

LONGWOOD
GARDENS

June 7, 2016

So You Want To Build a Green Wall

Jim Harbage
Floriculture Leader

What Is a Green Wall

- Living wall vs Façade Greening
- Actively growing plants mounted on a wall

Eco-Wall

Bio-wall

Green-wall

Living-Wall

Vertical Garden



Why Build a Green Wall

- Temperature buffer (exterior)
- Air quality – filter pollutants and add oxygen (interior)
- Water quality - Filter gray-water
- Capture rain-water
- Noise reduction
- Calming
- Architectural/aesthetic statement
- Vertical farming



Some Things to Consider

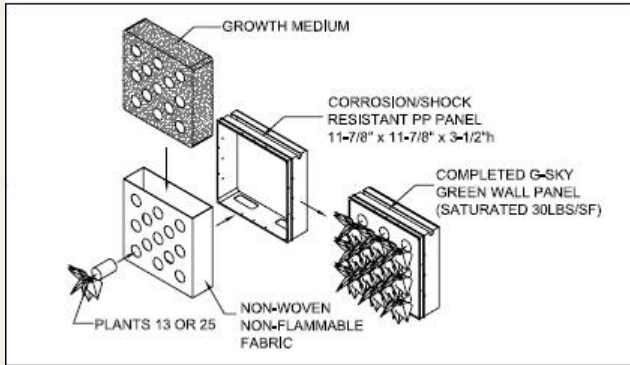
- Design
 - System Choice
- Production & Installation
- Maintenance
- Replacement



Design (system)



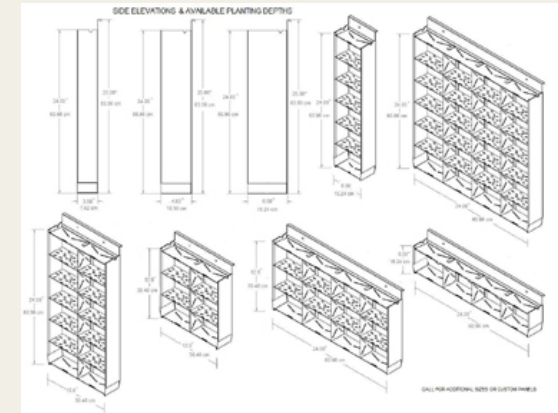
G-SKY GREEN WALL PANEL ASSEMBLY



SCALE: 1/2" = 1'-0"
(CAD FILE #1101)

General Types

- Fabric (felt) Walls
- Structured Panels
- Felt Pockets
- Horizontal pots

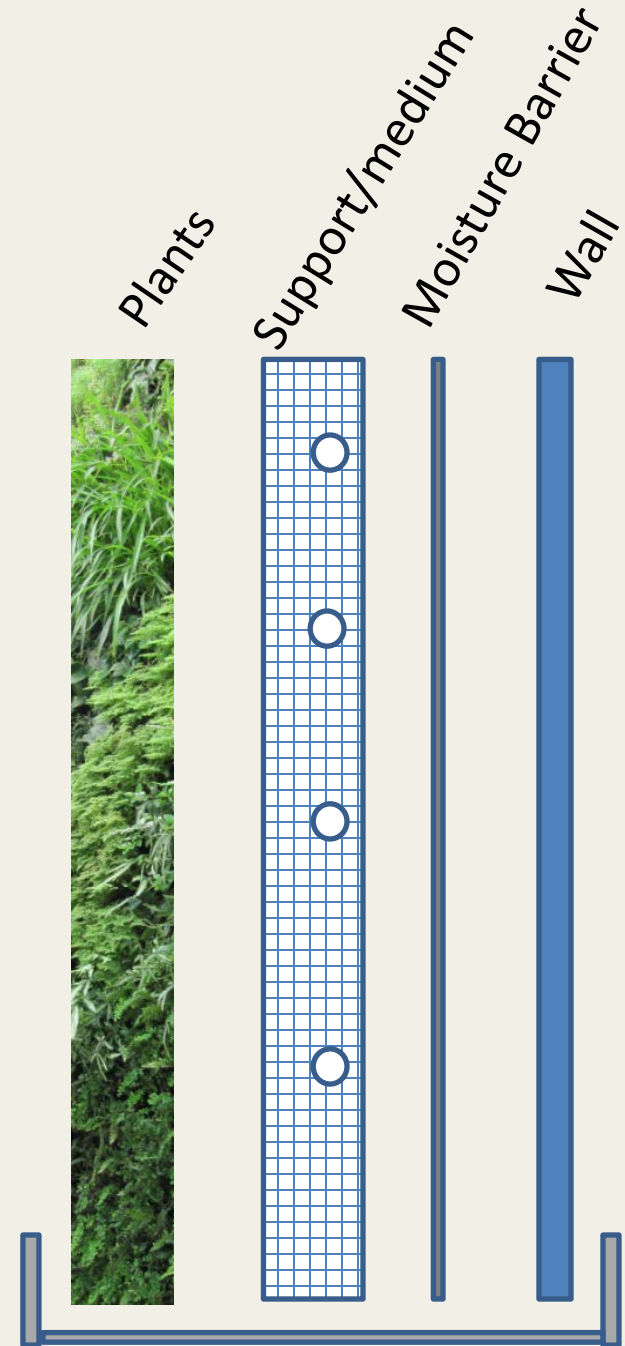


gardening.en.alibaba.com



Design – Wall Components

- Wall
- Moisture barrier
- Growing support/medium
 - Soil based/organic
 - Synthetic/inert
- Plants
- Water/nutrient delivery
- Water recovery

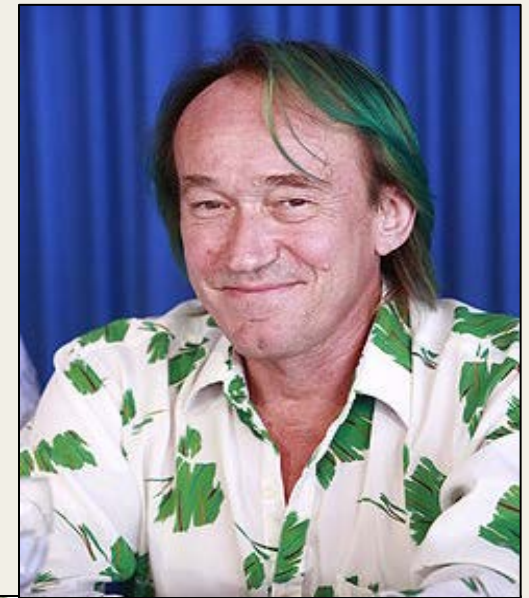


Fabric Systems

- Felt sheets – 2 vertical layers
- Front layer with slits
- Bare-root plants inserted through
- Hydroponic fertigation
- Medium has very long lifespan
- Better choice for air quality management



**Patrick
Blanc**



A vertical garden wall featuring a variety of green plants, including ferns and leafy greens. The wall is partially covered by a wooden structure with several curved, metallic-looking panels. To the left, there is a wooden door with a silver handle. A yellow caution sign is visible on the wall near the door.

Dansko

A large, modern indoor atrium. A prominent feature is a tall, vertical garden wall covered in dense green foliage. The space is characterized by wooden columns and a glass railing. People are seen in the foreground, and the background shows multiple levels of the building with glass railings and bright lighting.

Drexel University

Structured Panels - GLT

- Stainless steel – 18" x 24"
- Potting soil medium
- Plants grown in before installing
- Fertigation similar to container culture
- Medium requires frequent replacement
- Good for water management?





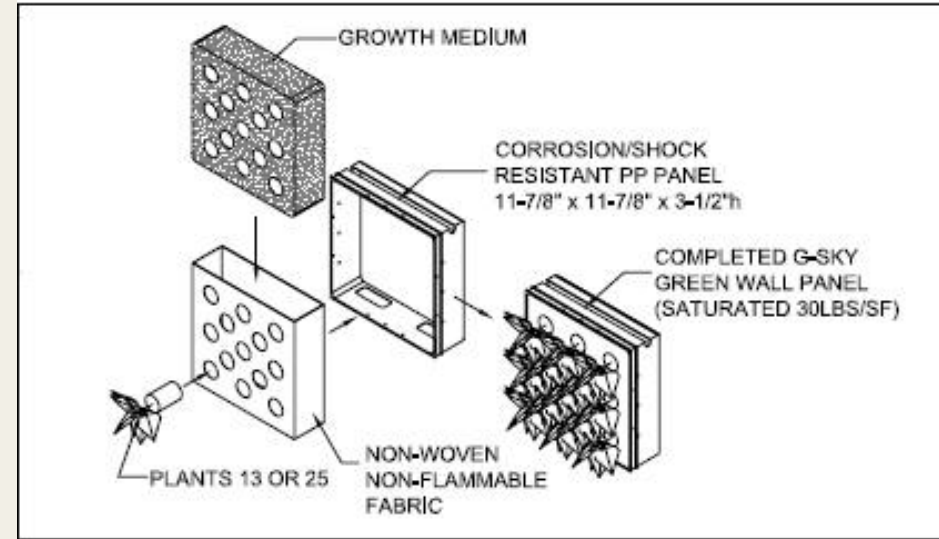
Structured Panels – G-Sky

“Pro-wall”

- Stainless steel – 12” x 12”
- Coconut coir medium
- Plants grown in before installing
- Fertigation semi-hydroponic
- Medium less frequent replacement
- Good for water management



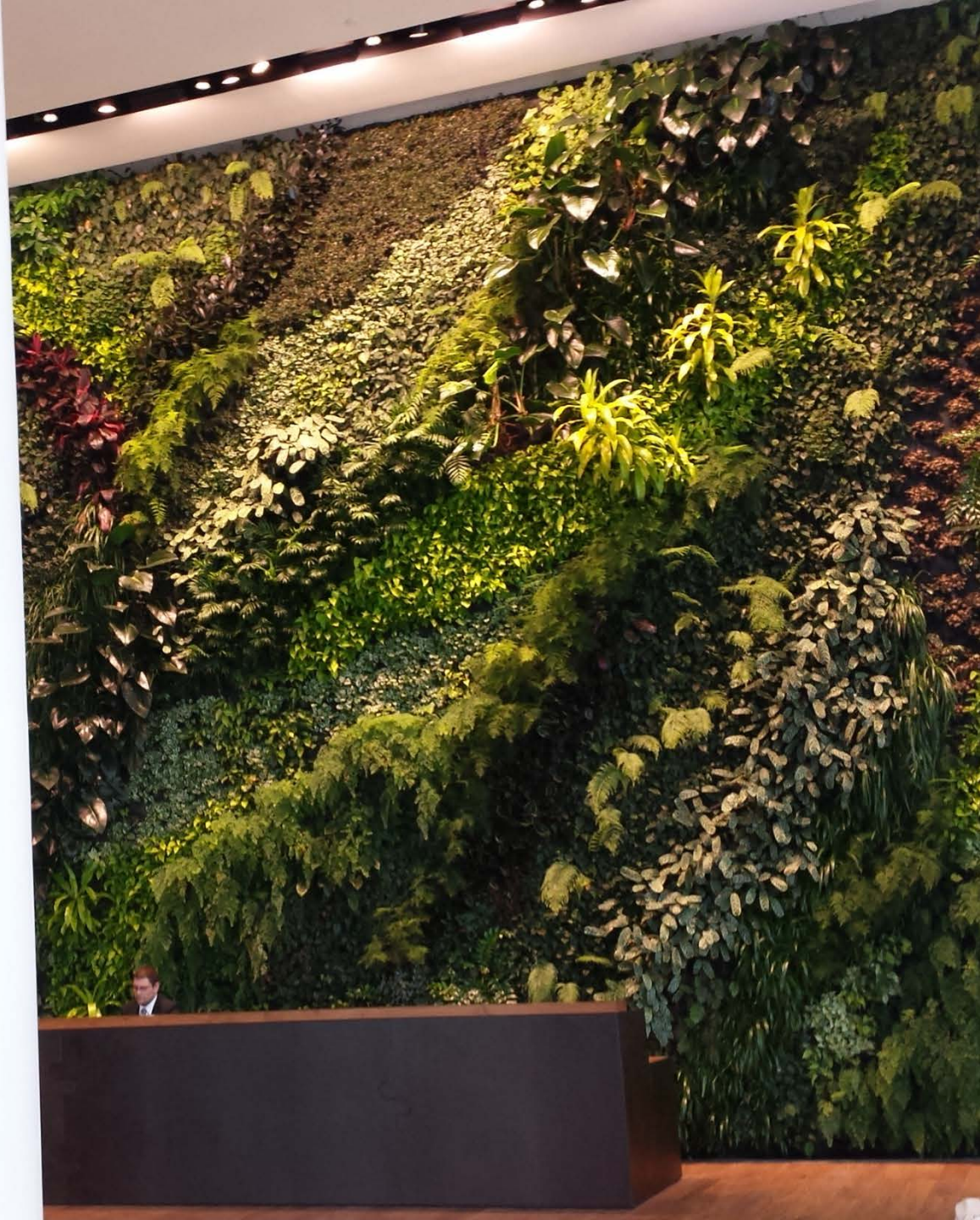
G-SKY GREEN WALL PANEL ASSEMBLY



Felt Pocket System

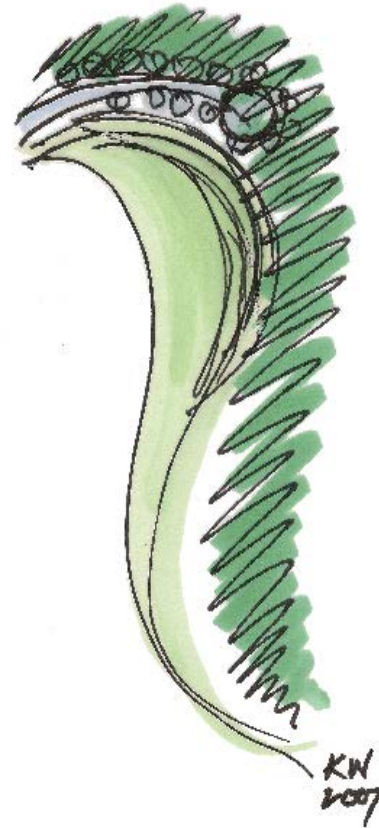
- Felt – recycled soda bottles
- Stapled to polycarbonate panels
- Pockets filled with potting media
- Felt long-lived, media less so
- Could be hand-watered?





Green Wall at Longwood Gardens

- Evolved from a need to expand restroom facilities
- Became part of a grand new entrance connecting the formal Conservatory structure to beautiful natural woodlands





Plant Selection

- Prior experience by vendor was a major factor in plant selection
- Selection dependent on:
 - temperatures requirements
 - light requirements
 - growth rate
 - foliage texture
 - plant availability
- Started out with 40 different taxa, pared down to 25



Final Plant List

Adiantum capillus-veneris
Aeschynanthus radicans
Arachniodes simplicior 'Variegata'
Asparagus densiflorus 'Sprengeri'
Asplenium antiquum 'Victoria'
Asplenium dimorphum x *difforme*
Asplenium scolopendrium
Athyrium filix-femina 'Frizelliae'
Chlorophytum, solid green
Cissus rhombifolia
Cyrtomium falcatum
Davallia fejeensis
Microsorium scolopendria
Nephrolepis cordifolia 'Duffi'
Nephrolepis exaltata 'Compacta'
Nephrolepis exaltata 'Dallas'
Pellaea rotundifolia
Philodendron scandens
Pilea microphylla
Polypodium aureum 'Green Wave'
Poylpodium pseudo-aureum
Poylpodium scolieri
Polystichum polyblepharum
Pteris cretica 'Albo-lineata'
Rumohra adiantiformis 'Iberia'
Selaginella kraussiana 'Gold Tip'

Maidenhair Fern
Lipstick Plant
East Indian Holly Fern
Asparagus Fern
Ruffled Bird's Nest Fern
Austral Gem Fern
Hart's Tongue Fern
Tatting fern
Spider Plant
Grape Ivy
Japanese Holly Fern
Rabbit's Foot Fern
Wart Fern
Lemon Button Fern
Compact Boston Fern
Dallas Fern
Button Fern
Heart Leaf Philodendron
Artillery Plant
Golden Fern
Virginia Blue Fern
Scouler's Polypodium
Japanese Tassle Fern
Brake Fern
Leatherleaf Fern
Krauss' Gold Tips Spikemoss



SECTION O

CUSTOM A

| | | | | | | |
|-----|----|-----|-----|-----|-----|-----|
| H2 | H2 | H10 | H10 | H5 | H5 | H5 |
| H4 | H4 | H2 | H2 | H10 | H10 | H10 |
| H4 | H4 | H4 | H4 | H2 | H2 | H7 |
| H10 | H4 | H4 | H4 | H4 | H2 | H7 |
| H1 | H6 | H6 | H6 | H1 | H1 | H7 |
| H6 | H6 | H6 | H1 | H1 | H1 | H1 |
| H6 | H6 | H1 | H1 | H1 | H1 | H6 |
| H6 | H1 | H1 | H1 | H1 | H6 | H6 |
| M1 | M1 | H1 | M6 | M6 | M6 | M3 |
| H9 | M1 | M6 | M6 | M6 | M3 | M3 |
| M1 | M1 | M6 | M6 | L1 | L7 | L7 |
| L3 | L3 | L4 | L4 | L1 | L7 | L7 |
| L3 | L3 | L4 | L4 | L1 | L7 | L7 |

120

SECTION P

| | | | | | | |
|-----|-----|-----|-----|----|----|----|
| H5 | H5 | H5 | H10 | H7 | H7 | H7 |
| H5 | H10 | H10 | H7 | H7 | H7 | H7 |
| H7 | H7 | H7 | H2 | H2 | H2 | H4 |
| H7 | H2 | H2 | H6 | H6 | H6 | H6 |
| H7 | H2 | H2 | H6 | H6 | H6 | H6 |
| 112 | | | | | | |

SECTION Q

CUSTOM A

| | | | | | | | |
|----|----|----|----|----|----|----|----|
| H7 | H2 | H4 | H4 | H9 | H9 | H9 | H9 |
| H2 | H2 | H4 | H9 | H9 | H9 | H9 | H9 |
| H4 | H4 | H9 | H9 | H9 | H9 | H9 | H9 |
| H6 | H9 | H9 | H9 | H9 | H1 | H1 | H5 |
| H6 | H1 | H9 | H9 | H1 | H6 | H6 | H5 |
| H1 | H9 | H9 | H1 | H6 | H6 | | |
| M7 | M2 | M2 | M2 | M6 | M6 | | |
| M7 | M2 | M6 | M6 | M6 | M6 | | |
| M3 | M2 | M6 | M3 | M3 | M9 | | |
| M3 | M7 | M3 | M3 | M3 | L9 | | |
| M3 | M7 | L1 | L1 | L1 | L2 | | |
| L7 | L7 | L1 | L1 | L7 | L1 | | |
| L7 | L7 | L1 | L1 | L7 | L1 | | |

130

Production & Installation



Production & Installation

- Plant sourcing / availability
- Scheduling
- Quality control
- Delivery









Shipment of Panels







Installation Process



As panels were hung,
irrigation was
installed.



Irrigation system

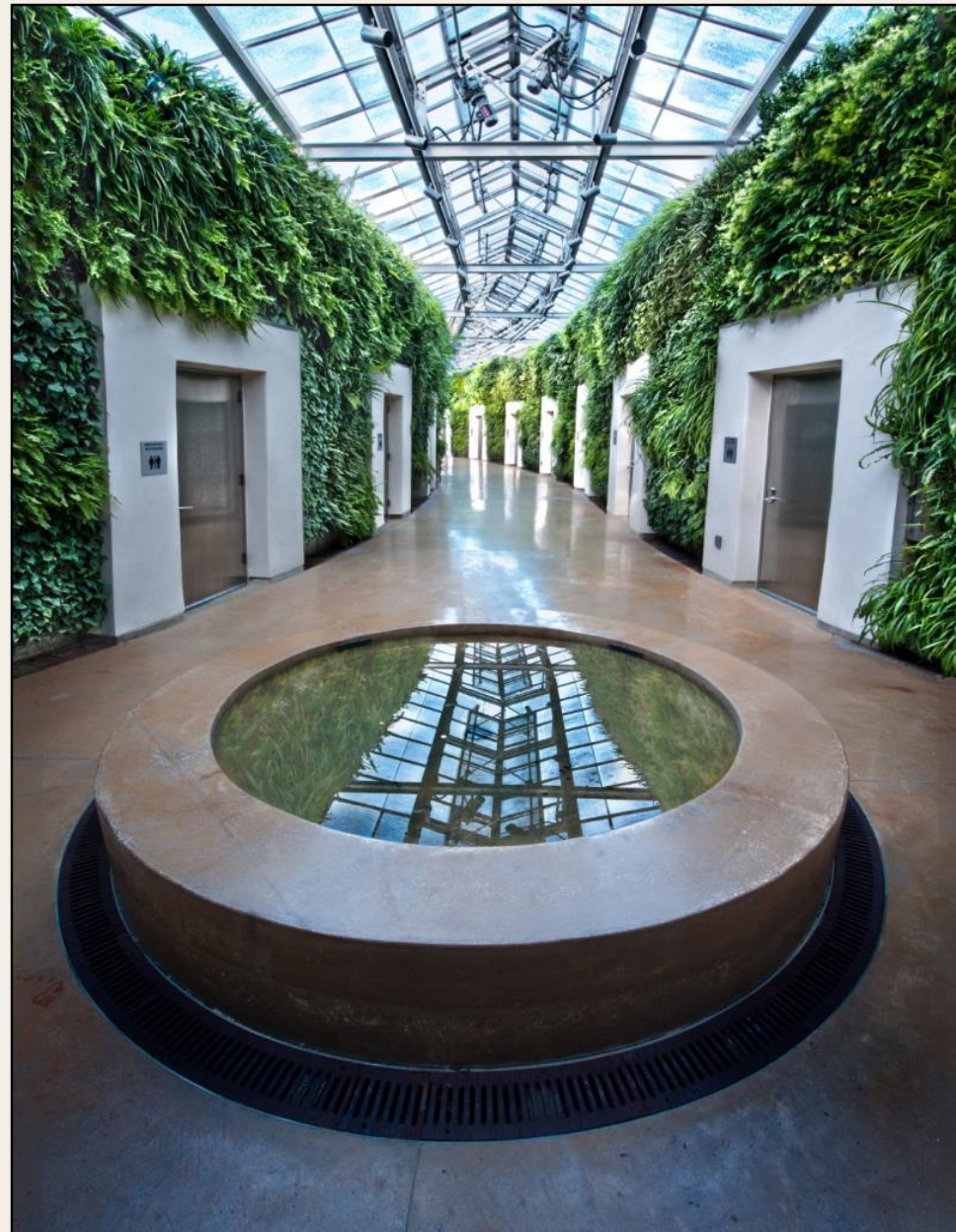
- Hunter irrigation clock is controlled remotely through the phone line.
- 24 different zones are used to irrigate the wall allowing high light areas to be watered more heavily than low light areas.
- Green wall uses the SuperDos “fertigation” system.



Restroom Corridor Became a Display Destination

Seventeen unisex comfort stations surrounded by :
The Largest Green Wall in North America

- 4,072 square feet
- 3,590 planted panels
- 47,000 plugs of plants
- 25 plant taxa
- 3,900 feet of irrigation



Maintenance



Maintenance

- Maintenance contract vs DIY
- \$5.00 - \$20.00 / sq ft / year



Maintenance

- Nutrition
- pH, EC management
- Grooming
- Planting medium deterioration
- Pest control



Initial Plant Loss

- *Tolmiea menziesii* (Piggyback Plant): Couldn't withstand high temperatures and intense sun.
- *Peperomia obtusifolia*: Did not have same water requirements as other plants.
- Results: Root diseases, poor performance



Daily Maintenance

- Labor dependent on season and age
 - initially ~16 hours per week
 - later ~ 24 hours per week or
- ~20 min / sq ft / yr
- Major efforts:
 - Pruning, thinning plant material
 - peak growth in spring and fall



Keeping the Wall “Green”: Biocontrol

- *Aphidius colemani* and *Aphidius ervi*
 - Parasitic wasps for aphid species
- *Eretmocerus eremicus*
 - Parasitic wasp for whitefly
- *Orius insidiosus* (Minute Pirate Bugs)
 - A general predator; for adult thrips
- *Phytoseiulus persimilis*
 - Predatory mite for spider mite
- *Amblyseius swirskii* (Swirskii mite)
 - Whitefly eggs and larvae, larval thrips



Why isn't our
Green Wall
green?



Maintenance Challenges

- Learning curve: growing semi-hydroponically
- pH fluctuations
- Micronutrient balance
- Plant sensitivity to media/growing conditions
- Degradation of coir



Biggest Issues

- Low pH
 - Resolved with potassium bicarbonate irrigation and changed fertilizer
- High zinc – 100 x normal levels – came from coir medium
 - Raising pH facilitated leaching it out
- Deteriorating coir medium
 - Resolved by replacing coir medium with “Rock Wool”



Final Plant List

| | | Performance |
|--------------------------|--|-------------|
| Lipstick Plant | <i>Aeschynanthus radicans</i> | Medium |
| Asparagus Fern | <i>Asparagus densiflorus</i> 'Sprengeri' | Medium |
| Ruffled Bird's Nest Fern | <i>Asplenium antiquum</i> 'Victoria' | High |
| Austral Gem Fern | <i>Asplenium dimorphum x difforme</i> | High |
| Spider Plant | <i>Chlorophytum</i> , solid green form | Low |
| Grape Ivy | <i>Cissus rhombifolia</i> | Low |
| Japanese Holly Fern | <i>Cyrtomium falcatum</i> | Medium |
| Rabbit's Foot Fern | <i>Davallia fejeensis</i> | Low |
| Wart Fern | <i>Microsorium scolopendria</i> | Medium |
| Compact Boston Fern | <i>Nephrolepis exaltata</i> 'Compacta' | Medium |
| Dallas Fern | <i>Nephrolepis exaltata</i> 'Dallas' | Medium |
| Fluffy Ruffles Fern | <i>Nephrolepis exaltata</i> 'Fluffy Ruffles' | Medium |
| Button Fern | <i>Pellaea rotundifolia</i> | Low |
| Heart Leaf Philodendron | <i>Philodendron scandens</i> | High |
| Hare's Foot Fern | <i>Polypodium aureum</i> 'Blue Star' | High |
| Golden Fern | <i>Polypodium pseudo-aureum</i> 'Green Wave' | Medium |

Replacement of plugs

- Remove poor performing plant from coconut coir
- Plant new plug directly into panel



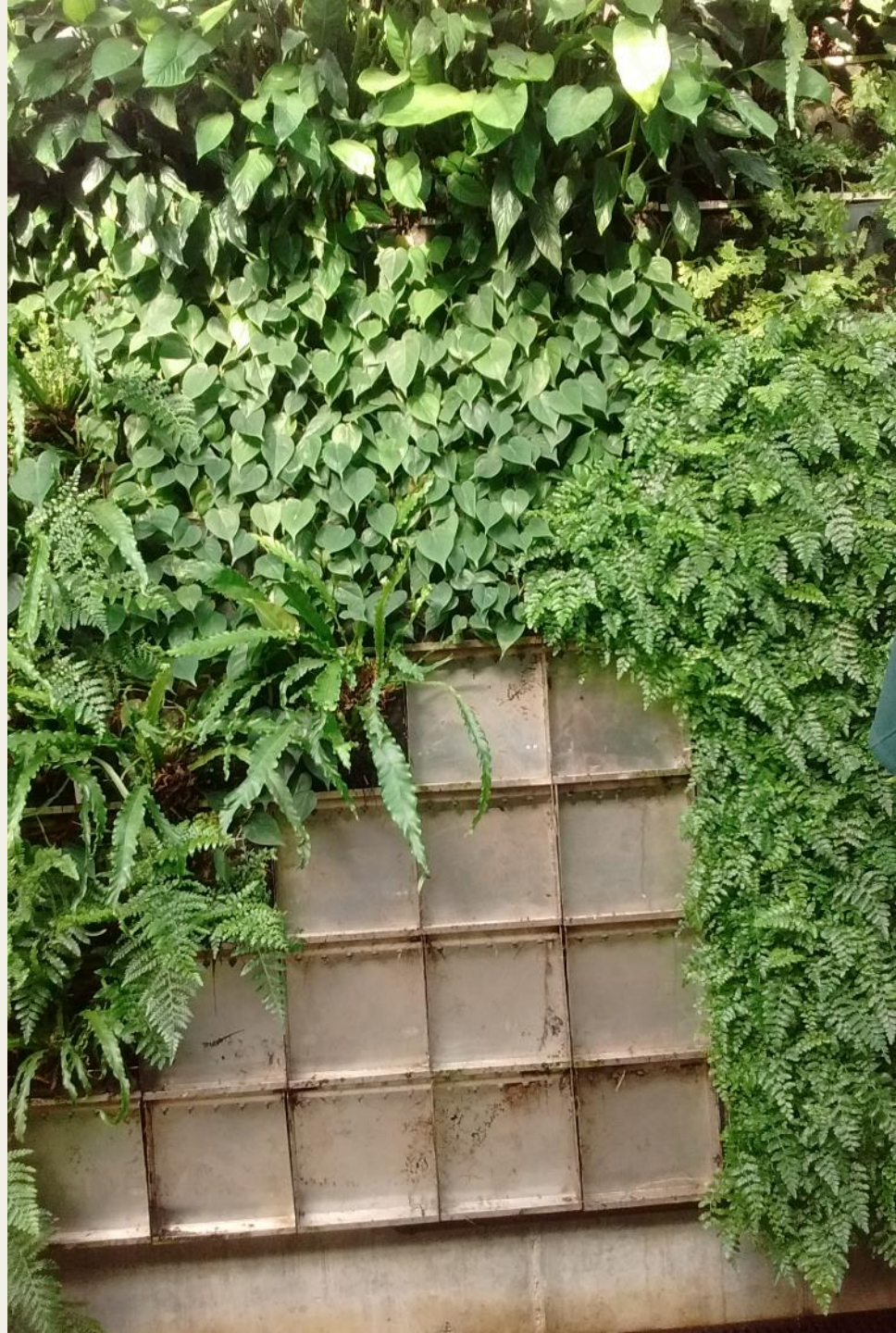


Replacement



Replacement of Panel Medium

- Wanted to find a better medium



Panel Medium Replacement Goals

- Medium that:
 - would work in existing stainless steel panels
 - would not decompose
 - would not have or hold excessive mineral levels
 - would have good aeration and water-holding properties

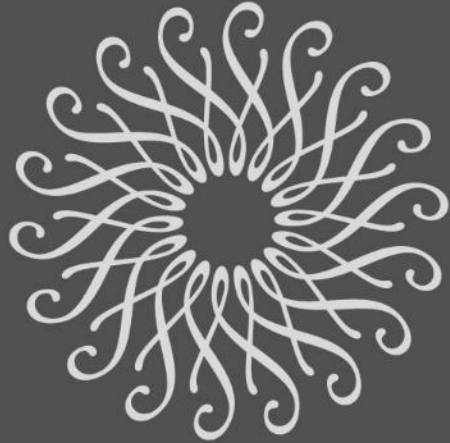








Prettiest Potties



LONGWOOD
GARDENS