What are nonnative species in a novel assemblage? Rethinking invasive species management

John Morton, PhD

ALASKA WILDLIFE ALLIANCE

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Glocianus punctiger

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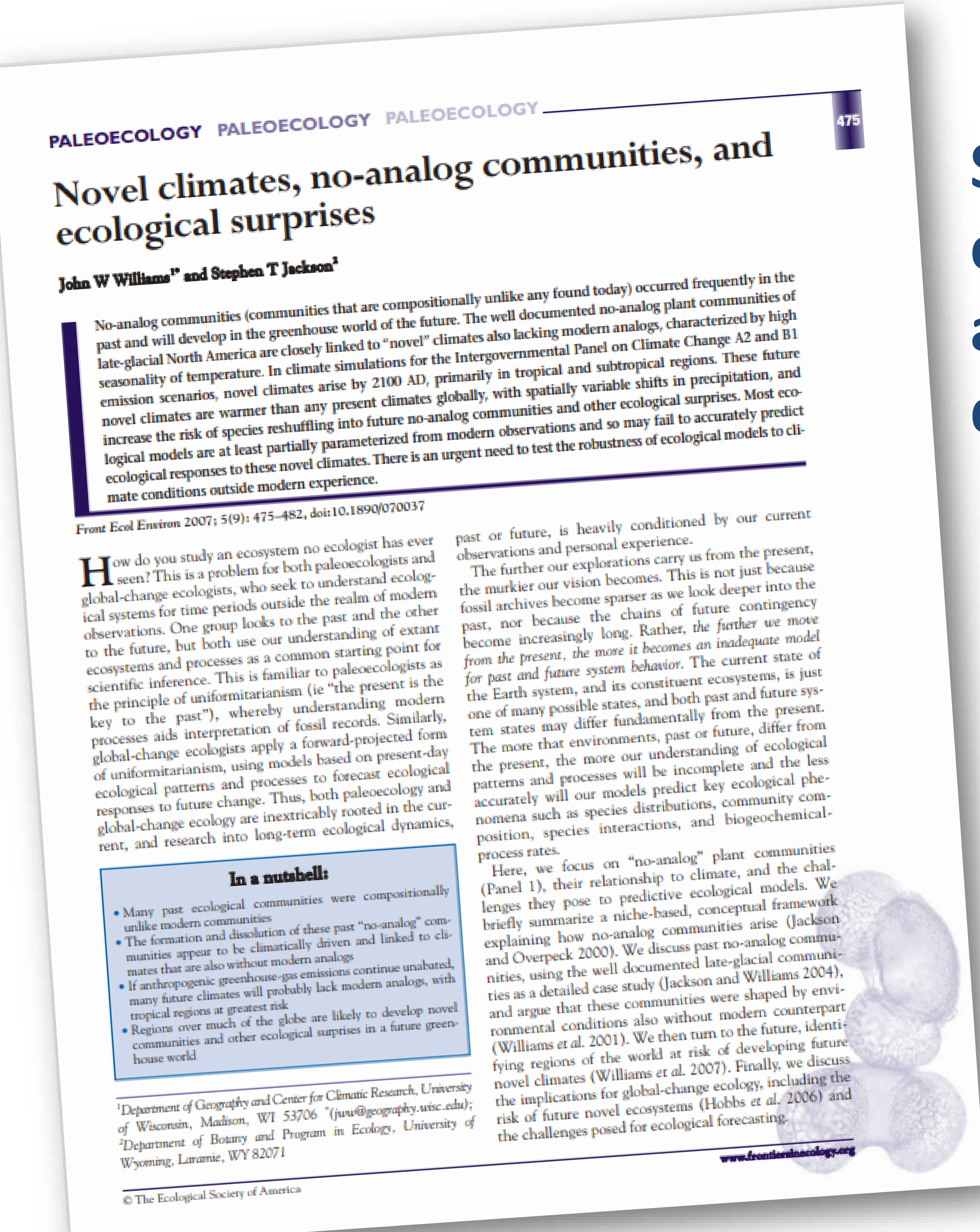
1,300 lbs per acre – 70 times moose biomass!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Novel climates, no-analog communities, and ecological surprises

John W Williams[1*] and Stephen T Jackson[2]

No-analog communities (communities that are compositionally unlike any found today) occurred frequently in the past and will develop in the greenhouse world of the future. The well documented no-analog plant communities of late-glacial North America are closely linked to "novel" climates also lacking modern analogs, characterized by high seasonality of temperature. In climate simulations for the Intergovernmental Panel on Climate Change A2 and B1 emission scenarios, novel climates arise by 2100 AD, primarily in tropical and subtropical regions. These future novel climates are warmer than any present climates globally, with spatially variable shifts in precipitation, and increase the risk of species reshuffling into future no-analog communities and other ecological surprises. Most ecological models are at least partially parameterized from modern observations and so may fail to accurately predict ecological responses to these novel climates. There is an urgent need to test the robustness of ecological models to climate conditions outside modern experience.

Front Ecol Environ 2007; 5(9): 475–482, doi:10.1890/070037

How do you study an ecosystem no ecologist has ever seen? This is a problem for both paleoecologists and global-change ecologists, who seek to understand ecological systems for time periods outside the realm of modern observations. One group looks to the past and the other to the future, but both use our understanding of extant ecosystems and processes as a common starting point for scientific inference. This is familiar to paleoecologists as the principle of uniformitarianism (ie "the present is the key to the past"), whereby understanding modern processes aids interpretation of fossil records. Similarly, global-change ecologists apply a forward-projected form of uniformitarianism, using models based on present-day ecological patterns and processes to forecast ecological responses to future change. Thus, both paleoecology and global-change ecology are inextricably rooted in the current, and research into long-term ecological dynamics, past or future, is heavily conditioned by our current observations and personal experience.

The further our explorations carry us from the present, the murkier our vision becomes. This is not just because fossil archives become sparser as we look deeper into the past, nor because the chains of future contingency become increasingly long. Rather, *the further we move from the present, the more it becomes an inadequate model for past and future system behavior.* The current state of the Earth system, and its constituent ecosystems, is just one of many possible states, and both past and future system states may differ fundamentally from the present. The more that environments, past or future, differ from the present, the more our understanding of ecological patterns and processes will be incomplete and the less accurately will our models predict key ecological phenomena such as species distributions, community composition, species interactions, and biogeochemical-process rates.

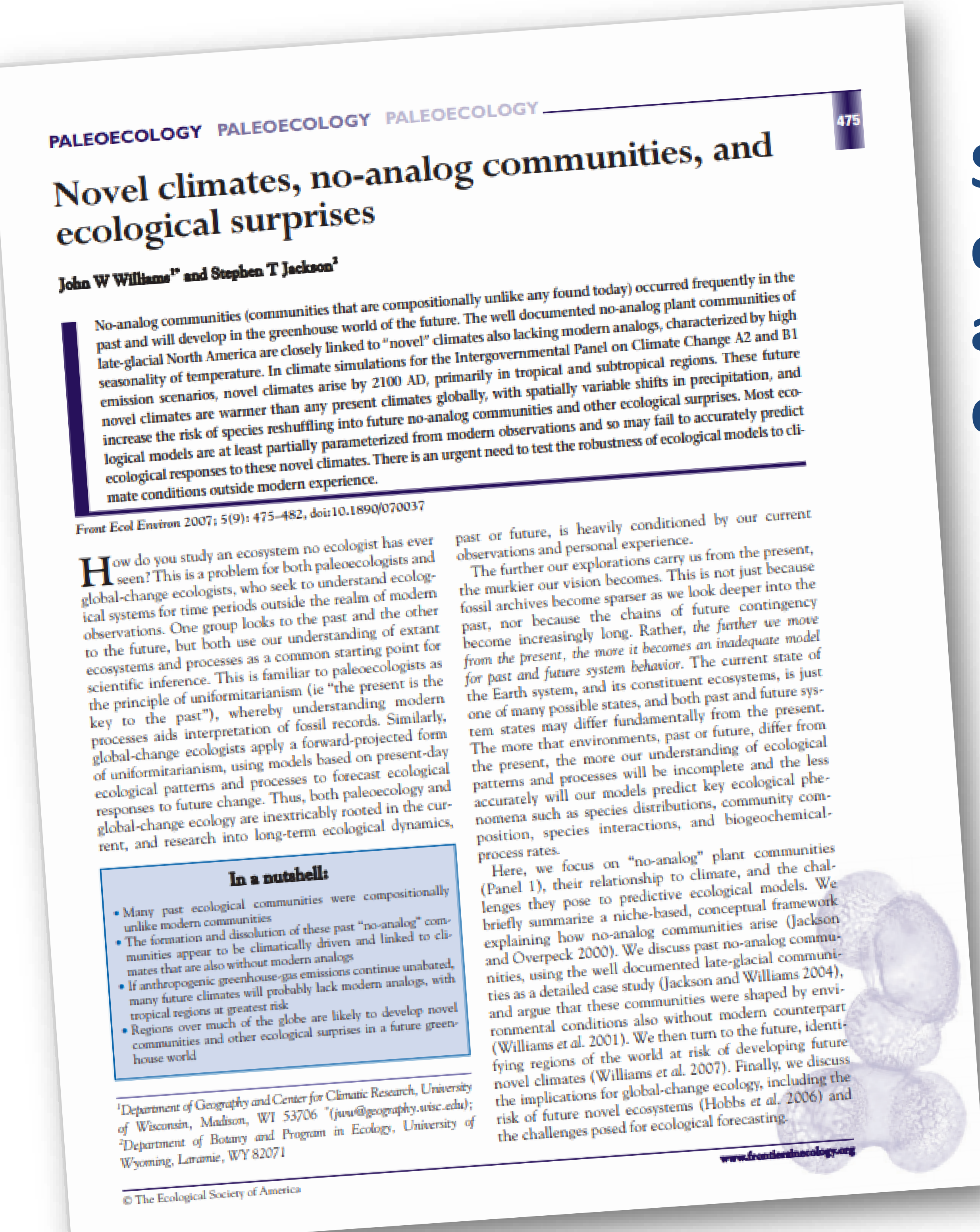
Here, we focus on "no-analog" plant communities (Panel 1), their relationship to climate, and the challenges they pose to predictive ecological models. We briefly summarize a niche-based, conceptual framework explaining how no-analog communities arise (Jackson and Overpeck 2000). We discuss past no-analog communities, using the well documented late-glacial communities as a detailed case study (Jackson and Williams 2004), and argue that these communities were shaped by environmental conditions also without modern counterpart (Williams *et al.* 2001). We then turn to the future, identifying regions of the world at risk of developing future novel climates (Williams *et al.* 2007). Finally, we discuss the implications for global-change ecology, including the risk of future novel ecosystems (Hobbs *et al.* 2006) and the challenges posed for ecological forecasting.

In a nutshell:

- Many past ecological communities were compositionally unlike modern communities
- The formation and dissolution of these past "no-analog" communities appear to be climatically driven and linked to climates that are also without modern analogs
- If anthropogenic greenhouse-gas emissions continue unabated, many future climates will probably lack modern analogs, with tropical regions at greatest risk
- Regions over much of the globe are likely to develop novel communities and other ecological surprises in a future greenhouse world

[1]*Department of Geography and Center for Climatic Research, University of Wisconsin, Madison, WI 53706* *(jww@geography.wisc.edu); [2]*Department of Botany and Program in Ecology, University of Wyoming, Laramie, WY 82071*

So which species will compose novel assemblages in dynamic systems?



Novel climates, no-analog communities, and ecological surprises

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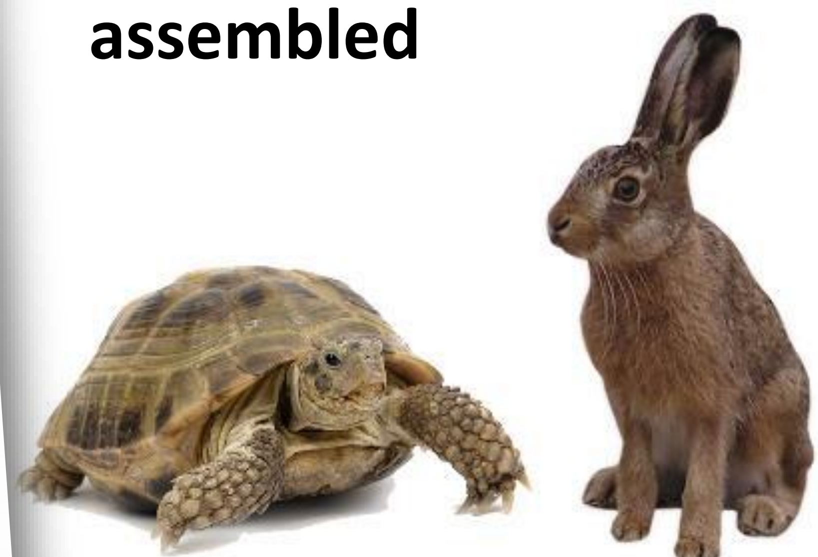
So which species will compose novel assemblages in dynamic systems?

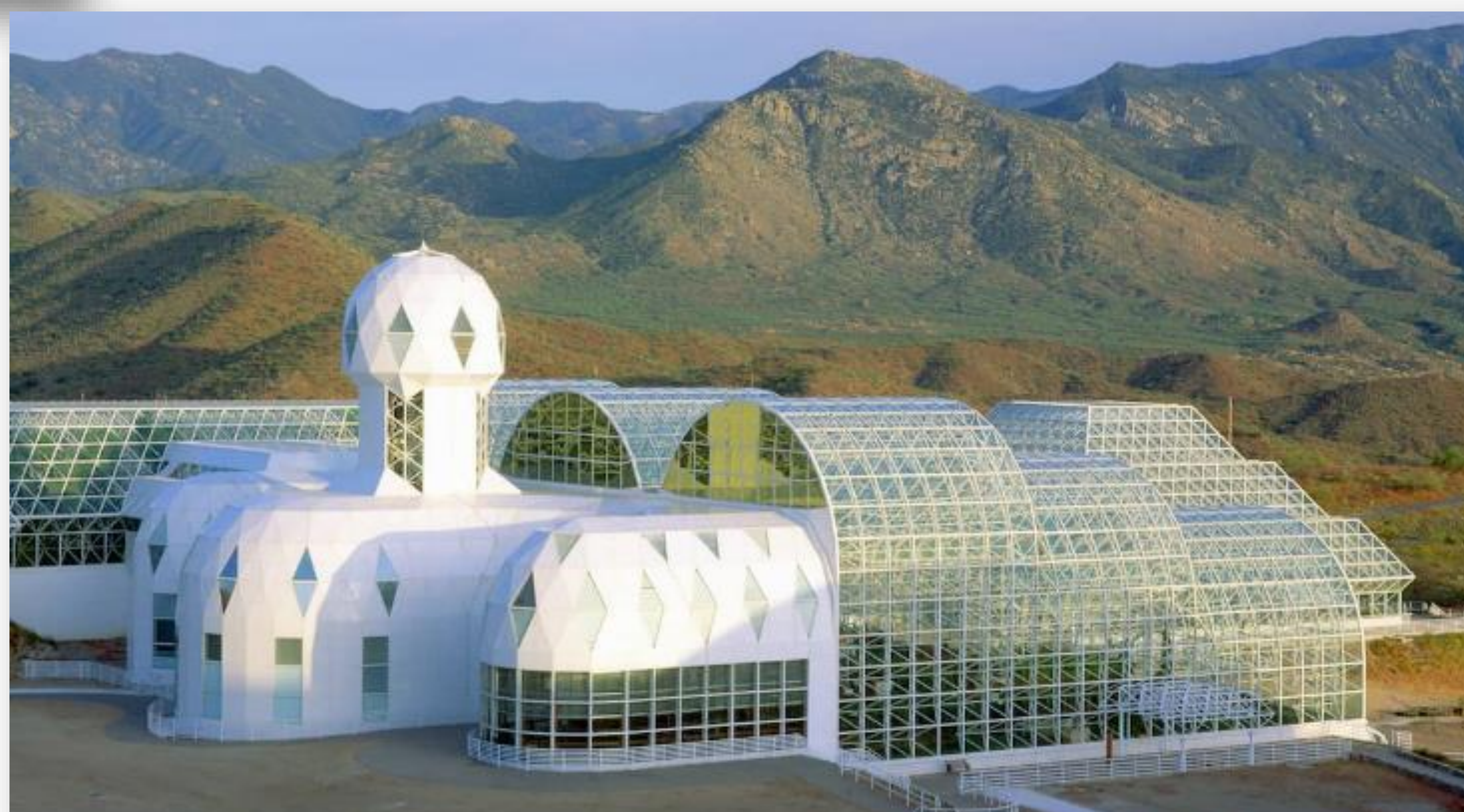
The ones that are there when its being assembled



Tony Burgess

As systems ecologist Howard Odum advised the Biosphere 2 staff…

“shovel the species in, and let extinction sort it out”`



We need a reality check on which species are "packing" our changing systems..

11,174 non-native species in U.S.

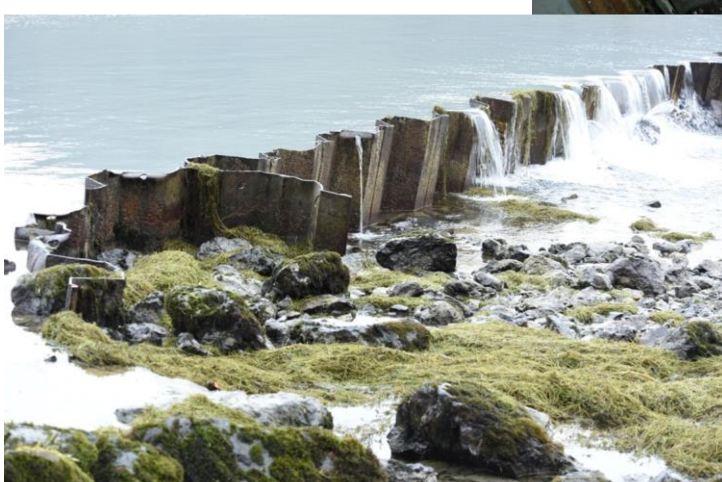
Alaska = 563 / Hawaii = 5870 / Lower 48 = 6553

Simpson, A., Eyler, M.C., Sikes, D., Bowser, M., Sellers, E., Guala, G.F., Cannister, M., Libby, R., and Kozlowski, N., 2019, A comprehensive list of non-native species established in three major regions of the United States: Version 2.0, (ver. 2.0, 2019): U.S. Geological Survey data release, https://doi.org/10.5066/P9E5K160.

Does it matter how nonnative species get here?

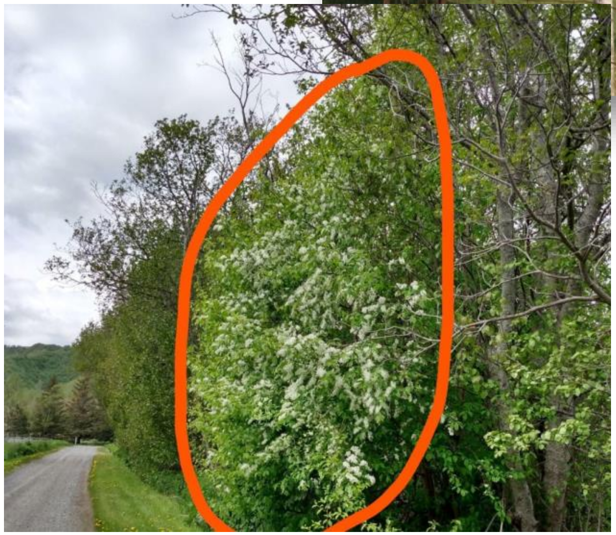
Photo by William Hanlon; courtesy of Willis Osbakken

FIGURE 3. The deer catching team of 19-year-old Ike Hanlon and his dog Tuffy with 4 captured deer on the Sitka dock, ca. 1924



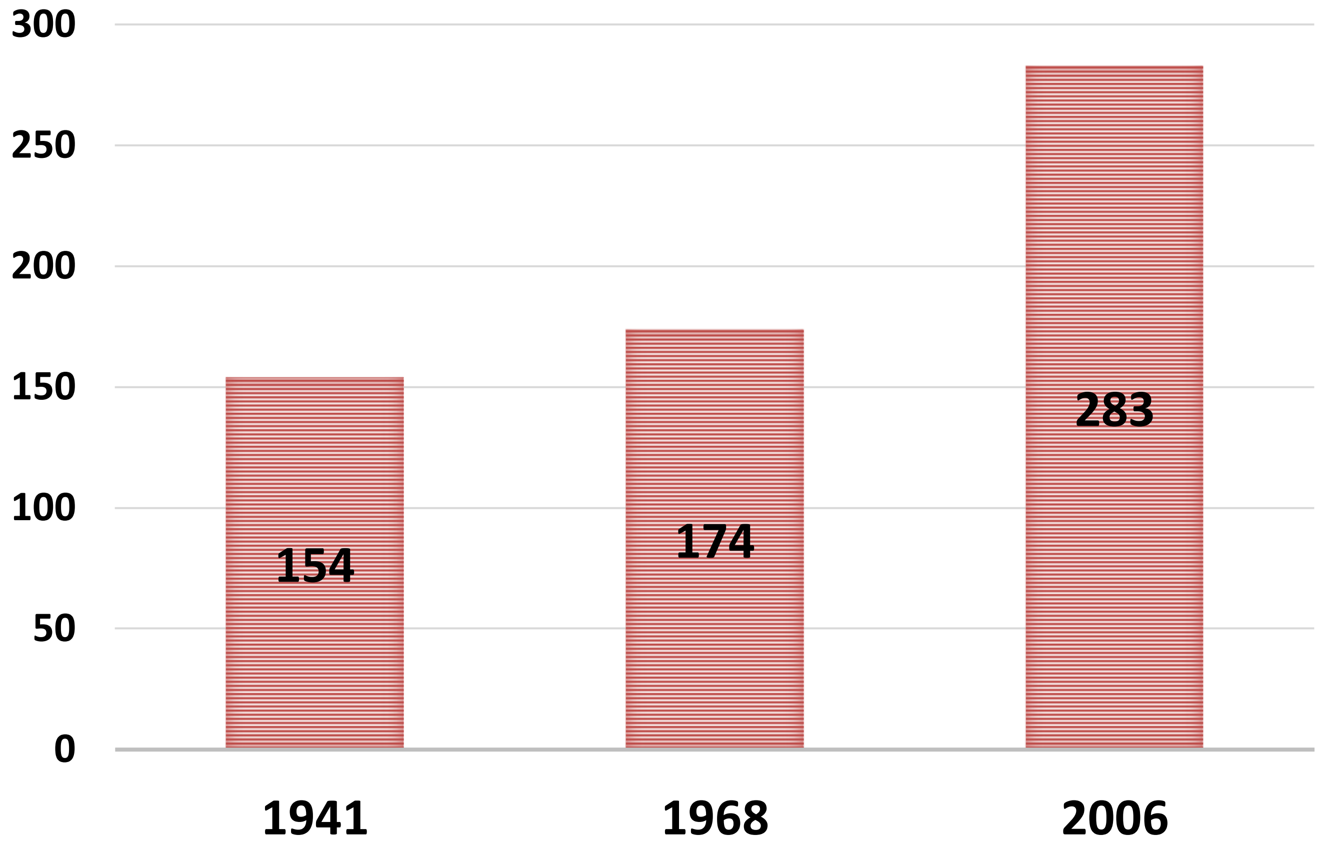
14 native trees but >60 nonnative tree species on the Kenai Peninsula represent "evolutionary potential"

- Green ash
- birches (2)
- Siberian elm
- lindens (2)
- maples (5)
- European mountain ash
- oaks (2)
- Russian olive
- Norway poplar
- willows (11)
- cedars (2)
- firs (9)
- Eastern hemlock
- juniper
- larches (4)
- pines (11)
- spruces (5)



Is the spread of nonnative plants in Alaska accelerating?

157 (55%) species naturalized
36 (13%) species extirpated

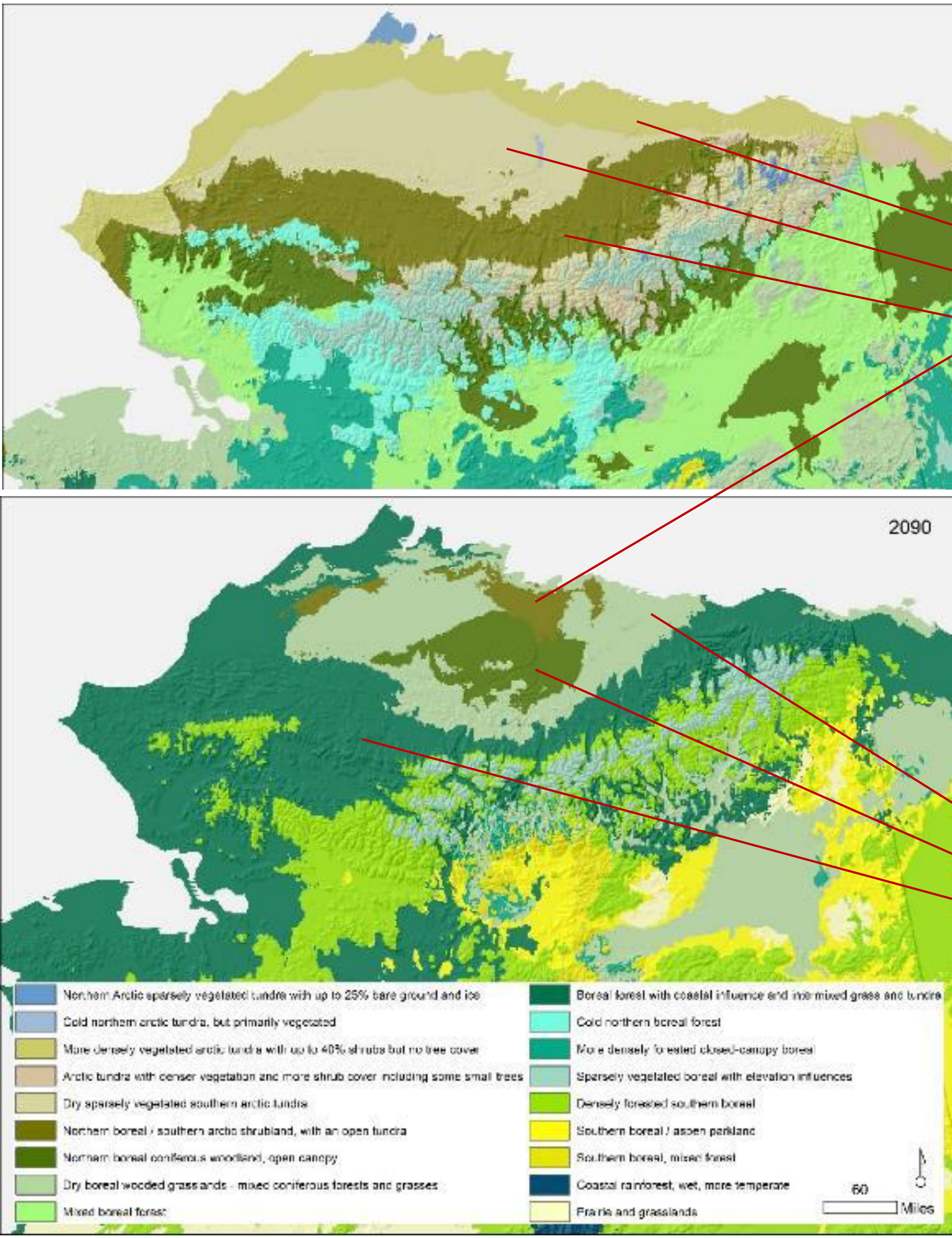


Nonnative plant records in Alaska

Carlson and Shephard 2007

The Arctic is warming 4 times faster than the rest of the globe

P. Jacobs et al. 2021 American Geophysical Union



In 2000, 100% is TUNDRA

- tundra < 40% shrubs and no trees (23%)
- tundra but sparsely vegetated (35%)
- shrubland with open tundra (30%)

By 2100, >55% is CONIFER

- dry boreal wooded grasslands (28%)
- northern boreal coniferous woodlands (9%)
- mixed boreal forest (46%)

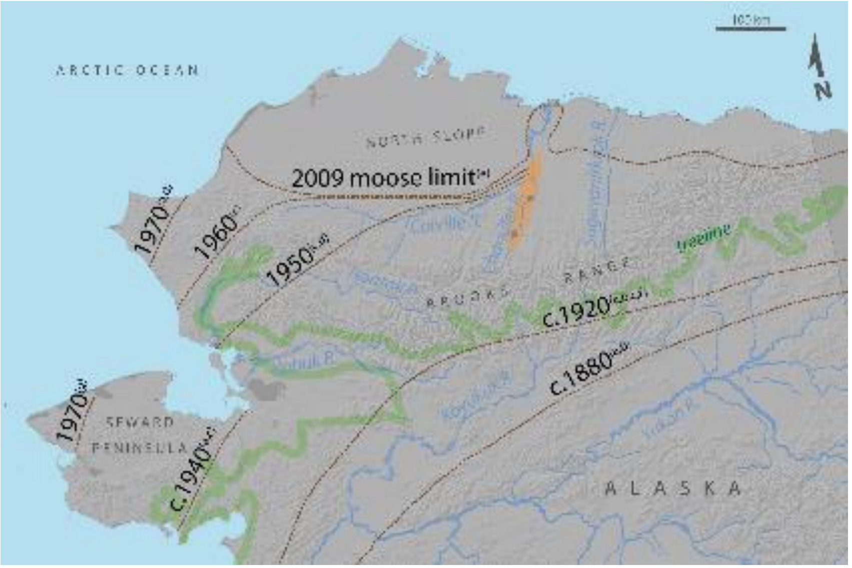
Predicting Future Potential Climate-Biomes for the Yukon, Northwest Territories, and Alaska. 2012. Scenarios Network for Arctic Planning and EWHALE lab, UAF

Extant species

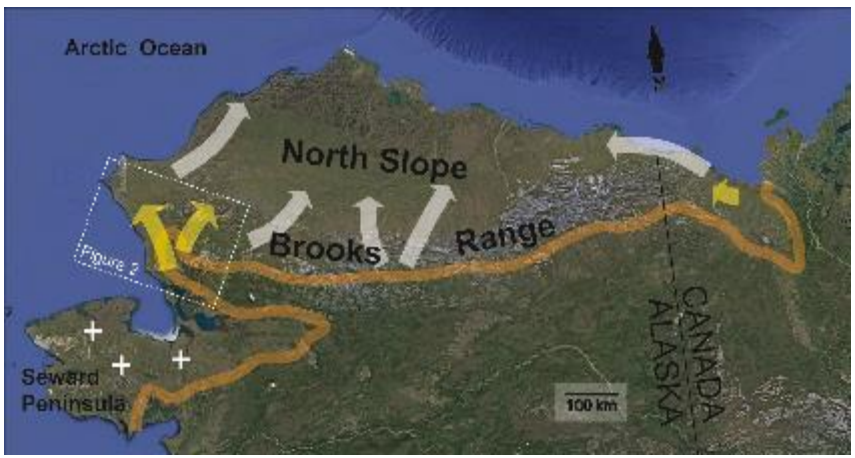
Departing Alaskan species

Departing Alaskan species

Arriving Alaskan species



Tape et al. 2016. Range expansion of **MOOSE** in arctic Alaska linked to warming and increased shrub habitat.
PLoS ONE 11(4):e0152636



Tape et al. 2018. Tundra be dammed: **BEAVER** colonization of the Arctic.
Global Change Biology 24:4478-4488.

Breen. 2014. **BALSAM POPLAR** (*Populus basamifera* L.) on the Arctic Slope of Alaska.
Phytocoenologia 44:1-17.

Arriving Alaskan species

"The authors welcome comments on whether to protect or pull this likely human-introduced seedling or leave its future to chance"

Elsner and Jorgenson. 2009. White spruce seedling (*Picea glauca*) discovered north of the Brooks Range along Alaska's Dalton Highway. Arctic 62:342-344

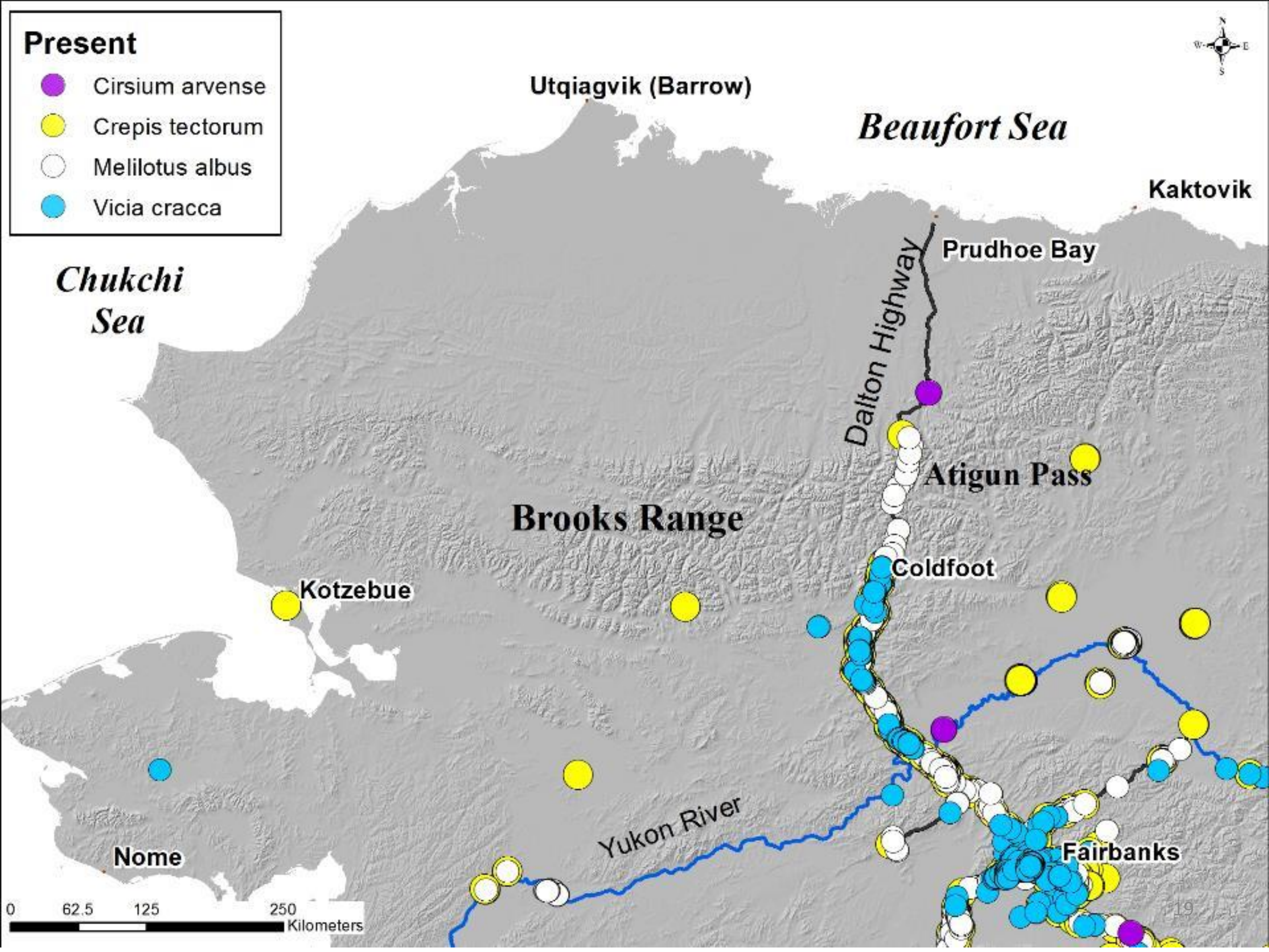
Arriving Eurasian species

Bird vetch

White sweetclover

Creeping thistle

Narrowleaf hawksbeard


Present
Cirsium arvense
Crepis tectorum
Melilotus albus
Vicia cracca
Utqiagvik (Barrow)
Beaufort Sea
Kaktovik
Prudhoe Bay
Chukchi Sea
Dalton Highway
Atigun Pass
Brooks Range
Coldfoot
Kotzebue
Yukon River
Fairbanks
Nome
0 62.5 125 250 Kilometers

Creeping thistle 50 miles north of Atigun Pass

Straw erosion wattles likely vector

Despite efforts to control creeping thistle, it has “creeped” across North America

- ✓ **Native to southeastern Europe and eastern Mediterranean**
- ✓ **Probably introduced in 1600s as contaminant of crop seed and/or ship's ballast**
- ✓ **Rapid spread led to control legislation as early as 1795 in Vermont and 1831 in New York**
- ✓ **Listed as a noxious weed in > 29 states (including AK) and 7 Canadian provinces**
- ✓ **Now occurs throughout most of Canada and US, north of the 35th parallel, where it is one of the most tenacious and economically impactful agricultural weeds and invader of native forest and range**

USDA Fire Effects Information System
https://www.feis-crs.org/feis/

Does it make any difference that it took 400 years?

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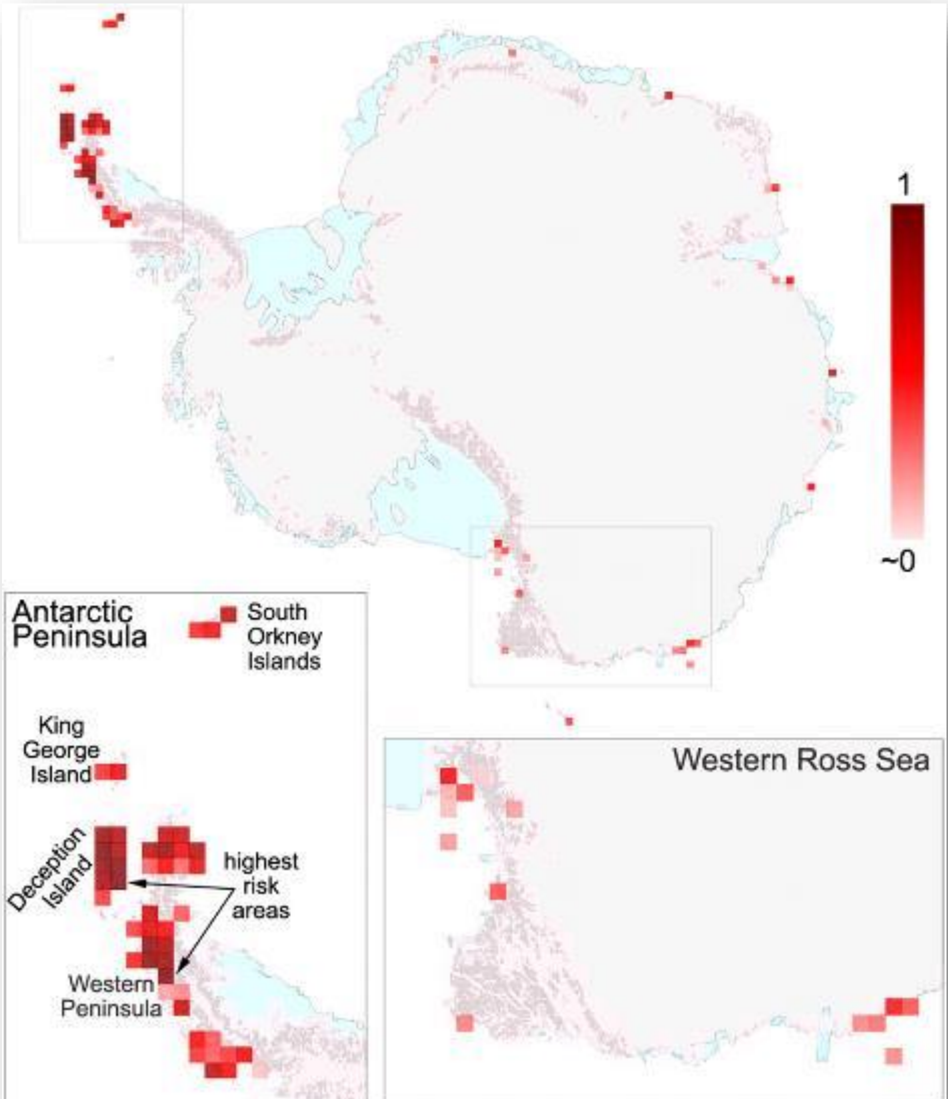
We need to question our collective ability to regulate nonnative species at a landscape scale…

~70,000 seeds (40 families) carried to Antarctica by 40,000 tourists and scientists during one summer



Risk of alien vascular plants establishing in Antarctica

Poa annua **(1 of 3 nonnative plant species)**

Steven L. Chown et al. PNAS 2012;109:13:4938-4943

Two sides of the same coin

Translocate

Eradicate

With one hand you giveth…and the other you taketh

We need a sophisticated interdisciplinary perspective on managing exotic species…

- The Land does not understand human will or intent or values – it only responds to outcome
- Expect novel assemblages, but appreciate we can (and we do!) influence their composition
- Focus on <u>eradicating</u> novel species (spatial scale)
- Be circumspect about invasive species rankings (temporal scale)
- When in doubt, kill it! We can always introduce it