Invasive non-native plants in the arctic: the intersection of natural and anthropogenic disturbance

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Figure 1. Imachuk River and Fink Creek Mine, Seward Peninsula Alaska. Anthropogenic source for introduced species and two disturbance regimes intersecting.

Figure 4. Infestation of *Melilotus alba* along the Stikine River, Alaska. This species is spreading along numerous rivers in interior and southern Alaska.

Abstract

Arctic tundra and taiga habitats have remained relatively insulated from the negative ecological, economic, and social impacts due to invasive non-native plant species. Most non-native plant populations in Alaska are small and largely restricted to areas of anthropogenic disturbance, and it may be possible to prevent the large ecological disasters that have plagued most other biomes. However, arctic and boreal habitats are generally subject to significant natural substrate disturbances, making them susceptible to invasion by weedy non-native species that are primarily disturbance specialists. Further, the natural disturbances display high connectivity. Areas of anthropogenic disturbance may act as foci for invasions into arctic and boreal habitats. Here we present data on the identity, distribution, and threat to natural habitats for non-native plants in Alaska. Potential impacts and overall patterns are discussed.

Introduction

With increased trade and travel, invasions by introduced vascular plants are becoming commonplace and are widely recognized as one of the most serious threats to biodiversity and to economies [1, 2, 3]. Introduced plants can have wide-ranging negative effects on ecosystems. These include alterations to the physical structure of habitats, nutrient cycling, fertility and productivity, hydrological regimes, and food webs. All of these alterations would likely negatively impact local subsistence economies greatly. However, not all introduced plants are serious threats. Roughly 1% of species that become established in natural areas become a serious problem [4]. Therefore, understanding of patterns of species richness is important to predict and limit plant invasions.

There are a number of characteristics that may make the arctic susceptible to invasion. Most weedy, introduced species are adapted to open areas with soil disturbance, aspects of most arctic habitats [Figs. 1 & 2]. Additionally, high connectivity of river systems, and strong winter winds increase opportunities for seed dispersal.

Figure 2. Natural soil disturbance (frost boils & gelifluction soil) in the arctic.

Methods

Vascular plant databases from four sources (AKEPIC, ALA, AKNHP, & Alan Batten) containing introduced species information were compiled and integrated. This included over 12,000 records. Sites containing one or more introduced species were mapped in ArcView over a map of Alaska, identifying arctic, boreal, and south-coastal ecoregions of Alaska [5]. We calculated species richness for each quad (ca. 150,000 ha) in the state. Quads were categorized as having 0, 1-5, 6-14, 15-29, 30-56, or 57-107 introduced plant species, and coded with increasing color saturation. Sampling intensities differed strongly among quads (not shown). Therefore, introduced species richness is likely an underestimate for many poorly botanized regions of the state. We include a list of all introduced plants collected in the Alaskan arctic and note their potential to affect community composition and ecosystem function. Nine species have been formally ranked using a recently developed ranking system for Alaska (see http://aknhp.uaa.alaska.edu/). Values > 50 = Highly invasive, 40-50 = Moderately invasive, < 40 = Low threat.

Figure 3. Species richness of introduced plants in Alaska. Collection localities are shown as circles. The arctic ecoregion is outlined in bold. Species richness is indicated for each quad by color intensity (see Methods).

Results & Discussion

Despite low human population densities and anthropogenic disturbances, non-native plants are widely established in arctic Alaska. A total of 39 introduced taxa are present (Table 1), roughly 7% of the total arctic flora (based on [6]). Establishment of non-native plants is also documented in the high arctic - in Svalbard, Norway (80° N), 15% of the flora is introduced [7].

Species richness of non-native plants is low relative to other regions of Alaska (Fig. 3), and populations tend to be isolated. Many non-native plant populations have established in remote areas of Alaska, including villages, National Parks, and hunting lodges. The greatest densities and richness of introduced plants is focused on the major population centers of the state: Anchorage, Mat-Su Valley (> 100 species), and Fairbanks (89 species). Lower numbers of introduced species are found on the road system outside of population centers. A number of quads have no introduced species recorded. These areas tend to be mountainous and have have lower sampling intensity for vascular plants in general. Nearly all arctic quads had between 1-5 introduced plants. One quad on the Seward Peninsula had 17 introduced species. This area has a long history of mining (Figs. 1 & 3).

Most species that are present in the arctic do not have a history of severe ecosystem perturbation and their invasiveness is believed to be relatively low (Table 1). However, in the boreal and south-coastal regions of Alaska *Melilotus alba* and other non-native plants are causing severe habitat alterations (Fig. 4).

Table 1. List of introduced plants in arctic Alaska. Widespread = > 200 km between sites. Potential ecological impact (invasiveness) is noted on the right. Plants formally ranked have values presented parenthetically.

SCIENTIFIC NAME	# Coll	AK Arctic Distribution	Invasiveness
Achillea millefolium	27	Widespread	Med
Agrostis stolonifera	1	Narrow	Med
Alopecurus geniculatus	1	Narrow	Low
Alopecurus pratensis	3	Widespread	Med
Amsinckia lycopsoides	1	Narrow	Low
Amsinckia menziesii	1	Narrow	Low
Brassica rapa	1	Narrow	Low
Capsella bursa-pastoris	2	Widespread	Low
Cerastium arvense	1	Widespread	Low
Chenopodium album	1	Narrow	Low (35)
Chenopodium glaucum	2	Narrow	Low
Chenopodium rubrum	1	Narrow	Low
Crepis tectorum	2	Narrow	Med (43)
Descurania sophia	2	Widespread	Med (47)
Elytrigia repens	1	Narrow	High (59)
Epilobium ciliatum	5	Widespread	Med
Erysimum cheiranthoides	15	Widespread	Med
Galeopsis bifida	1	Narrow	Med (43)
Gnaphalium uliginosum	1	Narrow	Low
Hordeum jubatum	3	Widespread	High
Matricaria discoidea	10	Widespread	Low (34)
Papaver nudicaule	5	Widespread	Med
Phleum pratense	2	Widespread	High
Plantago major L. var. major	3	Widespread	Low
Poa pratensis	>100	Widespread	Very High (57)
Polygonum aviculare	5	Widespread	Low
Polygonum lapathifolium	2	Narrow	Med
Ranunculus repens	6	Widespread	Med
Rumex acetosella	2	Widespread	Low
Rumex crispus	2	Narrow	Low
Rumex longifolius	1	Narrow	Low
Stellaria media	6	Widespread	Med
Taraxacum officinale	4	Widespread	Med
Thlaspi arvense	1	Narrow	Low
Trifolium hybridum	7	Widespread	High (57)
Trifolium repens	4	Widespread	High (59)
Tripleurospermum inodorum	1	Narrow	Med
Veronica serpyllifolia	5	Widespread	Med

Ranking of introduced plants in Alaska –

The Alaska Natural Heritage Program in collaboration with the U.S. Forest Service and National Park Service has developed a numerical ranking system to evaluate the threat to natural communities in Alaska for individual weed species. Species are evaluated on climatic compatibility, ecosystem and community impacts, biological characteristics, and ability to be controlled. We have ranked 45 species to date (included parenthetically in Table 1 for 9 species). Ranks and species biographies can soon be accessed at http://aknhp.uaa.alaska.edu/.

Conclusions

The arctic is not immune to ecological disruption caused by introduced plants. Currently, introduced plants compose a small percentage of the flora and biomass of arctic Alaska. However, weed outbreaks in adjacent regions in river systems have accelerated in the last five years, highlighting the need to control incipient invasions. Such invasions may change the ecology and economies of the arctic.

In particular, attention must be placed on monitoring and eradicating introduced plants in areas where anthropogenic disturbances intersect with natural disturbances [8]. Roads and pipelines act as sources and corridors for introduced plants. At river crossings, plants can be easily dispersed into a new, extensive natural corridor system that is also dominated by substrate disturbance.

Increased efforts need to be concentrated on introduced plants in the arctic before wide scale ecological perturbations occur.

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