Foundational concept of ecology tested by experiment

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Male blue dasher (*Pachydiplax longipennis*), is one of about 10 dragonfly species commonly seen buzzing the artificial pond systems at the Tyson Research Center, WUSTL's field station for ecosystem studies. A new study showed that the dragonflies were the liaisons that connected aquatic to terrestrial ecosystems, allowing the plant purple loosestrife to "tug" on the interconnections between organisms in both ecosystems. Credit: Travis Mohrman/Tyson Research Center

An elementary school science activity asks children who have each been assigned a wetland plant or animal to connect themselves with string and tape to other "organisms" their assigned plant or animal interacts with in some way.

Once an ecosystem web has been created, the teacher describes an event that affects one "organism." That "organism" tugs on its string. Other "organisms" that feel the tug then tug on their strings in turn.

The lesson is that every organism is important to the health and balance of a wetland and that every organism in the wetland is connected to every other organism in some way.

That's more or less an article of faith among ecologists, but how true is it really? Ecologists rarely have the time or resources to test this foundational concept through experiment.

Now a summer-long study shows that the flowering invasive plant purple loosestrife (Lythrum salicaria) triggers a chain of interactions that ultimately alters the diversity of zooplankton populations in artificial ponds.

The interactions cross traditional ecosystem boundaries, connecting aquatic to terrestrial systems on the wings of dragonflies that exploit, at different times in their lives, the resources of both the water and the land.

"It's easy to say that everything is connected in some way, but how much these connections matter is something that we don't always know," says Kevin G. Smith, PhD, adjunct professor of biology in Arts & Sciences at Washington University in St. Louis and associate director of the Tyson Research Center, WUSTL's 2,000-acre field station.

By verifying one of the foundational ideas of ecology, the experiment, published electronically May 24 by the journal *Oecologia* in advance of print, will help inform decisions about biological control of invasive species, restoration of degraded habitats and similar ecological issues.

Stock tanks at the Tyson Research Center hold artificial pond communities that are manipulated in various ways to explore ecological interactions. Scientists also survey natural ponds at the research center and in its vicinity. Credit: Travis Mohrman/Tyson Research Center

A study long meditated

Smith says the experiment was inspired by work his colleague Tiffany Knight published in 2005. Knight, PhD, associate professor of biology at WUSTL, had showed that plants do better if they are near ponds with fish, because the fish eat dragonfly larvae, reducing the population of dragonflies that prey on plant pollinators.

Smith was intrigued by the study because the effect was indirect and cut across ecosystems as traditionally defined. "Ecologists tend to study forests, or ponds, or glades, but there is a lot of border crossing going on," he says, "and Tiffany's study demonstrated that."

His idea was to see if he could find links that went the other way, connecting land to water instead of water to land. If fish affected land plants, could plants affect fish —or at any rate aquatic communities?

One plant that might tug hard on ecosystem connections, Smith thought, was the purple loosestrife, which produces many showy flowers and displaces native plants such as cattails that produce few or none.

"The flowers make it functionally different from the native plants," Smith says, "so it seemed possible its presence would cause a disturbance that would ripple through the wetland communities."

But it took a few years for Smith to start the experiment.

"Everybody I talked to about it thought that one of the links would fail; that it wasn't possible for every connection from the plant to the aquatic system to hold as I had hypothesized it would," Smith says. "I sort of felt that way, too. It seemed like a long shot."

Here's looking at you, kid. Dragonfly larvae are voracious predators and can grow to be three inches long. Credit: Travis Mohrman/Tyson Research Center

Eight artificial wetlands

But the tradition at Tyson Research Center is to challenge fundamental ecological ideas with the methods and tools of science, and so in the summer of 2009, Smith finally undertook what he knew would be a labor-intensive experiment.

He and colleagues Laura A. Burkle, PhD, then a postdoctoral fellow who is now a faculty member at Montana State University, and Joseph R. Mihaljevic, then a WUSTL undergraduate and now a graduate student at the University of Colorado, Boulder, created eight artificial wetlands at Tyson, each consisting of a central stock tank and four smaller surrounding pools.

The tanks were stocked with six species of aquatic plants and three species of snails and inoculated with the smaller zooplankton and phytoplankton drawn from local ponds. The remainder of the aquatic community, such as frogs, dragonflies, flies, beetles and bugs, was allowed to assemble naturally.

Loosestrife plants in pots were placed in each of the four small pools. The pools were separated from the tanks so that only the flowers — and not plant litter and pollen — would play a role in the ecosystem of the central pool.

The eight "wetlands" thus created were divided into four treatment groups and the number of loosestrife flowers in each "wetland" was manipulated to mimic differences in loosestrife density.

The loosestrife in two wetlands were left alone but flowers at the other wetlands were picked to reduce their numbers to 75 percent, 50 percent or 25 percent of the flowers at the untouched wetlands.

During the course of the experiment, the small insects visiting the pools were regularly counted and categorized, as were the dragonflies and their behaviors.

At the end of the summer and the experiment, the zooplankton and phytoplankton in the eight central tanks were sampled and identified.

What happened?

The scientists were able to track the effect of the loosestrife flowers across four trophic levels, or levels in the food web, and two ecosystems, the terrestrial and the aquatic ones.

The links worked as follows: Wetlands with abundant flowers attracted more pollinating insects; the insects in turn attracted more of the carnivorous dragonflies; the well-nourished dragonflies laid more eggs in the central ponds; the voracious dragonfly larvae that hatched from the eggs altered the diversity of the zooplankton communities in the ponds.

In an unexpected turn, flowering loosestrife actually increased zooplankton species richness, perhaps, speculates Smith, because they preferentially ate a dominant zooplankton species, releasing others from competition.

"To be honest," Smith says, "although the increase in zooplankton diversity is interesting and surprising, I don't think that specific detail matters too much. Nor, is the point simply that purple loosestrife might be affecting aquatic ecosystems, although that is important from a management perspective.

"What matters is that we showed the interconnections are actually strong enough to transmit disturbances through and across webs. We pushed on one link and something four links away in another ecosystem moved."

Provided by Washington University in St. Louis