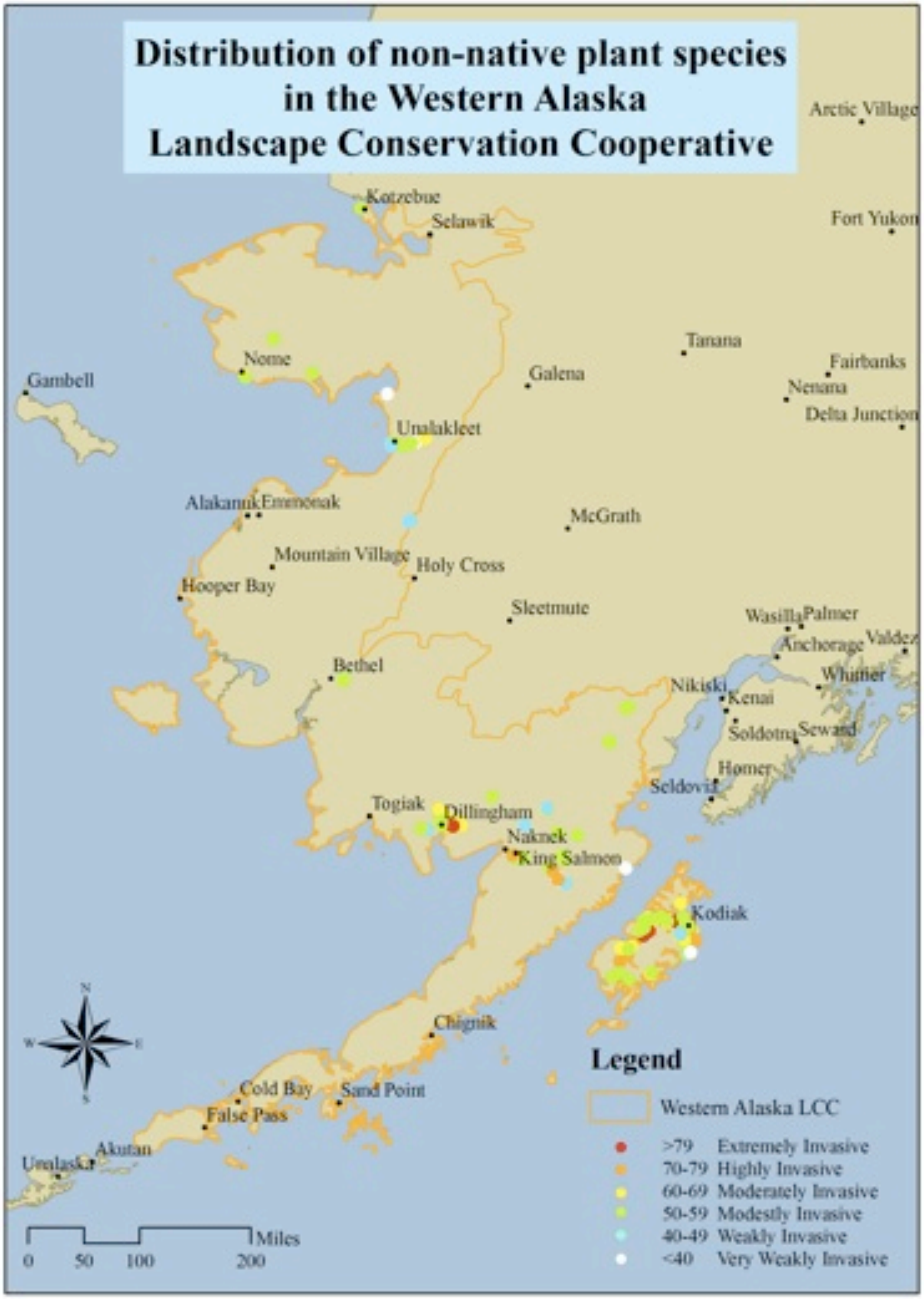
Non-Native/Invasive Plant Species



Non-native Plant Species Identified within the Western Alaska LCC (prior to 2010)

Scientific Name	Common Name	Invasiveness[1]
Aegopodium podagraria	Bishop's Goutweed	---
Amaranthus retroflexus	Redroot Pigweed	---
Bromus inermis	Smooth Brome	62
Brassica napus	Rapeseed	---
Brassica rapa	Field Mustard	50
Caragana arborescens	Siberian Peashrub	66
Capsella bursa-pastoris	Shepherd's Purse	40
Cerastium fontanum Baumg. ssp. vulgare	Big Chickweed	36
Chenopodium album	Lamb's Quarters	37
Cirsium arvense	Canada Thistle	76
Cirsium vulgare	Bull Thistle	61
Crepis tectorum	Narrowleaf Hawksbeard	54
Descurainia sophia	Tansy Mustard	41
Digitalis purpurea	Purple Foxglove	51
Elymus repens	Quackgrass	59
Euphrasia nemorosa	Common Eyebright	42
Galeopsis tetrahit	Brittlestem Hempnettle	40
Hesperis matronalis	Dame's Rocket	41
Hieracium aurantiacum	Orange Hawkweed	79
Hordeum jubatum	Foxtail Barley	63
Hordeum vulgare	Common Barley	---
Hypochoeris radicata	Cat's Ears	---
Leontodon autumnalis	Fall Dandelion	51
Lepidium densiflorum	Common Pepperweed	25
Leucanthemum vulgare	Ox-eye Daisy	61
Linaria vulgaris	Butter and Eggs	69
Matricaria discoidea	Pineappleweed	32
Melilotus alba	White Sweetclover	81
Phalaris arundinacea	Reed Canarygrass	83
Phleum pratense	Timothy	54
Plantago major	Common Plantain	44
Poa annua	Annual Bluegrass	46
Poa pratensis ssp. irrigata & Poa pratensis ssp. pratensis	Spreading Bluegrass and Kentucky Bluegrass	52
Polygonum aviculare	Prostrate Knotweed	45
Polygonum cuspidatum	Japanese Knotweed	87
Polygonum sachalinense	Giant Knotweed	87
Ranunculus repens	Creeping Buttercup	54
Rheum rhabarbarum	Garden Rhubarb	---
Rumex acetosella	Sheep Sorel	51
Senecio vulgaris	Common Groundsel	36
Sonchus asper	Spiny Sowthistle	46
Spergula arvensis	Spurry	32

Stellaria media	Common Chickweed	54
Taraxacum officinale ssp. officinale	Common Dandelion	58
Tanacetum vulgare	Common Tansy	57
Trifolium hybridum L.	Alsike Clover	57
Tripleurospermum inodorum	Scentless False Mayweed	48
Trifolium repens	White Clover	59
Vicia cracca	Bird Vetch	73
Viola tricolor	Johnny Jumpup	34

[1] "Invasiveness Score" (1 = low, 100 = high) from AKEPIC; [---] = no assigned score

Invasive Species (Human Induced)

(DRAFT - from Arctic Biodiversity Assessment, Arctic Council, April 2011)

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1. Synthesis

As human society has become more mobile, the movement of species beyond their native ranges has similarly increased. Biological invasions now occur around the world and are a leading cause in the loss of biodiversity. While fewer invasions are currently known from the Arctic, changes in climate and patterns of human use are likely to increase the susceptibility of Arctic ecosystems to invasion. Much of that increased risk of invasion may come from increased shipping, energy development, mineral exploration, and associated shore-based developments such as ports and roads.

Because future change will be best understood when measured against a credible baseline, much more work is needed to define the current status of native and invasive species populations in the Arctic. The development of cost-effective early detection monitoring networks will be a challenge, but may benefit from engaging a network of citizen scientists. There also needs to be increased and targeted prevention efforts to limit the influx of non-native species (e.g., ballast water treatment and the effective cleaning and treatment of ship hulls and drilling rigs brought in from other marine ecosystems).

2. Introduction

As humans and their goods and services have become increasingly mobile, the intended and unintended movements of species have also increased. In many cases, the intended benefits of species movement (food, fiber, recreation) have been realized. In other cases, both unintentional and intentional introductions have had harmful results (OTA 1993). The term "invasive species" is used here to reflect this latter situation and refers to species that are not native to a given ecosystem (i.e., when a species is present due to an intentional or unintentional escape, release, dissemination or placement into that ecosystem as a result of human activity) and which may cause economic or environmental harm (including harm to subsistence species and activities) or harm to human health. It should be noted that even non-native species considered to pose no invasive threat at the time of introduction may exhibit explosive population growth long after their initial establishment in a new environment (Sakai *et al.* 2001), leading to invasive impacts despite initially being considered benign.

Biological invasion is now widely recognized as second only to habitat alteration as a factor in the endangerment and extinction of native species, and may be the less reversible of the two (Lassuy 1995; Wilcove *et al.* 1998). Indeed, many consider invasive species, together with climate change, to be among the most important ecological challenges facing global ecosystems today (Vitousek *et al.* 1997, Mainka and Howard 2010). The impacts of invasive species are not limited to ecological harm. The annual economic impact of invasive species has been estimated at between $13 and $34 billion CAD for a subset of just 16 of Canada's over 1400 identified invasive species (Colautti *et al.* 2006) and considerably more in the United States where estimates of economic impacts are in excess of $138 billion USD per year (Pimentel *et al.* 2000).

Impacts of invasive species on cultural systems are harder to define, but we believe that two things are clear: 1) as native biodiversity is lost, so too are the potential human uses of that biodiversity, and 2) climate change will increase the likelihood of biological invasions in the Arctic. The combination of these two factors, plus the reliance of many Arctic residents on native flora and fauna for subsistence, suggest that biological invasions are a critical issue requiring further study and action.

3. Status and Trends

Biological invasions are known from around the globe but relatively fewer are known from the Arctic. This may in part reflect that there have been fewer Arctic studies, but it is also consistent with the findings of de Rivera *et al.* (2005) who noted a pattern of decreasing diversity and abundance of non-native species with increasing latitude. This does not mean the Arctic is not susceptible to invasion. In fact, changes in climate and patterns of human use are likely to increase that susceptibility. For example, de Rivera *et al.* (2007) suggested that several marine invasive species, including the European green crab *Carcinus maenas*, had the potential to expand to sub-Arctic and Arctic waters even under moderate climate change scenarios. Similarly, Ruiz and Hewitt (2009) concluded that "environmental changes may greatly increase invasion opportunity at high northern latitudes due to shipping, mineral exploration, shoreline development, and other human responses."

The introduction of invasive species complicates ecological interactions that are already responding to northward expansion of naturally occurring species (Cheung *et al.* 2009). Another study found that the rate of marine invasion is increasing; that most reported invasions are by crustaceans and molluscs; and, importantly, that most invasions have resulted from shipping (Ruiz *et al.* 2000). In particular, the external hull and ballast tanks of vessels operating in ice-covered waters can support a wide variety of non-native marine organisms (Lewis *et al.* 2003; Lewis *et al.* 2004). Given the findings of the recent analysis of current Arctic shipping (Fig. 1) and the potential for climate change to expand such shipping (Arctic Council 2009), this has high relevance for future marine invasive risks to Arctic waters.

To date, there are many fewer invasive terrestrial plants known from the Arctic than in the more highly altered and invaded ecosystems of lower latitudes. However, over a dozen invasive plant species are already known from the Canadian Arctic and many more occur in the sub-Arctic (Canadian Food Inspection Agency 2008), thus presenting additional invasion risk for Arctic regions. In the Alaskan Arctic, 39 taxa of introduced plants (approximately 7% of the total Arctic flora) have been reported, including several highly invasive grasses and clovers (Carlson *et al.* 2008). Highly invasive white sweetclover, *Melilotus alba*, was extensively used as a forage crop for cattle and a nectar source for introduced honeybees but has now spread up the road system to above the Arctic Circle in Alaska. This nitrogen fixing invader has the potential to alter soil chemistry, with unknown consequences for native plant species that have evolved in low nitrogen systems. Even in the high Arctic, 15% of the flora from a survey in Svalbard was reported to be non-native (Elven & Elvebakk 1996).

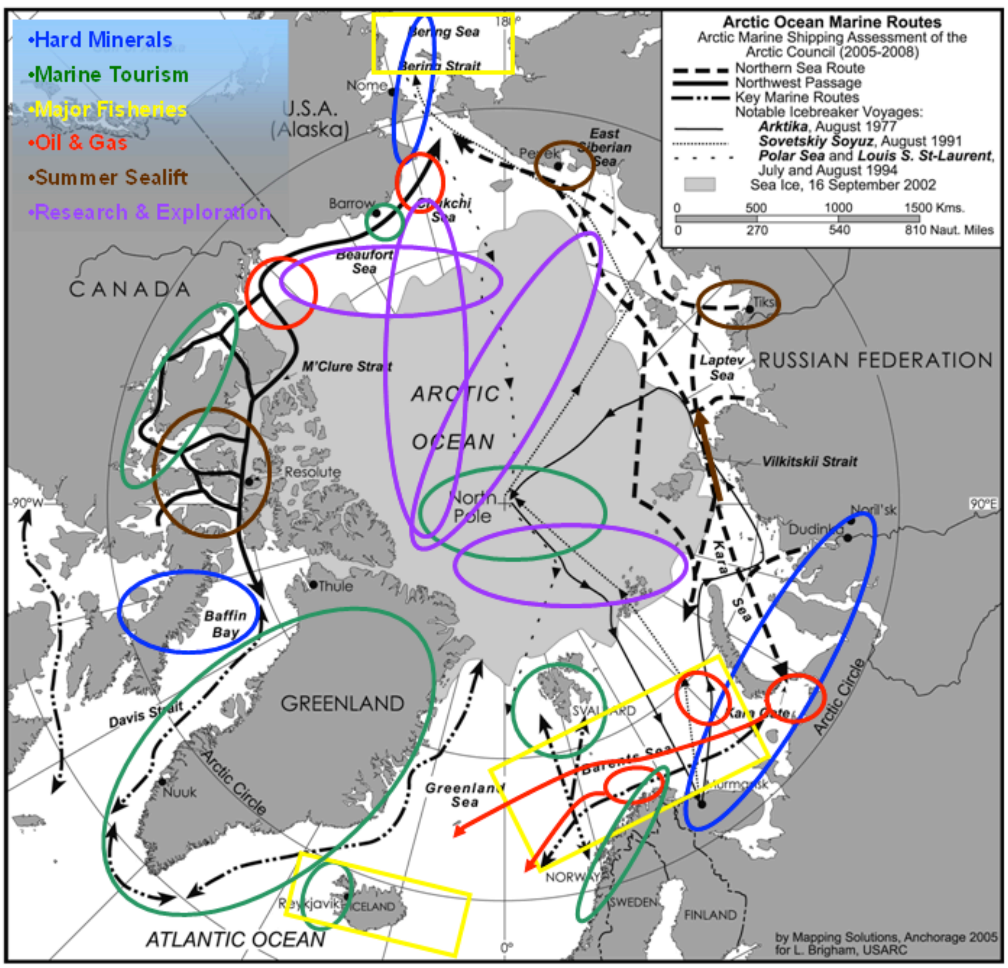

Fig. 1. Schematic of current marine shipping uses in the Arctic (Credit: L.W. Brigham, adapted from data prepared for Arctic Council 2009).

4. Conclusions and recommendations

As climate change alters Arctic ecosystems and enables greater human activity, biological invasion in the Arctic is likely to increase. Arctic terrestrial ecosystems may be predisposed to invasion because many invasive plants are adapted to open disturbed areas (Hierro *et al.* 2006). If fire frequency and intensity increase with climate change (Hu *et al.* 2010), this may further enhance invasion susceptibility. Areas of human disturbance and those located along pathways of human activity (e.g., shipping and road corridors) are the most likely sites of invasion into Arctic habitats. For example, Conn *et al.* (2008) noted the susceptibility of gravel-rich river corridors to white sweetclover invasion dispersal from bridge crossings. The ability for climate change to directly enhance invasion has been demonstrated for marine tunicates (Stachowicz *et al.* 2002) and the spread of invasive marine tunicates to the Arctic could interfere with access to benthic food sources for already at risk marine mammals like benthic-feeding whales and pinnipeds.

Benthic communities in northern Norway and the Kola Peninsula are already facing significant disturbance from the introduced red king crab (Joergensen *et al.* 2007), and further introductions may contribute to accelerated and synergistic impacts (e.g. Simberloff *et al.* 1999). Range map scenarios developed for 16 highly invasive plants either occurring in or at risk of invading Alaska (Bella 2009) also paint a sobering outlook for the future. Fig. 2 depicts the potential expansion of one well-known invasive aquatic plant, *Hydrilla veticillata*, northward into the aquatic ecosystems of Arctic Alaska and far eastern Russia. Another recent study examining global distribution trends associated with climate change predicted that marine communities in the Arctic and Antarctic will be the most at risk from climate-induced invasions (Cheung *et al.* 2009).

Because future change will be best understood when measured against a credible baseline, much more work similar to that of Ruiz *et al.* (2006) will be needed. Due to the distribution of resources in the Arctic, the development of cost-effective early detection monitoring networks will be a challenge. Engaging a network of citizen scientists might present a viable alternative to traditional monitoring approaches. Such networks could represent an excellent opportunity to employ the traditional ecological knowledge of northern residents whose cultures have used the native species of that ecosystem for millennia.

In addition to valid baselines, there will need to be increased and targeted prevention efforts to limit the influx of non-native species (e.g., ballast water treatment and the effective cleaning and treatment of ship hulls and drilling rigs brought in from other marine ecosystems). Such measures should be complemented with targeted management plans for activities known to present a high risk of introduction. For example, petroleum drilling rigs have been identified as a significant risk for modern marine introductions, and the increase of petroleum extraction in the Arctic should be accompanied by stringent cleaning and monitoring requirements (NIMPIS 2009).

Finally, two additional future Arctic risks that may accompany climate change: 1) much like climate change, invasive species can decrease stability and increase uncertainty in ecosystem function and the evolutionary trajectories of species; and 2) as more temperate ecosystems feel the effects of these climate-induced uncertainties, there may be a push to resort to using Arctic ecosystems as refugia at the receiving end of well intended but risky efforts to "assist" species in the colonization of new habitats (Ricciardi & Simberloff 2009). Since species' ability to successfully invade will vary with their mobility and physiological capacities, much work is also needed on basic biology and life history traits of potential Arctic invaders in order to effectively assess Arctic vulnerabilities and risks.

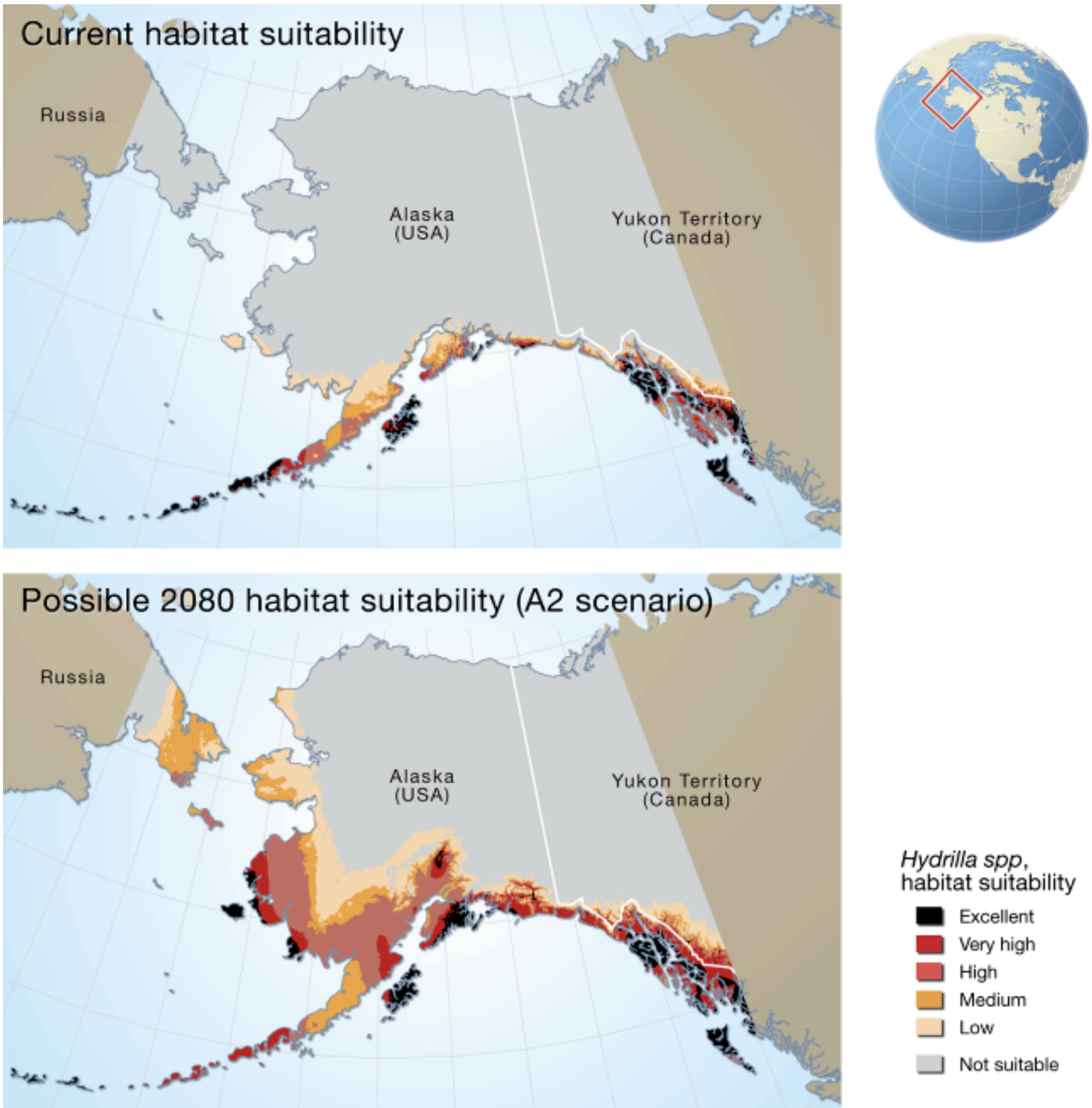

Fig. 2. Current potential range of invasive aquatic plant, Hydrilla verticillata in Alaska and projected potential range with climate warming (adapted from Bella 2009).

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