Urban Ecology Study Witnessing the Birth of a 'Designer Ecosystem'

When Arizona State University's Central Arizona-Phoenix Long Term Ecological Research Project (CAP LTER) was funded by the National Science Foundation in 1997, more than 50 scientists signed on to do the multidisciplinary research knowing that they were embarking on something unusual - the first ever long-term ecological study of "a human-dominated ecosystem," aka, a city.

Seven years later, the first phase of the research has been completed and NSF has renewed the project with a second grant of $4.9 million for six more years of study, indicating the agency's satisfaction with the research's accomplishments. The long-term study has made more than just a good start, however -- the project has produced results that may transform the study of ecology.

After seven years, the project scientists are increasingly convinced that they are looking at a new kind of ecosystem - an ecosystem that is radically different from the native desert that surrounds it and driven in part by forces unlike those usually studied by ecologists.

"It's not what people generally think - they think there's either nature or there are cities," said Charles Redman, director of ASU's Center for Environmental Studies, and one of the project's principal investigators. "That's what this is all about - there is nature in the city. The city is part of nature."

Along with their partner LTER in Baltimore, the development of urban LTERs was considered a major leap forward in the field of ecology both because they included human culture as a "driver" of - and "responder" to -- the ecosystem being studied, and also because the research would include studies far outside traditional ecology or even the biosciences, climatology and earth sciences: sociology, anthropology, engineering, and economics.

Phoenix as chosen as one of the two urban LTER sites because it is a fast growing desert city, like many of the world's emerging cities, with an archeological record for the area going back more than 2,000 years. The city has gone from a small farming center to a major metropolitan area in little more than a century, with the major growth occurring after World War II.

"It's an ideal situation, because the development of the city has literally been happening as we watch," said ASU Life Sciences Professor Nancy Grimm, CAP LTER's other principal investigator. "We've made an assault on understanding the structure and function of the urban ecosystem on numerous fronts. From air quality to birds and bugs and plants to water quality and usage, to landscaping choices, climate, economics, zoning, pets… we are considering everything that is part of the ecosystem."

One of the most interesting things that has been revealed is the special nature of the urban biota, which has a distinctive mixture of native and exotic plants and animals, but differs even further in the dynamics of how these organisms interact.

"We have been defining the Phoenix urban ecosystem, which, it turns out, functions very much like an ecosystem with bugs and birds and plants -- but in different sets of relationships, with much different abundances," said Redman. "The abundance of organisms is higher overall. If you just measure it, it is richer in town than in the desert."

The scientists note that the urban environment differs from the surrounding desert in that it has an ample, year-round supply of basic life resources such as water, that in the native environment is seasonal or highly localized. This leads to a larger and more consistent supply of growing plants, which are the base of the

food chain, and ultimately to a greater number of animals, such as birds.

“If you know anything about abundances of birds in desert environments, you know that birds are concentrated along river corridors and riparian zones and that diversity also is concentrated there,” said Grimm. “What Phoenicians have done is to take this river, which was one localized area, and capture the water and distribute it over a very, very large area. If you fly in you can see this - you can see that we have a lot more plant biomass, a lot more trees. There are little lakes scattered all over the place. Scottsdale since 1940 has gone from zero to 167 little lakes.”

However, the larger populations of birds that thrive in the city’s oasis are not the same as those in the desert, but are less diverse in species, with “generalist” native and non-native species (such as mourning doves, grackles and English sparrows) being favored over many of the more highly specialized birds found in the natural desert.

“What we’ve found is that some species are missing, while others, in fact, are enriched,” said Redman. “What you have, in fact, is the creation of an urban ecosystem which is quite distinct but not necessarily impoverished.”

One study in the project, for example, found that Abert’s Towhee, a mid-sized bird that is relatively uncommon in the desert, thrives in Phoenix because the city is crisscrossed with canals, which mimic the riverbanks the species normally frequents, and giving the birds ready access to lawns and golf courses which are ideal for its ground-feeding habits. There are also populations of birds not normally found in the low desert at all, including Ravens and Peach-Faced Lovebirds.

While any birder can see that the diversity and abundances of birds are different, to the researchers, a more important detail is something that is practically invisible -- a major shift in the environment’s food web - what ecologists call the “trophic structure” - making the city’s biology systematically different from the desert’s.

“We’ve been monitoring and assessing the nature of trophic structure of Phoenix’s wildlife - the big animals, the smaller animals that they eat and the plants that they eat,” Redman said. “You’re spreading water all over the environment, and this is one of the prime reasons for the greater abundances of birds. This also has consequences for many, many other things. A fun thing is that this high abundance of birds, in turn means that a variety of insects are kept at very low abundance.”

Through experiments, the group found that insects, whose populations are controlled in the native desert mainly by seasonal scarcity of vegetation, instead are kept in check in the city by a larger population of birds. Bird populations are large because of ample water and the absence of their natural predators -- especially hawks (though they are partially replaced by cats). In turn, the lack of predation leads the city birds, most of whom are mainly seed-eating species, to spend more time hunting nutrient-rich insects, a behavior that would be risky around predators.

Other behavioral and trophic shifts also appear to follow. Particularly intriguing is the further implication that populations and trophic structures vary somewhat within the city depending on the economic status of the neighborhood. Economic issues appear to be a controlling factor for the urban ecosystem, much like climate and the abundance or absence of resources is in the surrounding desert environment.

“The urban ecosystem is driven very largely by the local economy,” said Grimm. “The populations are systematically altered by the decisions that we make and the relationships of the animals have been shuffled.”

“There’s also a relationship our researchers are seeing between the spatial distribution of where the water

is, where all the plants are and where the wealth is," she noted. "This is something that we still don't know the mechanisms of, but one of the most interesting findings is that the diversity of plants in the Phoenix area is related strongly to family income -- higher family income, higher plant diversity; lower family income, lower plant diversity. We don't know the mechanisms, but it's an interesting phenomenon."

Grimm and Redman note that the findings also point out that human choices are also modifying the physical environment, from its soil chemistry to the urban heat island and microclimates, and that the implication is that the urban ecosystem, while complicated, could potentially be manipulated and controlled.

"There are things that humans can deliberately manipulate, like the water system. But then there are a lot of by-products of our activities -- big changes in our ecosystem that we don't necessarily recognize or try to control," Grimm said. "The good example of one of these is a big increase in nitrogen input, which comes about because of the burning of fossil fuels in cars. Driving around fertilizes the ecosystem.

"Is fertilizing a good thing? One of the things that we are going to do in the next phase is to investigate the consequences," she said.

While the team's interest is in doing fundamental ecology research, there are also some important applied science issues behind the project. "What we really want to know is whether we can have a sustainable urban ecosystem in this kind of environment and setting. What are the elements of it that are warning signs of vulnerability, of some kind of event that could cause collapse? How do our institutions and the systems we have set up stand up against various kinds of stress? Is the urban ecosystem resilient?" Grimm asked.

"People in ecology are beginning to talk about designer ecosystems - systems that have been heavily influenced by humans. What we're doing is pioneering this," Grimm said.

Source: Arizona State University