



The green roof at the Recreation and Wellness Center at UNL is a small project, measuring 18.5' x 12'. While it is a great demonstration project, Sutton cautions about the challenges of working with biochar on a large scale. As of now, few green roof substrate providers use biochar in their blends so on-site mixing may be the easiest way to incorporate biochar in the growing medium. Mixing the components together is crucial to creating a successful green roof soil bed. Biochar is a bulk product and can be difficult to handle and keep free from contamination. Ensuring a hard surface—like an empty parking lot—is available for mixing reduces the chance of weed contamination.

More research and demonstration projects are needed before the addition of biochar to green roof substrates becomes commonplace. Sutton believes it all comes back to runoff, and how the industry addresses the issue. Demonstrations and research will advance our understanding of how biochar can improve green roof runoff. However, if neither markets nor industry demand cleaner runoff, the issue will persist or grow as development in urban areas continue.

Biochar is a promising solution to the myriad challenges of green roofs.

# GREEN ROOFS

## BIOCHAR AND YOU

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A University of Nebraska-Lincoln student looks over the grasses in a “green roof” at the University’s East Campus. (Courtesy Troy Feddersen.)

“Green roofs” are an increasingly popular practice that can accomplish a wide variety of jobs in the urban landscape. Whether you are looking for reductions in utility costs, providing habitat for resident and migrating wildlife, or even utilizing your roof for hyper-local food production—there isn’t much a green roof can’t do. However, that is not to say establishing your aerial Eden doesn’t take a bit of preparation. This publication will talk you through the opportunities to incorporate biochar into your green roof.

### COMMUNITY BENEFITS

It is well established that urban greening has myriad community benefits. The urban heat island effect is a well-studied phenomenon of cities. Due to the hard surface infrastructure in cities such as asphalt, concrete, stone, and roofing materials, temperatures in cities can be substantially higher than surrounding rural areas. Like tree planting, green roofs are a type of green infrastructure that reduce storm water runoff, lessen the heating and cooling requirements of build-

ings, and regulate the microclimate. Green infrastructure can improve public health by reducing the particulate matter in the air, preventing smog production, and capturing airborne pollutants. Urban green spaces are also touted to reduce stress and crime, improve property values, and enhance overall well-being and sense of community.

### ECOSYSTEM BENEFITS

Green roofs offer many ecosystem benefits. They can serve as habitat for pollinators, soil invertebrates, and bird species. They may be part of a green corridor that spans a city, or provide a way station for migratory birds and butterflies. Probably the most commonly boasted benefit of green roofs is the role they play in storm water management. Green roofs have the potential to retain up to 90% of precipitation from rainfall events in the summer months, and up to 40% during winter. Not only do they reduce the volume of runoff, they can improve the quality of the runoff by reducing levels of common pollutants.



# GREEN ROOF CHALLENGES



By using biochar as a substrate, Dr. Sutton and his students were able to achieve a weight of 21.1 pounds per sq. ft. (see next page).

## STRUCTURAL LOAD LIMITS

While green roofs provide many social, economic, and eco-system benefits, they are not without their challenges. One such hurdle is during the first years after the installation of a green roof.

Green roofs, while reducing pollutant runoff, exhibit increases in runoff of phosphorus and nitrogen. This often results in a yellow or tea-colored water which is likely the result of humic acids. After the first couple of years, the roots stabilize the soil and the runoff becomes less tainted with nutrient runoff. However, the question remains of how to provide plants with the nutrients they require while not simultaneously increasing pollutants during the establishment period.

A second challenge of green roofs is the overall weight of the substrate that is required to prevent damage to the rooftop while supporting plant growth. Most roofs have a minimum load requirement of 30 pounds per square foot to accommodate snowfall, and adding soil to a rooftop can quickly exceed load requirements.

## BIOCHAR & GREEN ROOFS

Biochar is a product that shows promise in addressing issues of green roof weight and runoff. Biochar is a solid carbon material produced from organic material. It is similar to charcoal in its composition, but it's used as a soil amendment, not fuel. Biochar is highly porous, lightweight, and long-lasting. It prevents nutrients from leaching while simultaneously making them available to plants. The water holding capacity of biochar is also attractive because it is often only a few inches thick. Additionally, biochar production is carbon neutral contributing to the environmental sustainability of a green roof.

A green roof project completed in Oregon provided valuable insights into the use of biochar in green roof substrates. Biochar was added to a typical green roof at a rate of 7% and planted with sedum and ryegrass. Measurements and analysis showed the addition of biochar improved the water quality of the runoff (see table 1). The runoff had measurable decreases in the concentrations of nitrate, total nitrogen, phosphorus, total phosphorus, and organic carbon, an increase in water retention, and a decrease in overall runoff quantity.

SITE ATTRIBUTE	BIOCHAR	CONTROL	%Δ
Added Water Retained by Soil (%)	31.05	26.1	19
Nitrate (mg/L)	12.25	40.65	69.9
Phosphate (mg/L)	8.25	11.05	25.3
Total Phosphorus (mg/L)	8.35	13.85	39.7
Total Organic Carbon (mg/L)	23.65	76.2	69.0
Total Inorganic Carbon (mg/L)	14.95	15.95	6.3

# CREATING A GREEN ROOF

When Richard Sutton, emeritus professor of agronomy and horticulture at the University of Nebraska-Lincoln, heard about the use of biochar for green roofs at a conference, he was intrigued by the concept. In 2017, Sutton and his students established a green roof on the University's Recreation and Wellness Center on East Campus. With a focus on sustainability, all materials were chosen from recycled or locally sourced products. Crumb rubber, one of the substrates for the project, is produced by reducing scrap tires to uniform sizes. The biochar used was produced from Nebraska ponderosa pine waste wood. Using these ingredients, Sutton's green roof substrate achieved a weight of 21.1 pounds per square foot.



## STEP BY STEP PROCESS

1. Biochar was comingled with compost for two weeks at a rate of 50:50 and turned daily.
2. The biochar compost mixture was blended with crumb rubber in a soil cement mixer.
3. Students layered the green roof substrate starting with a waterproof membrane.
4. Weed barrier/geotextile installed to prevent the breakdown of the waterproof membrane.
5. A turf reinforcement mat (such as Enkamat) was used to allow the water to move horizontally towards the drainage point.
6. Another layer of geotextile was used to prevent downward movement of fine particles.
7. Biochar, compost, and crumb rubber mixture were applied next. A moisture retention mat was not required because the biochar and compost have sufficient water holding capacity.
8. A 1" cap of a commercial green roof material covered the biochar, compost, crumb rubber mixture.
9. Native plants were selected and planted.

### NEBRASKA'S GREEN ROOF PLANT LIST

- Little bluestem (*Schizachyrium scoparium*)
- Big Bluestem (*Andropogon gerardii*)
- Purple prairie clover (*Dalea purpurea*)
- Gayfeather (*Liatris aspera*)
- Butterfly milkweed (*Asclepias tuberosa*)
- Sideoats grama (*Bouteloua curtipendula*)
- Purple lovegrass (*Eragrostis spectabilis*)
- Prairie coneflower (*Ratibida columnifera*)
- Hairy grama (*Bouteloua hirsuta*)
- Blue grama (*Bouteloua gracilis*)
- Many-flowered onion (*Allium multiflora*)
- Sun sedge (*Carex inops heliophila*)