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Advancing our Understanding of Green Roofs with Samantha Hartzell

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Welcome to PDXPLORES, a Portland State research podcast, featuring scholarship, innovations and discoveries, pushing the boundaries of knowledge, practice and what is possible for the benefit of our communities and the world.

My name is Samantha Hartzell and I'm an Assistant Professor in the department of Civil and Environmental Engineering at PSU.

My research is focused on ecohydrology, which is the study of the interactions between water and ecosystems. And so a lot of my research focuses on water use by vegetation in both dry land and urban ecosystems.

Green roofs are roofs which are covered by a layer of vegetation and then typically under that is a drainage layer which captures all the runoff from the system. And so green roofs provide a number of ecosystem services. One of them, particularly in climates like Portland, is a decrease in runoff and so plants transpire water back into the atmosphere and when they do that, they decrease the amount of water that leaves the system as runoff and enters our stormwater system.

Another benefit provided by vegetation on green roofs is evaporative cooling. And so when they transpire water back into the atmosphere, they provide evaporative cooling and they can decrease the urban heat island effects.

Not all vegetation is equal in terms of the ecosystem services that it provides. And so a lot of the ecosystem services provided by vegetation depend on the amount of transpiration or the amount of water that vegetation returns to the atmosphere. Species that transpire more water will tend to have more runoff reduction and more of a cooling benefit whereas species that transpire less water will have less ecosystem services. However, those species tend to be more hardy and easier to maintain so there tends to be a trade-off between costs and benefits of various vegetation types.

I have a new NSF study in which we're studying the impacts of various vegetation types on green roof ecosystem services. And so a lot of plants that tend to be used on green roofs are CAM photosynthetic species. And these species are really unique because they transpire water back into the atmosphere at night, instead of during the day, like most plants, and this allows them to use about 5 to 10 times less water than typical plants like grasses.

The focuses of our study are twofold. We're planning an experiment in which we're planting sedum which is a typical green roof species and grasses, and we're measuring the difference in runoff between these two vegetation types. Then secondly, we're going to be developing a computer model, which takes into account species specific differences and plant photosynthesis and hydrology in order to better understand ecosystem services of these various vegetation types.

CAM stands for *crassulacia acid metabolism* and this comprises about 6% of plant species. And these plant species are unique because they transpire water during the night instead of during the day. And they also have this really unique circadian rhythm. And so you can kind of think of it like a human sleep wake cycle. So humans tend to wake up when the sun rises and they tend to go to sleep when the sun sets. And similarly CAM plants are influenced by the environmental conditions. But they also have what's called an endogenous or a built in circadian rhythm. So if I were to put a human in a bright room for several days, they would still fall asleep and wake up on roughly a 24 hour cycle.

And just like that CAM plants have a built in circadian rhythm. And so if I put a CAM plant in a bright room for several days, it's still going to essentially fall asleep and wake up with the circadian rhythm. And so that's made it really difficult to capture CAM plants in a photosynthesis model because most models of photosynthesis that we have depend on the current environmental conditions and don't take the circadian rhythm into account.

Back in 2014, Mark Bartlett and Amilcare Porporato at Duke University developed this really elegant circadian rhythm model for CAM species. And that has allowed us to understand their carbon and water fluxes on a detailed level really for the first time. So I've been building on some of the work that they did to better understand the role of CAM plants in both natural and built environments.

One thing that we're going to be doing in this study to advance CAM modeling is taking into account facultative CAM plants. And these are plants that can actually switch from typical C3 photosynthesis when they're well-watered to CAM photosynthesis under drought conditions and this really enables them to optimize their water use and a lot of plant species that are used on green roofs are actually facultative CAM plants like sedum so we're hoping that this will both advance our understanding of green roofs, but also advance the state of CAM modeling.

We're currently working with the CEE Senior Capstone design class to build six trays, which are going to simulate the green roof environment. So these trays will have a layer of vegetation and then underneath that they're going to have a drainage layer, which is going to enable us to capture all the runoff from the system. And so at these sites, we're going to be measuring environmental conditions like solar, radiation, temperature, humidity, and rainfall. And then we'll also be measuring outcomes like soil moisture and we'll be doing this for three different types of plants, a sedum, which is like CAM species, a warm season grass and a cool season grass.

And so the goal of this is to simultaneously develop a computer model, which can help us understand species specific impacts on runoff reduction and we're going to use the data that we collect from this experimental site to parameterize and validate the model. We're hoping to develop a computer model which can help us understand the impacts of various vegetation types as a function of prevailing climate conditions.

So there's been a lot of increase in green roof policy guidelines recently, both green roof mandates and green roofs incentives. We've seen recently the city of Portland developed the central city 2035 plan, which mandated the use of green roofs on buildings over 20,000 square. And so even though there's more and more policy guidelines there is still not a lot of guidance as to which types of vegetation are best to use and in which climates. We're hoping our research will help add to this body of knowledge.

I think that it's interesting that we can use the green roof environment as a microcosm for other types of environment. And so as well as learning about green roofs, this study will help us advance the state of CAM modeling and better understand what's going on in dry land ecosystems.

CAM plants are very common in dry land ecosystems. And because the state of CAM modeling is behind that of typical plants. It makes it really difficult for us to understand the carbon and water fluxes in dry land ecosystems. And so the more that we advance the state of CAM modeling, the better we can constrain, expected carbon and water fluxes and dry land ecosystems, especially under the influence of climate change.

I'm Samantha Hartzell, and my research focuses on the interactions between vegetation and the water cycle to help us optimize the use of water resources.