

What's an exotic plant in a rapidly changing climate?

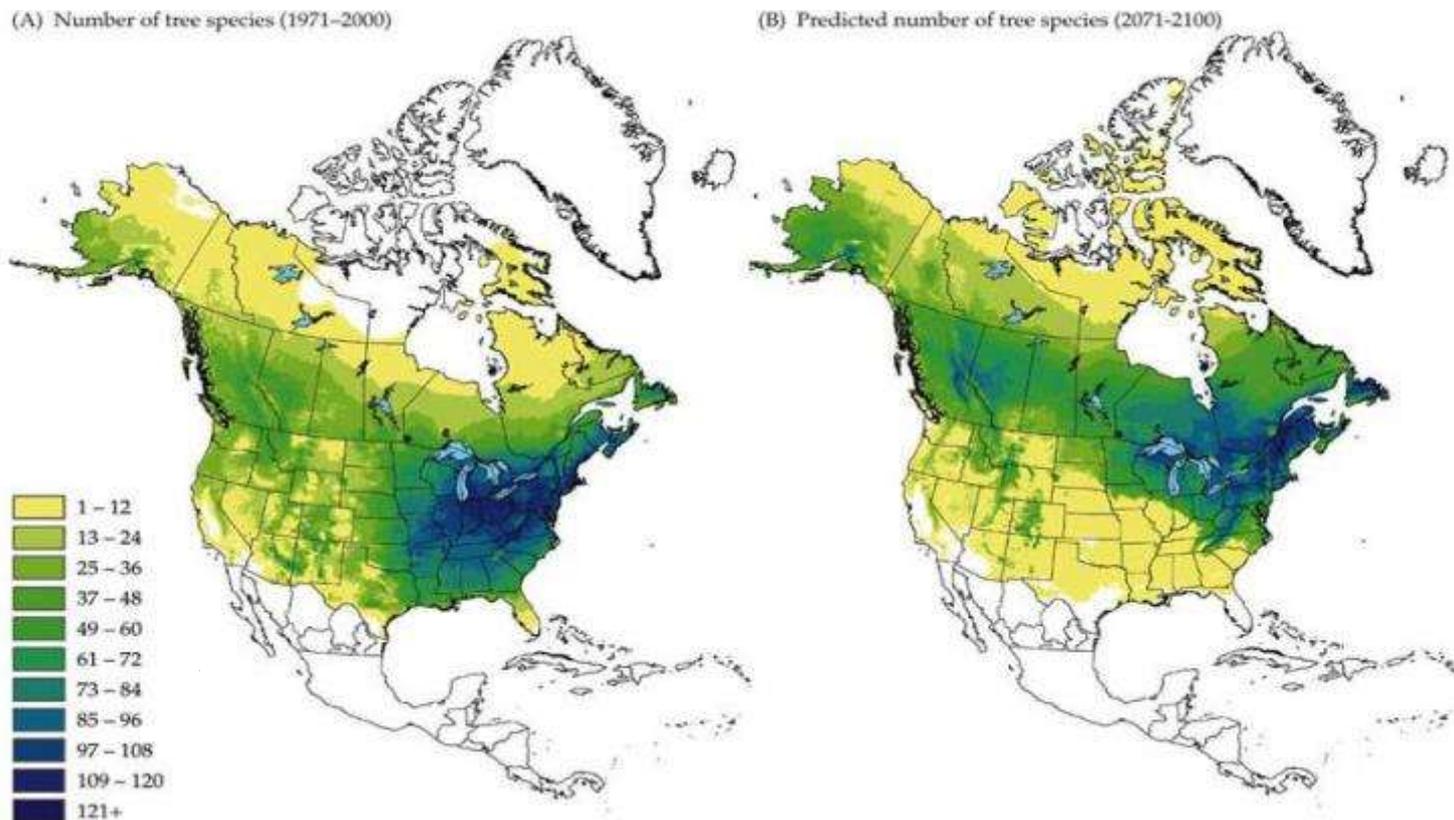


John Morton
Kenai National Wildlife Refuge

Boreal forest – impacts of climate change

- Northward expansion of species range limits
 - Treeline advance
 - Distribution shifts

(McKenney et al. 2011)



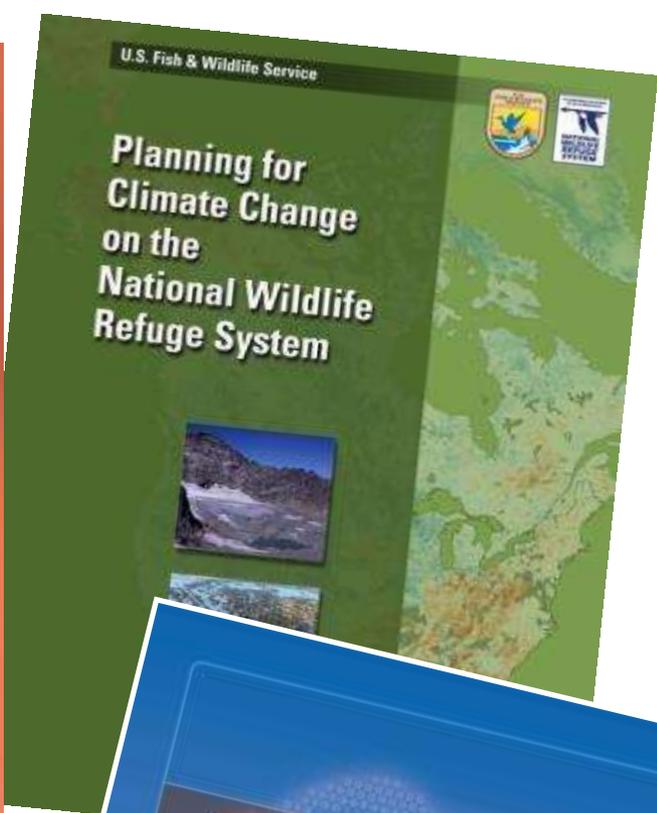
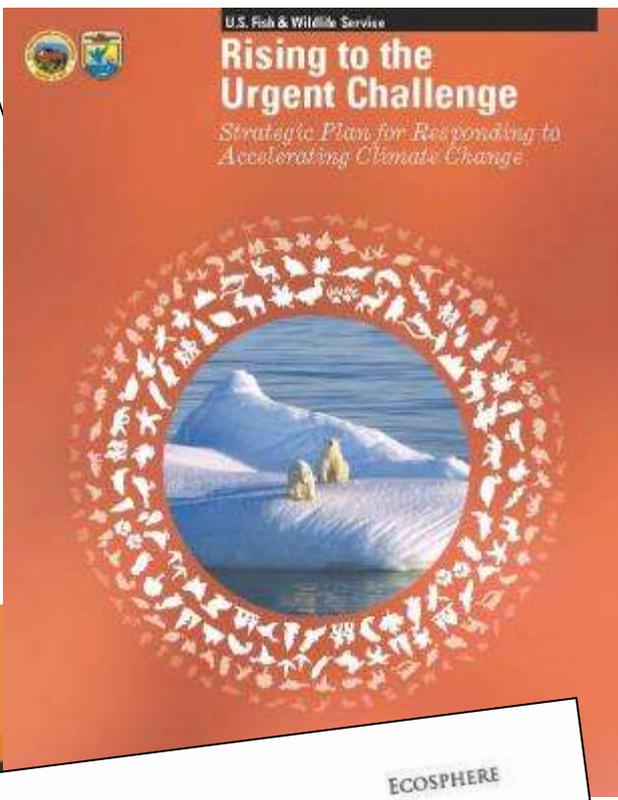
GAO

United States Government Accountability Office
Report to Congressional Requesters

August 2017

CLIMATE CHANGE

Agencies Should Develop Guidance for Addressing the Effects on Federal Land and Water Resources



NATIONAL fish, wildlife & plants
CLIMATE ADAPTATION STRATEGY



ECOSPHERE

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

Dore E. Mendenhall^{1,2}, Amy M. Warren², Eric Hornberger², & Anne Coates, III²
1-14 • 14 April 2015

Abstract Rapid climate change, in combination with other anthropogenic drivers, has the potential to alter ecosystem structure and function. To maintain the resilience of many species and their ecological interactions, conservation reserves must be managed to reduce vulnerability to climate change. We developed a framework to assess the vulnerability of 101 reserves to climate change across the continental United States. We used a risk and gain to assess the vulnerability of 101 reserves to climate change across the continental United States. We used a risk and gain to assess the vulnerability of 101 reserves to climate change across the continental United States. We used a risk and gain to assess the vulnerability of 101 reserves to climate change across the continental United States.



CONNECTING ALASKA LANDSCAPES INTO THE FUTURE

Results from an interagency climate modeling, land management, and conservation project

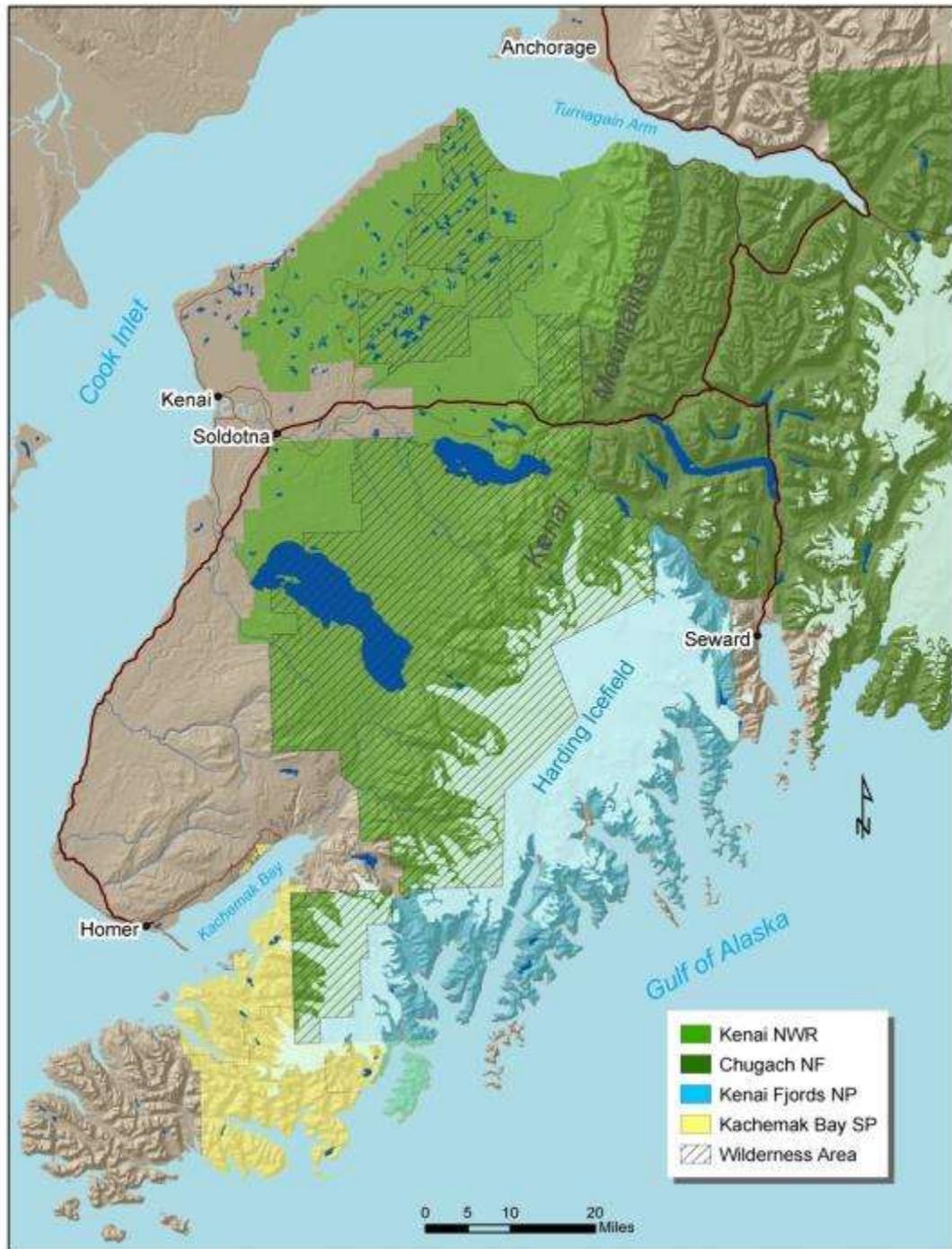
FINAL REPORT • AUGUST 2010

Karen M. Martin, Director
Paula J. Fiedler, Manager
Susan M. Martin, Manager
Susan M. Martin, Manager



Greg Kearnes









05.15.2007



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6/14/2004 9:



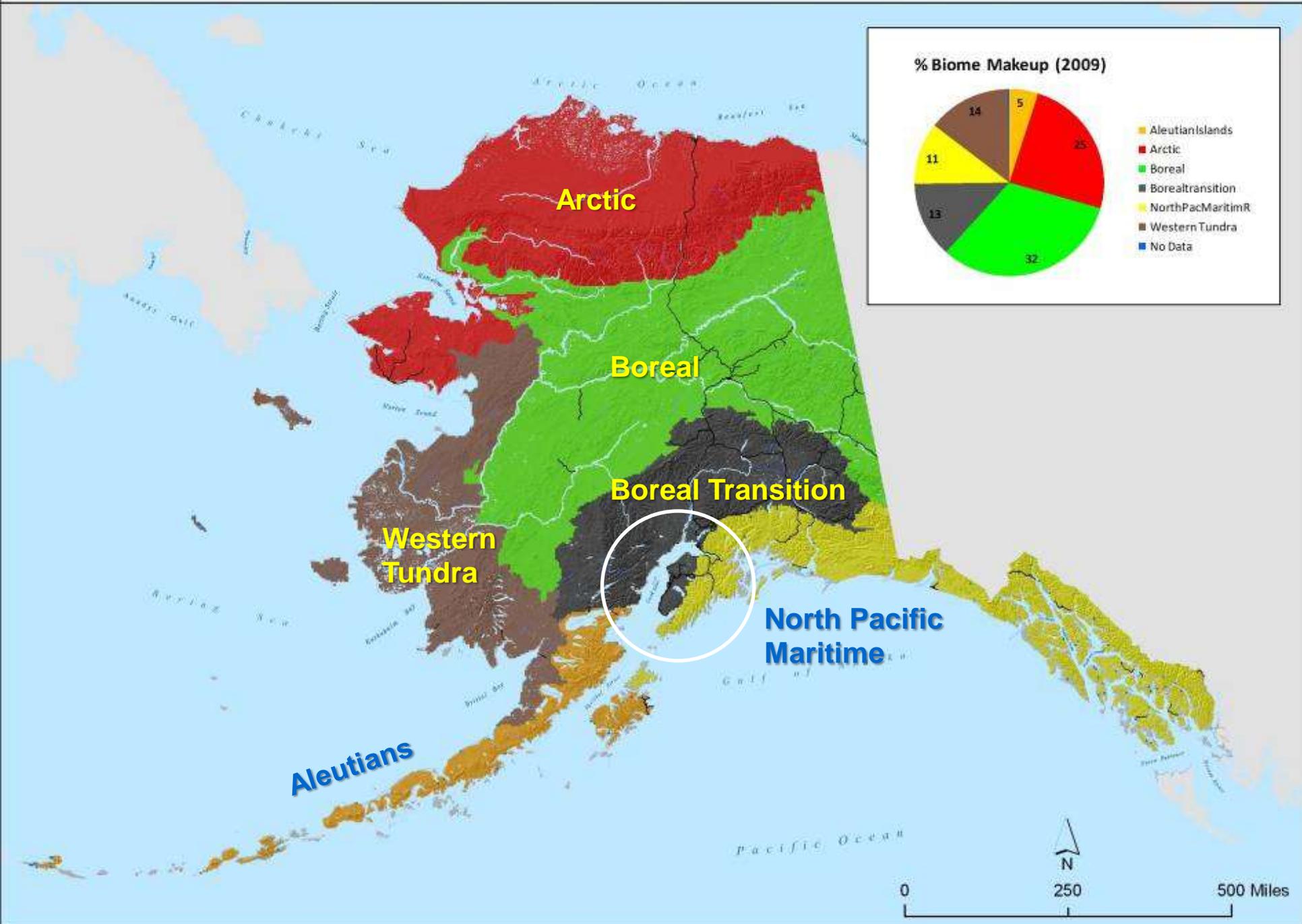




1,865 species recorded on Kenai National Wildlife Refuge

- 34 mammals
 - 154 birds
 - 20 fish
 - 1 amphibian
 - 611 arthropods
 - 7 molluscs
 - 11 other animals
 - 493 vascular plants
 - 180 bryophytes
 - 29 fungi
 - 325 lichens
- *1,771 native, 89 non-native, 5 include both native and non-native subspecies

Biome in 2009



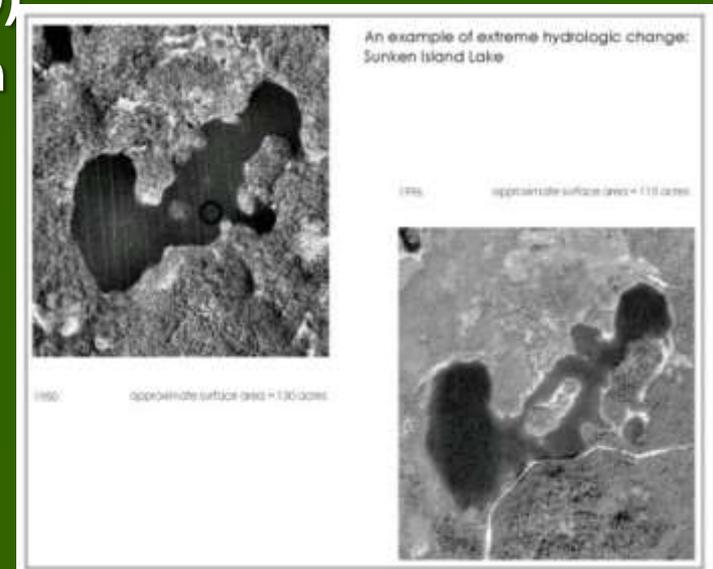
We are ground zero for climate change

- ✓ Alaska is warming at twice the rate of Lower 48
- ✓ Homer has jumped 2 USDA plant zones
- ✓ Available water on western Kenai declined 58% since 1968
- ✓ Official start of Alaska fire season changed from May 1 to April 1 due to 2005 Tracy Avenue Fire
- ✓ Kenai winters have warmed more than summers
- ✓ Kenai nights have warmed more than days
- ✓ Biggest future uncertainty on Kenai Peninsula is form and variation of increasing precipitation

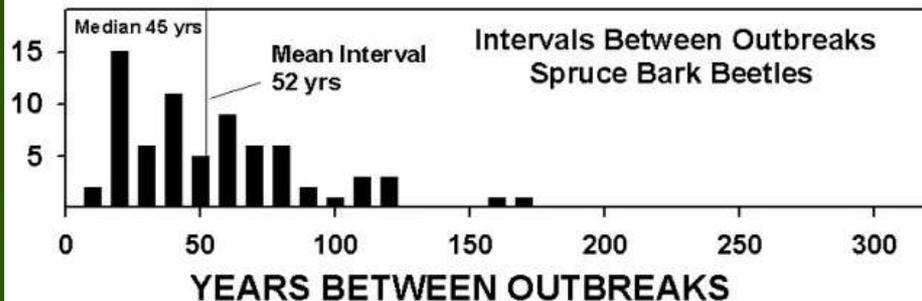
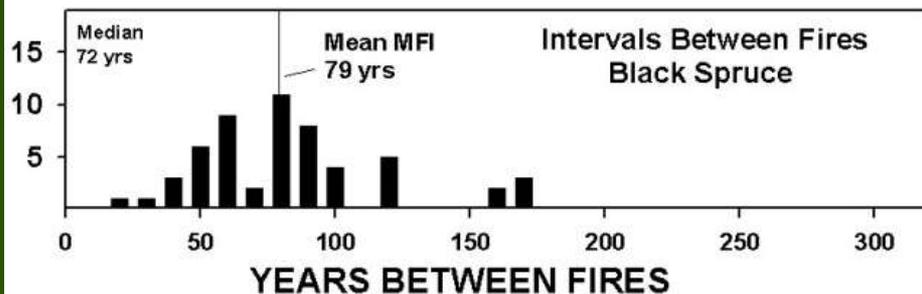
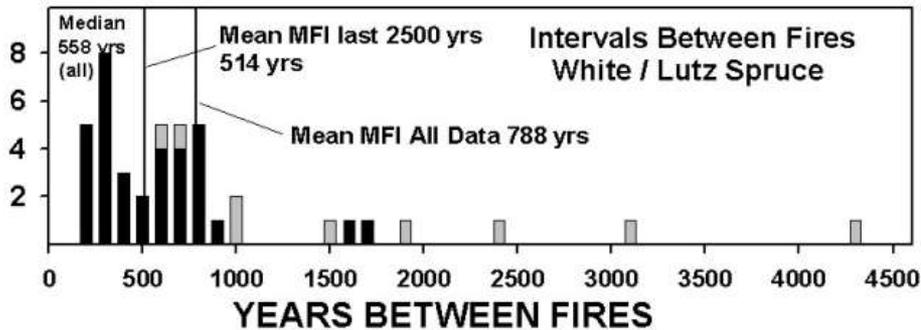
Measured rates of climate change effects on the Kenai Peninsula



- 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



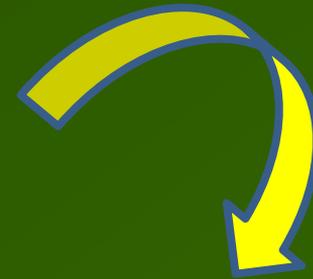
Changing fire regime? 2005 fire season



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

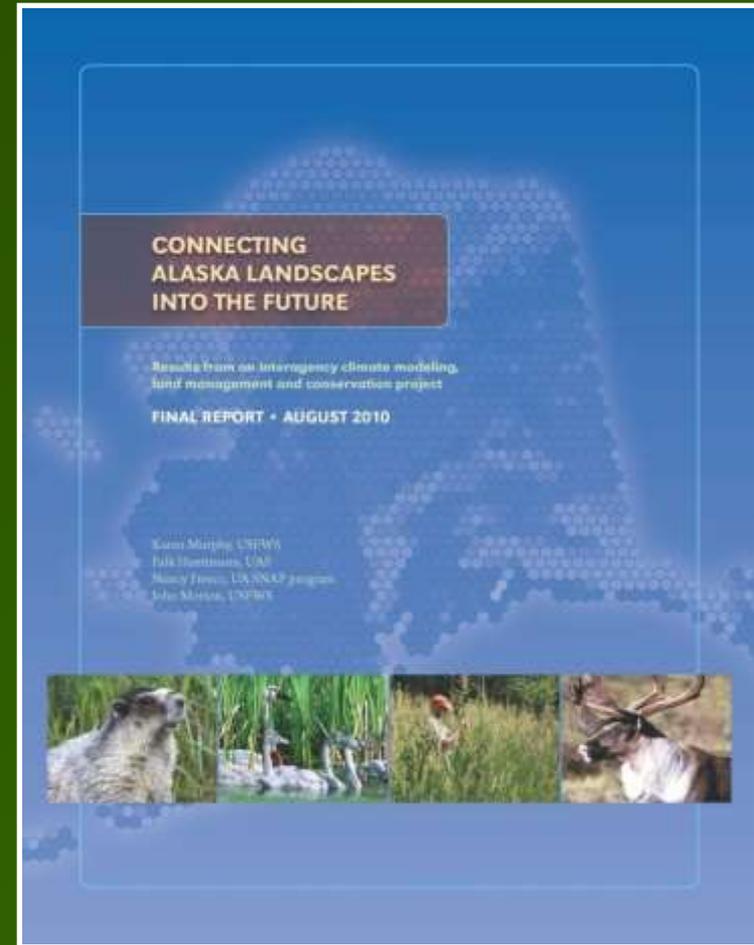
- ✓ 13 new species in last 5 years
- ✓ Earlier arrival records for 33 species
- ✓ Later departure records for 38 species

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

Early January 2016



Interagency effort to pioneer the assessment of climate change impacts on biome and species distributions using climate envelope models



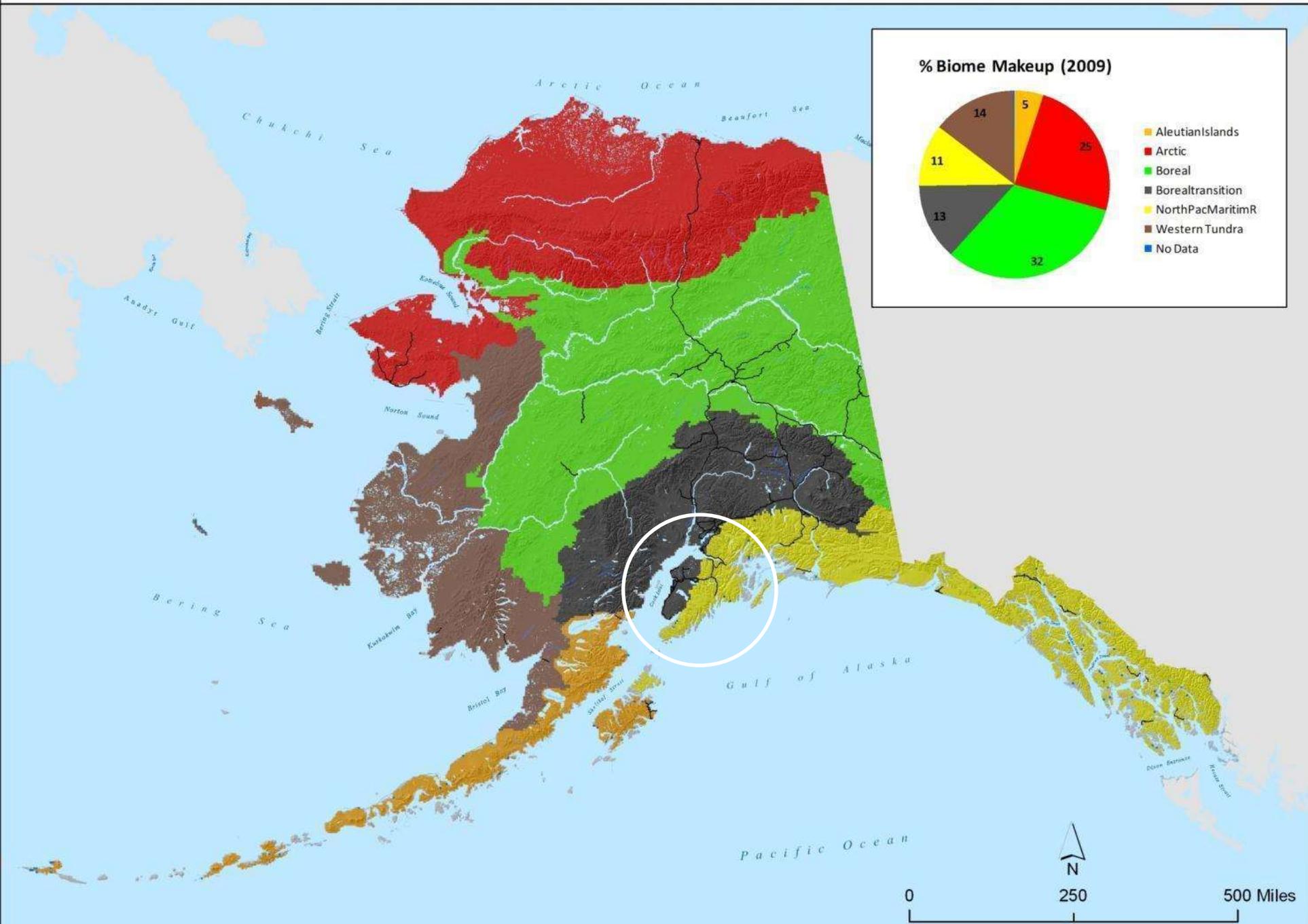
Take this with a grain of salt....



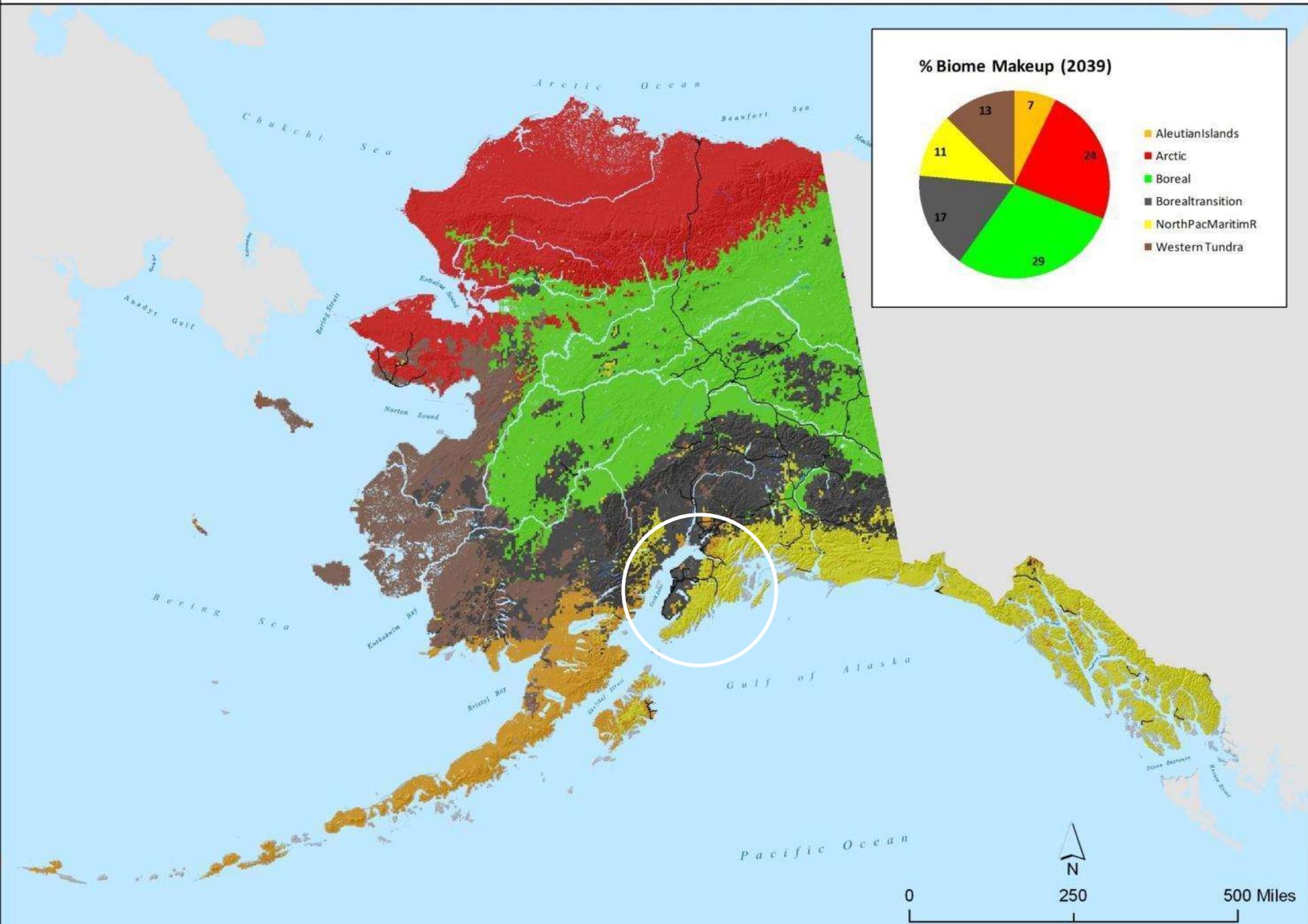
Why are potential and realized niches different?

- ✓ Climate (photoperiod, temperature, precipitation)
- ✓ Species-specific generational times
- ✓ Competitive interactions with other plants
- ✓ Competitive interactions with herbivores
- ✓ Soil (soil type/litter, mycorrhizal fungi, soil temperature, permafrost)
- ✓ Host-parasitoid relationships
- ✓ Dispersal mechanisms (wind, cones, insects, birds)
- ✓ Barriers (mountains, glaciers, oceans)

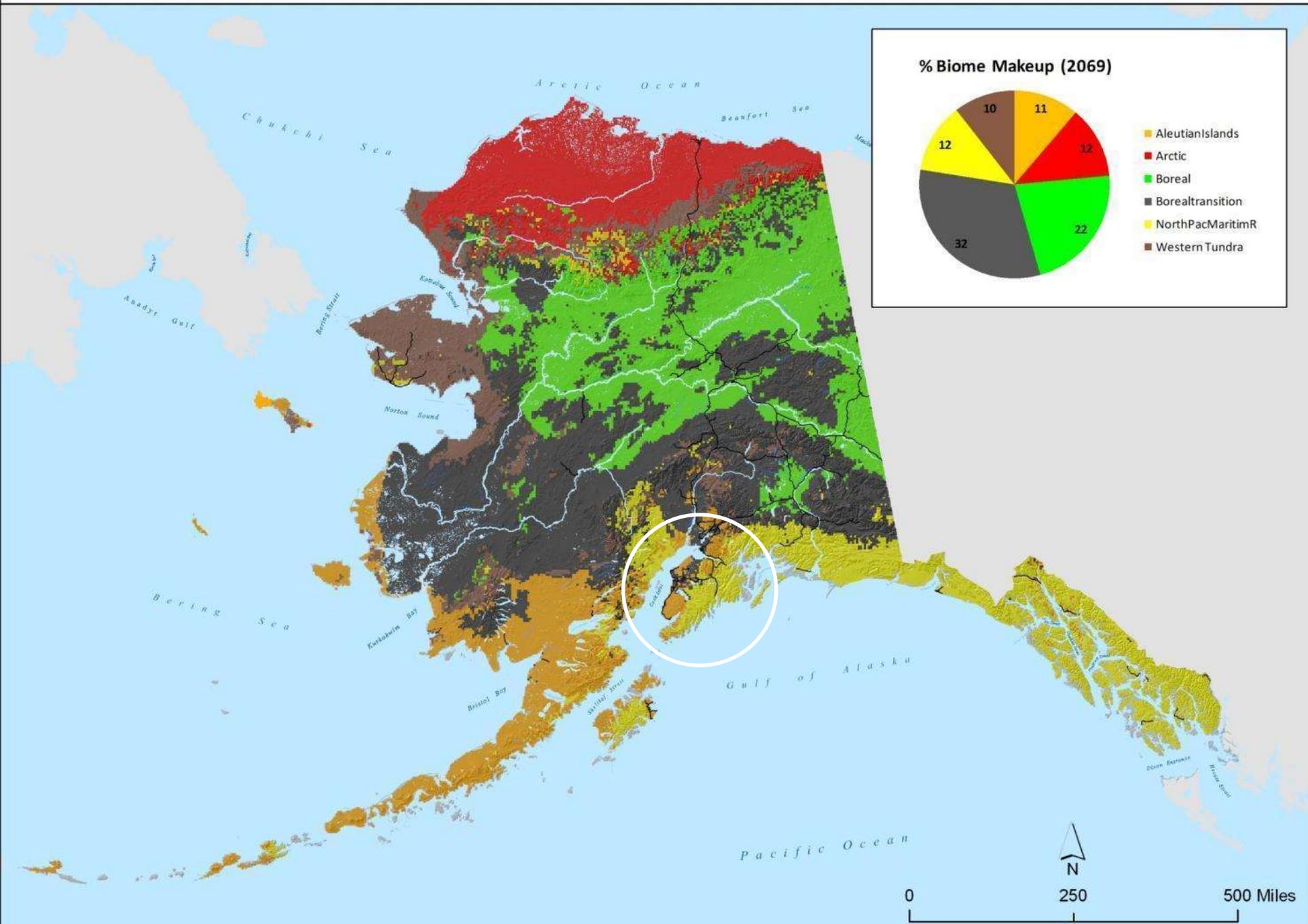
Biome in 2009



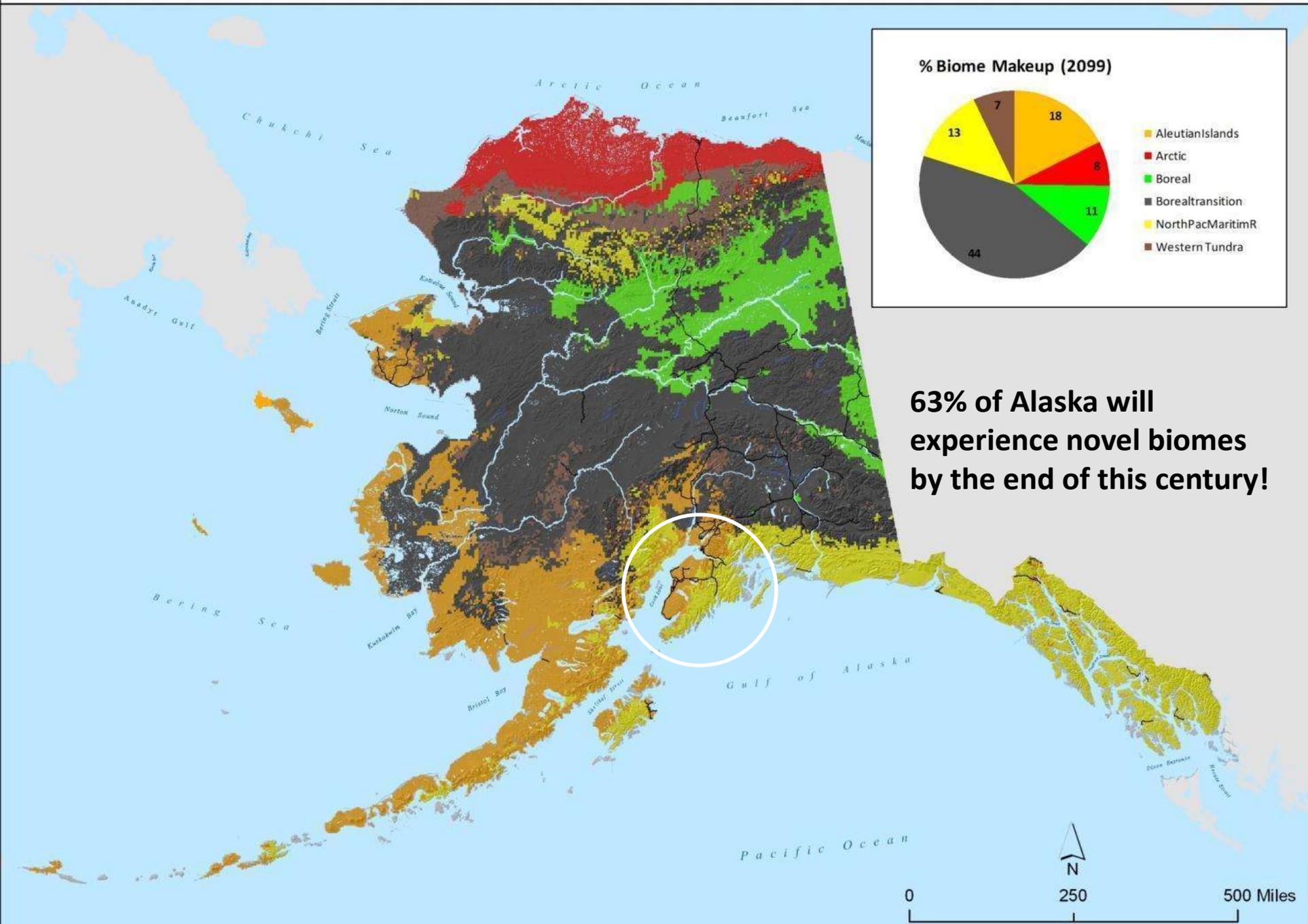
Biome in 2039



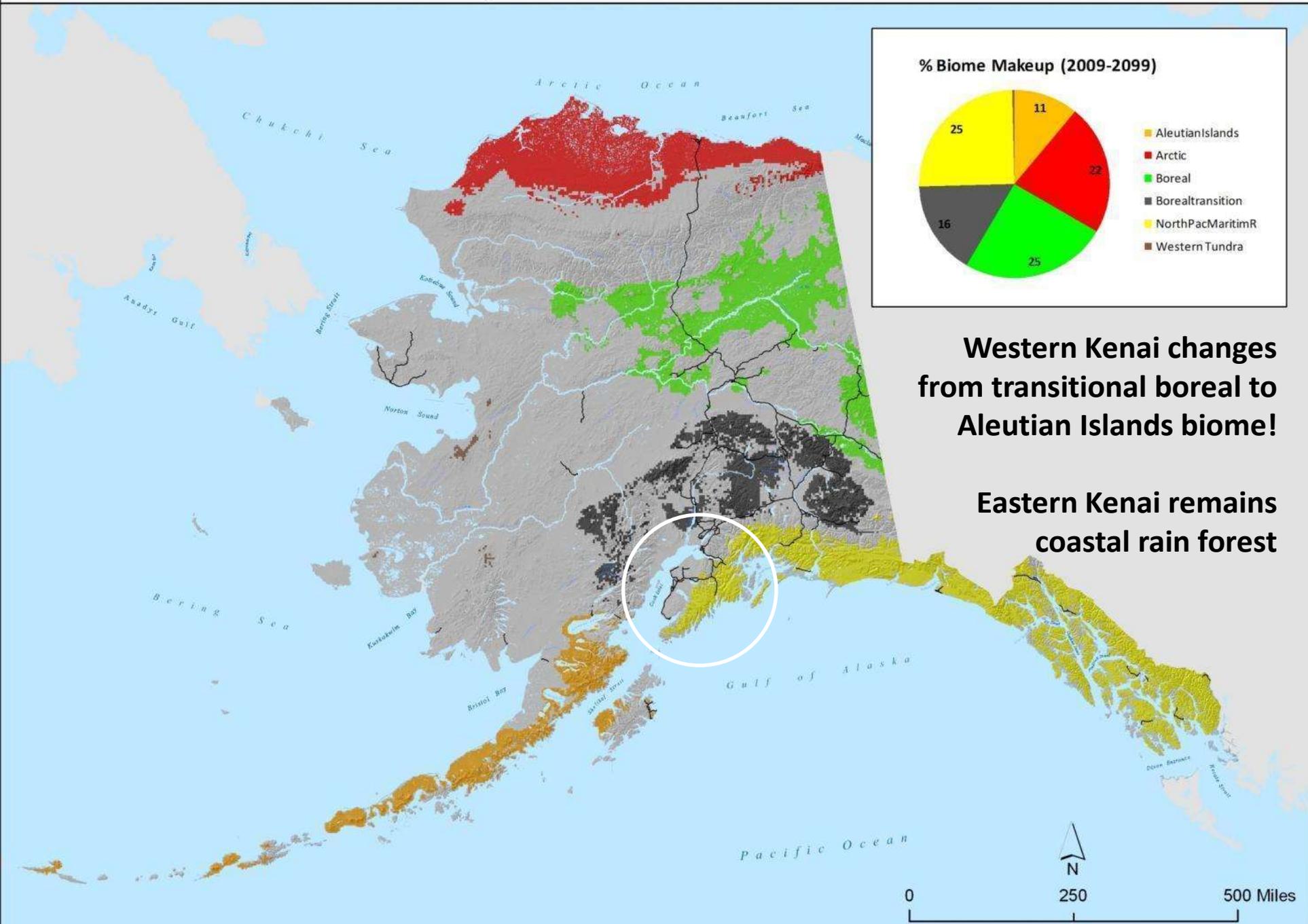
Biome in 2069



Biome in 2099



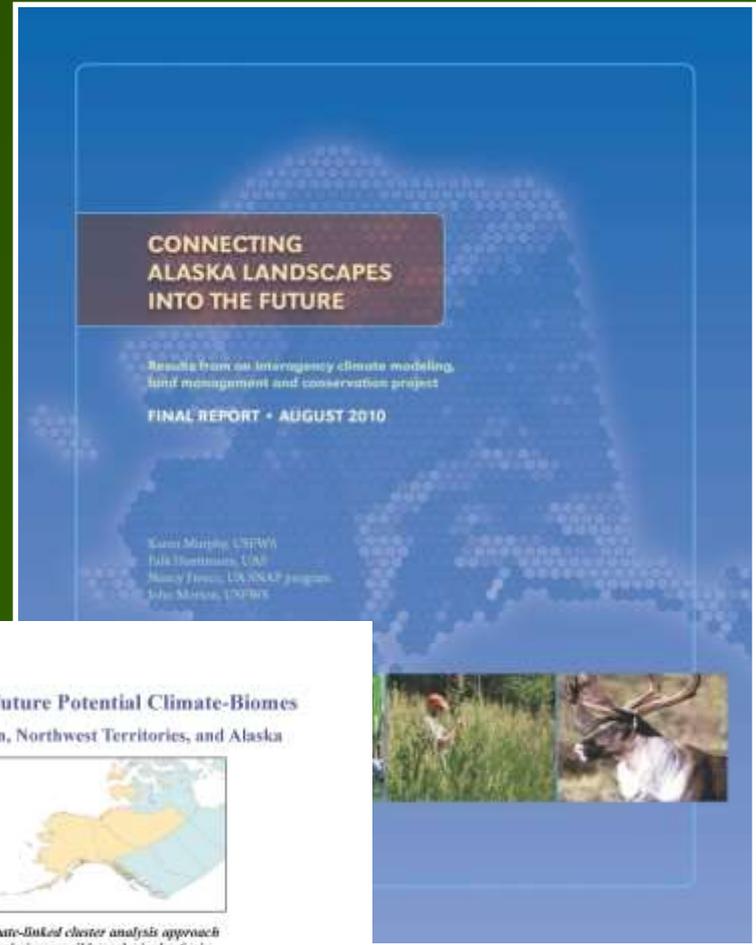
No Change in Biome from 2009 to 2099



Take this with a grain of salt....



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 Scenario Network for Arctic Planning and the ESWHALE lab, University of Alaska Fairbanks

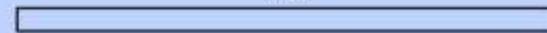
on behalf of

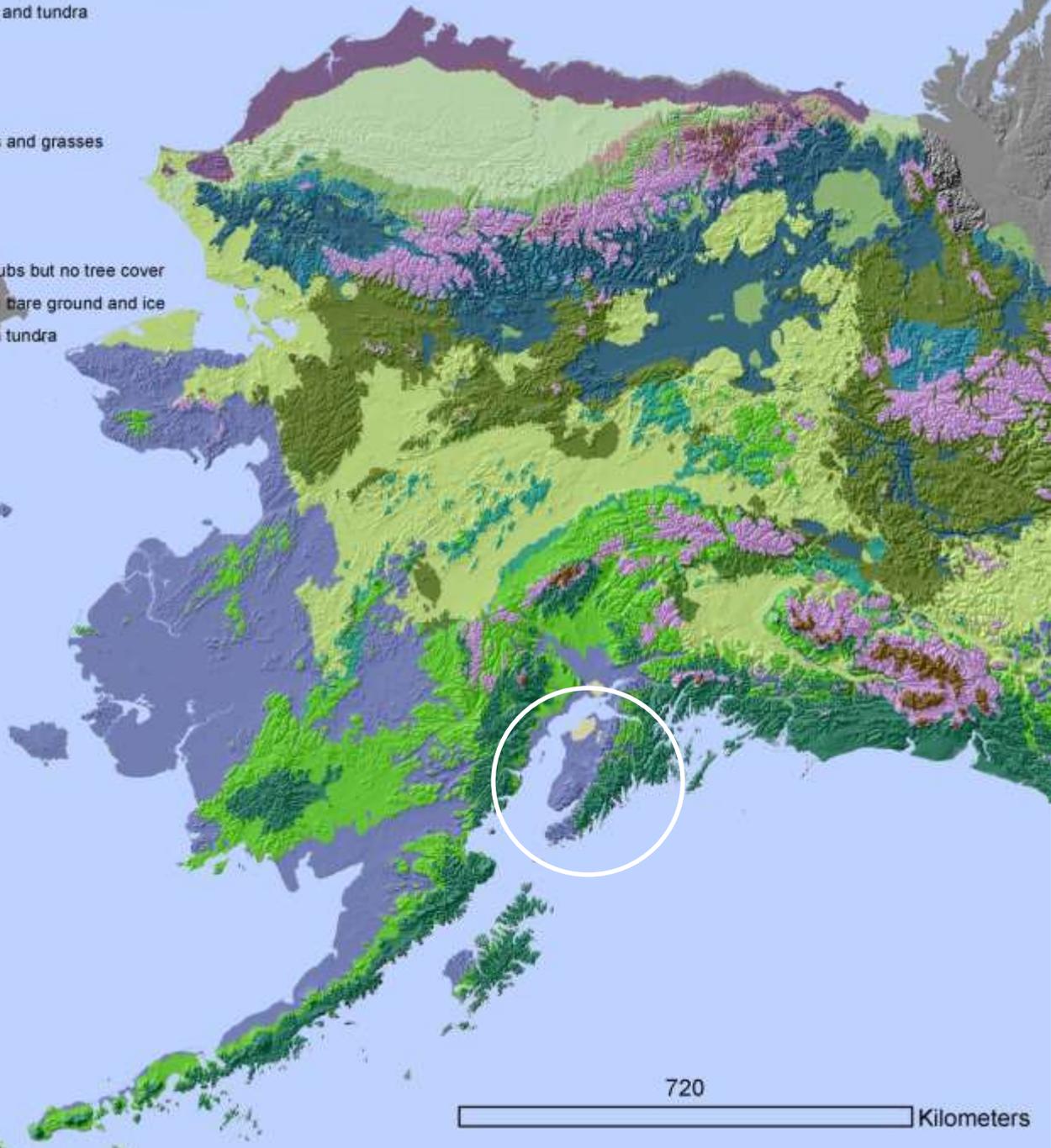
The Nature Conservancy's Canada Program
Arctic Landscape Conservation Cooperative
The US Fish and Wildlife Service
Ducks Unlimited Canada
Government Canada
Government Northwest Territories



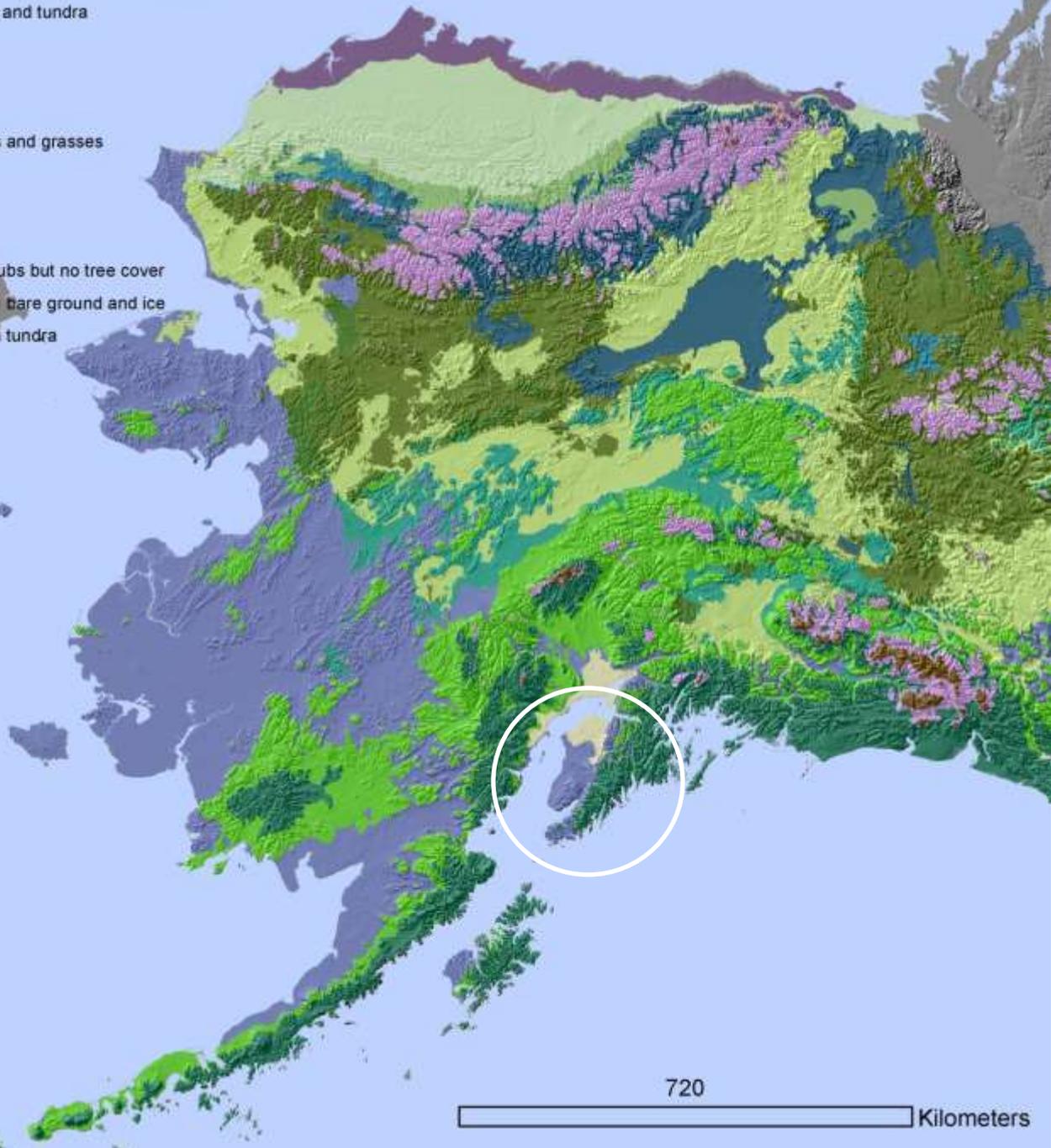
- Arctic tundra with denser vegetation and more shrub cover including some small trees
- Boreal forest with coastal influence and intermixed grass and tundra
- Coastal rainforest, wet, more temperate
- Cold northern boreal forest
- Densely forested southern boreal
- Dry boreal wooded grasslands - mixed 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

 **2009**

720
 Kilometers



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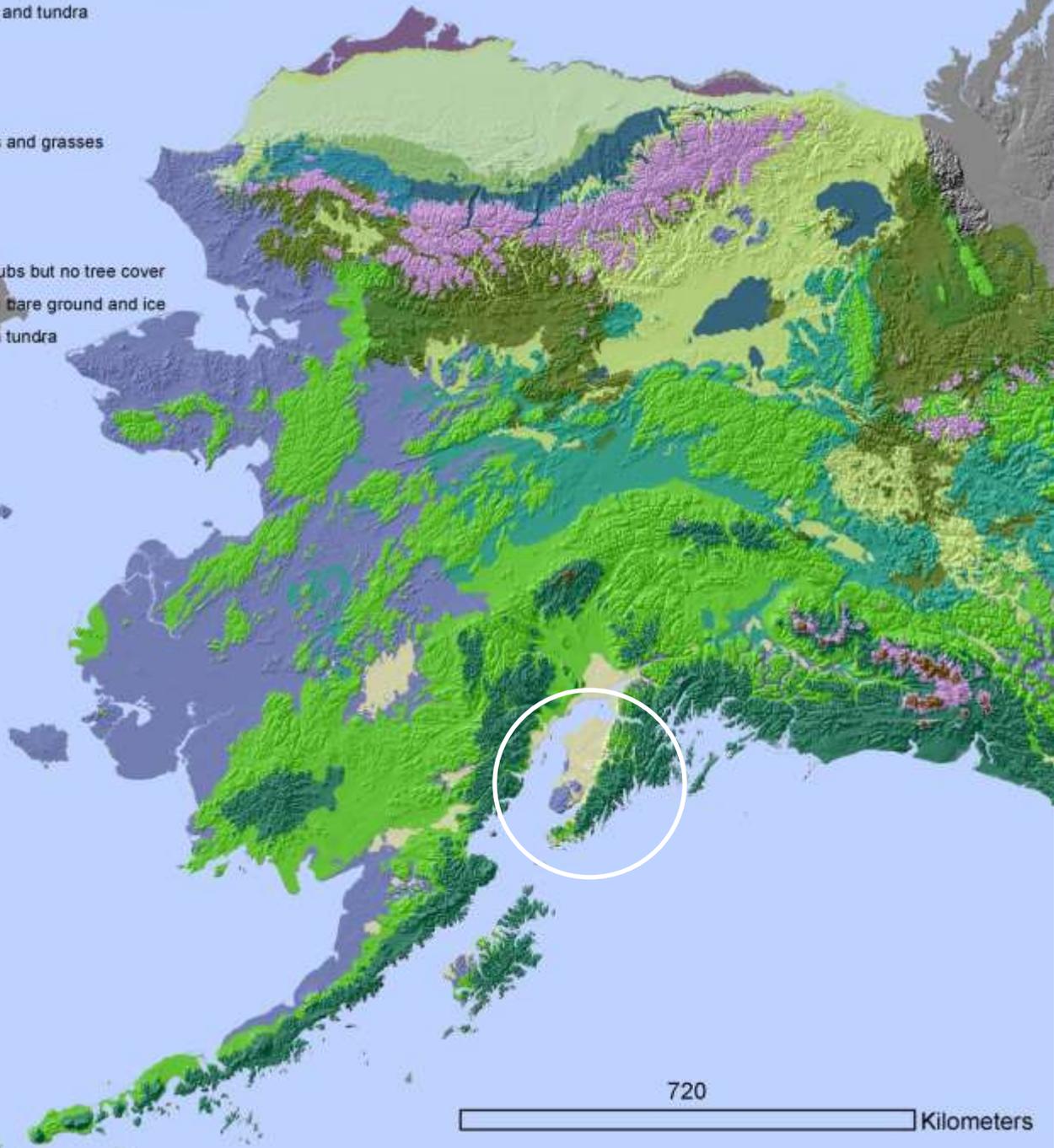
2039

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2069

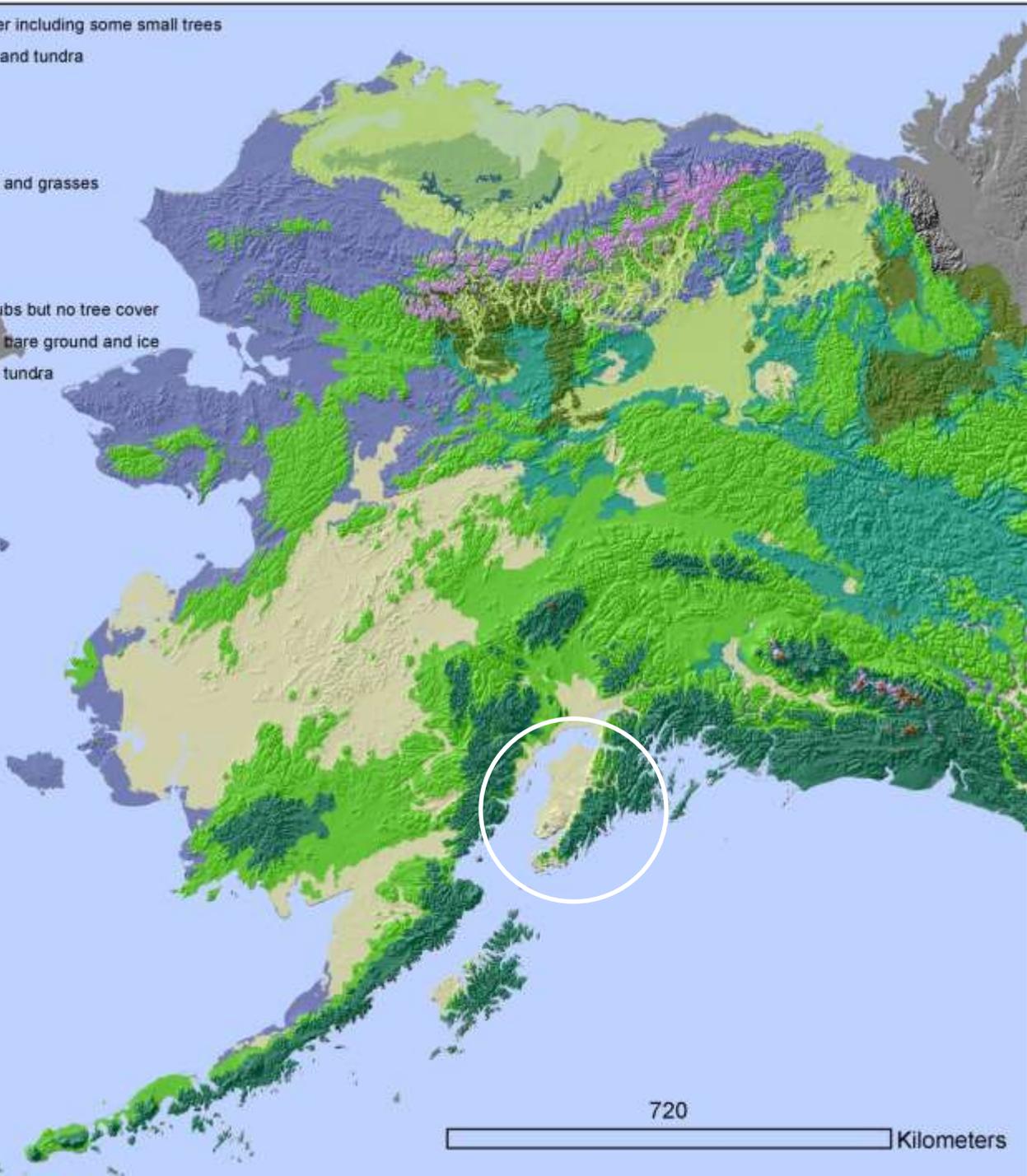
720 Kilometers



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2099

720 Kilometers





By 2100...

- ✓ Only 25% of Alaska remains as biome refugia
- ✓ Western Kenai goes from boreal forest to grasslands
- ✓ Eastern Kenai stays coastal rainforest

2099



Take this with a grain of salt....

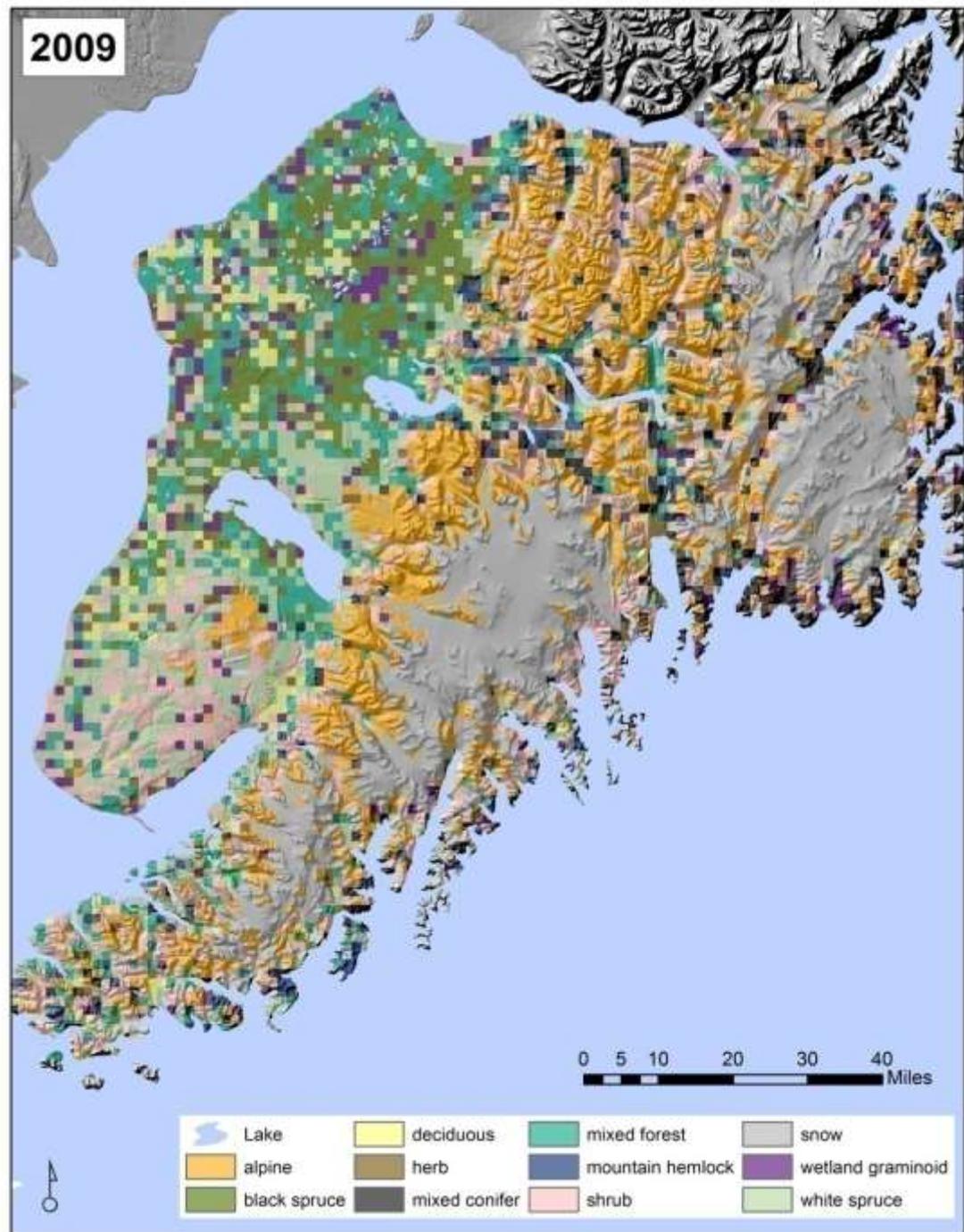


Forecasting the Kenai Peninsula's landscape through 2100

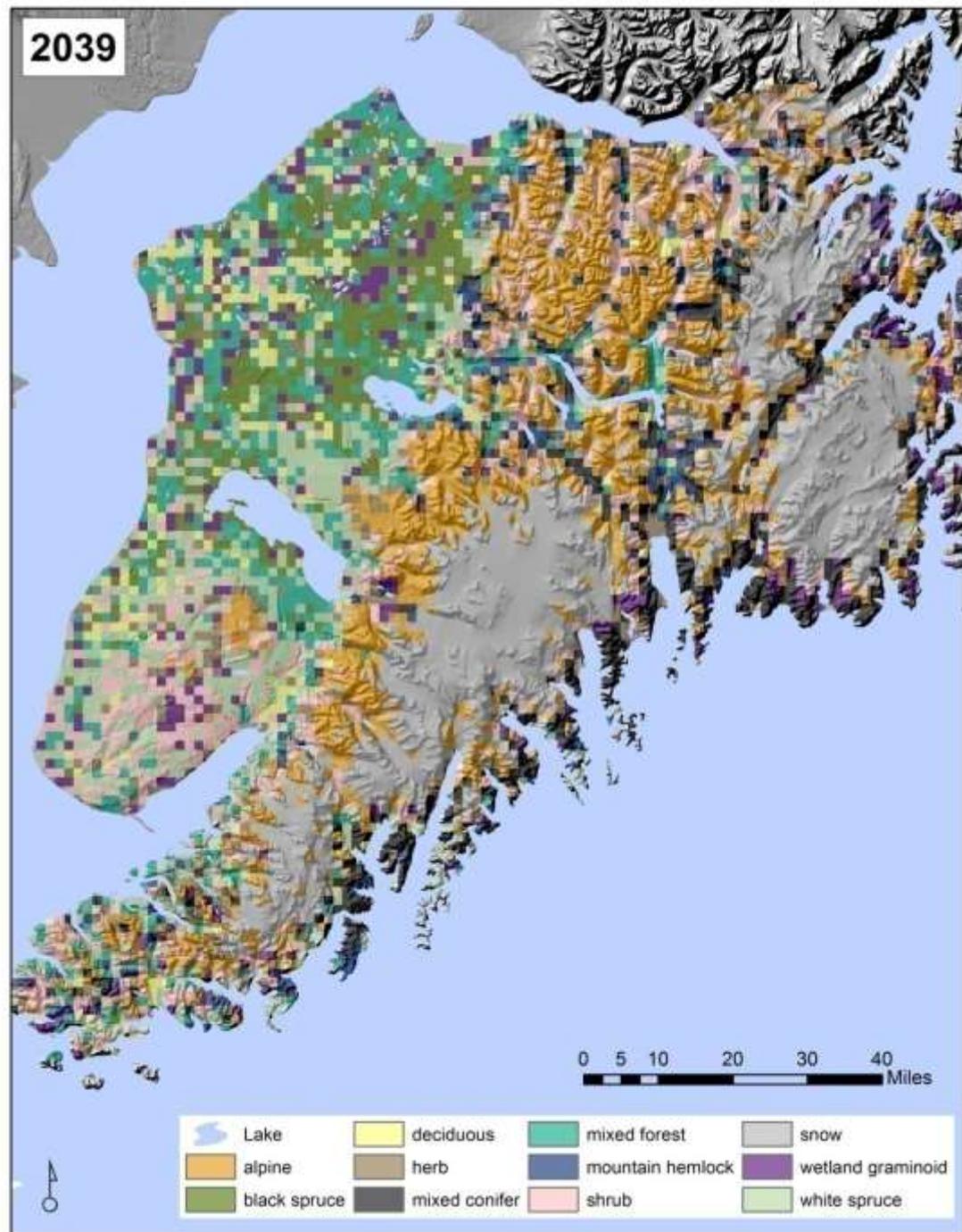
- ✓ Climate envelope modeling using Random Forests™
- ✓ a1b scenario decadal averages for temperature, precipitation (SNAP)
- ✓ landcover type with the greatest % cover in 2km pixels
- ✓ if previous landcover type for each timestep (2039, 2069, 2099) $P > 0.5$ then stay; if $P < 0.5$ then landcover type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



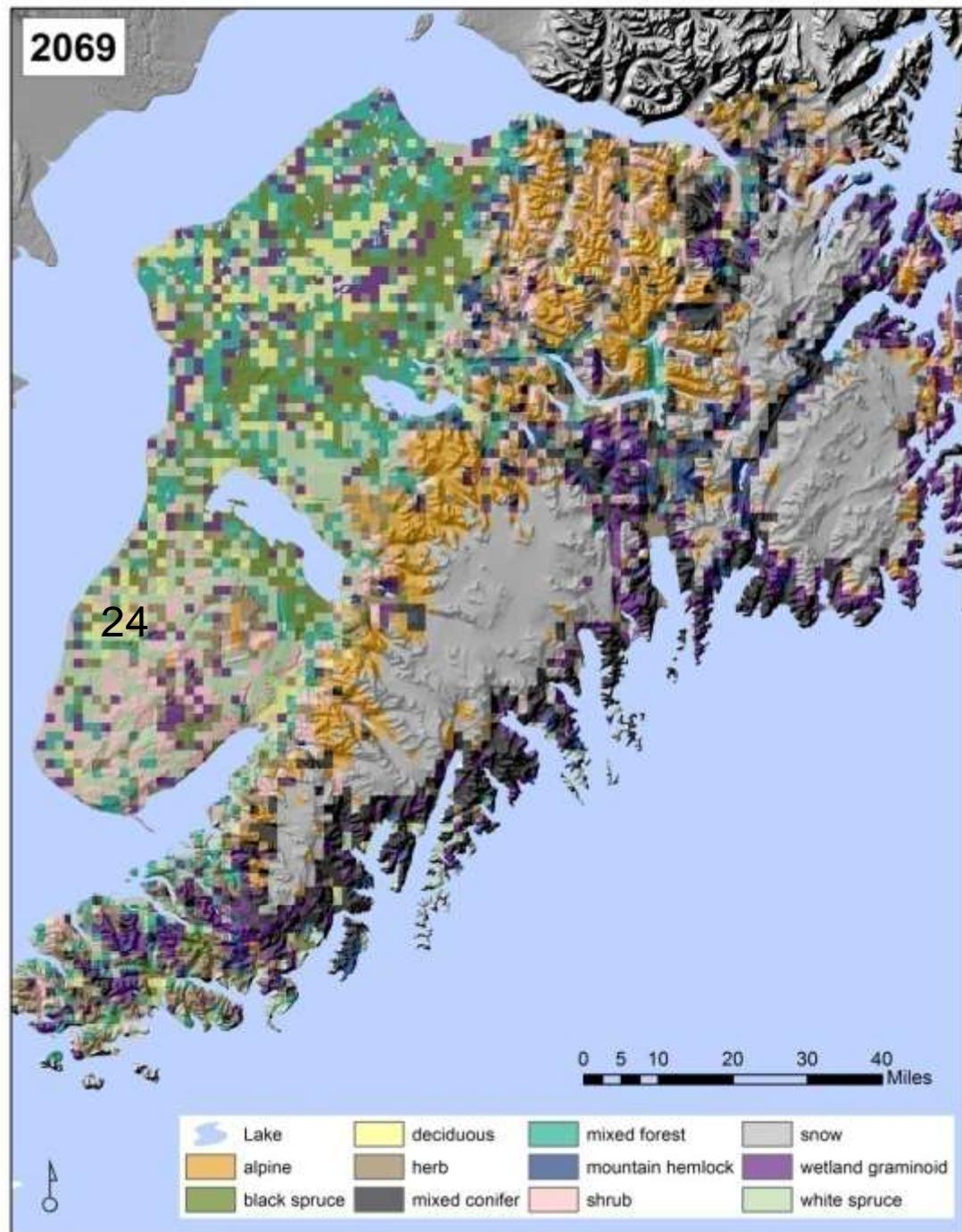
LANDCOVER	km ² 2009
Herbaceous	408
Hemlock	740
Mixed conifer	1332
Wetland graminoid	1076
Black spruce	1932
Hardwood	868
Hardwood-softwood	2564
Alpine	4752
Shrub	3624
White/Lutz/Sitka spruce	2568
Glaciers	5472



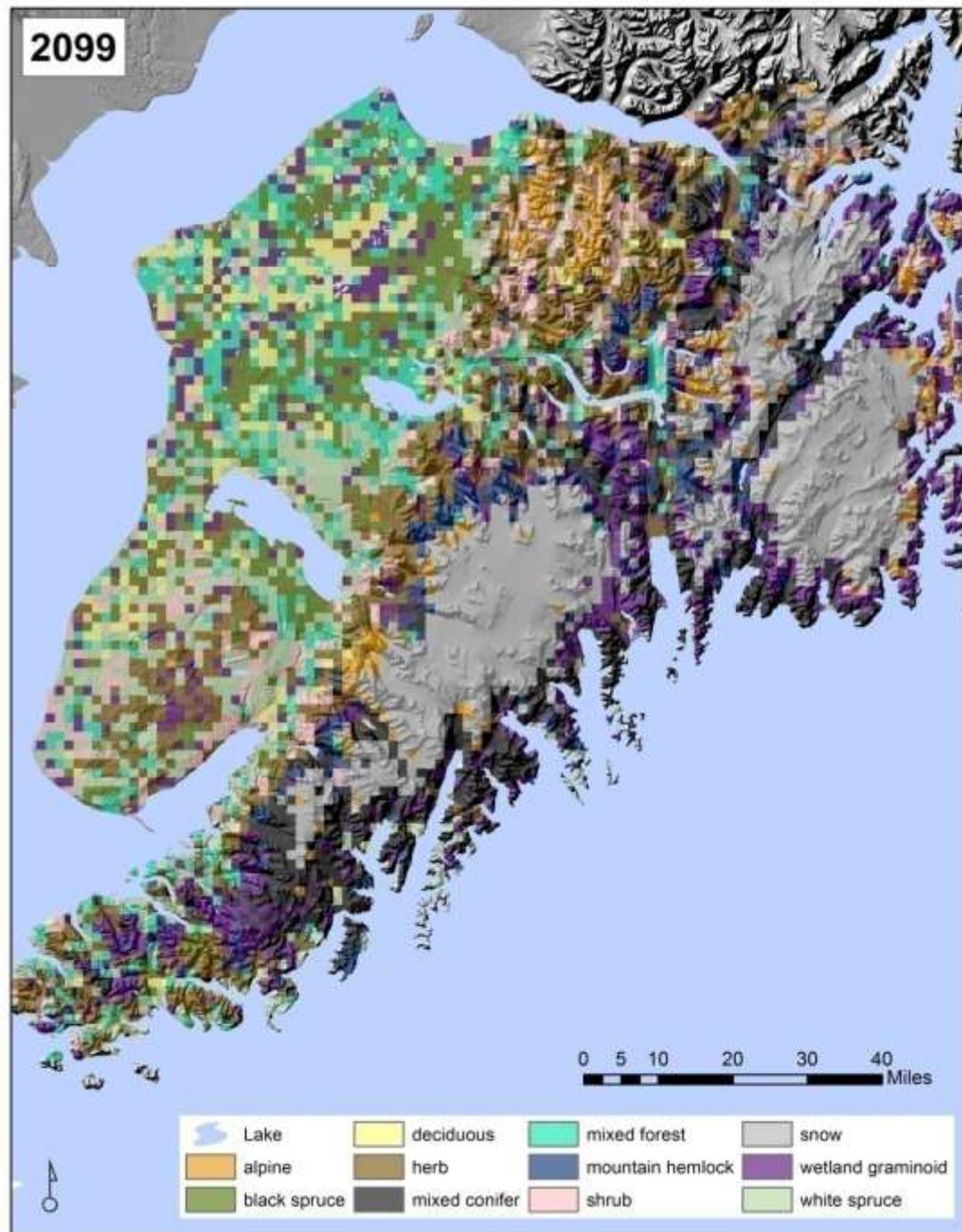
LANDCOVER	% CHANGE
	2009-39
Herbaceous	150
Hemlock	24
Mixed conifer	56
Wetland graminoid	34
Black spruce	-7
Hardwood	9
Hardwood-softwood	-6
Alpine	-13
Shrub	-20
White/Lutz/Sitka spruce	-7
Glaciers	-3



LANDCOVER	% CHANGE
	2009-69
Herbaceous	397
Hemlock	29
Mixed conifer	91
Wetland graminoid	158
Black spruce	-10
Hardwood	33
Hardwood-softwood	-14
Alpine	-48
Shrub	-39
White/Lutz/Sitka spruce	-9
Glaciers	-10

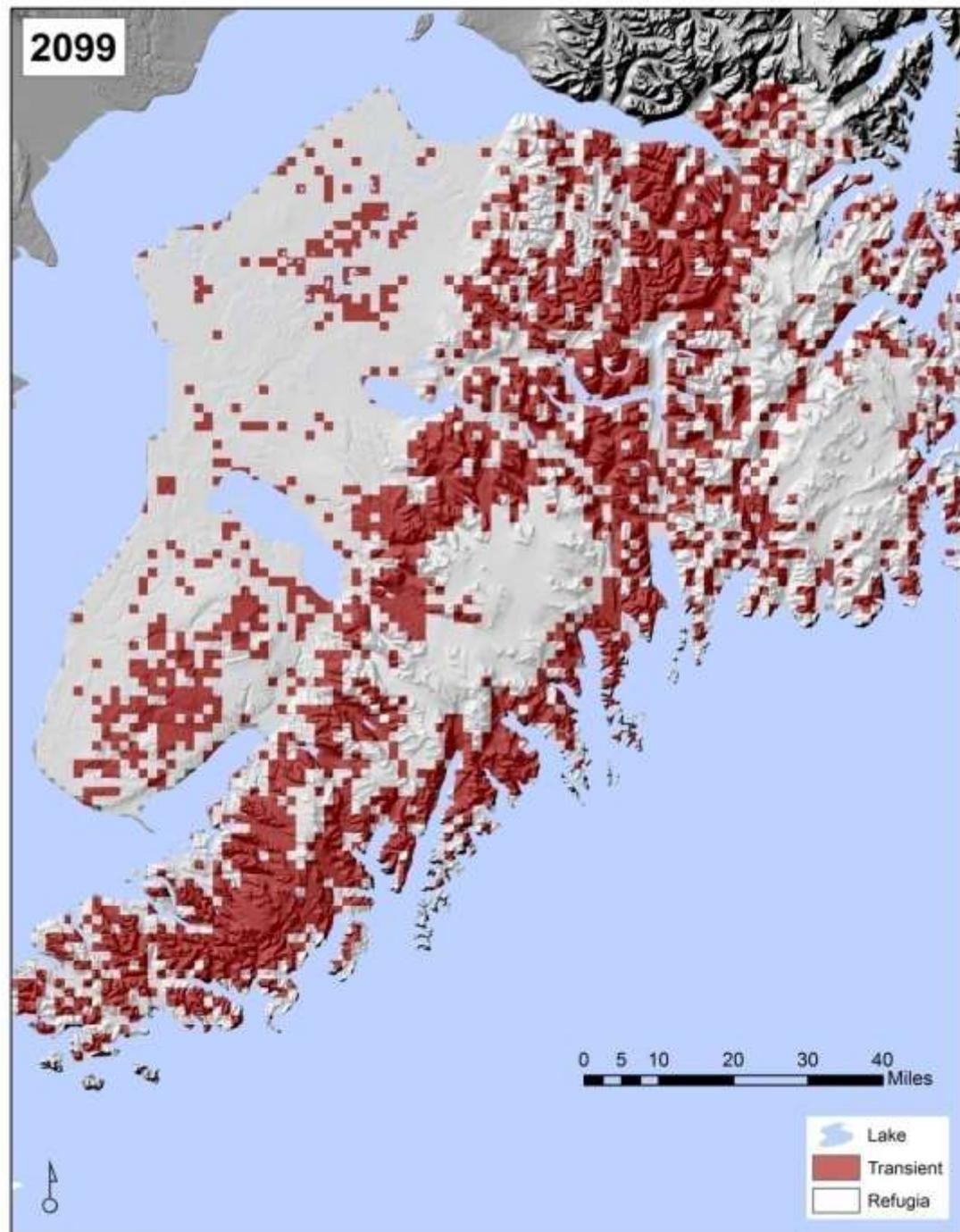


LANDCOVER	% CHANGE
	2009-99
Herbaceous	714
Hemlock	50
Mixed conifer	111
Wetland graminoid	207
Black spruce	6
Hardwood	29
Hardwood-softwood	-17
Alpine	-81
Shrub	-56
White/Lutz/Sitka spruce	-9
Glaciers	-15



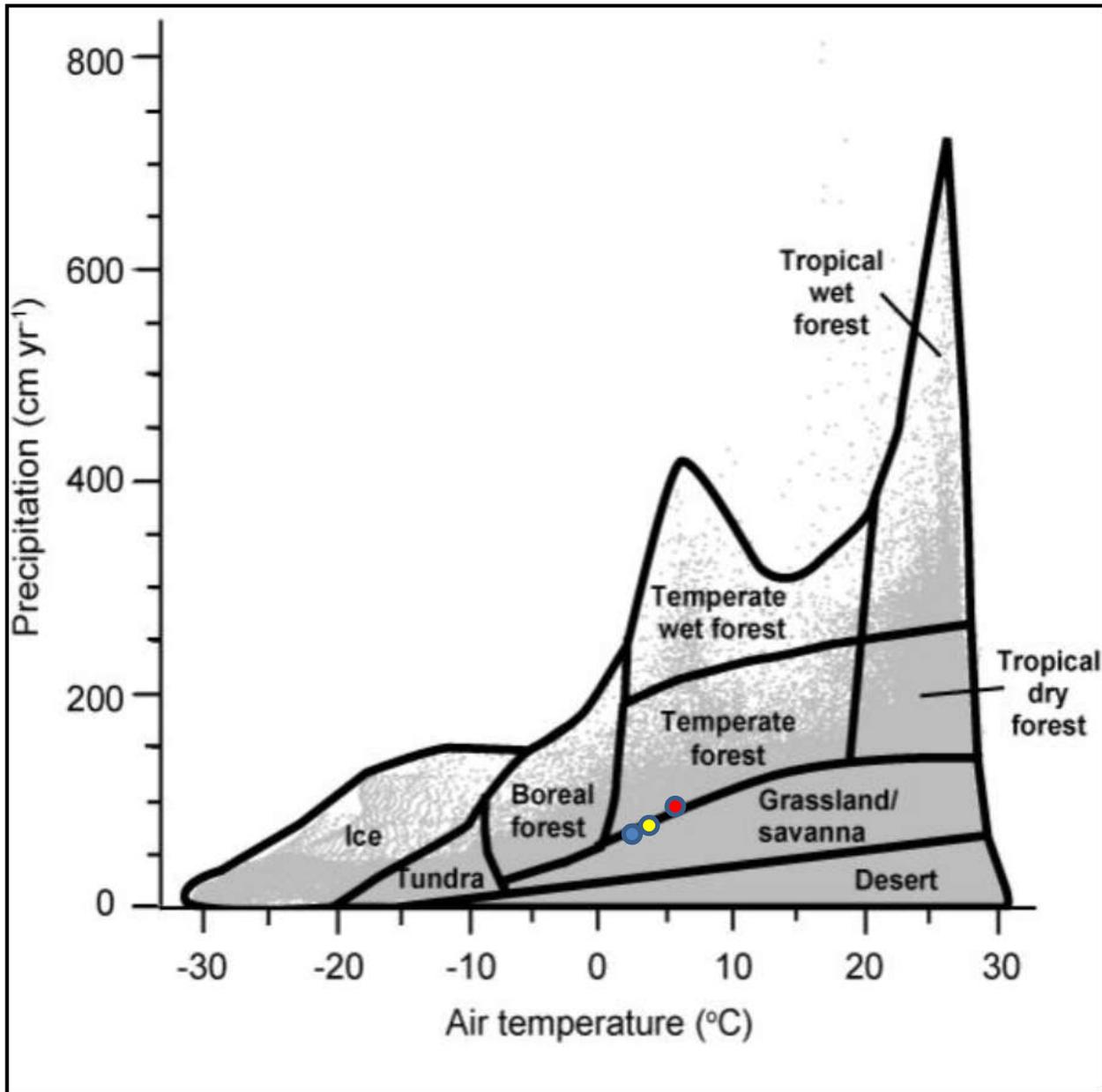
37% of the Kenai Peninsula is forecasted to change landcover type by 2099!

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



Take this with a grain of salt....

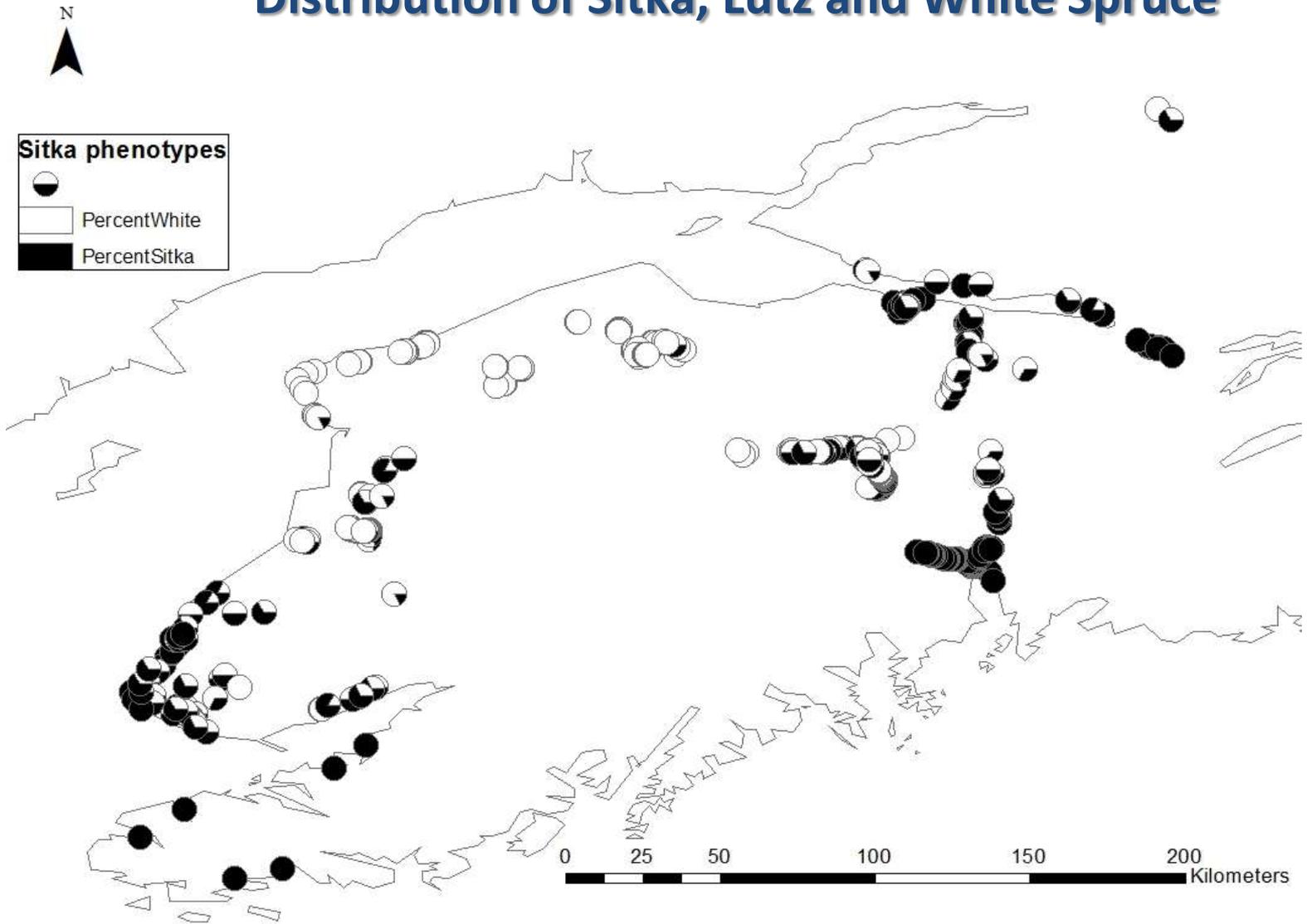




- 1900 68 cm, 2.3° C
- 1980 73 cm, 3.3° C
- 2090 84 cm, 6.8° C

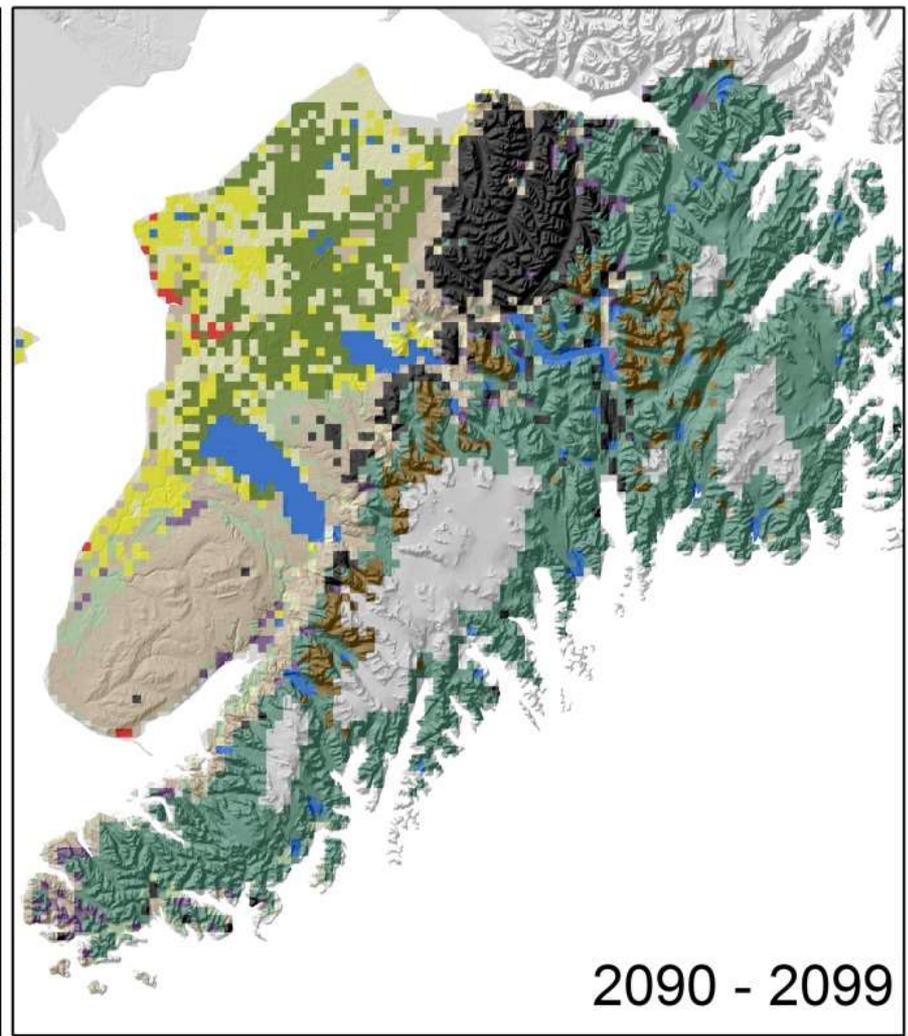
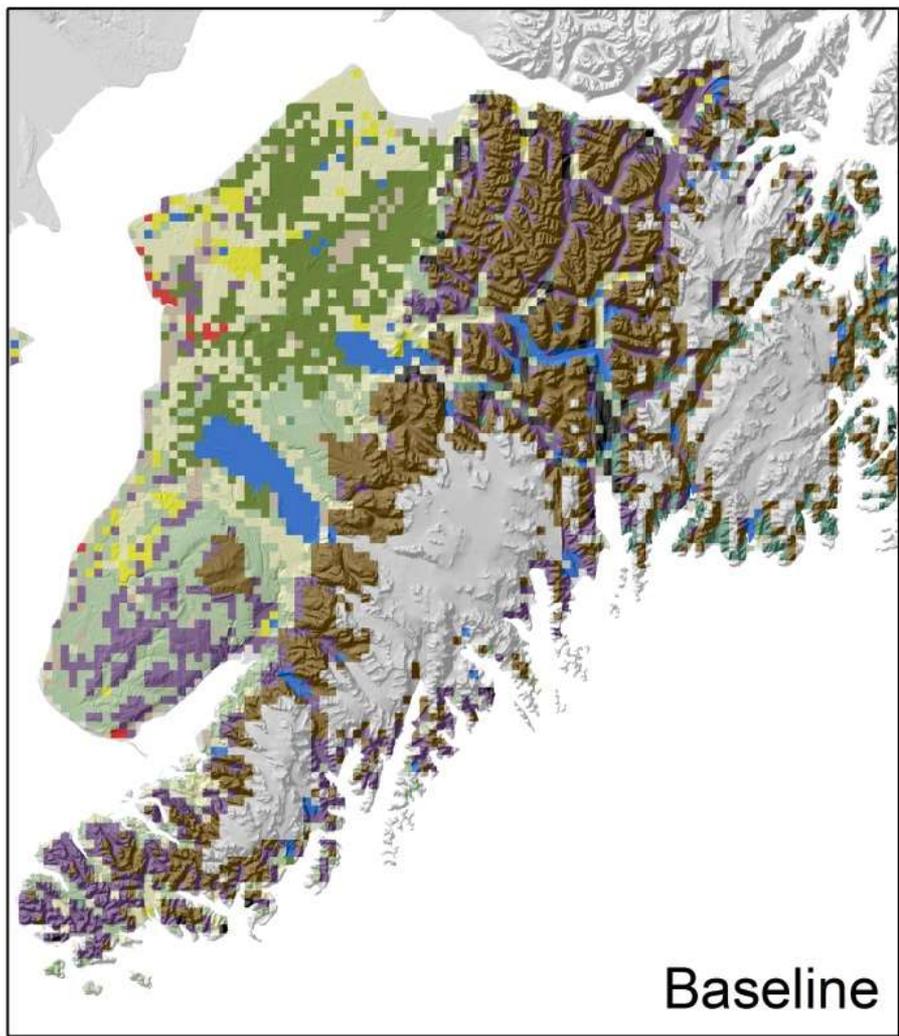
Staudinger, M.D., N. B. Grimm, A. Staudt, S. L. Carter, F. S. Chapin III, P. Kareiva, M. Ruckelshaus, B. A. Stein. 2012. Impacts of Climate Change on Biodiversity, Ecosystems, and Ecosystem Services: Technical Input to the 2013 National Climate Assessment. Cooperative Report to the 2013 National Climate Assessment.

Distribution of Sitka, Lutz and White Spruce



John Alden's introgression scale (1-7)





- | | | |
|--|---|--|
|  Alpine |  Herbaceous |  Mountain Hemlock |
|  Anthropogenic |  Ice |  Shrub |
|  Black Spruce |  Mixed Conifer |  Water |
|  Deciduous |  Mixed Forest |  White-Sitka Spruce |



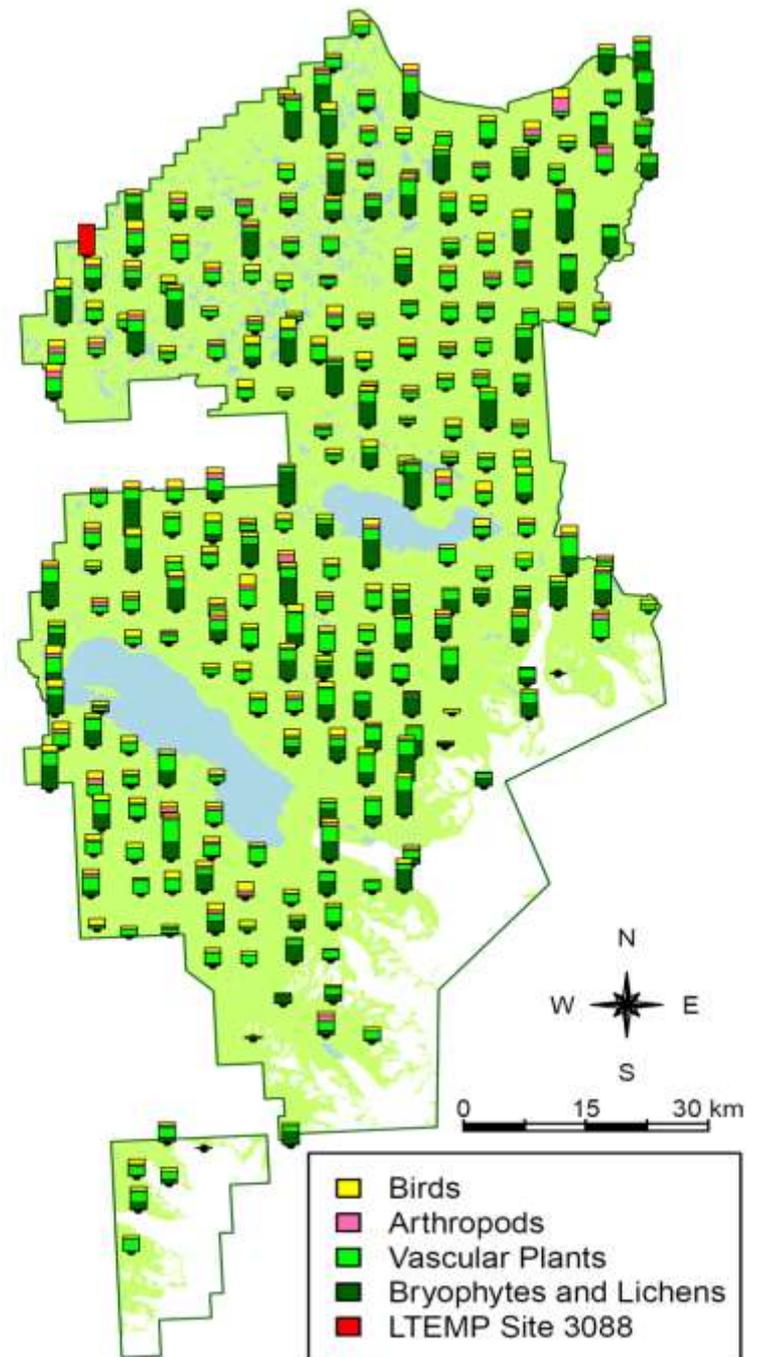
44% of 1,037 native species are unique to one of 10 landcover types

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
Mixed Forest	249,209	0	-	86
Shrub	330,011	0	-	57
White-Sitka Spruce	230,408	0	-	38
Deciduous	38,401	37,601		21
Herbaceous	48,001	65,202	+	15
Mixed Conifer	79,603	330,411	+	1
Mountain Hemlock	34,401	109,604	+	10
Snow or Ice	550,419	50,802	-	8



> 138 exotic species of flora (108) and fauna (30) occur on the Kenai Peninsula and are poised to fill novel assemblages





Orange hawkweed
Oxeye daisy



Birds vetch in Cooper Landing

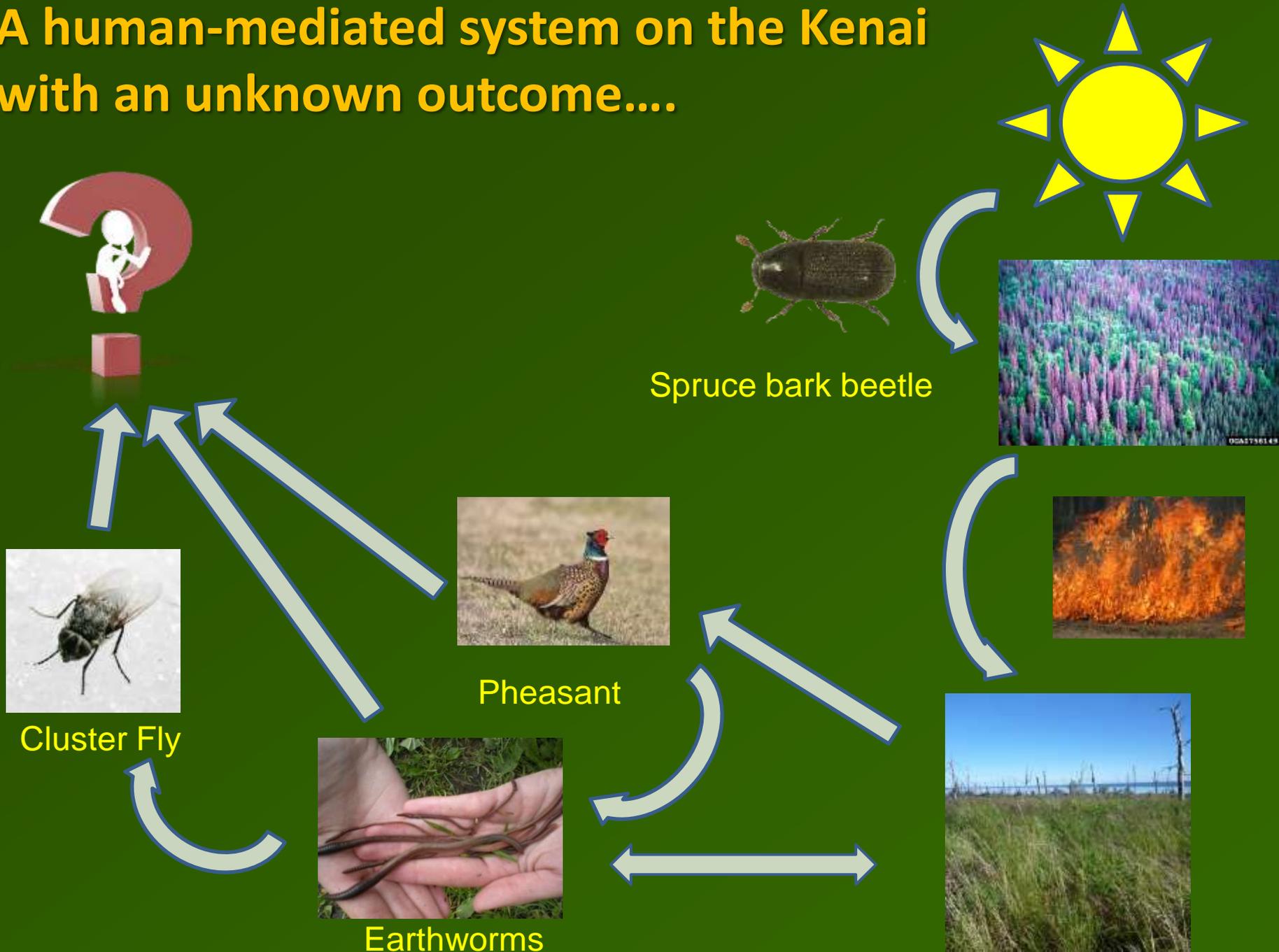
Cheatgrass



Take this with a grain of salt....



A human-mediated system on the Kenai with an unknown outcome....



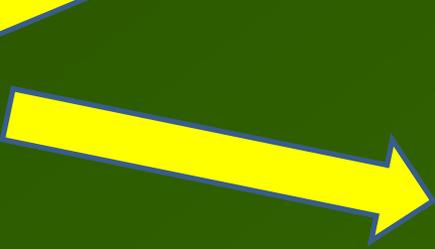
Do what you want with the salt, but the Kenai is changing...

- ✓ Kenai Peninsula is already responding to a changing climate and forecasted to continue doing so
- ✓ Novel assemblages ≠ simple re-shuffling of native flora and fauna
- ✓ Many extant native species are on a trajectory for extirpation
- ✓ Many exotic species already introduced and more enroute
- ✓ How do we influence these outcomes?

**Same climate forecast
but potentially
different outcomes....**



Boreal Transitional



**We are already
making choices!**

What's an exotic plant in a rapidly changing climate?





Questions????