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Selecting Plants for Extensive Green Roofs in the United States

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What is a Green Roof?

Green roofs, or vegetated roofs, are an alternative roofing technology in which plant material is established on the rooftop. They provide numerous ecological and economic benefits, including stormwater management, energy conservation, mitigation of the urban heat island effect, increased longevity of roofing membranes, and mitigation of noise and air pollution. Green roofs also help provide an aesthetically pleasing environment to work and live in.

Green roofs are categorized as intensive or extensive systems. Intensive green roofs are similar to landscaping found at ground level, and require media depths greater than 6 inches and have intense maintenance needs. By contrast, extensive green roofs use shallower media depths (less than 6 inches) and require minimal maintenance. Because of the challenges of selecting plants for shallow media, this publication focuses on extensive green roofs.



Figure 1. A 10.4-acre extensive green roof in Dearborn, Mich. at the Ford Motor Co. River Rouge assembly plant.

Considerations for Plant Selection

Factors in selecting plant material are design intent, aesthetic appeal, environmental conditions, media composition and depth, installation methods and maintenance. Design factors that may influence plant selection include accessibility to and use of the roof, stormwater management objectives, xeriscaping objectives and thermal insulation objectives. Before selecting species on the basis of the design

intent, expectations of aesthetics should be addressed because many species have dormant periods when the green roof may not appear so green. For example, many native prairie grasses and perennials will normally dry and brown in the summer. Although this is a natural occurrence, some may find it unacceptable.



Figure 2. An extensive green roof during dormancy in East Lansing, Mich.

Regardless of the desired aesthetic effect, climate and microclimate have a major impact on plant selection. In particular, average high and low temperatures, extreme hot and cold temperatures, irradiance levels, wind, and the amount and distribution of rainfall throughout the year will determine what species can survive in a specific area. Drought tolerance is important because high levels of solar radiation and low media moisture are usually the norm in shallow extensive systems. Likewise, microclimates on the roof must be considered. Roof slope and orientation may influence the intensity of the sun and media moisture content, surrounding structures may shade a portion of the roof, air vents from heating and air conditioning units may dry the media, and chemical exhaust from industrial buildings may influence plant growth. Environmental conditions, especially the amount and distribution of rainfall and temperature extremes, will eliminate the use of certain species or will dictate the need for irrigation. Although aesthetic appeal is an important criterion on many roofs, survival and stress tolerance are the primary criteria.

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Media composition and depth have a major impact on plant selection for green roof systems. The ideal extensive green roof medium consists of a balance of lightweight, well-drained materials, possesses adequate water- and nutrient-holding capacity, and will not break down over time. Shallow media depths found on extensive green roofs dry out fast and usually do not support woody species, deep-rooted grasses, and many annual or perennial flowering plants. Conversely, shallow media often limit the growth of many undesirable weeds, and many desirable species are naturally found growing under these shallow conditions.



Figure 3. Typical extensive green roof medium.

In addition, installation method may influence plant choice. Plants can be established at ground level - grown as plugs or established on a blanket, mat or tray and then placed on the roof directly - or on the green roof medium via seed, plugs or cuttings. The availability of individual species in any of these forms may influence plant selection. In addition, the method of installation chosen may influence how much irrigation is required during initial plant establishment. And the long-term need of individual species for irrigation will also be an issue in plant selection.

Plant Characteristics

The variability of green roof designs and climates in the United States makes it impractical to list every possible plant candidate for extensive green roofs. As a general rule, potentially suitable species can be found by looking at the microclimate (media depth, solar levels, water availability, etc.) of the green roof in question and comparing it to a plant's native habitat. Some species have evolved in extreme conditions, such as mountainous terrains, high altitude

environments, coasts, limestone media or arid areas and are probably suitable for green roofs.

In choosing which plants to use, consider plant characteristics such as rate of establishment, longevity, ground cover density, and disease and pest resistance. The ideal species are long-lived and reseed themselves or spread vegetatively. Drought tolerance is one of the most limiting factors on extensive green roof systems because of their shallow media depths and usual reliance on natural precipitation. However, be careful to avoid drought-tolerant species that rely on deep taproots to obtain moisture – this situation cannot exist on a shallow extensive roof.

Succulent plants are well-adapted to the conditions often found on extensive green roofs because of their ability to limit transpiration and store excess water. Species such as *Sedum*, *Delosperma*, *Euphorbia* and *Sempervivum* are popular choices.

Presented here are species suggestions taken from scientific literature, as well as grower recommendations.



Figure 4. Green roof established with plugs.



Figure 5. Green roof established with seed.

Plants for Extensive Green Roofs in the United States**

Botanical name	Common name	Scientifically tested	State tested	Media depth tested (inches)	Grower recommended?	Recommended region ^z	Notes ^y	Reference ^x
<i>Achillea tomentosa</i>	Western yarrow	X	OR	2-4			1	5
<i>Agastache foeniculum</i>	Blue giant hyssop	X	MI	4			2,4	9
<i>Allium cernuum</i>	Nodding wild onion	X	MI, WA	4,6	X	MW	2	3, 8, 9
<i>Allium maximowiczii</i>	Ornamental onion				X	MW		
<i>Allium schoenoprasum</i>	Ornamental onion				X	MW,NE		
<i>Allium senescens</i>	Ornamental onion				X	MW, MA, SE		
<i>Allium stellatum</i>	Prairie onion				X	MW		
<i>Allium tanguticum</i>	Ornamental onion				X	MW		
<i>Antennaria neglecta</i>	Pussytoes				X	MW		
<i>Aquilegia canadensis</i>	Red columbine				X	MW		
<i>Arctostaphylos uva ursi</i>	Kinnikinnick	X	MA, WA	5, 6			2	6, 8
<i>Artemisia tridentata</i>	Desert sage				X	NE	3	
<i>Asclepias tuberosa</i>	Butterfly milkweed				X	MW		
<i>Asclepias verticillata</i>	Whorled milkweed				X	MW		
<i>Aster ericoides</i>	Heath aster				X	MW		
<i>Aster laevis</i>	Smooth blue aster	X	MI	4			2,4	9
<i>Aster oblongifolius</i>	Aromatic aster				X	MW		
<i>Bouteloua curtipendula</i>	Side oat grama				X	MW		
<i>Buchloe dactyloides</i>	Buffalo grass				X	MW		
<i>Carex flacca</i>	Heath sedge	X	MI	4				3
<i>Carex pensylvanica</i>	Pennsylvania sedge				X	MW	2	
<i>Carex radiata</i>	Fox sedge				X	MW	2	
<i>Cerastium tomentosum</i>	Snow-in-summer	X	OR	2-4			1	5
<i>Chrysanthemum vulgare</i>	Ox-eye daisy				X	MW		
<i>Convallaria majalis</i>	European lily of the valley	X	MA	6			2	6
<i>Coreopsis lanceolata</i>	Lanceleaf coreopsis	X	MI	4			2,4	9
<i>Coreopsis palmata</i>	Tickseed				X	MW		
<i>Coreopsis rosea</i>	Pink tickseed	X	MA	6				6
<i>Dalea purpurea</i>	Purple prairie clover	X	MI	4	X	MW	4	9
<i>Danthonia spicata</i>	Poverty oatgrass	X	MA	6				6

Botanical name	Common name	Scientifically tested	State tested	Media depth tested (inches)	Grower recommended?	Recommended region ^z	Notes ^y	Reference ^x
<i>Delosperma congestum</i>	Ice plant				X	NE		
<i>Delosperma cooperii</i>	Ice plant	X	OR	2-4	X	NE		5
<i>Delosperma nubigenum</i>	Ice plant	X	NC, OR	2-6, 2-4	X	MA, SE, NE		5,10
<i>Deschampsia flexuosa</i>	Wavy hairgrass				X	NE	3	
<i>Dianthus deltoides</i>	Maiden pink				X	MA,SE	1	
<i>Elymus elymoides</i>	Bottlebrush grass				X	NE	3	
<i>Epimedium perralderianum</i>	Epimedium	X	MA	6			2	6
<i>Eragrostis spectabilis</i>	Purple lovegrass				X	MW		
<i>Eryngium yuccifolium</i>	Button eryngo			3	X	MW		
<i>Euphorbia myrsinites</i>	Myrtle spurge				X	MW		
<i>Festuca glauca</i>	Blue fescue	X	OR	4	X	NE		5
<i>Festuca ovina</i>	Sheep fescue				X	MA,SE, NE	1, 3	
<i>Fragaria virginiana</i>	Wild strawberry	X	MI	4	X	MW	2, 4	9
<i>Gaultheria procumbens</i>	Eastern teaberry	X	MA	6			2	6
<i>Geum triflorum</i>	Prairie smoke				X	MW		
<i>Gilia capitata</i>	Bluefield gilia	X	OR	2-4			1	5
<i>Heuchera americana</i>	American alumroot				X	MW		
<i>Heuchera villosa</i>	Hairy alumroot	X	MA	6			2	6
<i>Jovibarba</i> species	Hens and chicks				X	MW, NE		
<i>Juncus effusus</i>	Common rush	X	MI	4			2,4	9
<i>Koeleria macrantha</i>	Prairie Junegrass	X	MI	4	X	MW	2,4	9
<i>Liatris aspera</i>	Tall blazing star	X	MI	4			2,4	9
<i>Lobelia siphilitica</i>	Great blue lobelia	X	MA	6			2	6
<i>Lupinus bicolor</i>	Miniature lupine	X	OR	2-4			1	5
<i>Lysimachia clethroides</i>	Gooseneck yellow loosestrife	X	MA	6			2	6
<i>Maianthemum canadense</i>	Canada mayflower	X	MA	6			2	6
<i>Monarda punctata</i>	Spotted beebalm	X	MI	4			2,4	9
<i>Muscari</i> species	Grape hyacinth	X	OR	2-4			1	5
<i>Nierembergia</i>	Cup flower	X	OR	2-4				5
<i>Oenothera macrocarpa</i>	Bigfruit evening primrose				X	MW		
<i>Opuntia humifusa</i>	Prickly pear	X	MI	4	X	MW, NE	3	9
<i>Pachysandra procumbens</i>	Allegheny spurge	X	MA	6			2	6

Botanical name	Common name	Scientifically tested	State tested	Media depth tested (inches)	Grower recommended?	Recommended region ^z	Notes ^y	Reference ^x
<i>Penstemon hirsutus</i>	Beardtongue				X	MW		
<i>Petrorhagia saxifraga</i>	Saxifrage pink	X	PA	2-5				11
<i>Phedimus spurius</i>	Caucasian stonecrop	X	MA, MI	6, 1-4			2	1, 6, 9
<i>Potentilla anserma</i>	Cinquefoil	X	MI	4	X	MW	2,4	9
<i>Potentilla neumaniana</i>	Cinquefoil	X	OR	2-4			1	5
<i>Rudbeckia hirta</i>	Black-eyed Susan	X	MI	4			2,4	9
<i>Ruellia humilis</i>	Wild petunia				X	MW		
<i>Schizachyrium scoparium</i>	Little bluestem	X	MI, MN	4, 2-6	X	MW	2,4	7, 9
<i>Sedum acre</i>	Biting stonecrop	X	MI, OR	1-6, 2-4	X	MA, SE, MW, NE		1, 3, 5, 9
<i>Sedum aizoon</i>	Stonecrop				X	NE		
<i>Sedum album</i>	White stonecrop	X	MI, NC, OR, PA	1-6, 2-6, 2-4, 1-6	X	MW, NE, MA, SE		1, 3, 5, 9, 10, 11
<i>Sedum anacampseros</i>	Stonecrop				X	NE		
<i>Sedum caudicola</i>	Stonecrop	X	MI		X	MW, NE	4	2
<i>Sedum cyaneum</i>	Stonecrop				X	NE		
<i>Sedum dasyphyllum</i>	Thick-leaved stonecrop	X	MI	1-3			1	1
<i>Sedum diffusum</i>	Stonecrop	X	MI	1-3			1	1
<i>Sedum divergens</i>	Cascade stonecrop	X	MI, OR	2-4	X	MW	4	3, 5
<i>Sedum ellacombianum</i>	Orange stonecrop	X	MI	4	X	MA, SE, MW, NE		9
<i>Sedum ewersii</i>	Stonecrop	X	MI	1.5-4	X	NE	1	2
<i>Sedum floriferum</i>	Stonecrop	X	MI, NC	2-4, 2-4	X	MA, SE, MW, NE		2, 10
<i>Sedum grisbachii</i>	Stonecrop				X	MW, NE		
<i>Sedum hispanicum</i>	Spanish stonecrop	X	MI, OR	2-4, 2-4	X	NE	1	1, 2
<i>Sedum hybridum</i>	Hybrid stonecrop				X	MA, SE		
<i>Sedum japonicum</i>	Stonecrop				X	NE		
<i>Sedum kamtschaticum</i>	Orange stonecrop	X	MI, OR	1-4, 2-4	X	MA, SE, MW, NE		1, 4, 5, 9
<i>Sedum lydium</i>	Stonecrop				X	NE		
<i>Sedum matrona</i>	Stonecrop				X	MA, SE	1	
<i>Sedum middendorffianum</i>	Stonecrop	X	MI	1-3	X	MW, NE		1,9
<i>Sedum oreganum</i>	Oregon stonecrop	X	OR	2-4	X	MW, NE	3	5

Botanical name	Common name	Scientifically tested	State tested	Media depth tested (inches)	Grower recommended?	Recommended region ^z	Notes ^y	Reference ^x
<i>Sedum pachyclados</i>	Stonecrop				X	MW,NE		
<i>Sedum populifolium</i>	Stonecrop				X	NE		
<i>Sedum pulchellum</i>	Bird's claw sedum	X	MI	4	X	MW,NE	2,3	3, 9
<i>Sedum reflexum</i>	Crooked stonecrop	X	MI, NC, OR	2-4, 2-6, 2-4	X	MA,SE,MW	1	1, 2, 3, 5, 10
<i>Sedum rupestre</i> 'Angelina'	Stonecrop	X	MI	2-4			1	2
<i>Sedum sarmentosum</i>	Stringy stonecrop	X	MI	2-4	X	NE		2
<i>Sedum sediforme</i>	Pale stonecrop	X	MI	2-4	X	NE		1, 2
<i>Sedum sexangulare</i>	Tasteless stonecrop	X	MA, MI, NC, OR, PA	6, 2-4, 2-4, 1-5	X	MA, SE, MW, NE		2, 4, 5, 6, 10, 11
<i>Sedum sieboldii</i>	Stonecrop				X	MW, NE		
<i>Sedum spathifolium</i>	Broadleaf stonecrop	X	OR	2-4	X	MW		5
<i>Sedum spectabile</i>	Showy stonecrop				X	MW		
<i>Sedum spurium</i>	Creeping sedum	X	MI, NC, OR	1-4, 2-4, 2-4	X	MA, SE, MW, NE		1, 2, 3, 4, 5, 9, 10
<i>Sedum stefco</i>	Stonecrop	X	MI	2-4	X	MA, SE, MW		2
<i>Sedum stenopetalum</i>	Narrow-petaled stonecrop	X	MI		X	MW	4	3
<i>Sedum tatarinowii</i>	Stonecrop				X	NE		
<i>Sedum telephium</i>	Stonecrop	X	OR	2-4	X	MW,NE		5
<i>Sedum ternatum</i>	Woodland stonecrop	X	MA	6	X	MW, NE	2,3	6
<i>Sedum tetractinum</i>	Chinese sedum				X	NE		
<i>Sedum urvillei</i>	Stonecrop	X	MI				4	3
<i>Sempervivum</i> species	Hens and chicks				X	MA,SE, MW, NE		
<i>Sempervivum tectorum</i>	Common houseleek	X	OR	2-4			1	5
<i>Sisyrinchium angustifolium</i>	Blue-eyed grass				X	MW		
<i>Solidago nemoralis</i>	Gray goldenrod	X	MN	2-6				7
<i>Sporobolus heterolepsis</i>	Prairie dropseed	X	MI	4	X	MW	2,4	9
<i>Talinum calycinum</i>	Fameflower	X	MI		X	MA,SE, NE	1, 3	3
<i>Tradescantia ohiensis</i>	Spiderwort	X	MI	4				9
<i>Viola pedata</i>	Bird's-foot violet				X	MW		

^z:MA= Midatlantic, SE=Southeast, NE=Northeast, MW=Midwest

^y: 1=accent plant, 2=suitable for shade, 3=native to U.S., 4=may need irrigation for survival.

^x: See references (next page).

****NOTE:** Any species listed here may perform differently depending on the specific micro- and macro-environmental conditions of the roof.

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Little has been published for species tested in southern portions of the United States. However, scientists in Singapore (likely comparable to a U.S. hardiness zone of 10 or 11) have found the following species to be thriving on a 2- to 4- inch deep roof: *Aglaia odorata*, *Aloe vera*, *Aptenia cordifolia*, *Callisia repens*, *Carpobrotus edulis*, *Delosperma lineare*, *Furcraea foetida*, *Ixora coccinea*, *Kalanchoe tomentosa*, *Liriope muscari*, *Lonicera japonica*, *Murraya paniculata*, *Ophiopogon intermedius*, *Pandanus amaryllifolius*, *Portulaca grandiflora*, *Sanseveria trifasciata*, *Sedum acre*, *Sedum mexicanum*, *Sedum nussbaumerianum*, *Sedum sarmentosum*, *Sedum sexangulare*, *Tradescantia pallida*, *Zephyranthes candida* and *Zephyranthes rosea*.

In addition, the following species are currently being tested in southern regions of the United States. No results have yet been published, but they serve as a good starting point for extensive green roofs in these regions. In Florida, with 5 inches of media, the following species are being tested: *Gaillardia pulchella*, *Liatris spicata*, *Sisyrinchium atlanticum*, *Coreopsis grandiflora*, *Helianthus debilis*, *Licania michauxii*, *Phyla nodiflora*, *Muhlenbergia capillaris*, *Arachis glabrata* and *Salvia coccinea*. In Texas, with 4 inches of medium, the following species are being tested: *Bouteloua curtipendula*, *Bouteloua gracilis*, *Bouteloua rigidiset*, *Carex texensis*, *Nassella tenuissima*, *Panicum hallii*, *Bignonia capreolata*, *Dalea greggii*, *Erigeron modestus*, *Hesperaloe parviflora*, *Manfreda maculosa*, *Salvia farinacea*, *Salvia greggii*, *Scutellaria wrightii*, *Stemodia lanata* and *Tetrandeum scaposa*.

In California, a statewide effort to increase energy efficiency of buildings is under way. The creators of that outreach campaign suggest the following species may work on an extensive green roof in the Los Angeles area: *Aloe nobilis*, *Carex stricta*, *Carex testacea*, *Delosperma alba*, *Delosperma cooperii*, *Dudleya hassei*, *Dudleya pulverulenta*, *Echinocactus grusonii*, *Kalanchoe beharensis*, *Lampranthus deltoideus*, *Lampranthus productus*, *Muhlenbergia rigens*, *Opuntia basilaris*, *Opuntia violacea santarita*, *Sedum sieboldii* and *Sedum spathulifolium*.

Other Resources

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- The Green Roof Research Program at Michigan State University Web site: www.hrt.msu.edu/greenroof/.
- Green Roof for Healthy Cities Web site: <http://www.greenroofs.org/>.

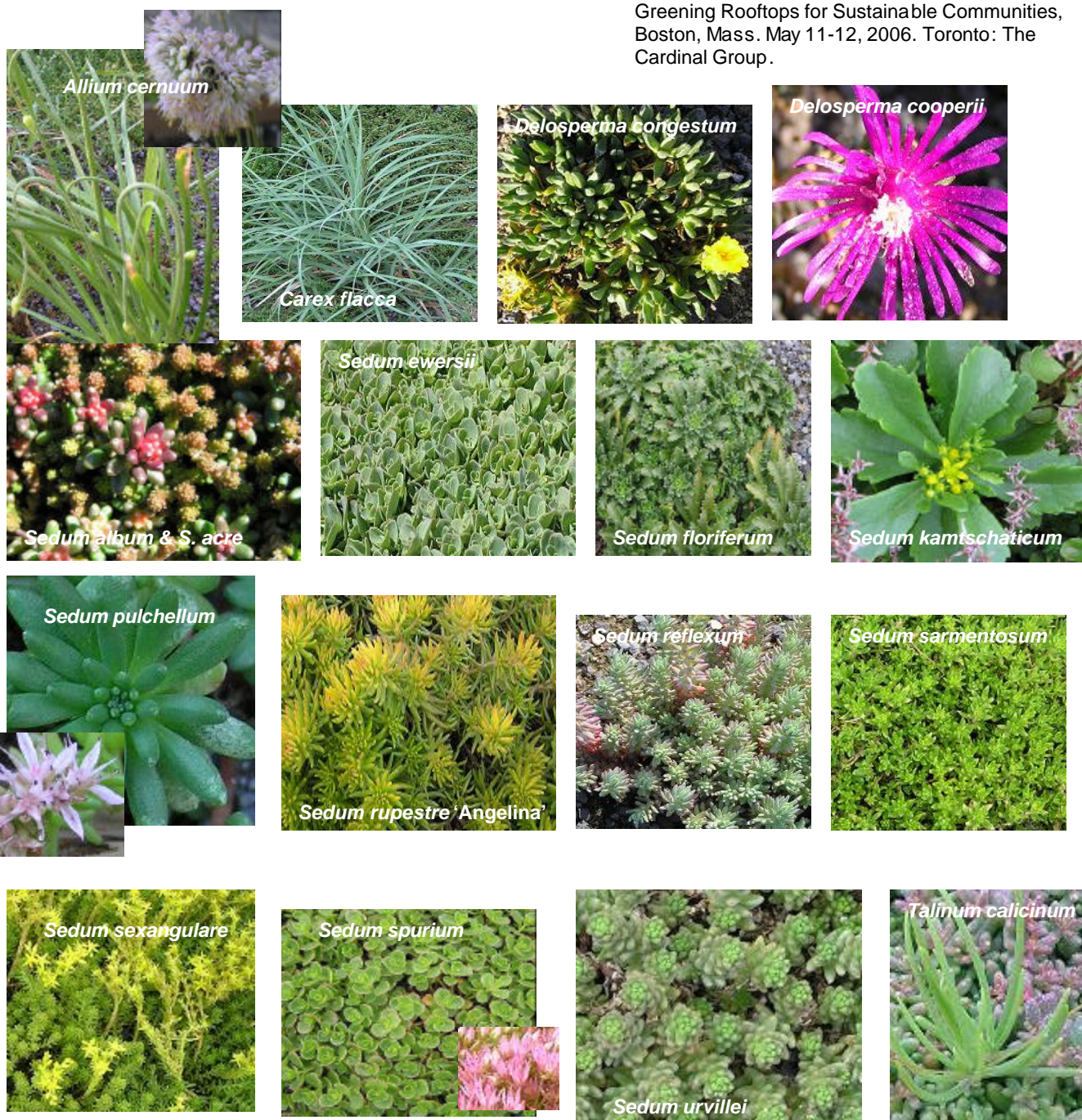
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