, 20 in spring 2010 and 23 in spring 2011.

Species are selected for a variety of characteristics including their rate of establishment, their environmental tolerances, their ease of availability and/or propagation, their aesthetic value and their potential wildlife habitat value. Since 2010, the data collection categories include plant height, spread, foliage appearance, bloom time and survival counts, ending with an overall rating for each species (Figure 2).



FIGURE 2

Another significant feature of these selected species is their tolerance of minimal supplemental irrigation. Irrigation totals have been tracked for both the 2010 and the 2011 growing seasons.

IRRIGATION INFORMATION

In both 2010 and 2011, with the exception of new plantings, which are watered by hand, no regular irrigation was given to the Green Roof until the month of July.

In 2010, the Green Roof received 0.5 inch of irrigation per week, starting the first week of July and continuing through the end of October, for a total of approximately 8 inches of supplemental irrigation for the year. Figure 3 shows an irrigation audit in 2011, re-determining the length of time irrigation has to run to get 0.5 inch.



FIGURE 3

The month of July 2011 saw some of the most significant summer rainfall in recent history, a total of 6.65 inches, resulting in no need for July irrigation. It also resulted in the demise of a few species seemingly intolerant of any water at all. Figure 4 shows *Acantholimon armenum* in the far southwest corner of the green roof, all plants except one dead, after almost 7 inches of rain.

In August 2011, the summer temperatures rapidly climbed to the upper 90s and low 100s, necessitating the irrigation system be turned back on. However, irrigation was cut back from the 2010 schedule to 0.5 inch every other week, ending the first week of November, for a total 1.0 inch per month. The total for the 2011 growing season was 3.5 inches of supplemental irrigation.

The 23 new species added in spring 2011 were given additional irrigation by hand to encourage establishment. They were watered by hand twice a week for the first three weeks. After these three weeks ended, they were watered once a week until the rain in July took over. They were then expected to adapt to the regular irrigation schedule.

All of the trials are performed using the same planting media, composed of 80 percent expanded shale, 10 percent compost and 10 percent mulch. The roof has an 18" deep berm in the center for growing trees and shrubs. The flat area of the rest of the roof has a media depth of about 5 inches. Most of the plants mentioned below were planted from 2.5 inch pots unless otherwise indicated. No fertilizers or herbicides are used. The roof is checked for weeds daily. In 2010, seven weeds were found on the roof and removed, and in 2011, nine weeds (two species) were removed.

SPECIES SUMMARY

Carpet Forming Plants

Some of the most sought after plants for green roofs are known as "carpet formers." These plants grow laterally, growing over the ground and covering it up. Many carpet forming plants on other green roofs are commonly available and proven *Sedum* species. Denver Botanic Gardens has sought out other carpet forming plants other than *Sedum*, selecting several that have performed nicely, creating large carpets of their own.

The most impressive of these is *Chrysanthemum weyrichii*. Sixteen plants were installed in November 2007 and have grown to form a carpet 8 feet long and 5 feet wide. It is covered with flowers every autumn (Figure 5).

Another performer in this category was *Delosperma nubiginum*, planted in November 2007 (Figure 6).

Twenty-one *Delosperma nubiginum* plants formed a 5 x 2.5 foot carpet on the north facing sloped hillside with deeper planting media. In a second spot on the west side of the roof, it has grown at a slower rate in a shallow flat area. The *Delosperma* is also worth noting for two



FIGURE 4



FIGURE 5



FIGURE 6

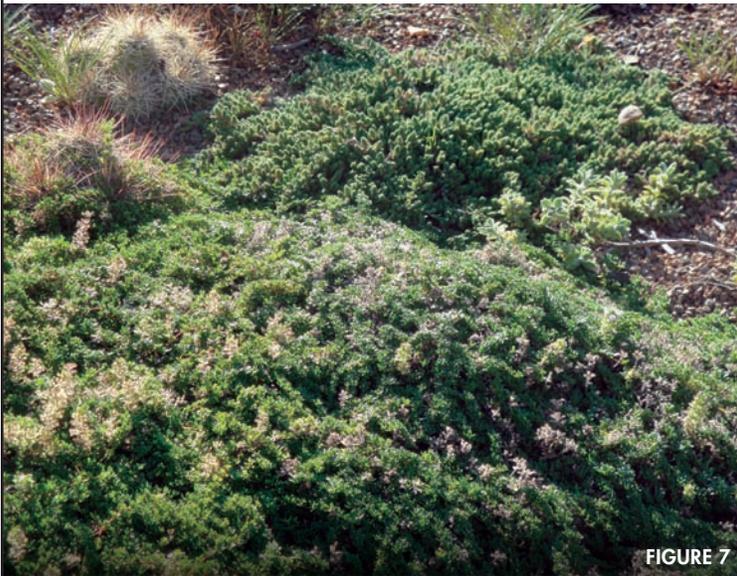


FIGURE 7



FIGURE 8

other reasons. When it is covered with yellow flowers during June, it attracts hundreds of bees. In the fall, the foliage turns a beautiful burgundy red, adding color to the roof all winter. *Thymus neiceffi* and *Veronica thymoides* (Figure 7) have grown into carpets similar in size to what would be normally expected if they were growing on the ground. This is true of both the *Chrysanthemum* and *Delosperma* as well.

Some Issues

Several of the species appear healthy but seem to be growing at a much slower rate than when planted in the ground. This noticeable trait affects several plants on the green roof, including *Hesperaloe parviflora*, *Nolina microcarpa*, and all three species of *Arctostaphylos*. The eight *Hesperaloe* are only slightly larger than they were two years ago, and the *Nolina* (Figure 8) is only 3.7 feet tall after four growing seasons.

The woody shrub *Amorpha nana* (Figure 9), is only a foot tall after three years on the roof. While this growth rate is low and the plants are small, they appear vigorous and green. Their small sizes may be caused by the harsh conditions on the roof and the lack of moisture, shade and nutrition. Both the *Hesperaloe* and *Amorpha* bloomed in 2010 and 2011.

The two *Chilopsis linearis* (2007) were grown from wild collected seed from Texas. They were planted from one-gallon containers, and as of September 2011 are both approximately five feet tall and about 2.5 to 3 feet wide, again smaller than expected. They are situated at the top of the berm in the southeast corner in full sun all day. Since they are surrounded on two sides by concrete walls, they get absolutely no circulating air. This is undoubtedly the hottest, driest area on the roof, yet they remain green and bloomed for the first time in 2011 (Figure 10).

More high performing species are the *Opuntia*, original to the 2007 design. There are three species on the roof (Figure 11).



FIGURE 9



FIGURE 10

EXCEPTIONAL PLANTS OF 2010 AND 2011

There are a few noteworthy performers even after a short time on the Green Roof. Some of these have grown to large sizes and are performing exceptionally just after one or two growing seasons. These include *Penstemon angustifolius* (planted 2010), which was one of the most asked about plants in the summer of 2011, *Penstemon cyananthus* (planted 2010) and *Ephedra minuta* (planted 2009) .

One of the clear performers in this 2010 group is *Ipomopsis aggregata* (planted 2010), which is just like the *Ipomopsis rubra* planted in 2008 (Figure 12). *Ipomopsis aggregata* has seeded itself over a 15-foot long area on the entire western side of the roof, with both species growing fairly tall (about 2-5 feet). Their height is providing shade, keeping themselves and their neighboring plants and their roots cool. These plants are a feasting area for hummingbirds, especially in the early morning. In Figure 1, the *Ipomopsis*, with its height of five feet plus and distinctive orange red flowers, is visible over the right side of the roof. This speedy self-sowing has to be monitored since it could easily take over the entire roof in a few years. For the present time, spent stalks are removed each spring and the beds are thinned. On other green roofs this plant may pose some control concerns, depending on the size of the roof.

One last 2011 planting must be mentioned, due to its amazing establishment rate and almost immediate and continual blooming habit. Twenty 2.5" pots of *Scutellaria prostrata* were planted on June 12, 2011 and were noticeably growing and blooming within a month. While not exactly a carpet former, it is covering the ground around itself while leaving small open areas between its stems (Figure 13).

POOR PERFORMANCES

Some of the poorest performances came from *Artemisia* (planted 2007). Four different species were planted in 2007; as of November 2010, all were dead except a small patch of *Artemisia* 'Green Mound' which continually appears both tiny and near death.

Another very poor performer (unless it was watered daily) is *Antennaria* (planted 2007). Two small living spots remain from the original two flats of plants.

A surprisingly poor performance by *Cercocarpus breviflorus* (planted 2007), a deciduous Mountain Mahogany from Texas, is now being watched. The leaves have looked floppy with some brown spots throughout the past two summers. It may have received too much water for the past two seasons. In these cases, the plants are watched to see if they recover, since the irrigation totals seem to be working for the surrounding majority of plants. They may be moved elsewhere if they do not show significant improvement.

Any of these plants may succeed on a different roof with conditions Denver Botanic Gardens Green Roof physically does not provide; for example, more shade or air circulation.



FIGURE 11



FIGURE 12



FIGURE 13

PLANT SELECTION FOR FRONT RANGE GREEN ROOFS

Some of these and many other of the useful species growing on Denver Botanic Gardens Green Roof originate from areas of the world which are extremely dry - either from desert, semi-desert, steppe, or even arctic in origin, as in the case of *Chrysanthemum weyrichii* (found growing as far north as Kamtschatka). There are undoubtedly hundreds more cold-tolerant plants suitable for green roof use along the Front Range. The year-round dryness of our climate may not be as much of a challenge to green roof plants as first thought, once the initial establishment years have passed.

NEXT STEPS FOR THE GREEN ROOF

Grassland communities featuring short prairie grasses and clumping grasses are the next types of species to be explored on the Green Roof in the coming years. Grasses with shallow roots that may go dormant under the usually dependable drought-like conditions of a Colorado summer and then recover fully with rain or irrigation are being sourced for trialing over the next few years.

Questions and comments regarding green roof plants may be directed to SchneidA@botanicgardens.org

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ABOUT DENVER BOTANIC GARDENS:

Green inside and out, the Gardens is considered one of the top botanical gardens in the United States and a pioneer in water conservation. Accredited by the American Association of Museums, the Gardens' living collections encompass specimens from the tropics to the tundra, showcasing a plant palette chosen to thrive in Colorado's semi-arid climate. The Gardens' dynamic, 24-acre urban oasis in the heart of the city is now in its 52nd year, offering unforgettable opportunities to flourish with unique garden experiences for the whole family – as well as world-class education and plant conservation research programs. Additional sites at Denver Botanic Gardens at Chatfield, a 750-acre wildlife and native plant refuge in Jefferson County, and Mount Goliath, a high-altitude trail and interpretive site on the Mount Evans Scenic Byway, extend this experience throughout the Front Range. For more information, visit us online at www.botanicgardens.org.



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