Leaf Litter
Spring Equinox 2009 Restore the Earth and Inspire Ecological Stewardship www.biohabitats.com
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Thoughts on Green Roofs & Living Walls

In the 7th century B.C., King Nebuchadnezzar II constructed the Hanging Gardens of Babylon, a series of simulated mountains with planted terraces.

According to the writings of an ancient historian, the site had "plants cultivated above ground level," with "roots of the trees ... embedded in an upper terrace rather than in the earth." While the King was more likely concerned with pleasing his wife, who missed her verdant homeland, than with sequestering carbon or cooling the palace, the site became one of the earliest examples of a green roof.

Many forms of green roofs followed, including the sod roofs of northern Scandanavia, the roof garden atop the Hermitage in St. Petersburg, Russia, and the tiny garden on the Tower of Guinigis in Lucca, Italy. It wasn't until the 1960s and 70s in Germany, however, that people began using green roofs as a means of improving the quality of the urban environment. It wasn't long before the rooftop greenery expanded to cover walls.

Source: Robert Berghage, Ph.D.

Today, as the benefits and logic of green roofs and living walls become increasingly obvious, a new form of real estate is emerging. Once thought of merely as a protective covering and space to store unsightly air conditioning units and water tanks, rooftops are becoming new and powerful landscapes. In addition to adorning a property and adding space for living and recreation, green roofs and living walls have the potential to save energy, reduce maintenance costs, retain and use stormwater, create habitat, provide agricultural space, filter air, reduce noise and improve the quality of life.

But are all green roofs and walls reaching this potential? Who is leading the way? What techniques and materials are proving to be the most effective in green roof construction? Are green roofs and walls beginning to influence the fields of architecture and engineering? Join us as we take a look at what is, in North America at least, a new and very exciting industry.

We begin with a visit to Emory Knoll Farms, a nursery specializing in green roof plants. We not only had the chance to chat with the nursery's owner, Ed Snodgrass, but also got to climb on top of his office and check out his own green roof.

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View the video of our visit to Emory Knoll Farms on YouTube.

Click the thumbnail to the left or click here

We then head to Penn State University to speak with two gentlemen who are at the forefront of green roof and living wall research in the U.S. Dr. Robert Berghage, associate professor of horticulture and director of the Center for Green Roof Research, and Ph.D. Candidate Bob Cameron talk about the ups and downs of these relatively new technologies. They also take us on a tour of their greenhouse.

View the video of our visit to Penn State's Horticulture Greenhouse on YouTube.

Click the thumbnail to the left or click here

In this issue of Leaf Litter, we are pleased to launch a new section - our Non-Profit Spotlight. We are delighted to highlight Green Roofs for Healthy Cities.

For those interested in learning more about green roofs and living walls, we provide loads of resources. Be sure to check them out. Finally, catch up on the latest at Biohabitats.

As always, we want to know what you think. Share your thoughts on Leaf Litter by contacting our editor.

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Leaf Litter Talks with Ed Snodgrass

Owner, Emory Knoll Farms

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Ed Snodgrass, a fifth generation farmer and nurseryman, is president and founder of Emory Knoll Farms, Inc. and Green Roof Plants, North America's first nursery specializing in green roof plants and horticultural consulting. Since its inception, Emory Knoll Farms has supplied plants for over 300 green roof projects throughout the United States and Canada. Ed collaborates on green roof research with academic institutions including Penn State University, North Carolina State University and Michigan State University, and he advises clients such as the Singapore Botanic Gardens and the U.S. Botanic Garden on green roof installations. A popular speaker and published author, Ed lectures widely at universities and regional, national and international conferences and has been featured in *The New York Times* and on the Sundance Channel's Ecobiz documentary series, among others. Ed co-authored *Green Roof Plants: A Resource and Plant Guide* (Timber Press, 2006) and is currently at work on two new books for Timber Press.

When did you decide to dedicate your agricultural business to rooftop plants?

I took over the farm in 1972 and stopped farming in 1983. I made money every year, except 1982. That year, the Soviets invaded Afghanistan and we embargoed the Soviet Union, which was our biggest grain customer. This cut the price by a third. Ironically, I had my best year in 1982 in terms of yield, weather, and everything - except price. Also, at that time, interest rates were very high – 19%. So for all the money I borrowed to put my crop in I was paying back $1 out of every $5 in interest. These combined factors created a tsunami of economics, so I left farming. I came back to the farm in 1997.

I wanted to get the lexicon of "plants on top of things" out there. Since I didn't have any green roof customers yet, I started by building little green roof birdhouses and bird

feeders and selling them at farmers markets. That got people thinking about the concept.

What sort of reaction did you get – from friends, family, members of the farming community - when you made the decision to return to farming and focus on plants for rooftops?

I was under the radar at first, because I had plants before I had customers. Sure there *were* some raised eyebrows. A couple of years ago, however, we won the Innovative Farmer of the Year Award, which is awarded by a peer group of farmers in the county. So obviously, I've gained the acceptance of local farmers.

How did your journey into sustainability begin? I read that the "The Natural Step" framework played a role. Is that true?

My father and grandfather were sustainability people for their generations. I remember getting lessons like, "Work with nature; not against it" as a little boy.

The Natural Step really gave me a framework in which to operate. It helped me make decisions when I "rebirthed" the farm from agricultural production into niche nursery.

How did you first hear about The Natural Step?

I can't actually recall. I was Director of Education at Living Classrooms Foundation and was doing a lot of ecological, environmental and social curriculum development, and may have first run across it then. I went to Natural Step conferences in Atlanta and San Francisco. I ended up in Stockholm for something unrelated, and since I had a business card with Karl-Henrik Robèrt's (founder of The Natural Step) address on it, I decided to find him and talk to him.

Was that the turning point for you, when you decided to go back to farming in a new way?

Yes.

I didn't leave the farm willingly. I left because I went broke. When I was off the farm, I was always trying to find a way back.

When I looked back at farming, I decided that as a businessperson, I was not controlling the revenue side of my equation because the price is set on a world commodity market. Soybeans, corn, wheat, etc. are controlled by the Chicago Board of Trade. And I wasn't controlling the expense side of the equation. If you do row crop agriculture, you're planting hybrid seeds, using certain chemicals, etc. If you choose to go organic, it takes you seven years to get your certification. You have to be off chemicals for seven years, so the bridge is very difficult.

We tend to have this iconic view of farmers as rugged, independent individualists. But when I looked at this from a business point of view, I discovered I was very dependent. I had no control over expense or revenue. One of the things that inspired me was to get out of that cycle of dependency and find a way that was a little more bucolic than being on a tractor in a paper suit with a respirator spraying chemicals on the land.

When you're generational, you come into that. I also realized that the farm operation wasn't of my design. The time away helped gestate all of that. Out of that gestation, The Natural Step became the framework to operate in. It gave me a scorecard to use. I was able to say, "If I try this crop, how does that fit in the Natural Step?"

Do you sell plants for green/living wall construction as well?

Yes.

From where is most of your demand coming? How has this demand changed since you decided to focus solely on plants for roofs?

Our plants are sold in states that have evenly distributed rainfall. That goes from Georgia up through Maine, across the Great Lakes, and down through Missouri. We also have some customers in Hawaii and the Pacific Northwest. If you look at plants growing up on top of buildings without irrigation, you have to have the rainfall spread out.

Do you have any customers outside of the U.S.?

We have sold plants in Canada, Singapore, Hong Kong and Japan. But these have been more for research. The Singapore Botanic Gardens did a green roof research project. We sent starter plants to nurseries in Hong Kong and Japan. Ironically, I think a lot of the plants we sent there were Asian natives.

Has the demand for rooftop plants changed since you started this business? If so, how?

We have grown about 70% a year since 2001, from a financial point of view. The projects have increased in number and in size. The competition has increased, and we've still been able to increase volume, so the total market is growing.

But when your multiples are very low to start with, your percentages can be very high. I had one customer in 2000 and two in 2001, so I had 100% growth that year!

How many customers do you have now?

Hundreds. We are pushing 300 projects.

We are trying to figure out how we can ship across the whole U.S. with a very low carbon footprint. We have five or six other nurseries throughout the U.S. so we can take an order here, but fulfill it in the neighborhood where the green roof is.

Your operation is, itself, striving toward sustainability. In addition to the challenge of shipping plants throughout the U.S. while maintaining a low carbon footprint, what have been the major challenges to becoming a sustainable operation here at the farm?

Most of the technology associated with sustainability is new and unreliable. You end up doing a lot yourself, with a lot of trial and error. From a labor point of view, it's expensive.

John Shepley, my business partner, spearheads and designs those systems for the most part. His background is in engineering. He has been steadily working through the challenges associated with some of the technologies we use.

We use alternative fuel for heating our office and greenhouses. We've had biodiesel gunk up some of our machinery. We've had vegetable oil coagulate in our boiler. When you replace fossil fuels, which have been refined and taken through the whole weights and measures and standards filter, and go instead to backyard and garage production, you get a very uneven and unreliable form. The price is low, but the quality is not consistent.

We pump all of our water with solar. That has been more reliable, but the pumps are expensive. When a pump burns up, we have to get a new one shipped from Arizona. If I had a traditional well pump go up, I'd run four miles out to the hardware store and get a new pump.

The whole alternative energy system is more disparate, unorganized and unreliable. That doesn't mean we'd ever abandon it, but those are challenges when you're running a commercial operation.

One of the things that is most sustainable here is what we don't do. We grow crops that don't need a lot of embodied energy. Most nurseries consume a great deal of energy trying to produce plants that are not easily produced in their geographic region. We limit what we grow and we keep our systems fairly simple. We don't get a lot of off-the-shelf, expensive machines. Even for flat filling, we have a farm wagon and loose soil. It may look inefficient, but the way we measure it, we're not buying a $65,000 flat filler and running a bunch of electricity for it. We also have a sustainable metric that goes along with a profit metric.

I read that you have dedicated a significant portion of your land to restoring indigenous trees and meadows. Is this an attempt to regenerate the landscape that was used for dairy and crop farming for so long (almost 300 years)?

I think there's this notion that we have in the west of maximizing all of your assets all the time. We even have laws called fiduciary responsibility for corporations, where you have to maximize profit. That's such a narrow view of what 'profit' means.

We have about 140 acres that my wife and I own. The family owns another couple hundred acres. We don't have an economic reason to use every square foot of the farm. We make a pretty good living off of about 10 acres of that. Why put all that in production and have all that stuff when we can be a bit restorative? There's another principle at work. We view things very monolithically. When you restore habitat for ground birds and have more diversity in animals and plants, you have a stronger ecosystem. It certainly could go back to agricultural production at some point. It'd be a lot easier to put a meadow back into agriculture than to put a suburb back into agriculture. You'd have to tear up septic systems, driveways, etc. I really think it's economically viable to let it be restorative, from an ecosystem services point of view.

We are in a suburban area between Baltimore and Philadelphia. Until the downturn, the land was very valuable to sell for housing lots. I did the math in my head and said, even if our generation maximizes it by putting as many houses as we'd be legally able to put on it, the money still doesn't last past a generation. In a generation, a million dollars goes away. But the land is producing every year, and has for generations and generations. Any generation previous to me could have sold the land and had that money in their pocket. I'm the beneficiary of their patience. So I don't feel like it's a light decision for me to cash out at any point either.

Has the economic gloom cast its shadow on your business?

We are still getting estimates and seeing business activity. We're kind of a lagging indicator, though, because a lot of the projects we do are commercial or federal, so the budgets may have already been in place. I really don't know. I think there is a bit of a green bubble. My guess is that we'll be even or a little bit ahead of where we were last year. We are small, though. We are a six-person company, so we don't have a lot of labor and overhead. We're also scrappy.

What, in your opinion, is the single most important factor to consider when selecting plant material for a green roof?

The design intent and the maintenance budget. There's way too much deciding on plants before you know what you want your roof to do and what your maintenance budget is.

For example, it seems to be intuitively obvious that you may want to use natives on green roofs because that's an ecological system. But first you have to ask, "What is native? What concentric circles are you going to operate in? The Deer Creek Valley? The

Susquehanna watershed? The East Coast?" After you define what native is, then you have to look at the conditions of that native ecosystem. This land was a mature, deciduous forest. Does that resemble the rooftop? So then you have to determine what kind of support system is needed for regional natives. In my estimation, in this area, that would mean deeper, richer soils, so you'd need to increase the loading for your building. You'd probably need irrigation. In the maintenance of your roof, you'd have to guard against succession, because as you make the system deeper, seedlings and everything else start coming in.

If someone says they want natives, I ask, "Why do you want natives?" If you drill down into the question, you get to the value. I want natives for pollinators. I want natives for bird food. I want natives for macroinvertebrates. I want natives for butterfly habitat. Then, you need to select the plants that suit that group of animals you are trying to attract. You must then understand what scale you need to create habitat, and how you treat and keep it. For example, with butterflies, if you only put up nectar plants, you'll attract adults, and they'll lay eggs, but there's no larval food. The eggs hatch out and the larva will starve to death on top of the building. Larval foods are typically ugly plants and nectar plants are better looking. Everybody plants their butterfly gardens for nectar and not for larval food. This gets down in to very specific choices.

On the other hand, if you're looking for an ecosystem service like stormwater management, you want plants that can absorb water after a drought very rapidly. You want plants that slough root systems and regrow them. If you're looking for cooling, you want plants with a high evapotranspiration rate.

You need to look at the desired function and organize the plants according to that function.

Based on what you see with your own clients, is there one primary reason people are constructing green roofs?

In this area, most of the impetus for green roofs is stormwater management. There's a kind of nexus between the amount of weight a building can hold and maximizing efficiency for stormwater. Obviously, if every building in a city could have a foot of soil on it, you would have almost no runoff from rooftops. But that's an impractical financial thing to ask. It ends up being about 3 inches of media. That's a typical profile for a green roof.

Is this true for commercial *and* residential buildings?

Yes, because that is around 25 pounds of load and that can be accommodated without a lot of extra expense in the construction process. Stormwater engineers have found that somewhere within that three to four inch range, they are getting the performance they need for their system and if you spend the money to go beyond that, you have a declining curve of performance relative to cost. What stormwater engineers are looking

for is to dampen the peak flow. Say you get a half inch of rain in 20 minutes. It's not a lot of rain, but fills all of the pipes in the cities and overflows. If you have that same amount of rain on a green roof, it goes off very slowly. It dampens the peak flow. A three or four inch system will dampen the peak flow just as well as a thicker system.

Another factor is total annual volume. With three to four inches on your green roof, depending on your climate, 50-60% of annual rainfall never leaves the roof. That means if you put green roofs on enough rooftops in an urban area, you can cut in half your total volume [of stormwater] going through the system. Ninety percent of our rain events are under ¾ inch in volume. If you know these things, why build a more expensive system? At least from a stormwater management perspective.

Unless your primary goal is something other than stormwater management, such as aesthetics, increased living or recreation space and evaporative cooling, right?

Yes, but the thing about green roofs, and living systems in general, is that it's hard for any one single thing to give you a true return on investment because emerging technologies are more expensive. But green roofs are very competitive because they do many things at the same time. You get aesthetic value, stormwater value, evaporative cooling, insulation when the system is dry, pollinator food, etc. You get all these benefits layered together.

John Todd at the University of Vermont, talks about living systems longitudinally, because they can become locally adapted to the conditions.

When he builds sewage treatments just out of biological parts. He found that after a generation or two, the plants get used to the effluent they are treating and they get better. If the system collapses, it tends to self repair. Living systems tend to self actualizing and adjusting. Mechanical systems are subject to the laws of entropy. Bearings, seize up, belts stretch, motors burn up, etc. Mechanical systems don't adapt to variable flows very well. In a living system, if the effluent slows down, the system dampens down and goes into a stasis and can come back up as the flow increases. Treatment plants have to have a certain volume coming in at all times in order to keep al the bacteria moving.

There is a cascade of benefits on green roofs. So while you probably have a single design intent, the subsidiary benefits don't go away. If you're designing it for butterfly habitat, you'll still get some carbon sequestration, evaporative cooling, aesthetic value, etc.

Have you looked at putting dollar values to the benefits for the ecosystem services provided by green roofs?

I'm on a green roof committee for LID (Low Impact Development). We have to have a long enough market to understand some of this stuff. We're about ten years in. Roofing

membranes are supposed to last 20 years, because generally, roofing manufactures give 20 year warranties. We have a ten year old industry against a 20 year warranty. At the 40-year mark, we'll know more. There's a big economic unknown.

We also don't have any city that has enough green roofs to have affected their stormwater infrastructure. Philadelphia needs a $2 billion pipe, Portland needs a $1.5 billion pipe Atlanta needs a big pipe. D.C. is going to need a big pipe. They have this $1-3 billion project out there and the question is, "Could you put enough green roofs up to not have to spend that?" A lot of planners are saying, "Let's do that, because that's going to be private sector money and not public money." There are big return on investment variables in the equation that are unmet.

There are some that are available that are site specific. In Portland, Oregon, there is a neighborhood development called South Waterfront that was built on a 200-acre brownfield. They did all of their stormwater management using roofs and raingardens. They needed no detention ponds at all. I believe that saved them in the neighborhood of 15 acres in detention pond that became revenue generating footprint. That pays for the green roofs right there.

Your readers should go on the City of Portland's Bureau of Environmental Services web site and look at their green roof regulations. Chicago is doing something similar. D.C. is going to start with a different water tax rate if you have impervious area or not, which is kind of a German model. All this is changing through public policy.

At their core, cities are not getting richer. So they face this dilemma of how to provide basic services to citizens in the face of declining revenues and increasing cost.

If we go to the highest level of thinking, our city problems that are not sociological are from an imbalance of green cells vs. impervious area and animal cells. We have very high animal cells, very high impervious and very low green cells. As we raise those green cells up and get the relationship back in order, good things start happening. We don't have as much stormwater. We have cooler cities. There are even studies showing that crimes go down around good landscaping. The University of Illinois at Urbana-Champaign has a study about this.

The German model is: if we have to spend more money because you created a bunch of impervious area, then you should participate more fully in the taxes than someone who doesn't have any runoff. It's like a user tax. There's road tax in the price of gasoline. If you don't own a car, you're not paying for the roads to be kept up. If you own a trucking company and you're creating more of the road wear, then you pay disproportionately high taxes. That's where I think we're going with city infrastructure, too.

Cities have established floor/area ratios relative to certain areas. Some cities are now saying to developers, "If you green your roofs and make your site zero discharge, we'll give you an extra floor or three floors. It doesn't cost the city any money. The city says

to the developer, "You're helping us with our infrastructure problem; we'll give you more revenue." The developer can then look at construction cost vs. revenue and make a decision. Let's say, hypothetically, that you are a developer. Your construction cost, at the high end, is $250/square foot, including your total burden cost of your development, and you're getting $300-$500/square foot for your property when you sell it. You can pay for a lot of green roofs and rain gardens for $200/square foot when your green roof cost might be $20/square foot. It doesn't take much to figure out that that's a very net positive. But not everybody is going to view it that way. You have to be able to sell the real estate.

What do you think about the feasibility of growing food on green roofs?

Everything is more trouble on a roof. The last place I'd look to grow food in the city is on a roof. It's more dangerous. It's windier. It's going to dry out faster. You're going to have to replace soil. You have issues like fall protection liability. If you look at a city like Baltimore....how many empty alleys are there? How many vacant buildings out there that could be knocked down and made into allotments? There is so much opportunity at grade, where there is water, where you can back a truck up to it, etc. It's just a problem to do things on roofs. Maintenance is much more expensive on a roof. You'd have to have a really good reason for putting that food on a roof.

You also have to consider air quality. Some cities have horrible air quality. How much is that vegetable sequestering chromium, cadmium, mercury, lead, etc. That is all atmospheric.

The National Atmospheric Deposition Project has a web site that will show you what is at any given geographic area in terms of atmospheric deposition. If you're downwind from a bituminous coal power plant, there's atmospheric mercury and lead. So that's probably not where you want to put your vegetable production. Roofs get a lot of deposition on them.

You mentioned maintenance being more expensive. Are maintenance costs generally high with green roofs?

Everything on a roof is more expensive than the corollary at grade.

How about the cost of maintaining a green roof vs. a traditional roof?

The roofing industry is a warranteed industry. The warranty has replaced the maintenance. Regular roofs *should* be maintained two to three times a year. Flashings, drains and other items should be inspected, repaired, etc. But the owner has probably gotten a warranty from the manufacture so there is no incentive to maintain.

So it's not an apples to apples comparison.

No, it isn't. There's more maintenance on a living system than an inert system. That's for sure.

Who, in your opinion, is leading the way, in terms of doing green roofs right?

Irrespective of geography the green roof customer is someone who probably owns and operates his or her own buildings. So someone who is a speculator –who builds a building to sell it when construction is done – is generally not a green roof candidate, because it's a bigger up front cost with benefits down the road. Generally, it's someone who wants to own and operate his or her buildings for a long time. They tend to be more institutional clients – governments, colleges, corporate campuses. They are looking at the long term energy benefits, re-roofing costs, and possibly some kind of goodwill marketing benefit of doing a green roof.

Portland and Seattle are very concerned with stormwater. Chicago was horrified one year to have several hundred people die from heat prostration, so that got them thinking about how to cool the city in non-electrical way. A lot of tree planting, bioswales and green roof initiatives

DC, Baltimore and New York are also incentivizing green roofs in one way or another.

So you see these cities as leading the way?

Yes, but none of them requires green roofs. Go to Lintz, Austria or Stuttgart and Frankfurt, Germany...you put up a new building in one of these cities, and it is going to have a green roof on it.

That would lead me to assume that in places where green roofs are required on flat rooftops, green roofs must greatly influence the architecture and design of new buildings. But here in the U.S., if, as you say, most speculative developers aren't interested in green roofs, perhaps green roofs haven't influenced architecture and engineering very much here. Is that true?

Yes, I think that's true. But we also build differently here. Europe has the experience of having older civilizations. They build buildings to last longer, so they tend to be built heavier to start with. Their roofs tend not to need much engineering anyhow. Frankly, they have degraded their environment over a longer period of time so they need more solutions than we may need right now. We still have a lot of very good habitat left in this country. We have a different set of problems.

Do you think rating systems like LEED are furthering green roofs?

I think it's a double edged sword. LEED provides incentive for green roofs, but there are LEED Gold and Platinum projects with failed green roofs. LEED might provide incentive, but it doesn't necessarily ensure proper design, execution and maintenance. There is this notion

A graduate student at Kansas State wrote a paper about LEED and Green Roofs and the concept of "chasing points." Her paper is entitled *Promoting Sustainable Green Roofs Through Leadership in Energy and Environmental Design (LEED)*. When you really just chase the points to get the points, there's some voo doo there that doesn't help with the success of the project. I think the points should be derived as a result of good, overall design. I think the LEED people would probably agree.

You mentioned failed green roofs. Have you had any "great failures" from which you've learned valuable lessons?

We're not installers, but certainly we have learned a lot more about plants. We've had plants die. We've worked with designers and installers, and we have learned a lot about the weed pressure. Unlike Germany, we have warm nights. So we have a lot more weed pressure than I think many of us anticipated. We have learned that f you don't stay on top of that in the first couple of years, you'll see what I call "horticultural failures." In the hierarchy green roof failures on green roofs, the most catastrophic - which I've never seen or heard of - is the building falls down. After structural failure, the next level of failure would be waterproofing. Then you get into the living part of failure. These are not insurmountable, but they can be pesky. If you get weeds in that produce viable seeds; if you have inappropriate plants or the wrong media, etc. After all the cranes are gone and construction is over, the costs of addressing these problems goes up.

What are some of the most common misperceptions about green roofs?

As you'd find in any emerging market, there are a lot of products and services that are untested. There's a misperception that it's easier than it is. One of the biggest misperceptions is that they are self-supporting systems that need no maintenance. This same thing happened about 20 years ago, when the perennial gardens were sold as low maintenance alternatives to lawn and old-style landscaping. Of course, they turned out to require just as much maintenance as any other garden. The maintenance factor has yet to rear its ugly head because the majority of roofs are under five years old.

When I asked about misperceptions, I expected the answer to be on the fear side.

On the fear side, it's not the load, it's the leak. People worry that their roof is going to leak.

I may have a skewed perspective because I'm on the inside. Right now there are more vendors selling green roof systems than customers. Anything that may exit you out of the sales cycle tends not to be said. Say you're developing a new federal office building in D.C. and you want to do a green roof. You'll have a line of roofing salespeople coming to your door. If any one of them mentioned that the roof will need after market money for maintenance, I'd be surprised. That makes the project look more expensive than

their portion of it. What incentive do they have to bring up the total cost when their price is just for their portion?

How do you feel about the need to educate people about maintenance?

I'm a big believer in full disclosure because I think if you're really on top of it from the start, maintenance is not that expensive. If you don't allow for it, then it can get very expensive.

As the concept of green roofs is *relatively* new in the U.S., it is no surprise that you are very involved in research and development. Can you tell us about any exciting, recent findings? Any cutting edge techniques or materials that look promising? What about from abroad?

There's been this notion from some of the stormwater people that we don't really need plants on green roof, and that all you really need is the media, because that's the sponge, and the plants don't contribute to the system. We work with the Penn State Center for Green Roof Research. They have just proven that the plants do have a real effect on making the system more efficient for stormwater.

The other thing we are learning is that succulents evapotranspirate when water is present at about the same rate per leaf area index as corn. They are very efficient at getting water out into the atmosphere. But when the system dries up, they change their metabolism and go into survival mode. They close their stomata (pores) and can hunker down, whereas most plants continue to evapotranspirate and then sweat themselves to death.

The universities are now getting good local plant information. I think we're a little bit away from hybridizing and breeding plants for green roofs to maximize systems.

The University of Central Florida is taking a whole other approach because it's Florida. They are putting plants with a very high leaf index, such as bananas and calla lilies, on top of a roof. They are trying to get as much leaf area as possible. They have a pond. The stormwater goes off the roof and into the pond, and they continually pump it back up on the roof through these vascular systems.

In the cast of plant characters in the world of green roofs, is there one plant that is a star – a universally strong performer?

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The genus sedum is the number one. If you took all plants off the earth and said, "Design a plant for a green roof. Here are the conditions: it has to live on existing rainfall; it can't add weight to the structure over time; it has to be able to slough all its roots in dry periods and regrow them within a day in the presence of rain; it has to have food for pollinators." You'd design a sedum. It has the metabolism for that. People seem to want to move beyond sedum and get into other bunches of plants, though I'm not sure why.

Courtesy of Ed Snodgrass

Perhaps for diversity?

Well, nothing's diverse if it doesn't live. Nothing is ecological if you have to add a bunch of plastic for irrigation and more steel for load and more embodied energy in terms of expanded materials for media. It doesn't seem to be net ecological to deepen the soil and widen the plant palette. That's why we always go back to design intent. If you are designing for biodiversity and aesthetics, then make that a goal, and make your building accommodate that and put a program in place to maintain that over time. I like to think of these in terms of 50-year systems. If you're beginning with the end in mind, and you think, "I want this garden to be a 50-year garden, which I'm going to maintain two times a year," you're going to have a very narrow list of plants. But if you say, "I'm going to be up there every week taking care of it," then in the same conditions, your plant list grows much wider. Again, maintenance is really a key.

There are little things you can do to remarkably change your plants. You can take a big, flat roof and put some mounds of 10-12 inches in there – possibly over columns – and you wouldn't have a lot of extra expense. You could then put groups of plants in there that would not be sedums. But if you take sedum out entirely, you will have a failed green roof.

How early on do you generally get involved? Do you get the opportunity to ask these questions? I imagine you're not like a typical nursery where customers come to you with a plant list.

Normal, wholesale nurseries do order fulfillment. They have an inventory, they get orders and they ship plants. When they run out of plants, they say they are sold out. We have a lot of opportunities to push back upstream into the design community. I often consult with designers. Also, if we get a list of plants we think will not lead to success, we push that information back upstream – gently. They are free to order what they originally wanted, but we feel an obligation to speak up because we care a lot about green roofs and we want them to be as successful as possible. We do see things like plants on specifications that are not hardy in that geographic region. It's pretty easy to say, "That plant is not going to live through the winter. Is that what you intend?" The same is true if we are asked for plants that we know will be maintenance headaches. For

example, if there are plants that have windborne seeds, we may say, "This is going to blow off of your roof and possibly be a problem for your neighbor."

In researching for this issue, I have seen so many amazing examples of green roofs. What's your favorite and why?

Courtesy of Ed Snodgrass

I think my favorite is the one above our heads because I get to see it every day. It's just so much fun to participate in a garden every day. It's living. It changes from day to day.

My wife and I walk a trail on the farm every day and we see something different every day. I'm very longitudinal, perhaps because my family has been here so long. I enjoy that kind of incremental, steady event, rather than the one, bright, glamorous moment. Getting to know a piece of land intimately over a lifetime is more enjoyable to me than seeing some spectacular thing for an hour. So it's kind of in my ethos to have my favorite garden be the one I see all the time.

The changing hues of Ed's rooftop garden, winter through fall.
Photos courtesy of Ed Snodgrass.

The roof is about three years old. It's always evolving. It was all sedums. Then I put in some bulbs and I've been doing some desert annuals. So it's evolving into something more diverse. It's in a little design of a river, and it's very colorful. Every three or four months, it changes color.

In your travels abroad, have you seen one standout green roofs that really blew you away?

I think my favorite was on a brewery in England called Adnams. Their business was expanding and they needed to build a new, refrigerated warehouse. They were able to eliminate all of their refrigeration units. They doubled the size of their warehouse and now, in their new warehouse, they have no refrigeration units due to their green roof and architectural features. Adnams produces the first "carbon neutral beer." They really think about their whole supply chain.

Adnams warehouse. Photos courtesy of Ed Snodgrass.

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Leaf Litter Talks with Robert Berghage, Ph.D.

Associate Professor of Horticulture and Director of the Center for Green Roof Research at Penn State University

Robert Berghage is an Associate Professor in the Department of Horticulture at Penn State. Dr. Berghage is involved in teaching, research and extension and is the director of The Penn State Center For Green Roof Research. Dr. Berghage's research focus is on phytoremediation systems including green roofs, rain gardens, bioswales, constructed wetlands, and living walls. His extension focus includes these areas and greenhouse crop production and landscape use of herbaceous plants.

Dr. Berghage's primary research focus is on the function and benefits of green roofs, particularly remediation of stormwater runoff, energy conservation, biodiversity benefits, and materials testing and evaluation for green roof systems. The Center for Green Roof Research has documented 50-60% annual reduction in stormwater runoff with a 4" thick roof system, delay in peak runoff flows, reductions in acidity and some nutrient pollutants in runoff. Their research also shows reductions in air conditioning demand in buildings with green roofs. The Center is also evaluating green roof plant materials for pollinator food and habitat.

The roof of Penn State's Cellar Market is a living lab for students in Dr. Berghage's EcoRoof Technology course. Source: Robert Berghage, Ph.D.

This research has resulted in an ongoing partnership with Penn State Physical Plant and the use of green roofs on many of the new campus building projects including the Forest Resource Building, The Cellar Market, The Student Health Services Building, The Dickinson School of Law Buildings, The Hershey Medical Center in Hershey, and the planned Life Sciences III Building.

How did you become interested in green roofs and living walls?

Within the university, you're always hunting for money. The whole reason we got the green roof center started was because, about ten years ago, an industrial client came to us with a product they wanted evaluated for potential agricultural uses. It's the spongy material that's inside your car bumper. It was a sole use material; it was not used for anything other than car bumpers. Around 2000, GM had a strike, and this company had to shut down its factories because they didn't have anything else to use this material for. They came to Penn State looking for alternative uses.

We tried a bunch of things with flow culture, hydroponics, underlayment for playground equipment, etc. - because the material has a spongy resilience. We also put it on green roofs. It worked for a lot of these applications, but it was a little too expensive relative

to other, comparable systems. The only place where it is now used extensively is in acoustics. Because it has very good acoustic properties and is a plastic material that can withstand weather, it's really good in marine engine rooms. So it's used in the engine rooms of boats now.

That's how our green roof research started. From there, we graduated into doing other work in green roof research. We got some funding from the Pennsylvania Department of Environmental Protection to set up the research center. In terms of green roof research in North America, we were probably the first group to get started. In Europe, of course, they've been doing this for years.

What were you doing/teaching before the Center for Green Roof Research was established?

My background is in phytoremediation. I started out with greenhouse and nursery industries, using constructed wetlands to treat wastewater. It's an interesting wastewater stream because it's high in nutrients and very low in carbon. Treating it is very challenging because you don't have a carbon source for all of the microorganisms. It's not like a traditional treatment wetland where you're feeding sewage or some other good carbon source for the microbes to feed on.

If you think about what you're doing when you construct wetlands for wastewater treatment, it's not a big leap to do the same thing on a rooftop or wall. It's all phytoremediation.

One of our water resources engineers wanted to know about soil specs for green roofs. I'd like to take it a step further and ask you to describe the anatomy of a green roof.

There are intensive and extensive roofs. An intensive roof is one that's thick. An extensive roof is a thin soil layer of up to 6 inches. Some people even consider anything up to 12 inches extensive. They are very different animals.

The intensive group is basically landscape over structure. Anything I'd do with my landscape outside, I can do over a structure if I build a solid enough structure and put enough soil on top. The structured soils that go into an intensive roof are a bit different from the soils that go on an extensive roof.

Extensive roofs, which have a very thin soil layer, are put on top of buildings primarily for stormwater management purposes. Although there are energy benefits and other benefits, stormwater management is the real impetus for extensive green roofs.

In Germany, whenever it would rain - very much like it does here - all of this impervious surface in cities like Stuttgart, would cause a lot of runoff. This runoff would go through the sewer system because they've got one set of pipes under the city. Then it would dump raw sewage into the Rhine. So the Rhine was an open sewer every time it rained.

Alternatives for fixing this were very expensive. The idea was to distribute that stormwater management as much as possible -on as many impervious surfaces as possible. A rooftop is a great impervious surface to think about. It's wasted space for the most part. The extensive green roof came about as a result of that.

The structured soils - or media - that we use for extensive roofs are designed to hold moisture. In terms of specifications, we usually want to hold something between 40-50 % by volume moisture when it's at field capacity. We also want about 10-20% air space at field capacity. We generally want a lightweight, aggregate structure. In North America, it's usually something like a clay, slate or shale that has been run through a rotary kiln and popped like popcorn. It becomes a lightweight rock.

In Europe, they use much heavier materials, such as ground up bricks, roof tiles and slates.

They just build their buildings a little bit stronger than we do. In North America, we're stuck in this lightweight aggregate mode. A lot of our buildings aren't built well enough to have much weight on top of them.

As we progress with this industry and do more and more green roofs, I think you'll see more compromises between the weight of the structural soil and the structure of the building -- particularly from an energy standpoint. When you think about the carbon footprint of the green roof, a lot of the carbon costs of that roof is the embodied energy that goes into manufacturing the lightweight aggregate and then trucking it from, say, North Carolina, to the site where you're going to use it. If we used heavier, locally sourced materials, we could get away from a lot of that embodied energy use. The whole LEED and green building idea makes sense: perhaps go with a little heavier grade structural steel and use a locally sourced material.

Out in the West Coast, they've got lava rock - pumice - everywhere. You just mine that stuff and use it directly. You don't have to run it through a rotary kiln. It's there, it's ready, and it has all of the physical properties we're looking for in terms of being lightweight and having large surface areas for microbial attachment and to hold water.

The aggregate material we use is usually very porous. We stay away from sand and silt particles for the most part. We want very low silt and clay percentages. We want it to drain very fast, because when it does rain, we want the media to work as a sponge, but we want the excess water to move off the roof as quickly as possible. We don't want excess weight on the roof, we don't want extra water sitting around, and we certainly don't want surface flows of water because that would cause erosion. You want excess water to go through the roof, hit some kind of drainage layer, and then flow off the roof.

Have you ever seen coarse grade diatomaceous earth used?

No, but it would be a reasonable choice of material. There are a lot of materials you can think about using. Anything that looks like or acts like a gravel or golf course sand

material, or some mix of those, is potentially suitable. The lighter it is, the better it is because of the structural constraints.

What do you think about the use of Styrofoam and other reuse materials as media on green roofs?

Styrofoam is very lightweight, which is good. But it is sterile and inert, which is stupid. It's a non-natural material, which is somewhat problematic in my mind. I have the same problem with using tire crumb. I guess it's a good idea to use waste products in some way, and I guess if you put a waste product upon a roof, it gets rid of it...sort of. But it really just pushes off the need to deal with it.

Have you done any research on any of these materials?

We've done some work with tire crumb. I really don't like styrofoam. I don't use it in my greenhouse nursery soils either. It's just too lightweight. It floats away. I think it's just an environmental nightmare.

To me, a more ideal solution for an old tire would be to grind it up and make a new tire.

So back to the anatomy....I assume the first layer of a green roof is the roof deck, right?

The first thing you have is a roof deck. It might be wood, metal or concrete. Any roof deck made out of concrete is usually capable of supporting a green roof. Most wooden roof decks - like the one on my house, which was built in the 1960s - are not capable of supporting much more than the shingles. In those cases, you'd have to have a structural engineer come in and do some kind of retrofit. Some metal roof decks are capable of supporting a green roof and some are not. Most fiberglass roofs are not capable of supporting a green roof. If it's a new structure you can design the structure with a wooden deck to support the weight.

You have some kind of waterproofing layer on top of the roof deck. The waterproofing material is the same kind of material that we use on any other rooftop - the kind of rubberized, rolled sheet material. Most of the time, on a green roof, we like the waterproofing to be adhered to the roof deck. The advantage to an adhered layer is that if you get a leak, it's easier to identify the source of the leak.

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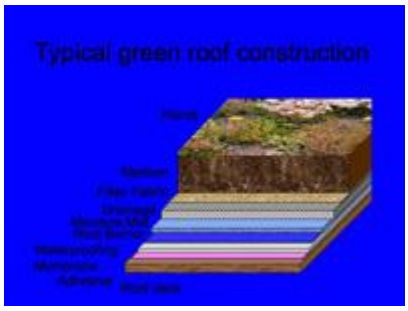

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On top of the waterproofing, you need a root barrier. Some waterproofings are root resistant. Many are not. Any amount of asphalt will be attacked by roots, for example. What we do is lay a layer of plastic - basically construction grade polyethylene - overlap it so the roots cannot get through, and tape the seams so that the whole system is integral and the roots cannot get through.

On top of that, things start to vary depending on whose roofing system you're using, what can be gotten cheap, what they can charge you extra for, and all that good stuff. There will always be some kind of drainage layer. This will either be a coarse gravel type material with some kind of geotextile on top (to keep the media out so fine particles don't fill the pore spaces and extra water can wick off) or it will be a geotextile sheet type drain. This sheet drain would be the same stuff we use at grade in landscapes for the same purposes. The drain layer is contiguous with whatever roof drains you have. If you have a flat roof with stand up drains, the layer will be contiguous with that. If you're sloping down to a gutter, your drain layer will be contiguous with the gutter connection.

On top of the drainage layer, you'll have a layer of some kind of aggregate media. That aggregate media may be anywhere from two to four to eight inches thick, depending on the project. Four inches seems to be a reasonable compromise between weight and function, from a stormwater standpoint.

Have you learned that from your research at the Center?

We've learned it through research we've done, as well as research done in other places. You do get additional benefit from going beyond four inches. With a four inch layer, I can store 50-60% of the stormwater. If I go to a 12 inch layer, I'll store 75% of the annual water. So it's more, but I've added an awful lot of weight, a lot of extra structural materials, and a lot of cost associated with getting that stuff up there to get incrementally much smaller gains in my stormwater management.

Then you have plant material up on top. The material we select is usually what the people would consider rock garden plants. If you think about the environment on the roof and the kind of media we're using, it is kind of like a rock garden. It is well drained, it's usually open to a full sun environment very frequently, it's often very windy or droughty, and so it's either very dry or very wet.

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Things like *Sedum*, stone crops like hens and chicks (*Sempervivums*), other species like chives, *Dianthus* and *Campanula* -- anything you'd see typically growing in someone's rock garden -- is potentially a plant you could put on your green roof.

Depending on the climate, you might use different plants. Here in central Pennsylvania, I can't use the ice plant type species *Delosperma* because they freeze out for me in the winter. Further south, in Washington, DC, there are a whole bunch of ice plant species you can use on a roof. They are very successful and they provide a lot of interest and color.

Typical of most roof systems is that plant diversity really follows soil depth. In places where the soil is not very deep you have very restricted diversity in the plant species. It's mostly the *Sedums*, some of the *Talinums*, and some of the *Sempervivums* that have survived. When you go from four inches of soil to six inches, you suddenly get a lot more species that you can grow. Certainly, when you get beyond six inches, you have a lot of choices of plant species, including a lot of natives. There are some native species of *Sedum*, but most of them are not native.

If you're designing a roof and you want to have a lot of plant species up there, you should probably use more than one kind of soil. If we go outside or in a wild area and look at where things are thriving and where they're not, we find that where species are thriving, there is usually a slight difference in the soil type or soil structure or depth. If you think about putting something up on a green roof and you want a variety of plant material and an interesting plant palette, the way to make that a sustainable landscape is to vary the soils. The plants will naturally follow the varied soils. You can go up there and plant lots of different things, but if you don't vary the soil, it's kind of naïve to think that the plant design you put there will stay the way you put it without a lot of maintenance and intervention.

Does climate also affect the choice of media?

Absolutely. The media you'd use in Florida is going to be very different from the media we use here. Around here, we want a relatively low organic matter by weight. Most of it is an inorganic aggregate. If we used a potting soil, which is 100% organic, it'd disappear in a couple of years. This is even more the case as you go further south. If you go north to a much colder climate, you can probably get away with using a higher percentage organic matter soil because it's not going to decompose as fast.

What types of research is going on at the Center right now?

Our emphasis is on trying to quantify the benefits of the green roof in terms of ecological services and other benefits. A lot of the work we've done in the past and continue to do centers on the stormwater management function of the roof. This is where the incentives are coming from.

If you think about putting a green roof on, it's an expensive proposition. Why are you going to do it? What's the return on investment? You're either doing it because someone is giving you a grant and you can write it off, or there's some other financial incentive. That incentive is probably going to be based on stormwater management. If you think about Chicago, New York, and any other city built before 1960, there is probably only one set of pipes underground to carry away all of the wastewater - storm and sewage. Every time it rains, you get too much water for the sewage treatment plant, and you dump raw sewage into the nearest open water supply. The whole idea of a green roof is to eliminate or reduce that. The municipality that has to deal with it has a choice. They can either store the water someplace, build a bigger treatment plant, or they can make people do something to manage their stormwater. There are a lot of different ways to manage stormwater: build cisterns, put aside ponds, set up mud puddles, etc. Depending on the cost of the land and the amount of stormwater management you need to do for a given site, a green roof may or may not be cost competitive. That's why we're focusing on stormwater. From a return on investment standpoint, it looks to me as though most of the incentives are going to come from regulations and legislation around stormwater.

I see. No one is going to give you a break because you're providing bird habitat.

Not yet. It doesn't make sense from a carbon trading standpoint either. Even if we get into carbon trading on a large scale basis, I can plant two trees and store as much carbon as I can on an acre of green roof.

From a stormwater management standpoint, if I'm on a 10-acre site in an urban area and I want to build a new commercial center. It's probably going to be 20-30% building space and about 70% parking lot with a few little islands in between. It's mostly impervious surface. If I have stormwater regulations associated with that, then I'm going to have to take all of the water coming off that impervious surface and do something with it. If that is underground storage, detention basins, whatever, there's a cost associated with that. I can offset some of that cost with a green roof.

We may also see some offset of costs coming as municipalities try to figure out how to pay for stormwater improvements. You're going to see more and more stormwater utilities formed. As with sewer and water utilities, you'll be charged for your stormwater. The charges are probably going to be based on impervious surface on your property. You will have a stormwater fee associated with the amount of your property that's

impervious, related to the amount of water that's going to run off. If you're paying for it, and you get a discount because your roof is no longer impervious, then you're not paying as much to that utility.

This is all very *quantity* based. What about water quality?

At this point, from an incentive standpoint, there are areas where you get a stormwater quality credit for putting a green roof on. There is no requirement by any of those regulations to actually prove that it does anything.

The problem with stormwater quality is that it is very hard to come up with good data to prove that something is a stormwater quality feature. If you really want to prove it, you have to have data from multiple years, multiple storm events, and different kinds of roofing systems over the long term of the roof, relative to all of the maintenance that goes on the roof. Sampling is expensive, so the amount of samples we have is limited. The data sets are fairly limited.

Quantity, on the other hand, is easily proven. And you better be able to prove that it not only works, but continues to work. If it is part of your stormwater management plan and someone has signed off on that plan, you are legally required to maintain that structure and it must continue to function the way it is supposed to function.

What do we know about nutrient loading coming off of green roofs?

It depends on which nutrient you're talking about. It also depends on what you compare it with. Let's talk about acid rain. Acid rain is an issue in much of North America and in Europe. Because you filter that acid precipitation through a media that has buffering capacity, you neutralize the acidity. So the runoff from a green roof is basically neutral regardless of how acidic the rainfall is when it hits the roof. Looking at measurements we have taken on the roofs at the [Center for Green Roof Research] farm, runoff from the green roof will be 6 or 7 pH from a 4.5 pH input. So, from that standpoint, a green roof is a water quality feature.

Now let's look at nitrate. Whether or not it is a water quality feature from a standpoint of nitrate depends on a number of things. It depends on how much you fertilize, and that depends on what plant species you put up there. If I put up a very diverse, landscape-like palette of plant material and it's an aesthetic type garden, most of those species require a fair amount of nitrogen, so I'm going to have to fertilize them. This means that some of the fertilizer is going to run off. That runoff may be higher than my rainfall. If I put just a sedum meadow on a roof, and I keep them hungry and starve them, I might be able to get enough nitrogen out of my rain to keep the plants alive

without additional fertilizer. In that case, I'm going to tie up nitrogen that's coming from rainfall and my runoff is going to be no higher in concentration than the rainfall that's hitting it. The mass balance is going to be in favor of the green roof. My green roof is, in that case, a water quality feature.

If I'm in an area of the country that has very clean rainfall, then I'm not going to get enough nitrogen from the rainfall to keep a sedum meadow alive. As a result, I'm going to have to fertilize some, and I'm going to end up with more runoff nitrogen than what's coming in.

Let's take phosphorous as another example. I'm always going to have more runoff from the green roof, in terms of phosphorous, than I'd get in my rainfall. In my rainfall, the runoff from the green roof will be something like 10 or maybe 100 times more concentrated. But when you're talking about .02 parts per million of phosphorous in the rainfall and maybe .2 parts per million in the runoff from my green roof, that kind of keeps things relative, but there's more in my green roof runoff. If I'm going to keep any healthy plant community healthy on that roof, there has to be phosphorous in the media and there is going to be more phosphorous in the soil solution than there is coming in the rainfall. Long term, I'd have to fertilize that roof to keep it functioning as my buffer of phosphorous is leeched out. In that regard, the green roof probably isn't a water quality feature.

Now let's look at zinc. There is relatively low zinc in rainfall. If you're in or near an industrial site, you can get dry deposition of particulate material, so you can get quite a bit of zinc. Zinc is also in the soils. If I look at runoff from a green roof and I compare it to a plastic roof where there is no additional input except maybe the particulate disposition. I'm always going to measure the zinc in the runoff from a green roof, whereas often, I won't even be able to detect it in the runoff from a flat roof because once I wash the particulate off, there's no source of zinc. When I compare a green roof to a plastic or bare rubber roof and look at the bulk solution, the green roof is going to lose. But if I compare the green roof to a metal roof, the green roof is going to win hands down because the metal roof leeches far more zinc than the green roof does.

This is why water quality is hard to talk about. It really does depend on the individual nutrients, what you're comparing it to, and where you are relative to sources of atmospheric deposition.

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The sheds at the Center for Green Roof Research. Source: Robert Berghage.

Aside from stormwater quantity and quality, what other types of research are underway at the Center for Green Roof Research?

Other things we're working on now are energy. Again, we're focused on return on investment. If I'm going to look at return on investment for a green roof, one of the places I can get that is in energy savings. A green roof acts as an evaporative cooler, it reduces air conditioning demand on a building. Our research suggests that on small buildings (like the 6' x 8' sheds at the Center), we reduce air conditioning demand by about 10%. If I were to scale that out to a larger building, I might save as much as 30%...or even more.

Is this true in newer construction, where the building is going to be more efficient anyway?

It depends. It depends on how much insulation you stick in. Our garden sheds at the Center have four inches of fiberglass insulation in the roof. That's way less than what you'd normally call for in a normal building in this climate. The more insulation I put in, the lower the benefit of the green roof is going to be, depending on what else I have.

If I have a commercial building with a flat roof and I put in four feet of insulation in the rooftop, the green roof doesn't do anything for the building itself. It has a huge effect on heat island, though, which is another story. For return on investment, I'm interested in my own building. Where that equation changes dramatically is when you perforate the roof and put in skylights. With "green" building, one of the things you try to do is get as much natural light in as possible. As soon as you start allowing natural light to get through that insulated layer, then you have thermal load coming into the building and that thermal loading changes. Then, my green roof starts to have a benefit from a total energy standpoint.

Can your research that is done on small sheds really be applied to larger buildings?

Obviously, there are differences. Not just with the thermal stuff, but with stormwater. Any time you're doing research on a small scale and you say, "My 144,000 square foot roof on top of a strip mall is going to behave the same way as my 6' x 8' roof," in terms of overall function, that's a pretty risky leap. The data that we have suggests that the larger scale roofs are actually more effective than our small scale roofs.

We are monitoring a 75,000 square foot roof right now in Chicago and it appears to be far more functional than my little roofs. That makes sense, because you don't have the edge effects.

Do you foresee corporations becoming partners in green roof research?

For corporate users to put a green roof on building and do it routinely there has to be a reasonable return on investment. Any company that is interested in doing large scale green roofs on lots of buildings needs to be able to prove that there will be a return on investment. The things they'll look for are stormwater quantity and peak flows. Both of those are regulated and easy to determine. Both can give a return on investment. Building energy consumption can also be a return on investment for the individual building owner. For commercial buildings, those are probably the best places to look for return on investment.

The Old Main building at Penn State

For an institution like Penn State, we can also look at roof longevity. When we build a building here, we expect to be in it for hundreds of years. A lot of commercial buildings are built with the knowledge that the initial owner may or may not be in the building ten years down the road, so the return on investment has to occur before that. For us, that's not true. With governments, schools, and really any kind of institution where you're building for the long term, you also get the benefit of having two to three times (or more) roof life as return on investment.

A lot of our research focuses on, "Where can I get return on investment and let's prove it."

Have you done any work on assigning dollar values to any of the green roof benefits?

We try all the time. It's a very difficult problem. It is very site specific and very project specific. For any given project, if you give me data on energy consumption of the building, stormwater alternatives, etc. you can work out some kind of reasonable return on investment numbers. A lot of it is back in the envelope at this point, where you're making some pretty gross assumptions.

Is the public relations/goodwill aspect of "being green" perceived as a return on investment?

That's a really hard one to quantify. Can I say that? Absolutely. It's probably a lot easier to quantify for the mixed commercial buildings where you can track occupancies. There's at least some decent anecdotal evidence that occupancy in green buildings is better and you get better rents for your office space.

There's a lot of good data - much of which is from Europe - that hospital stays and outcomes are improved if you have a green view from your hospital room. That green view could be a landscape or a garden, but it could also be a green roof. And that is something you can consider a direct return on investment.

Do you think LEED is furthering green roofs?

Definitely. LEED is driving a lot of these roofs. If you want to be LEED Platinum or Gold, you get a lot of points for putting a green roof on. If you ask me if we "chase LEED points" on green roofs vs. other things, the official response is "no," but we are putting green roofs on all of our new buildings.

Is putting on a green roof a relatively economical way to get LEED points?

I don't know if it's as economical, but it's a way to get points. Once you get into that green building thing and start talking about trying to be LEED certified at the highest level and becoming a leader in terms of green campuses or whatever, the economic return on investment becomes far less important than the good will factor that comes along with being "green."

The new, LEED certified Lewis Katz Building, which houses Penn State's Dickinson School of Law, was designed for energy efficiency. Its green roof will create a habitat for birds and animals, reduce storm water runoff, absorb air pollution, and reduce the structures' "heat island" effect.

Ed Snodgrass of Emory Knoll Farms, a supplier of green roof plant material, mentioned that the pursuit of LEED points can sometimes lead to failed green roofs.

There are roofs that have failed because people didn't think enough about what they're trying to do with them. If the roof is supposed to be an aesthetically pleasing showcase and it doesn't look like a showcase, then I'd consider it a failure. If the roof is a stormwater management roof and you have slapped it up on top of a strip mall and no one sees it and some stuff grows and some doesn't but you have reasonable plant coverage. Even if it doesn't look very good, is that a failure? No, I'd say it's actually a success because it's doing what it was designed to do.

Has there been any great failure from which you learned a great lesson?

The easiest way to kill a green roof - and most of the failures I have seen - is poor water management in the soils. The plant species that we use on the roof, the rock garden species, do not like to have their feet really wet. If you have a heavy media that retains a lot of water, what you will do is induce root rot and these plants will die. You'll end up with a brown roof.

The second area in which I have seen a fair number of failures is in weeds and weed pressures upon the roof. It's usually coming up in the media - the media is not clean to

begin with. Maintaining it is usually not a high priority for the building owner so you end up with a roof that's nothing but weeds.

In the case where it's not a showcase garden that people will see, is that really a failure? As long as you have vegetation growing, isn't that roof still providing ecological services?

That approach is being used in Europe, and it's not a bad approach. In some cases, what they'll do in Europe is push aside several inches of topsoil when they're putting up a building, and then they'll put it up on the roof and let whatever can germinate in that seed bank germinate and grow on top of the roof?

Our president, Keith Bowers, recently wrote something on our blog expressing his frustration about, "...green roofs consisting of plastic trays filled with three inches of soil planted with three varieties of non-native sedum." I realize this comment raises two issues for debate: the use of non-native sedum and plastic trays?

Let's start out with the native vs. non-native question. Just as with my landscapes at grade, I don't usually make the distinction between native and non-native. I'm more interested in function in the environment for what I'm trying to do. That being said, the biggest argument for native plant material is to increase or maintain the biodiversity in an area. You can do a lot more toward maintaining biodiversity by planting a lot of different species.

Regarding trays with three species, that's a stupid idea. Yeah, okay, I have a little diversity, but it's not much. If I really want biodiversity, I want some short stuff, medium stuff and relatively tall stuff. I want a few simple grasses like some fescues. I want flowers that bloom from spring to fall, so I have a food source for my pollinators. Providing habitat and food for pollinators is a good thing. Our urban areas are basically deserts for most pollinators. A lot of our native pollinators are also in decline - not just honeybees suffering from colony collapse disorder. One of the reasons is habitat destruction.

The green roof at Penn State's Forestry Building

You can take a green roof that is a sedum meadow, like our Forestry Building roof. It has five different species of Sedum, which bloom at different times. It has campanula, dianthus, lavender, a few grasses. By having that diversity of plant material up on the roof, you provide food, shelter and habitat for organisms. In my mind, what you want to do is select species that are going to be successful on this rooftop environment, and you want to select a variety of species to provide the ecological function that you're looking for.

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There's nothing really wrong with sedums. If you look at almost anybody's list of pollinator-friendly plants, you'll find sedums on that list. They produce nectar and pollen. They end up being a food source, so it is a pollinator-friendly plant. Mix it with a few other things, and the more diverse the palette, the more biodiversity you're going to encourage.

Biodiversity on the roof of Penn State's Forestry Building.

Unless you leave it alone and let it go to a native weed patch, a sedum meadow like the one on the Forestry Building roof, is not a stable climax community. A stable climax community in Pennsylvania is a forest. So some degree of maintenance has to go into that to maintain the kind of community you want to keep up there.

Now let's talk about plastic trays. Plastic trays have a place. They provide you with the ability to provide an instant green roof. Here in North America, a lot of us are into instant gratification. I want to be able to have my green roof, and the day that the contractor is finished with it, I want it to look like it has been there for 10 years. In order to achieve that, my vegetation has to be fully grown before I move it up to the roof, and it has to be transportable to the roof. How do we do that? There are two choices. It's either going to be a vegetated mat or a plastic tray. Both allow you the option of: Boom. I'm done. My roof is green. There are places where that is what's going to sell.

From a cost advantage standpoint, the plastic trays may make sense on some small jobs where you're not going to achieve any kind of economies of scale by doing something different. The plastic trays can make sense in some areas where you're dealing with logistics issues. If it's really hard to get to the area where you're going to put this roof, and everything has to go through a freight elevator and then you have to crawl through a window to get it on the roof and spread it around, the plastic tray might make sense. You grow it somewhere else, you haul it up the elevator, you pass it through the window from one person to the other, you lay it down, and you're done. So that makes some sense.

Do the plastic trays make sense on a 150,000 square foot commercial building? To me, no. When you start talking about a stormwater roof on a 150,000 or 200,000 square foot building, you want to fluidize the installation process as much as possible. You want to blow the media up. You want to blow cuttings over it. You want to spread hydromulch. The fewer things I have to touch, carry, handle and move on a roof like that, the better, if I'm to get the cost down to the point where it becomes a reasonable stormwater management feature. For a building like that, I don't think you could ever get the cost low enough to make it a competitive stormwater feature using trays.

Would trays make more sense in a situation where you had a highly sloped roof and needed structure?

You need something. The tray can be a structure, but you can do something else for structure. I don't think the tray is the only solution to that, but you do have to have some kind of structure to hold the soil in place. There are sloped applications where that makes sense.

I read that a major part of the Center's mission is to "promote the use of green roofs through education and outreach." What are some of the key points you are trying to communicate? Who are the audiences you are trying to reach? What have you found to be the most effective method of communication?

We do everything we possibly can! At this point, it's still a lot of speaking engagements at ASLA, Greenbuild, and other large conferences. There is a real thirst for information and knowledge about green roofs. There are a lot of people doing green roofs who don't have a lot of experience and don't really understand the whole system.

Is there one common misperception among those audiences about green roofs?

The biggest misconception I come across - and the one that bugs me the most - is that extensive green roofs are being promoted as no maintenance roofs. There is no such thing as a no maintenance landscape, and a green roof is a landscape - unless we're talking about a weed patch.

When I looked at the syllabus for the EcoRoof Technology course taught by you and Bob Cameron, I was surprised to read, "There is no appropriate text for this course unless you read German." Is this really such a new academic area in the U.S. that there isn't even an appropriate textbook in English?

Ed Snodgrass' book Green Roof Plants is good, but there is no good practitioner type book yet. There are a number of books, and there are more coming out all the time. But in my mind, they are all pretty picture books. They are full of case studies of pretty buildings. You can learn a lot from that, but are they appropriate textbooks for anything other than a landscape architecture class? Probably not.

What is one thing you hope your students come away from the EcoRoof Technology course with?

An understanding of the maintenance issue, of course, so they are not promoting green roofs blindly. The other thing I hope people come away from my course - or any seminars or anything else where they are learning about green roofs - is that the one-size-fits-all roof or one-size-fits-all media mentality is inappropriate. You need to really think about where the system is being installed, what its purpose is.

Are there any other universities, in the U.S. and abroad, who have something similar to the Center for Green Roof Research.

A fair amount of work that has been done over the years has been done in Germany. The University of Von Steffen in Germany has done a lot of stuff. Technical University of Munich, Weinstephan campus.

Here in North America, there are a number of places that have done work. Michigan State University did some work at one point surrounding the Ford Motor Company's River Rouge Plant Their program is less active than it once was, though. We have worked closely with Columbia University on the energy management stuff. We have worked with North Carolina State University on all kinds of stormwater management projects. There is a green roof research center at the British Columbia Institute of Technology. We are working with the University of Maryland. There is a research group at the University of Central Florida that is doing some very interesting things, which makes a lot of sense to me. Florida is such a different environment. Nothing I do here translates there. Everything from media to plant species selection.

What is the best clearinghouse for information about green roof research?

There are two I recommend. The first is the Green Roofs For Healthy Cities Research Links. The other is Greenroofs.com, a commercial site compiled by Linda Velazquez. Both of those sites provide good collections of what information is out there.

The green roofs must bring an educational benefit to Penn State. What are some of the lessons your students have learned on top of the green roofs that they couldn't learn in the classroom?

Just getting up on a roof...seeing it, touching it, putting plants in it and working on it at any level is a real benefit, as opposed to just showing pictures. When we first started doing this ten years ago, I couldn't show students anything other than my little research roofs out at the [Center for Green Roof Research farm. The only other roof within a reasonable driving distance was done at a senior community in Tyrone, PA called Epworth Manor. The green roof was put on around 2000. That was the only other green roof around for a long time.

In your travels, is there one standout example of a green roof that was done right?

I have seen a lot of impressive green roofs. I tend to like the meadow type of roof. It's managed, but lightly managed, and there's fair amount of biodiversity. I'm not really into the monoculture carpet roof. I think those are boring and ugly.

While I like the intensive rooftop gardens, those are too maintenance prone for me. The Church of Jesus Christ of Latter-Day Saints Conference Center has a beautiful green roof. If you ever get up on top of it, it's incredible. But it takes a lot to maintain.

Speaking of intensive green roofs, what do you think about growing food on rooftops?

You can do it if you want to. Certainly people in downtown Manhattan have had pots of tomatoes on their balconies and rooftops as long as there have been buildings there. Does it make sense for large scale, commercial food production? I don't think so. You have a bunch of little postage stamps, when you think about it. None of them are big enough to gain in terms of economies of scale. Access is problematic. Getting materials up and off of the roof is problematic.

If you are trying to use your roof as a water quality feature and you are growing food on it, those are diametrically opposed purposes.

A good exception to having food produced up on the roof is apiculture. If you have a convention center or shopping mall where you have four acres of green roof and you plant it with species that are attractive to pollinators, why not put some pollinators up there and harvest the honey? That makes sense to me as a cottage industry and a potential additional economic benefit to putting the roof up there. If you think about keeping bees in an urban or suburban environment, they're kind of protected.

Our folks up in our Great Lakes Bioregional office want to know what you think about some of the roofs that are popping up in Chicago.

I like what Chicago is doing to promote green roofs. They have lots of issues with stormwater and it's a hot place. Reducing urban heat island and reducing stormwater by using green roofs is a good thing. It's also great for the city in terms of PR. I grew up in Grand Rapids, and I remember going to Chicago to visit museums and it is so much prettier and more livable now than it was 40 years ago. They have done great things with trying to green up that urban space.

Many of our readers are practitioners and project managers involved in ecological restoration, conservation planning and regenerative design. What is one thing you'd like to say directly to them?

Design to purpose.

For example, if I'm in Atlanta, Georgia, and I want a roof that will reduce air conditioning demand on the building, I am going to install an irrigation system and I'm going to put some cisterns into the system so I can capture the excess water and pump it back onto the roof. It just makes sense. It's going to be so much more functional and effective when the roof is wet and you've got evapotranspiration occurring. If my primary purpose is stormwater management, then design to stormwater management.

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Leaf Litter Talks with Bob Cameron

Ph.D. Candidate and
Co-Instructor of Penn State University's EcoRoof Technology Course

Robert D. Cameron is pursuing a Ph.D. in Horticulture at Penn State University after several decades in industry directing the environmental programs of a diversified multi-national. Bob's areas of focus are sustainable technologies, including green roofs, living walls, and constructed wetlands, and the evaluation of these technologies at a molecular level to improve design efficiencies. Though his concentration is on green roofs, he has a palpable passion for living walls. Rumor has it he's even installing one in his shower at home!

We were thrilled to have the chance to chat with Bob in the horticultural greenhouse at Penn State University.

Why living walls?

My question is always, "why not living walls?" From an aesthetic standpoint so much of our interior and exterior architecture is ugly. Especially some of our buildings that are strictly concrete or masonry and have no covers on them. By coating them with plants, there are so many benefits. You have already discussed the benefits of green roofs. Many of those parallel with the benefits of a living wall. It just makes sense to incorporate plants into our environment. They clean the air and can be integrated into graywater treatment systems. Living walls on masonry structures in urban areas can reduce noise pollution.

A green roof can be an "island in the sky." If you're looking at them from a habitat standpoint, it may make sense to be able to connect a green roof to ground level via a living wall . For a green roof designed for stormwater runoff, connecting a living wall can further detain and treat rainwater. The living wall can become a functional part of your landscape architecture.

Describe the anatomy of a living wall.

There is a little more variability with a living wall than there is with a green roof, depending on what you're trying to accomplish. A thin film [as is used in the orchid wall in the Penn State horticultural greenhouse], has a lot of applications with an interior, where you don't want the mess of soils in a house. It can also be used exterior, providing a small air pocket between it and a masonry wall, as long as you provide an irrigation system for it.

There are larger, wider systems. If you want something with less maintenance, you can do those. If you want to provide an insulating factor for a wall, you'd go with a much larger dimensional wall. There is so much variability.

Remember, living walls are very new. Green roofs have been in Germany for 40 years. In the U.S., much less. But living walls have even less of a history. At this point, there is no one design for them. So many people like us are experimenting with different materials to see what makes the most sense.

Can you give us the 30 second history of living walls?

There are examples of green walls from 2,000 years ago. We know that the Egyptians used different types of biofilters to treat waste water and to apply opportunities for gardening in their urban areas.

In modern times, I think primarily of Bill Wolverton**.** Back in the late 70s, Bill was with NASA, and he was looking at biological ways of treating wastewater for the future space station. He had done some very creative uses of constructed wetlands, and then began looking whether we could use some of those plants to address indoor air pollution. Bill was really a pioneer with some of these initial applications.

Green roofs, living walls, and constructed wetlands are all examples of biofilters. Taking people who have worked with biofilters and realizing that this is all a matter of geometry - how you place these things. Therein is how living walls were born.

What' the most exciting thing happening today in the world of living walls?

There are a number of areas. Integrating them with green roofs and constructed wetlands greatly expand the versatility of living walls. Developers and planners are beginning to realize that we don't need to build treatment mega plants and transport waste for miles to them. Why not look at our buildings as stand alone entities, whether it's from an energy standpoint, wastewater, etc.?

The extension of that is: we need to change our vocabulary and quit using the word "waste." If we begin to look at our buildings as their own enterprise, wastewater is really an unused resource. How can we take that resource, recoup the inherent energy out of it, and then reuse it back to that building? Living walls are an integral part of that

solution. They can allow us to clean the water and reuse it for flushing commodes. When you think about it, why do we use one of our most precious resources - potable water - for flushing commodes? It makes no sense. It's the same way with materials. Here we are, in the midst of an ongoing energy crisis, and yet what are the two most common building materials we use in the United States? Asphalt shingles, which are made of petroleum, and vinyl siding, which is made of petroleum. So we wrap our architecture in oil! Living walls provide a sustainable alternative to that.

Have you ever had naysayers comment that living walls seem energy *intensive* (since some of them have artificial lighting, complex irrigation systems, etc.)?

It's all a matter of design. There are some notable "green" projects that are anything but green. Designers need to utilize tools such as life cycle analysis to ensure designs are sustainable.

We had a student from Ghana, where very little water per person is used and it is very valuable. We worked with her to design a system to treat gray water that could also be used for food production. For them, just to get some tomatoes...that's a high value crop. If they could have something outside their door where they take water, after is has been used several times, recycle it and produce some tomatoes, it's turned the water from waste to a resource. The issue was doing a pump. So we were looking at something that has been used successfully in other projects: having a stationary bicycle, like one you'd see in an exercise room, that village children could come and ride, and have a great time watching the water go up and around. We find that you don't need to provide circulation 24 hours a day. Actually, these systems do better with intermittent flows. Just to have a child come over periodically, get on the bike and have fun, and pump it, you would have a very low energy way of providing irrigation.

Living walls really should not be high energy systems. In their infancy, many of these technologies start off with materials that may not be perfect. That's where research comes in to find more sustainable materials.

How are living walls better than a typical air or water filter?

Let's look at the NASA program as an example. In the future, we'll colonize Mars. Do you want to be transporting materials back and forth at an outrageous cost - materials with a mechanical filter that you have to throw away and reproduce? It's not a sustainable model. Using that same logic on Earth, why should we be taking mechanical systems that are using up resources and then get tossed afterwards, and have to be transported?

Why not use a biological system that you grow? We need to get away from the way we've developed industry around producing an item that goes through a certain life and then has to be thrown away.

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When you look at the life cycle analysis of a green roof or living wall, that's where the superiority comes in. Use the analogy of an asphalt shingled roof. You may be lucky to get 15 years out of a 30-year asphalt shingled roof. So many of the numbers that people crunch to see how effective these are only go out a decade. What you need to look at is, over the course of so many years, how many times do you have to replace that roof?

Living systems are, by far, superior. That does not mean they are without maintenance issues or certain types of negatives. They are living systems. If people add an herbicide, pesticide, or something else to it, they will disrupt that biological cycle. It's not a perfect system, but I think it's far superior to comparable mechanical systems.

What are some of the challenges to living wall constructions- in terms of logistics, maintenance, and your overall carbon footprint?

All biofilters are the same. The same issues you'd have with green roofs and constructed wetlands, you have with living walls.

First, there's permitting. So often, local regulators have not yet developed permits for these. So that becomes an issue. If you're putting up a large, two-story wall, you have structural issues. The last thing you want is for a wall to come down on top of someone. The same is true for green roofs. We have to make sure our buildings are sound and designed for the load. So many regulators are unfamiliar with these technologies. That brings us to the second challenge.

Lack of familiarity makes people feel uncertain so they'd rather not have [these technologies] and go with traditional types. If you're looking at wastewater systems, living walls would be considered "experimental." The hurdles you'd have to go through with most local regulatory agencies are much greater.

Like so many designs you do in a building, you have to make sure you're designing these units for the site. If you have an area that's in an alley that gets zero sunlight during the day, you don't want to put a living wall with a bunch of plants that require a lot of sun. These are some of the common sense things you have to deal with.

A model living wall in Penn State's horticultural greenhouse.

It looks like green roofs are beginning to have some influence on the way buildings are designed. Is this happening yet with living walls?

I think they are much farther behind. Green roofs are still in their infancy in the U.S. Living walls are just after conception.

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Are their any other "surfaces" that people are thinking about "greening?" Are people starting to put green roofs and walls on cars and trucks?

Well, if you have the ground, the vertical and the roof structure, you have the opportunity to apply this technology to different places. Other than a "wow" factor, I can't see much practicality to green roofs on cars. But, it certainly makes for an interesting site!

One of the newer concepts people are talking about is wet roofs. Certainly, it can increase the diversity of a roof, be functional and an aesthetic feature. However, water adds a lot of weight on a roof, and improper design could create numerous problems. Also water is a precious commodity, and in some areas, the local regulators say, "thou shalt not take our (rain) water." But, incorporating biofilters such as living walls into our building designs are forcing us to reevaluate our notions of architecture.

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Step Inside the Greenhouse

Ph.D. candidate Bob Cameron takes us inside Penn State's horticultural greenhouse and shows us some interesting models of living walls and constructed wetlands. Join us...

Click the image to view this video.

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Non-Profit Spotlight

Green Roofs for Healthy Cities - North America
www.greenroofs.org

Maintaining momentum for green roofs and living walls involves continuing research, translating the research into practice and sharing information with interested parties. We are delighted to shine Leaf Litter's first official Non-Profit Spotlight on Green Roofs for Healthy Cities - North America, Inc. (GRHC) for their role in both researching and sharing information about green roofs. Founded in 1999 and growing rapidly, this 501(c)(6), not-for-profit organization has become the industry association for green roof experts in North America. GRHC's mission is to increase the awareness of the economic, social and environmental benefits of green roofs, green walls, and other forms of living architecture through education, advocacy, professionalism and celebrations of excellence.

Steven W. Peck, the organization's founder and president, articulated some of the many public and private benefits of green roofs and walls, including stormwater management, reducing urban heat islands and air pollution, and improving livability. Because of these benefits, he said, "many jurisdictions are investing in green roof installation, through a variety of measures such as grants, tax abatements, density bonusing, through direct procurement for their buildings and through the use of regulations. Leaders in this field include Chicago, New York City, Washington, DC, Portland, Seattle, Philadelphia and Toronto, to name a few."

Can Any Roof Be A Green Roof?

Despite the many benefits of green roofs, Peck noted that some locations are better suited than others for installation. He explained that structural loadings, slope, and size of a project all play a role in determining the suitability of a green roof. "Green roofs are not effective on existing buildings with excess structural loading less than 10 lbs. per square foot. This number rises in areas of extreme cold and wind desiccation and extreme drought. Green roofs are not good for buildings with more than a 40% roof slope. Green roofs may be cost prohibitive on smaller projects, like single family dwellings, because the upfront costs may be too great, relative to a project's overall size." Peck also added that despite how they are sometimes promoted, green roofs are not a 'do-it-yourself' technology; there are important engineering and health and safety considerations.

"Green roofs are a fantastic way to expand the amount of useable space on a building," stressed Peck, "and they can deliver a wide range of benefits if they are incorporated into a new building design early on." For those interested in examples of effective green roofs, Peck recommended "Award Winning Green Roof Designs" published by Schiffer Publishing. The book features over 40 award-winning green roof projects identified by GRHC over the past five years. "There are so many different applications of green roofs,"

said Peck. "[Green roofs] are a very versatile technology that allow designers to maximize for a variety of benefits including: energy efficiency, solar energy efficiency improvement, stormwater management, biodiversity, food production, aesthetics, horticultural therapy, active and passive recreation, noise reduction and a host of other benefits."

Green Roof Training & Accreditation

GRHC delivers professional training courses throughout North America and is now implementing an accredited Green Roof Professional program to help support quality green roof design and construction practices. The program will also allow practitioners to differentiate themselves in the marketplace by demonstrating that they have passed a multi-disciplinary exam, developed by subject matter experts, covering key information on best practices from design, installation through to maintenance. "Eventually," said Peck, 'we hope to provide GRPs with a break on their insurance premiums and an advantage on bidding on government projects. Governments will see the GRP as a method of overall quality assurance."

Four one-day professional training courses are being provided in different locations around North America in support of the Green Roof Professional Designation. They average about $350 per course and include a resource manual. The Green Roof Professional exam is based on material in these courses. The cost of the exam, which is to be proctored by Prometric is $395.00. Alternatively, people can purchase the manuals directly from "GreenInfrastructureStore.com," study them intently and take the exam. The material for the GRP accreditation is based on six years of work with over 100 subject matter experts ranging from structural engineers to horticulturalist and irrigation specialists.

The GRP exam is being launched in Atlanta, Georgia on June 5, at the end of GRHC's 7th Annual Greening Rooftops for Sustainable Communities Conference, Awards and Trade Show. The conference also includes a half day course on Ecological Green Roof Design. According to Peck, "a number of papers on biodiversity will be presented in Atlanta from June 3-5, 2009."

If attending the conference is not a possibility, GRCH's Green Roof Tree of Knowledge is an excellent resource. It contains summaries of research projects, including a number on designing for biodiversity. "The field of urban biodiversity is very promising," said Peck, "but still at a very early stage in its development." Leaf Litter looks forward to keeping in touch with GRHC for this and other exciting green roof developments.

Resources

In addition to the many links that appear throughout this issue we have gathered the following recommended resources on green roofs and walls.

Award Winning Green Roof Designs
Steven W. Peck. Schiffer Publishing, 2007.

Center for Green Roof Research

Green Roof Plants: A Resource and Planting Guide
Edmund C. Snodgrass and Lucie L. Snodgrass, Timber Press.

Check out the research links posted by the Green Roof Industry Resource Portal.

Green Roofs for Healthy Cities' mission is to increase the awareness of the economic, social, and environmental benefits of green roof infrastructure across North America and rapidly advance the development of the market for green roof products and services. Their web site includes The Green Roofs Tree of Knowledge (TOK), a full-featured database on research and policy related to green roof infrastructure.

Green Roofs for Healthy Cities' Research Links

The Green Roof Research Program at the Michigan State University

The Green Roof Centre of Excellence Neubrandenburg

Living Architecture Monitor
A quarterly magazine published by Green Roofs for Healthy Cities.

U.S. Green Building Council Leadership in Energy & Environmental Design

Penn State University Horticulture Department

North Carolina State University's BAE Green Roof Research

Southern Illinois University, Edwardsville, Green Roof Environmental Evaluation Network

William McDonough & Partners

Sustainable Design Web Resources

Green Building Products by McGraw-Hill Sweets

Getter, K.L. and D.B. Rowe. 2008. Selecting plants for extensive green roofs in the U.S. Extension Bulletin E-3047, Michigan State University.

Green Roof Environmental Evaluation Network (Southern Illinois University Edwardsville)

Green Roofs as Urban Ecosystems: Ecological Structures, Functions, and Services

World Green Roof Infrastructure Network

Dunnet, Nigel. Planting Green Roofs and Living Walls. Nigel Dunnet and Noel Kinsbury. Cambridge, UK: Timber Press, 2004.

Osmundson, Theodore. Roof Gardens: History, Design and Construction. New York: W.W. Norton & Company, 1999.

Earth Pledge. Green Roofs: Ecological Design and Construction. Atglen, PA: Schiffer Publishing, Ltd., 2005.

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Biohabitats' Projects, Places and People

Biohabitats' Projects

A Sustainable Future For Alabama's Largest Living Museum

The 68-acre Birmingham Botanical Gardens is Alabama's largest living museum, with more than 10,000 different plants in its living collections and over 25 unique gardens. With public education being an important part of its mission, the Gardens turned to the Oasis Design Group-Biohabitats team for help in developing a master plan that would help demonstrate sustainability principles for their 350,000 annual visitors. Biohabitats focused primarily on establishing a more regenerative approach to stormwater management that makes use of natural ecological processes and emphasizes native vegetation. Our engineers, landscape architects and ecologists helped conceptualize the restoration of a prominent creek and the conversion of a concrete-lined pond into a wetland and riparian ecological community. We also led a seminar on sustainability. The Gardens strives to "enhance life by connecting people with plants." With a master plan that promotes a high level of sustainability, they are well poised to forge these connections for generations.

Ecological Design-Build Project On Lake Erie Marina

The Lake Erie Marina on Middle Bass Island was in dire need of safety upgrades to fulfill the pressing needs of the boating community. Joining forces with our sister company Ecological Restoration & Management, we applied a unique approach to the marina's landscape which allowed for marina upgrades and the establishment of campground facilities while also enhancing ecological function. Our planting plan recommendations included: vernal pool planted with 133 trees (red maple, black gum, swamp white oak, and pin oak); category 3 wetland planted with 37 shrubs (bar willow, alder, black willow, and red maple); vegetated shallows planted with 6,898 submerged aquatic plants (water lily, wild celery, sago pondweed, and long-leafed pondweed); and 0.24 acres of American lotus replacement. Construction/installation of this design-build project is slated to begin this spring. The marina will be the first Lake Erie marina to be surrounded by high quality restored wetlands.

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A Woodland Memorial To Kentucky Veterans

In the southwest part of Jefferson County, Kentucky, at the northern edge of the Kentucky Knobs, over 6,000 wooded acres of steep hills and hollows form the Jefferson Memorial ForestEstablished in the 1940s as a tribute to Jefferson County veterans, the Forest is a natural oasis just miles from the commercial and residential developments of Louisville. Biohabitats helped put together a consultant team, headed by architectural firm Jones & Jones, which was selected by Metro Parks to carry out the development of a master plan for the Forest. By engaging stakeholders and performing a natural resources overview that examined geological characteristics, soils, watersheds and streams, forest communities, and ecological hubs and linkages, Biohabitats was able to help guide the formulation of a plan that respects and enhances the ecological significance of this immensely large and important park. With a completed draft master plan, and a community committed to its stewardship, Jefferson Memorial Forest should stand, expand and continue to pay tribute to its honorees for a very, very long time.

Places

The Chesapeake Bay Chesapeake Research Consortium's Ecosystem Based Management: The Chesapeake and Other Systems Conference will be held in Baltimore March 22-25.

Biohabitats President Keith Bowers will participate in a session entitled "The Past, Present, and Possible Futures of Small Tributaries to the Chesapeake Bay: Implications for Ecosystem Services."

Biohabitats ISM Vice President, Kevin Heatley, will join members of the National Association of College and University Business Officers (NACUBO) at the Smart and Sustainable Campuses Conference in College Park, MD on April 5-7.

The Salt Lake Sustainable Building Conference will take place on April 7. Biohabitats San Francisco Bay Bioregion leader Allegra Bukojemsky will present, "The Sustainable Sites Initiative - Guidelines for Landscape Sustainability."

Given the "Designing For Life," theme of this year's meeting of the Utah Chapter of the American Society of Landscape Architects it's no surprise that Allegra will be presenting there as well. The meeting will be held April 24-25 in Park City, UT.

The California chapter of the Society for Ecological Restoration (SERCAL) is teaming with the California Native Grasslands Association to present the SERCAL/CNGA Joint

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Conference April 29-May 1 in Folsom, CA. Biohabitats San Francisco Bay Bioregion Leader Allegra Bukojemsky wouldn't miss this one for the world.

Representatives from Biohabitats Great Lakes and Ohio River Bioregions will be on hand at the 2009 Ohio Stormwater Conference. Water Resources Engineer Jennifer Zielinski will showcase our approach to conservation planning, which is applicable to many growing communities in the region. Water Resource Specialist Ivette Bolender will deliver a presentation on Biohabitats' Nine Mile Creek project. Environmental Scientist Suzanne Hoehne will also join in the fun. Be sure to stop by the Biohabitats booth. We are proud to sponsor this conference presented by the Mill Creek Watershed Council of Communities, the Ohio Water Environment Association, the Regional Storm Water Collaborative, and the Tinkers Creek Watershed Partners.

People

Water Resources Engineer **Jennifer Zielinski** was recently invited to join the Board of Directors of the Chesapeake Stormwater Network, a new nonprofit working towards more sustainable stormwater management in the Chesapeake Bay. With her background in stormwater and her experience managing programs in the non-profit sector, Jen was a natural choice for the role of Treasurer. As such, she will help guide the organization and provide oversight of its financial health. As the organization's only out-of-state Board member, Jen also bring a national perspective to the organization.

Across the United States, there is a pressing need for a national framework to guide sustainable community initiatives. Inspired by the success of the LEED Green Building Rating System™ developed by USGBC, the ICLEI-Local Governments for Sustainability USA has initiated development of a national, consensus-based system with indicators and metrics that will help local governments set priorities and maximize their investments in strategic actions. Biohabitats own Amelia Greiner was appointed to a Technical Advisory Committee of the STAR Community Index. In this role, Amelia will help develop the indicators and metrics that this benchmarking tool will use.

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Glossary

- **Acid Rain** - The result of sulfur dioxide (SO2) and nitrogen oxides (NOx) reacting in the atmosphere with water and returning to earth as rain, fog, or snow. For more information, visit EPA's Acid Rain Web site. (source: USEPA)
- **Embodied Energy** - the otal energy sequestered from a stock within the earth in order to produce a specific good or service including extraction, manufacture, and transportation to market. (source: whygreenbuildings.com)
- **Evapotranspiration** -The loss of water from the soil both by evaporation and by transpiration from the plants growing in the soil. (source: USEPA)
- **Extensive Garden** - Extensive gardens have thinner soil depths and require less management and less structural support than intensive gardens. They do not require artificial irrigation. Plants chosen for these gardens are low-maintenance, hardy species that do not have demanding habitat requirements. The goal of an extensive planting design is to have a self-sustaining plant community. (source: USEPA)
- **Geotextiles** - Cloth or clothlike materials intended for use in the soil, usually for filtering or containing soil water. Some types are used to prevent or control erosion. (source: whygreenbuildings.com)
- **Green Roof** - Also known as rooftop gardens, green roofs are planted over existing roof structures, and consist of a waterproof, root-safe membrane that is covered by a drainage system, lightweight growing medium, and plants. Green roofs reduce rooftop and building temperatures, filter pollution, lessen pressure on sewer systems, and reduce the heat island effect. (source: USEPA)
- **Grey Water** - Non-drinkable water that can be reused for irrigation, flushing toilets, and other purposes. (source: USEPA)
- **Heat Island Effect** - This phenomenon describes urban and suburban temperatures that are 2° to 10°F (1° to 6°C) warmer than nearby rural areas. (source: USEPA)
- **Intensive vs. Extensive Gardens** - Intensive gardens have thicker soil depths and generally require more management and artificial irrigation systems. The plants chosen for these gardens must thrive in the specific roof environment they inhabit. Intensive gardens are heavier than extensive gardens, requiring more structural support. Extensive gardens have thinner soil depths and require less management and structural support. They do not require artificial irrigation. Plants chosen for extensive gardens are low maintenance, hardy species and do not have demanding habitat requirements. The idea of an extensive planting design is to have a self-sustaining plant community. (source: USEPA)
- **LEED Certification** - Certification through the Leadership in Energy and Environmental Design process, currently the most definitive such process. LEED certification is based on a variety of categories, such as site sustainability,

energy, materials, and indoor quality. It divides buildings into four categories: basic certification, silver, gold, and platinum. (source: whygreenbuildings.com)

- **Life-Cycle Analysis** - the study of the environmental impacts of a product or service over its entire life cycle, from the extraction of raw materials, through to the consumption and final disposal of the product. It is a concept and a method to evaluate the environmental effects of a product or activity holistically, by analyzing the entire life cycle of a particular product, process, or activity. Life-cycle assessment is typically described in three complementary phases: inventory analysis, impact assessment, and improvement assessment. (source: whygreenbuildings.com)
- **Living Wall** - part of a building envelope system, comprising pre-vegetated or planted on-site panels containing plants, growing medium or liquid nutrient installed in or on a frame, secured to a structural wall or it can be free standing (source: www.greenroofs.com)
- **Low Impact Development (LID)** - A sustainable landscaping approach that can be used to replicate or restore natural watershed functions and/or address targeted watershed goals and objectives. (source: USEPA)
- **Noise Reduction (NR)** - The simple loss of sound level that occurs in passing through a medium. Most often noise reduction refers to a single octave or one-third octave-band noise.
- **Particulate Matter** - A complex mixture of extremely small particles and liquid droplets. It is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles. (source: USEPA)
- **Thermal Load** - Amount of heat discharged by an outlet into a water body per unit time. (source: American Meteorological Society)
- **Volatile Organic Compounds (VOCs)** - Emitted as gases from certain solids or liquids, VOCs include substances-some of which may have short- and long-term adverse health effects-such as benzene, toluene, methylene chloride, and methyl chloroform. (source: USEPA)

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About Leaf Litter

Leaf Litter is a publication of Biohabitats, Inc. Coinciding with the earth's biorhythms, it is published at the Fall Equinox, Winter Solstice, Spring Equinox and Summer Solstice to probe issues relating to conservation planning, ecological restoration, and regenerative design. Biohabitats has attempted to ensure the accuracy and veracity of the information provided in *Leaf Litter*, however, information contained in *Leaf Litter* should not be construed as a recommendation or endorsement by Biohabitats. Please click here to contact Leaf Litter editors with questions, comments or content ideas.

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Biohabitats is an ecological design and consulting firm specializing in conservation planning, ecological restoration, and regenerative design. To learn more about our ecological services, mission and vision, visit us at www.biohabitats.com.

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