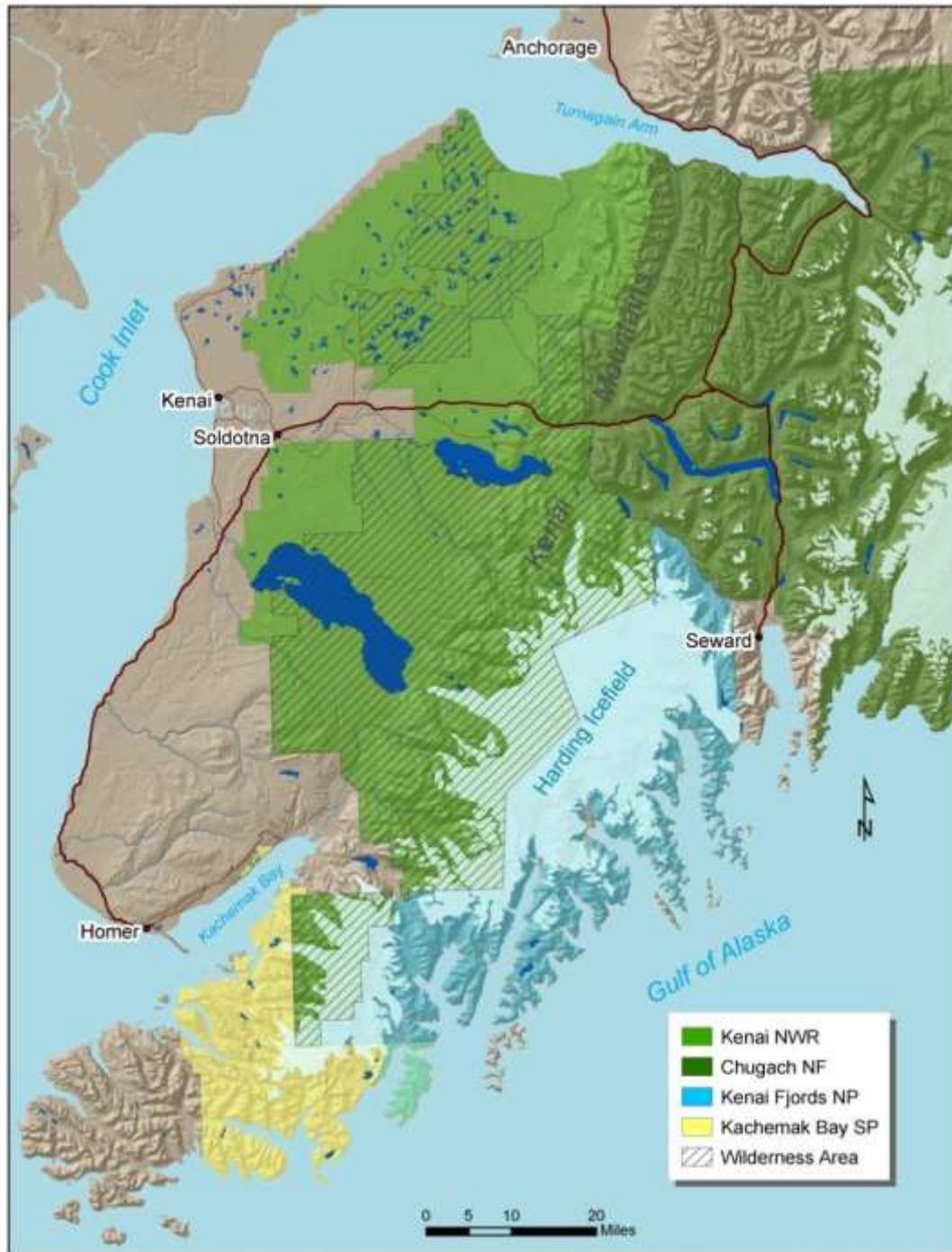


Effects of a Rapidly Warming Climate on Kenai National Wildlife Refuge

John Morton
Kenai National Wildlife Refuge





- ✓ Alaska warming 2–3 times faster than Lower 48
- ✓ Climate warming effects not masked by other human-caused drivers of change
- ✓ Kenai Peninsula may be best studied locale in AK outside of high arctic

REFUGE PURPOSES

1980 ANILCA

- conserve fish & wildlife populations and habitats in their *natural diversity* including but not limited to....
- fulfill international fish & wildlife treaty obligations
 - ensure water quality and quantity
 - opportunities for *scientific research*, interpretation, EE and land management training
 - compatible fish & wildlife-oriented recreation

REFUGE PURPOSES

1980 ANILCA

- conserve fish & wildlife populations and habitats in their *natural diversity* including but not limited to....
- fulfill international fish & wildlife treaty obligations

fish and wildlife = any member of the animal kingdom including without limitation any mammal, fish, bird, amphibian, reptile, mollusk, crustacean, arthropod or other invertebrate...

OTHER REFUGE PURPOSES

1964 Wilderness Act

- secure an enduring resource of wilderness
- protect and preserve wilderness character
- leave them unimpaired for future use as wilderness

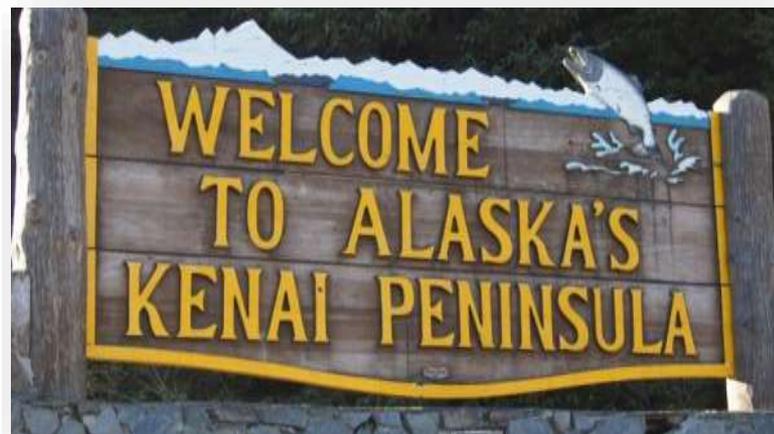
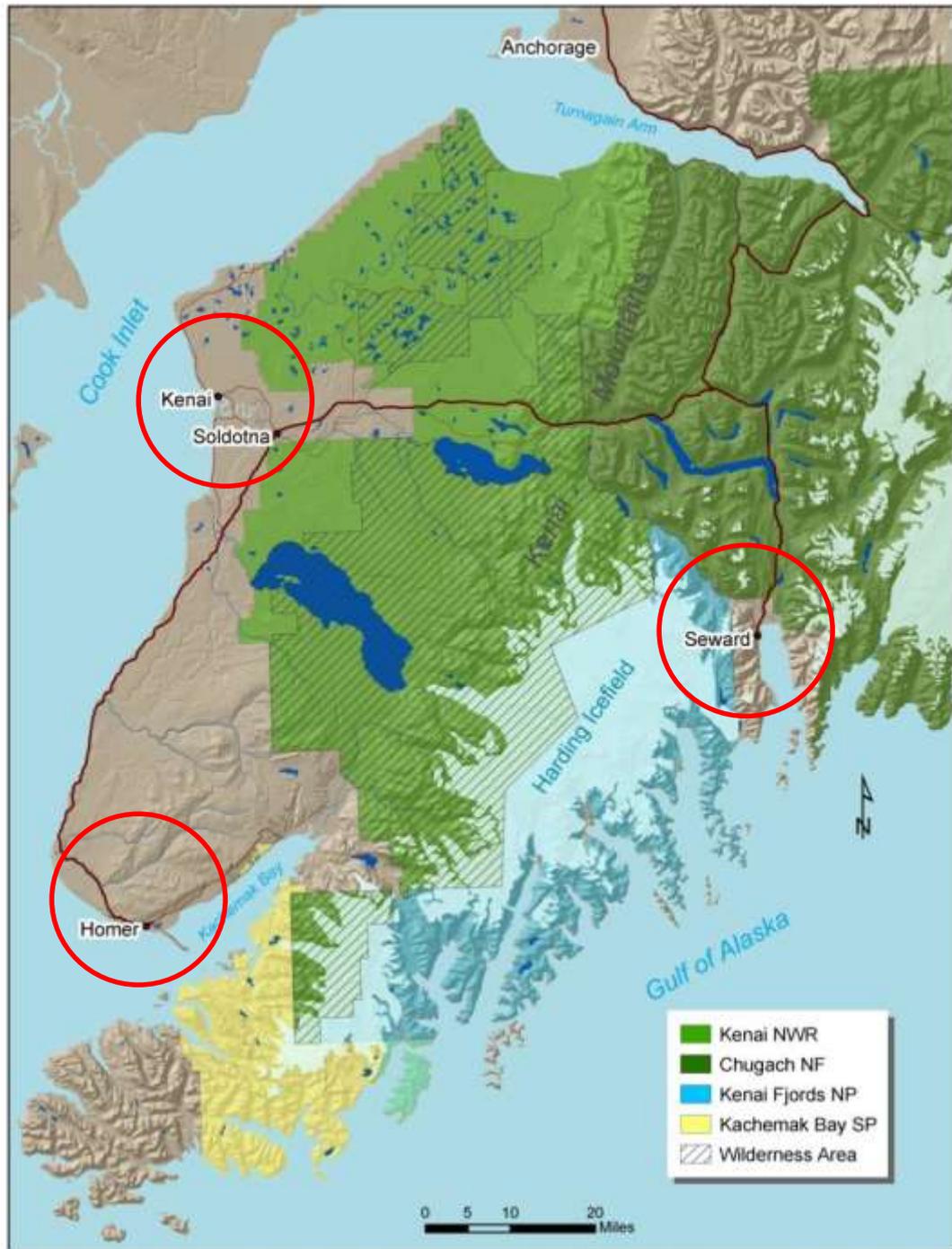
1997 Refuge Improvement Act

- ensure biological integrity, diversity and environmental health

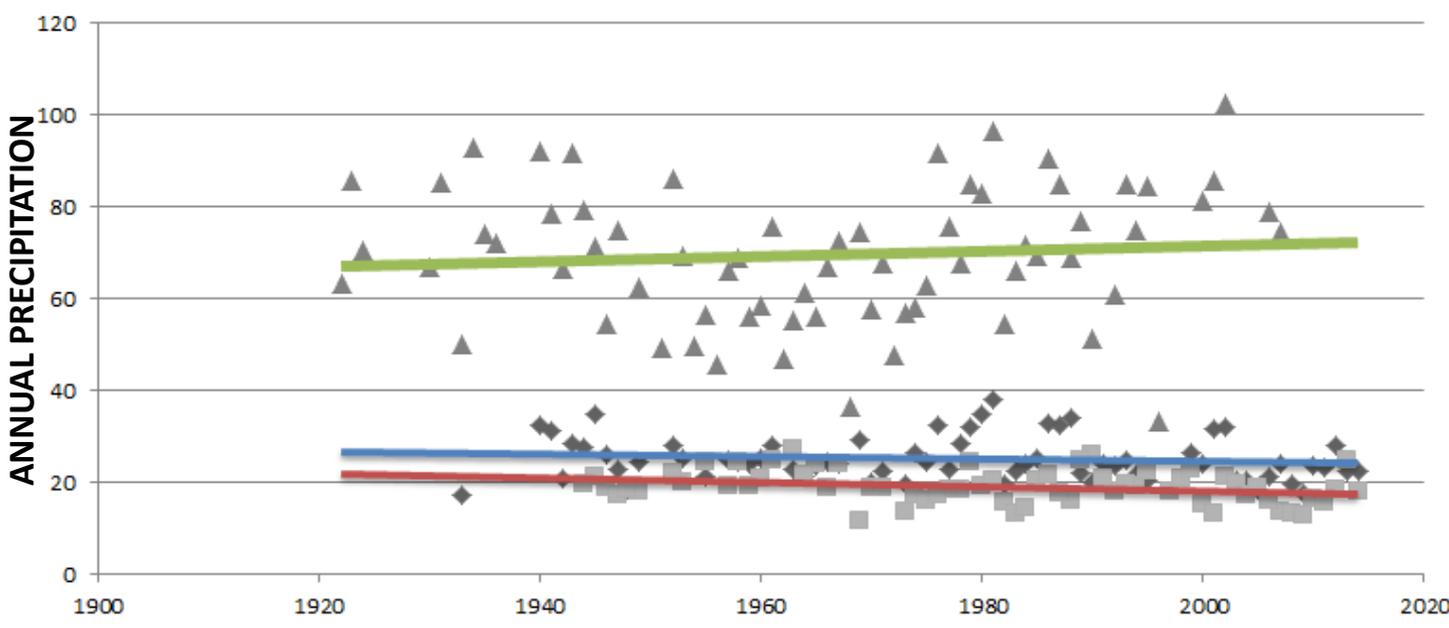
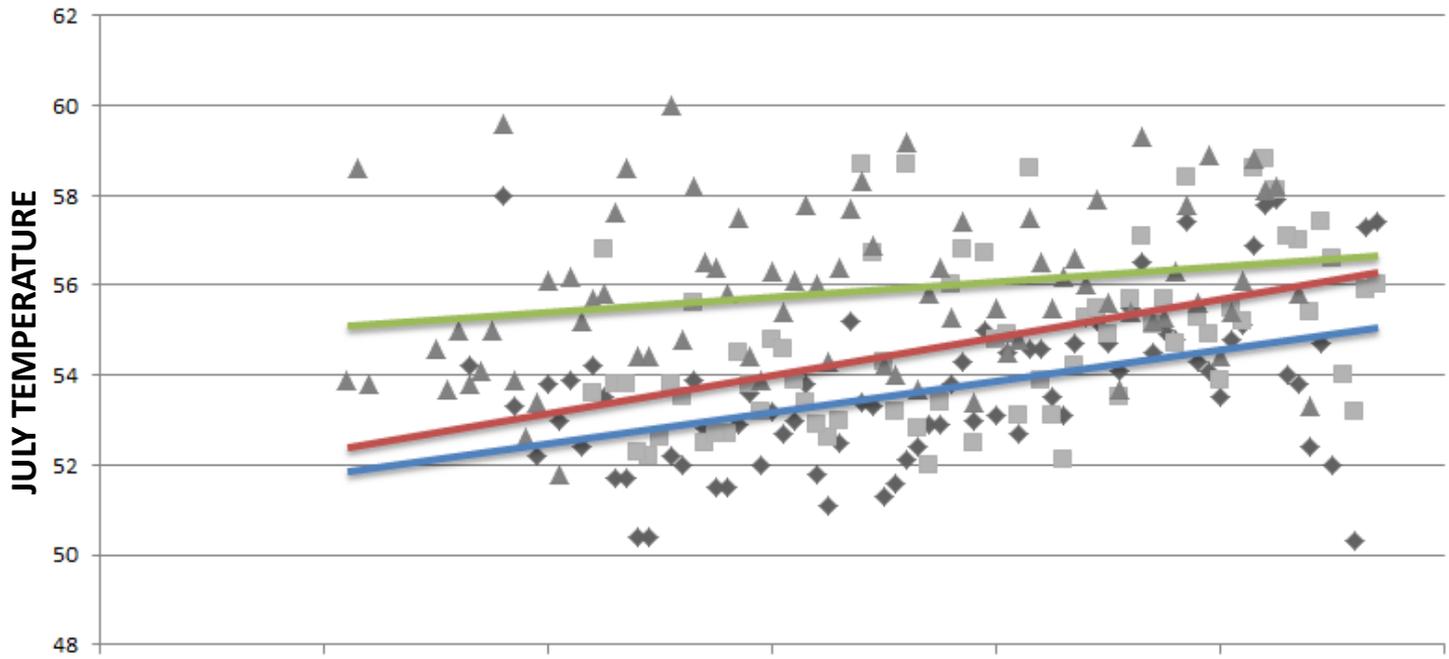








**Nexus of two biomes:
Coastal Rainforest and
Transitional Boreal**

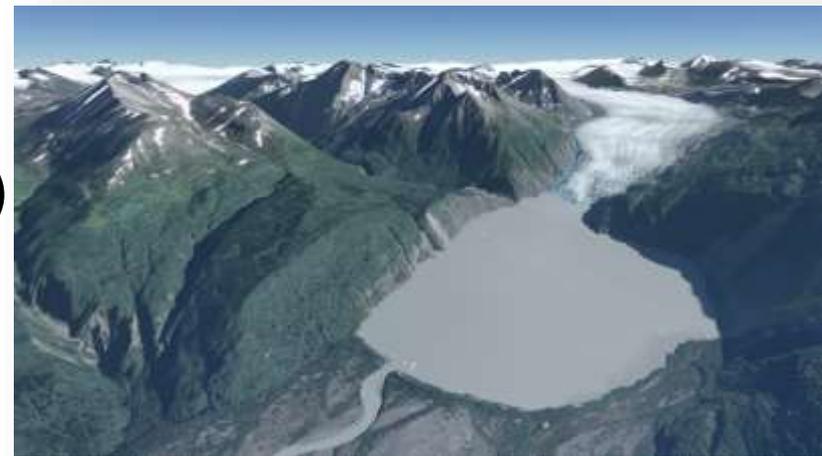


SEWARD
KENAI
HOMER

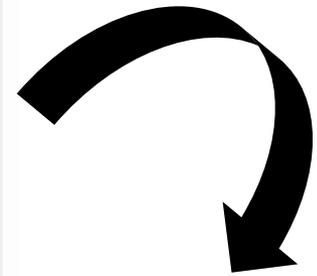
Dramatic changes in last 50 years in response to warming and drying



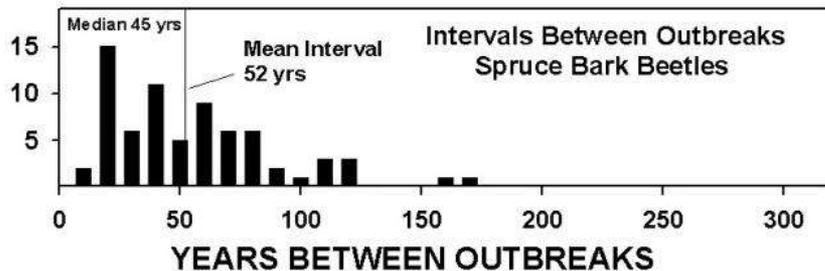
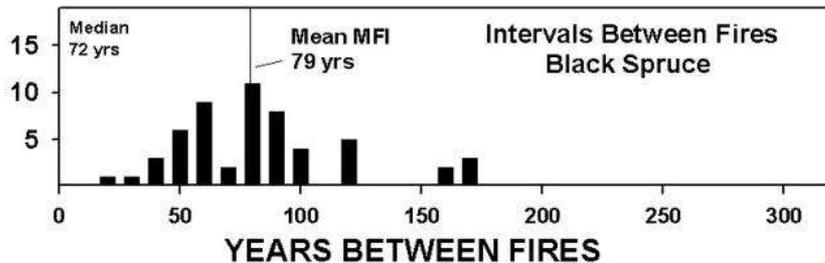
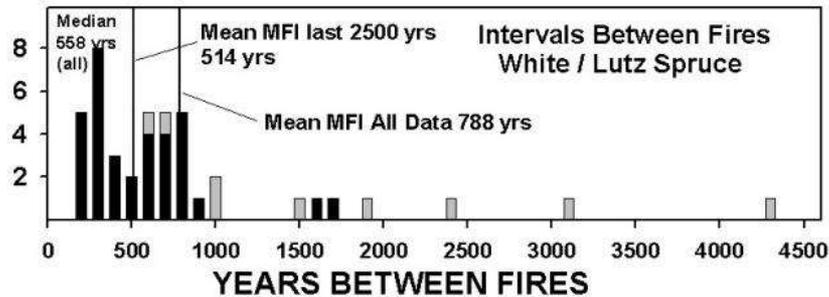
- decreasing available water (60% loss since 1968)
- drying wetlands (6 – 11% per decade)
- receding glaciers (11% surface area, 21m elevation, +55% thinning rate)
- + rising treeline (1m/yr), shrubline (2.8m/yr)
- + unprecedented SB beetle outbreak (triggered by 2 consecutive warm summers)



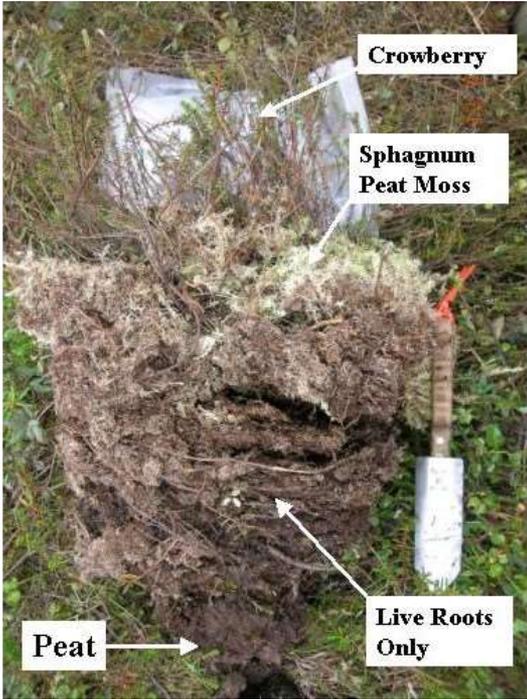
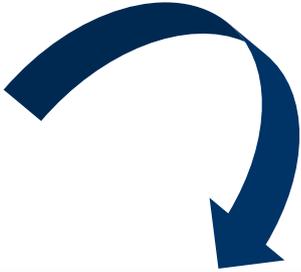
Conversion of white/Lutz spruce forests to Calamagrostis savannah



Official fire season is now April 1 instead of May 1



Woody shrub encroachment into 8000 year old Sphagnum peatlands

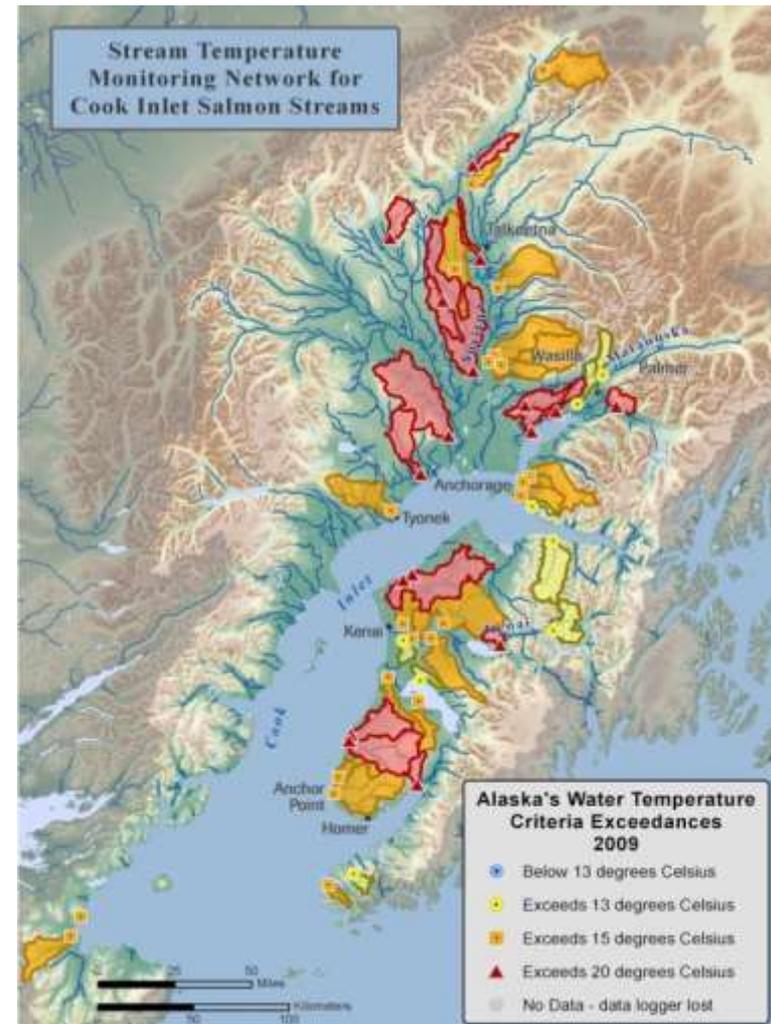


Salmon in 47 of 48 non-glacial streams experience thermal stress in July



Maximum temperatures not to be exceeded:

- egg & fry incubation = 13°C
- spawning areas = 13°C
- migration routes = 15°C
- rearing areas = 15°C
- and may not exceed 20°C at any time



Changing migration window in last decade



eBird data

- ✓ Earlier arrival records for 33 species
- ✓ Later departure records for 38 species
- ✓ 27 new species since 2007

Eurasian-collared dove*
Redwing*
Jack snipe*
Skylark*
Long-billed murrelet*
Black-tailed godwit*
Northern mockingbird
Spotted towhee
Turkey vulture
Western kingbird
Western meadowlark
Willow flycatcher
Northern wheatear
Western tanager
Yellow-bellied sapsucker
Warbling vireo
Swamp sparrow
Tennessee warbler
Cape May warbler
Nashville warbler
Wilson's phalarope
Great egret
Willet
Red-footed booby
Black guillemot
Heerman's gull
Lesser black-backed gull

Some harvested species likely to change in abundance



Dall sheep



American marten



Caribou

Some harvested species likely to change in abundance



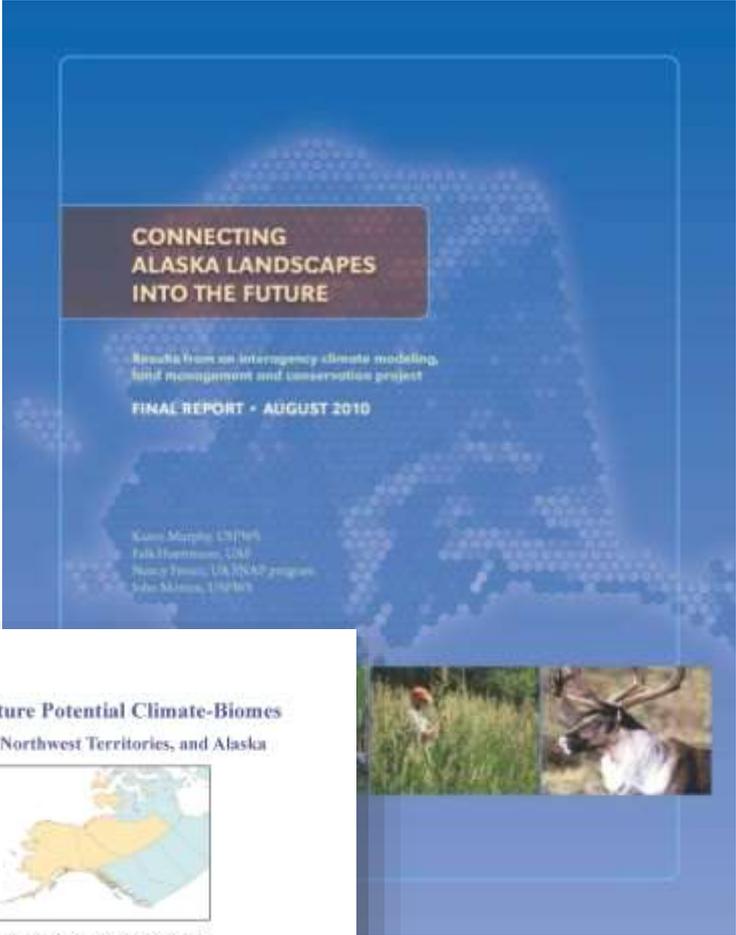
Alpine habitat loss and novel pathogen

Warmer winter nights in Lowlands



Wetter and more snow at high elevations

Interagency effort to assess climate change effects on biome distributions using climate envelope models



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



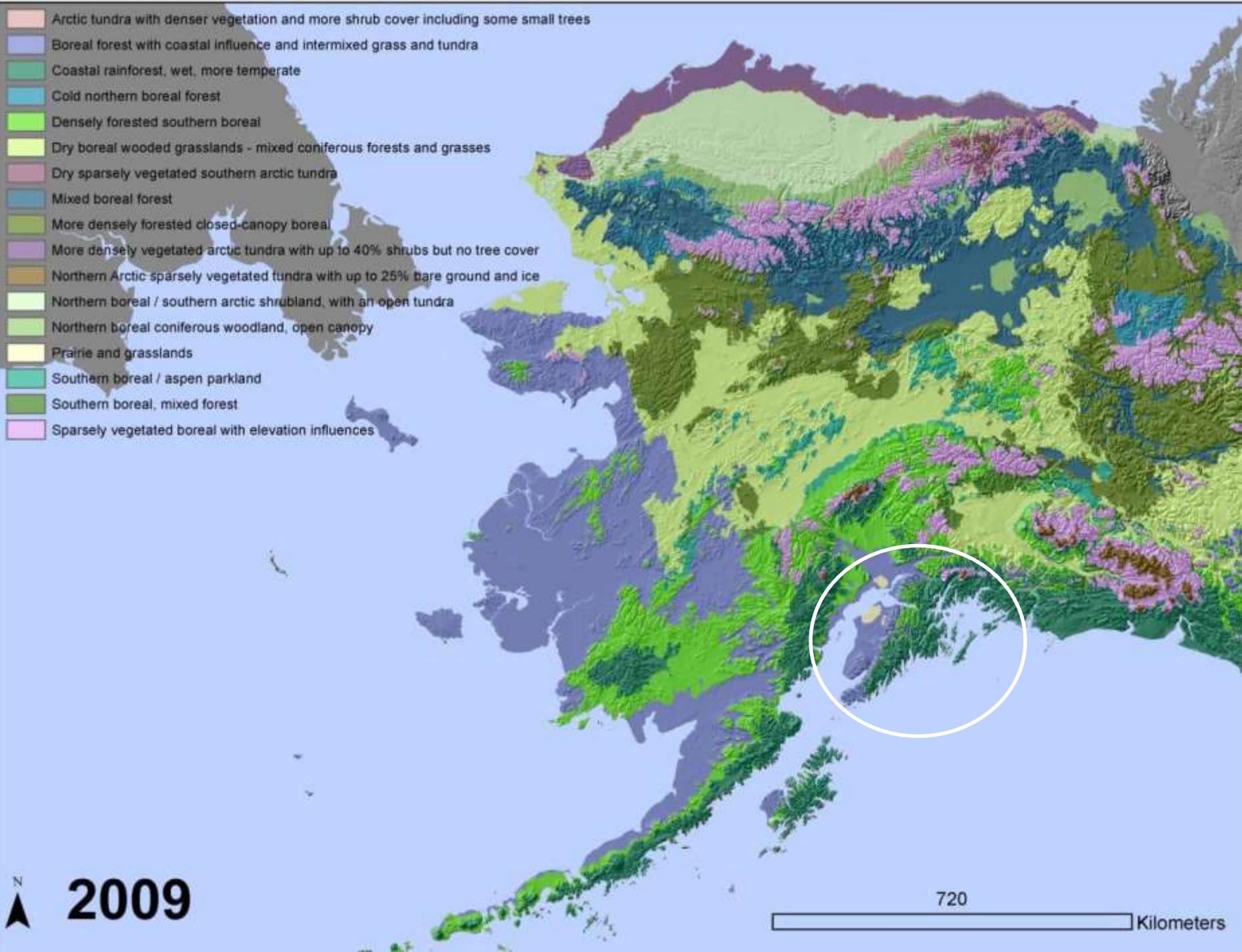
2012



- 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

2009

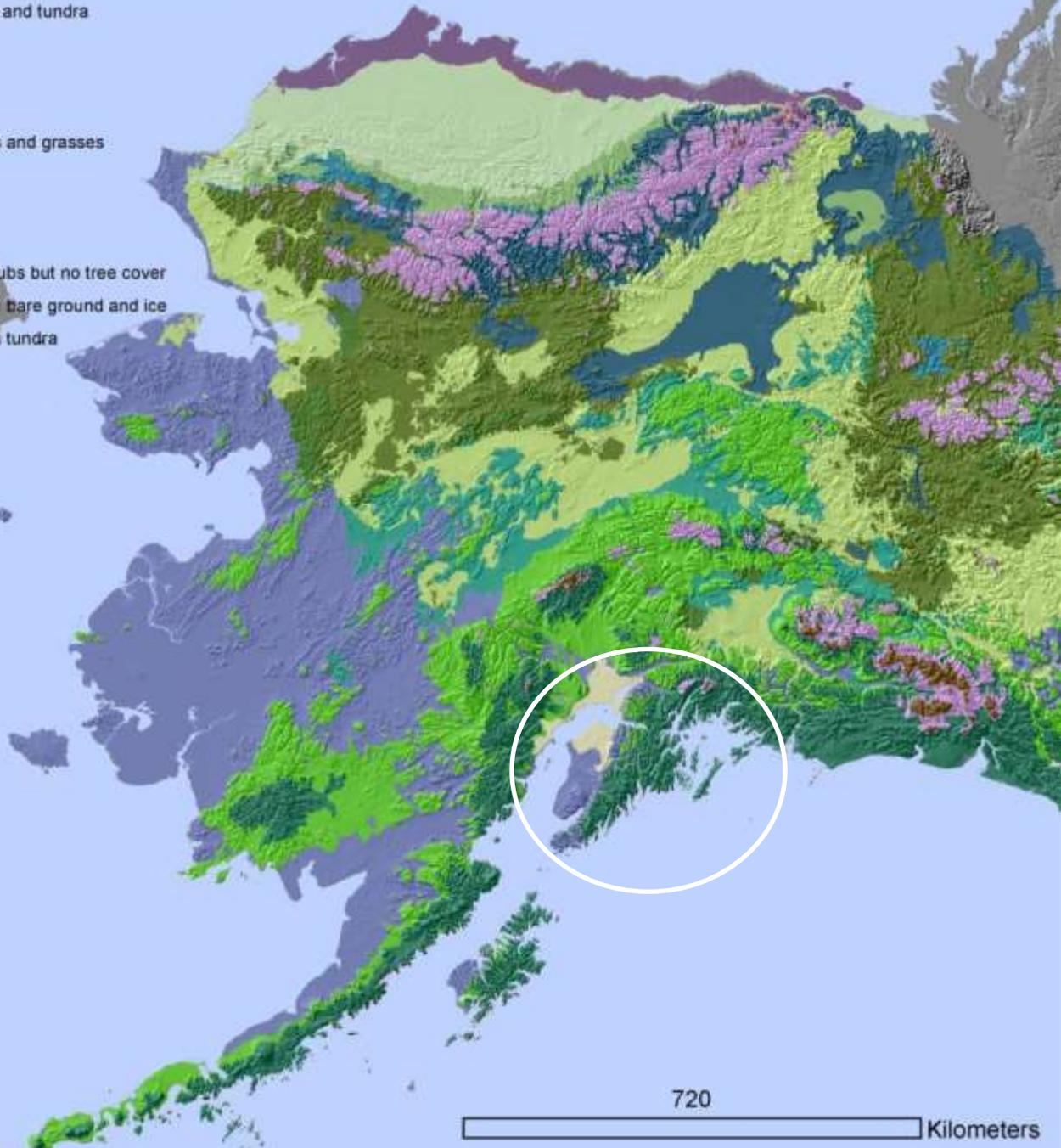
720 Kilometers



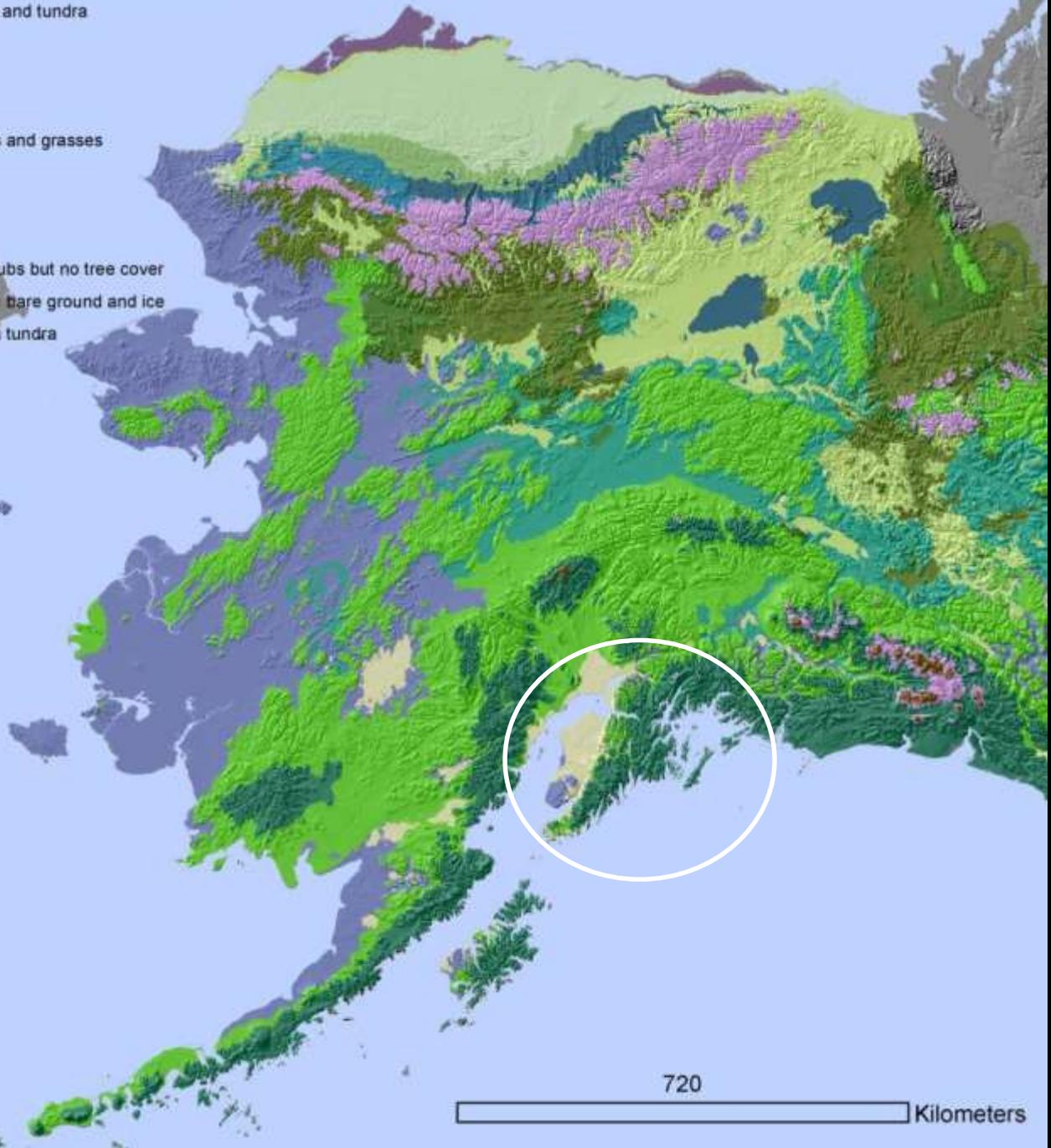
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2039

720 Kilometers



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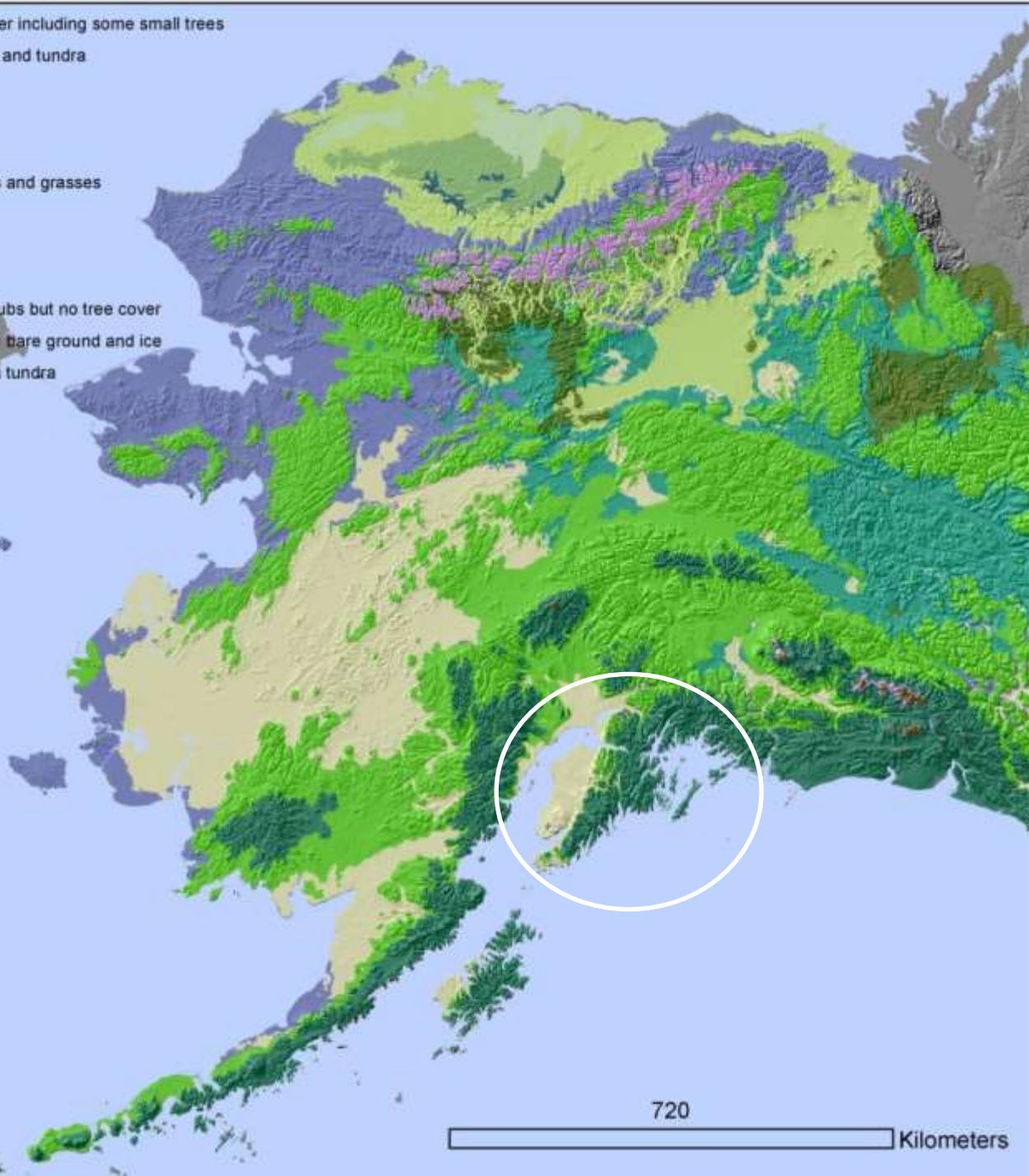
2069

720 Kilometers

- Arctic tundra with denser vegetation and more shrub cover including some small trees
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2099

720 Kilometers





By 2100...

- ✓ only 25% of Alaska remains as biome refugia
- ✓ eastern Kenai and Prince Williams Sound remains rainforest
- ✓ western Kenai converts to grasslands from boreal forest

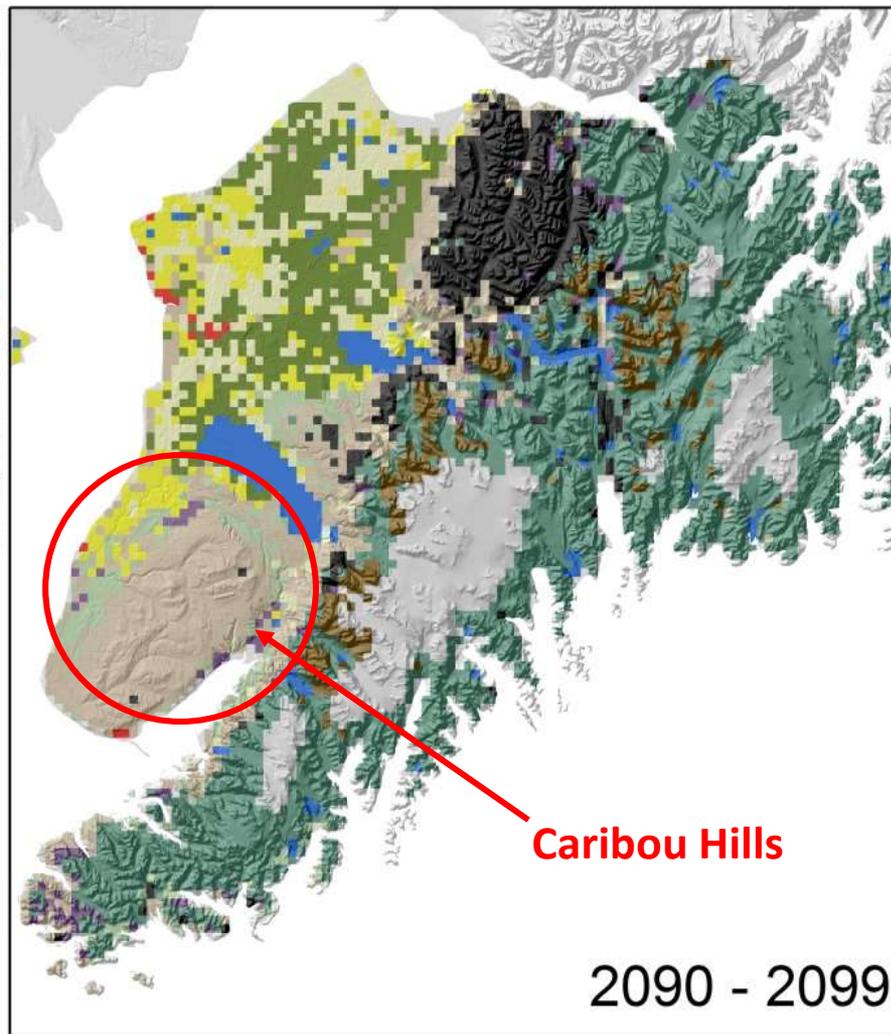
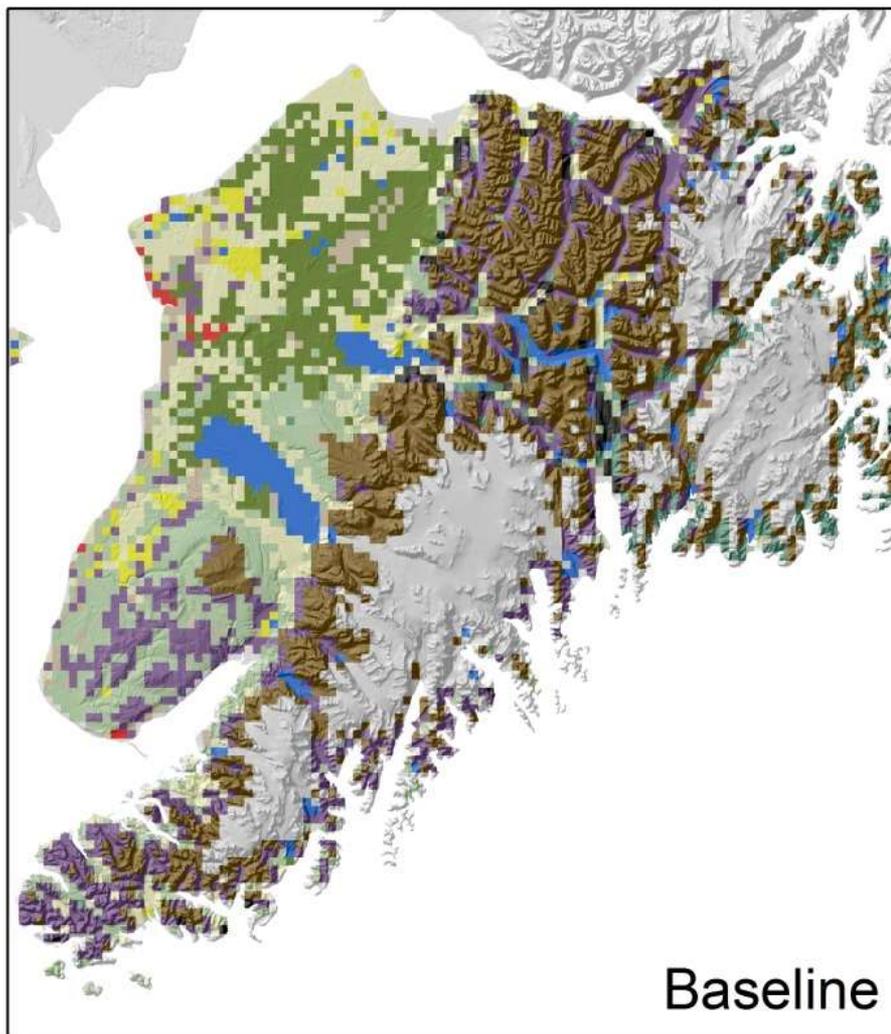
2099



Forecasting the Kenai Peninsula's landscape through 2100

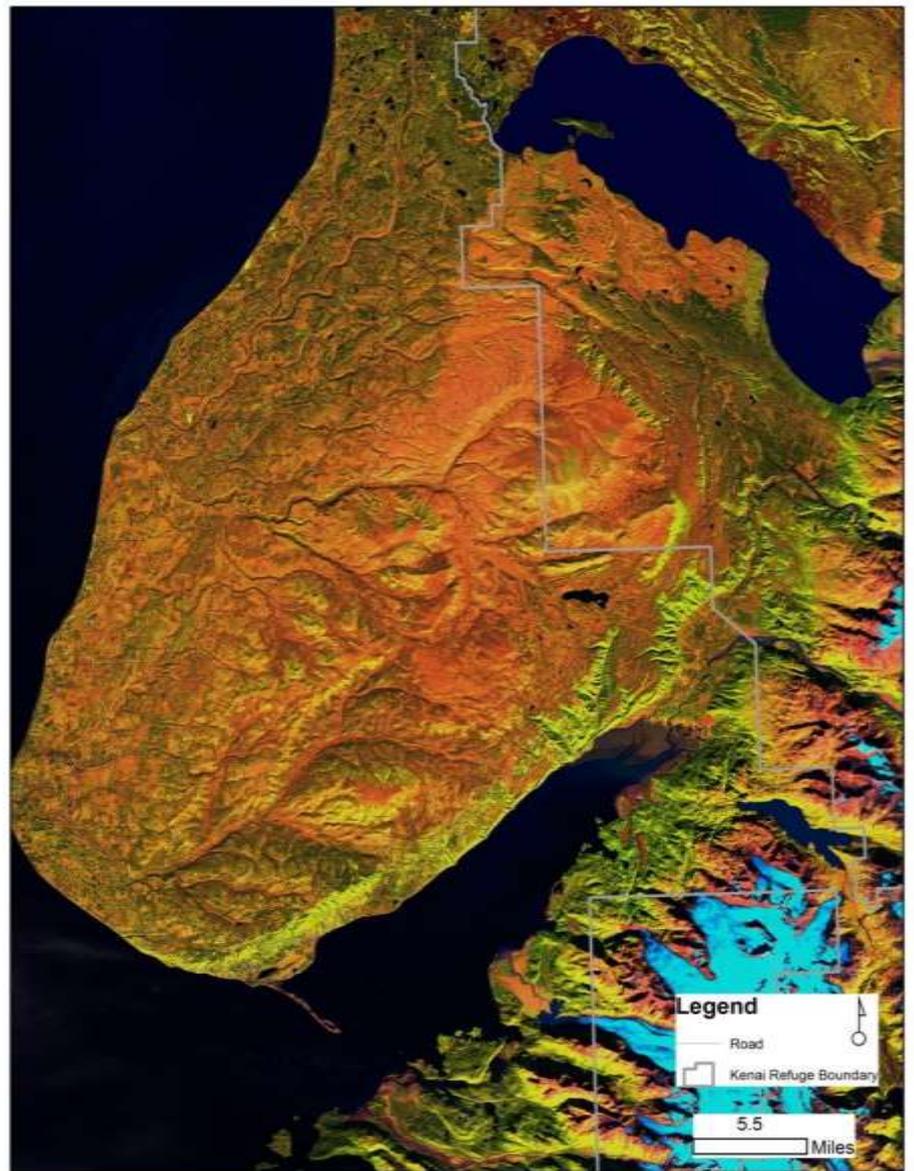
- ✓ Climate envelope modeling using Random Forests™
- ✓ A1B scenario decadal averages for temperature, precipitation (SNAP)
- ✓ landcover type with greatest % cover in 2km pixels
- ✓ if previous landcover type for each timestep (2039, 2069, 2099) $P > 0.5$ then stay; if $P < 0.5$ then landcover type with highest probability







SEPT 1985



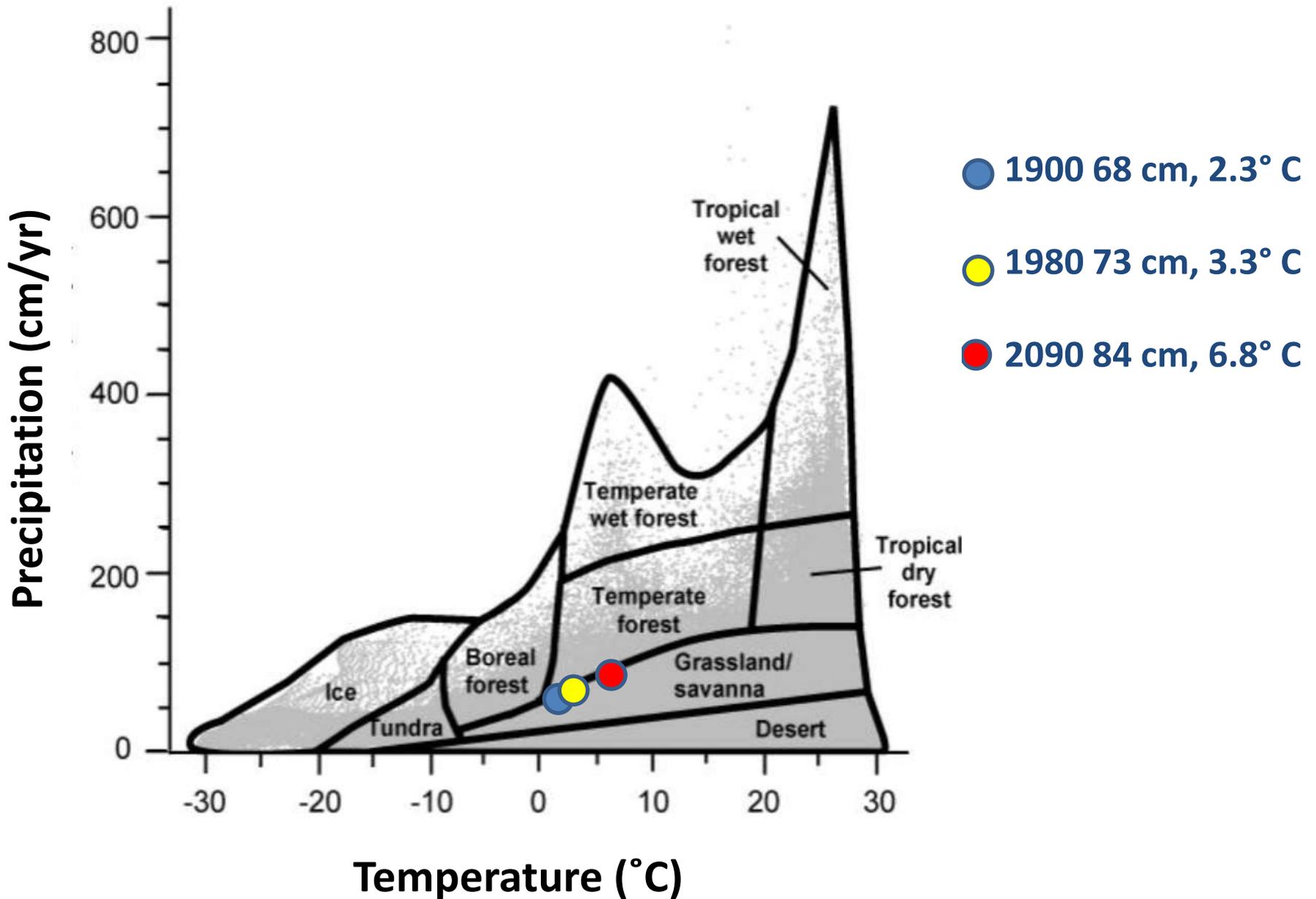
SEPT 2014



2015/07/19

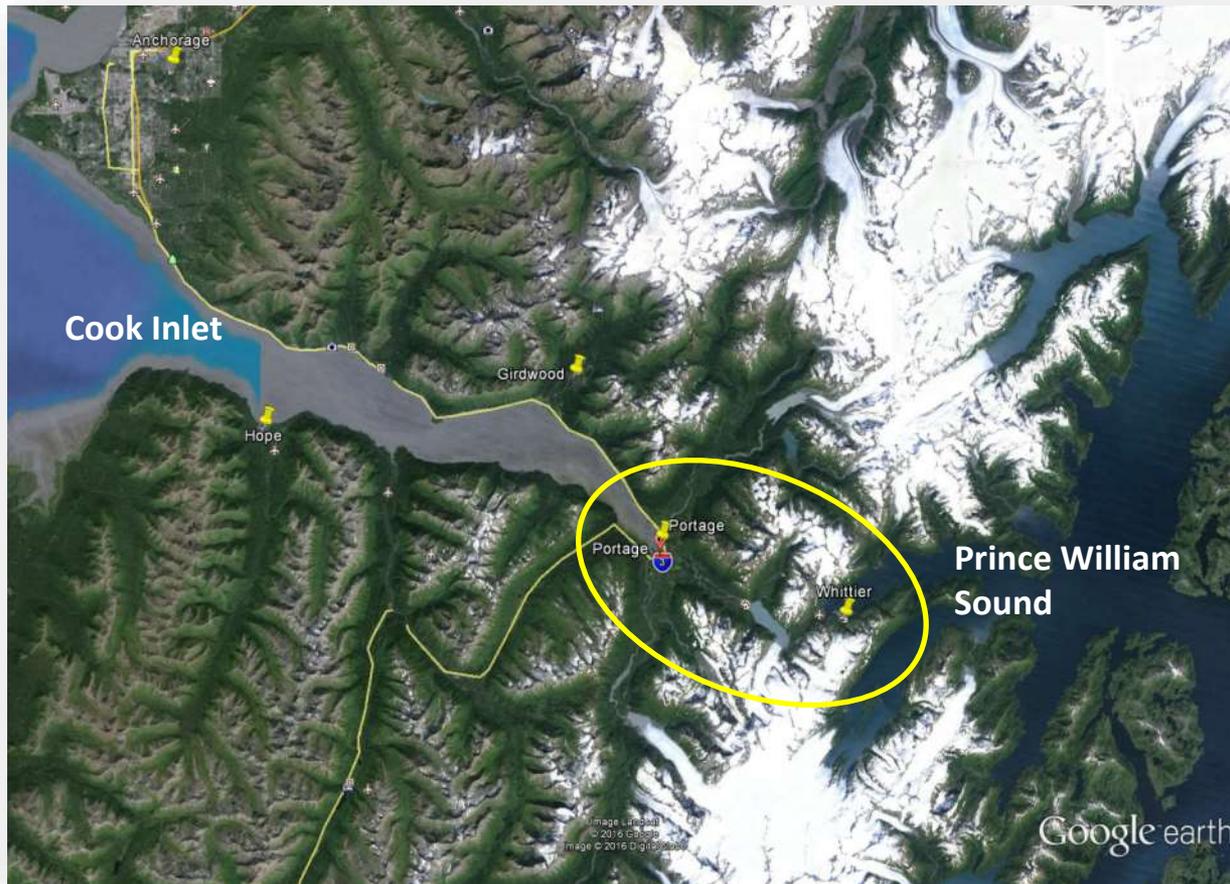






Staudinger et al. (2012). Impacts of Climate Change on Biodiversity, Ecosystems, and Ecosystem Services: Technical Input to the 2013 National Climate Assessment

10-mile wide isthmus is a migration barrier



Wilson et al. 2015



Tomasik and Cook 2005



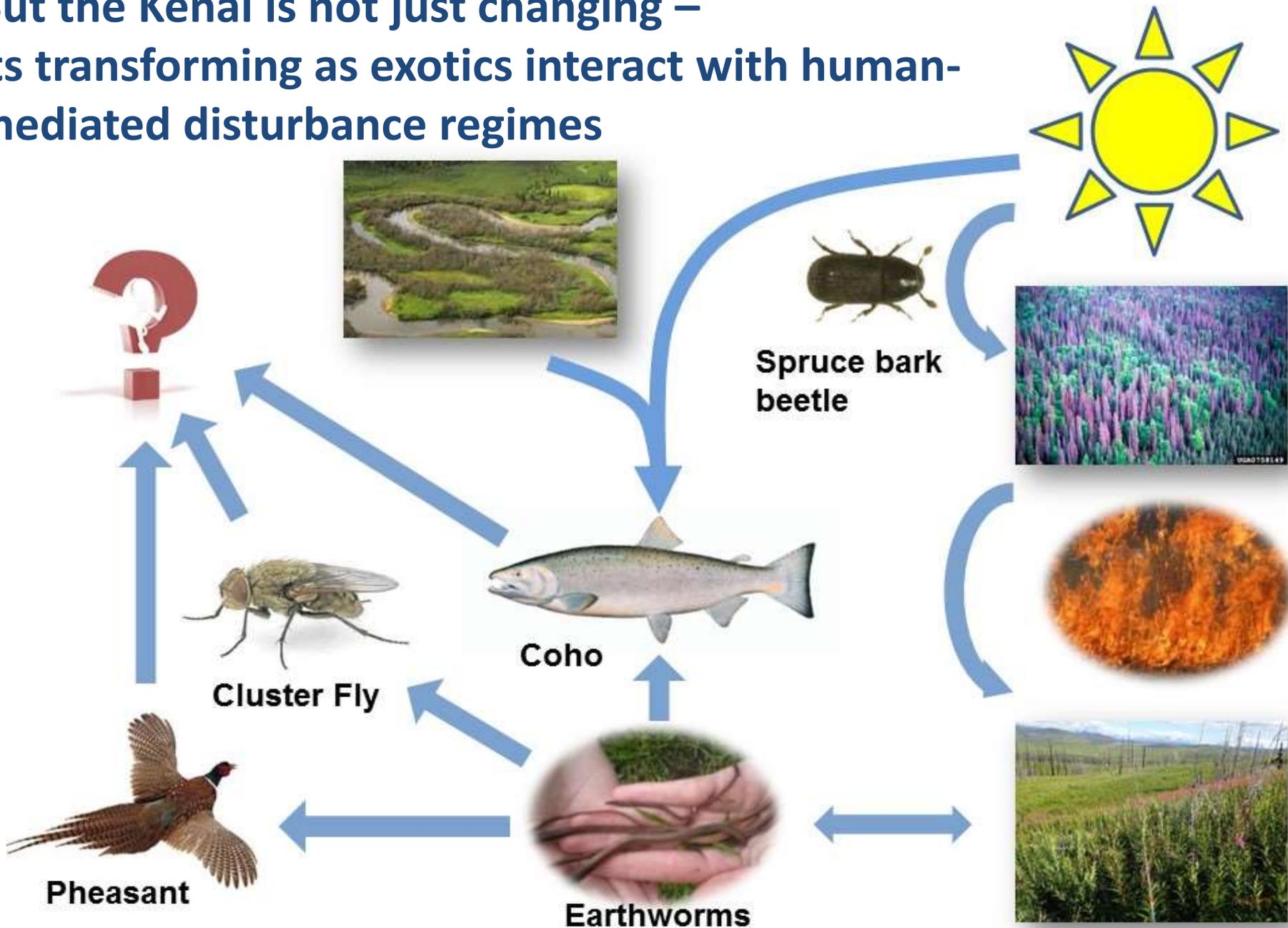
Jackson et al. 2008



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



But the Kenai is not just changing –
its transforming as exotics interact with human-
mediated disturbance regimes



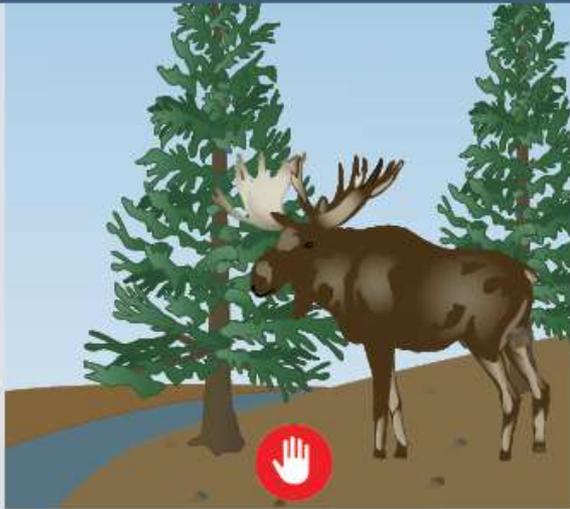
The RAD Decision Framework

RESIST

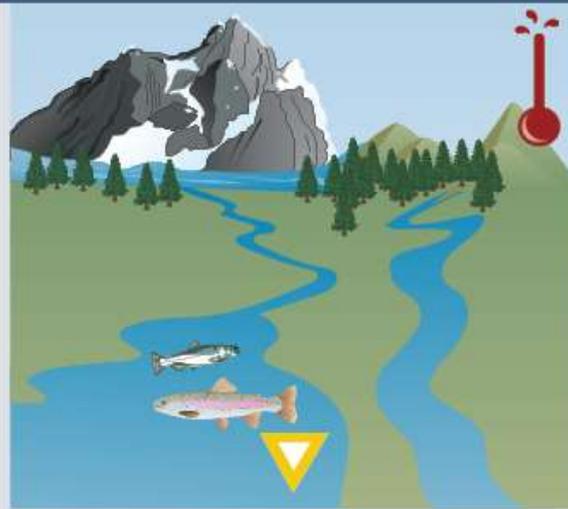
ACCEPT

DIRECT

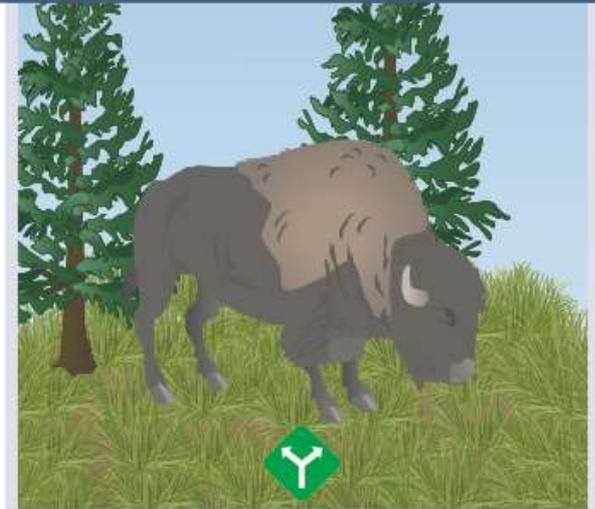
Kenai Peninsula, Alaska: A Case Study



Stream banks are restored, some invasive species are eradicated, fire is managed progressively, and landscape connectivity is maintained through fish and wildlife passages under or over highways. Many invasives are not managed either due to infeasibility or lack of perceived threat.



Glaciers are melting, non-glacial streams are warming, tree line is rising, and wetlands are drying. Yet, the effects have not been severe enough to prompt a management response. Society has accepted the changes in fish and wildlife communities, even with higher costs to ecosystem services.



A spruce bark beetle epidemic and human-caused fire have shifted white spruce forests into a novel grassland ecosystem. Non-native trees are being planted, and the introduction of large grazers is being considered to stabilize the new grasslands and related communities.

Questions????

