

A larger context (RAD) to local-scale climate adaptation actions (BDA)



John Morton, PhD



A new way of thinking about adapting to climate change



Responding to Ecosystem Transformation: Resist, Accept, or Direct?

FEATURE

Laura M. Thompson | U.S. Geological Survey, National Climate Adaptation Science Center | University of Tennessee, Department of Forestry, Wildlife and Fisheries, Knoxville, TN, E-mail: lthompson@usgs.gov

Alfred J. Lynch | U.S. Geological Survey, National Climate Adaptation Science Center, Reston, VA

Eric A. Brewer | U.S. Geological Survey, Northern Rocky Mountain Science Center, Bozeman, MT | Montana State University, Department of Ecology, Bozeman, MT

Angela C. Eganow | University of Tennessee, Department of Forestry, Wildlife and Fisheries, Knoxville, TN

Jeffrey A. Fahrig | U.S. Geological Survey, Alaska Cooperative Fish and Wildlife Research Unit | University of Alaska, Fairbanks, Fairbanks, AK

Stephen J. Jackson | U.S. Geological Survey, Southeast and South Central Climate Adaptation Science Centers, Reston, VA | University of Arizona, Department of Geosciences and School of Natural Resources and Environment, Tucson, AZ

Trevor J. Kivshinich | University at Buffalo, Department of Biological Sciences and Robert Roswell, Buffalo, NY

David J. Lawrence | National Park Service, Climate Change Response Program, Fort Collins, CO

Before and after photos of a coral bleaching event in American Samoa. Photo credit: The Ocean Agency/USL Catin Seawave Survey. © 2016 National Park Service. The photo has been modified to fit USGS content requirements and does not work in the public domain as it is.

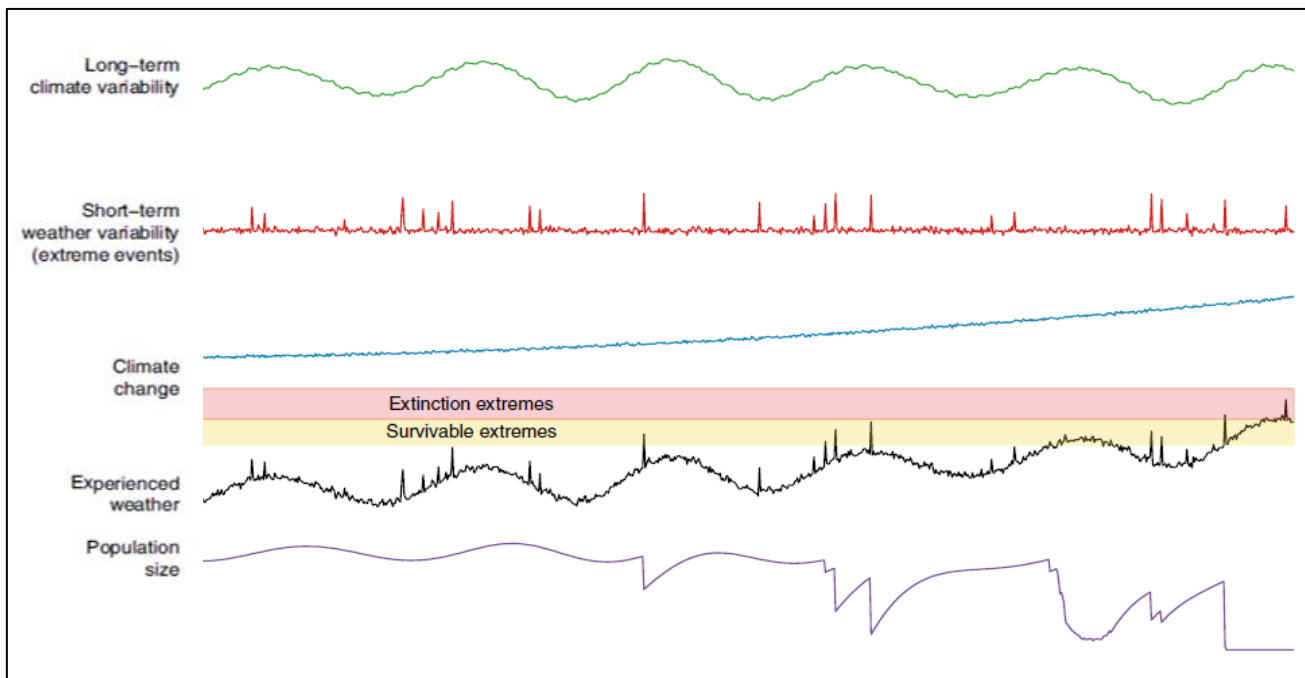
FRONTIS | www.iberlin.org |

Natural Resource Stewardship and Science

Resist-Accept-Direct (RAD)—A Framework for the 21st-century Natural Resource Manager

Natural Resource Report NPS/NRSS CCRP/NRR—2020/2213

RAD addresses Directional Change and Ecological Transformation



Directional Change
unrelenting and unprecedented change in key drivers of ecological conditions

Ecological Transformation
“a dramatic, persistent, and statistically ‘extreme’ shift in multiple ecological characteristics, the basis of which is dramatic changes in species composition”

Harris et al. 2018. Nature Climate Change 8:579-587

RAD is a decision framework

"One day Alice came to a fork in the road and saw a Cheshire cat in a tree.

'Which road do I take?' she asked.

'Where do you want to go?' was his response.

'I don't know', Alice answered.

'Then', said the cat, 'it doesn't matter.'"



RAD framework squarely assigns the adaptation response to a managerial/societal decision

RESIST	ACCEPT	DIRECT
<p>Many changes will be RESISTED by managers, to maintain ecosystem processes, function, and composition toward a <u>historical</u> baseline</p>	<p>Many changes will be ACCEPTED by managers, perhaps because...</p> <ul style="list-style-type: none"> • Infeasible to be managed • insufficiently impactful to warrant response • acceptable to (even desirable by) stakeholders • unknowingly occurring • lack of will or impetus despite sufficient knowledge or resources 	<p>Some changes will be DIRECTED by managers toward a specific <u>future</u> state because...</p> <p>so dramatic that resisting is untenable and there is a feasible opportunity to steward change towards a more desirable outcome than what would be achieved with acceptance</p>

...with the goal of a self-sustaining, self-organizing system

Crib Notes

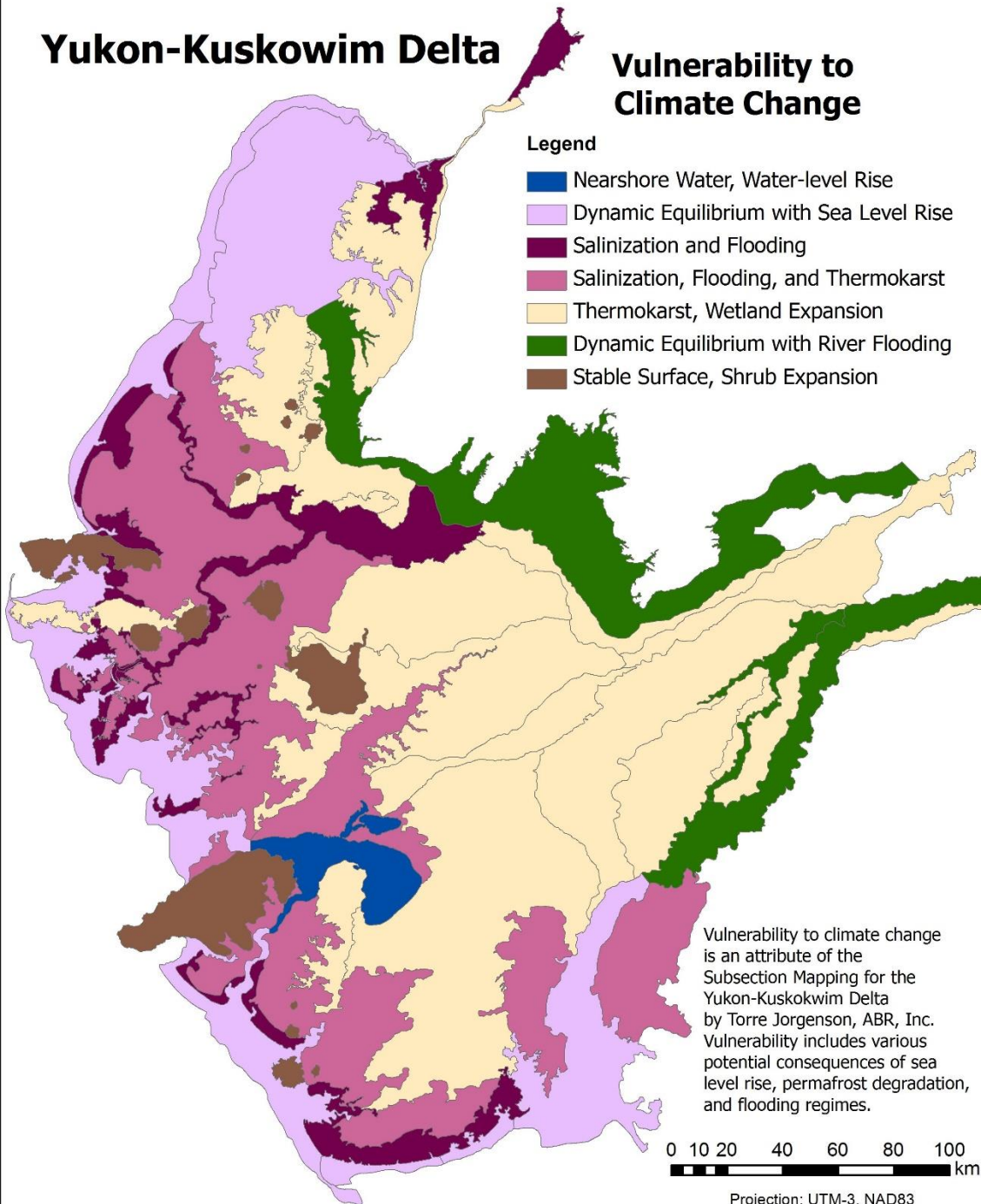
- 1) Goal is a self-sustaining, self-organizing system; not continual intervention
- 2) Three bins are all encompassing (i.e., nothing outside decision space), mutually exclusive, and NOT a continuum
 - however, one or all three bins can be applied sequentially or concurrently (i.e., portfolio approach)
 - comparison is among the three choices (all of which involve change), not with a static historic or natural baseline
 - awareness of all three bins promotes bet hedging
- 3) Technology (or the absence of it) does not dictate whether approach is R, A or D
- 4) ACCEPT does not imply the absence of management
- 5) Decision paralysis because of uncertainty is NOT an option; consider experimentation to test ecological outcomes and/or pilot studies of novel climate adaptation that can be scaled up (if successful)

Yukon-Kuskowim Delta

Vulnerability to Climate Change

Legend

- Nearshore Water, Water-level Rise
- Dynamic Equilibrium with Sea Level Rise
- Salinization and Flooding
- Salinization, Flooding, and Thermokarst
- Thermokarst, Wetland Expansion
- Dynamic Equilibrium with River Flooding
- Stable Surface, Shrub Expansion



Vulnerability to climate change is an attribute of the Subsection Mapping for the Yukon-Kuskokwim Delta by Torre Jorgenson, ABR, Inc. Vulnerability includes various potential consequences of sea level rise, permafrost degradation, and flooding regimes.

0 10 20 40 60 80 100 km

Projection: UTM-3, NAD83

Predicted changes on Y-K Delta

- ✓ ~40% of 18.2 million acres subject to salinization, flooding and sea-level rise
- ✓ Sea level will rise 0.5-1 m
- ✓ Decreasing winter sea ice and open water throughout winter
- ✓ Storm flooding season all year
- ✓ Overbank flooding on biweekly basis affecting nesting birds
- ✓ Loss of fresh drinking water and camping sites
- ✓ Permafrost mostly gone by 2040
- ✓ Loss of important bird nesting habitats
- ✓ Increased tundra fires
- ✓ **Coastal erosion/flooding of villages**

Same problem but three structural adaptation approaches



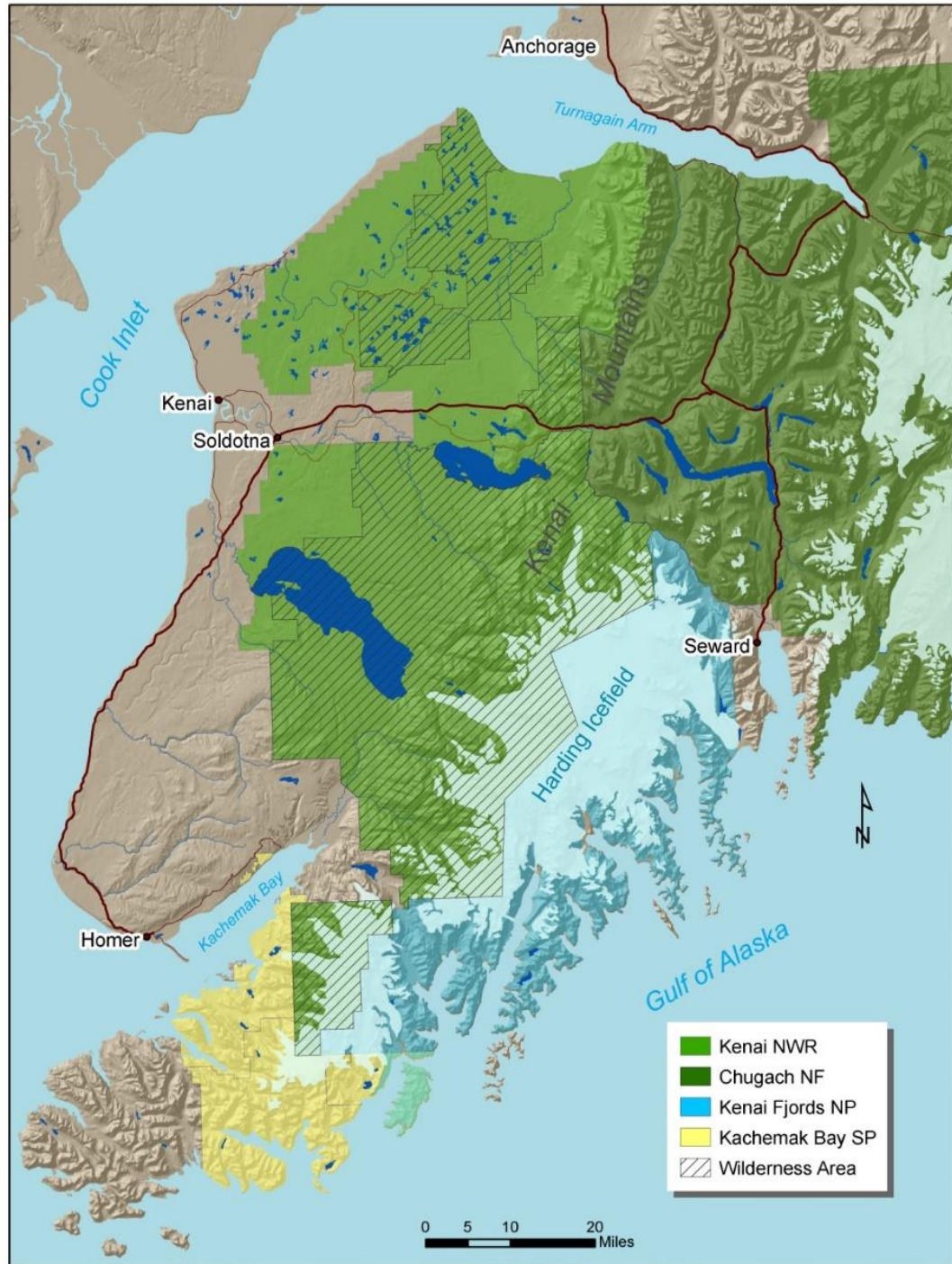
RESIST: Hard armoring of Kivalina



ACCEPT: Allow the loss of Newtok



DIRECT: Construct Evacuation Road/Center at Mertarvik

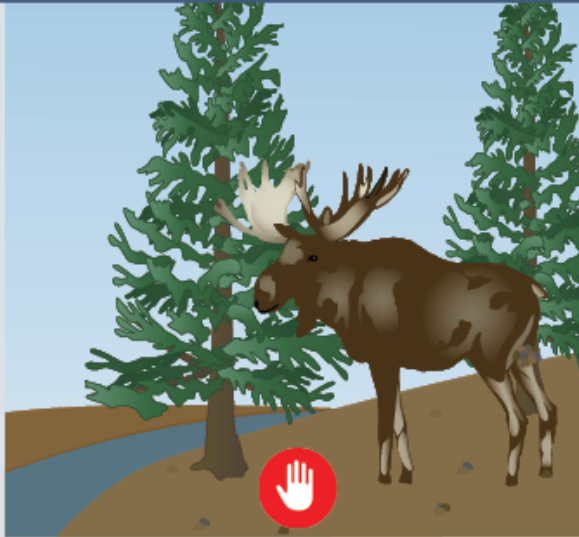


RESIST

ACCEPT

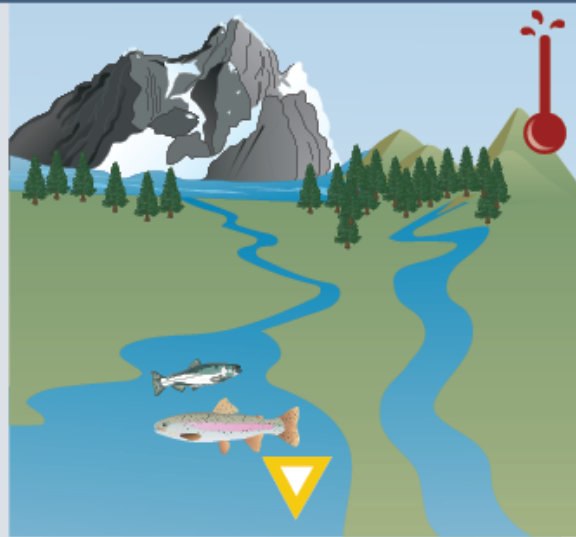
DIRECT

Kenai Peninsula, Alaska: A Case Study



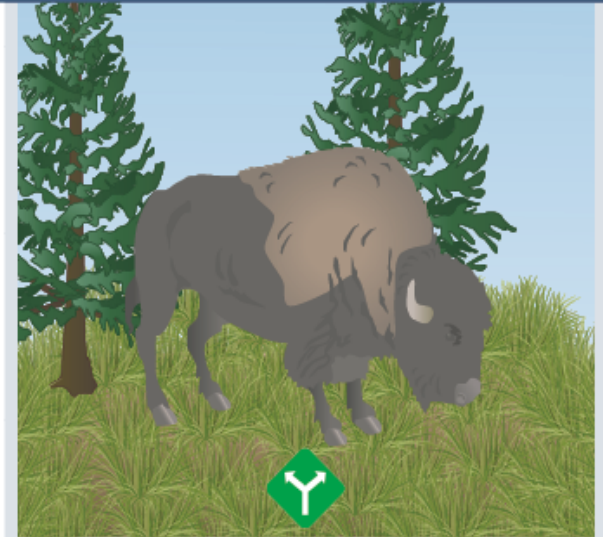
Stream banks are restored, some invasive species are eradicated, fire is managed progressively, and landscape connectivity is maintained through fish and wildlife passages under or over highways. Many invasives are not managed either due to infeasibility or lack of perceived threat.

Conventional management issues



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.

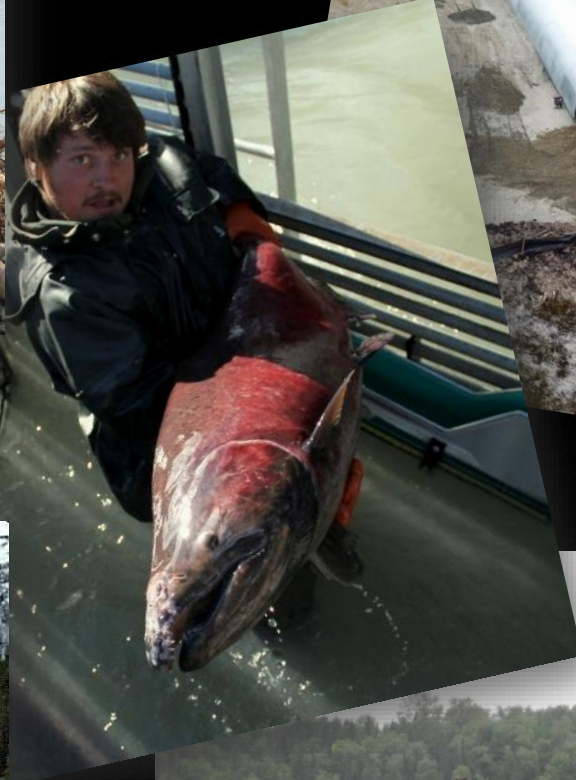
Most ecological responses to climate change (directional)



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.

Deforestation (transformational)

RESIST



RESIST



DIRECT



DIRECT

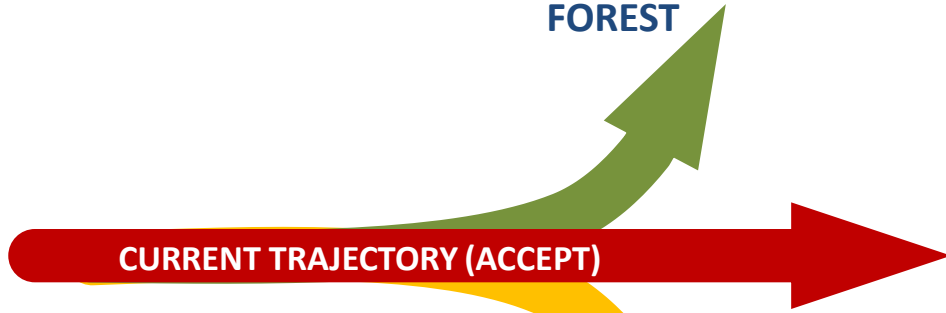


LOGEPOLE PINE



BLACK-TAILED DEER

FOREST



PRESCRIBED FIRE

GRASS



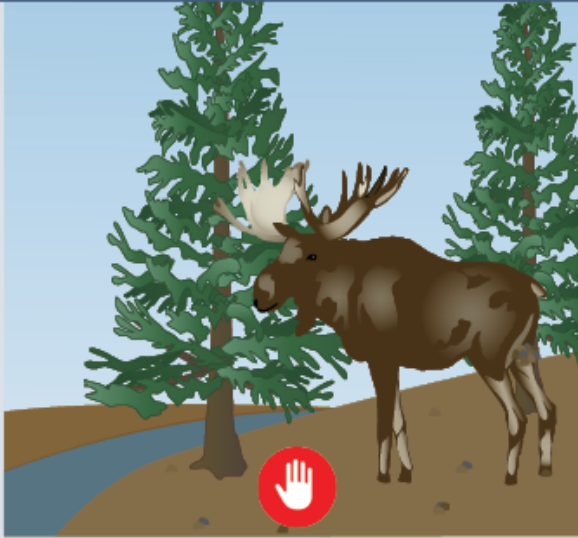
INTRODUCED GRAZERS

RESIST

ACCEPT

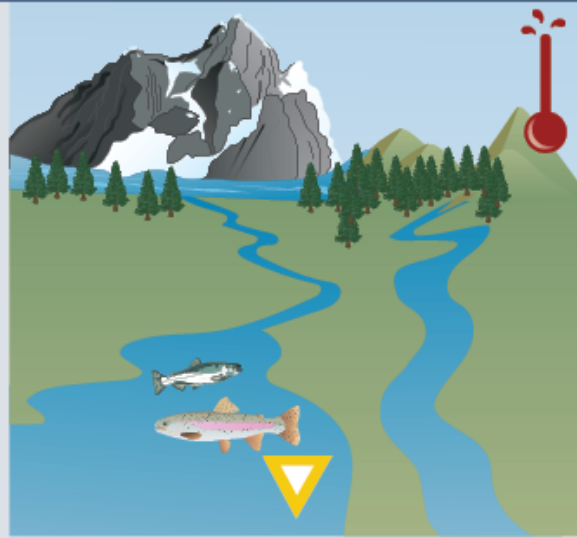
DIRECT

Kenai Peninsula, Alaska: A Case Study



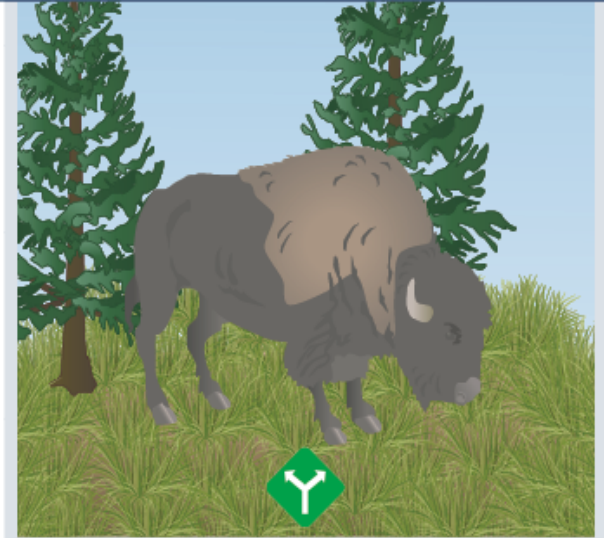
Stream banks are restored, some invasive species are eradicated, fire is managed progressively, and landscape connectivity is maintained through fish and wildlife passages under or over highways. Many invasives are not managed either due to infeasibility or lack of perceived threat.

Conventional management issues



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.

Most ecological responses to climate change



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.

Deforestation

Dramatic changes in last 5 decades in response to warming and drying



- annual available water declines (62% loss since 1968)
- wetlands dry (6 – 11% per decade), peatlands afforest
- glaciers recede (11% surface area, 21 m elevation)
- + nonglacial salmon streams warm (17 of 48 sublethal in July)
- + afforestation (trees~1 m per yr, shrubs~2.8 m per yr)
- + spruce bark beetle outbreaks (triggered by 2 consecutive warm summers)
- Δ fire regime (lightning, grass, spring, shorter MFRI)



Dramatic changes in last 5 decades in response to warming and drying



- annual available water declines (60% loss since 1968)
- **wetlands dry (6 – 11% per decade), peatlands afforest**
- glaciers recede (11% surface area, 21 m elevation)
- + nonglacial salmon streams warm (17 of 48 sublethal in July)
- + afforestation (trees~1 m per yr, shrubs~2.8 m per yr)
- + spruce bark beetle outbreaks (triggered by 2 consecutive warm summers)
- Δ fire regime (lightning, grass, spring, shorter MFRI)



RESIST: Could engineering by beavers and humans recharge drying peatlands?



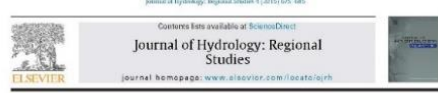
Analyzing peatland discharge to streams in an Alaskan watershed: An integration of end-member mixing analysis and a water balance approach

Michael B. Garcia^{1,2,3,4}, Mary F. Meffert¹, Donald I. Siegel¹, Paul H. Glaser^{5,6}

¹Department of Biology, University of Pennsylvania, 3441 South University Avenue, Philadelphia, PA 19104, USA
²Department of Earth Science, University of Minnesota, Duluth, MN 55812, USA
³Department of Geological Engineering and Science, Stanford University, 380 Serra Mall, Stanford, CA 94305, USA
⁴Department of Earth Science, University of California, Berkeley, CA 94720, USA
⁵Department of Earth Science, University of Minnesota, Duluth, MN 55812, USA
⁶Department of Earth Science, University of Minnesota, Duluth, MN 55812, USA

ARTICLE INFO
 Received 17 May 2015
 Received in revised form 25 September 2015
 Accepted 15 October 2015
 Available online 1 December 2015

KEYWORDS
 Peatlands
 Discharge
 Streamflow
 Water balance
 End-member mixing analysis



Simulating the effects of a beaver dam on regional groundwater flow through a wetland

Kathleen Feiner¹, Christopher S. Lowry¹

¹University of Idaho, 421 Conner Hall, Idaho Falls, ID 83402, USA

ARTICLE INFO
 Received 17 May 2015
 Received in revised form 25 September 2015
 Accepted 15 October 2015
 Available online 1 December 2015

KEYWORDS
 Beaver dam
 Groundwater flow
 Wetland
 Hydrology
 Simulation

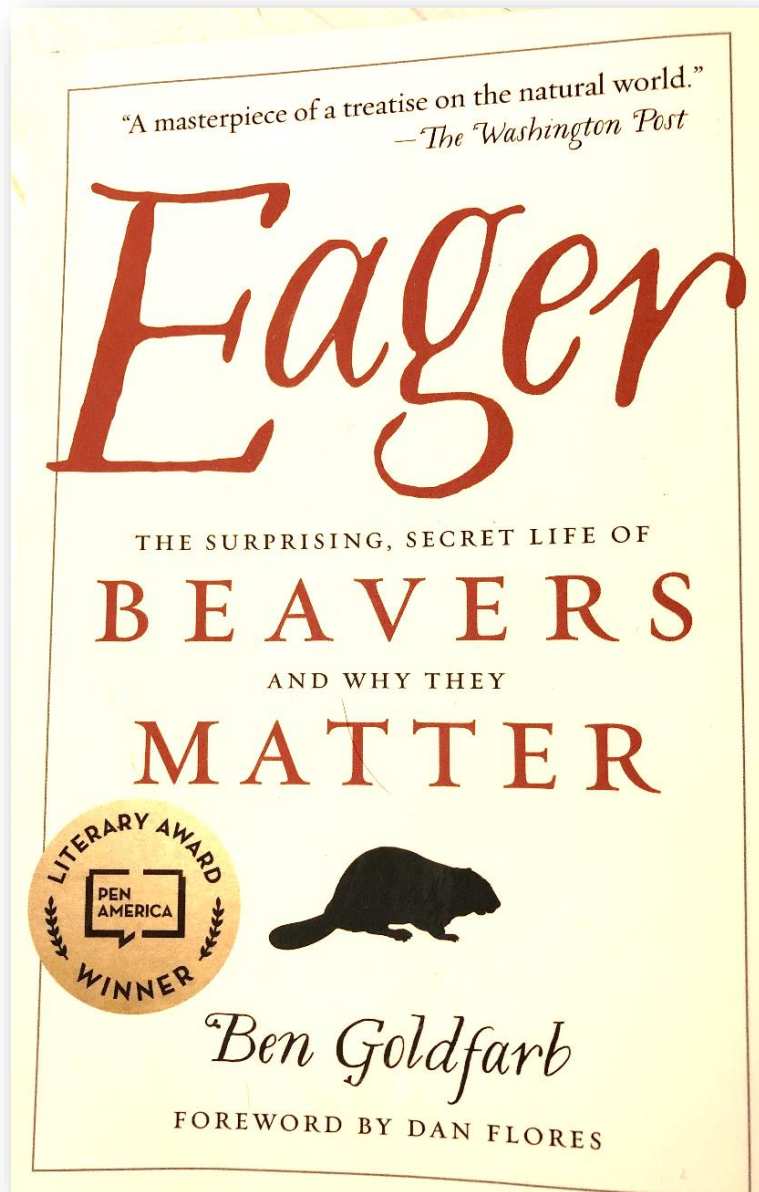
1. Introduction
 The IPCC (2007) predicts a global warming trend that began in the late 1950s century will continue to warm northern regions by as much as 2–4 °C by 2100. Rising air temperatures will probably result in less snow accumulation, particularly during droughts when low base flows are less capable of buffering stream temperatures (Vannote et al., 1980; Jones and Peterson, 2013). In Southwestern Alaska, stream temperatures have already exceeded the threshold for spawning hils shiners (*Oncorhynchus tshawytscha*) during the yearly dry season (Savage, 2005), and the type of environmental stress may be more extensive. Shorter dry seasons may increase stream anoxic conditions and affect discharge elements, affecting the relative contribution from different discharge elements to streamflow discharge (Savage, 2005). Other explanations for the relationship between peatlands and lower stream flows during dry seasons are (a) reduced water storage in the relatively porous upper layers of peat deposits (Dun, 1997; Ineson, 1997; Ineson et al., 1999) and (b) poor drainage related to the low hydraulic gradient and permeability of peat deposits (Johler and Verry, 1977; Szymanski, 1980a; Burt, 1993). In contrast, Jones (1982) reported higher dry season flows in streams

1. Introduction
 The North American beaver (*Castor canadensis*) construct an ecosystem engineer in low gradient streams, building complex and lasting effects through dam building and stream diverting activities (Doall et al., 2005; Jones et al., 1997). A newly constructed beaver dam can change both the distribution of water in a stream system and the groundwater surface water interactions directly surrounding the dam (Cass et al., 2008; Hoover and Doyle, 2008; Jones and Westbrook, 2011). Beavers can have an especially large impact in areas with low topographic gradients where flooding caused by damming can have a widespread effect, such as wetlands and streams with well-connected floodplain (Johnson and Naiman, 1997; Pollock et al., 2003; Westmoreland et al., 2005). Wetlands perform many important functions, such as serving as an intermediary between surface water and groundwater, filtering sediments and toxic substances, such as nitrogen and phosphorus, from surface runoff (Mitsch et al., 2005). In addition, wetlands act as major reservoirs of carbon, holding large quantities in their soils (Silliman et al., 2003). By storing water, wetlands also serve to reduce flood peaks and reduce the risk of flooding downstream (Johler and Kercher, 2003). They also provide an essential habitat for many plant and animal species, including beavers.

Peatlands 55% of streamflow during low flow

Beaver dams increase groundwater discharge 70% (no clay) to 90% (clay pan)



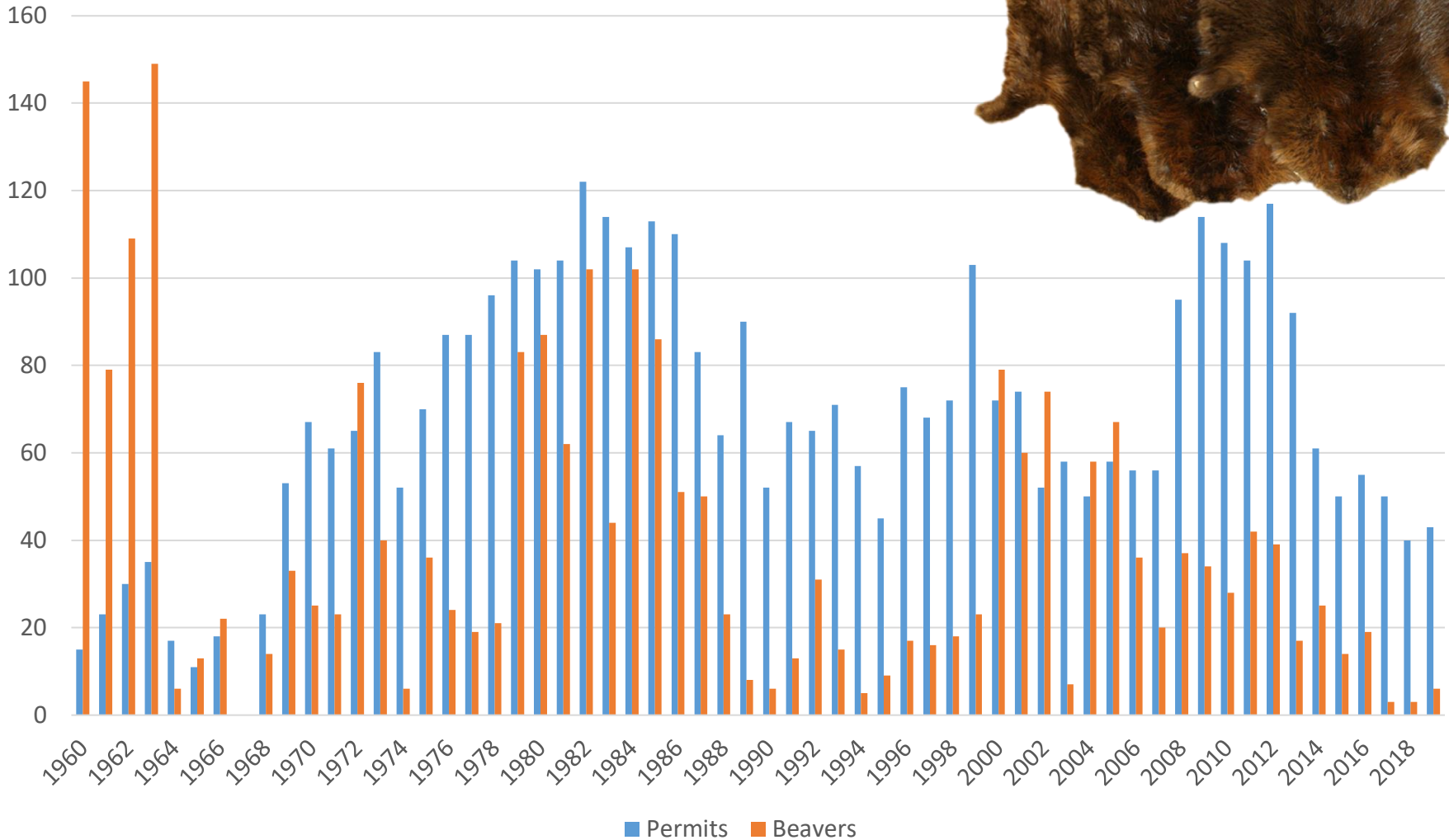


- ✓ 15-250 million ponds in North America
- ✓ 0.1 – 4.5 acre average pond
- ✓ 234,400 miles² ponded water
- ✓ 150m radius (17 acres) stabilized and raised water table

Beaver populations may have been 7 – 30 times higher on the Kenai Peninsula

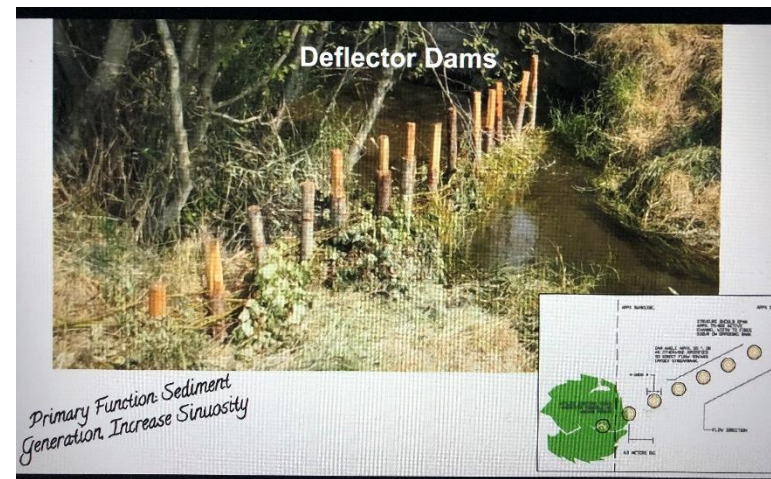
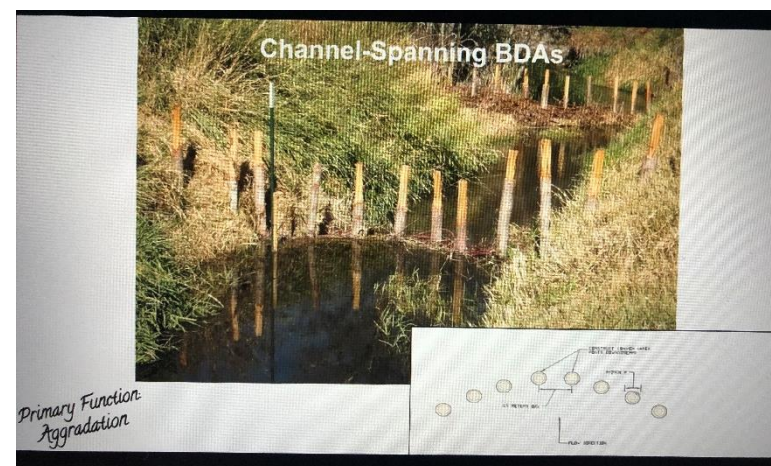


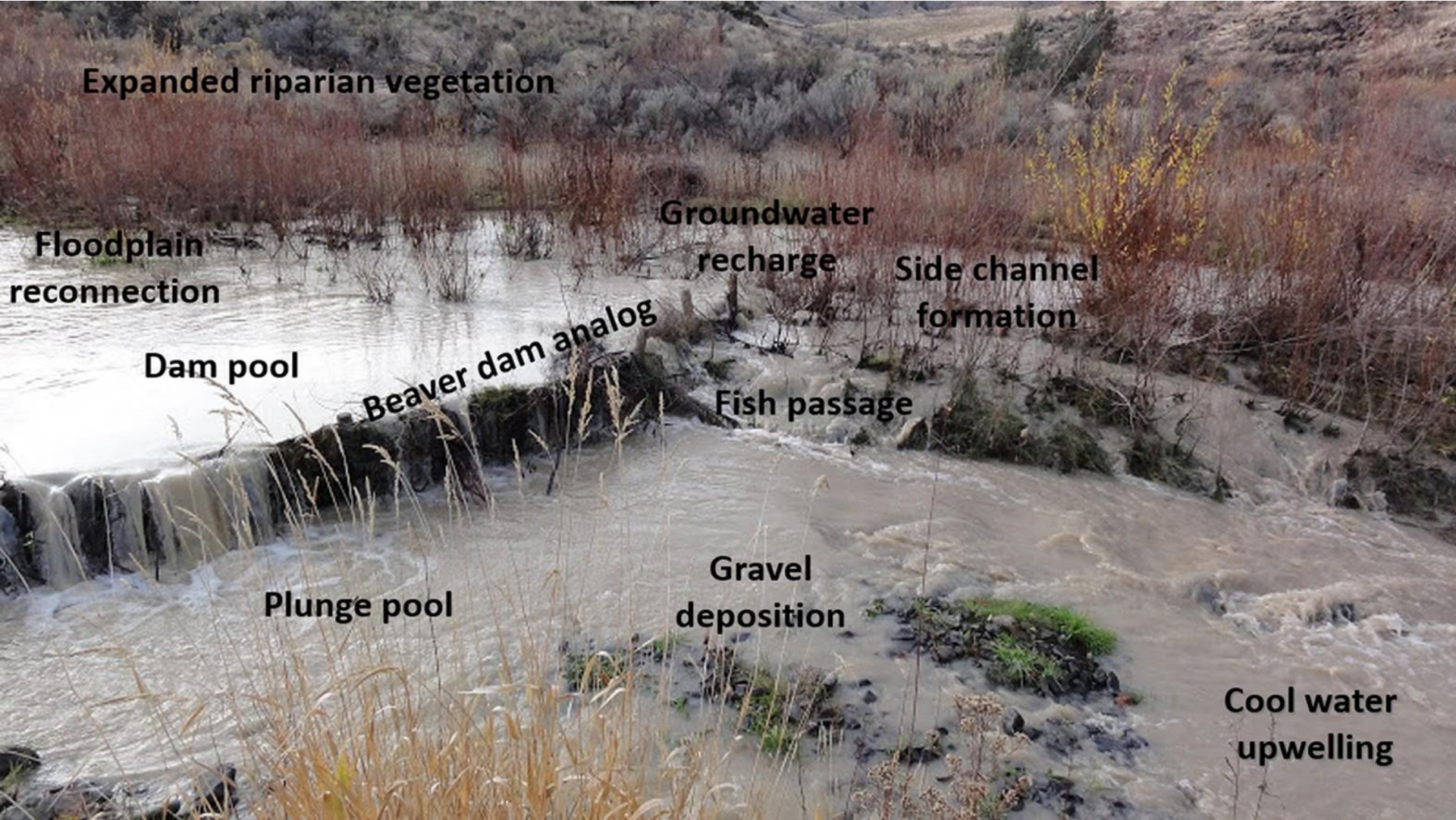
Beaver Harvest on Kenai National Wildlife Refuge



Why Beaver Dam Analog?

- Stream aggradation (incised channels)
- Sediment capture
(post-fire or sediment-prone watersheds)
- Channel complexity for fish habitat
- Wetland creation or expansion
- Water storage (slow release)
- Flood attenuation
- Climate change amelioration





Expanded riparian vegetation

Floodplain
reconnection

Groundwater
recharge

Side channel
formation

Dam pool

Beaver dam analog

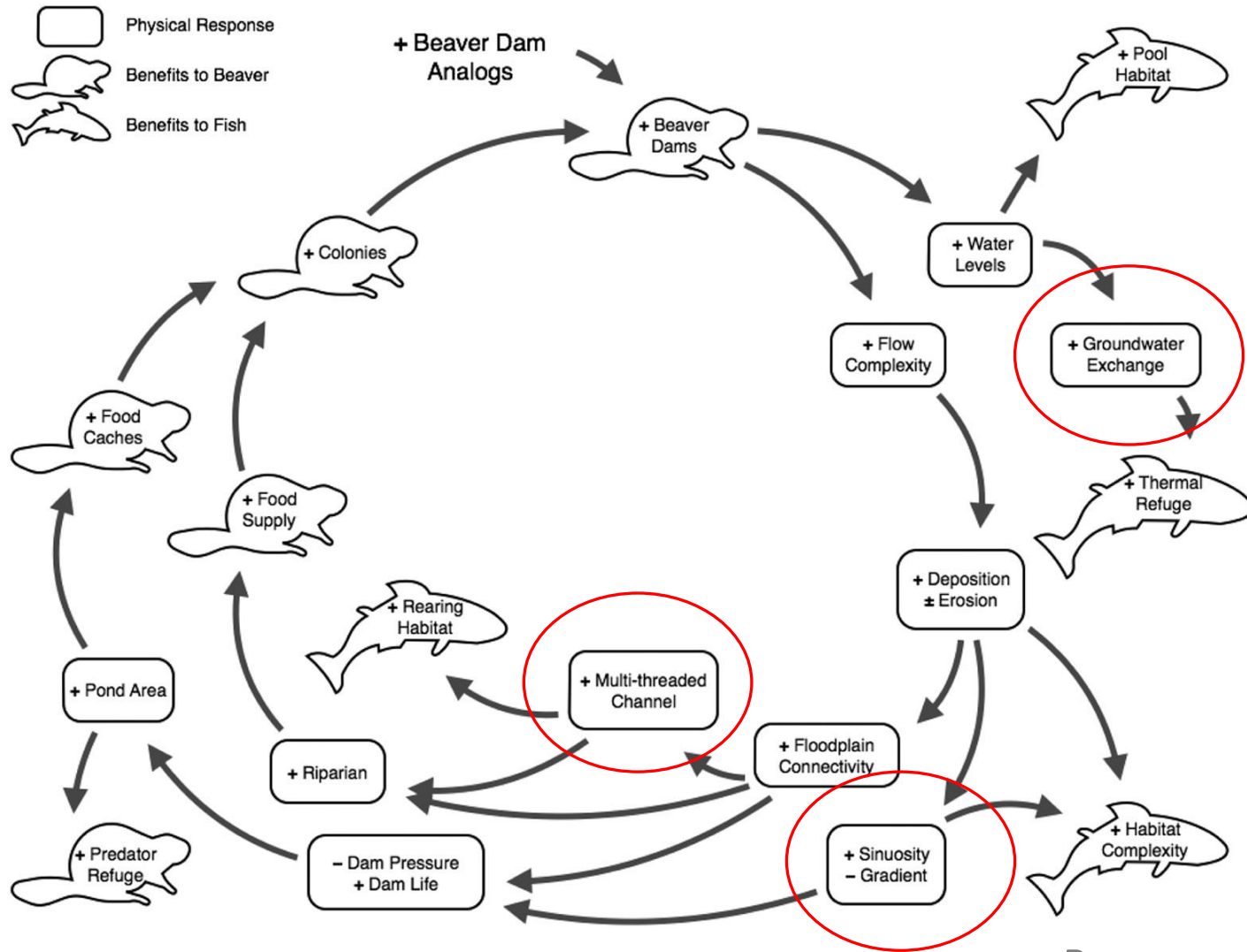
Fish passage

Plunge pool

Gravel
deposition

Cool water
upwelling

Benefits of natural and simulated beaver dams to steelhead



Using Beaver Dam Analogues for Fish and Wildlife Recovery on Public and Private Rangelands in Eastern Oregon

Rachael Davee, Hannah Gosnell, and Susan Charnley



Pacific Northwest
Research Station

Research Paper
PNW-RP-612

July
2019

Questions?

<https://www.peninsulaclarion.com/sports/healthy-peatlands-store-carbon-and-help-salmon/>