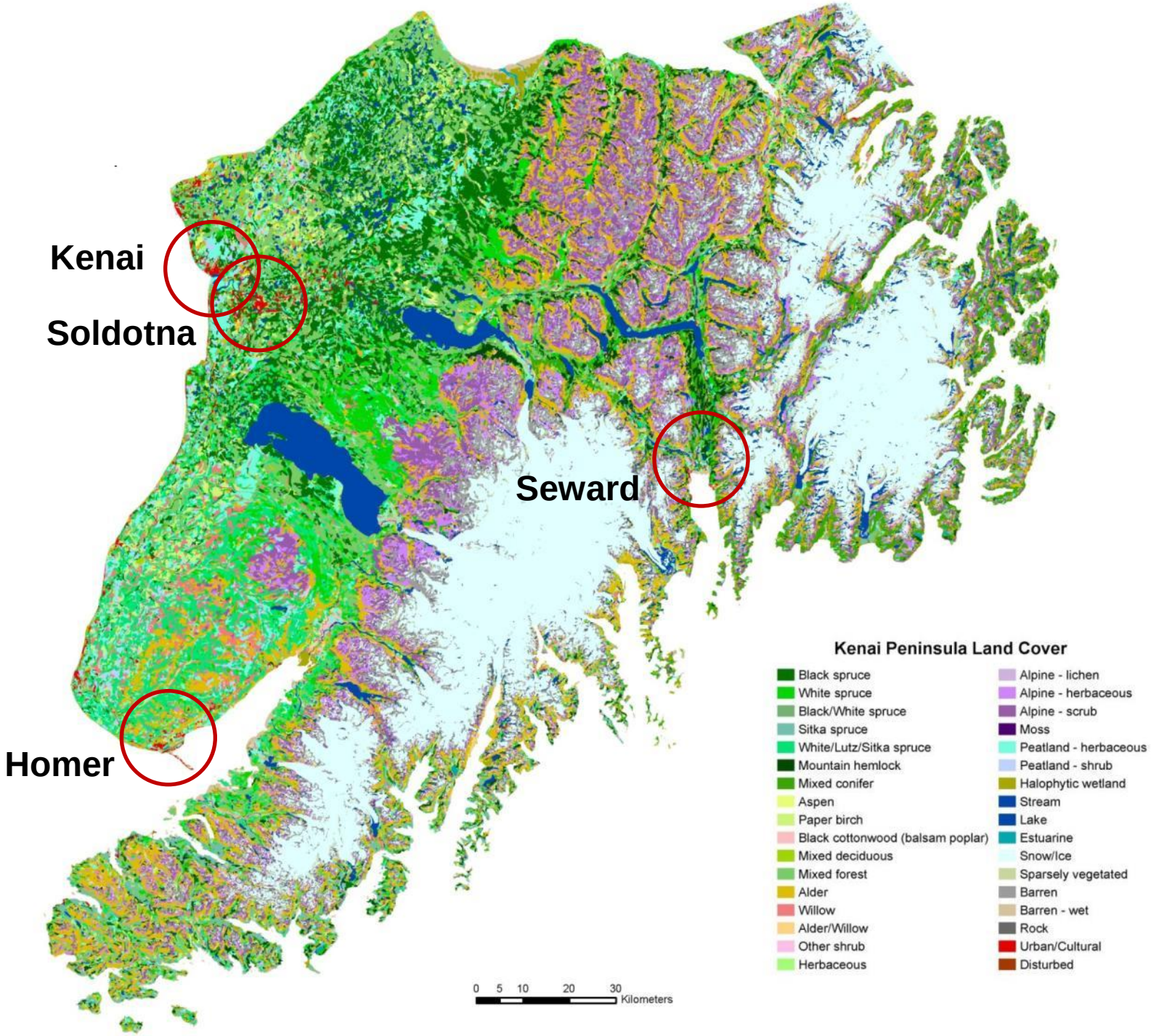
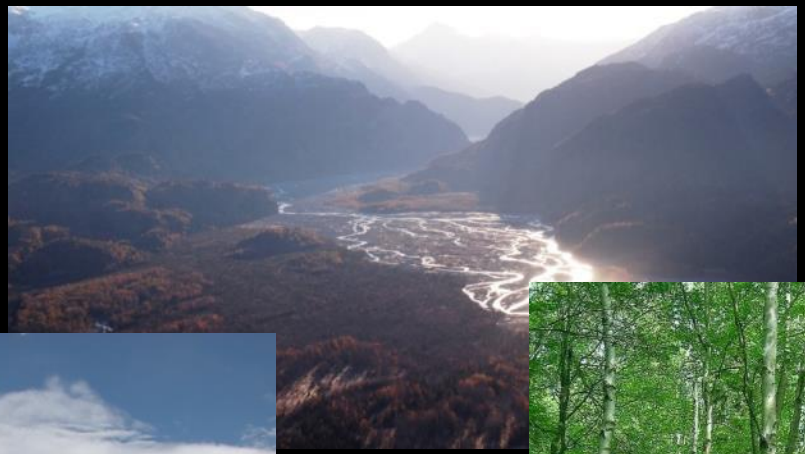
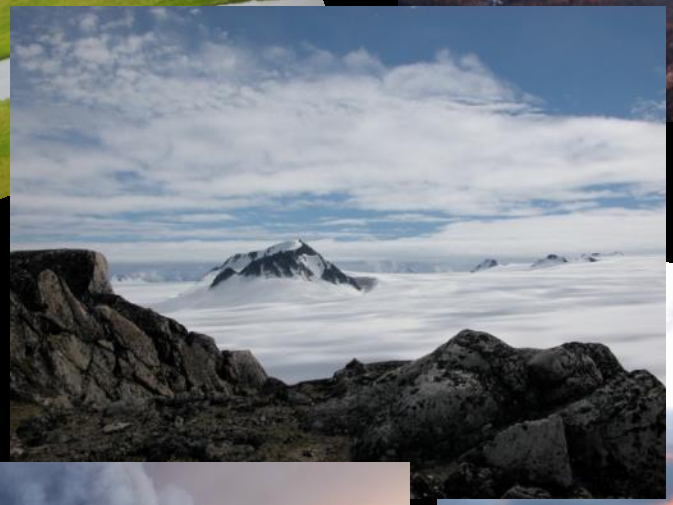
Early responses of Kenai's wildlife and vegetation to rapid climate change

- ✓ What we know
- ✓ What we think will happen
- ✓ Facilitating adaptation

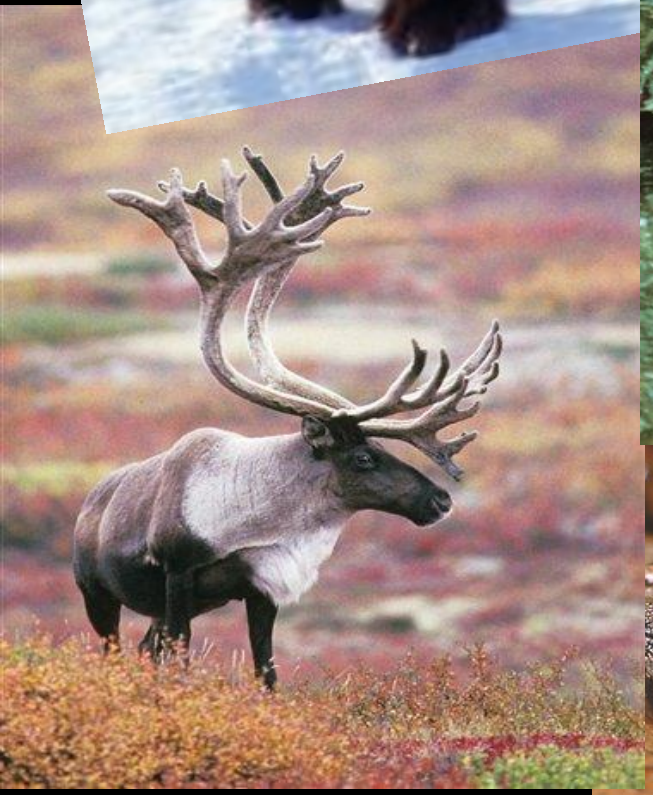
John Morton
Kenai National Wildlife Refuge


Kenai
Soldotna
Seward
Homer
Kenai Peninsula Land Cover
Black spruce
White spruce
Black/White spruce
Sitka spruce
White/Lutz/Sitka spruce
Mountain hemlock
Mixed conifer
Aspen
Paper birch
Black cottonwood (balsam poplar)
Mixed deciduous
Mixed forest
Alder
Willow
Alder/Willow
Other shrub
Herbaceous
Alpine - lichen
Alpine - herbaceous
Alpine - scrub
Moss
Peatland - herbaceous
Peatland - shrub
Halophytic wetland
Stream
Lake
Estuarine
Snow/Ice
Sparsely vegetated
Barren
Barren - wet
Rock
Urban/Cultural
Disturbed
0 5 10 20 30
Kilometers

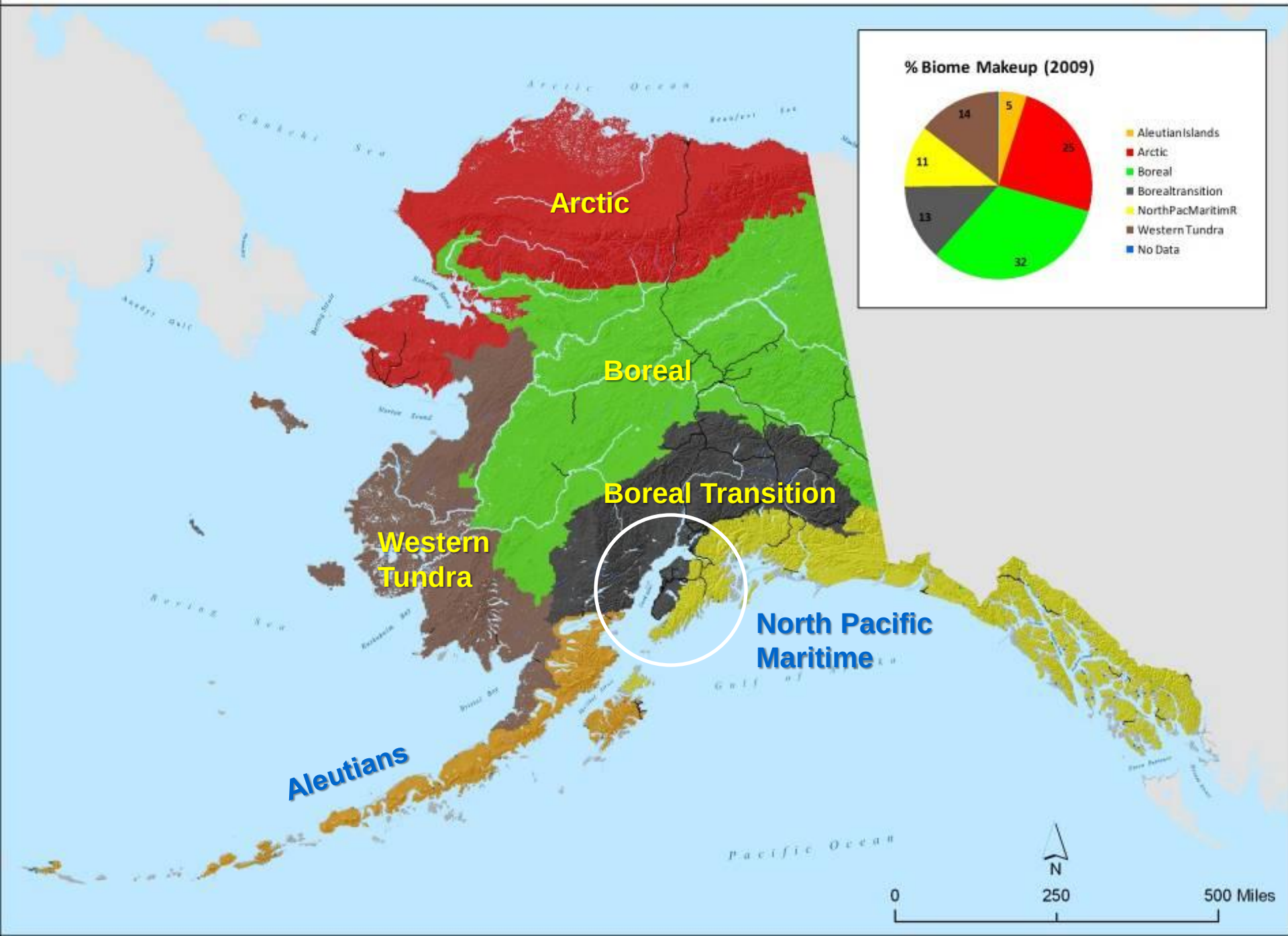




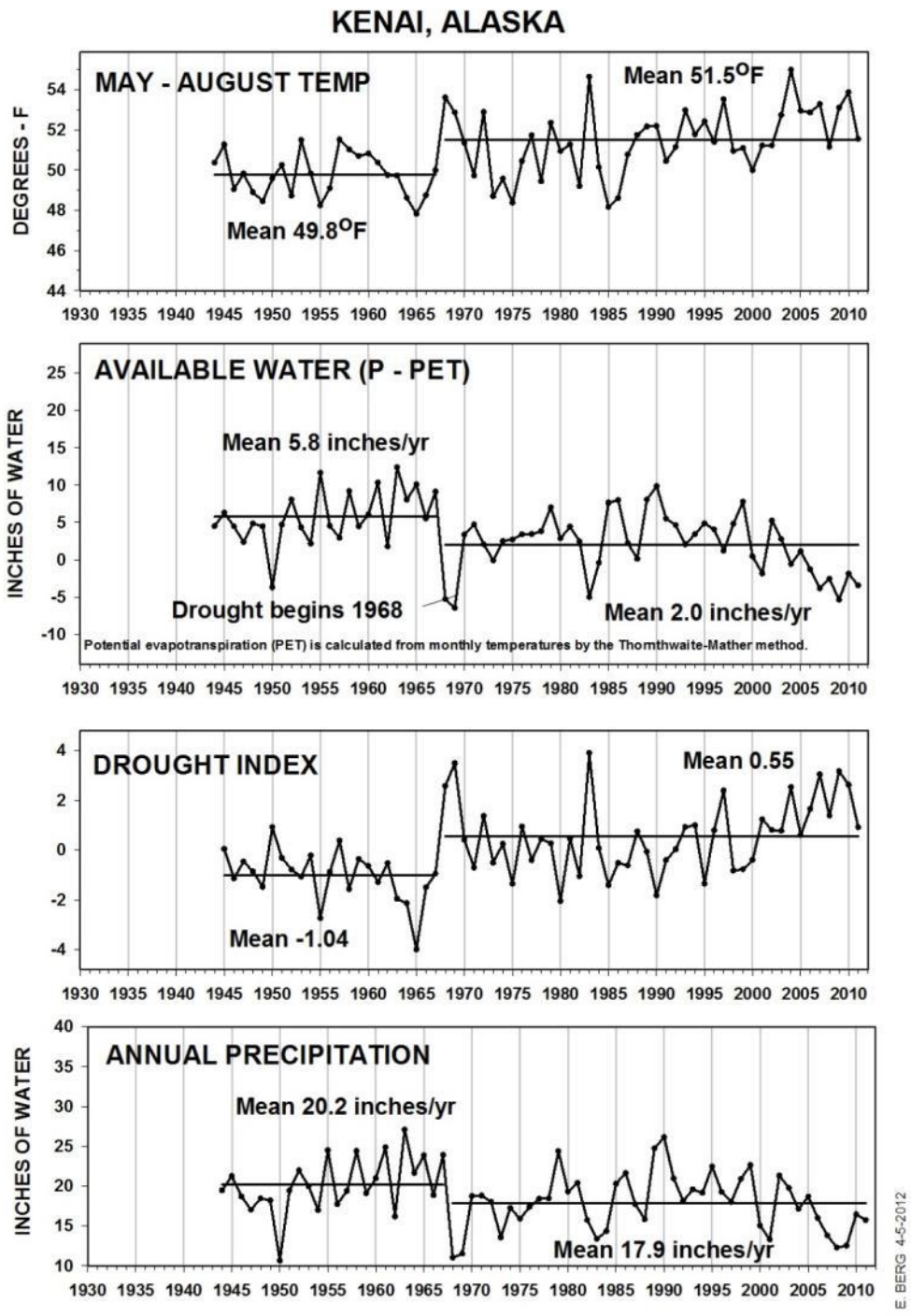




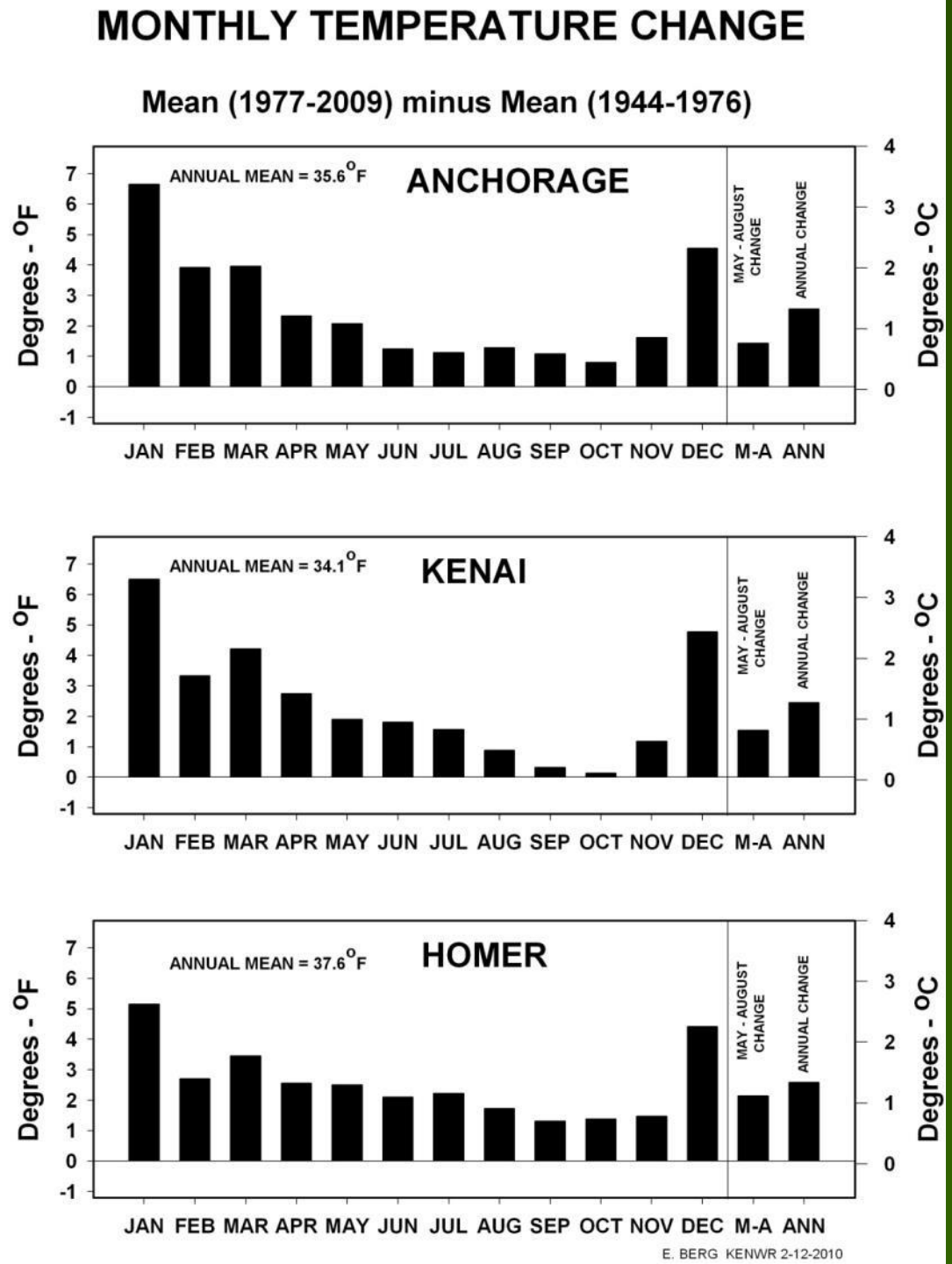



Biome in 2009





The Kenai has gotten warmer and drier in the last 4 decades



Kenai winters have warmed 2-7 deg F over the same period

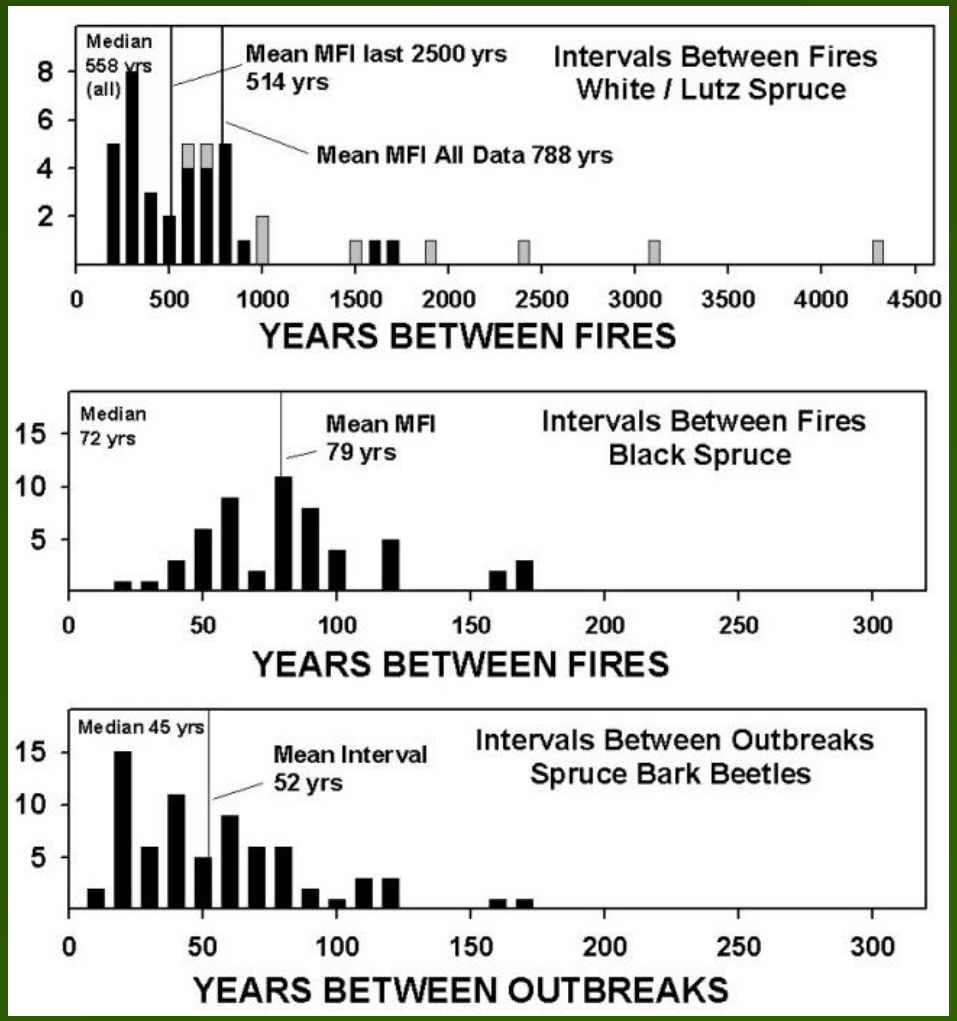
Measured rates of climate change effects on the Kenai Peninsula

- available water (60% loss since 1968)
- wetlands (6 – 11% per decade since 1950)
- glaciers (5% surface area, 21 m elevation since 1950)

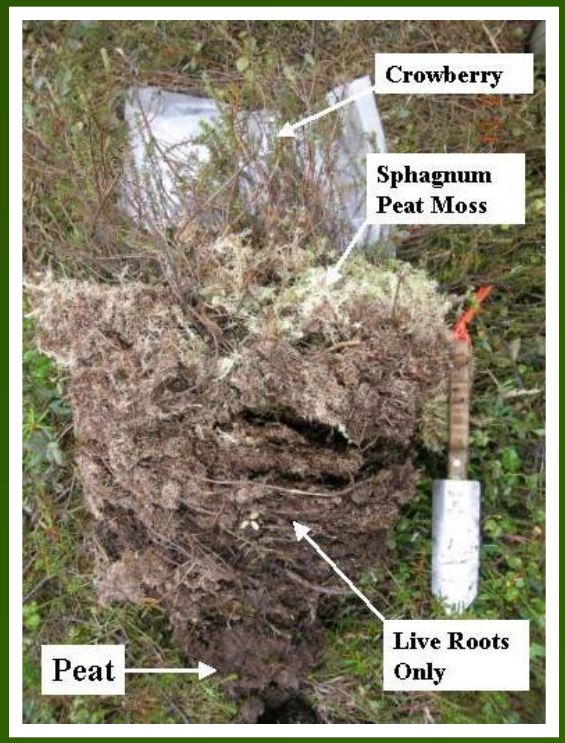
+ treeline (10 m per decade)
+ SB beetle outbreaks (triggered by 2 consecutive warm summers)

Δ wildfire (spring, grass)
Δ species distributions

Changing fire regime?
2005 fire season



Woody shrub encroachment into Sphagnum peatlands



Conversion of white/Lutz spruce forests to *Calamagrostis* savannah

Changing migration window

- eBird records for the Kenai Peninsula in 2007-12

- ✓ 13 new species in last 5 years
- ✓ Earlier arrival records for 33 species
- ✓ Later departure records for 38 species

Eurasian-collared dove
Heerman's gull
Jack snipe
Lesser black-backed gull
Long-billed murrelet
Northern Mockingbird
Redwing
Spotted towhee
Turkey vulture
Western Kingbird
Western meadowlark
Willow flycatcher
Wilson's phalarope

Birds that are more common in winter on the Kenai Peninsula

Horned lark
Lapland longspur
McKay's bunting
Rusty blackbird
White-throated sparrow
Gray -crowned rosy finch
Cedar waxwing
American robin
Red-breasted nuthatch
Northwestern crow
Steller's jay
Northern saw-whet owl
Short-eared owl
Dunlin
Sanderling
Iceland gull
Slaty-backed gull

CBC data

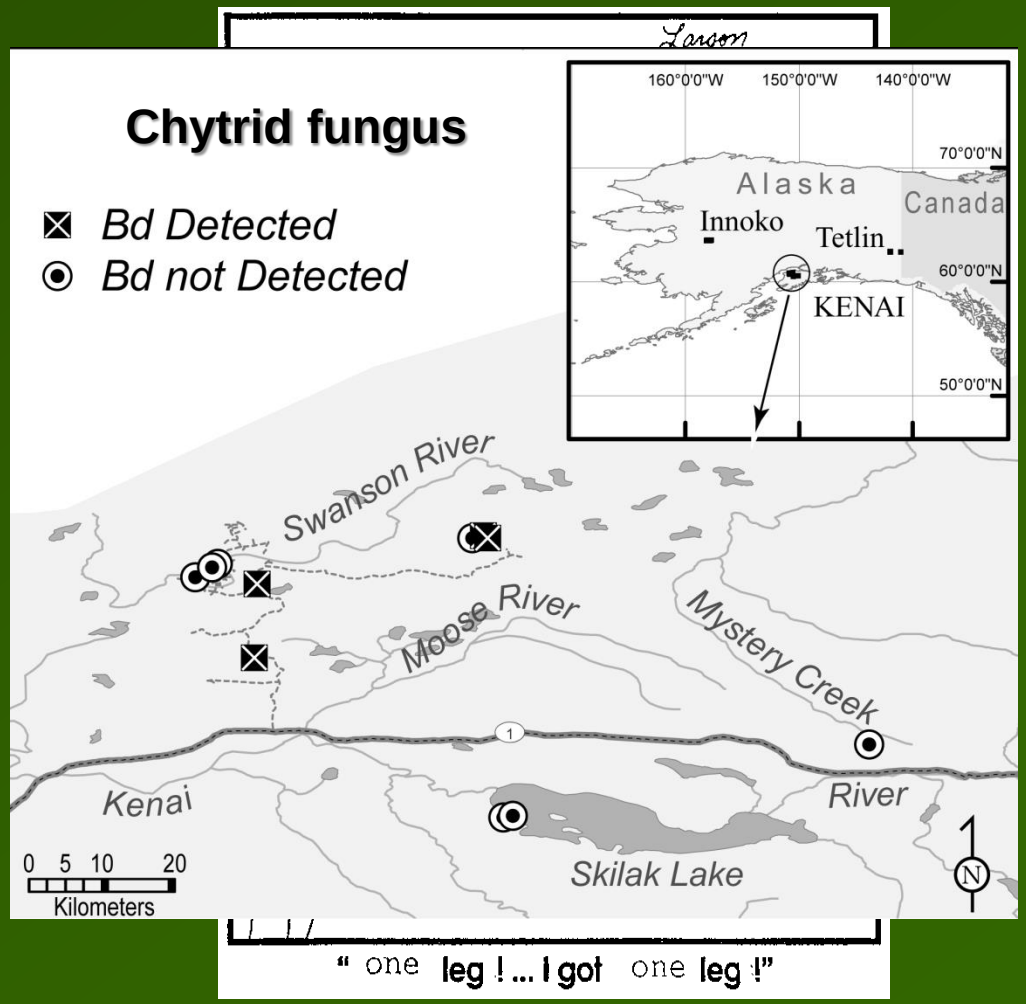
American marten colonized western Kenai Peninsula ~2002

Alpine rest sites

Lowland rest sites

Baltensperger, 2009, Behavior and distribution of American marten in relation to snow and forest cover on the Kenai Peninsula, AK, MS thesis, Colorado State University

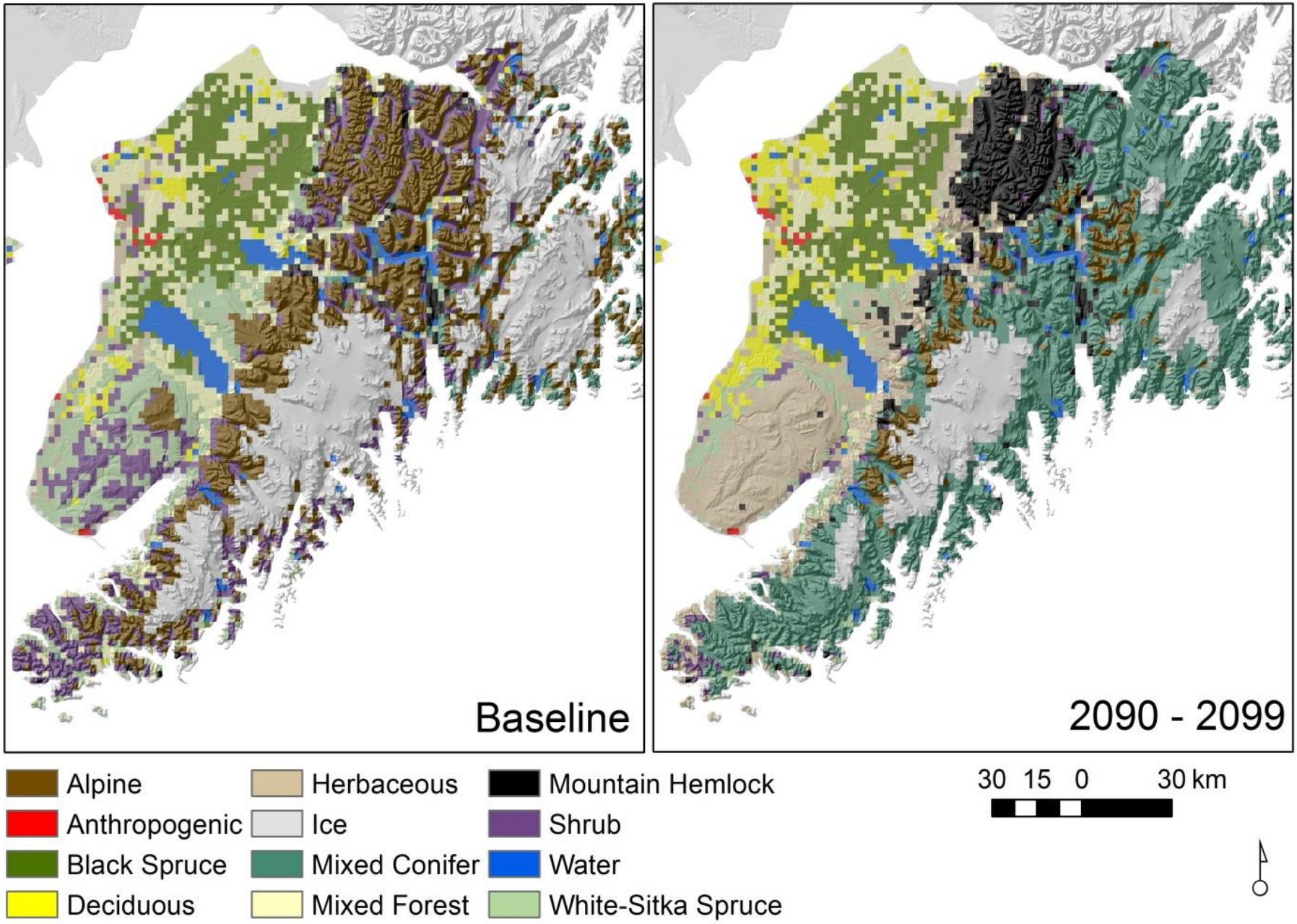
Abnormal wood frogs



Harvested species likely to diminish in abundance on the Kenai Peninsula

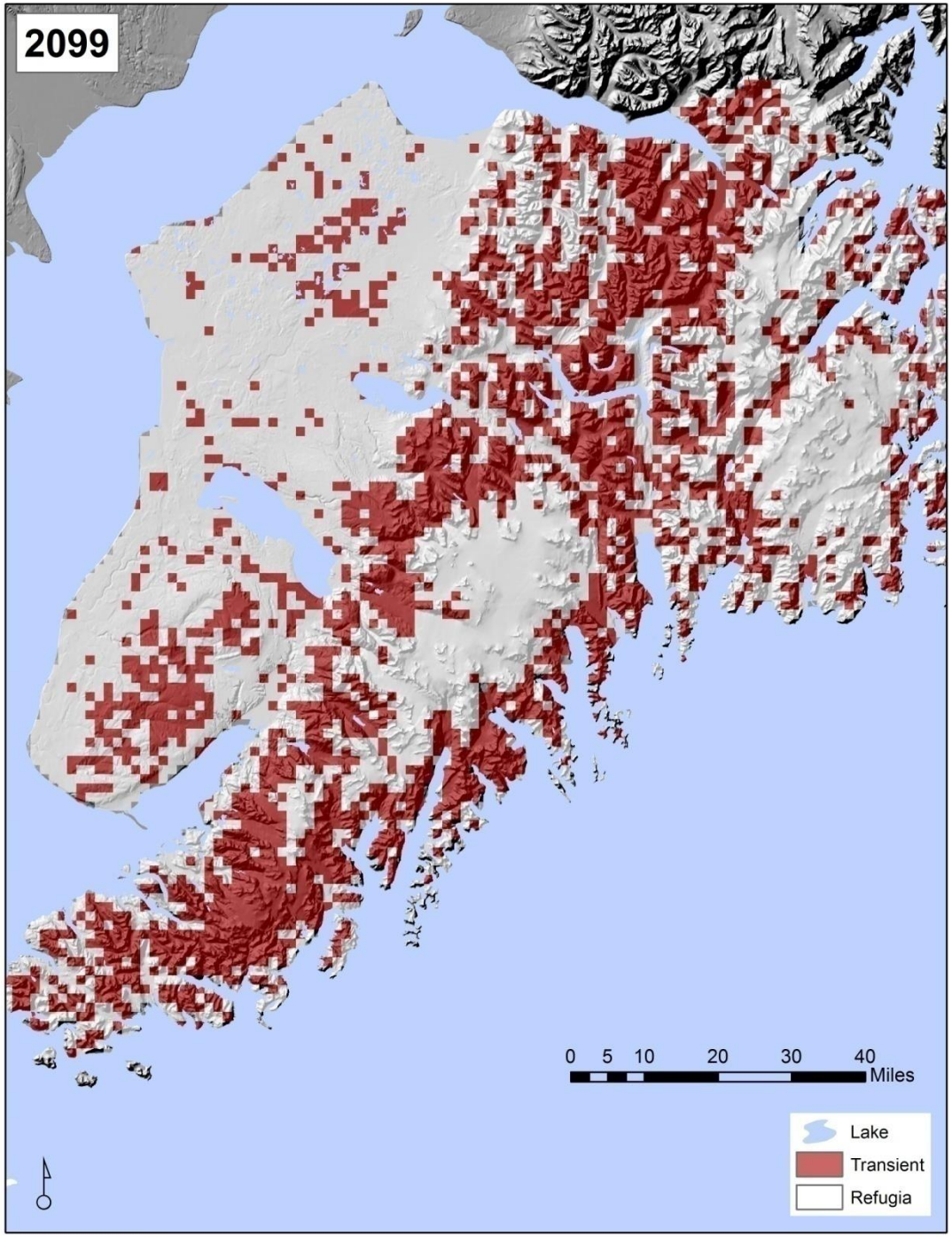
Forecasting the Kenai Peninsula's landscape through 2100

- ✓ Climate envelope modeling using Random Forests™
- ✓ a1b scenario decadal averages for temperature, precipitation (SNAP)
- ✓ landcover type with the greatest % cover in 2km pixels
- ✓ if previous landcover type for each timestep (2039, 2069, 2099) P >0.5 then stay; if P <0.5 then landcover type with highest probability


Baseline
2090 - 2099
Alpine
Anthropogenic
Black Spruce
Deciduous
Herbaceous
Ice
Mixed Conifer
Mixed Forest
Mountain Hemlock
Shrub
Water
White-Sitka Spruce
30 15 0 30 km

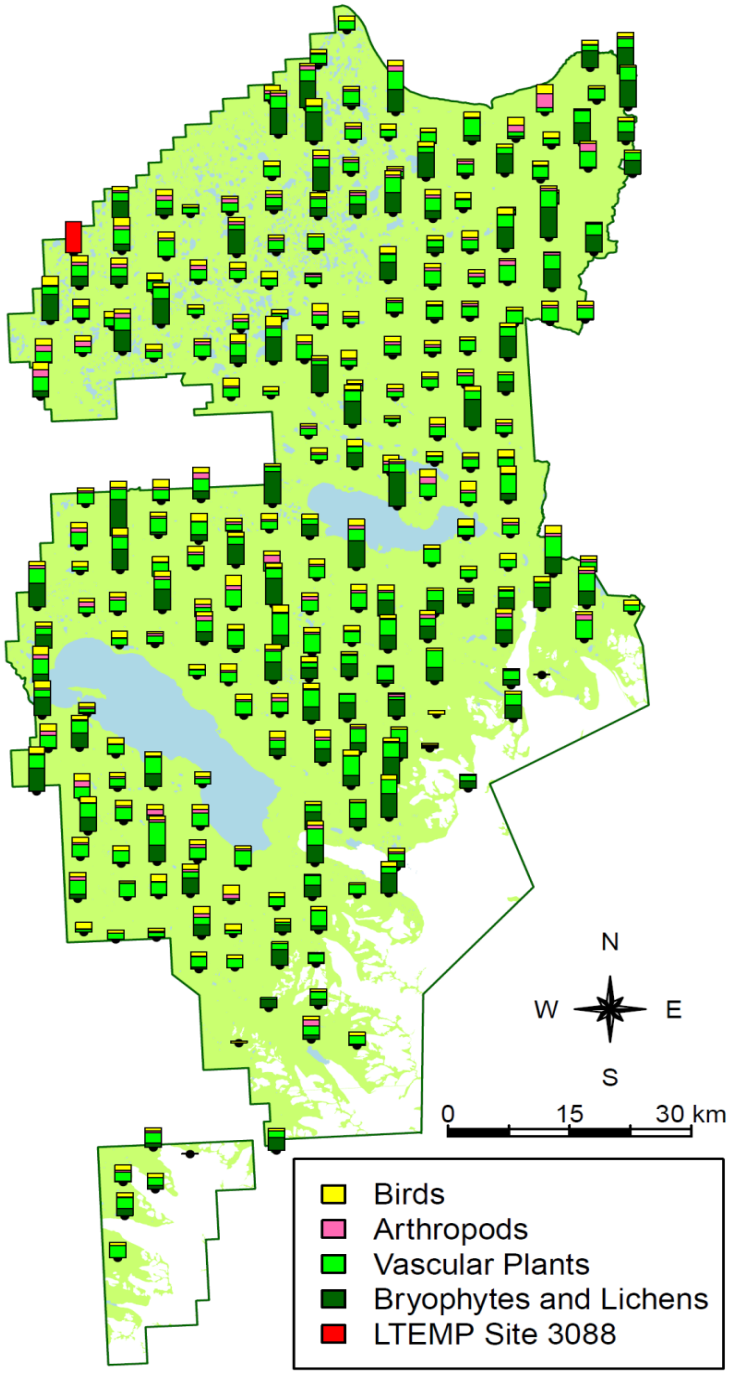
37% of the Kenai Peninsula is forecasted to change landcover type by 2099!

- ✓ Eastern side shows afforestation of alpine (hemlock) and coast (Sitka spruce)
- ✓ Western side shows deforestation (white and black spruce), expanding grasslands



44% of 1,037 native species are unique to 1 of 10 landcover types

86 birds
333 vascular plants
477 nonvascular plants
141 arthropods

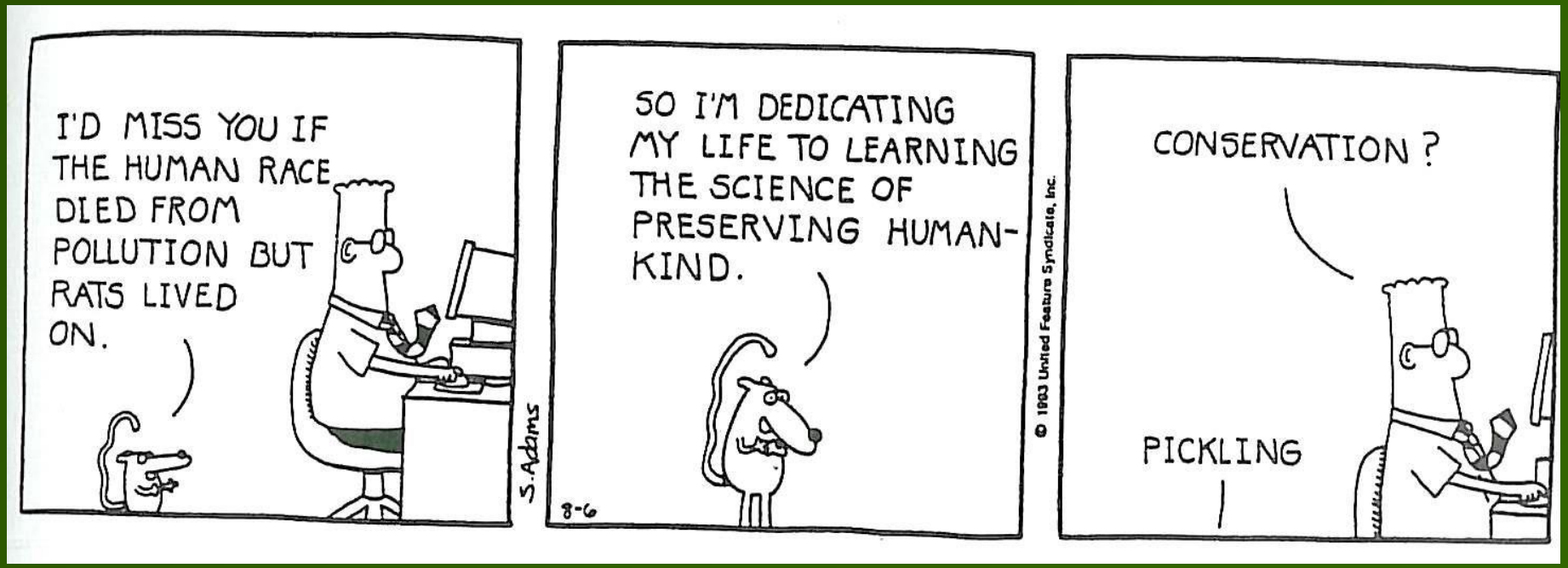


In a worst case scenario, > 400 native species are on a trajectory for extirpation from the Kenai Peninsula by 2099!

Land cover Type	2009 (Ha)	2099 (Min Ha)	Trend	Unique Species
Alpine	556,419	0	-	170
Black Spruce	188,406	0	-	56
Deciduous	38,401	37,601		21
Herbaceous	48,001	65,202	+	15
Mixed Conifer	79,603	330,411	+	1
Mixed Forest	249,209	0	-	86
Mountain Hemlock	34,401	109,604	+	10
Shrub	330,011	0	-	57
Snow or Ice	550,419	50,802	-	8
White-Sitka Spruce	230,408	0	-	38

> 138 exotic plants (108) and animals (30) on the Kenai Peninsula and its near-shore marine environment are poised to replace or impact native species

So what can we do?



Adapting to climate change impacts

Adaptation= *an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities* (IPCC)

esa ECOSPHERE

A climate-change adaptation framework to reduce continental-scale vulnerability across conservation reserves

DAWN R. MAGNESS,[1,2,†] JOHN M. MORTON,[1] FALK HUETTMANN,[2] F. STUART CHAPIN, III,[2] AND A. DAVID MCGUIRE[3]

[1]U.S. Fish & Wildlife Service, Kenai National Wildlife Refuge, Soldotna, Alaska 99669 USA
[2]Institute of Arctic Biology, Department of Biology and Wildlife, University of Alaska, Fairbanks, Alaska 99775 USA
[3]U.S. Geological Survey, Alaska Cooperative Fish & Wildlife Research Unit, University of Alaska, Fairbanks, Alaska 99775 USA

Citation: Magness, D. R., J. M. Morton, F. Huettmann, F. S. Chapin, III, and A. D. McGuire. 2011. A climate-change adaptation framework to reduce continental-scale vulnerability across conservation reserves. Ecosphere 2(10):112. doi: 10.1890/ES11-00200.1

Abstract. Rapid climate change, in conjunction with other anthropogenic drivers, has the potential to cause mass species extinction. To minimize this risk, conservation reserves need to be coordinated at multiple spatial scales because the climate envelopes of many species may shift rapidly across large geographic areas. In addition, novel species assemblages and ecological reorganization make future conditions uncertain. We used a GIS analysis to assess the vulnerability of 501 reserve units in the National Wildlife Refuge System as a basis for a nationally coordinated response to climate change adaptation. We used measures of climate change exposure (historic rate of temperature change), sensitivity (biome edge and critical habitat for threatened and endangered species), and adaptive capacity (elevation range, latitude range, watershed road density, and watershed protection) to evaluate refuge vulnerability. The vulnerability of individual refuges varied spatially within and among biomes. We suggest that the spatial variability in vulnerability be used to define suites of management approaches that capitalize on local conditions to facilitate adaptation and spread risk across the reserve network. We conceptually define four divergent management strategies to facilitate adaption: refugia, ecosystem maintenance, "natural" adaptation, and facilitated transitions. Furthermore, we recognize that adaptation approaches can use historic (i.e., retrospective) and future (prospective) condition as temporal reference points to define management goals.

Key words: climate change; conservation reserve; National Wildlife Refuge System; prospective adaptation; resilience; retrospective adaptation; species extinction; U.S. Fish and Wildlife Service; vulnerability.

Received 8 July 2011; revised 25 August 2011; accepted 26 August 2011; final version received 30 September 2011; **published** 18 October 2011. Corresponding Editor: D. P. C. Peters.

† **E-mail:** Dawn_Magness@fws.gov

INTRODUCTION

Rapid climate change heightens the need for coordinated reserve networks to accommodate dynamic ecological patterns (Halpin 1997, Hannah 2010). However, to be effective, conservation reserve networks must be coordinated at continental, regional and local scales (Soule and Terborgh 1999). This criterion of planning at multiple spatial scales for multiple resources within a reserve network is problematic because many climate change vulnerability assessments have been based on single species or resources, such as a habitat or ecosystem type (Dawson et al. 2011). A new approach is needed for assessing the vulnerability of reserve units, which are

ECOSPHERE ❖ www.esajournals.org 1 October 2011 ❖ Volume 2(10) ❖ Article 112

We have choices….

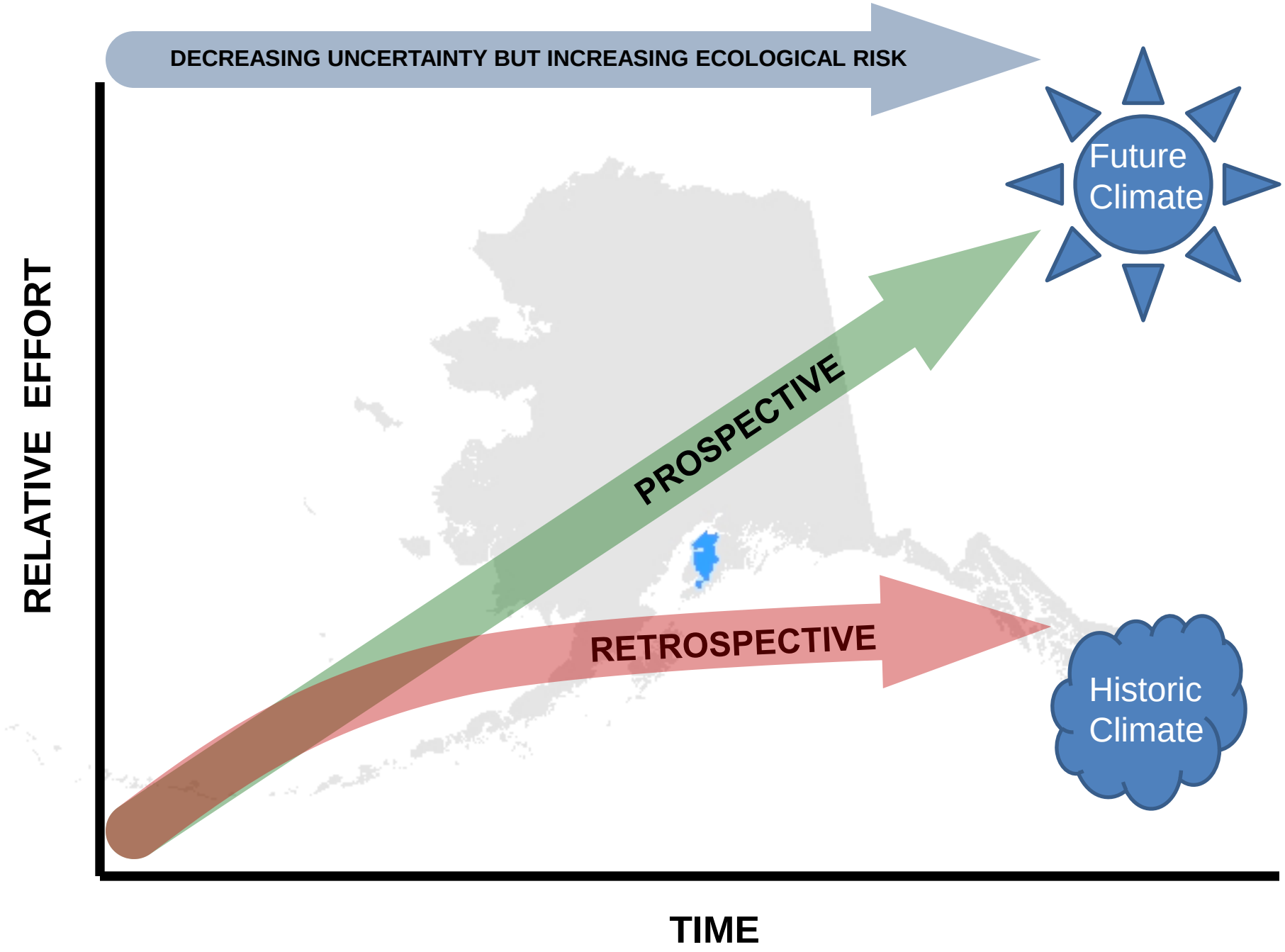
(1) Retrospective adaption = Managing towards historical conditions

(2) Prospective adaptation = Managing towards future conditions

(3) Do nothing

What is the risk of doing nothing?

- ✓ Kenai Peninsula has already changed in response to a changing climate and is forecasted to continue doing so
- ✓ Many native species are on a trajectory for local extirpation (more likely because Kenai is a peninsula)
- ✓ Many exotic species already here and more enroute
- ✓ Accept these outcomes? Or are we willing to accept responsibility for stewarding these outcomes?

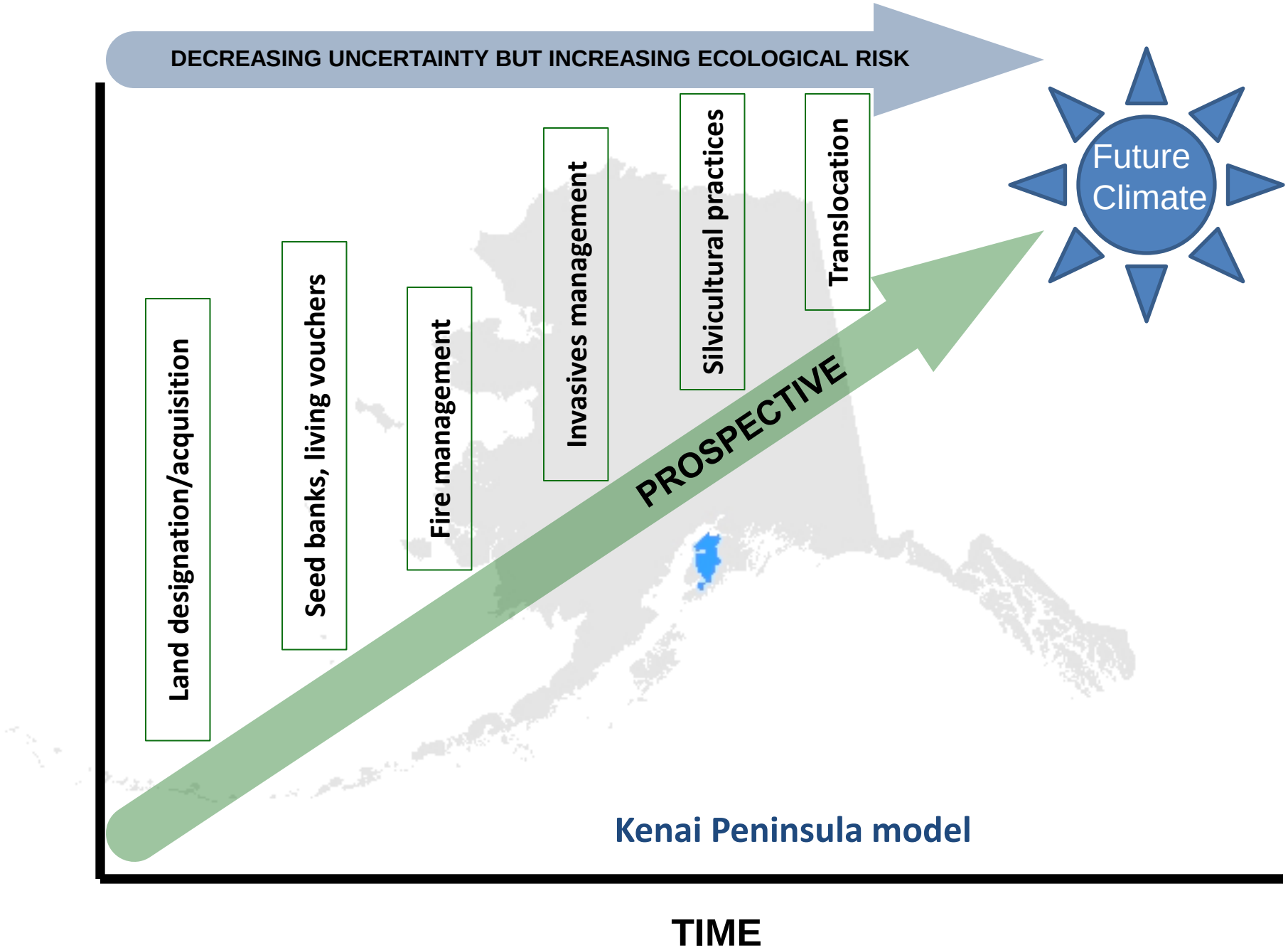

DECREASING UNCERTAINTY BUT INCREASING ECOLOGICAL RISK
Future Climate
PROSPECTIVE
RETROSPECTIVE
Historic Climate
RELATIVE EFFORT
TIME

Same problem but two adaptation approaches

retrospective adaptation

prospective adaptation

From Mike Coffey (AK-DOT&PF)


DECREASING UNCERTAINTY BUT INCREASING ECOLOGICAL RISK
Land designation/acquisition
Seed banks, living vouchers
Fire management
Invasives management
Silvicultural practices
Translocation
PROSPECTIVE
Future Climate
Kenai Peninsula model
TIME

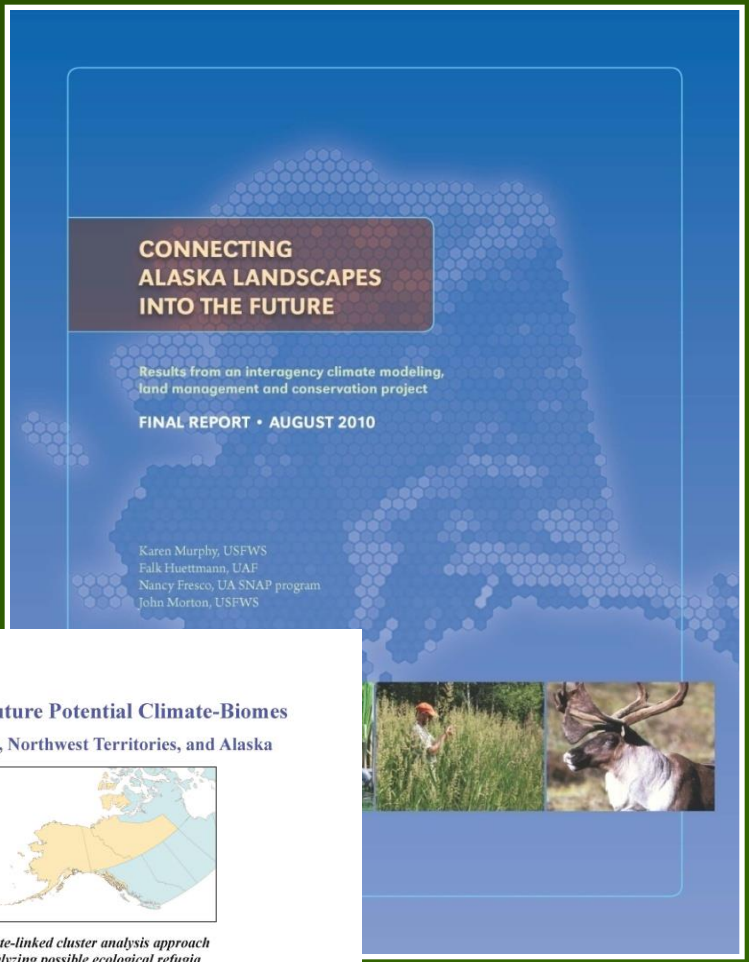
Same climate forecast but potentially different outcomes….

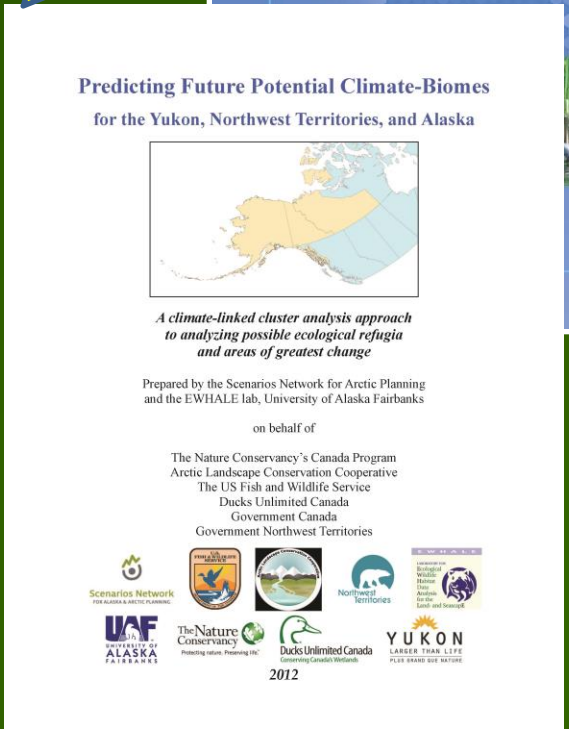
Boreal Transitional

We are already making choices!

Questions????

Interagency effort to pioneer the spatial modeling of climate change impacts on biome and species distributions





Predicting Future Potential Climate-Biomes

for the Yukon, Northwest Territories, and Alaska

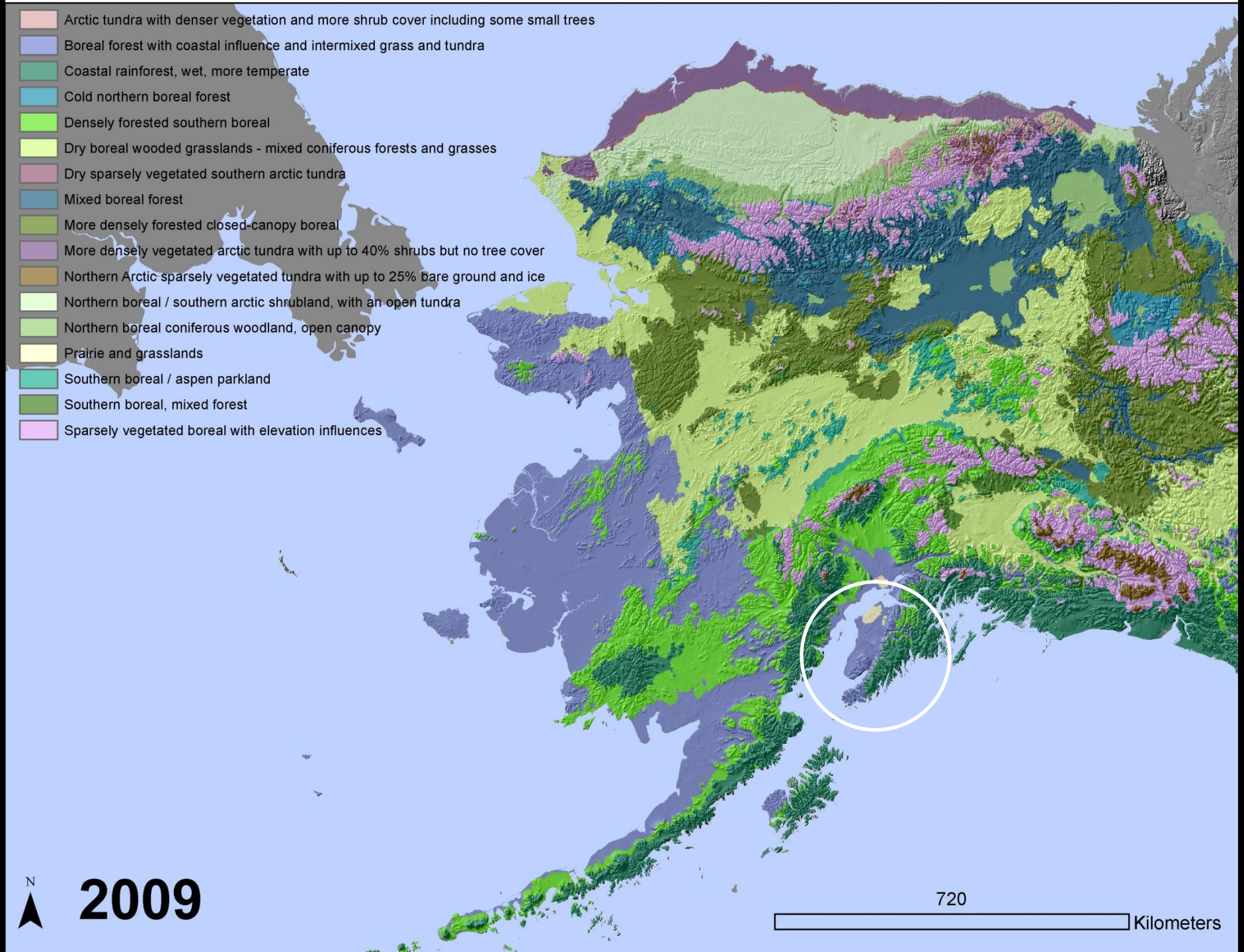
A climate-linked cluster analysis approach to analyzing possible ecological refugia and areas of greatest change

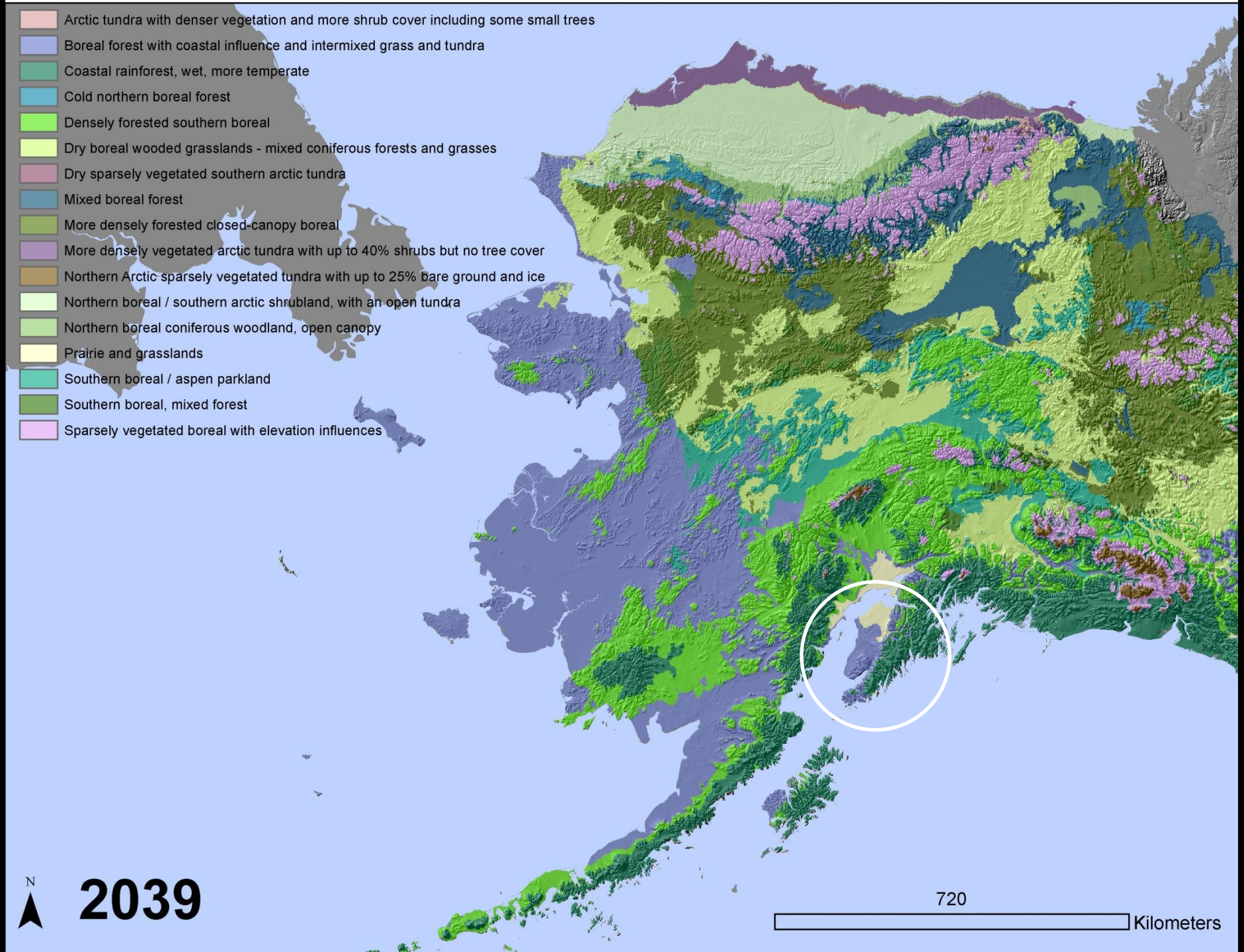
Prepared by the Scenarios Network for Arctic Planning and the EWHALE lab, University of Alaska Fairbanks

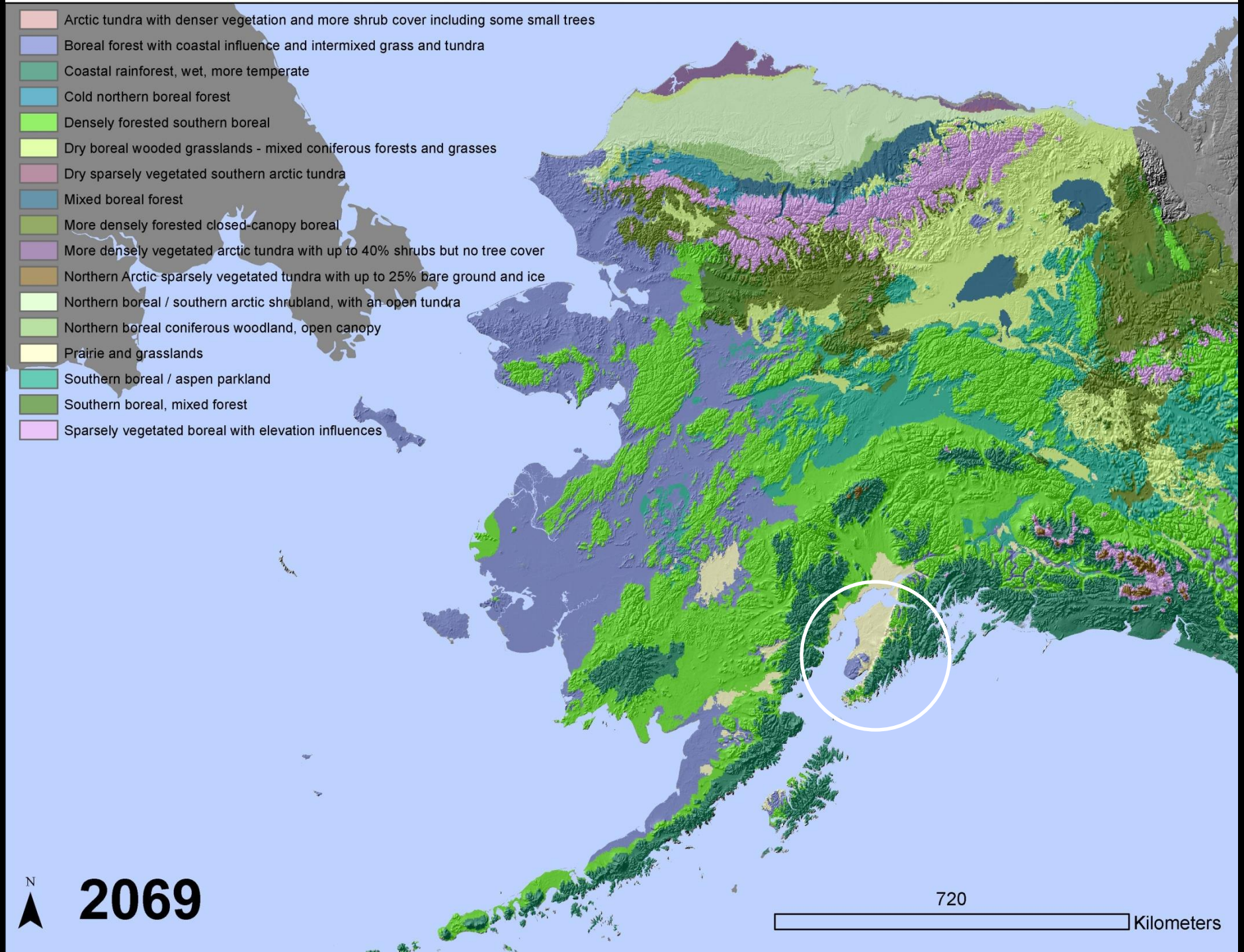
on behalf of

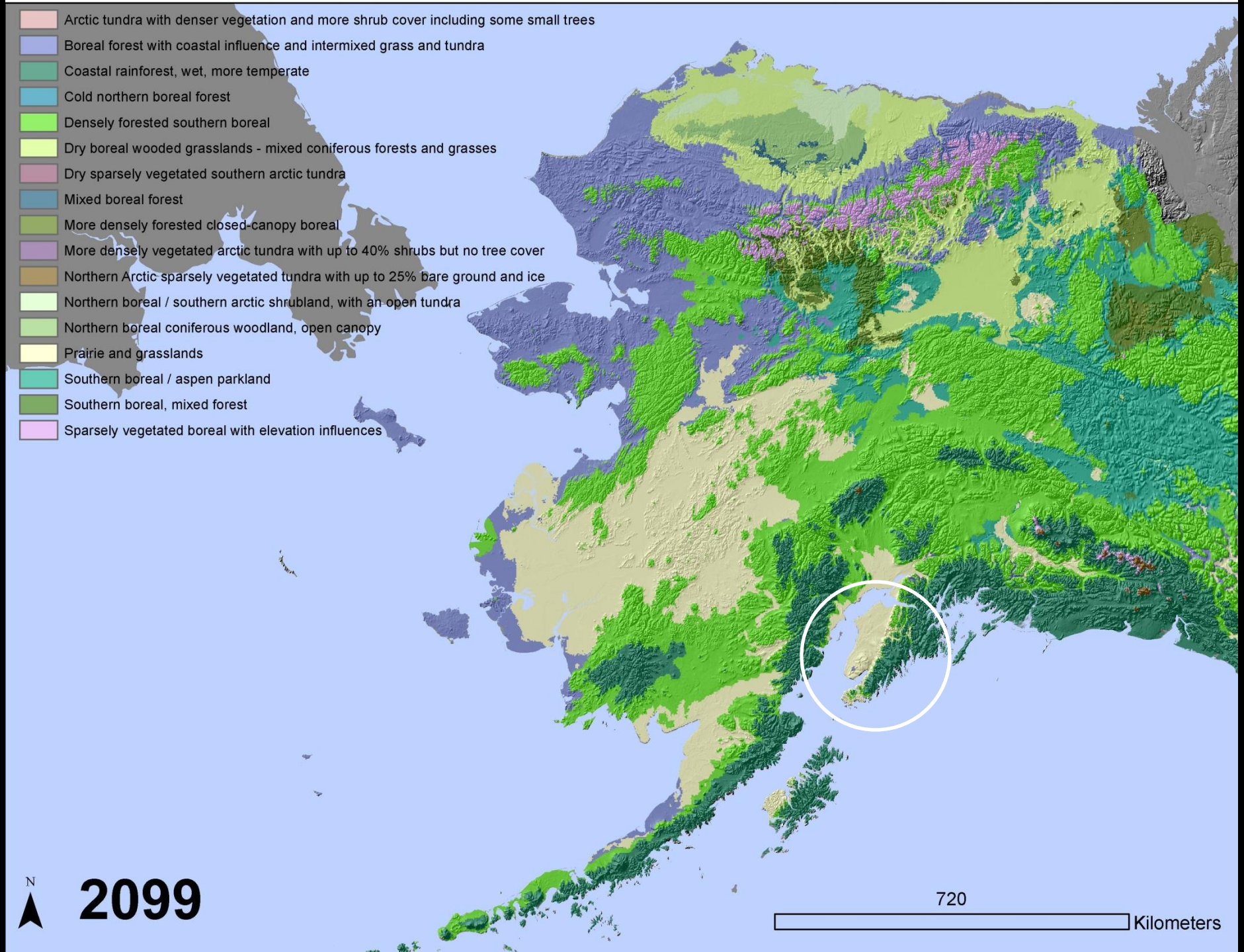
The Nature Conservancy's Canada Program
Arctic Landscape Conservation Cooperative
The US Fish and Wildlife Service
Ducks Unlimited Canada
Government Canada
Government Northwest Territories

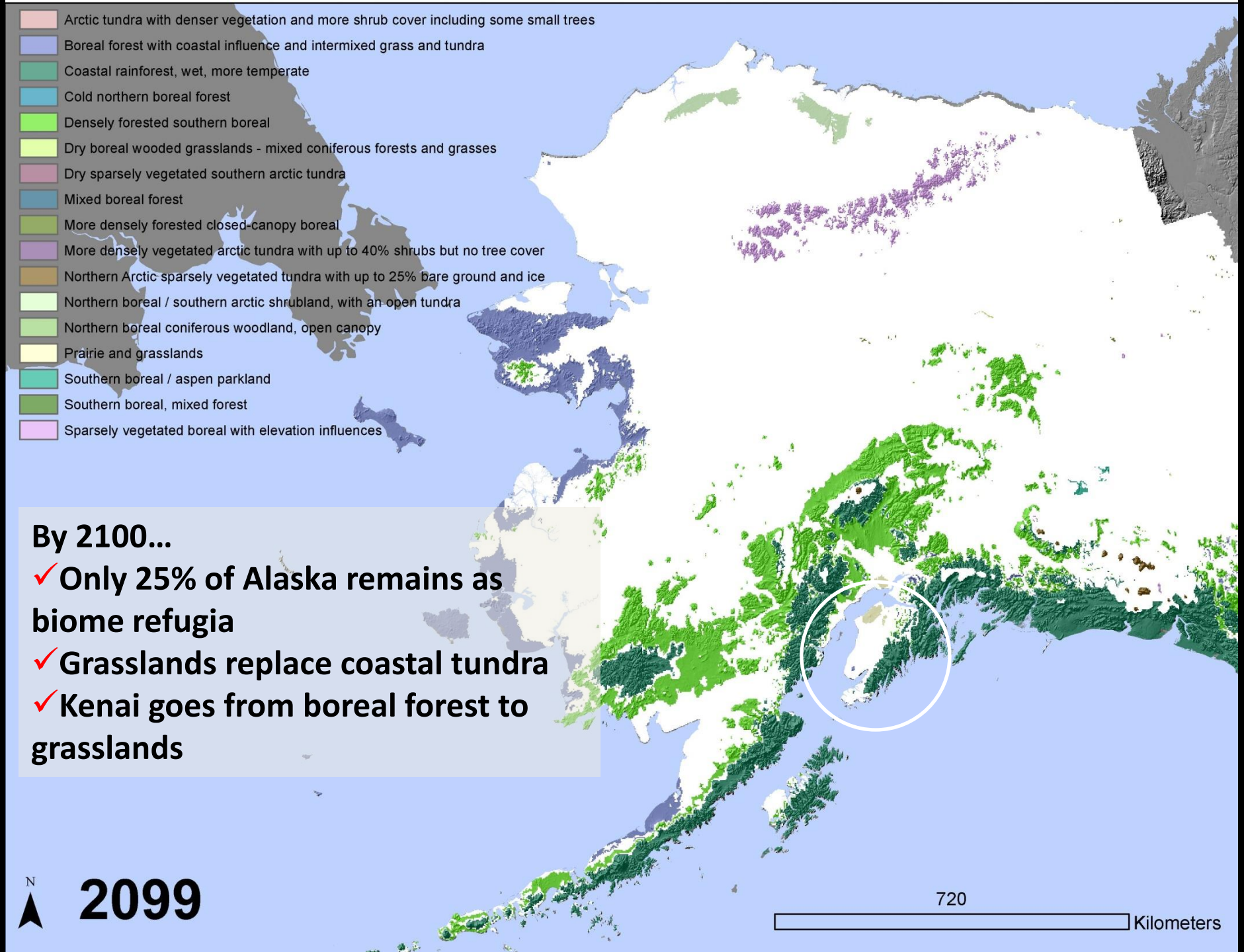
2012


Arctic tundra with denser vegetation and more shrub cover including some small trees
Boreal forest with coastal influence and intermixed grass and tundra
Coastal rainforest, wet, more temperate
Cold northern boreal forest
Densely forested southern boreal
Dry boreal wooded grasslands - mixed coniferous forests and grasses
Dry sparsely vegetated southern arctic tundra
Mixed boreal forest
More densely forested closed-canopy boreal
More densely vegetated arctic tundra with up to 40% shrubs but no tree cover
Northern Arctic sparsely vegetated tundra with up to 25% bare ground and ice
Northern boreal / southern arctic shrubland, with an open tundra
Northern boreal coniferous woodland, open canopy
Prairie and grasslands
Southern boreal / aspen parkland
Southern boreal, mixed forest
Sparsely vegetated boreal with elevation influences
N
2009
720
Kilometers


Arctic tundra with denser vegetation and more shrub cover including some small trees
Boreal forest with coastal influence and intermixed grass and tundra
Coastal rainforest, wet, more temperate
Cold northern boreal forest
Densely forested southern boreal
Dry boreal wooded grasslands - mixed coniferous forests and grasses
Dry sparsely vegetated southern arctic tundra
Mixed boreal forest
More densely forested closed-canopy boreal
More densely vegetated arctic tundra with up to 40% shrubs but no tree cover
Northern Arctic sparsely vegetated tundra with up to 25% bare ground and ice
Northern boreal / southern arctic shrubland, with an open tundra
Northern boreal coniferous woodland, open canopy
Prairie and grasslands
Southern boreal / aspen parkland
Southern boreal, mixed forest
Sparsely vegetated boreal with elevation influences
N
2039
720
Kilometers


Arctic tundra with denser vegetation and more shrub cover including some small trees
Boreal forest with coastal influence and intermixed grass and tundra
Coastal rainforest, wet, more temperate
Cold northern boreal forest
Densely forested southern boreal
Dry boreal wooded grasslands - mixed coniferous forests and grasses
Dry sparsely vegetated southern arctic tundra
Mixed boreal forest
More densely forested closed-canopy boreal
More densely vegetated arctic tundra with up to 40% shrubs but no tree cover
Northern Arctic sparsely vegetated tundra with up to 25% bare ground and ice
Northern boreal / southern arctic shrubland, with an open tundra
Northern boreal coniferous woodland, open canopy
Prairie and grasslands
Southern boreal / aspen parkland
Southern boreal, mixed forest
Sparsely vegetated boreal with elevation influences
N
2069
720
Kilometers


Arctic tundra with denser vegetation and more shrub cover including some small trees
Boreal forest with coastal influence and intermixed grass and tundra
Coastal rainforest, wet, more temperate
Cold northern boreal forest
Densely forested southern boreal
Dry boreal wooded grasslands - mixed coniferous forests and grasses
Dry sparsely vegetated southern arctic tundra
Mixed boreal forest
More densely forested closed-canopy boreal
More densely vegetated arctic tundra with up to 40% shrubs but no tree cover
Northern Arctic sparsely vegetated tundra with up to 25% bare ground and ice
Northern boreal / southern arctic shrubland, with an open tundra
Northern boreal coniferous woodland, open canopy
Prairie and grasslands
Southern boreal / aspen parkland
Southern boreal, mixed forest
Sparsely vegetated boreal with elevation influences
N
2099
720
Kilometers



By 2100…

- ✓ **Only 25% of Alaska remains as biome refugia**
- ✓ **Grasslands replace coastal tundra**
- ✓ **Kenai goes from boreal forest to grasslands**