A New Tool in Conservation of Prairies and Other Plant Communities: Plant-Pollinator Network Science

A new approach explores the effects of restoration by looking at interactions between plants and pollinating insects

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The beautiful glacial outwash prairies of South Puget Sound are among the rarest ecosystems in the United States. Their charismatic spring bloom and the rarity of some of the species they support have made remaining prairie fragments the focus of many conservation and management efforts. Some efforts have been very successful: restoration is increasing native plant diversity on multiple preserves, and plants that were once rare can now be found in abundance in some places.

But as we continue to learn more about community ecology, there may be new ways to evaluate the success of restoration beyond enumerating plant species and their persistence. Specifically, there is increasing interest in understanding how ecological communities are structured and how the many interactions between community members (predator and prey, pollinator and pollinated, pathogen and host) affect a community’s resilience and the context within which individual species interact. In the South Sound, we are using an analytical tool called network science to explore such community structures and their application to restoration and conservation.

Restoration of South Puget Sound Prairies

Agriculture, development, fire suppression, and invasion have taken a heavy toll on our prairies, and at last estimate only about 3 percent of their original extent remains functional native prairie (Crawford and Hall 1997). In recent years, conservation science practitioners, land managers, and native plant lovers have painstakingly developed and implemented techniques to restore these prairies. First, volunteers and botanists collect native seed from a few extant populations, and native seed farms amplify the amount of seed by growing it out and harvesting more. Meanwhile, land managers prepare sites by removing non-native plants and returning the historically common ecological disturbance of fire through prescribed burning. Eventually, they sow in native seed or plant seedlings. The process is iterative and ongoing.

These years of restoration have led to a visually glorious uptick in native floral diversity. (If you haven’t been to Glacial Heritage Preserve—or even if you haven’t been in the past 5
years—a wonderful spring pilgrimage awaits you. Along with the camas (Camassia quamash), western buttercup (Ranunculus occidentalis), and spring gold (Lomatium utriculatum) that often persist in degraded habitat, native bunchgrasses such as Roemer’s fescue (Festuca roemeriana) and a variety of native forbs have been reestablished in some preserves, including sicklekeel and Pacific lupines (Lupinus albicaulis and L. lepidus var. lepidus), Columbian saxifrage (Micranthes integrifolia), large-flowered blue-eyed Mary (Collinsia grandiflora), sea blush (Plectritis congesta), and golden paintbrush (Castilleja levisecta).

The restoration successes are profoundly praiseworthy—seeing Scott’s broom-invaded fields or grazed lands transformed into a community of native plants is exciting. Yet the very successes raise questions about the next steps. For example, restoration is augmenting native plant diversity, but will this bring back other species that used to inhabit prairies, such as insects that interact with these plants? How well do our human-con-structed prairies do at recreating the conditions that support plant species that are truly rare? And will these restored prairies be resilient to future species losses?

**Pollinators, Plants, and Prairie**

I became interested in exploring these questions relative to western Washington prairie pollinators, because I study plant-pollinator interactions. Animal pollinators (mostly insects) are essential to reproduction for about 87.5 percent of land plants on average (Oliver et al. 2011), and locally, we have found that about 80 percent of our South Puget Sound forbs require animal pollination (Waters et al., unpublished data). Since our prairies are typically dominated by forbs, that means we owe our prairie landscapes in part to the pollinators that keep the plants reproducing. Therefore, it makes sense to ask whether increasing native plant diversity will also bring in pollinators and restore their functional links with native plants.

**Studying Species within Whole Communities Using Networks**

To tackle these questions, I used network analysis, which is a way to look at whole communities to visualize and analyze the interconnectedness of their interacting members. Think of a social network that connects people to each other, or a vast telecommunications network. Plants, of course, interact in networks with other species, such as pollinators, herbivores, and soil microbes. There is a large and expanding literature on ecological networks in academic ecology, but this approach has been rarely used in conservation and restoration contexts. However, ignorance of the network of interactions within which a rare species is embedded can lead to poor assumptions about how to protect it. For example, a shared pollinator might visit a native plant more often when a particular exotic plant blooms nearby, making exotic removal an option to consider carefully (Waters et al. 2014). In addition, some communities have network structures that are more resilient to species losses than others, making it relevant to compare networks in restored and “intact” ecosystems (Tylanakis et al. 2010).

To find out how plant and pollinator species are interconnected in South Sound prairies, our research team collected data in 2017 at six preserves whose plant communities varied in the number of years they had undergone restoration. We visited each preserve about every 10 days throughout the season, assessing floral abundance and performing 30 minutes of observations at patches of each flowering species during each visit. We either visually identified (butterflies and some bumble bees) or collected and later identified (all other insects) every.
insect that contacted a floral reproductive organ. Then we used information about the visitors to each plant to construct and analyze plant-pollinator networks.

**Insights in Restoration**

As expected, sites with more years of restoration actions had higher floral diversity overall, as well as higher native floral diversity. Happily, pollinator diversity generally increased with floral diversity. Even more interestingly, the composition of pollinators also changed with restoration: flies dominated at low-restoration sites, while more bee groups were represented at higher-restoration sites.

In addition to changes in diversity and composition, we also saw changes in network structure—that is, how plants and pollinators were interconnected—in response to restoration. Several of those changes were interesting. First, we found that both pollinators and plants were more specialized at more-restored sites in terms of their interactions: they had fewer partners on average. That suggests a hypothesis that plants might be better pollinated at highly restored sites, since it increases the chances that a given pollinator arrives bearing pollen from the same plant species as the one it’s visiting. Second, we found that some metrics tentatively associated with “resilience” (Tylianakis et al. 2010) increased as restoration progressed. Finally, we found that notorious non-native plants played very different roles in restored versus unrestored sites, showing up as “hubs” that supported many types of pollinators in unrestored sites but becoming much more peripheral in sites that were more florally diverse.

**Insights in Species Conservation**

In terms of conservation of individual species, we were most interested in two plants, golden paintbrush (Castilleja levisecta) and harsh paintbrush (C. hispida). These are two of the three perennial native host plants for a federally endangered butterfly, Taylor’s checkerspot (Euphydryas editha taylori), that inhabits South Puget Sound prairies. (The third is the non-native lance-leaved plantain, Plantago lanceolata.) They are called “host plants” because they host the eggs and larvae of the butterfly. Taylor’s checkerspot adults will only lay eggs on these host plants, and their larvae must feed on these host plants to gain defensive chemicals that make them toxic to their predators (Kaussaari 2004). Having these plants in Taylor’s checkerspot habitat is an important part of recovering the butterfly, because without them, the adult butterfly is unlikely to lay eggs, and the larvae, if hatched, will starve. Consequently, both plants are of conservation concern because of the butterfly. In addition, golden paintbrush is itself listed as federally threatened. Both golden and harsh paintbrush have been restored to prairie preserves, and we wanted to know how they were connected to pollinators and other plants.

We found that both paintbrush species were mostly visited by bumble bees. Both species had low rates of visitation and a low diversity of visitors compared to other species, such as camas. Harsh paintbrush, in particular, was very little visited. We know from other projects that both paintbrushes require pollinator visits to produce seed, raising the question of whether the harsh paintbrush is successfully reproducing in the restoration sites.

Using networks allowed us to detect indirect interactions between plants via their pollinators. For example, at one preserve, we observed only two pollinator species visiting golden paintbrush all season. One pollinator, the California bumble bee (Bombus californicus), was only observed nectaring on one other plant besides the paintbrush. What was the plant? A later-blooming forb, heal-all (Prunella vulgaris var. lanceolata). This is a great example of an “invisible” indirect interaction between plants, mediated by a pollinator, which is probably positive for both plants. Since the two plants never bloomed simultaneously at this site, the heal-all wasn’t competing with the golden paintbrush for pollinator attention. On the contrary, the heal-all provided nectar to support the bumble bee later in the season, without which the bumble bee population visiting golden paintbrush the following year could be diminished.

Once we realized how important bumble bees were to the two paintbrushes, we used networks to crudely simulate what might happen if we were to have a year when there was low or no bumble bee activity: we simply rebuilt the networks leaving out the bumble bees. (This exercise comes with big caveats,
because it makes the unwarranted assumption that other pollinators will visit the same flowers regardless of whether or not bumble bees are there as possible competitors. While that almost certainly isn’t true, it allows us to explore a hypothetical worst-case scenario, that is, no compensation by other pollinators for the bumble bee loss. We saw that the loss of bumble bees would indeed lead to losing some plants at some preserves—specifically, golden and harsh paintbrush, the very plants we’re interested in! While we aren’t expecting to lose bumble bees any time soon, this allows us to be especially tuned in to the fact that bumble bees are really important for the native paintbrushes. Since the paintbrushes themselves are very important to Taylor’s checkerspot butterfly, we find that caring about butterflies means caring about plants means caring about bees.

We look forward to exploring plant communities of all kinds using this new analytical tool. In 2018, we used this approach at several new sites, including a large Portland landfill undergoing restoration. We hope insights from networks can help develop important conservation questions that may not have been considered previously and lead to new studies that help us understand the plants, pollinators, and ecological communities we love.

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Literature Cited


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