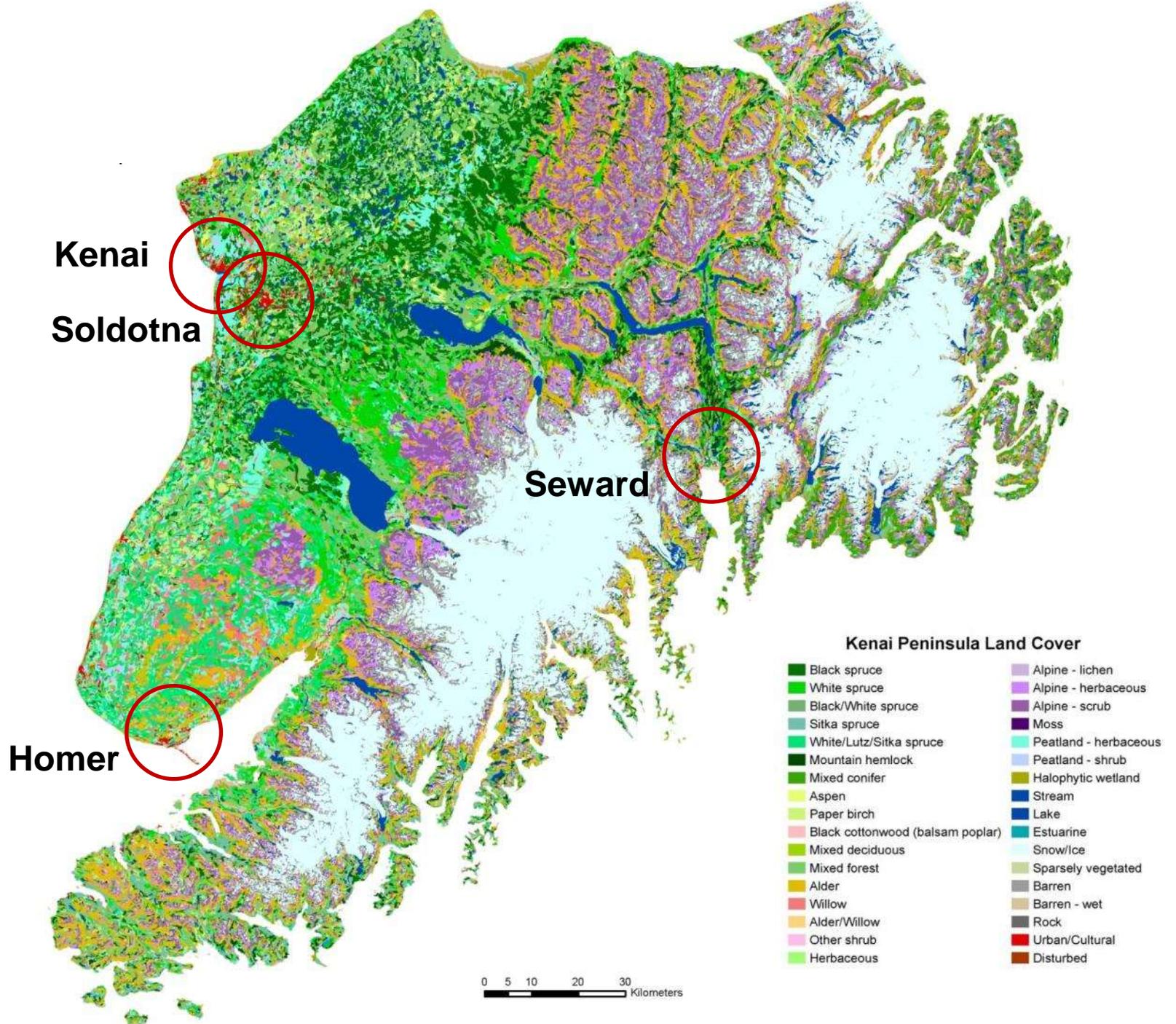


Early responses of Kenai's wildlife and vegetation to rapid climate change

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

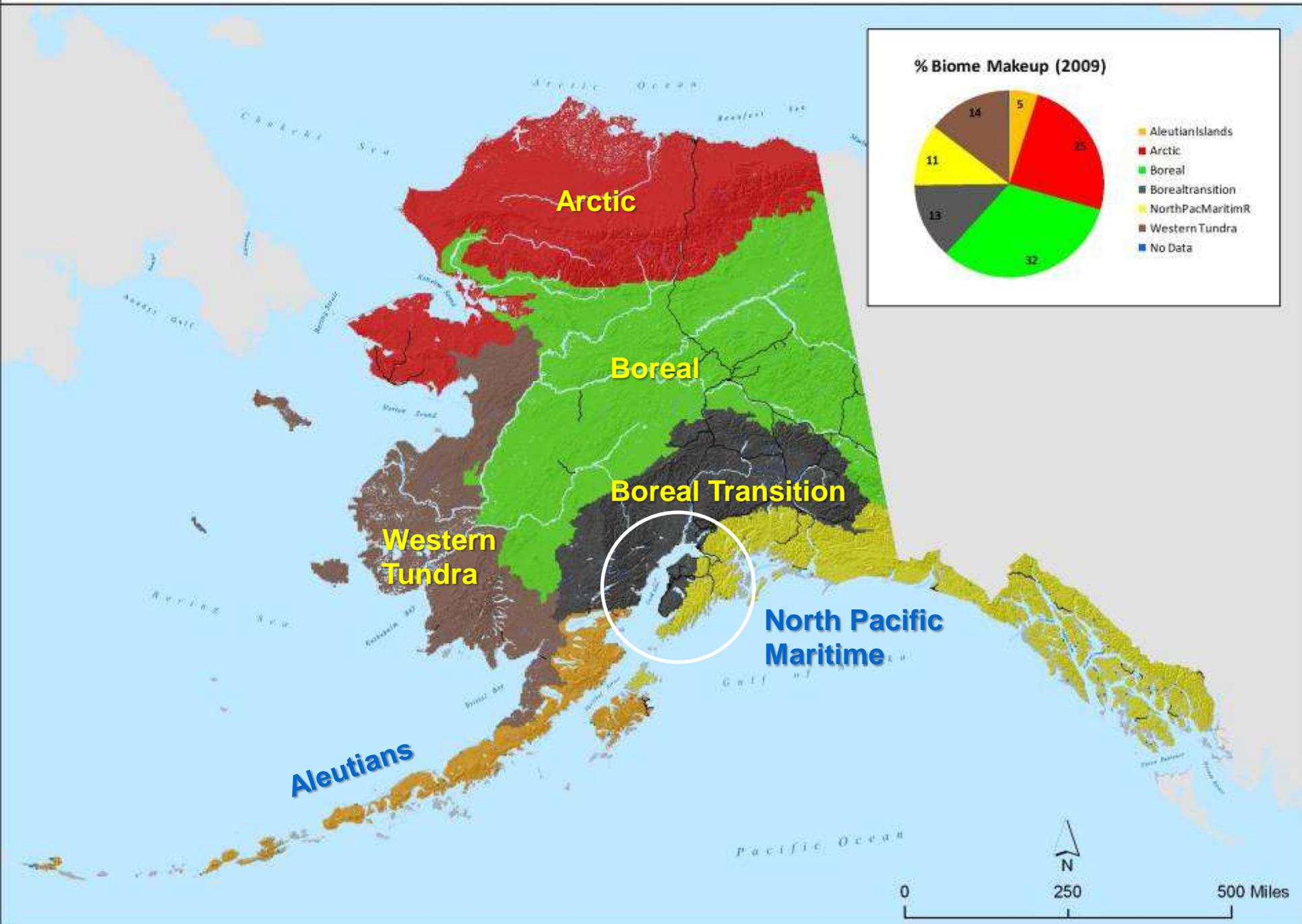
John Morton
Kenai National Wildlife Refuge



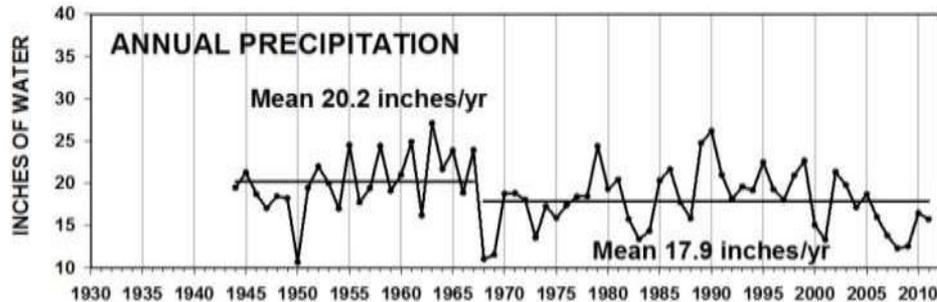
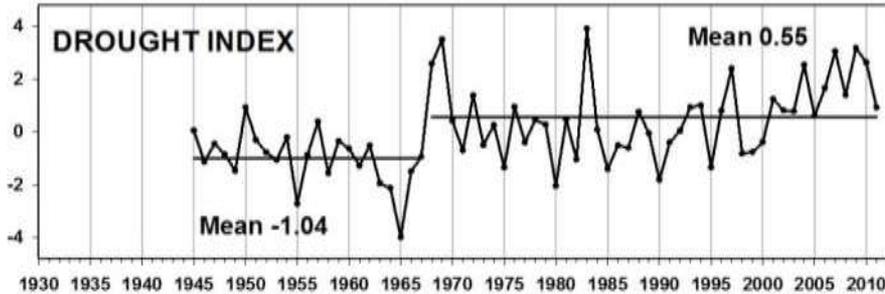
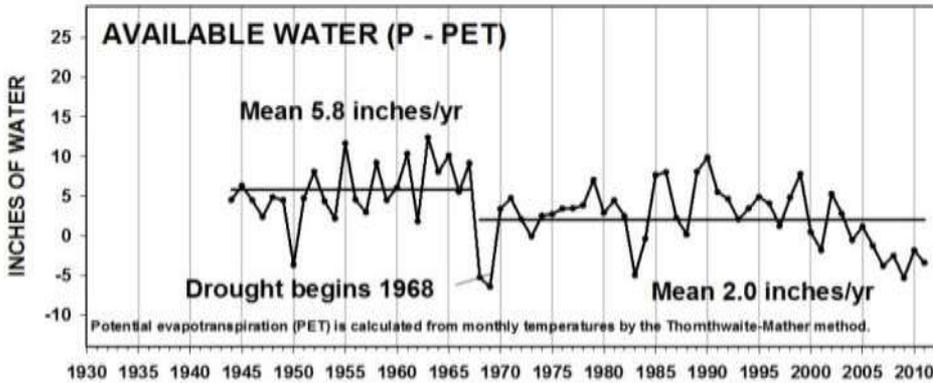
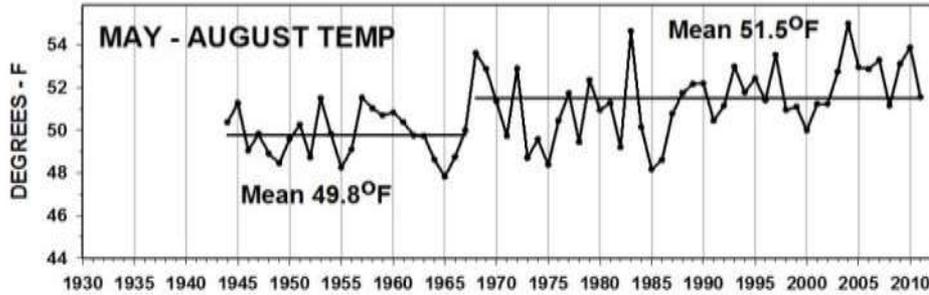




Biome in 2009



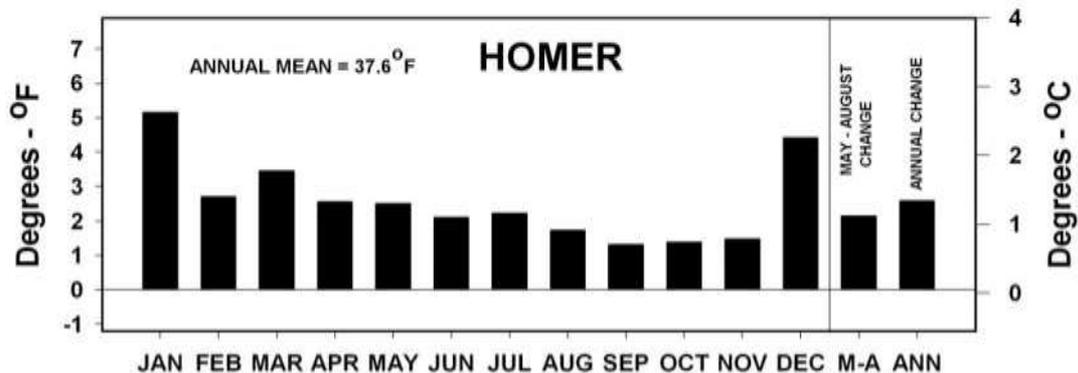
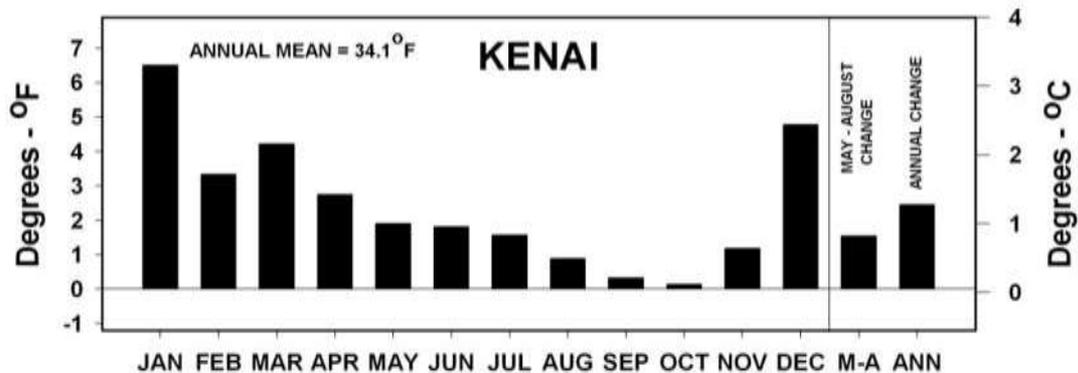
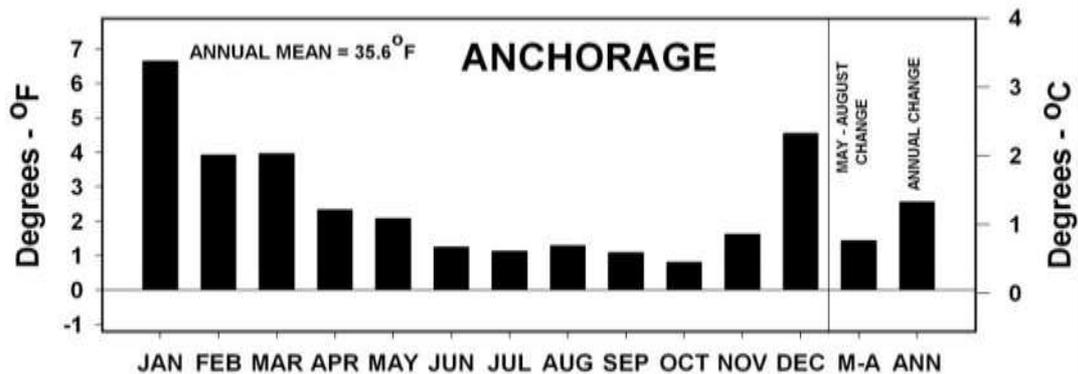
KENAI, ALASKA



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

MONTHLY TEMPERATURE CHANGE

Mean (1977-2009) minus Mean (1944-1976)

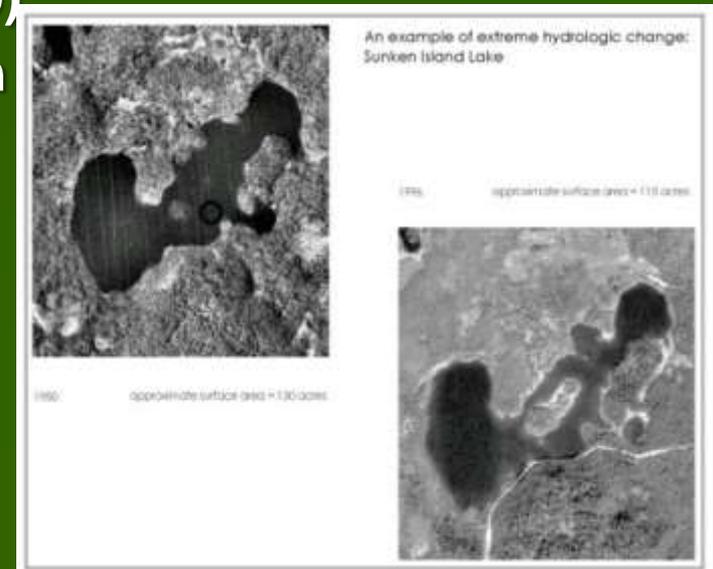


Kenai winters have warmed 2-7 deg F over the same period

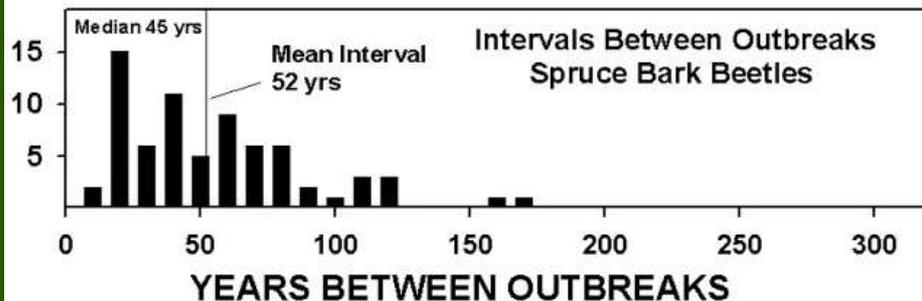
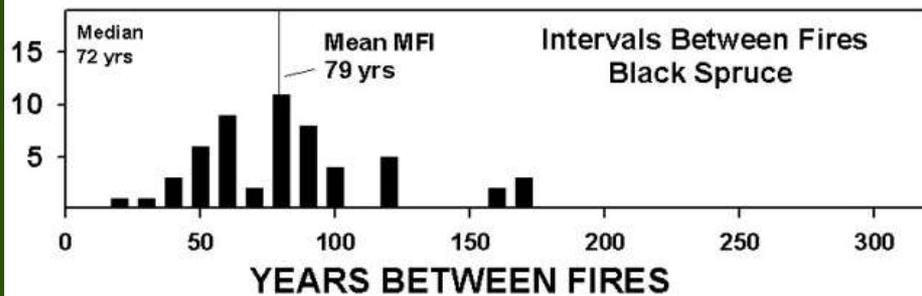
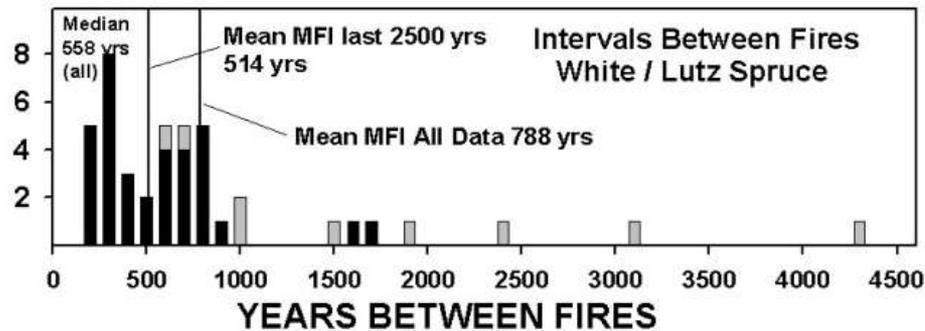
Measured rates of climate change effects on the Kenai Peninsula



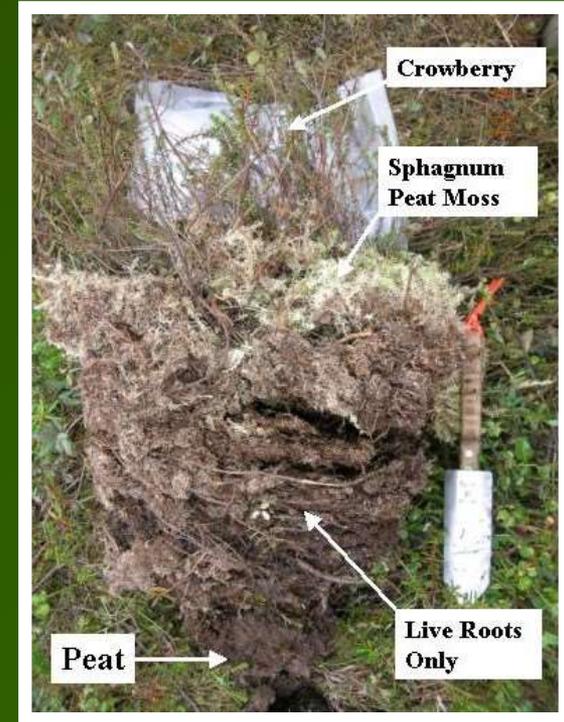
- available water (60% loss since 1968)
- wetlands (6 – 11% per decade since 1950)
- glaciers (5% surface area, 21 m elevation since 1950)
- + treeline (10 m per decade)
- + SB beetle outbreaks (triggered by 2 consecutive warm summers)
- Δ wildfire (spring, grass)
- Δ species distributions



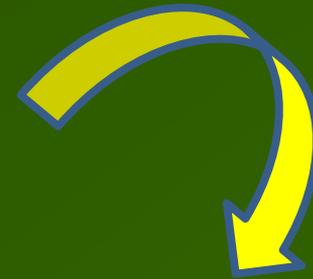
Changing fire regime? 2005 fire season



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



American marten colonized western Kenai Peninsula ~2002

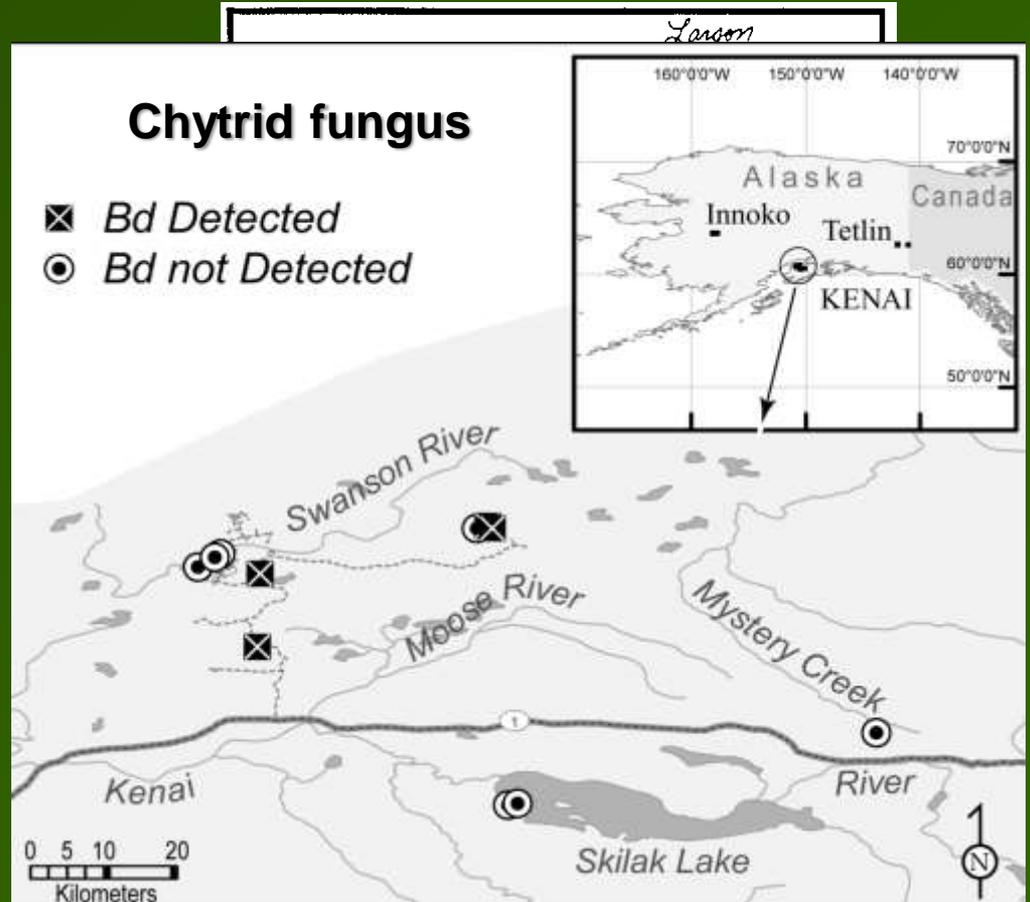


Alpine rest sites



Lowland rest sites

Abnormal wood frogs



"one leg !... I got one leg !"

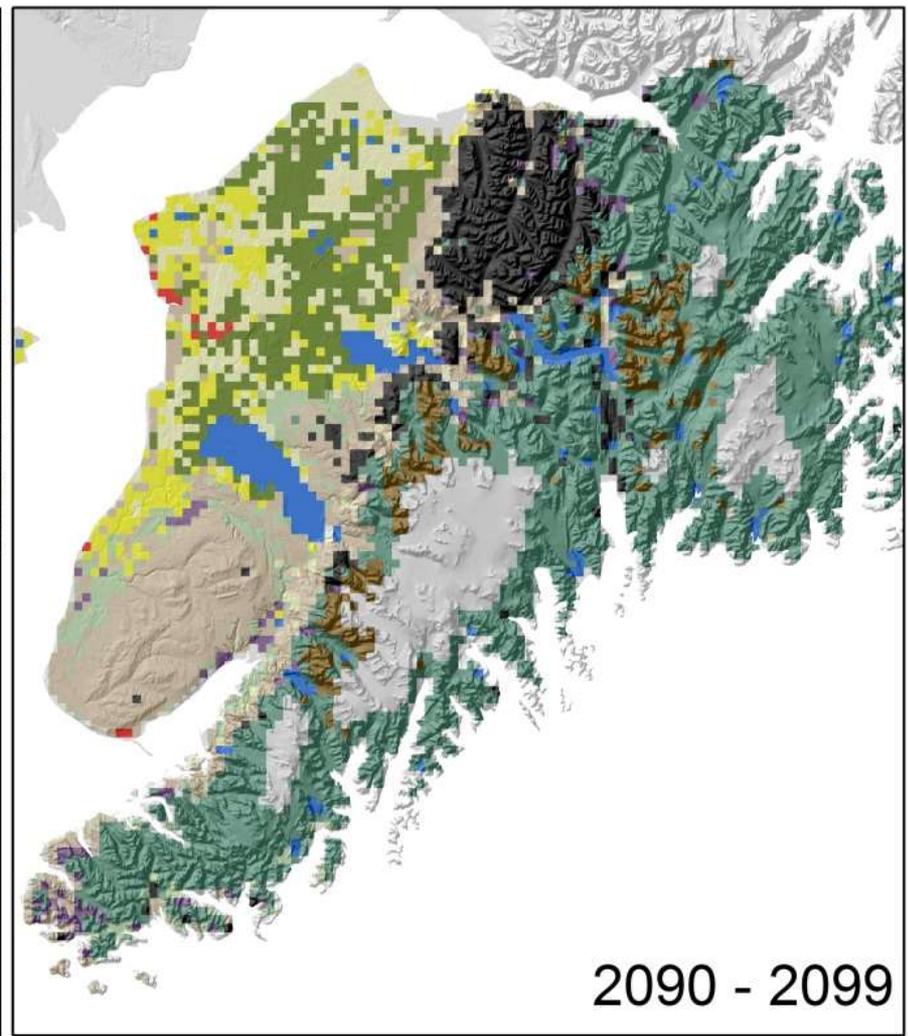
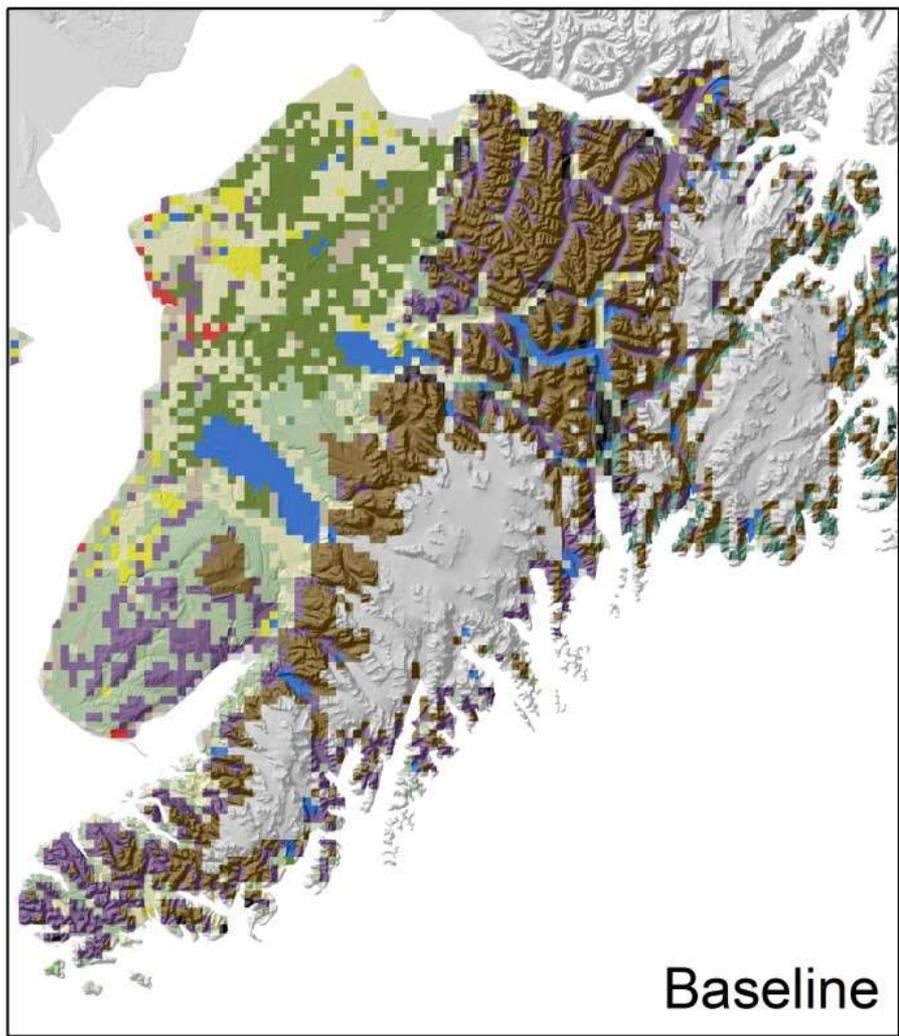
Harvested species likely to diminish in abundance on the Kenai Peninsula



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



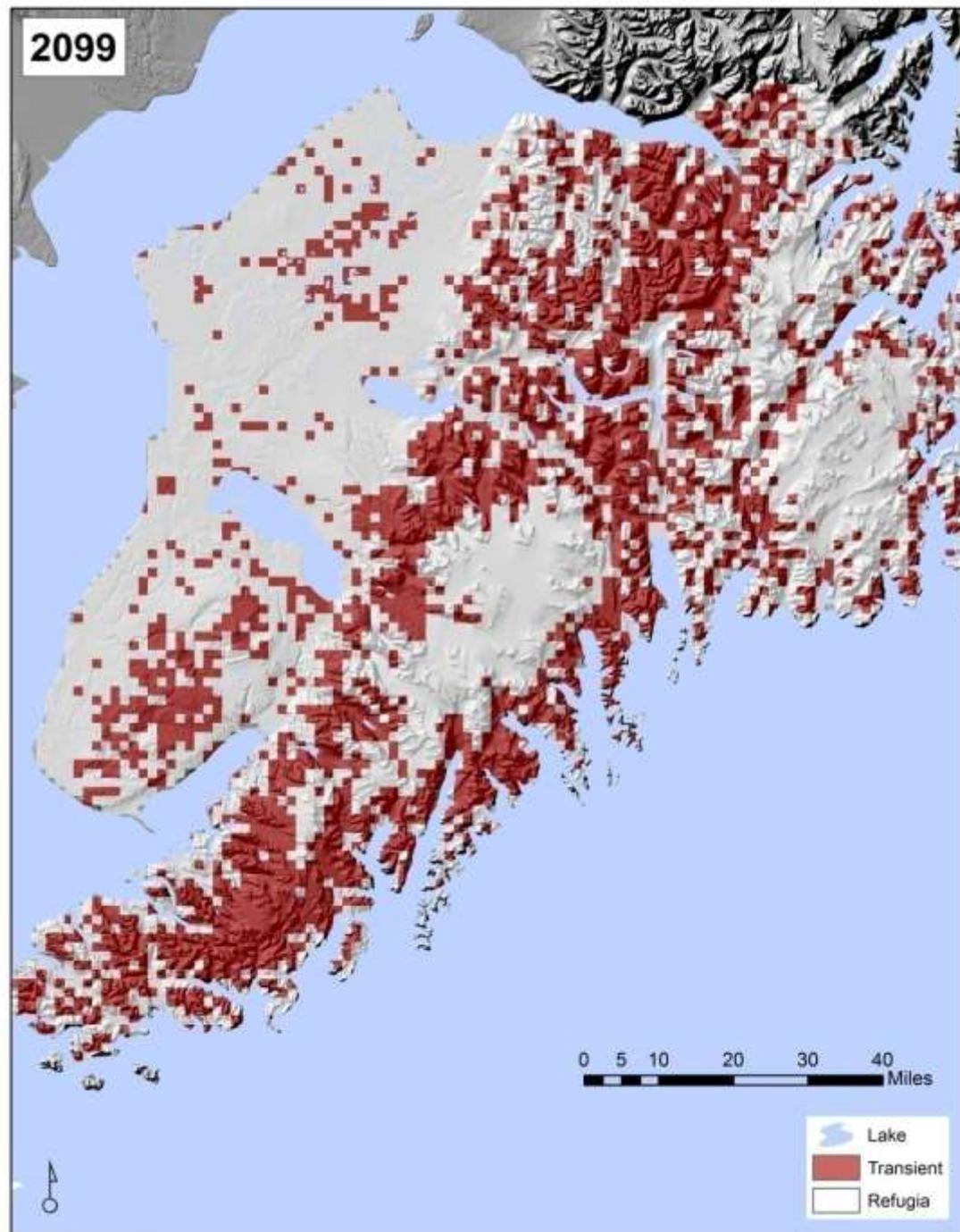


- | | | |
|--|---|--|
|  Alpine |  Herbaceous |  Mountain Hemlock |
|  Anthropogenic |  Ice |  Shrub |
|  Black Spruce |  Mixed Conifer |  Water |
|  Deciduous |  Mixed Forest |  White-Sitka Spruce |



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



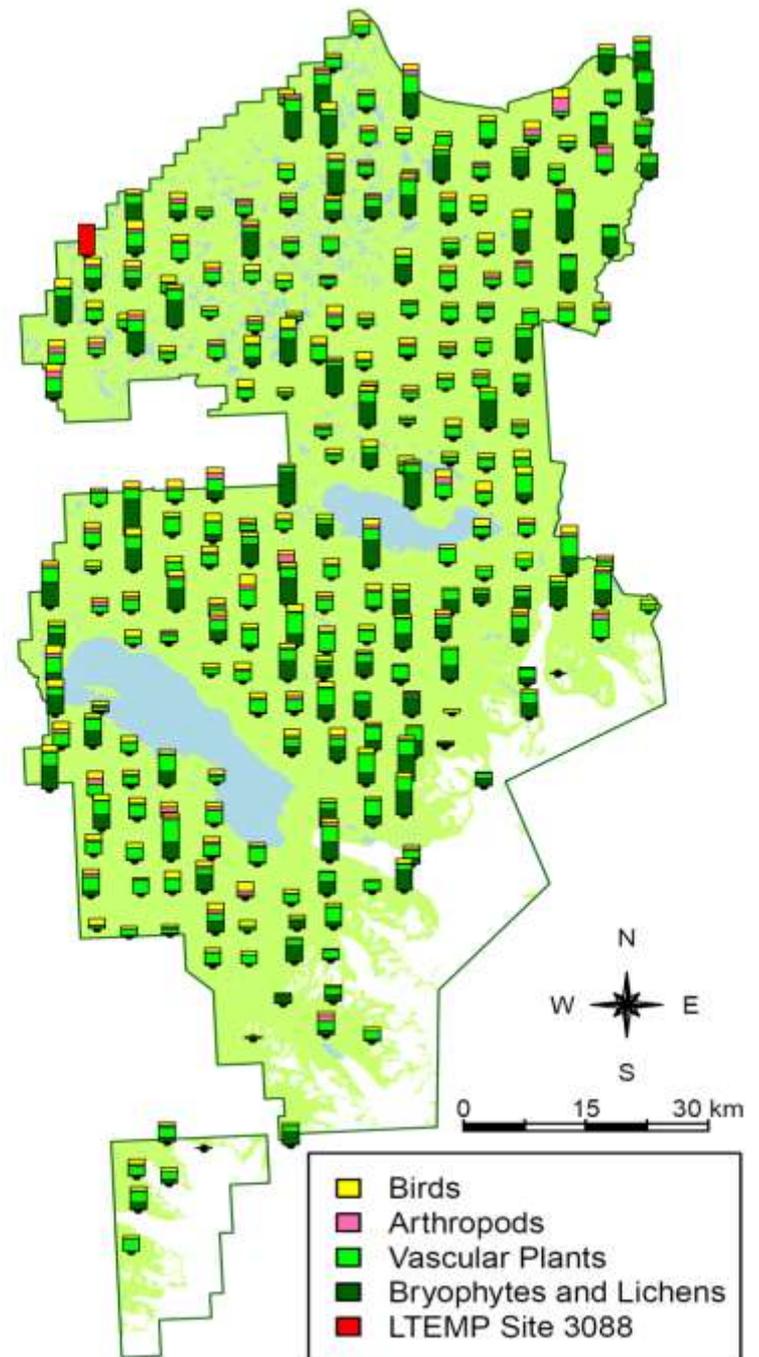
44% of 1,037 native species are unique to 1 of 10 landcover types

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!

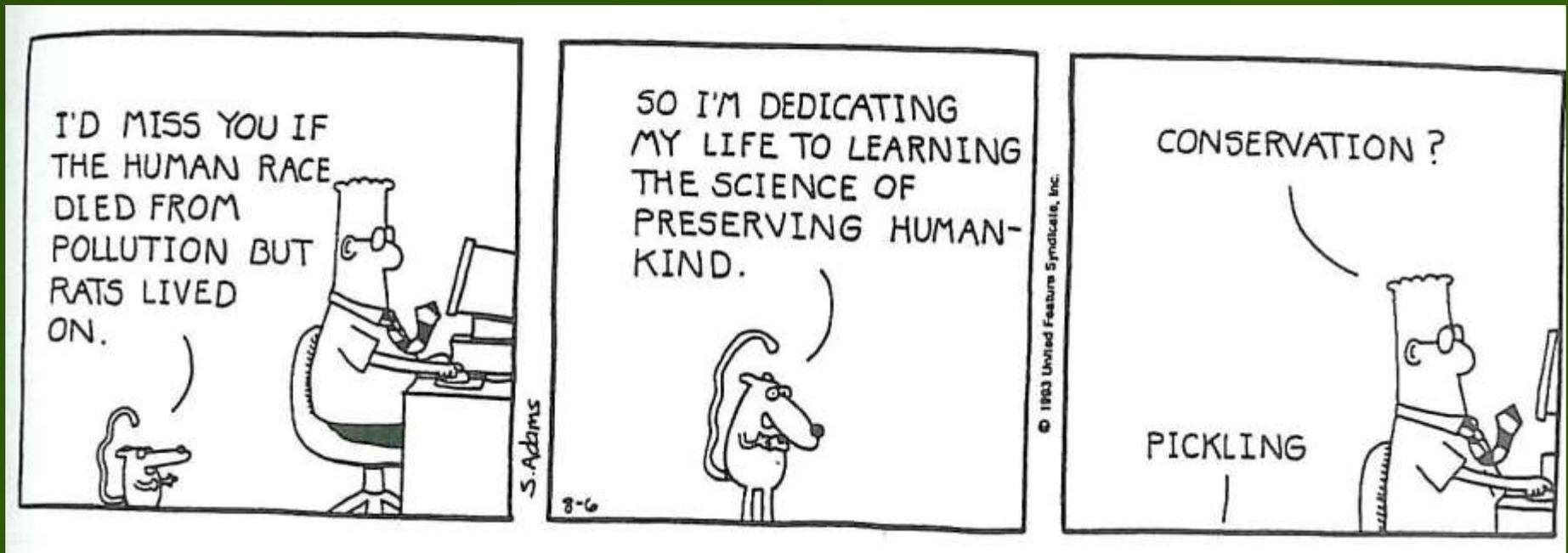
Land cover Type	2009 (Ha)	2099 (Min Ha)	Trend	Unique Species
Alpine	556,419	0	-	170
Black Spruce	188,406	0	-	56
Deciduous	38,401	37,601		21
Herbaceous	48,001	65,202	+	15
Mixed Conifer	79,603	330,411	+	1
Mixed Forest	249,209	0	-	86
Mountain Hemlock	34,401	109,604	+	10
Shrub	330,011	0	-	57
Snow or Ice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



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?

RELATIVE EFFORT

DECREASING UNCERTAINTY BUT INCREASING ECOLOGICAL RISK

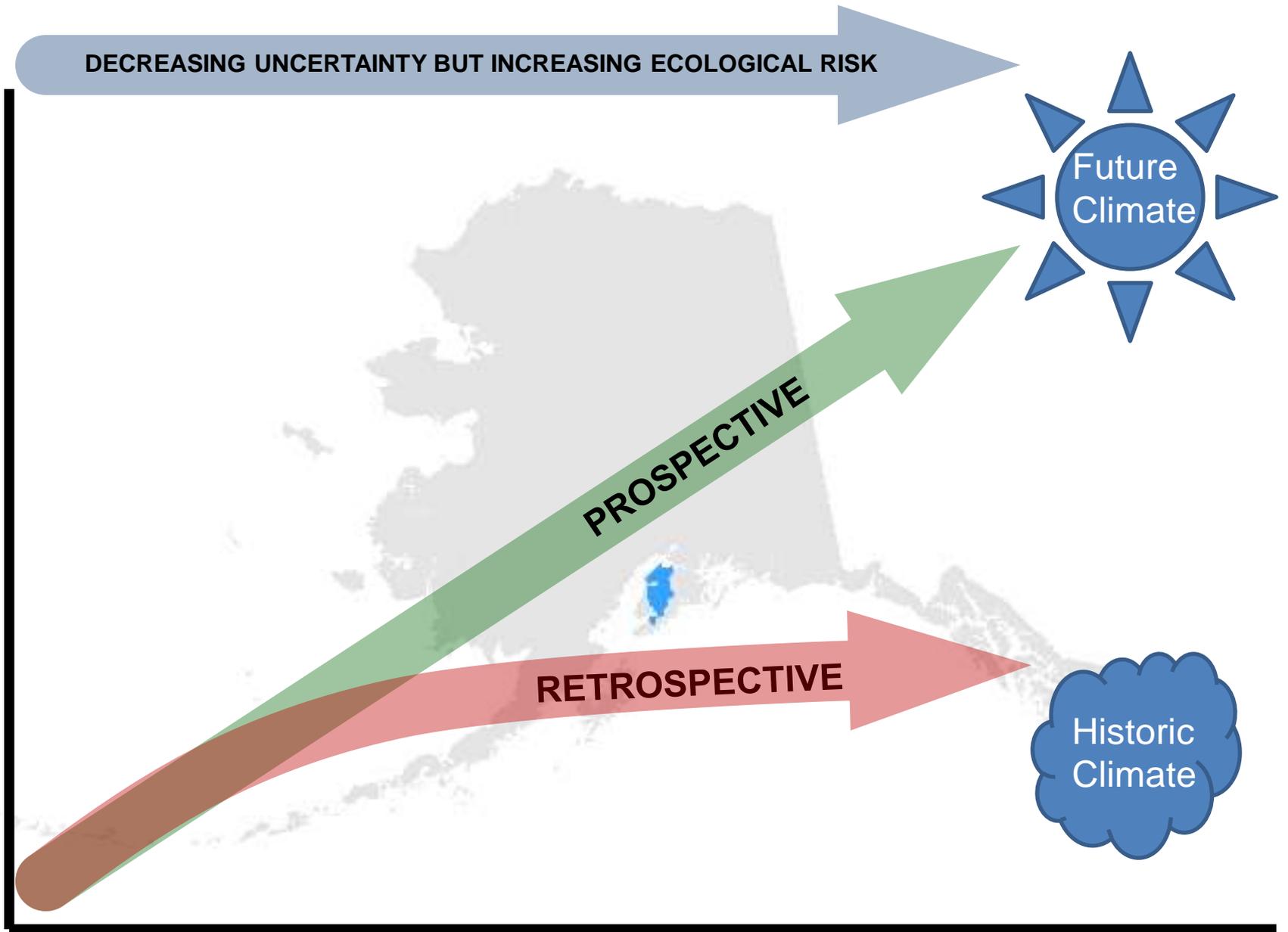
PROSPECTIVE

RETROSPECTIVE

**Future
Climate**

**Historic
Climate**

TIME



Same problem but two adaptation approaches

Six Communities in Jeopardy

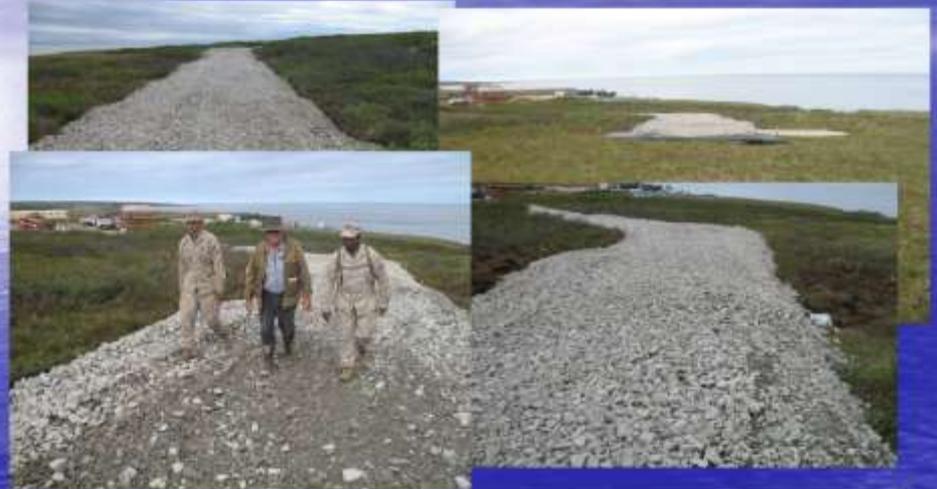
- Kivalina*
- Shishmaref*
- Newtok*
- Unalakleet
- Koyukuk
- Shaktoolik



* Have already begun relocation plans

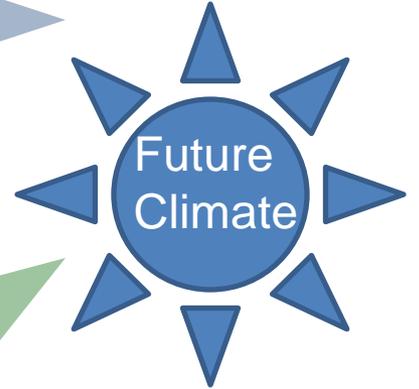
retrospective adaptation

Mertarvik Evacuation Road



prospective adaptation

DECREASING UNCERTAINTY BUT INCREASING ECOLOGICAL RISK



Land designation/acquisition

Seed banks, living vouchers

Fire management

Invasives management

Silvicultural practices

Translocation

PROSPECTIVE

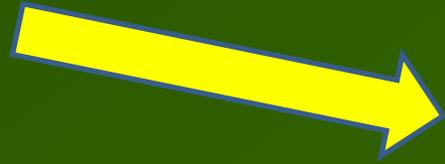
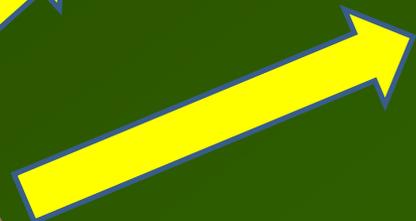
Kenai Peninsula model

TIME

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



Boreal Transitional

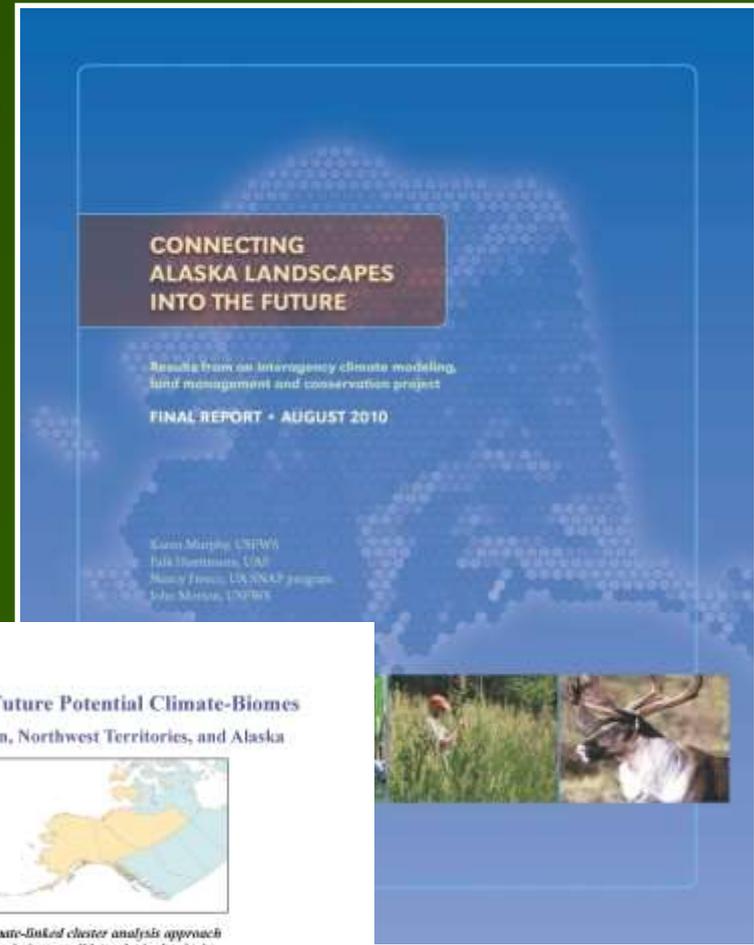


**We are already
making choices!**



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

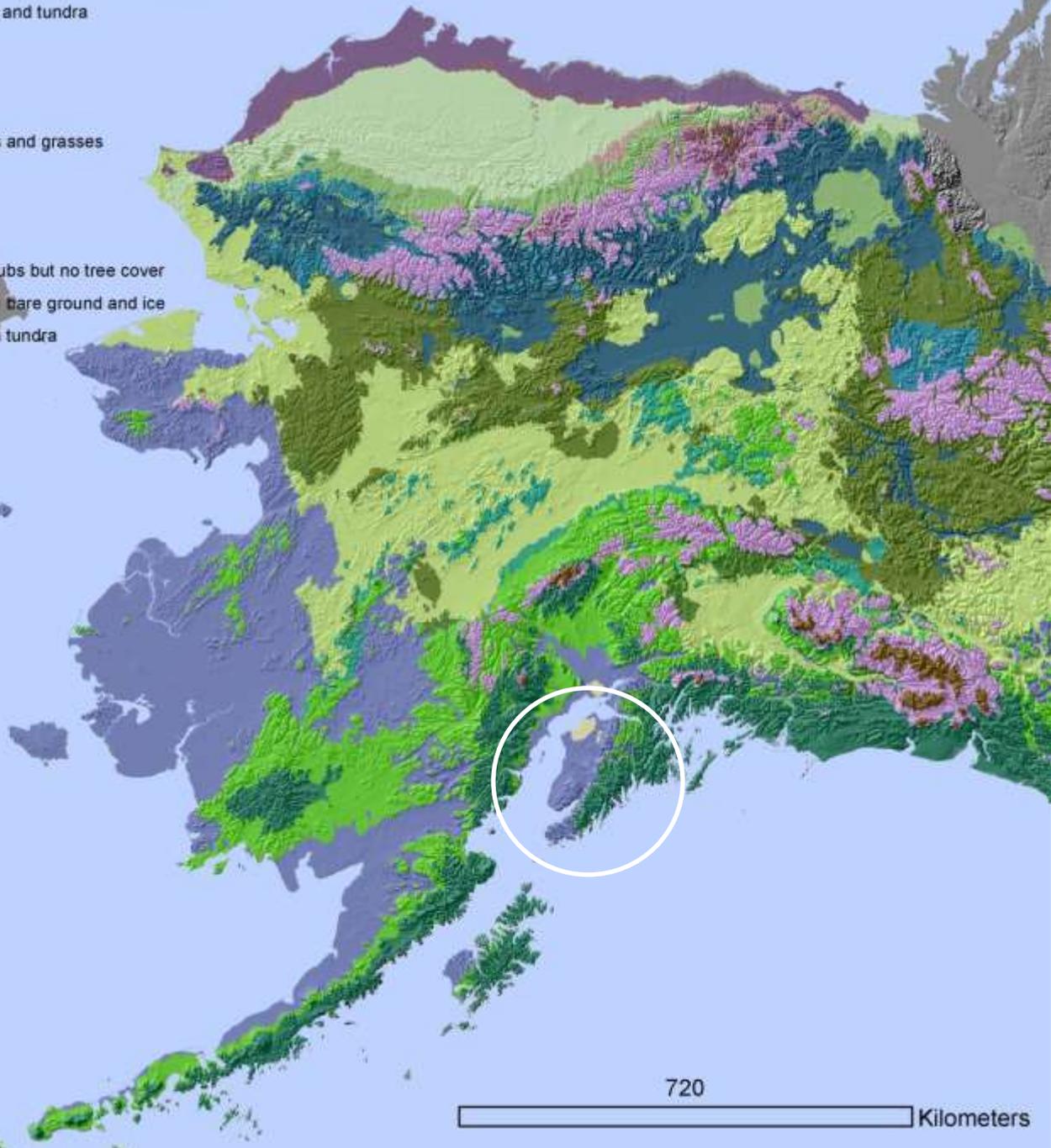
Prepared by the Scenario Network for Arctic Planning and the ESWHALE lab, University of Alaska Fairbanks

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



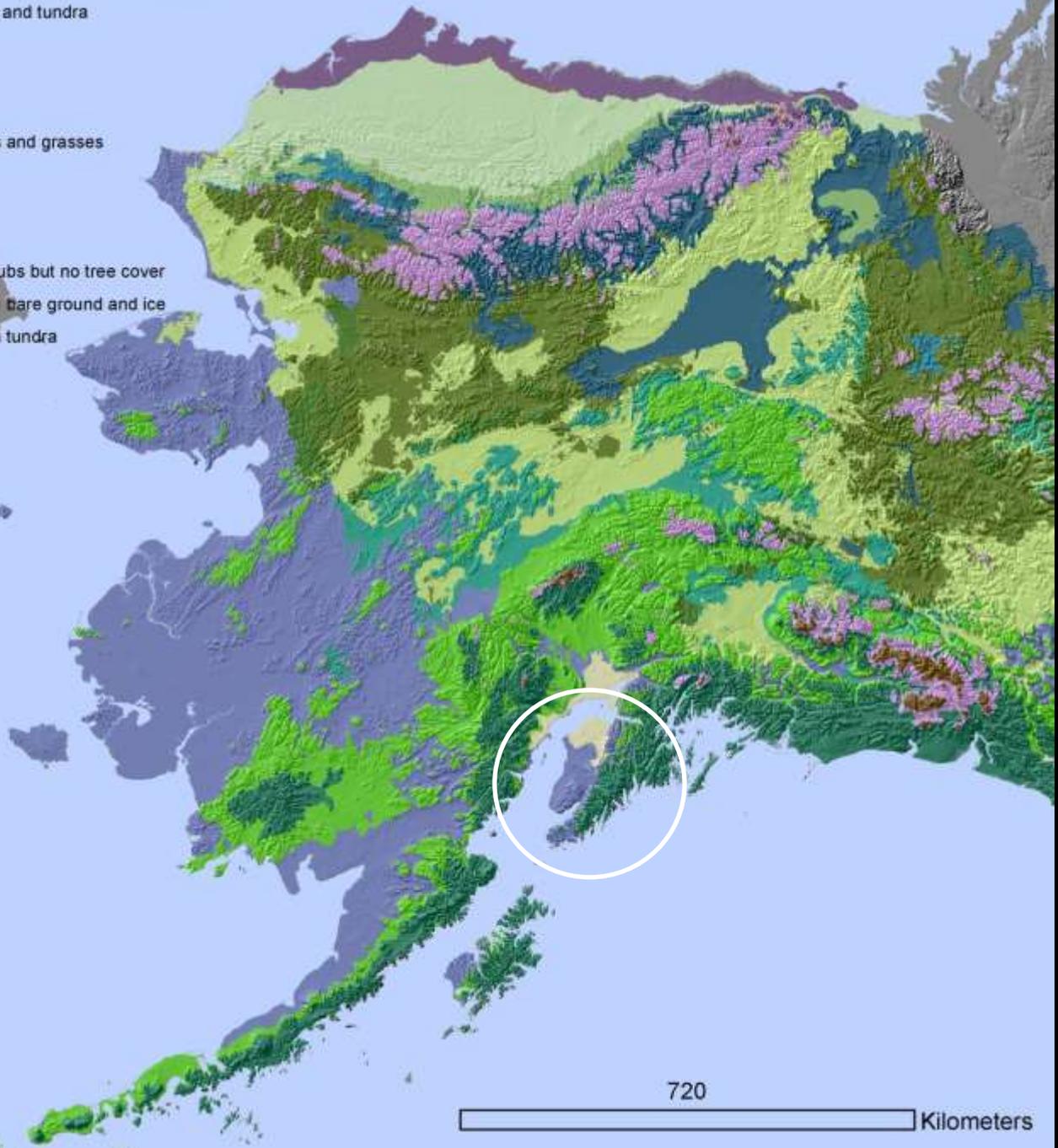
- Arctic tundra with denser vegetation and more shrub cover including some small trees
- Boreal forest with coastal influence and intermixed grass and tundra
- Coastal rainforest, wet, more temperate
- Cold northern boreal forest
- Densely forested southern boreal
- Dry boreal wooded grasslands - mixed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

- 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



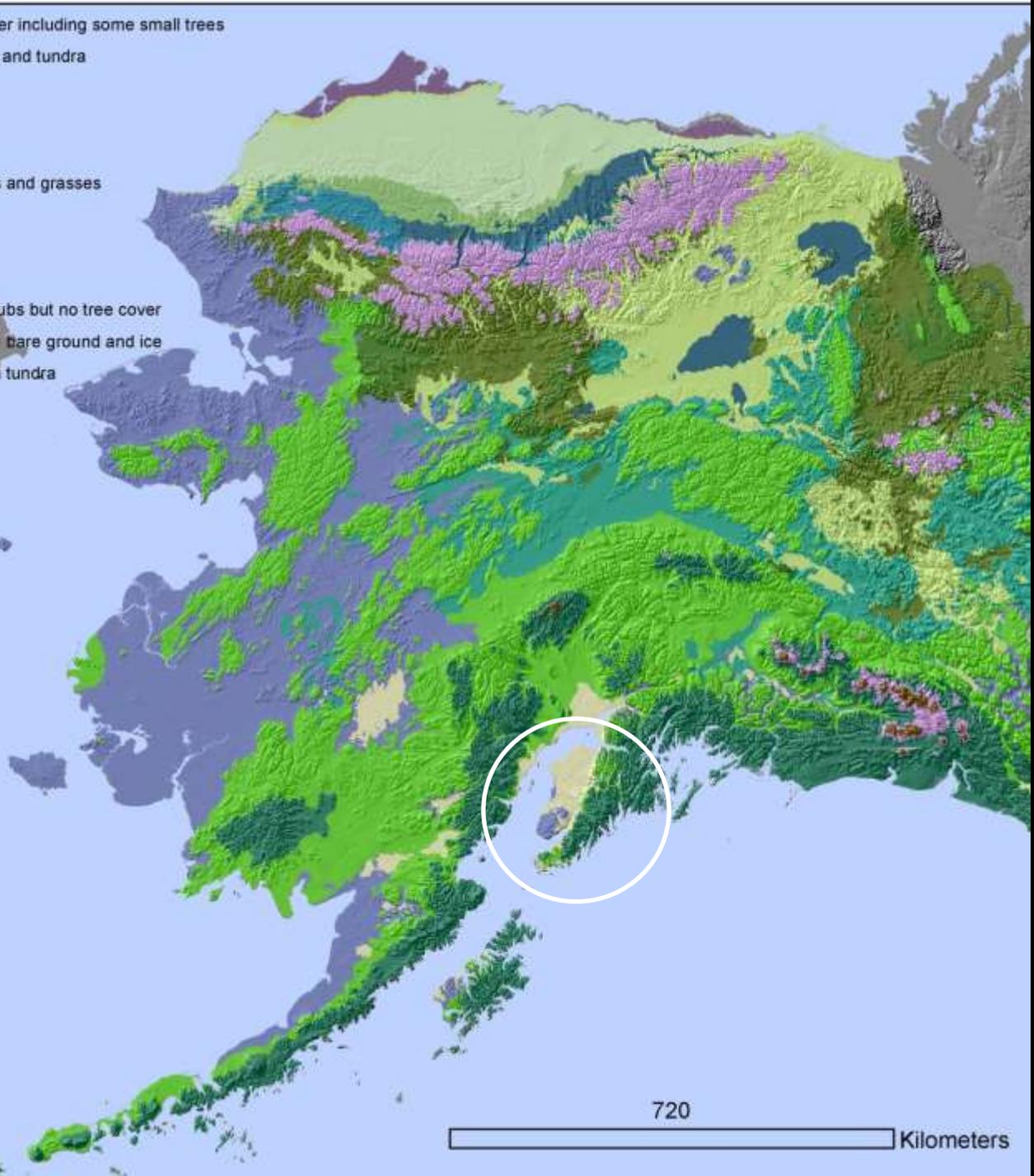
2039

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

2069

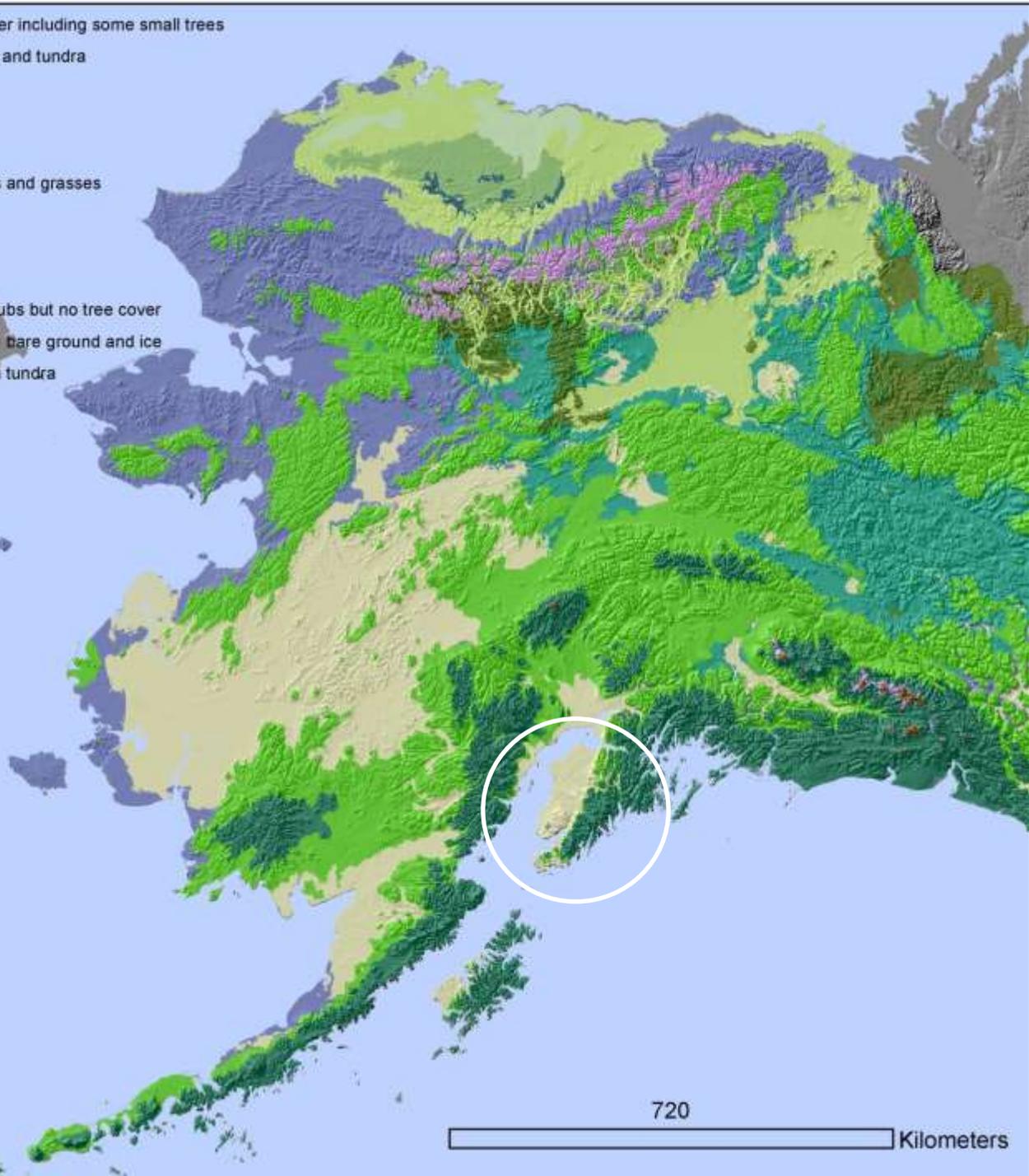
720 Kilometers



- 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

2099

720 Kilometers





By 2100...

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

2099

720

Kilometers