Invasive Plants as Indicators of Ecosystem Health

by Stefanie D. Wacker

Looking northwest from the North Entrance of Yellowstone, the town of Gardiner, Montana, on the right. The yellow hue is blooming desert alyssum, a very invasive winter annual that has significantly expanded in the last decade, largely in the drier parts of the park, but has been found in Lamar and Hayden valleys. Photo taken April 15, 2017. (NPS PHOTO - S. WACKER)

Healthy, native plant communities provide sustainable habitat for wildlife, insects, and soil biota. They can persist through drought and contribute to ecosystem services, such as clean air and water. When invasive species are introduced into a native plant community, there can be numerous deleterious effects with minor to major consequences. For example, a non-native species might co-exist with only minor influence on the community or be highly invasive and cause major, wholesale community change. In the latter instance, invasive species can out-compete native plants for water and nutrient resources, have prolific seed production with high viability, and benefit from highly plastic life strategies which allow them to maximize resources. Long-term monitoring of plant communities in Yellowstone National Park (YNP) has numerous benefits, but principally, knowledge gained in the patterns and process of invasive species that threaten the native flora and compromise important ecosystem processes. Currently, there are 225 exotic plant species in the park, which represents approximately 15% of the taxa recorded (Whipple unpublished), a 50% increase from what was reported in Hansen et al. (2014). However, this is a measure of the number of recorded species and not the percent of vegetation cover. Long-term monitoring data can be used to assess the actual area covered by individual species. Additionally, information gained can be used to set priorities and guide landscape-level and species-specific management strategies, evaluate treatment efficacy, and identify specific disturbances that can lead to plant invasions (Blossey 1999).

Long-term monitoring of vegetation communities also helps in developing the state and transition model for different plant communities (e.g., sagebrush steppe, wet meadows, lodgepole forest) as well as identifying unique environmental stressors. In each community, the "state" of each community is represented by current species composition and abundance. The "transition" represents an in-between state where a change in species composition and/or abundance is triggered by one or more disturbances. State and transition models illustrate the resistance and resilience of a plant community to disturbances (Chambers et al. 2014). An example in the sagebrush steppe community would be a shift from sagebrush dominant with native, cool-season grass understory to an exotic, winter-annual understory, triggered by disturbances such as abandoned bison wallows or social trails. The scale of these changes can remain localized or progress to a landscape scale. The ability for a community to resist significant compositional change can be greatly affected by the type of disturbance and the presence, abundance, and biology of non-native species. These characteristics also affect the resilience, that is, the ability of a community to return the previous, pre-disturbance state.

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In 2015, a sagebrush steppe monitoring program was initiated in the northern range, Hayden Valley, and Pelican Valley in YNP. The silver sage (*Artemisia cana*) and big sage (*A. tridentata, sensu lato*) communities make up roughly 7% of the park, with big sage occupying the drier sites. However, computer models predict big sage could expand into novel locations, driven by both climate and exotic plant invasions (Bradley 2010, Bradford et al. 2014). Through careful inventory, National Park Service (NPS) scientists developed a list of native and non-native species in both the big sage and silver sage vegetation types. The monitoring program is designed to detect changes in frequency and abundance of both native and non-native species, with a particular interest in the current populations as well as identifying introductions of non-natives. By tracking numerous species, valuable information is gained regarding fluctuations in species abundance and can link spatial distribution with climate conditions, past disturbance, patterns of plant invasions, and other environmental, topographic, and edaphic gradients. Long-term vegetation monitoring is critical in this time of rapid climate change to better understand the complexities of the sagebrush steppe and to anticipate the future changes in species distribution. This knowledge will also prepare us for the transition to novel communities and give insight to the environmental conditions which may be drivers of change. Novel communities are unique assemblages of plants and associated biota that are the direct result of human-related impacts which drive communities beyond ecological thresholds and result in the transition to new, alternative states that are unlikely to return to a previous or historic state (Morse et al. 2014).

In order to anticipate and mitigate the effects of rapidly changing climate, YNP must continue to invest in long-term monitoring of plant communities. The dry sagebrush communities of Yellowstone are particularly susceptible to unprecedented invasions by winter annual grasses and forbs, specifically annual wheatgrass (*Eremopyrum triticeum*), cheatgrass (*Bromus tectorum*), and desert alyssum (*Alyssum desertorum*). Having witnessed complete community change in the Gardiner Basin in less than 30 years, it is clear that rapid and large-scale changes in other parts of the northern range are possible. While the arid conditions of the Gardiner Basin combined with a long history of varied land use is not replicated elsewhere in the park, it does illustrate the ability for non-native winter annuals to outcompete most native and even other non-native species in arid and/or drought conditions. Because these dry sagebrush communities are at high risk for catastrophic plant invasions, nine long-term monitoring locations have been established between the park boundary at Beattie Gulch and Mammoth Hot Springs. Figure 1 shows the proportion of desert alyssum in each foliar cover class (an estimation of abundance; follows Daubenmire 1959)

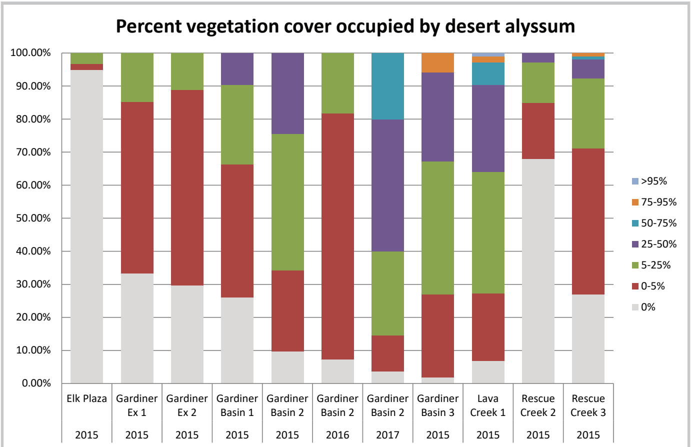

Figure 1. The proportion of desert alyssum (Brassicaceae: *Alyssum desertorum*) vegetation cover at nine long-term monitoring sites. Vegetation cover is collected in 50-100 1-m^2 sample plots. Data for approximately 100 species is collected at each study site. Desert alyssum was selected to monitor because of its ability to become extremely invasive. It is the most widespread and has the highest vegetation cover of the winter annuals in YNP.

at each location. Desert alyssum plus other winter annual species threaten other parts of the park, such as Lamar and Hayden valleys, particularly under the stress of projected climate scenarios of warmer, drier conditions. Only through consistent, continued monitoring will NPS scientists be able to detect the changes and determine ecological thresholds that when crossed, can result in potentially irreparable change to critical habitat.

Even though invasive species have plagued YNP for decades, we are now in a period of rapid environmental change, as well as increased threat by ever-expanding invasive species populations. A dedicated, long-term vegetation monitoring program is the best way to understand the state, transitions, and stressors of our sagebrush plant communities. Combining field collected data with remote sensing techniques such as those described by Thoma et al. ("Patterns of Primary Production and Ecological Drought in Yellowstone," this issue) allows us to quantify the magnitude of change and adjust management to help sustain the wild landscapes that define Yellowstone as the nation's first national park.

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