Interactions between two endangered butterflies and invasive, exotic grasses in western Oregon, USA

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Invasion by non-native animals, plants, and pathogens is a burgeoning problem in many areas of the world (Kolar and Lodge 2001). While many species brought into a new habitat do not become invasive, there appear to be a growing number of species that can severely disrupt ecosystem functioning (D'Antonio and Vitousek 1992, Shafroth et al. 2005) and displace native species, culminating in a local loss of biodiversity (e.g. Schooler et al. 2006). While cheat grass (*Bromus tectorum*) may change fire return intervals in the Great Basin of western North America (D'Antonio and Vitousek 1992) and saltcedar (*Tamarisk* spp.) may disrupt water regimes in the desert southwest (Shafroth et al. 2005), native animals and plants frequently coexist with these exotic, invasive species and evolve relationships that may enable native species to persist (Shapiro 2002, Shafroth et al. 2005). Increasing pressure on rare, threatened, and endangered species from habitat loss, fragmentation, degradation, land conversion, and global climate change places a premium on the understanding of species-species interactions. If we are to successfully manage threatened and endangered species, an understanding of interactions between species that either limit or enhance rare species survival and reproduction is essential.

Remnant grasslands of the Pacific Northwest in North America are often dominated by exotic plants to such a degree that grasslands with < 20% of the total species richness belonging to exotic species may be considered "high quality habitat" (personal observation). Native grasslands in western Oregon, USA, are heavily dominated by exotic plants, both forbs and graminoids (Clark and Wilson 2001, Lawrence and Kaye 2006). Exotic grasses and invasive woody plants can quickly overrun the historically bunchgrass dominated prairies and appear to outcompete many native grassland plants (Wilson and Clark 2001). Population persistence of two endangered butterflies from western Oregon, Fender's blue butterfly (*Plebejus icarioides fenderi*) and Taylor's checkerspot (*Euphydryas editha taylori*), may be negatively impacted by the relatively recent invasion of exotic grasses. I compare how the dominance of exotic grasses threatens the persistence of Fender's blue and Taylor's checkerspot butterfly populations and highlight the key interactions that appear to impact butterfly reproduction. By presenting these two case studies, I hope to provide land managers and conservation biologists with concrete examples of how studies targeting species-species interactions may benefit conservation in our rapidly changing ecosystems.

Taylor's checkerspot

Taylor's checkerspot (Fig. 1) was once widespread in western Oregon, with numerous populations spanning the approximate 200 km length of the Willamette Valley (Hinchliff 1994, Warren 2005). Before 1980, the butterfly was so abundant that Ernst Dornfeld (1980) wrote that it "swarmed" in meadows north of Corvallis, Oregon. Now, however, the butterfly is known only from three sites near Corvallis with population size estimates in the low to high hundreds depending upon the year (Dana Ross, Oregon State Arthropod Collection, personal communication). In Oregon, Taylor's checkerspot is dependent on one larval host plant, English plantain (*Plantago lanceolata*), an exotic species from Europe, for its survival (Severns and Warren 2008). There are no records of Oregon populations using a larval host plant other than English plantain. Native Plantago species are not known from the Willamette Valley (Kozloff 2005) but there are species from two plant genera, *Castilleja* (paintbrush) and *Collinsia* (blue-eyed Mary), which may be potential native host plants because they are used by other closely related subspecies of Edith's checkerspot (Warren 2005, Singer and Wee 2005).

Unfortunately, when post-diapause Taylor's checkerspot larvae become active in mid to late January, native plants that could serve as potential larval food plants are not available for caterpillar feeding. *Castilleja levisecta*, an endangered, perennial plant, now extinct from Oregon, does not typically produce

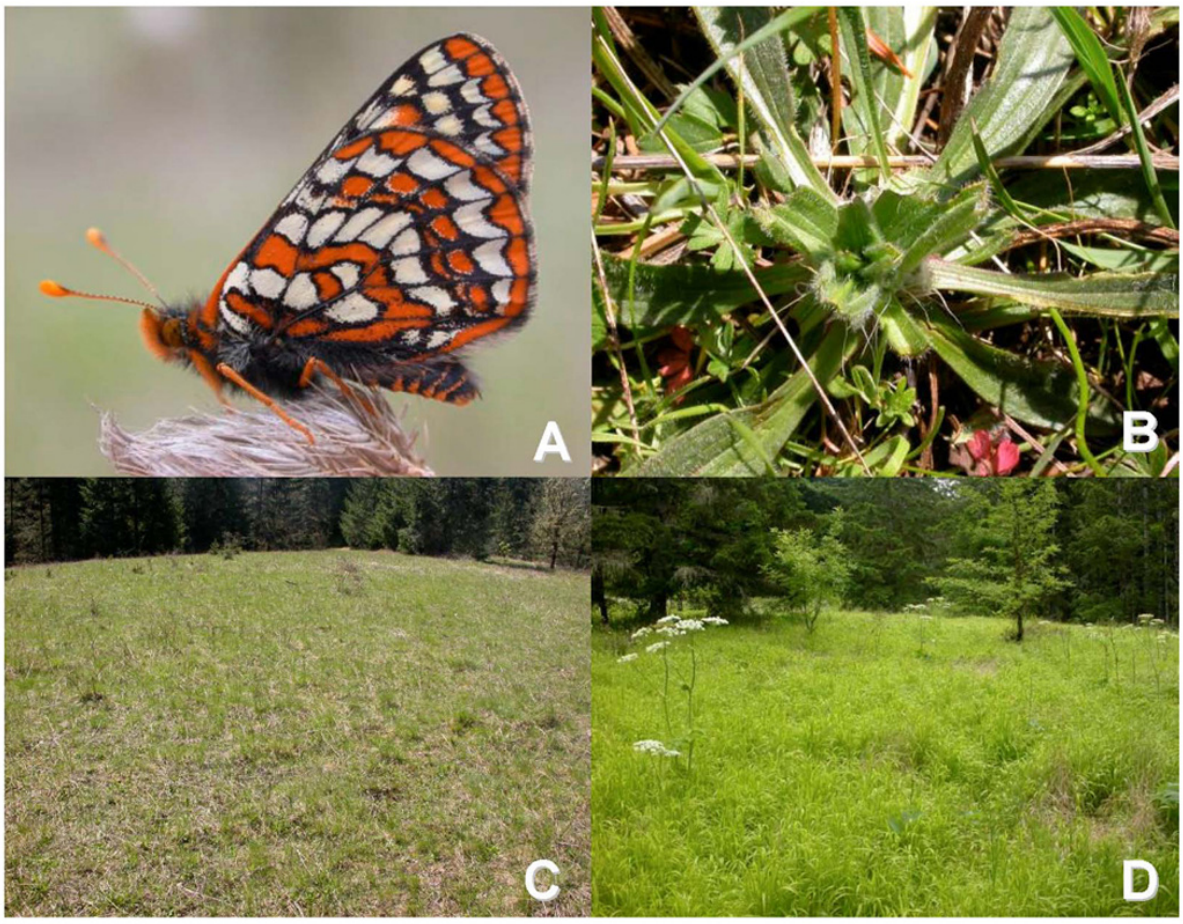

Figure 1:
A). Adult male *Euphydryas editha taylori* (Taylor's checkerspot) near Corvallis, Oregon. B). Feeding damage to the youngest leaf tissues on *Plantago lanceolata* by post-diapause Taylor's checkerspot larvae (mid Feburary). C). "High quality" bunchgrass dominated egg-laying habitat for Oregon Taylor's checkerspot butterflies. D). A historically bunchgrass dominated area similar to the habitat in Fig. 1C that maintained 100-300 butterflies in the late 1990's ten years after the invasion of *Brachypodium sylvaticum*. The site lacks *Plantago lanceolata*, strawberry plants, and Taylor's checkerspot is now extinct from this location.

Figure 2:
A population of Lupinus oreganus (Kincaid's lupine) growing in a degraded bunchgrass dominated habitat that is being invaded by the taller stature Arrhenatherum elatius (tall oat grass). The inset figure in the lower, left corner shows a male Plebejus icarioides fenderi (Fender's blue butterfly) basking on a Kincaid's lupine leaf.

aboveground tissues until early March (B. A. Lawrence, Oregon State Univeristy, pers. com.). *Collinsia parviflora*, an annual, spring plant does not appear to germinate in time to be suitable for Taylor's checkerspot post-diapause larval feeding (manuscript in prep.). Instead, post-diapause larvae appear well timed to the expansion of young *Plantago lanceolata* leaves, on which they appear to preferentially feed (Fig. 1), suggesting that the Oregon populations of Taylor's checkerspot have adapted to *P. lanceolata*.

Although Oregon populations of Taylor's checkerspot depend on an exotic larval host plant for survival, butterfly oviposition occurs on *P. lanceolata* growing within a mix of grass species that are similar in stature and cover of native *Festuca* spp and *Danthonia californica* bunchgrasses (Severns and Warren 2008). The increase in abundance of grass species that are taller than the native grasses correlates well with a decrease in *P. lanceolata* abundance (Severns and Warren 2008). Additionally, relatively tall exotic grasses reduce the abundance of strawberry flowers (*Fragaria virginiana*), the primary food resource for adult Taylor's checkerspot butterflies (Severns and Warren 2008).

The relationship with exotic grass abundance and the presence or absence of Taylor's checkerspot plant resources suggests a classic interspecific competitive exclusion scenario where the invading grasses outcompete strawberry and *P. lanceolata*. One exotic grass species in particular, false brome (*Brachypodium sylvaticum*), can so thoroughly outcompete the grassland vegetation Taylor's checkerspot depends upon (Fig. 1) that it can lead to population extinction (Severns and Warren 2008). Similar exclusion of key butterfly resources by competitively superior plants has been documented for other rare, grassland butterfly species (Thomas 1983, Thomas and Jones 1993, Weiss 1999, Mouquet et al. 2005), one of them, *Euphydryas editha bayensis* (bay checkerspot), is an Endangered Species of central California grasslands.

Fender's Blue Butterfly

Plebejus icarioides fenderi (Fender's blue butterfly) (Fig. 2), is restricted to rem-

nant Willamette Valley grasslands of western Oregon, USA., and is currently known from 25-30 sites. Fender's blue butterfly was presumed extinct for nearly 60 years until it was rediscovered in the late 1980s. Kincaid's lupine (*Lupinus oreganos* = *L. sulphureus* ssp. *kincaidii*), a Threatened Species, is the primary larval host plant for Fender's blue butterfly in most populations (Wilson et al. 2003). However, four Fender's blue butterfly populations are known to feed on either *Lupinus albicaulis* (sickle-keeled lupine) or *L. arbustus* (spurred lupine) (pers. obs., P. Hammond pers. com), but populations of these two lupines are rare in the Willamette Valley (pers. obs.).

Similar to Taylor's checkerspot, Fender's blue butterfly habitat is overrun by tall, invasive grasses that eventually dominate remnant grasslands (Wilson and Clark 2001). *Arrhenatherum elatius* (tall oat grass) and *Festuca arundinacea* (tall fescue), are commonly found at Fender's blue sites and are three to four times the height of the native bunchgrass species they replace. These tall grasses overtop Kincaid's lupine (Fig. 2) and lower the physical apparency of host plants so that females do not lay as many eggs per leaf on lupines that are overtopped by tall grasses as they do on lupines surrounded by grasses of the native stature (Severns 2008a). While Kincaid's lupine seed germination appears to be inhibited by tall grasses (Severns 2008b) and lupine leaf production may be hampered (Severns 2008a), established lupine plants still persist and flower under the canopy of tall, exotic grasses. Exotic grasses do not appear to substantially reduce the amount of lupine leaves for oviposition and prediapause larval feeding but disassociates the co-evolved cues for host plant detection and oviposition from the host plant resource.

Potential ramifications of exotic grass invasion on butterfly persistence

In comparing the effect of tall exotic grass invasion on the two species presented in this manuscript, some parallels and contrasts are immediately apparent. Tall exotic grasses reduce the amount of reproductive habitat available for Taylor's checkerspot and Fender's blue butterfly either by excluding key butterfly resources or by degrading reproductive habitat so that key resource use declines. In either scenario, the loss of reproductive habitat or its degradation is likely to affect two processes essential for species persistence: migration and colonization. It is likely that decreases in the amount of reproductive habitat and reproductive habitat quality will lead to emigration from the natal site when butterfly tolerance for small reproductive habitat size or habitat degradation thresholds are surpassed (e.g. Severns et al. 2006).

The three possible fates of a dispersing individual are to return to the natal site, colonize or occupy a non-natal population, or to continuously disperse through non-reproductive habitat. Because western Oregon grasslands are highly fragmented and degraded (Wilson et al. 2003), high quality reproductive habitat outside the currently occupied sites are relatively rare, usually small in area, and are far enough apart that frequent immigration by female butterflies seems unlikely. It will be essential for Taylor's checkerspot and Fender's blue butterfly that habitat conditions suitable for reproduction are maintained, not only in the currently occupied sites but unoccupied habitats that have the potential to be naturally colonized.

For Taylor's checkerspot, reclamation of high quality reproductive habitat through exotic grass management does not present the same issues as it

does for Fender's blue butterfly. Both the larval host plant and adult nectar resources diminish rapidly with exotic grass abundance, so heavy-handed vegetation treatments (e.g. prescribed fire, ground disturbance, broadcast herbicide spraying) in areas dominated by exotic grasses are unlikely to impact key butterfly resources. However, the active propagation of an exotic larval host plant, *Plantago lanceolata*, may be unappealing to those who advocate for the restoration of pre-European settlement grassland communities.

Management of tall exotic grasses in sites occupied by Fender's blue butterfly presents some practical problems. Because Kincaid's lupine does not appear to be outcompeted by the invasive grasses, methods to control the grasses are likely to impact both the lupine and the butterfly. Tall oat grass (and probably tall fescue) can be controlled through repeated active season mowing when the grass flowers and begins to set seed (Wilson and Clark 2001). However, active season mowing would co-occur with Fender's blue flight, oviposition, and pre-diapause larval feeding. Kincaid's lupine plants are tall enough that setting most mechanical mowers to the highest off-the-ground mow deck setting will still remove vegetation from Kincaid's lupine (pers. obs.); therefore, entire lupine patches occupied by the butterfly cannot be treated by active season mowing without placing butterfly eggs and pre-diapause larvae at risk. In acceptably large Fender's blue populations where lupines are overtopped by tall grasses, active season mowing in a portion of the sites could occur without placing the entire population at risk, providing conscientious mow timing, treatment size, and mow deck height is addressed. Spot treatments of smaller areas with grass-specific herbicide may be an effective option to maintain habitat quality and control tall grass encroachment, but herbicide impacts on Fender's blue butterfly larvae and other non-target species are unknown.

It is likely that attractive reproductive habitat could be created by clipping exotic grasses around key butterfly resources during the flight time that females are laying eggs. However, we do not know how tall grasses will affect pre- and post-diapause larval survival after the grasses grow back from clipping. Researchers should consider investigating interactions between tall grasses and larvae to understand whether temporarily creating an attractive reproductive habitat by clipping exotic plants to a native grass height ultimately results in lower butterfly survival. For both Fender's blue butterfly and Taylor's checkerspot, it is clear that once a high quality reproductive habitat is found or created, effort must be placed into the maintenance of the habitat condition. Annual "weeding" forays for tall, exotic grasses may be labor intensive and perhaps perceived as a waste of valuable time, but maintenance of high quality reproductive butterfly habitat is more likely to result in population persistence than wholesale attempts to reclaim occupied sites from degraded habitat conditions. Unfortunately, the latter option is often the one that is consistently fiscally supported. In cases such as the two butterfly examples in this manuscript, land managers should consider prioritizing habitat maintenance and management.

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