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Spalding's Catchfly: A Monitoring Challenge

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It is a common belief that plants are easier to monitor than animals; they can't run away. Most plant demography studies assume all plants will be detected, i.e., their detection probability = 1; however, values <1 are widespread in demography studies and can lead to biased results (Kéry and Gregg 2003). Some plants exhibit prolonged dormancy in which a plant remains alive but invisible belowground for one or more growing seasons. This presents an obvious detection problem. Tracking marked plants in permanent plots for consecutive years is needed to distinguish dormant from dead plants. Additionally, for plants with an unobservable dormant stage, all plants emerging aboveground for a growing season need to be detected with certainty or dormancy will be overestimated (Kéry et al. 2005). Aboveground plants, however, often go undetected as well due to such factors as stage class size, surrounding vegetation, herbivory, and observer ability.

The Threatened plant Spalding's catchfly *(Silene spaldingii)* is a long-lived perennial forb with whitish flowers and glandular stems that occurs in Palouse and canyon grasslands, sagebrush steppe, and open-canopy pine stands of the inland Pacific Northwest. Aboveground portions of the plant die back completely over winter and emerge in late May/early June as either rosette plants, single-stemmed plants, or multi-stemmed plants from an underground stem, the caudex. Flowering occurs from mid-July into October. This species is known to exhibit prolonged dormancy (Lesica 1997).

Most surveys and monitoring have been conducted at flowering time. A Montana demographic study conducted at flowering time reported high levels of prolonged dormancy, up to 50% annually, and considered all rosettes to be recruits (Lesica 1997). Other researchers also reported high levels of prolonged dormancy and considered rosettes to be recruits or questioned whether rosettes can be adults (Taylor et al. 2012, Luke 2013). Studies of this species in Idaho canyon grasslands, however, documented: 1) several stemmed plants flagged early in the season had disappeared completely by flowering (Hill and Gray 2000), and 2) several rosette plants were connected to mature caudices and/or occurred at sites that supported reproductive stemmed plants in previous years (Hill and Fuchs 2003, Hill and Weddell 2003). This indicated that all aboveground plants may not be detected at flowering and that rosette plants may be adult plants.

The Recovery Plan for Spalding's catchfly (U.S. Fish and Wildlife Service 2007) stipulates: 1) demographic monitoring for 10 consecutive years to obtain good estimates for population viability studies, and 2) trend monitoring every 5-10 years

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to determine if populations demonstrate stable or increasing trends for at least 20 years. These monitoring programs are part of a comprehensive plan for recovery of this Threatened species that also includes other on-going conservation efforts such as additional field surveys, weed control efforts, genetic research, pollinator studies, seed collection/propagation/plantings, habitat restoration, and research to determine effects of fire and livestock grazing.

Spalding's catchfly. Photo by Karen Gray.

Two Demography Studies

Two demography studies of Spalding's catchfly were conducted by IDNHP botanists in the canyon grasslands in the Craig Mountain area of west-central Idaho: 1) the BLM study funded primarily by the Bureau of Land Management from 2002-2011 (Hill 2012), and 2) the FWS study funded primarily by the U.S. Fish and Wildlife Service from 2004-2013 (Gray et al. 2011, Hill et al. 2014). To detect all aboveground plants and clarify the status of the rosette plant, we included two complete monitoring periods each year, one soon after emergence and one at flowering time, and included ground-level searches for small rosette plants at both periods. Both studies tracked individual plants in permanent plots (meter-wide belt transects) for 10 consecutive years. During sampling, meter tapes were extended the length of the transects and two reference coordinates, the linear distance along the tape and the perpendicular distance to the tape, were recorded for each Spalding's catchfly plant. We followed a total of 947 plants (152 BLM) and (795 FWS) during the studies. We identified four stage classes: three aboveground stage classes based on features consistently recognizable at both early and late monitoring: 1) R (rosette): no visible stem between sets of leaves; vegetative; did not bolt into stemmed stages, 2) S (single-stem): one stem; capable of reproduction, 3) M (multi-stem): more than one stem; capable of reproduction, and one belowground stage class: 4) D (dormant): produces no aboveground vegetation. Demographic estimates were based on stage-based transition matrix and mark-recapture analyses.

Results

Our two studies had different sites, plot designs, and primary observers, and were conducted over slightly different time periods; however, the results of both studies were very similar (Hill and Garton 2017). Our results differed considerably, however, from studies that monitored at flowering (Lesica 1997) or did not conduct ground-level searches for R plants (Taylor et al. 2012).

Detection of Aboveground Plants:

The two monitoring periods allowed us to determine that we detected essentially all (99.9%) aboveground plants at early monitoring; however, by flowering time, 48% of these aboveground plants were not detectable (disappeared or became unidentifiable). Therefore, we based the determination of demographic parameters on our early data when all aboveground plants were detected. Although early monitoring cannot provide reproductive data, it does provide the total number of plants present in the plots, a number that is essential for determining several demographic parameters, including percent flowering, stage class distribution, transition probabilities, percent recruitment, dormancy, and mortality.

Canyon grassland habitat, Craig Mountain, Idaho. Photo by Janice Hill.

Plant Numbers and Stage Distribution:

Plant numbers changed over the study periods. Two periods of high mortality occurred in both studies associated with two cycles of high rodent activity. This resulted in a large decrease in plant numbers at the beginning of the BLM study and further decrease at the end of the study; low levels of recruitment (1% annually) did little to offset this decline and plant numbers were considerably reduced at the end of the study. Levels of recruitment were slightly higher early in the FWS study (5% annually), plant numbers were more stable, and large increases in recruitment during the last three years of the study (22% annually) resulted in increasing plant numbers at the end of the study. Although stage class proportions varied annually, averages based on the middle eight years of the studies indicate plants spent 42% (BLM) and 38% (FWS) of their lives in the S stage, 31% (BLM) and 36% (FWS) in the R stage, 19% (BLM) and 18% (FWS) in the M stage, and 8% (both studies) in the D stage.

Adult R plant (3-4 cm) at least 9 years old; was an S, M, and D plant in previous years; no cotyledons. Photo by Janice Hill.

Status of the Rosette:

Other demography studies considered all R plants to be only recruits (Lesica 1997, Taylor et al. 2012). However, our studies showed the R stage was a major vegetative stage for the species with over 1/3 of plants emerging as R plants each year. Most R plants (>65%) were established plants present in previous years as either D, R, S, or M plants. R plants could be either: 1) a first-year recruit (was a seedling the previous year), 2) a juvenile (has not reproduced; remains in the R stage four to six years before reproducing as S or M plants), or 3) an adult (has reproduced as an S or M plant in previous years). The R plant was not a seedling; it lacked the distinctive cotyledons that were present on the much smaller seedlings. Plants often remained as R plants several years, i.e., 28% (BLM) and 38% (FWS) of plants were R plants for three years or longer; several were R plants all 10 years of the studies.

No morphological differences could be distinguished between R plants that were first-year recruits, juveniles, or adults, making the determination of recruitment especially challenging. Several consecutive years of tracking individual plants in permanent plots and monitoring early with ground-level searches were needed to determine maturity status of R plants.

Prolonged Dormancy:

Our studies indicated prolonged dormancy was a relatively minor component of the life history of this species. Average annual dormancy rate was 10-11% (ranging from 3-19%) and dormancy duration was either one year (90-93%) or two years (7-10%). Other studies conducted at flowering or not including ground-level searches for R plants indicated much higher average annual dormancy rates, i.e., 50% (Lesica 1997), 33% (Lesica and Crone 2007), 42% (Taylor et al. 2012). Dormancy rates also varied considerably from year to year, ranging from 11-74% (Lesica 1997, Lesica and Crone 2007), and bouts of dormancy lasted up to six years (Lesica and Crone 2007).

Transition Probabilities and Life Cycle:

All possible transitions occurred between the four stage classes. The majority of aboveground stage class transitions were stasis transitions in which plants stayed in the same stage from year to year. Remaining transitions were equally divided between growth from smaller to larger stages and retrogression from larger to smaller stages. Another study that sampled at flowering indicated much higher probability of aboveground stages transitioning to the dormant stage (especially the R to D transition), much lower R to R stasis transitions, no growth transitions from R stage to the stemmed stages, and no retrogression transitions from the larger stemmed stages to the smaller R stage (Lesica 1997).

Response to Stress...Become Smaller:

Our studies were the first to document retrogression from the larger stemmed stages to the smaller R stage. These retrogression transitions increased with two episodes of high rodent activity (a major threat) and a July 2007 fire. The larger stemmed plants were more targeted by rodents [likely the montane vole *(Microtus montanus)*] than the smaller R plant. The R plant likely plays a major survival role for this species. Transitioning to a smaller form in response to disturbance or a harsh environment can result in a higher speed of recovery from disturbance than dying and requiring recruitment to replace that individual (Salguero-Gomez and Casper 2010).

Fire Increase Recruitment?:

A July 2007 wildfire burned the majority of our plots. Recruitment, which was relatively low prior to the fire

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[1% (BLM) and 5% (FWS)], showed no increase for several years after the fire. The fire may have created conditions that inhibited recruitment (i.e., killed moss - a major ground cover in several plots), reduced plant litter and biomass, and darkened the soil surface. These conditions can increase soil temperature and evaporation and reduce moisture in upper soil layers (Redmann 1978, Defossé and Robberecht 1996). Recruitment increased markedly in the FWS study three to four years after the fire as mosses re-established. Dew deposition on moss may have aided seedling survival. Our findings differed from a demography study that considered rosettes to be only recruits and reported that fire enhanced recruitment (Lesica 1999).

Small seedlings (<1 cm) with distinct cotyledons. Photo by Juanita Lichthardt.

Detectability Declined over the Growing Season:

Almost half of aboveground plants disappeared or became undetectable or unidentifiable by flowering time. The R stage was disproportionately affected; on average, ~80% of them were not detectable at flowering. The R plant is ephemeral, i.e., it is present early but does not increase in size or bolt into a stemmed plant or become reproductive, and usually disappears completely by flowering. Some stemmed plants also disappeared by flowering, including 25%-30% of S plants and 15% of M plants. Another 15% of M plants became unidentifiable because they lost stem(s) and appeared to be S plants at flowering. Spalding's catchfly is a late-blooming species that occurs in areas characterized by hot, dry summers. Its long taproot enables it to survive, yet aboveground plant tissue is subject to desiccation, herbivory and fire damage that can reduce detectability over the growing season.

Detection probability at flowering showed high annual variability and was considerably reduced from that of ~1.0 for each aboveground stage at early monitoring. Average detection probability at flowering time (averaged over the 10 years of both studies) was 0.21 ± 0.15 for the R stage, 0.73 ± 0.27 for the S stage, and 0.65 ± 0.28 for the M stage. This high annual variability decreases the usefulness of using these average detection probabilities as correction factors for monitoring at flowering.

Bias of Late Monitoring:

How biased would our results have been if we had monitored only at flowering time in our studies after almost half of the plants had disappeared? Determination of demographic parameters based only on our late monitoring data showed: 1) underestimation of plants emerging aboveground each year by 48%, 2) underestimation of the number of plants in our plots by 40%, 3) overestimation of prolonged dormancy two to three times (70% of indicated dormancies were false), 4) missing 90% of recruitments, 5) over-representing the D stage and the role of dormancy in this species, 6) underestimating the R stage and its importance for survival, 8) many false positives (recruitments, dormancies and mortalities that had not actually occurred) and false negatives (missed recruitments, dormancies and mortalities that had actually occurred), and 9) declining plant numbers the last three years of the FWS study (plant numbers actually increased during this time). Monitoring only at flowering time misses most recruitments and juvenile periods. New recruits are R plants, they remain in the R stage for four to six years before reproducing as stemmed plants, and 80% (on average) of R plants have disappeared or become undetectable/unidentifiable by flowering. A detailed analysis of the influence that time of monitoring has on demographic estimates for this species is presented in Hill and Garton (2017).

Monitoring Challenges:

Monitoring should occur soon after emergence when all aboveground plants can be detected. Experienced observers are needed to identify vegetative Spalding's catchfly plants, locate the small R plant on the ground surface, and distinguish it from several similar-appearing rosettes of associated forbs such as western groundsel *(Senecio integerrimus)* and shooting star *(Dodecatheon* sp.*)* In our plots, the presence of retrorse cilia hairs was the distinguishing feature for Spalding's catchfly, but confirming their presence required examining the R plant, in place, with a hand-lens.....not an easy task!

It is also difficult to determine what constitutes an individual plant because of belowground connections of shoots to the caudices, the presence of both single-stem and multi-stem plants at the same site, and the tendency for several plants to occur in close proximity from recruitment events (individual plants can occur within two to three cm of each other). Some researchers have considered each stem as a plant, while others have included all stems within a 20 cm-diameter as an individual plant. A couple methods we used were finger-tracing stems below the ground surface or moving one stem to detect movement in an adjacent stem.

Looking for retrorse hairs on R plant leaves requires close inspection. Photo by Karen Gray.

Trend Monitoring:

Methodology for monitoring population trend is currently being developed (U.S. Fish and Wildlife Service 2012). The results of our studies indicate an effective and accurate trend monitoring method that could be accomplished with minimal time and effort. The number of plants in plots could be determined by following marked plants in permanent plots for two consecutive years, monitoring once each year soon after emergence and including ground-level searches for R plants. Count all plants seen the first year and add any additional plants seen in the second year; this will detect any plant in a one-year dormancy and probably at least one of the years of any plant in a two-year dormancy. This procedure could be conducted every 5-10 years to determine trend.

Conclusion

Spalding's catchfly is a challenge to monitor due to detection problems with both dormant and aboveground plants. The detection of all plants that are visible aboveground, including those that are small or only visible for a brief period of time, is a critical factor in determining the number of dormant plants that are invisible belowground. When and how monitoring occurs is extremely important in obtaining unbiased demographic data. Our demographic studies demonstrated that 1) essentially all plants emerging aboveground for a growing season are present and detectable soon after emergence, 2) many plants disappear/become undetectable or unidentifiable by flowering time, and 3) monitoring only at flowering time has high potential to considerably bias demographic estimates. Early monitoring that includes ground-level searches for small R plants can eliminate detection problems of aboveground plants and allow for unbiased estimates of prolonged dormancy and other demographic parameters. Our studies have implications for other plants with small, inconspicuous, ephemeral, or dormant stage classes, and those with long growing seasons in harsh environments where detectability of aboveground plant tissue may decrease over the growing season.

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White Pine Chapter Awards First Grant

By Judy Ferguson, White Pine Chapter

The White Pine Chapter of INPS is now sponsoring a grant program. The proceeds to fund this program come from profits from our annual native plant sale. This program was developed to promote awareness and use of local native plants across the many landscapes and plant communities found in north-central Idaho (as well as neighboring parts of eastern Washington). A few examples of projects that are appropriate for this program include: restoration of degraded sites using native plants, incorporating native plants into landscaping projects in public places, trail or other educational signs, seed collection, and research that involves all aspects of native plants. We want to make sure that teachers, graduate students, land management entities involved in ongoing research, and other potential applicants are aware of our program. We hope to use the local grant program as a supplement to the State INPS ERIG (Education Research Inventory Grant) program. For more information on applying, please see the White Pine Chapter website (http://www.whitepineinps.org/).

The first White Pine Chapter grant was awarded to the Palouse-Clearwater Environmental Institute (PCEI). The $1000 grant award will help PCEI expand the breadth of their outdoor educational programming with permanent native plant identification signage. Their project fits the purposes of the White Pine Chapter grant program—to promote awareness of and the use of local native plant species in habitat restoration and landscaping in our region. PCEI hosts field trips year-round for local school children, who come to tour the group's hiking trails and native plant nursery. The White Pine Grant Committee agreed that PCEI provides a very effective learning environment. The addition of signs with common and scientific names and information about native plants on site will help to further educate both school children and the public about native plants. •