White Paper

A Blue-Green roof enhances plant growth and reduces irrigation requirements

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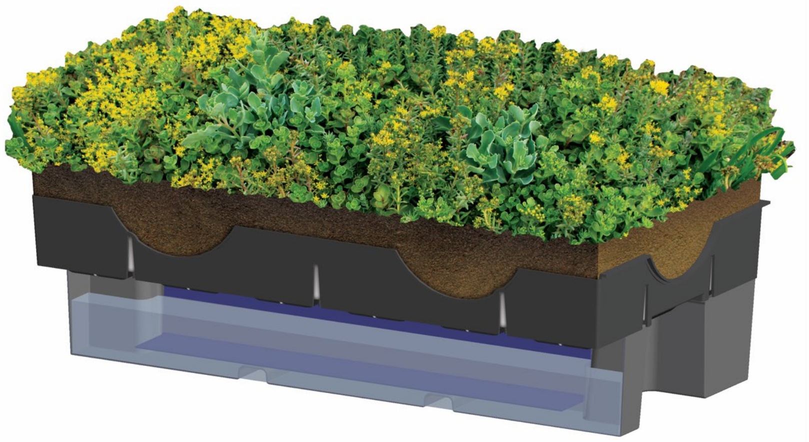


LiveRoof RoofBlue® RETAIN™

Introduction: Stormwater retention represents an important benefit provided by green roofing systems, and continues to be a priority in the development of stormwater management policies regarding green roof installation in North America. This can lead to water retention standards that exceed what can be accomplished with soil (growing media) alone. And, there are various methods that have been conceived to boost water retention. However, enhancing stormwater retention can result in trade-offs regarding plant health and green roof functioning.

Plants require a growing medium that is well-oxygenated, and neither too dry nor too wet in order to be healthy and sustainable. Therefore, any additional stormwater retention beyond the soil's water holding capacity must be designed in a manner to avoid over-saturating the soil—as over-saturated soil causes oxygen depletion (in the root zone of the plants), triggers root-rot diseases, and compromises plant health and longevity. This is particularly true of sedums, which are succulent plants commonly used in green roof systems. The goal of this study was to compare plant health (as measured by biomass) and water conservation between three LiveRoof hybrid green roof system profiles (Lite 2.5" soil, Standard 4.25" soil, Deep 6" soil), and the same system profiles with the addition of the LiveRoof RoofBlue® RETAIN™ water retention component.

Watch Video: Introducing LiveRoof RoofBlue® RETAIN™

This experiment follows work on stormwater retention done by Bradley Rowe, PhD and Kristin Getter, PhD (2022), entitled "Improving Stormwater Retention on Green Roofs," and seeks to quantify plant growth and irrigation savings.

Specifications: In the Rowe and Getter study, the LiveRoof RoofBlue® RETAIN™ system was used as the water retention feature and proved to be an excellent method to enhance stormwater capture and as an alternative to rockwool. It is a sturdy, water-holding design that resists frost damage, compression, and degradation over time. Expected to last a lifetime, RoofBlue® RETAIN™ is 100% recyclable with a lower carbon footprint than rockwool.

Study Design: In April 2022, twelve treatments containing 24 individual modules were each planted with the same type, arrangement, and quantity of plants. Each module was overlayed with a mixture of sedum cuttings – to be used as a living mulch, along with two plug-planted accent plants. Planting was conducted in a greenhouse for establishment. During the third week of May, the plots were placed at-grade outdoors at LiveRoof LLC. in Nunica, MI. All the plots were placed overtop a single layer of dimple board for drainage.

Module type	**Soil depth (in)**	**Max weight at capacity (lbs./ft^2)**	**Max water volume retention (gal/ft^2)**	**RETAIN max water holding capacity (gal/ft^2)**
RETAIN - Lite	2.5	≤ 29.5	0.6	1.35
RETAIN - Standard	4.25	≤ 41.5	1.0	1.35
RETAIN - Deep	6.0	≤ 62.5	1.3	1.35

LiveRoof Hybrid Green Roof System properties for the lite, standard, and deep modules.

	Plants per module (module size 2ft^2)		
	Lite	**Standard**	**Deep**
Control (n = 24)	Sedum cuttings + 2 Alliums	Sedum cuttings + 1 Allium + 1 Grass	Sedum cuttings + 1 Grass + 1 Forb
Experimental with RoofBlue® RETAIN™ (n = 24)	Sedum cuttings + 2 Alliums	Sedum cuttings + 1 Allium + 1 Grass	Sedum cuttings + 1 Grass + 1 Forb

Plants per module for the control (module only) and experimental (module + RETAIN) plots.

Treatments included lite, standard, and deep modules, with and without a RETAIN feature, with half left unirrigated, and the other half irrigated as needed (as evidenced by wilting at 8:00 AM).

Plot number	Module type	RETAIN accessory	Watered as needed
2	Lite	–	–
1	Lite	RETAIN	–
8	Lite	–	Yes
7	Lite	RETAIN	Yes
4	Standard	–	–
3	Standard	RETAIN	–
10	Standard	–	Yes
9	Standard	RETAIN	Yes
6	Deep	–	–
5	Deep	RETAIN	–
12	Deep	–	Yes
11	Deep	RETAIN	Yes

Experimental treatments. Each plot number represents a single block composed of 24 modules.

Methods: A photograph was taken of each plot on the first of every month. Half of the plots were not irrigated at any point during the study, and the other half were irrigated only when any accent plant was visibly wilted at 8:00 AM. When visible wilting occurred, the plots were irrigated as follows: 1.2 gallons per module for lite modules (0.6 gal/sf), 2 gallons per module for standard modules (1 gal/sf), and 2.6 gallons per module (1.3 gal/sf) for deep modules. All irrigation events were recorded.

In October 2022, plots were harvested completely, washed, and weighed. Later the same plants were dried and reweighed for comparison. Drying was conducted under infrared heat at 70^{0}F.

Results and Discussion - Water Conservation Assessment: With the irrigated plots (where irrigation occurred only when signs of wilting were present at 8:00 am), the RETAIN plots required 43-78% less irrigation than the module-only plots, depending upon soil depth.

	Qty	# Times irrigated	Total gallons added	Net irrigation reduction
Lite	28.8	6	172.8	
Lite RETAIN	28.8	3	86.4	50% less H_20
Standard	48	9	432	
Standard RETAIN	48	2	96	78% less H_20
Deep	62.4	14	873.6	
Deep RETAIN	62.4	8	499.2	43% less H_20

Total gallons added to the plots that were irrigated when visible wilting occurred at 8:00 am.

The RETAIN plots demonstrated better tolerance for drought as they required substantially less watering over the course of the experiment, regardless of soil depth. Upon dismantling the plots at the end of the experiment, the soil was observed to hold significantly more moisture than the module-only plots, with visible root growth penetrating the RETAIN wicking material. This implies that water is migrating from the RETAIN basin to the soil of the modules, and recycling water and nutrients that would have been lost to runoff – thus resulting in significant water conservation. The higher soil moisture also supported more biomass growth as the plants were able to utilize the excess water after rain or irrigation events, and presumably capture more nutrients.

Results and Discussion - Plant Growth Assessment: In terms of plant biomass, plant growth was 37.17-122.74% higher in RETAIN plots for the non-sedum species, compared to the module-only plots. The sedum species weighed more with the RETAIN accessory for the lite and standard plots that were not irrigated (56.84% and 0.73% respectively), while the irrigated standard and deep plots had less biomass in the module + RETAIN plots (-12.3% and -25.41% respectively).

Module	RETAIN	Watered	Sedum avg (lbs.)	% Change	Non-sedum avg (lbs.)	% Change
Lite	–	–	11.03		2.38	
Lite	RETAIN	–	17.30	+56.84	3.58	+50.40
Lite	–	Yes	11.28		2.83	
Lite	RETAIN	Yes	16.00	+41.84	5.70	+101.41
Standard	–	–	16.38		2.90	
Standard	RETAIN	–	16.50	+0.73	5.15	+77.58
Standard	–	Yes	16.25		5.38	
Standard	RETAIN	Yes	14.25	-12.30	7.38	+37.17
Deep	–	–	15.05		2.55	
Deep	RETAIN	–	9.78	-35.01	5.68	+122.74
Deep	–	Yes	9.05		12.38	
Deep	RETAIN	Yes	6.75	-25.41	17.25	+39.33

Average dry weights of sedums and non-sedums in pounds (lbs.).

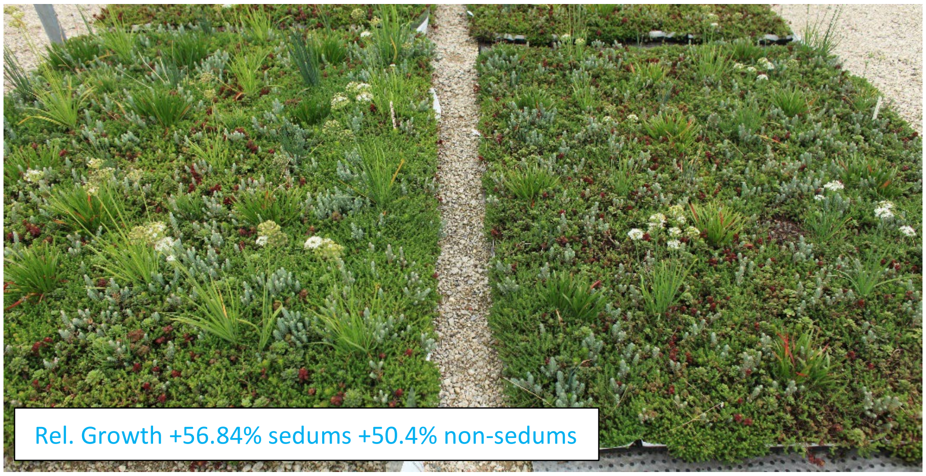
The RETAIN plots substantially increased the amount of plant growth across all the RETAIN plots for the grasses, alliums and other forbs. This could indicate that the increased water availability supported more plant growth. The sedums showed less differences between the RETAIN and module-only plots, which may be because they rely less on irrigation to remain robust and healthy. In addition, the lower biomass of sedum in the standard and deep plots is likely due to the increased growth in non-sedum plants, crowding out the sedums.

Summary: Overall, RoofBlue® RETAIN™ represents a potential solution to increase stormwater management while maximizing plant growth and minimizing irrigation use. A recent study by

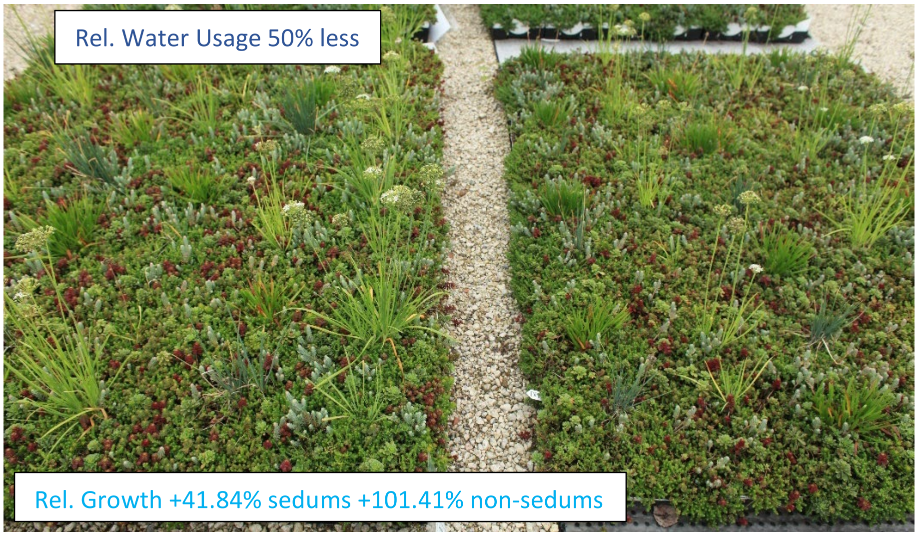
Droz et al. (2021) showed that unirrigated blue-green roofs were able to support a diverse range of plants, and that the soil within them held onto soil organic matter longer than other green roofs. This may be what is occurring in RoofBlue® RETAIN™, with the nutrients in the soil remaining in the system long enough to support the plants within. For projects where traditional methods (cisterns and/or rain gardens) prove impractical or expensive, or where irrigation water is scarce, the RETAIN system may be a practical solution for stormwater conservation, reduction of irrigation water, and optimization of plant growth.

	Lite	**Standard**	**Deep**
Sedum Base Cover Mix	*Sedum reflexum* Sagebrush® *Sedum reflexum* Pine Forest® *Sedum floriferum* Emerald Carpet® *Sedum hybridum* Siberian Greenfast® *Sedum spurium* Peach Blush™ *Sedum sexangulare* Elatum *Sedum hybridum* Mini-Grunchen™ *Sedum spurium* Rhubarb®	*Sedum reflexum* Sagebrush® *Sedum reflexum* Pine Forest® *Sedum floriferum* Emerald Carpet® *Sedum hybridum* Siberian Greenfast® *Sedum spurium* Peach Blush™ *Sedum sexangulare* Elatum *Sedum hybridum* Mini-Grunchen™ *Sedum spurium* Rhubarb®	*Sedum reflexum* Sagebrush® *Sedum reflexum* Pine Forest® *Sedum floriferum* Emerald Carpet® *Sedum hybridum* Siberian Greenfast® *Sedum spurium* Peach Blush™ *Sedum sexangulare* Elatum *Sedum hybridum* Mini-Grunchen™ *Sedum spurium* Rhubarb®
Forb Accent Plants	*Allium schoenoprasum* 'Pink Giant' *Allium cernuum* *Allium* Balloon Bouquet® *Allium tuberosum* 'Geisha'	*Allium schoenoprasum* 'Pink Giant' *Allium cernuum* *Allium* Balloon Bouquet® *Allium tuberosum* 'Geisha'	*Agastache foeniculum* *Allium schoenoprasum 'Pink Giant'* *Amsonia hubrichtii* *Asclepias tuberosa* *Aster laevis* *Callirhoe involucrata* *Coreopsis lanceolata* *Dalea purpurea* *Echinacea purpurea* *Liatris aspera* *Penstemon digitalis* *Rudbeckia hirta* *Solidago speciosa* *Tradescantia ohiensis*
Grass Accent Plants	None	*Bouteloua curtipendula* *Koeleria macrantha* *Schizachyrium scoparium* *Sporobolus heterolepis*	*Andropogon gerardii* *Bouteloua curtipendula* *Chasmanthium latifolium* *Eragrostis spectabilis* *Koeleria macrantha* *Panicum virgatum* *Schizachyrium scoparium* *Sporobolus heterolepis*

Plant species used in each module depth (lite, standard, deep).



Lite module system, unirrigated. Left is module + RETAIN plots, right plot is module only.

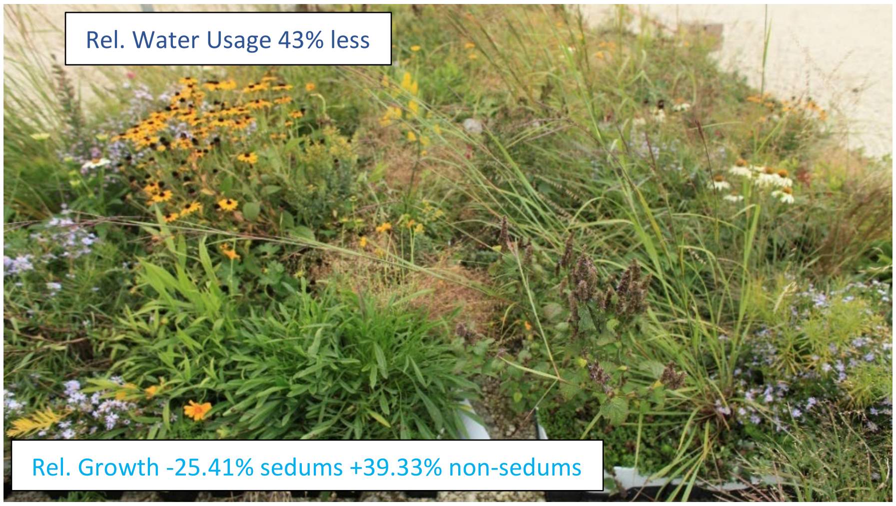


Lite module system, irrigated. Left is module + RETAIN plots, right plot is module only.

Standard module system, unirrigated. Left is module + RETAIN plots, right plot is module only.

Standard module system, irrigated. Left is module + RETAIN plots, right plot is module only.

Deep module system, unirrigated. Left is module + RETAIN plots, right plot is module only.



Deep module system, irrigated. Left is module + RETAIN plots, right plot is module only.

References:

Droz, A. G., Coffman, R. R., Fulton, T. G., & Blackwood, C. B. (2021). Moving beyond habitat analogs: Optimizing green roofs for a balance of ecosystem services. *Ecological Engineering*, 173, 106422.

Rowe, D. B., Getter, K. L. (2022). Improving stormwater retention on green roofs. *J. Liv. Arch*, 9 (1), 20-36.