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An Urban Prairie

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An urban prairie

How university green roofs enrich city life and improve ecosystems

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Plants and other vegetation enliven the Ted and Jill Spaid Terrace, located on the north roof of the university's Regnier Hall.

At first glance, the rows of grasses and wildflowers on the roof of Kansas State University's Regnier Hall are a pretty sight and a peaceful respite for visitors.

But Lee Skabelund in the College of Architecture, Planning & Design sees much more.

To Skabelund, the grasses and wildflowers represent the diversity of the Kansas Flint Hills. They are pieces of the prairie brought to an urban rooftop. They are ways to improve local ecosystems. And, along with other types of living infrastructure, they represent a pathway to enriching life in cities across the world.

Known as green roofs, the concept of planting flowers or even food crops on the rooftops of buildings dates back centuries — the hanging gardens of Babylon, thought to be constructed around 600 B.C., is one of the Seven Wonders of the World. Yet, only in recent years has green roof construction become trendy. Designers are building gardens to reduce storm water runoff, to cool buildings and to reduce noise, among other benefits.

"Green roofs have been explored now from a research point of view for about 15 to 20 years," said Skabelund, associate professor of landscape architecture and regional and community planning. "In the last 5 to 10 years, it has really blossomed in terms of all kinds of research around the world. Much of the research is being done outside of the U.S., but there are so many people interested in it now."

Researchers plant hardy varieties, called sedums, to help establish vegetation on green roofs, such as this sedum on Regnier Hall's roof.

K-State has four active green roof research projects: a lower and upper roof of Seaton Hall's west wing; a roof on Regnier Hall; and two large roofs covering nearly 43,000 square feet — about 1 acre — at Memorial Stadium.

"Memorial Stadium is intended to be a reflection of the surrounding area," said Pam Blackmore, master's student in landscape architecture who leads a portion of the research on the stadium's roofs. "We are trying to bring some of the biodiversity of the Flint Hills to the edge of campus."

The stadium recently was remodeled to house the Berney Family Welcome Center, the Purple Masque Theatre and other university offices. The current green space was designed to limit the number of people on the two roofs, which decades ago was seating for fans at football games. Each of the roofs has more than 20 species of native grasses and wildflowers.

"Most of the plants are local natives," Blackmore said.

She noted that the green roof design incorporates several purple flowering plants as well as other colors. Native grasses, such as big bluestem and Indian grass, are also in the mix and can grow more than 6 feet tall.

In other words, it's as if the nearby Konza Prairie Biological Station, a research centerpiece of the Kansas Flint Hills, has been nurtured on the main K-State campus.

Not a simple task

But what seems to be a simple process of growing wildflowers is really not so simple at all.

Take the Memorial Stadium project, for instance, where the roofs were insulated first and then a system of webbed plastic cells, called geoweb, was set in place to keep several tons of sandy soil from falling down the steeply sloped surfaces. The geoweb is held in place by stainless steel cables attached to eye bolts at the top of the green roofs.

Because of an error during design, the initial west side construction failed nearly three years ago when the geoweb could not hold the sandy soil in place and it all slithered down to the bottom of the 22-degree sloped roof.

> **"We are trying to bring some of the biodiversity of the Flint Hills to the edge of campus." — Pam Blackmore, master's student**

A recent water leak on the east side of the stadium was another learning experience.

"As with all roofs, it can take a while for roofing professionals to determine where the leak is coming from," Skabelund said. "A green roof makes finding the leak a little more complex because you may need to take some green roof materials off to find the leak."

Research on Regnier Hall's experimental roof focuses on plants' survival and growth, including their height and coverage.

The lush vegetation that covers the east roof of the university's Memorial Stadium represents the biodiversity of the Kansas Flint Hills.

K-State's other green roof projects may not be at such a large scale, but they can be just as complex. Visitors to the green roofs can see soil and plants, but what they cannot see are as many as eight layers of material beneath the surface, including the engineering substrate or soil, filter fabric, a drainage layer, root barrier, waterproofing membrane and roof insulation.

"Green roofs are harsh environments for plants because the substrates or soil depths are very thin, so plants may not have a lot of room for their roots to spread out and establish," said Priyasha Shrestha, master's student in landscape architecture. "The plants have to be very hardy, very drought-tolerant and maybe will only do well when there is ample rainfall on a green roof."

Therein lies the challenge for researchers: design green roofs that can survive in challenging climates while providing a beautiful setting for visitors.

Critical for the Flint Hills region

Shrestha, who studied architecture in her native Nepal, is monitoring the health and growth of plants atop the Regnier Hall roof. The plants are grown in two substrates that are 4, 6 or 8 inches deep.

"We are looking at the plant's survival and looking at growth in terms of height and coverage," Shrestha said. "I'm also looking at physiological health in terms of stomatal resistance, which relates to how water vapor and carbon dioxide move to or from the stomata, or pores, on the leaves of plants."

Shrestha's work is important because, as Skabelund notes, the first step in managing a green roof is getting plants established. A number of sedums — hardy plants normally not native to the area — can establish quickly, while native plants typically take more time and care to survive on a green roof.

"We think you need two years to really get the roots established," Skabelund said.

He noted other studies in which native plants died after being watered for only a couple of months or a single growing season.

Blackmore said that more than 1 million gallons of water were used to maintain the Memorial Stadium rooftops in 2017. Part of her challenge going forward is to determine how to be more strategic regarding when and where to apply water.

"There are some areas that are getting too much water and other areas that don't have as much water," she said. "Distribution uniformity is key for irrigation design, and it gets challenging to achieve when you are dealing with the sloped surface and tall vegetation of Memorial Stadium."

Another student, Allyssa Decker, doctoral student in environmental design and planning, is gathering data from soil and temperature sensors. She is combining it with weather station data to determine the relationship to plant survival and growth.

Her work will help improve irrigation and management practices to make green roofs more sustainable and to minimize nonessential costs, she said.

The following projects also use the green roofs.

- *David Haukos, associate professor of biology, is working with Blackmore to study the community of butterflies on the Memorial Stadium rooftops.*
- *Trisha Moore, assistant professor of biological and agricultural engineering, and Gerard Kluitenberg, professor of agronomy, are helping Skabelund and Decker assess soil moisture data.*
- *Dale Bremer, professor of horticulture, is using drones to monitor drought and other stresses in grass. He is collaborating with Ajay Sharda, assistant professor of biological and agricultural engineering; Harman Singh, master's student in biological and agricultural engineering; and Deon van der Merwe, adjunct faculty member in diagnostic medicine and pathobiology.*

"Our work requires what we call 'ground truthing,'" Bremer said. "We can see patterns from aerial images and may have ideas as to what is happening to the vegetation. But ultimately we need boots on the ground to evaluate the areas where we suspect plants may be suffering stress of some kind to determine exactly what is going on."

Mary Beth Kirkham, university distinguished professor of agronomy, is guiding research on plant health and soil moisture on the Regnier Hall roof and helping Shrestha measure stomatal resistance. She said the work at K-State is extremely important for this part of the country.

"Much of the research on green roofs has been done in the eastern part of the United States, a temperate zone where rainfall is plentiful," she said. "Little research has been done in semi-arid areas like Kansas."

"Professor Skabelund and his students are leading the way in understanding how plants can grow on roofs in dry regions," Kirkham added. "They are studying different kinds of plants, including prairie plants found at Konza Prairie. Prairie plants are adapted to dry conditions, so some are good candidates for species to grow on green roofs."

Research on the K-State green roofs was supported by the Mary K. Jarvis Distinguished Faculty Chair, which Skabelund held from 2015 through the summer of 2018.

Seek more

Learn more about K-State's green roof projects and view a photo gallery.
k-state.edu/seek