Green Roofs

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LID 201 Workshop
Green roofs are multi-beneficial structural components that help to mitigate the effects of urbanization on water quality by filtering, absorbing, detaining and evapotranspirating rainfall.
Residential High Rise

Solaire Residential Tower, New York. Photo courtesy of NASA Earth Observatory
Commercial High Rise

Lincoln Mercury Headquarters, Irvine, CA. Photo courtesy of Roofscapes, Inc.
Commercial Building

MEC Building, Toronto. Photo courtesy of Treehugger.com
Single Family Residential

Photo courtesy of Urban Agriculture Online
Building Entrance

Photo courtesy of Urban Agriculture Online
Innovative Design

Sinagapore Office Building
Photo courtesy of Earth First.com
California Academy of Sciences

Photo courtesy of Earth First.com
Extensive Green Roof

- Passive
- Shallow soil system
- Vegetation
  - Grasses & Succulents
- Non-recreational
Intensive Green Roof

- Active
- Deep Soil System
- Vegetation
  - Trees & Shrubs
- Recreational
Green Roof Design
Design Considerations

- **Structural Roof Support**
  - Additional weight of green roof: saturated weight
  - 10-50 pounds per square foot (extensive)
  - 80-120 pounds per square foot (intensive)
Design Considerations

- **Waterproof Membrane**
  - Can be various materials including:
    - Modified asphalts (bitumens)
    - Synthetic rubber (EPDM)
    - Reinforced PVC

- **Water Resistant Fabric**
  - Provides extra layer of protection
  - Synthetic
  - 15-30 oz per square yd.
Design Considerations

- **Root Barrier**
  - Made of dense materials that inhibit root penetration
  - Need for a root barrier depends on the waterproof membrane used

- **Drainage Layer**
  - Applied over the entire roof area to carry away excess water
  - Plastic sheets
  - Thin layer of gravel
Design Considerations

- Engineered Growing Medium/Soil Substrate
  - Minimum of 2.5 inches thick (extensive)
  - 3-6 inches thick (extensive)
  - 8-24 inches thick (intensive)
  - Well drained
- Typical mix of 25% topsoil, 25% compost, 50% sand but dependant on:
  - Type of plants
  - Depth of soil
  - Allowable weight
  - Climate
  - Irrigation needs
Design Considerations

- **Plantings**
  - **Extensive**
    - Shallow root system
    - Good regenerative qualities
    - Resistance to direct sunlight, drought, frost, and wind
    - Minimum of 90% vegetation coverage is recommended
    - Native plants are recommended
  - **Intensive**
    - Allows for greater variety
    - Grasses, perennials, shrubs, trees
    - More maintenance
    - Irrigation

[Image of plantings]

[Image of extensive plantings]

[Image of intensive plantings]
Native Plant Pallet (Northern CA)

<table>
<thead>
<tr>
<th>Trees</th>
<th>Shrubs</th>
<th>Ground covers, Perennials</th>
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<tr>
<td>Cercis occidentalis</td>
<td>Arctostaphylos (many)</td>
<td>Achillea millefolium</td>
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<tr>
<td>Chamaecyparis lawsoniana</td>
<td>Baccharis pilularis</td>
<td>Artemisia californica</td>
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<td>Cornus nuttallii</td>
<td>Ceanothus (several)</td>
<td>Heuchera (several)</td>
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<td>Lyonothamnus floribundus</td>
<td>Galvezia speciosa</td>
<td>Lilium (several)</td>
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<td>Platanus racemosa</td>
<td>Lavatera assurgentiflora</td>
<td>Muhlenbergia rigens</td>
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<td>Myrica californica</td>
<td>Penstemon heterophyllus</td>
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<td>Sisyrinchium bellum</td>
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<td></td>
<td>Catalina Ironwood</td>
<td>Lilies</td>
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<td>California Sycamore</td>
<td>Deer Grass</td>
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<td></td>
<td>Coast Redwood</td>
<td>Beard Tongue</td>
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<td>Blue-eyed Grass</td>
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Native Plant Pallet Southern (CA)

**Grasses & Grass-like Plants**
- Achnatherum hymenoides
- Nassella pulchra

**Groundcovers & Perennials**
- Castilleja foliolaris
- Lotus scoparius

**Shrubs & Shrubby Groundcovers**
- Artemisia tridentata
- Ceanothus ‘Joyce Coulter’
- Eriogonum fasciculatum polifolium
- Haplopappus linearifolius
- Sphaeralcea ambigua

**Annuals**
- Antirrhinum multiflorum
- Eschscholzia californica
- Lupinus suculentus
- Phacelia campanularia
- Lasthenia californica
- Trifolium gracilentum

Indian Rice Grass
Purple Needlegrass

Wooly Indian Paintbrush
Deerweed

Great Basin Sage Brush
Joyce Coulter Mountain Lilac
Interior California Buckwheat
Narrowleaf Goldenbush
Apricot Mallow

Multiflowered Snapdragon
California Poppy
Arroyo Lupine
California Blue Bells
Dwarf Goldfields
Pin Point Clover
Construction Concerns

- Waterproof membrane
  - Protect from construction punctures
  - Inspect for leaks before other installed
- Water resistant fabric
  - Ensure proper installation and even layout
- Drainage Layer
  - Immediate inspection of drainage flows prior to soil
- Soil
  - Even distribution
  - No compaction
Operations & Maintenance

- Initial Establishment
  - Irrigation
  - Fertilization
  - Weeding
- Slow release fertilizer twice per year to prevent acidification of thin soil layer
- Maintain 90% vegetation cover
  - Weeding
  - Remove dead vegetation
Operations & Maintenance

- Inspect for standing water
  - Removal of sediment that impedes dewatering
- Inspect roof for leaks annually
  - Repair any damage to the waterproofing membrane, root barrier or drainage layer
- Irrigation
  - Vegetation
  - Climate
- General Maintenance
  - Intensive
  - Extensive
Costs

- **Extensive:** $15 to $25 per square foot
- **Intensive:** $25 to $40 & up per square foot
- **Long-term benefits and the energy savings outweigh the original investment**

**Cost Breakdown**

- Root Barrier/Waterproof Membrane $10-15 per sq ft
- Drainage Layer/Soil $5-10 per sq ft
- Plants $1-3 per sq ft
- Installation and labor $3-8 per sq ft
- Maintenance $1-2 per sq ft
- Irrigation system $2-4 per sq ft
Performance

- **Water Quality**
  - Metals 90-95%
  - Nitrate 75-80%
  - Phosphate 65-70%
  - Soil filtration
  - Biological uptake

- **Water Quantity**
  - 60-75% of annual rainfall retention
    - Evapotranspiration
    - Soil retention
    - Biological uptake
Other Environmental Benefits

- **Energy Savings**
  - Reduction of cooling costs 50-70%
  - Reduction of heat loss up to 25%
- **Reduction in the Heat Island Effect**
  - Reduction of dark surfaces
  - Plants cool through dew and evaporation cycles
- **Improved Air Quality**
  - 1 square meter of green roof can remove 0.2 kg or airborne particulates per year
  - Carbon dioxide reduction
Other Environmental Benefits

- Creation of habitat
  - “Stepping Stone” habitat connecting natural isolated habitats to each other
  - Endangered or threatened species
- Minimize waste by increasing roof lifespan
  - Elimination of exposure to the sun’s ultraviolet radiation
  - Last up to twice as long as a conventional roof
- Sound reduction
  - A green roof with a 12 cm substrate can reduce sound by up to 40 decibels
Other Benefits

- Aesthetics/Quality of Life
- Recreational Opportunities
- Increased Property Values
- Improve Employee Productivity
- Food Production
Leadership in Energy & Environmental Design (LEED)

- SS Credit 5.1 Protect or Restore Habitat
- SS Credit 5.2 Maximize Open Space
- SS Credit 6.1 Stormwater Design: Quantity Control
- SS Credit 6.1 Stormwater Design: Quality Control
- SS Credit 7.2 Heat Island Effect: Roof
- WE Credit 1.1 Water Efficient Landscaping: Reduce by 50%
- WE Credit 1.2 Water Efficient Landscaping: No potable Water Use or No Irrigation
- EA Credit 1 Optimize Energy Performance
- ID Credit 1-1.4 Innovation in Design
Issues with Green Roofs

- Water leakage and drainage backups
  - Need to select appropriate waterproof membrane system
- Pesticide leakage
  - Do not use pesticides
- Unwelcome wildlife
  - Raccoons, squirrels, rats etc.
- Vegetation die off
  - Select vegetation appropriate for climate and exposure
  - Irrigation if necessary
- Irrigation requirements
  - Select plants appropriate for conditions
  - Some irrigation may be needed
  - Do not over irrigate
Green Roofs: Lessons Learned

- Benefits of Green Roofs must be presented early in the design process
- Green Roofs should be presented as cost effective over the lifecycle costs
- Identify the benefits (other or environmental) that target what the owner/developer values
- Specific to climate
- Installation by experienced contractor
Questions?

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