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A FOUR YEAR STUDY OF THE EFFECTS OF SUBSTRATE DEPTH ON THE SURVIVAL OF DIFFERENT PLANT SPECIES IN PORTLAND, OR

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Abstract

The changes in green roof plant species composition was observed after a four year time period. Twelve plots were planted in either native or non-native species at two different substrate depths according to a 2 by 2 factorial design. The list of original species from installation was used to identify which species survived over time in their respective plots. After four years, 9 out of 12 native species and 13 out of 14 species survived. The high survival of 26 original species must be compared to the colonization of 68 new species. With minimal maintenance, new species colonized plots. Extensive plots were composed of 33% original planting and 67% colonizing species. Intensive plots were composed of 24% original plantings and 76% new species. The original species that had the highest survival were *Sedums* and *Festuca*.

Background & Significance

Why green roofs?

Green roofs provide ecosystem services (contributions for humans by the ecosystem) like reducing urban heat-island effect, regulating a building's temperature, improving storm water management, increasing urban habitat, and providing a space where people and nature can connect (Oberndorfer *et al.*, 2007).

What is the difference between extensive and intensive green roofs?

Extensive green roofs have a depth of 3-6 inches. Intensive green roofs have depths greater than 6 inches. The different depths affect the performance of the roof, the types of plants to use, and its maintenance plan (Dunnett *et al.*, 2008)

Figure 1: Green roof at Portland State University (Bolkan, 2011).

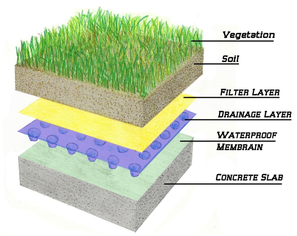


Figure 2: Green roof layers (Details of green roof).

Study Site

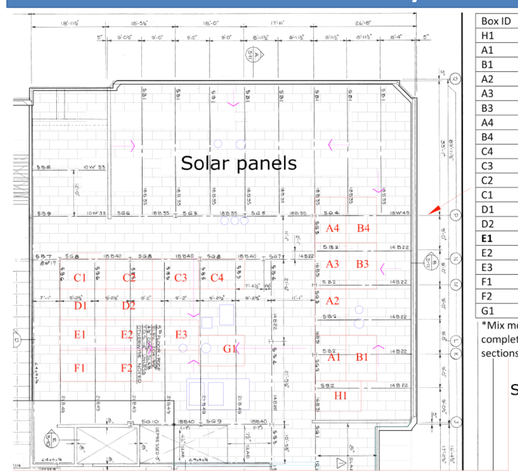


Figure 3: Cramer Hall green roof layout.

Box ID	Soil type	Plant type
H1	Pumice/potting soil	Non-native
A1	Pumice/potting soil	Native
B1	Extensive E	Native
A2	Extensive E	Non-native
A3	Extensive C	Non-native
B3	Extensive C	Native
A4	Intensive A3	Non-native
B4	Intensive A3	Native
C4	Intensive B4	Native
C3	3" Extensive C	Mix (2 non-native, 1 native)
C2	Extensive C	Native
C1	Extensive C	Non-native
D1	3" Extensive C	Mix (2 non-native, 1 native)
D2	Biomax mat	Mix (1 non-native, 1 native, 1 edible)
E1	Intensive B4	Non-native
E2	Extensive E	Mix (1 non-native, 2 native)
E3	Potting soil	Mix (2 non-native, 1 native)
F1	Intensive B4	Non-native
F2	Intensive B4	Native
G1	Intensive B4+	Mix (1 non-native, 2 native)

*Mix means that native and non-native plants will both be used in a completed box in separate sections. Each completed box has three sections inside. The edible section contains wild strawberry and thyme.

What is the Cramer Hall Eco-Roof Project (CHERP)?

A green roof installed by the Portland State University Engineers Without Borders in 2012. The purpose of CHERP is to "support sustainable storm water management while fostering eco-conscious education and green technology research" (Engineers Without Borders, 2012).

Why study CHERP?

CHERP has been not been maintained heavily after its installation. This provides a rare opportunity to study a neglected green roof and observe what originally planted species succeed in the Pacific Northwest climate.

Research Question

After four years, what plant species from the original installation of the Cramer Hall Eco-Roof Project succeeded in the extensive and intensive plots?

Material & Methods

- During spring of 2016, a class collected the following samples from the Cramer Hall green roof: substrate, insects, temperature, plant coverage, plant height, and plant diversity. For the purpose of this study, strictly plant diversity data was used.
- The original plant list was referred to, to compare with the observed species that survived in the plots after 4 years.
- Observations were made between extensive native, extensive nonnative, intensive native, and intensive nonnative plots.

Figure 3: Photo of students collecting samples from CHERP.

Results

Table 1: Original species that have survived in the extensive and intensive plots after 4 years.

Extensive

Type	Species	Frequency
Native	Campanula rotundufolia	1
Native	Festuca Idahoensis	3
Native	Fragaria chiloensis	1
Native	Sedum moranii	1
Native	Sedum oblanceolatum	1
Native	Sedum oreganum	2
Native	Sedum spathylifolium	1
Native	Thymus fragantissimus	1
Non-Native	Festuca glauca	2
Non-Native	Sedum acre	1
Non-Native	Sedum album	3
Non-Native	Sedum ewersii	1
Non-Native	Sedum kamatschaticum	1
Non-Native	Sedum nevii	1
Non-Native	Sedum rupestre	2
Non-Native	Sedum spurium	1
Non-Native	Thymus fragantissimus	1

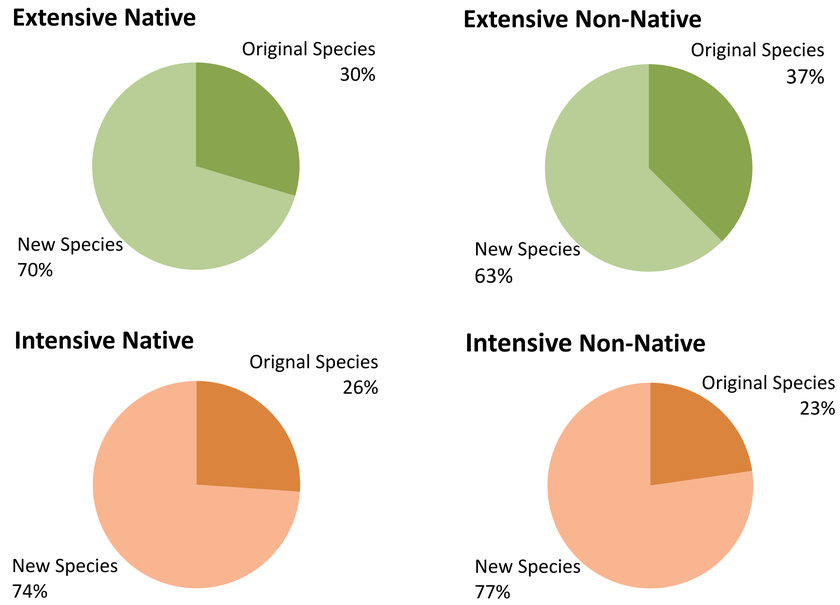
Intensive

Type	Species	Frequency
Native	Allium cernuum	1
Native	Festuca idahoensis	1
Native	Fragaria chiloensis	1
Native	Sedum spathulifolium	1
Native	Sedum stenopetalum	1
Non-Native	Festuca glauca	1
Non-Native	Sedum album	2
Non-Native	Sedum ewersii	1
Non-Native	Sedum rupestre	3
Non-Native	Sempervivum tectorum	1

Figure 4: Species that had the greatest success on the green roofs. Left to right: Sedum album, Festuca glauca, Sedume rupestre, Festuca idahoensis, and Sedum oreganum.

Results

Figure 4: Pie charts of percent composition between original species and new species between plots.



Discussion

The species that had the greatest survival on the extensive plots were *Festuca idahoensis, Festuca glauca, Sedum oreganum,* and *Sedum rupestre*. On the intensive plots, the species with the greatest survival were *Sedum rupestre* and *Sedum album*. Knowing the long term survival of these species indicate they are adaptable and resilient to the Portland climate and should be considered for other local green roofs.

The colonization by outside species indicate how important maintenance is to ensure the desired plant composition remains intact. The high percentage of new species across all plots suggest that research should be conducted to review the fit of colonizing species on green roofs. If these species colonized CHERP and prove to be resilient to the Portland climate, they should be added to the list of suggested plants for green roofs.

The overall, the plants chosen for CHERP did well on the Cramer Hall rooftop. After four years, 9 out of 12 native species and 13 out of 14 nonnative species survived.

A future study can be to repeat the study to see if the same observations can be made. In addition, compiling a more thorough study to incorporate substrate, insects, temperature, plant coverage, plant height, and plant diversity would provide a greater understanding of the Cramer Hall green roof. It would also be valuable to conduct the same study on other green roofs to see how the same species fair on different rooftops and green roof designs.

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