Journal of Environmental Management 150 (2015) 157–163

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Evaluating human-disturbed habitats for recovery planning of endangered plants

Julie Robinson [1], Luise Hermanutz*

Department of Biology, Memorial University, St. John's, NL A1B 3X9, Canada

ARTICLE INFO

Article history:
Received 22 January 2014
Received in revised form
20 August 2014
Accepted 13 October 2014
Available online

Keywords:
Anthropogenic disturbance
Recovering rare endemic plants
Vegetation structure
Human-disturbed habitat restoration
Limestone barrens

ABSTRACT

The recovery potential of endangered species is limited by the high prevalence of human-modified habitats, while effective *in situ* conservation strategies to identify and restore disturbed habitat within species ranges are lacking. Our goal was to determine the impact of human disturbance on the endangered endemic Barrens willow (*Salix jejuna)* to provide science-based protocols for future restoration of disturbed habitats; a key component of conservation and recovery plans for many rare plant species. Our study examined differences in substrate (e.g., % total plant cover, % species cover, substrate type) and vegetation in naturally- (via frost activity) vs human-disturbed limestone barrens (Newfoundland, Canada), across the entire species range of the endangered Barrens willow. There were distinct differences in substrate conditions and vegetation community structure between naturally- and human-disturbed limestone barrens habitat throughout the narrow range of this endemic willow. Human-disturbed sites are more homogeneous and differ significantly from the naturally-disturbed sites having a much coarser substrate (30% more gravel) with less fine grained sands, less exposed bedrock, decreased soil moisture, increased nitrogen content, and reduced phosphorus content. Substrate differences can inhibit return to the natural freeze-thaw disturbance regime of the limestone barrens, negatively affecting long-term persistence of this, and other rare plants. The structure of associated vegetation (specifically woody species presence) negatively affected willow abundance but was not linked to disturbance type. Human-disturbed sites are potential candidates for endangered plant recovery habitat if natural ecosystem processes, vegetation community structure, and habitat heterogeneity are restored, thereby supporting the establishment of long term viable populations.

1. Introduction

The recovery potential of endangered and threatened species is limited by the high prevalence of human-modified habitats (Kerr and Deguise, 2004), making habitat loss and fragmentation the primary cause of species extirpation (Alonso et al., 2001; Brooks et al., 2002). As a consequence of their unique habitats, restricted distributions, and requirement for particular disturbance regimes, endemic rare plant species are especially vulnerable to human induced change (Fiedler and Ahouse, 1992; Maschinski et al., 2004). Endemic plant species once covered 12% of the global land surface but only 1.4% of their historical habitat remains intact (Myers et al., 2000). In a Canadian study, Kerr and Deguise (2004) estimated that of the 243 species at risk examined, 113 had < 33% of their natural habitat remaining, 58 had < 10% remaining and 16 had no natural habitat detected.

The limestone barrens of Newfoundland (Canada) are part of a globally-imperiled ecosystem, also known as limestone pavements. Limestone pavements occur in Sweden, Estonia, North America, Britain and Ireland. In the Great Lakes region of Ontario (Canada), limestone pavement alvars harbor many provincially rare species (Belcher et al., 1992; Catling, 1995; Schaefer and Larson, 1997). The Newfoundland limestone barrens are hotspots of plant diversity, supporting three endemics and 114 of the province's 271 rare plant species (Bouchard et al., 1991). The unique flora of limestone pavements has been threatened by quarrying and residential development in the alvars of the Great Lakes (Catling and Brownell, 1995; Reschke et al., 1999) and throughout the limestone pavements of Britain (Goldie, 1993). In Britain, only 3% of limestone pavement remains intact (Anon, 2001). This is primarily due to farmland conversion and removal of stone for decorative use in the horticultural market (Bennett et al., 1995). In Newfoundland, road

* Corresponding author. Tel.: +1 709 864 7919; fax: +1 709 864 3015.
E-mail addresses: Julie.Robinson@ontario.ca (J. Robinson), lhermanu@mun.ca (L. Hermanutz).
[1] Present address: Ontario Ministry of Natural Resources, 3301 Trout Lake Road, North Bay, ON P1A 4L7, Canada.

http://dx.doi.org/10.1016/j.jenvman.2014.10.033
0301-4797/

development, quarrying, and off-road vehicle use (e.g., all-terrain vehicles, ATVs) over the last several decades have altered much of the habitat for three federally listed species endemic to the limestone barrens, with degraded landscapes accounting ~ 31% of limestone barrens (Hermanutz et al., 2009).

Human disturbance has been shown to adversely affect populations of rare endemic plant species. Disturbed populations of endangered *Braya* spp. (Brassicaceae) within the limestone barrens of Newfoundland have lower population persistence and higher rates of mortality due to increased risk of infestation and infection by pests and pathogens, as well as much higher seedling recruitment, with low survival in disturbed area (Squires, 2010). Parsons and Hermanutz (2006) demonstrated that human disturbance increased the likelihood of hybridization in localized populations of *Braya*. Barrens willow (*Salix jejuna* Fernald, Salicaceae) inhabiting disturbed habitats are shorter-lived, with a greater proportion of seedlings and lower levels of clonal growth than in naturally-disturbed sites (Robinson, 2010). In arctic tundra communities, human disturbance has altered species diversity (Sumina, 1994; Forbes et al., 2001), decreased plant cover by at least 40–50% (Kevan et al., 1995; Monz, 2002), and changed substrate conditions, such as soil nutrients (Kevan et al., 1995; Auerbach et al., 1997) and temperature (Chapin and Shaver, 1981).

Recovery efforts frequently need to include the restoration of human-degraded habitat to ensure long term persistence of at-risk endemic species (Kerr and Deguise, 2004). Unfortunately, restoration efforts are often carried out without a comprehensive knowledge of key habitat characteristics or requirements related to the target species or target ecosystem (Miller and Hobbs, 2007), and without specific restoration goals or the appropriate information required to critically evaluate restoration success (Hobbs and Norton, 1996) in the recovery of target rare species. Miller and Hobbs (2007) suggest that a full evaluation of habitat features such as vegetation structure, plant species composition and ground cover must be attained prior to initiation of restoration of recovery habitats for rare species. Biological surveys of human-disturbed habitats as well as adjacent undisturbed natural habitats, or "reference" sites allows for the development of a protocol framework and an effective evaluation of project goals.

This study informs future restoration of degraded habitat using the endangered, endemic Barrens willow as a case study. Barrens willow is a prostrate shrub endemic to the limestone barrens of Newfoundland. It inhabits naturally-(via frost activity) and human-disturbed soils, and is restricted to a 30 km linear distribution (Djan-Chékar et al., 2003). Previous research on Barrens willow has focused on developing *ex situ* conservation strategies (Driscoll, 2006); however, little research has been conducted to allow for the development of effective *in situ* conservation strategies, specifically identifying and restoring disturbed habitat within the species range, as outlined in the *Barrens Willow Recovery Strategy* (Djan-Chékar et al., 2003). Our goal was to determine the impact of human disturbance on Barrens willow in order to provide science-based evidence to inform future restoration of disturbed habitats, a key component of recovery and management plans for many rare plant species. Specifically, we asked 1) are there differences in substrate and vegetation between naturally- and human-disturbed habitats across the global range of Barrens willow?, and 2) how do habitat parameters (e.g., % total plant cover, % species cover, substrate type) that influence its abundance, vary across the entire species' range?

2. Methods

2.1. Study sites

Field surveys encompassed the entire global range of Barrens willow within the limestone barrens of the Great Northern Peninsula (51°30′N, 56° 12′W; Supplementary Map S1: exact locations of listed species are not published and hence not specified), which lies within the Strait of Belle Isle Ecoregion. Populations of Barrens willow are patchily distributed along a 30 km stretch of coastline made up of flat ancient beach ridges at ~30m elevation. Newfoundland limestone barrens are characterized by a cool, wet, and windy climate that supports tundra-like vegetation (Banfield, 1983). The substrate is characterized by bare limestone bedrock, limestone heath, and localized patches of thin glacial and marine sediment (Grant, 1992). Much of the limestone barrens in Newfoundland had been disturbed during the process of road construction from 1975 – 1980, and limestone quarrying (Hermanutz et al., 2002). Since 2000, off-road vehicles such as all-terrain vehicles (ATV) have further degraded Barrens willow habitat.

To understand the effect of disturbance type on the community context of Barrens willow, substrate and vegetation characteristics were compared on both naturally- (N = 5 sites) and human-disturbed (N = 3 sites) habitats, the latter referred to as "disturbed" (Table 1). Selected sites represent populations throughout the entire range of the species with willow populations that were sufficiently large and dense to obtain an appropriate sample size. Natural disturbance are identified by the presence of patterned ground (e.g., frost boils, frost stripes) and limestone bedrock shattering, without evidence of human degradation. Human-disturbed sites were classified visually on the basis of physical evidence including degree of soil compaction (visual estimation), amount of vehicle damage (number and depth of tracks), and proximity to continual disturbance source (e.g., road) at the time of sampling (Rafuse, 2005).

Table 1
Barrens willow study site information indicating disturbance type, description of the disturbance, site area, and number of plots per site on the limestone barrens of Newfoundland (Canada). Sites are listed by disturbance type from most southerly to most northerly within each site category; see Methods for details on sampling.

Site name[a]	Disturbance type	Description of disturbance	Site area (m^2)	# Plots/Site
BK1-N	Natural	Frost boils present; naturally shattered limestone; highly wind eroded	740	47
BK39-N	Natural	Frost stripes present; highly wind eroded	670	41
BHN-N	Natural	Largely exposed bedrock; highly wind eroded; most coastal site	945	40
CNC-N	Natural	Largely exposed bedrock; low wind erosion	330	41
CNA-N	Natural	Largely exposed bedrock; low wind erosion	450	83
BKD-D	Human	Organic layer removed, some remnants of patterned ground	265	24
CND-D	Human	Organic layer completely removed, rounded coarse sediment, vehicle tracks, continual exposure to vehicle dust	920	80
CNE-D	Human	Organic layer partially removed, vehicle tracks, rounded coarse sediment	280	33

[a] Site Name: Site naming is based on proximity to the nearest town site, e.g. BK = sites near the town of Big Brook; BH = site near the town of Boat Harbour; CN = sites near the town of Cape Norman; includes an additional site identifier.