DISTRIBUTION OF ECOLOGICALLY-INVASIVE PLANTS ALONG OFF-ROAD VEHICLE TRAILS IN THE CHEQUAMEGON NATIONAL FOREST, WISCONSIN

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ABSTRACT

To describe the invasive flora of off-road vehicle (ORV) trails, I combined field surveys for 7 invasive plant species along 2 ORV trails and seed surveys via soil samples taken from the undercarriage of ORVs. Field surveys identified 4 of the 7 species (*Centaurea biebersteinii*, *Phalaris arundinacea*, *Hieracium aurantiacum*, and *Lotus corniculata*), and at least one invasive plant occurred along 88% of the 100 m trail segments surveyed. *Alliaria petiolata Euphorbia esula,* and *Lythrum salicaria* were not present, but are included in the analysis for comparative purposes. Some ORVs dispersed seeds. While none of the seeds were invasive species, they were the same size as the invasive plants in this study. Because many invasive species have seed traits that predispose them for vehicular dispersal, ORVs occasionally contribute to long-distance dispersal events.

INTRODUCTION

Reducing the threat of invasive species requires that we identify and understand the ways humans facilitate their transport to and establishment in new areas (Floerl and Inglis 2005). Roads are known to harbor disproportionately more invasive plant species than surrounding habitats (Trombulak and Frissell. 2000; Watkins et al. 2003; Hansen and Clevenger 2005). Roadsides act as demographic source populations for some invasive plants, enabling them to disperse into habitats perpendicular to the road (Tyser and Worley 1992; Hansen and Clevenger 2005). Less studied are similar edge effects associated with other transportation corridors, including utility and railroad rights-of-way, and hiking, biking, and off-road vehicle (ORV) trails. Knowledge of the invasive flora along trails is important because recurring traffic provides a vector for long-distance dispersal.

Wisconsin has 35 public trail systems and connectors designed for ORV use (which include both motorcycles and 4-wheel all-terrain vehicles designed specifically for off-road use). These trails stretch over 2700 km. In this study, I recorded the frequency of 7 invasive species (Table 1) along trail segments in northern Wisconsin. I also indirectly evaluated the potential for ORVs as seed dispersal agents for these invasive species. My goal was to develop a better understanding the role of ORVs and ORV trails in facilitating the spread of invasive plants.

TABLE 1. Ecologically-invasive plants species included in this study. Seed mass is based on the mean weight of 10–20 seeds taken from herbarium specimens at the University of Wisconsin Herbarium in Madison.

Common Name	Scientific Name	Seed Mass (in mg)	Dispersal Mode
garlic mustard	*Alliaria petiolata* (M. Bieb.) Cavara & Grande (Brassicaceae)	1.8	gravity
spotted knapweed	*Centaurea biebersteinii* DC. (Asteraceae)	2.4	wind
purple loosestrife	*Lythrum salicaria* L. (Lythraceae)	4.0	gravity, water
leafy spurge	*Euphorbia esula* L. var. *esula* (Euphorbiaceae)	2.8	gravity, wind, animal
reed canary grass	*Phalaris arundinacea* L. (Poaceae)	0.4	gravity, water
orange hawkweed	*Hieracium aurantiacum* L. (Asteraceae)	0.2	wind
birds-foot trefoil	*Lotus corniculata* L. (Fabaceae)	1.1	gravity

METHODS

I conducted invasive plant field surveys along ORV trails in Price, Sawyer, and Ashland Counties in northern Wisconsin (46°N, 90.5°W), in the Chequamegon National Forest. The northern Wisconsin landscape contains a mixture of public lands, private-industrial and non-industrial forests, lakes, wetlands, and small towns. These particular trails are situated within the Chippewa Lobe Rocky Ground Moraine and the Chequmegon Morain and Outwash Plain subregions nested within the Northern Lakes and Forests ecoregion (Omernik et al. 2000). Forest is the dominant landcover in the region, covering approximately 70% of the area (MacKenzie 1994).

I surveyed for 7 non-native species (Table 1) classified as "ecologically invasive" by Wetter et al. (2001). These species invade wild areas in Wisconsin, outcompete native species, alter or degrade habitats, and cause extensive ecological damage (Hoffman and Kearns 1997, Czarapata 2005). Six are well-established in northern Wisconsin; only garlic mustard is not yet widespread. Nomenclature follows Wetter et al. (2001).

In August 2002, I conducted trail surveys along portions of the 90.1 km Dead Horse Run Trail and the 96.5 km Flambeau Trail. These unpaved trails are approximately 3 m wide, traversing mature and regenerating forest, shallow marshes, bogs, conifer swamps, and lakeshores. I divided trails into 100 m survey segments, and walked transects from a trailhead for a set distance (either 1000 m or 2000 m), recording the presence or absence of invasive species in each segment. I then traveled to another trailhead and repeated the procedure. Two segments were surveyed per trail (n = 30 segments per trail, 2 trails sampled, 6 km surveyed).

Because small seeds can be dispersed via soil adhesion to vehicles (Ridley 1930, Hodkinson and Thompson 1997), I collected soil from ORVs as riders exited the Dead Horse Run trail in August 2002. Of 14 vehicles sampled on a single day, only 6 had soil encrusted on the frame and undercarriage. I collected some of the soil (approximately 50–200 g) using a metal spatula, and placed the soil in a plastic bag. A separate bag was used for each vehicle. Rather than sieve soils for seeds, I elected to mix them with Jiffy Mix; I placed them in a flat, and stored them for 165 days at 5°C. Flats were periodically watered, and were subsequently moved to a growth chamber simulating a long day environment (16 hours of light, 8 hours of dark), and temperatures fluctuated between 6°C during simulated night to 30°C during simulated day. Flats were watered and monitored daily for seedling ger-

mination and for 140 days following the first day of germination. I recorded the number of flats with seeds germinating, and the number of germinating seeds per flat.

RESULTS

Four invasive species were encountered along at least one trail, with an average of 1.1 species per 100 m segment (Table 2). Invasive species were present in 88.3% of the sixty 100 m trail segments surveyed: 83.3% of the Dead Horse Trail segments and 93.3% of the Flambeau Trail segments had invasive species.

Some but not all ORVs transport seeds in soil adhering to the vehicle. Four of the 6 soil samples collected from ORVs germinated seeds, with 41 individual plants germinating. Of the 14 vehicles sampled for seeds, there were a mean 3.6 viable seeds per vehicle sample. All except two of the plants germinating were the native common oak sedge (*Carex pensylvanica* Lam.). Based on measurements from herbarium specimens, this species has an average seed mass of 3.0 mg/seed (n = 10), which is similar to the seed mass of the invasive species listed in Table 1.

DISCUSSION

Orange hawkweed and birds-foot trefoil were the most abundant species found along both trails surveyed (Table 2). Both are frequently found along roadsides in this region, and ORV trails provide suitable habitat. Orange hawkweed tolerates a broad range of ecological conditions. While it reaches its greatest abundance along roadsides, it is often found tens of meters beyond the forest edge (Wiegmann and Waller in press). Its impacts on native plant species are unknown. Because orange hawkweed is wind dispersed, ORVs most likely play only an incidental role in its dispersal. The nitrogen-fixing birds-foot trefoil is less shade tolerant than orange hawkweed, making it less likely to invade forest interiors. As with orange hawkweed, ORV trails provide suitable habitat. Infrequent dispersal of birds-foot treefoil by ORVs seems likely, as populations were encountered within 200 m of road crossings. Because this species is still pro-

TABLE 2. Percentage of 100 m segments of ORV trail occupied by invasive species in Table 1. N = 30 segments for each trail surveyed

Invasive species Common Name	ORV Trail Name	
	Dead Horse Run	Flambeau
garlic mustard	0%	0%
spotted knapweed	3%	3%
purple loosestrife	0%	0%
leafy spurge	0%	0%
reed canary grass	0%	10%
orange hawkweed	83%	93%
birds-foot trefoil	17%	10%

moted as a forage crop and is added to wildlife seed mixes, deliberate planting remains the most important dispersal vector for this species.

Reed canary grass and spotted knapweed were present, but both were still relatively uncommon. Both species are highly invasive (Barnes 1999; DiTomaso 2000), but are also less likely to invade upland forest interiors. Reed canary grass was found only along the shores of wetlands and lakeshores, and spotted knapweed was restricted to open habitats. Spotted knapweed benefits from the existence of ORV trails, but reed canary grass probably benefits little. Because both species are wind dispersed, ORVs probably do not account for ecologically-significant seed dispersal.

Garlic mustard, purple loosestrife, and leafy spurge were not observed in this study. Of these, garlic mustard is most likely to use ORV trails as an invasion pathway. This small-seeded, gravity-dispersed plant inhabits open and disturbed areas, forest edge, and forest interiors (Meekins and McCarthy 2001). In this region, I most often observed this species along the sides of frequently-driven roads, often near resort areas. I expect purple loosestrife and leafy spurge to exhibit many of the same invasion patterns as reed canary grass and spotted knapweed, respectively. Off-road vehicles will not account for ecologically-significant seed dispersal, but the trail infrastructure will provide suitable habitat for both.

Plant species most likely to be transported by motor vehicles are those with small seeds that are gravity or wind-dispersed, have high seed production, and form persistent seed banks (Schmidt 1989, Hodkinson and Thompson 1997). All 7 invasive species have these traits. In fact, these traits are characteristic of invasive plants generally (Rejmánek and Richardson 1996). Vehicular dispersal of seeds is not random; invasive species are better adapted to vehicular dispersal than noninvasive species.

Environmental assessment of ORVs is often limited to studies of soil compaction, erosion, and vegetation damage. The impacts associated with invasive species receive little attention. While vegetation and soil damage can be often be reversed after several years, invasive plants are difficult to eradicate once established. Also, while ORV damage to soils and vegetation is often localized, invasive species often spread beyond points of colonization. Thus, the spread of invasive plant species deserves attention as a potential environmental impact associated with ORVs. Botanists would do well to remind land managers that this is an unavoidable tradeoff of maintaining trails.

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