ALASKA WILDLIFE ALLIANCE

# Approaches to Adapting to Alaska's Rapidly Warming Climate

## | Workshop Report

**Acknowledgements:**

The success of this virtual workshop is thanks to the Workshop Steering Committee (Appendix I), the Workshop Sponsors, Co-Sponsors, and Supporting Organizations (Appendix II), the 23 experts and thought-leaders in the fields of climate science and the Resist-Accept-Direct framework who presented during the workshop (Appendix IV), and the more than 250 participants who listened, learned, and asked thought-provoking questions.

**This document, as well as the workshop recordings and individual presentation slides (if provided by speaker), are available on Alaska Wildlife Alliance's website at:**

https://www.akwildlife.org/workshop

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# Approaches to Adapting to Alaska's Rapidly Warming Climate | Workshop Report

**February 23 – 25, 2022**
8:00 AM AK – 12:00 PM AK

## EXECUTIVE SUMMARY

Alaska's climate is warming at 2-4 times the rate of elsewhere in the US, driving permafrost thaw, glacial retreat, sea ice loss, sea level rise, and extreme wildfire. Other than harvest and wildfire management, federal and state agencies in Alaska have generally not engaged in the active land management that is commonplace elsewhere in the US. We believe there is a broader pool of potential management actions that need to be considered and a need for creative thinking about alternative futures for a rapidly warming Alaska.

Hosted by the Alaska Wildlife Alliance, and developed by a diverse Steering Committee, this virtual 3-day workshop was implemented with the goal of exposing participants to a wide range of both conventional and novel options and approaches that are available for on-the-ground climate adaptation in Alaska. Although not the focus of the workshop, the Resist-Accept-Direct (RAD) decision framework was used to structure the workshop to ensure that a broad suite of adaptation strategies was considered. Over the three days, as many as 264 participants listened to 23 speakers deliver 25 presentations on thought-provoking questions and cutting-edge solutions to climate challenge in Alaska. The presentations were grouped according to five general themes/questions:

- Setting the stage: What are we resisting?
- Accept, until when?
- Setting the stage: Preparing to stop resisting?
- Can we resist at scales other than local?
- Setting the stage: What does ecological transformation look like?

Following each presentation, participants were invited to ask questions and provide prompts for the presenters during an open panel discussion. Discussion topics are summarized below:

- The objective of RAD decisions should be the achievement of a self-sustaining, self-organizing state that doesn't require perpetual management.
- Consensus building for RAD actions is a critical step.
- Managing to a historic or baseline condition is likely no longer possible.
- When applying Resist strategies, there will be a time when managers need to switch from Resist to Accept (or Direct).
- Organizations need to become more comfortable taking risks.
- Climate grief (i.e., solastalgia) is a real phenomenon.
- Assisted migration is a management option that agencies are already considering.

- Conservation goals differ by scale.
- In Alaska, it is possible to manage for carbon.
- Monitoring change has never been more important.
- Maintaining connectivity in Alaska is often low hanging fruit relative to the generally fragmented landscapes in the Lower 48.
- Trying innovative ideas, such as building rafts to serve as walrus haul-outs when there is not enough sea ice, is critical.
- The RAD Framework can be applied in other sectors, such as agriculture.
- The intersection of salmon management with climate change has long been a topic of interest in Alaska.
- The introduction of wildlife disease as species migrate north is a possible concern.
- Cost-benefit analyses, including valuating ancillary impacts, are informative.
- Avoiding scientific jargon is necessary when talking to non-scientists.
- It was debated whether climate change is intentional. It is never too late to start the conversation.

Immediately after the conclusion of the workshop, there was a one-hour brainstorming session open to all attendees on needs, ideas, and next steps.

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# ACRONYMS & ABBREVIATIONS

| | |
|---|---|
| ADF&G | Alaska Department of Fish & Game |
| AK | Alaska |
| ANILCA | Alaska National Interest Lands Conservation Act |
| AWA | Alaska Wildlife Alliance |
| BLM | Bureau of Land Management |
| BOF | Board of Fisheries |
| BOG | Board of Game |
| CASC | Climate Adaptation Science Center |
| CCP | Comprehensive Conservation Plan |
| ESA | Endangered Species Act |
| GHG | Greenhouse Gas |
| GMU | Game Management Unit |
| I&M | Inventory & Monitoring |
| MP | Milepost |
| NMFS | National Marine Fisheries Service |
| NPS | National Park Service |
| NWR | National Wildlife Refuge |
| PPM | Parts Per Million |
| RAD (R-A-D) | Resist Accept Direct |
| SEAK | Southeast Alaska |
| SOEP | Salmon Ocean Ecology Program |
| SWAK | Southwest Alaska |
| TECH | abbreviation indicating western systems of knowledge (differentiated from TEK) |
| TEK | Traditional Ecological Knowledge |
| US | United States |
| USFWS | United States Fish and Wildlife Service |
| USGS | United States Geological Survey |

# INTRODUCTION

Alaska's climate is warming at 2-4 times the rate of elsewhere in the US, driving permafrost thaw, glacial retreat, sea ice loss, sea level rise, and extreme wildfire. Even as polar bears are at risk of extirpation from Alaska and wood bison have been reintroduced to Alaska, other species such as mule deer, white-tailed deer and fisher have successfully emigrated from Canada while others have been accidentally (e.g., Elodea spp.) or deliberately (e.g., lodgepole pine) introduced. Alaska can be a global leader in climate adaptation by demonstrating how to apply extensive research and monitoring results to inform on-the-ground adaptation actions. The large size and mostly intact state of Alaska's ecosystems offer resilience against climate-driven ecological transformation, but that resilience is not boundless. Other than harvest and wildfire management, federal and state agencies in Alaska have generally not engaged in the active land management that is commonplace elsewhere in the US. We believe there is a broader pool of potential management actions that need to be considered and a need for creative thinking about alternative futures for a rapidly warming Alaska. Hosted by the Alaska Wildlife Alliance, this virtual 3-day workshop was intended to stimulate discussion around adaptation actions in Alaska and with transboundary partners.

# WORKSHOP OVERVIEW

**Workshop goal**
The Alaska Wildlife Alliance and partners designed this workshop with a goal of exposing participants to a wide range of both conventional and novel options and approaches that are available for on-the-ground climate adaptation.

**Workshop format**
The Alaska Wildlife Alliance worked with five partners to form a Steering Committee to plan the 3-day virtual workshop (Appendix I). Hosts and sponsors of the workshop are listed in Appendix II. The target audience was federal, state, and tribal land managers, although rural communities dependent on wild foods may find this relevant. In total, 264 participants registered and between 113-153 attended each day. The Resist-Accept-Direct (RAD) decision framework (Appendix III) was used to structure the workshop to ensure that a broad suite of adaptation strategies was considered. RAD was not the focus of the workshop but provided the framing.

Each morning's topics addressed either Resist, Accept, or Direct methods. Each day began with a welcome and a reminder of the workshop goal by the Alaska Wildlife Alliance. Presentations by many of the thought leaders and experts on climate change adaptation in Alaska and beyond (biographies in Appendix IV) were followed by a panel discussion in which participants asked questions of presenters and discussed important topics. Alaska Native Knowledge and traditional land management practices were included throughout the three days. Governance models, such as tribal co-management, were not included as the workshop's emphasis were adaptation methods and approaches, not governance.

Over the three days, as many as 264 participants listened to 23 speakers deliver 25 presentations on thought-provoking questions and ideas for climate adaptation in Alaska. Following the presentations,

participants were invited to ask questions and provide prompts for the presenters during an open panel discussion.

After the end of the workshop on day 3, there was a one-hour brainstorming session open to all attendees on needs, ideas, and next steps (Appendix V).

**Workshop outputs**
In addition to the workshop report, many of the presentation slides and the recording of the meeting are available at https://www.akwildlife.org/workshop. There may also be a listserv to continue the dialogue, serve as a platform for idea exchange, and to catalyze future efforts.

**Workshop outcomes**
Outcomes from this workshop include shared learning and building interest for taking action where there are places to move forward.

**Workshop report**
This report is organized by day: Day 1 Accept, Day 2 Resist, and Day 3 Direct, following the Resist-Accept-Direct (RAD) framework as discussed in Appendix III. The presentations are summarized in order they were given, with the major themes summarized in the Discussions section. In addition to the topics covered by speakers/panelists and through question-and-answer sessions, the discussion section of this report summarizes the main themes from the virtual chat feature.

# WORKSHOP PRESENTATIONS

Twenty five presentations were delivered to the audience at this workshop. This section provides both the author's abstract as well as main points captured during each workshop presentation. Presentations were grouped into five general themes/questions.

## Setting the stage: What are we resisting?

***Resist-Accept-Direct (RAD): A way of thinking about climate change*** (by Dr. John Morton)

> ABSTRACT: In response to climate warming (directional change), there are three possible decisions: to resist, accept or direct that change. This workshop is not about RAD, but it does offer a helpful framework for thinking about climate adaptation in Alaska. Whichever of the three decision bins is chosen, it begs the follow-up question: until when? And so promotes bet hedging and the deliberate reduction of uncertainties surrounding the other two choices.

- Provided an overview of the Resist-Accept-Direct (RAD) framework and made a case for how this approach can be used to identify the suite of discrete on-the-ground climate adaptation actions using his experience at the Kenai National Wildlife Refuge as an example. A list of publications and resources can be found at www.akwildlife.org/climate.
- The RAD concept is simply a decision framework (i.e., forces a decision) with the goal of assigning an adaptation response (R, A, or D) to a managerial/societal decision and ultimately development

of a self-sustaining, self-organizing system, so continuous intervention is not necessary. RAD helps prevent decision paralysis in the face of uncertainty.

- Each bin (R, A, or D) is mutually exclusive. Accepting means accepting change, not accepting the status quo. However, portfolios can allow coexistence of more than one approach.
- When there's uncertainty, can conduct experiments and pilot studies instead of just noting there is uncertainty (e.g., could test expansion of grasslands from fires in Kenai; testing restoration of beaver dams to decrease wetland loss).
- Three good examples of implementation of RAD are found on the East Coast where three National Wildlife Refuges (NWR) are all experiencing sea level rise: Chafee NWR (Resisting - restoring wetlands disappearing due to sea level rise); Blackwater NWR (Directing - they are accepting, resisting, and directing all at once, but in different areas); and Chincoteague NWR (Accepting - losing shoreline so moving infrastructure inland; after 60 years of trying to maintain shoreline and creating artificial dunes).
- In Alaska, good examples are Kivalina (Resist sea level rise by hard armoring with rip rap); Newtok (Accept sea level rise by abandoning the town further upstream); and Mertarvik (Directed - rebuilding the community and building an evacuation road for future).
- A special issue of the scientific journal BioScience[1] came out in January 2022 with several papers specific to RAD.
- Climate adaptation is much harder than rocket science because it involves people and requires good participation.

***RAD what? Climate-driven regional and landscape trajectories in Alaska*** (by Dr. Jeremy Littell)

ABSTRACT: Alaska's climates are changing at rates likely unprecedented in recent millennia. The resulting impacts on landscapes vary tremendously across Alaska, but regionally defining features are almost universally changing, and will change in ways for which historical experience doesn't prepare us. The characteristic snow, ice, and permafrost processes that shape coasts, rivers, and wetlands are changing rapidly. Forests and tundra are responding to changes in climate as well as climate-driven disturbances from wildfire and insects. As a result, the resources we manage and on which we depend are also changing, sometimes in surprising ways. These are the drivers of the climate change future, and our decisions to resist, accept, or direct depend in part on understanding how and where they occur.

- The last 10 years in AK have been 3-6 degrees warmer than in previous years; the Arctic is warming 2-3x faster than the rest of the Earth; Northern AK is experiencing higher rates of warming than the rest of AK.
- Risk averse: trying to prepare for larger impacts. Risk tolerant: accepting the increased risk and the cost that comes with warming.
- The rate of change in AK is sufficient that emerging systems don't much resemble those we have experience with.

[1] BioScience, Volume 72, Issue 1, January 2022. Available at: https://academic.oup.com/bioscience/issue/72/1

- RAD is implemented on the impacts of climate change, not changes in climate itself (e.g., temperature).
- Change in temperature can result in less water availability even if precipitation increases due to increased evapotranspiration, i.e., there may be more precipitation but the higher temps means more evaporation so there is still less water, which impacts wildlife habitats, from fish to birds to mammals.
- Climate impacts include more than just the "ice-free seasons." More storms, warmer temps, less water, impacts on people and wildlife statewide other than just changes in the arctic. More moisture can also build up vegetation which will eventually be fire fuel.
- We've focused a lot on changes in systems and exposure and sensitivity, but this is more consistent with the 'Accept' mindset. Focusing more on how we can affect system responses, or transformational knowledge, is needed to be consistent with 'Resist' and 'Direct'.

### ***'Natural' colonization of novel areas in Alaska*** (by Tom Paragi and Dr. Kimberlee Beckmen)

ABSTRACT: Increasing temperatures and changes in rain and snow patterns will enable invasive species to move into new areas. Invasive species such as mule deer and white-tailed deer carry with them the parasites and pathogens that can thrive in the changing environmental conditions and threaten our native cervids. Changing climate is also causing biome shift of shrubs and boreal forest into coastal and alpine tundra that will affect habitat and management of big game.

- Tom presented on two carnivores and two ungulates expected to come into Alaska soon (or recently have arrived).
- First, the Fisher (terrestrial mustelid) started appearing in SEAK from British Columbia in 1990s. Trapping season opened in Juneau area a few years ago. They prey on small mammals, birds, porcupine, berries and have ecological separation from martens who feed on different prey. There likely won't be dramatic mustelids/wildlife community disruption if fisher become established in SEAK.
- Second is the mountain lion. There have been two confirmed sightings in AK although detection can rely on roadkill, images, or predation kill using DNA. Primary prey is deer and if lions get established in SEAK, it will increase predation on Sitka deer (in addition to predation by wolves). There have been some reports of mountain lion tracks but were lynx tracks.
- Lastly, Mule deer and white-tailed deer were considered. Although Sitka black-tailed deer are in SEAK now, mule deer and white-tailed deer have much broader distributions in North America. Mule deer have been occasionally sighted in AK since the 1970s but in the last few years are reproducing in Eagle, Fairbanks, and Skagway. There is currently a hunting season for mule deer in AK. Mule deer are not expected to have major competitive interactions with existing large herbivores except Sitka black-tailed deer, but mule deer and especially white-tailed deer are likely to be a problem as parasite vectors if they establish in Alaska. Although pathogens usually co-exist with host-species, given environmental change, pathogens can begin to overwhelm host-species, causing disease.
- The biggest concern for Alaska regarding disease is the moose winter tick. If a moose has a bad infestation, it scrapes off hair in significant portion of neck/shoulder/back to get rid of ticks

(appearance in spring as “ghost moose”), and can result in mortality of calves and adults. If anyone sees a ghost moose, let ADF&G know so biological samples can be collected.

- Climate change is facilitating the northward movement of winter tick, which is spread by moose themselves. Snow on the ground hinders development of female ticks; less snow means ticks survive longer and reproduce in greater numbers. In Alaska, an environmental shift can tip the balance of the parasite and host species in favor of the parasite.
- Moreover, white-tailed deer is a main vector for the winter moose tick, brain worm, and liver flukes, adding to the risks of establishment of white-tailed deer in Alaska.
- Shrubs and conifers are expanding into coastal and alpine tundra in Alaska which changes the tundra snow distribution (positive feedback). More shrubs/trees in tundra favor moose over caribou/mountain goats/Dall sheep by increasing forage, providing ambush concealment for predators, and reducing wind near ground that mitigates insect harassment. Additionally, beavers in coastal tundra are increasing impounded water which also reduces permafrost. These impacts combined can drive biome shifts.
- In Fairbanks, a 30-100% increase in monthly rainfall during the growing season has been recorded since 2014. Although trees are no longer drought-stressed, an increase in growth of conifers and other flammable vegetation causes an increase in fire danger in the event of future droughts.

### ***Evidence of change in Alaska’s marine ecosystems and fisheries*** (by Doug Limpinsel)

ABSTRACT: Though the marine characteristics of the Arctic Ocean, Bering Sea and Gulf of Alaska are different, they are all influenced by larger Arctic and Sub-Arctic weather patterns. Once predictable, these weather patterns have changed reducing key drivers of marine ecosystem productivity; sea ice extent and the strength of oceanic mixing. Diminishing of these ecosystem processes disrupted marine trophic dynamics, the range and distribution of some marine fish species, forced conditions leading to the 2019 mass mortality events and led to commercial fisheries harvest reductions.

- No part of an ecosystem is independent from another part; all parts are interconnected.
- The Arctic ice cap has historically influenced weather patterns in the Northern hemisphere (atmosphere to ocean).
- Increasing greenhouse gas (GHG) emissions have increased solar irradiance warming air temperatures, forcing the reduction in Arctic sea ice cover and density, and weakening the Aleutian Low Pressure system that maintained the seasonal character of the Bering Sea and North Pacific.
- In the Bering Sea diminished seasonal sea ice and cold pool extent has occurred more often; while in the Gulf of Alaska the weakened Aleutian Low Pressure system reduced ocean mixing allowing high pressure systems and increased sea surface temperatures (e.g., Warm Blob) to persist for years.
- In both scenarios, marine food chain dynamics were altered dramatically decreasing plankton and forage fish populations causing declines in abundance and condition of several economically important fish species, in turn leading to harvest reductions in some federally managed fish species.

- More visual evidence of these changes was seen in the increase in harmful algal blooms and the dramatic number of unusual mass mortality events of invertebrates, sea birds and marine mammals from southern California to northern Alaska in 2019.
- Increasing variability in once historic climate and weather patterns may decrease the precision needed to consistently implement sustainable marine fisheries management measures in a changing Alaska.

## Accept, until when?

### ***Taking the long view: reflections on long-term ecological monitoring in Alaska*** (by Jim Lawler and Dr. Diane Granfors)

ABSTRACT: The Department of the Interior has three bureaus and agencies in Alaska that manage lands that are often remote and geographically expansive. Each of these agencies has in place Natural Resource programs that provide information to support day-to-day management decisions to address issues and threats to the resources within their jurisdictions. In the last two decades, each of these agencies have initiated long-term ecological monitoring programs to more explicitly address long-term threats, with climate change being the prime example. The Bureau of Land Management has the Assess, Inventory, and Monitor Program (AIM), the National Wildlife Refuge System, within the Fish and Wildlife Service, has the Inventory and Monitoring program, and the National Park Service has the Vital Signs program. In this presentation we focus on the monitoring programs embedded in Alaska Wildlife Refuges and the National Park Service. We discuss the commonality's shared by these programs and the information they can provide to the Resist, Accept, Direct framework. To close we highlight some examples of environmental change being detected by these programs.

- Jim and Diane gave an overview of two long-term AK ecological monitoring programs with the National Park Service (NPS) and US Fish and Wildlife Service National Wildlife Refuges (USFWS NWRs).
- The NPS Inventory & Monitoring (I&M) program has been ongoing for 50+ years.
- Inventory - determine current condition of a resource; Monitoring - determining status and trends of a resource.
- NPS 4 "networks" located in AK (Arctic, SWAK, Central AK, SEAK).
- I&M reports on subset of metrics (vital signs) to measure ecological health of parks. There are a lot of vital signs being monitored – major themes include climate change, wildlife populations, and water quality.
- For each vital sign they have a protocol document, the annual reports, peer-reviewed publications, and the resource briefs (simpler public documents).
- I&M for USFWS NWR system started in 2010 with a focus on providing science and planning support for adaptive management; goals are stepped down from the national program.
- They gather baseline data to help interpret what is on the refuges, support on-the- ground inventories to get knowledge of habitats and conduct significant data management to make data accessible and discoverable. Partnerships are a key part.

- USFWS NWR I&M is conducting a planning process now for their refuges; these planning efforts will help them figure out where/if to resist-accept-direct.
- NPS I&M program has a lot of similarities with USFWS programs.
- One example about "rapid elevational shift in Denali's passerine community parallels vegetation change" - found an upward shift among shrub/tundra bird distributions, although mean temperature in Denali was overall stable.
- USFWS NWRs collaborated with Audubon to see how bird communities might have shifted in refuges; there is predicted to be a large ecological transformation with species turnover in summer months and winter colonization with birds sticking around in winter in AK.
- Multiple partners are contributing to water quality monitoring across the state.
- These examples are how data can be used to help make RAD decisions.

***Preparing for a response: Inventorying species diversity by metabarcoding*** (by Matt Bowser)

ABSTRACT: The tables have turned: Though it has long been true that we could only manage for the conspicuous things like mammals, birds, and plants, recent metabarcoding methods enable simultaneous identification of whole communities of species from environmental samples, making it easier to document assemblages of bacteria, fungi, and insects than to survey for plants! Now we can proceed with a grasp of what current (soon to be historical) biodiversity is.

- It is possible to have a much better understanding of what species are present and what the level of biodiversity is; this presentation focuses on invertebrates.
- Invertebrates are going extinct at rapid rates, but if they're so important, why haven't we dealt with their decline? It is because of the Taxonomic Impediment - the large amounts of time and cost required to identify invertebrates.
- In the past, we would collect a sample, pin, dissect, view under microscope, and create a list of what was in a community. But many details would be missed (potentially due to immature or damaged specimens). We now ground up the specimens and do DNA analysis on the slurry. Potentially millions of reads/results of sets of DNA sequences are then compared to libraries of previously identified specimens.
- For example, they worked with ADF&G to eradicate invasive pike. Used genomic methods on a plankton sample to ID species of invertebrates and found 2 new unidentified invertebrates that had not been sequenced before.
- Another example: 40 samples around Kenai Refuge headquarters were taken and analyzed for metagenomics. In all, 671 species of invertebrates were found; 102 were new species distribution records in AK.
- Matt reported seeing invasive species in surveys, documenting that invertebrate communities are already changing.
- It is possible to easily scale up as they are not limited by sample size increases. The more species present, the workload per sample goes down (increasing efficiency).
- One surprise included detecting a wasp previously only seen in Ontario but found in AK.

- This type of sequencing is not very new anymore. The world is changing, and methods are getting better to detect and study biodiversity. There is no need to wait anymore. Sequencing can even be done in the field and in more equitable ways.

### ***Managing connectivity to accept change*** (by Dr. Dawn Magness)

ABSTRACT: Accept is an intentional choice to not intervene and allow an ecosystem to respond autonomously to change. In the past, species have moved in response to climate change. Accepting change can include management to design landscapes that restore, maintain, or enhance movement. I will talk about concepts and considerations from landscape ecology that are used to design connected landscapes in order to allow species to resort without human intervention.

- Dawn presented on connectivity as a climate adaptation strategy: species move in response to climate change as an adaptation to climate change. Maintaining and restoring landscape connectivity is a low-risk strategy (e.g., land bridges over highways for wildlife passage).
- In the 1980s, ANILCA thought about ecological function and allows people to live on land in sustainable ways; there are large intact landscapes in AK - connecting these landscapes is in the RAD strategy as "accept" and is doable but will require hard work.
- Efforts to maintain connectivity in ways that are climate smart: 1) connect enduring features that do not change (geodiversity); 2) connect historical climate to future climate (will need to consider uncertainty in climate models).
- Enduring features approach:
    - Example 1 - Multijurisdictional Planning in the Central Yukon Resource Management Plan. It's important to think proactively about connectivity across BLM lands to the conservation estate (NPS and FWS). She used a geodiversity approach to think about where connectivity may be planned for across conservation units, using geomorphology and topographic position of things such as ridges, slopes, canyons, as possible linkage areas. This process allowed BLM to consider 1% of the planning area which would connect 64 million acres of conservation lands.
    - Example 2 - Regional River Connectivity, Kenai Peninsula. This project considers how species might not be able to naturally disperse onto a peninsula naturally but recognizing connection by roads so things may come in via vehicles/tires. When we think about mountains to sea, it's important to think about streams that cross various land jurisdictions, not just on federal lands, to connect a significant number of salmon streams.
    - Example 3 - Local landscape connectivity within the Kenai Refuge. In this example, they looked at parts of the Sterling Highway mileposts (MP) 58-79. The volume of traffic is challenging for humans to cross, let alone wildlife. There are only a few places that may be good sites for connectivity regarding passage across the highway. They were able to create larger culverts for bear passage, and some culverts were converted to bridges giving greater space for larger wildlife (moose) to safely cross.
- Connectivity falls under "Accept" because it allows plants and animals to respond, but there are challenges because need to figure out multi-jurisdictional planning responsibility and identifying who is responsible for the connectivity.

***What does management of threatened and endangered species in Alaska look like in the face of climate change?*** (by Erin Knoll)

ABSTRACT: Get to know the threatened and endangered species found in Alaska. Understand how climate change is affecting them and how the U.S. Fish and Wildlife Service manages or doesn't manage the listed species in the state.

- The Endangered Species Act looks to protect vulnerable and declining species. The USFWS is primarily responsible for terrestrial and freshwater organisms, not marine organisms, and jointly manages anadromous fish or sea turtles. This presentation does not focus on the ESA-listed species under the jurisdiction of the National Marine Fisheries Service
- Currently, there are eight ESA-listed species under USFWS's jurisdiction in AK.
- A few species were listed due to climate change, including bearded and ringed seals and polar bears. Loss of sea ice habitat is the major driver for these listings.
- Spectacled eider was listed in 1993 following a 98% decline Western AK for unknown reasons. After molting, the birds move to south St. Lawrence Island where they overwinter in the sea ice. As sea ice continues to change, it could affect the eider. Ice changes impact the benthic biomass (their food changes).
- Some portion of the population is expected to move northward due to sea ice retreat, although it is uncertain what will happen to their survival or reproductive capacity.
- What does endangered species management look like? Some species need heavy forest management practices, some need fencing for protection, but many species don't need active management to protect them. USFWS works with other federal agencies to reduce impacts, such as noise management, mitigation of human-wildlife conflicts, or to reduce ship collisions.
- Active management includes:
    - Steller's eider was listed as threatened in 1997 in AK following declining populations from the Yukon-Kuskokwim Delta. A joint recovery team for the Steller's and spectacled eiders was formed, and a captive flock was established at the AK Sea Life Center. Release sites were evaluated, and two years of experimental release tested different husbandry methods. It was found insufficient to sustain a large-scale effort, and this project has not moved forward. It is still unknown why the eiders declined, so those factors are likely still present. Without addressing that, the birds could still decrease. The expense of efforts to raise birds and release them on the Delta would be very high, especially if they decline again for unknown reasons.
    - Wood bison were introduced by the ADF&G and USFWS under the ESA's 10j recovery tool. Individuals were kept geographically separate from nonexperimental populations of the same species/subspecies. This could allow the release of species outside the current range of the species if the release will further the conservation of the species. 130 bison were released under the 10j rule and the last count was ~103. Another release is planned for this year or next. Only 3 release sites were identified in the 10j rule. Sites required environmental assessment.

***Changes to ocean systems and management goals for Alaska commercial salmon fisheries*** (by Bill Templin)

ABSTRACT: Pacific salmon are incredibly important to Alaska for social, cultural, economic and ecological reasons, yet generally our interaction with them occurs when they are adults migrating through coastal marine waters and freshwater systems. However, much of their lives actually occur in marine waters where they are exposed to the changes occurring in northern oceans. In the presence of these changes, management of salmon for the benefit of Alaskans continues to happen through an adaptive management system in combination with established principles and research.

- Bill presented an overview of the principles and systems used by State of Alaska that allow for adaptive management of salmon, with a focus on the Yukon River.
- Early ocean survival is a key indicator of salmon returns. Juvenile abundance surveys in September can forecast the return of Chinook to the Yukon River. The most important factors affecting abundance happen before the first winter at sea; at least for now.
- The recent recurrent marine heatwaves in the Gulf of Alaska and Bering Sea are of particular concern for salmon survival.
- Historical data sets have looked at salmon harvest as an indicator of production.
- Low harvests in 1960s and 70s prompted the development and use of hatcheries to bolster the population size; hatcheries are not used for conservation purposes, but rather to increase harvest.
- The AK State Constitution contains provisions for natural resource management for the benefit of the people of the state and encourages local management of resources allowing for more adaptive solutions for management of local conditions, including effects of climate change.
- The goal is “sustained yield” and balances need to provide for resource uses in the present while not detrimentally affecting uses in the future.
- The Board of Fisheries (BOF; 7 members of public) serves as decision makers for policy, regulations, and allocations and allows public input and exploration of a wider range of potential actions.
- Sustainable Salmon Fisheries Management Policy includes a list of recommendations that reads similarly to managing for climate change.
- Simplified salmon biology: spawn in fall of year 0; spring hatch and stay in freshwater in year 1; many go to ocean in year 2 and stay in ocean for 1-3 years before returning to streams. This means returns in any year can be from multiple spawning years.
- Because salmon spawn once and die, managers can use models created for insect population and compare production from ranges of escapement. At lower escapements, the models show high reproduction. As escapement increases, competition increases and resources decrease. Models can give the probability of potential yields (how much are anticipated to come back as excess fish over a range of escapement). There is a flip-flop across years of too many and not enough fish – the goal is the maximum sustainable yield for human harvest.
- Escapement goals are set for yield, so not making the escapement goal does not mean there is a conservation concern.
- The time scales for salmon management vary greatly (data time series are 0-120 years; regulatory cycle [BOF] is 3 years; salmon lifecycle is 2-7 years; management of fishery is from days to 1 year).

- Major changes in the landscape result in a mixed bag of results for salmon - varies by species, life stages, locations within the river, etc.
- There is a new ADF&G Salmon Ocean Ecology Program (SOEP) which leverages state resources to build collaborations to answer questions about salmon and their marine life.
- The department also collaborates through the North Pacific Anadromous Fish Commission, a commission of 5 salmon-producing nations, with surveys ongoing of the northern Pacific Ocean.
- The ADF&G does not manage change, they manage salmon resources and uses in the presence of change, thus fitting well within the framework of RAD.

## Setting the stage: Prepare to stop accepting?

***Tundra ecosystem change and permafrost degradation: Using a novel field experiment to simulate a future warmer world*** (by Dr. Ted Schuur)

ABSTRACT: The impact of global warming of a few degrees on Arctic ecosystems has important consequences for people that live in the region as well as global society. This talk describes a field-scale experiment that manipulated soil temperature and degraded permafrost, providing unique insights into the changes that are expected for permafrost ecosystems in a warmer world. Permafrost thaw has consequences both for the animals and plants of the tundra, as well as for global climate change as a result of changing ecosystem carbon fluxes.

- Theme of Ted's talk is about using experiments to see how ecosystems may shift in the future. His experiments focus on permafrost and how AK and Arctic systems affect the globe as a whole. Permafrost is perennially frozen ground and underlies tundra and boreal forests.
- Permafrost thaws, it doesn't melt. Plants, animals, microbes live in upper active layer of soil. The next layer below is permafrost soil with carbon, and ice wedges are mixed in.
- Loss of permafrost affects people living in the arctic and affects the global carbon cycle by adding carbon to the atmosphere.
- How fast does this occur, what's the magnitude, and in what form does it occur?
- In a field study to monitor over time, Ted's team is studying the exchange of carbon into the ecosystem and asking if permafrost thaw can cause carbon release in order to managing ecosystems for carbon. Carbon sinks absorb carbon, carbon sources release it.
- They are also putting up snow fences to see what happens to the ground when snow piles up. They remove the snow in spring to help it warm. In the winter with extra drifts of snow, it helps to keep the ground warm and insulated, too.
- They also set up boardwalks to see over time how the boards shift as the permafrost melts.
- As they warm the ecosystem in their plots, the ground starts sinking and melting into pools of water. Warmed plots have continued to get warmer, and the land got more wet due to the melting. More snow=more ground warmth and water.

- Plants and animals liked the warmer earth (soil), but after a certain level of warming, they disliked it. Plants decreased the carbon they took in, but the ground continued to release carbon as carbon pools declined over time.
- Ted's research team is part of a group called the Permafrost Carbon Network (http://permafrostcarbon.org/).
- If we continue warming the planet like we are now, will jump 5-15% from current 75ppm $CO_2$ to 146-160 billion tons by 2100. By limiting climate change (global warming) to 2 degrees Celsius, we can keep some levels of permafrost.
- At a global scale, we can resist this change by managing humans to reduce emissions.

***Pilot studies to assess feasibility of intervention/assisted adaptation: thin-layer sediment augmentation at the Seal Beach National Wildlife Refuge*** (by Andy Yuen)

ABSTRACT: The Seal Beach National Wildlife Refuge, along with the Tijuana Slough and San Diego Bay National Wildlife Refuges and other coastal reserves in southern California, conserve significant populations of salt-marsh obligate species such as the endangered light-footed Ridgway's rail. Sea level rise and habitat modelling by the U.S. Geological Survey of salt marshes along the Pacific Coast identified the Seal Beach Refuge as particularly sensitive to the effects of sea level rise. The combined impacts of sea level rise, subsidence, lack of sediment input, and limited opportunities for landward expansion, threaten the long-term sustainability of salt marsh habitats and the light-footed Ridgway's rail at the Seal Beach Refuge. Identified in the Comprehensive Conservation Plan and in partnership with local, State, and Federal agencies and universities, Refuge staff and collaborators implemented and monitored the first Pacific Coast thin-layer sediment augmentation project at the Seal Beach Refuge.

- Andy presented on the first Pacific coast application of thin-layer sediment augmentation. His talk focused on the process to get to this point - it's a resistance project.
- Seal Beach is saltwater habitat plus uplands habitat and home to several endangered species. Sea level is rising and they are losing salt marsh and estuarine habitats, which is detrimental to several marsh and coastal-dependent species. Changes to the refuge were changing over time and at a rapid rate; at highest tides, the refuge fills up with water like a bathtub and left few habitat sites above water for rails (birds) and exposed them the rails to greater predation and encroaching on roads.
- The process started with a Comprehensive Conservation Plan (CCP), and several other projects by partners helped provide data to build the foundation for moving forward with the first thin-layer sediment project on the West Coast, helping to reduce uncertainty.
- The CCP was completed in 2012 and was a 15-year management plan. From the beginning it incorporated sea level rise.
- In 2015, they received $3.3M in funding to start augmentation and pre/post monitoring. They moved relatively rapidly from planning process to implementation.
- One of the fundamental pieces giving them confidence was work by USGS and others at the Seal Beach National Wildlife Refuge (elevation, vegetation, tidal flows, sediment flux) so they had a strong understanding of conditions at Seal Beach.

- As a result, Seal Beach had the lowest mean elevation and mean elevation relative to mean high water of the coastal salt marshes studied. This led them to recognize that there were significant sea level rise issues at Seal Beach. Intense urban development meant little freshwater or sediment input to Seal Beach. Subsidence due to underground extraction of fluids was also an issue.
- Partnerships allowed them to conduct climate adaptation planning to identify conservation priorities and come up with priority management actions; results of modeling led to revisions of management actions.
- Through early planning, in-depth studies, and sea rise scenarios, they felt confident they could successfully implement a sediment augmentation program.

## Can we resist at scales other than local?

***State wildlife management in Alaska: scope, scale, and process*** (by Chris Krenz, Tony Kavalok, Ryan Scott, and Tom Paragi)

ABSTRACT: As delegated by the State of Alaska Legislature and Governor, the Board of Game and the Commissioner of the Department of Fish and Game make wildlife management decisions within constitutional constraints. These decisions have a typical scope (bag limits, methods and means, hunt duration, allocation among users, etc.) and spatial and temporal scales. Management approaches vary from being hands-off when demand is far less than potential biological surplus, to intensive where ecological manipulations are done to increase yield. Understanding how wildlife management decisions are made is necessary when considering the degree to which the management system has flexibility to address issues that arise from a rapidly changing climate and uncertainty of climate forecast scenarios.

- Chris presented the State's wildlife management system; structure is derived from decisions of the state's representative government. Under the Alaska constitution, wildlife in the state must be managed for use on the sustained yield principle.
- Board of Game (and advisory committees) and the ADF&G Commissioner work to protect, maintain, improve, and extend the fish and game resources.
- Board of Game has 7 members with 3-year terms, each appointed by the governor.
- There are 84 advisory committees across the state and are locally elected. Focus on local issues.
- GMU= game management units. There are several GMU's throughout the state. Wildlife management in each region of specific units gets discussed once every three years at annual (rotating) BOG meetings.
- Spatial scale of management is based on biology in some cases and based on values in other cases. In general, most management decisions are on the spatial scale of the GMU subunit.
- Management is less restrictive when the desire to harvest is less than the harvestable surplus. Management becomes more restrictive when the desire to harvest is higher than the surplus (i.e., to ensure sustained yield).

- Intensive management = manipulating ecological dynamics.
- Climate change is broader in spatial and temporal scales than wildlife management occurs.
- Extreme climate-caused events can be positive or negative and state wildlife management can react quickly to ensure sustained yield.
- Does wildlife management fit within RAD? Yes, but resist and direct are done at more local scales.

***Offshore rafts as artificial haul-outs for walrus in absence of sea ice*** (by Rick Steiner)

ABSTRACT: The reduction of Arctic sea ice habitat necessitates more frequent swims to and from shore for Pacific walruses, increasing energetic demands. To reduce such climate change impacts, we propose a pilot project to retrofit and anchor a large (100m x 50m) raft/barge at a critical walrus feeding area - Hanna Shoal, Chukchi Sea, 100 miles offshore - to test its suitability as artificial haul-out/resting habitat for walrus in absence of sea ice. This presentation outlines the walrus raft proposal, and its potential benefits, risks, and costs. The presentation will discuss the arguments invoked by the USFWS in declining our initial proposal in 2015.

- Rick presented a proposal submitted to USFWS in 2015 and 2017 to deploy rafts for walrus use in the ice-free season at Hanna Shoal in the Chukchi Sea.
- Arctic sea ice decline is one of the ecological tragedies in human history and we are ignoring it - we just observe (science), restate the problem, and then do nothing.
- Most climate change impacts are in the ocean, carbon emissions keep increasing, and temperature keeps increasing. 90% of atmospheric heat is absorbed in the upper ocean, and the acidity of the ocean is increasing. The past 3 years have been the warmest ocean years, with significant increases in the Arctic resulting in a loss of about 30% of Arctic Sea ice over 30 years. The ice is ⅔ thinner, and summer sea ice will be gone soon, maybe by end of this decade.
- Pelagic and Benthic Arctic ecosystems are also in decline and transition. Benthic productivity decline affects walrus feeding. Several marine mammals are also in decline - seals, polar bears, walrus.
- Walrus distribution is limited to continental shelves, as they are bottom feeders and cannot feed in deep water. Due to sea ice loss, they are spending more time onshore (tens of thousands at onshore haul-outs in summer), and coastal communities are doing what they can to protect haul-outs. Offshore they are observing abandoned walrus calves, who likely died.
- In 2017, Netflix caught footage of about 250+ walruses plunging off a 260-foot cliff in the Russian arctic. There was some controversy about the cause, but it sparked conversation about sea ice loss and walrus populations.
- Walruses need offshore resting platforms in ice-free season to help feed, particularly at feeding locations far from shore, such as Hanna Shoal, over 100 miles from shore.
- Rick proposed anchoring rafts for walruses offshore in ice-free season to substitute for sea ice platforms. The rafts could be approximately the scale of an old fuel barge, or football field (100 m x 50 m), and ballasted to bring it down in the water for easy access when anchored. This would provide offshore haul-out habitat, allow more time at critical offshore feeding areas, provide energetic benefit, reduce drowning risks during extended open-water crossing between shore and

feeding area, reduce onshore crowding, and possibly improve reproduction. Rafts would need to be located outside of the shipping lanes, as they would pose a hazard to shipping.

- Rick shared a photo of a floating soccer field in Singapore Harbor as an example of a raft size (100 m x 50 m) that could work as a walrus haul-out.
- In 2015 USFWS declined the initial walrus raft proposal, saying such a measure was not warranted at the time and provided various justifications, but with serious math errors. USFWS argued that to benefit the walrus population, rafts would need to support a total of 10,000 - 20,000 walruses, and to do that, 11 $km^2$ of raft surface would be needed. However, the actual raft surface required would be just 0.011 $km^2$. Rick has requested that USFWS correct its math error. Further, there are several activities by government agencies that focus on protecting individual animals (e.g., oiled wildlife response; entangled animal response, etc.).
- Current politics seems to be weaponizing disinformation in order to ignore existential crises, which has biological consequences for humanity. Science is doing its job, but governments need to act on the science, especially for Arctic ecosystems.

### ***Active forest management as a means for climate change adaptation in the boreal forest*** (by Will Putman)

ABSTRACT: Active forest management involves manipulating vegetation in forest ecosystems to accomplish management goals. This presentation will provide a quick review of some forest management techniques that could be considered when adapting to climate change in the boreal forest, including selection of seed stock when reforesting, managed species selection, assisted migration of native tree species, introduction of non-native tree species, the risks of invasive species introduction, and the relative difficulty of dealing with long-term ramifications of many forest management decisions in light of uncertainty associated with climate change.

- In forestry, active management would mean manipulating vegetation to enhance some value, such as fire risk reduction, increasing wildlife habitat, goals to increase productivity and resilience (especially against climate change), recover, and improve forest conditions.
- With climate change, forest management could include doing nothing, silvicultural measures (resisting), selecting and breeding specific trees and organisms, change species (assisted migration) and promoting natural migration and gene flow.
- The boreal forest includes a limited number of native trees (only 6), a very dynamic environment, permafrost, and very little active management. Climate change affects standard disturbances like fire.
- Traditionally, when planting forests, we wanted to source local seeds of local species. When thinking of climate change, this may not always be the best case.
- With climate change considered, we may need more assisted migration and take advantage using genetic variability already present in tree species.
- The Seedlot Selection Tool (https://seedlotselectiontool.org/sst/) can be used to model assisted migration.

- Assisted migration with non-native trees is not a new concept, although there are risks involved. New species could become invasive and could bring in nonnative/invasive pests/insects or disease. But there is also a cost to doing nothing.

***Experimental approaches to resisting and redirecting high-latitude climate feedbacks*** (by Dr. F. Stuart "Terry" Chapin, III)

ABSTRACT: Many high-latitude ecological responses to climate change (permafrost thaw, sea-ice melting, shorter snow-covered seasons, and more severe wildfires) tend to amplify the warming of regional and global climate and exacerbate anthropogenic climate change. I will discuss some experimental approaches to assessing the strength of some of these feedbacks and factors that might reduce or reverse them at landscape scales. Specifically, I will discuss the impact of large herbivores on permafrost integrity and the roles of wildfire and wetlands on carbon storage.

- We know where climate change is headed, and we are not prepared to deal with it.
- Terry is concerned about the more frequent extreme weather events and social disruption faced by today's youth (e.g., food insecurity, mass migration). These are "today" issues, not a future issue.
- We know a lot about climate change causes and consequences, in a general way. Combined with increases in global population and uses of natural resources, there are multiple ecosystem consequences.
- We may be able to change the extent of these changes by becoming better stewards and actively shaping pathways of social-ecological change to enhance ecosystems health and human well-being. It is important to recognize people are part of nature, not separate from nature.
- We can manage for "fast variables" (soil nitrates, deer density, fire events) which eventually may improve "slow variables" and improve social variables.
- Permafrost thaw affects atmospheric carbon in several ways and may result in increased permafrost thaw (positive feedback).
- Some options for reducing carbon loss including reducing the rate of warming of global climate (e.g., reducing human emissions, injecting atmospheric aerosol into the stratosphere, increasing albedo from deforestation, altering summer/winter heat flux [this is usually at small scales], and changing vegetation over large scales to increase photosynthesis).
- Sergei's Re-Wilding Beringia experiments:
    - Hypotheses development, debates, and modeling have helped to estimate extent of key drivers.
    - Two sites were selected for experiments: forest-tundra border and forest-steppe border in Russia - experiments used large mammals to trample snow and reduce amount of insulation so heat can escape permafrost in winter. He set up fences and imported large herbivores
        - Confirmed mammals did trample snow
        - Measured changes in carbon stocks/fluxes

***Can saving ice save our way of life? Using glass microspheres to increase surface albedo*** (by Dr. Leslie Field)

ABSTRACT: The disappearance of reflective ice in the Arctic is speeding up the impacts of climate change in Alaska and throughout the world. We are working on ways to preserve ice that may serve as a useful start to codevelop solutions with Arctic communities to help adapt to some of the challenges brought on by our world's changing climate.

- Leslie, founder of another nonprofit in addition to NewCo, is also founder and CTO/CEO of the Arctic Ice Project. The next step is to move to more on the ground local development.
- The loss of older sea ice means loss of albedo.
- The Arctic Ice Project is a long-term project to co-develop large scale and immediate solutions to problems in climate change.
- Floating sand, white hollow glass microspheres (made of silica) can be spread on Arctic Sea ice to increase albedo. So far there have been no cons or damaging results, and it has shown promise to restore ice. When spread on sea ice, it brightens it and helps prevent melting. It can help to regrow multi-year ice over time.
- The intent isn't to carpet the whole Arctic, but rather to use it as a supplement in some areas.
- Co-developed adaptations of the approach could include: Could permafrost be preserved? Methane deposits kept in the ground? Buildings, roads, infrastructure stabilized? Lakes and rivers cooled? Fish health improved? Wildlife less stressed?
- Action must be done now. This could be our last decade to step up.

***Resist until when? Applying adaptive management*** (by Dr. Abby Lynch)

ABSTRACT: Most aquatic conservation and management approaches look to the past for precedent (e.g., restoration / rehabilitation). But, with climate change and other stressors, aquatic systems are transforming, making many of these approaches increasingly untenable. The RAD framework can help navigate the unfamiliar territory of 'what comes next' while still using some familiar tools and strategies (e.g., adaptive management).

- Ecosystems are changing and continuing to use the same management methods is an ineffective strategy.
- RAD can be a useful tool for supporting management for changing ecosystems, especially when experiencing directional change.
- We will have to reconsider/revisit decisions as systems continue to change. Familiar tools can be used within RAD framework (e.g., scenario planning, structured decision making, climate-smart conservation, adaptive management).
- Accept is most common choice for managers, given limited resources and ability to intervene, but it can be a deliberate choice, not just a default decision.
- Resist is the option we are typically most comfortable with, and it aligns with traditional concepts of management (e.g., restoration). But if we wait until the point when we can no longer resist, we will miss opportunities for adapting to ecosystem change, possibly resulting in greater

consequences to natural systems. The goal is to make a decision before management efforts are futile.

- There are very distinct decision points and alternative pathways that can be taken, depending upon decision points. We may have to switch RAD strategies due to continuing change.
- This is outlined in the publication "RAD Adaptive Management for Transforming Ecosystems" (https://doi.org/10.1093/biosci/biab091).
- RAD is like a compass, adaptive management is like a gyroscope.
- In a stable system, adaptive management often involves targeted monitoring (i.e., tracking progress towards objectives, detecting ecological tipping points) and pilot studies/experimentation.
- In a changing system, adaptive management helps determine if an existing management strategy is viable and can implement the RAD framework. This involves a broader surveillance monitoring (i.e., track ecological process without a targeted metric, refine plausible future trajectories), as well as pilot studies/experimentation. We can change strategies when objectives are no longer feasible or the selected RAD pathway is no longer viable.
- While no crystal ball is available, agencies can start preparing for adaptive management by reviewing and updating management actions and objectives periodically as well as building capacity. It's important to continue monitoring/pilot studies/experiments to understand what change is occurring, and employ bet hedging by using multiple strategies at a time (e.g., different locations have different strategies).
- For more information, visit usgs.gov/rad.

## Setting the stage: What does ecological transformation look like?

***If we direct change, to what ends do we direct it?*** (by Dr. Steve Jackson)

ABSTRACT: Directing change is the most difficult of the three RAD choices, because it intentionally manages a system out of its historical states toward something that's locally, and possibly universally, novel. And that management will be taking place under ongoing climate change, punctuated by climate variability and extreme events, that may affect the ecological trajectory. The ecological end-points of directed change must be at minimum desirable, attainable, and sustainable, bearing in mind that the end-points themselves may be transient under continued climate change. Properties of desirability, attainability, and sustainability must be gauged across a range of timescales, and considered in context of potential future transformations as well as uncertainties in climate trajectories. Meeting these challenges will require imagination, courage, nimbleness, and patience as well as knowledge and experience. Scientists, managers, and stakeholders need to work together in creative thinking about potential ecological futures, and initiation of experimental frameworks for adaptive learning.

- Steve was asked to summarize a transformational ecology and climate change paper, discuss the process of ecological transformation, and provide a perspective from paleontology.

- Resistance is:
    - Easy because it provides clear, discrete targets for management, and focuses on species, communities, ecosystems (known entities).
    - Hard because we act and intervene to resist environmental change and have to keep doing this; eventually there will be failure if the change is too great.
    - Barriers include resource limitations and potential for ultimate failure at some point in the future. Given failure may be far into the future, may have a mindset that the failure will be someone else's problem.
- Acceptance is:
    - Easy because it lets nature run its course, we live with the consequences, and we don't have to make hard decisions.
    - Hard because we are not sure what will happen under climate change, and we may not like what get.
    - Barriers include the deviation from historical norms, and the uncertain management of novel systems.
- Directing is:
    - Easy because... Nope, it's not easy.
    - Hard because it forces hard thinking about objectives and how to obtain them, deviates from the familiar (new ecosystems), there is a lot of uncertainty, and requires adjudicating among conflicting values - political, scientific, socioeconomic.
    - Barriers include: same types of things for acceptance (new systems not normally managing), but different from acceptance b/c intentionally choosing to cause change; requires accountability and accepting considerable risk regarding the outcomes; having to choose desirable, attainable, sustainable (at least short term) targets; self-sustaining systems in the long-term may not be possible given continued future change - need to know if choosing endpoints or waypoints; uncertainty about knowing how to get to the goal once goal is identified.
- The paleoecological record shows that most existing ecosystems are not very old. Some are just decades or centuries old, while others are a few millennia old. Terrestrial ecosystems usually don't persist in place more than 10k-12k years, because of natural climate change. There has been moderate to large change in terrestrial ecosystems across the globe since the last glacial maximum 20k years ago.
- Historical baselines are not reliable baselines b/c past ecosystems were dependent on past climates and past events. History isn't reliable for objective normal states for the proper state of the ecosystem and what to manage for, because ecosystem properties depend on the environment, which is changing.
- The turnover in ecosystem change is liberating and grants us permission to think about futures that are not like the past or present.

- Humans have a strong impact on ecosystems, and there's a long history of humans directing ecological change, including many millennia of Indigenous management of ecological change (e.g., fire management).
- When thinking about what the long-term goals are, consider Jonas Salk's questions "Are we being good ancestors?" How will things look in 2050, 2100, 2200 and beyond? We don't want our descendants and successors to curse us for our actions today.
- To be a good ancestor we need to save all the parts and minimize biodiversity loss (some of the dominant species today were very rare millennia ago, so conserve rare species today because they may be important tomorrow). We need to learn more and talk more.
- Realize uncertainty will persist, including uncertain climate futures, climate variability, and ecological outcomes. We can only measure success in hindsight, so we need to be relentless about experimentation to know what management regimes will/will not work, and adaptively change management strategies.

***Nature in the Anthropocene: What is no longer is, will never again be, and what it can become*** (by Dr. Roger Kaye)

ABSTRACT: Maintaining what is "natural" is no longer viable as a primary conservation goal, at least not as *natural* has been traditionally understood. This program explores whether we should replace the concept with a more scientific paradigm like biodiversity or ecological integrity, whether we should replace it with *wildness*, or keep and redefine it for the future we face.

- Nature: maintaining what's natural isn't necessarily a viable goal. Nature changes so must we and our perceptions of it.
- The Anthropocene: our current point in time where humans are becoming a dominant force on earth and causing change.
- "Natural" is defined as not shaped by humans. "Natural" in government agencies is defined as ecological systems can evolve and change freely without human influence.
- Nothing is free from human influence. In all spheres of earth system function, people have a footprint. Author Bill McKibben says our old view of nature is dead.
- Native American culture views humans as part of nature, not separate. How much of our land management systems is dominated by Western worldview?
- Arctic National Wildlife Refuge is an exemplar of "natural" areas, but even that is being affected by climate change and is shifting. The questions is, how to keep it natural? Should we just let that idea go of keeping it "natural"? Replace "natural" with biodiversity or ecological integrity goals?
- Nature makes us feel good; there are spiritual, psychological, aesthetic, and symbolic dimensions of nature.
- "Natural" definition will be based on models and future projections, the definition will not remain the same. Natural in the future will refer to areas or conditions that appear to be free from human developments, alterations, noises, or artifacts that connect to human civilization. Such areas are natural regardless of the degree of change that has occurred in response to global scale anthropogenic factors.

- The point of this presentation and the point of changing idea of naturalism: Maintain naturalism from a conservation standpoint and stimulate discussion on our longstanding beliefs on the future we face.

***The way forward through indigenous traditional ecological knowledge (TEK) and western systems of knowledge (TECH): Values, principles, practices and teachings to heal systemic trauma inflicted on humanity and the planet*** (by Meda DeWitt)

ABSTRACT: Our traditional stories have taught us about this time… our world is on the verge of societal and environmental breakdown. We are faced with the options of collective transformation, or collapse. They teach us that there is no going backwards, these stories lay out the actions necessary to survive and eventually thrive. Our ancestral wisdom is accessible but has to be communicated cross-culturally and at an epistemological level, in a way that people can understand and implement this guidance. Through utilizing both TEK and TECH innovation we will successfully navigate our way forward.

- AK is 20% of US landmass with 6 ecoregions, and 11 languages with 2 main language groups with different migration stories.
- Science is starting to recognize traditional stories.
- Many people think of AK in terms of hundreds of years (since 1700s).
- Systemic trauma is routed in an intentional process (gave list of documents hundreds of years ago to subjugate nature and indigenous or "other" people throughout history). This colonization is a theme in a supreme court decision in 1823 for developing US Indian laws.
- Fast forward to recent years, and climate change will likely cause relocation of significant portion of AK Native communities, because 90% are coastal.
- TEK and TECH values need to be combined for healing.
- The Western Extractive Model was achieved by separating humans and nature. We need a human/nature intersection to start to heal.
- Colonization and assimilation are the processes of disassociation from natural human or being a real human being. Colonization is prolonged trauma that becomes normalized.
- Trauma occurs when one cannot mitigate effects of stress.
- Climate grief and solastalgia are psychosocial trauma. Studies found action feels better than anxiety, but that feeling is fleeting, so we have to address climate change as a public health issue and go through stages of recovery. We can look at traditional migration strategies to address this.
- Evolution of species is bringing past solutions into the future. We have to change our internal program to change internal and external narrative – are we fated to go extinct and suffer, or do we have the ability to change ourselves?
- Looking at culture is intentional (we have control) and unintentional.
- We are evolving as a species; the same behaviors that got us into the problem will not get us out of the problem. We need to be a good relative to other humans.
- We are in the midst of an epic migration story, and are going forward, so we need to be the legendary ancestors.

***Biogeography, time lags, and forest responses to rapid environmental changes: Lesson for interior Alaska from studies of lodgepole pine*** (by Dr. Jill Johnstone)

ABSTRACT: Alaska's glacial history clearly shows that broad environmental changes inevitably bring shifts in species distributions. However, changes in tree distributions are constrained by slow processes of population spread and geographic barriers to migration. Once established in a location, the traits of individual tree species tend to support feedbacks that resist subsequent compositional changes, leading to lagged and often abrupt responses of forest communities to environmental changes. Case studies of lodgepole pine provide an interesting narrative about migration lags, expansion potential, and implications of spread for forest dynamics and ecosystem processes in interior Alaska. We will particularly focus on lessons for use of assisted tree migration as a tool for forest adaptation to contemporary environmental change.

- Changes in natural communities themselves can affect ecosystem processes. It's not just about arriving and spreading.
- This presentation focuses on *Pinus contorta*, or lodgepole pine. Lodgepole pine is an alternative dominant conifer in relation to other conifers in AK that often occurs together with trembling aspen in nearby Yukon. It is fire adapted, shade intolerant, displays rapid growth, and is a pioneer species in newly disturbed sites.
- Over time, the pine stomata and pollen start to appear in Yukon lake sediments, suggesting a slow range expansion that took place over thousands of years.
- Expansion was slow for two likely reasons: poor adaptation due to low genetic diversity, and habitat resistance from the intact vegetation.
- Experimental plantings of pine were established in interior AK after 2004 fires with rapid growth and high performance at many sites. They are currently not present in Interior AK, but it is only a matter of time.
- Why assist these pines into AK? They are very productive species in BC, drought tolerant, fire adapted, and have a diverse resistance to forest pests and disease. In addition, they are co-adapted with other North American boreal species and compatible with winter caribou habitat.
- Risks of assisted migration include that they may have new pathogens, impact ecosystems (fire, litter effects on lichens or moss), compete with native species, etc. Things will change.
- To implement RAD in the context of forest change, we should expect baseline declines in forest productivity (drought, insects, fire, etc.) at many sites. We can Resist at local sites and think about Accept and Direct at other scales.
- Should Alaska's adaptation plan include changes to trees in vulnerable habitats, including introduction of lodgepole pines?

***Science to inform directing ecological transition in Acadia National Park*** (by Abe Miller-Rushing)

ABSTRACT: During the coming decades, the forests in Acadia National Park are expected to shift from boreal to primarily hardwood typical of forests to the south of the park. However, without active

management nonnative invasive shrubs could choke forest regeneration and prevent the establishment of new forest species. Researchers and park managers are taking an experimental approach and testing options to facilitate the establishment of native southern genotypes and species that may help maintain ecological integrity and resist invasion.

- Acadia is on the east coast of Maine at the southern edge of boreal forest, and they need to restore degraded areas.
- We need to think about how the forests are changing by looking at the current composition of 10 most common tree species now vs. future and anticipate only one species to persist in current numbers.
- We are losing species very quickly and expect northward expansion of southern species, replacing current species, however, climate change is happening faster than trees can migrate.
- If we "Accept" these changes, we expect invasive shrub species to continue to encroach and choke out understory to prevent regeneration of native trees, facilitating a transition from native forest to nonnative shrubland. Accepting invasive shrubland is not acceptable.
- Restoration projects in the Parks are allowing for testing experiments. They looked at Resist, Accept, and Direct, and determined direct (assisting migration of forest from the south) is worth trying.
- They are conducting various scientific projects to test actions for managing change, including three pilot restoration projects to test various approaches.
- They realized they need to make their internal communications about the need to direct change available externally. They even invited the press to help explain why need to manage for future conditions.
- They are also supporting early-career researchers in trying to understand/manage/test change.

### ***Planting at the margins: Helping species move*** (by Scott McFarland)

ABSTRACT: Helping species move in response to disturbance events and future conditions is a controversial topic. In this presentation we will explore the concepts of RAD and assisted migration through the lens of ongoing restoration activities at Bandelier National Monument.

- Bandelier National Monument is an old park (est. 1916). The Jemez Mountains have experienced low-intensity fires over the historical record, yet the region is experiencing rapid changes over last century and a half. Climate change is causing increased flooding and more high-intensity fires.
- The National Park Service says we will continue to see a gradual shift in climate suitability. Some species will die off, some will migrate.
- Instead of just documenting the decline and feeling sorrowful due to the changes (Accept), we can also Resist.
- There is not enough people power, money, seeds, etc., to restore entire landscapes, but we can target areas to plant new trees, focus volunteers and work with local communities.

***What are nonnative species in a novel assemblage? Rethinking invasive species management*** (by Dr. John Morton)

ABSTRACT: An ecological expectation of rapid climate change is novel species assemblages due to different rates of migration and extinction. How should we consider the over 560 species of nonnative flora and fauna already in Alaska (with more arriving every year) that become part of reassembled communities? Consider we spend $millions on eradicating Elodea populations even as we plant lodgepole pine, yet both are nonnative flora from Canada. Translocation and eradication are two sides of the same coin, both means to affect "species loading" that may demand a different way of thinking about managing invasive species.

- John shared a photo of a black bear eating common dandelions that were introduced in 1944. In 2000, the dandelion weeble, which also feeds on native species of dandelions not just the nonnative variety, was found. We now have a food chain issue.
- Fishers leave behind earthworms/nightcrawlers introducing another non-native species. In some areas, you can find 1300 pounds per acre, which is higher than most areas. This is 70x more than the moose biomass. Earthworms are changing the soil, which is changing the system and creating novel assemblages.
- Novel assemblages are created because not all species are migrating north, and those that are do not all migrate at the same rate. This creates new species assemblages.
- One approach to manage for migrating species is species packing, in which we shovel species in and let extinction sort it out.
- AK has 1/10th the non-native species (>500) as found in Lower 48.
- Does it matter how non-native species get here? John gave several examples of different ways/reasons non-native species introduced to AK (or parts of AK) ranging from vegetation, clams, deer, hummingbirds, pheasant, and beaver.
- On the Kenai Peninsula we have 14 native trees but >60 non-native tree species. Some of the non-natives are invasive and outcompete native species. The spread of nonnative plants is accelerating (1941-2006), with 1968-2006 adding 3 new species of nonnative plant species per year. We are not doing very well from a management perspective at controlling non-native species.
- In the Arctic, new research says warming is up to 4x faster than the rest of the world; in 2000, the entire area was tundra, but modeling suggests that by 2100, >55% may be conifer.
- Also in the Arctic, we are seeing "white" species departing as losing snow/ice (e.g., Arctic foxes being replaced by red foxes).
- We are seeing white spruce starting to grow naturally, likely result of hunters harvesting wood/cones from one side of the Brooks Range and then leaving wood on other side of the range allowing trees to grow. Other seeds for other vegetation are moving up via the Haul Road. Creeping thistle is now north of the Brooks Range, and has colonized all of AK.
- The only place more remote than AK is Antarctica, and tourism/research is highly controlled. In one summer, tourists brought in thousands of seeds to Antarctica, so what is being brought into AK?
- It doesn't really matter how species got here. We need a sophisticated interdisciplinary perspective on managing exotic species. We should expect novel assemblages and should recognize that we

already influence their compositions, and we should focus on eradicating novel species (when in doubt, kill it because it can always be introduced in the future).

***Do we need new practices to direct change?*** (by Dr. Dawn Magness)

ABSTRACT: Western land management practices have generally assumed stability within a historical range of variability. Shifting from managing historical baselines that are generally observable, knowable, and agreed on to managing nonstationary conditions that are novel, uncertain, and contested will likely require new practices. I will discuss practices that may help address common land management challenges for navigating transformation and preparing to direct change.

- Dawn presented on ecological transformation on the Kenai Peninsula. The landscape is shifting from Lutz spruce forest to bluejoint grassland. Fires caused stand-level mortality in the spruce forest. Snow cover has been more variable throughout the year, so seedlings not able to establish.
- AK has experienced a shift in fire season up to accommodate earlier dryer conditions. There is a question as to whether this will just be the new normal.
- The climate niche is opening - what will fill it? What do we do? Do we accept this new grassland habitat? Or re-establish spruce? There are many factors to consider.
- What ecological features are possible? Just documenting decline isn't enough. We need to consider the range of plausible ecological trajectories. Can interventions be used to shape future conditions? As change gets accepted, what steps would be taken there? For example, (re)introduction of appropriate species, flora and fauna.
- Is the prairie and grassland climate signal a local anomaly or a regional trend? What's the regional conservation strategy, even statewide? We must know more local information.
- Pathway planning might give a space to address triggers for action, and for identifying legal, political, economic, technical, and other barriers. Also asking for opinions and values is important. We must have upstream and deliberative engagement.

# DISCUSSION TAKEAWAYS

This section summarizes the discussions held during the workshop, including those from the various question and answer periods. The information obtained through the discussions was summarized into major themes, focusing on RAD or other topics of interest which were brought forth.

## Discussions relating to the Resist, Accept, Direct framework

- The objective of RAD should be the achievement of **a self-sustaining, self-organizing state that doesn't require perpetual management**. In Alaska, our systems have historically been self-sustaining, although climate change is likely changing that.

- **Consensus building for RAD actions is a critical step**. Who is included in the conversations depends on scale and location, but consensus around the desired future state is needed for success.

- **Managing to a historic or baseline condition is likely no longer possible** in many instances, due to directional climate change and land use and land conversion. To learn from past climate changes, it is necessary to look backwards at least the last few thousand years to understand how current ecosystems came to be. Looking back to the Last Glacial Maximum may provide better context for how ecosystems have responded to climate forcing than arbitrarily choosing the last few hundred years.

- **When applying Resist strategies, there will be a time when managers need to switch from Resist to Accept (or Direct).** Resist can be an important strategy to buy time for species and habitats to migrate to new locations, or for other solutions to be tested. In some instances, Resist strategies may be planned for the foreseeable future, but in many cases, Resist strategies will be short term because of expectations of continued and dramatic change. Managers can identify triggers or thresholds about when to stop resisting (e.g., waning effectiveness of management action or cost of resisting) and move to either Accept or Direct.
    - The conversations around when to stop Resisting needs to go beyond human-built infrastructure and include natural systems/habitats.
    - It is necessary to articulate shared values to drive the decisions to Resist vs. Accept vs. Direct.

- **Organizations need to become more comfortable taking risks**, experimenting, and learning as we move forward. Failure needs to be accepted as an appropriate outcome in the iterative learning cycles of adaptive management; pilot projects/experiments should become a norm.
    - However, taking risks and accepting failures as part of normal operations would require a culture shift within agencies. Failure can present learning opportunities (e.g. Adaptive Management).
    - Agencies may appear risk averse due to the many considerations they must balance. Public trust and buy-in are ultimately important, but many of the immediate barriers to implementing climate actions come from within the agencies themselves.

- **Climate grief (i.e., solastalgia) is a real phenomenon** and requires looking internally for the emotions. Climate-related events (e.g., salmon runs crashing in the Yukon; California homes burning; Australia wildfires) are going to happen more regularly, so we have to recognize that human emotions are going to become traumatic, and many people do not have the coping skills to deal with this.

- **Assisted migration is a management option that agencies are already considering.** There is agreement that we need more data, but participants discussed that at some point, we have to switch away from investing resources into data collection and into experimentation and action.

    - Assisted migration/transformation is already happening daily in local landowners' backyards. Most decisions to plant non-native species are happening without data or other information regarding planting decisions.

- **Conservation goals differ by scale.** For example, biodiversity or extinction may be important at the national or continental scale, whereas species management (e.g., moose or salmon) may be more important at local scales. There are tradeoffs associated with each scale.

- **In Alaska, it is possible to manage for carbon.** One Resist strategy is to reduce introduced fire on the landscape, although higher fuel loads could result in larger and hotter fires which would release more carbon and thaw permafrost. Peatlands are also important features on the landscape to maintain. They are effective at sequestering carbon but release carbon when they decompose or burns. It was also noted that conifers are more drought resilient and support the caribou/lichen relationship better than deciduous trees, but it may be worth exploring both trajectories simultaneously.

- **Monitoring change has never been more important.** Deciding what/how to monitor is as important as asking the question of if we need more monitoring. Monitoring needs to be deliberate and tied directly to information needs. Inventories can be as important as monitoring and are often left out of the conversation.

    - Monitoring is critical to answer the question of how long we Resist. Agencies should incorporate triggers or thresholds for management intervention or for moving from Resist to Accept or Direct strategies.

    - Technological and cost improvements for biodiversity monitoring are game changers. The species most likely to go extinct are the ones we are not monitoring, like invertebrates.

    - Basic (i.e., simple) modeling information can form the foundation of more complex modeling or investigations.

    - More coordinated monitoring efforts can overcome limited financial or people resources, as well as allow for trend detection over large areas. Sharing data and protocols is likely better than trying to create a new method.

    - We need to monitor trajectories in order to test the models. It is important to identify surprises and where the models fail.

- **Maintaining connectivity in Alaska is often low hanging fruit relative to the generally fragmented landscapes in the Lower 48.** Allowing plants and animals to migrate on their own increases the resilience of the entire system. Slow moving species may require assisted migration.

- **Trying innovative ideas, such as building rafts to serve as walrus haul outs when there is not enough sea ice is critical.** There was enough interest among the participants to possibly start a working group to bring the floating rafts idea forward.

- **The RAD Framework can be applied in other sectors, such as agriculture.** We need a larger portfolio of examples and diverse applications.

- **It is never too late to start the conversation.** Many of the points listed here have been a decade in the making. There has been a shift in the appetite to consider novel management activities in

Alaska. Values have emerged as an important component of moving forward with appropriate social license. All of these decisions will have tradeoffs and public input and consideration is critical for supporting not only the decisions but understanding why the decisions are needed/important.

### Other discussions of interest

- **The intersection of salmon management with climate change has long been a topic of interest in Alaska.** This workshop brought up specific populations as well as discussion of spawning and ocean parts of the life cycle, including ocean acidification.

- **The introduction of wildlife disease** as new species enter Alaska or as pests migrate northward were brought forth as possible concerns.

- **Cost-benefit analyses**, including valuating ancillary impacts, were mentioned as being informative to the decision-making process.

- **Avoiding scientific jargon** is necessary when talking to non-scientists. An effective way to connect with people is to talk about topics that are important to your audience. We need to include local partners so the research does not go into vacuum. Telling the story using graphics and simple messaging is important because people do not have time to attend lengthy workshops.

- **It was debated whether climate change is intentional.** On one hand, society is not deliberately changing the climate (it is a byproduct of economic development, etc.), but on the other hand, we fully understand why and how we are changing the climate and society is incapable of doing anything to stop it.

## NEXT STEPS

Participants who were interested in continuing the conversation stayed on for an optional, unstructured brainstorming session on ideas for continued engagement after the workshop. Participants were encouraged to write ideas on virtual sticky notes. Participants were asked “what can we do?” and given the ability to place digital sticky notes on a shared idea board. The notes of these ideas are available in Appendix V.

# APPENDIX I: WORKSHOP STEERING COMMITTEE MEMBERS

The following individuals were instrumental in helping organize the workshop and develop the agenda.

Meda DeWitt, MA, TH
AKN Traditional Healer/PhD Candidate
Anchorage, AK

Jeremy Littell, PhD
Research Ecologist / Lead Scientist
USGS Alaska Climate Adaptation Science Center, Anchorage, AK

John M. Morton, PhD
Vice President
Alaska Wildlife Alliance, Anchorage, AK

Will Putman, MS
Forestry Director
Tanana Chiefs Conference, Fairbanks, AK

Joel H. Reynolds, PhD
Climate Science and Adaptation Coordinator
NPS Climate Change Response Program, Fort Collins, CO

Sue Rodman, MS
Program Coordinator for Wildlife Habitat Enhancement
Alaska Department of Fish & Game, Anchorage, AK

Facilitation by Amanda Sesser (21Sustainability LLC) and Nicole Schmitt (Alaska Wildlife Alliance)

# APPENDIX II: WORKSHOP SPONSORS

The following organizations provided funding to help cover the expenses associated with planning and implementing the workshop.

**ALASKA WILDLIFE ALLIANCE**

Alaska Wildlife Alliance (AWA) is excited to host this workshop as a pillar of our Wildlife & Climate Adaptation program. AWA is a grassroots, non-profit organization founded by Alaskans in 1978 to protect Alaska's wildlife for its intrinsic value, as well as for the benefit of present and future generations. We advocate for healthy ecosystems, scientifically and ethically managed to protect our wildlife in an increasingly dynamic world.

For more information, visit www.akwildlife.org or email Nicole Schmitt at nicole@akwildlife.org.

Co-Sponsord by

**USGS ALASKA CLIMATE ADAPTATION SCIENCE CENTER**

Established in 2010 as a partnership between the University of Alaska and the United States Geological Survey, the Alaska CASC is Congressionally mandated to meet state and federal needs around climate impacts, adaptation, and resilience. Hosted by UAFs International Arctic Research Center with a USGS-hosted office in Anchorage, the Alaska CASC provides scientific information, tools, and techniques that managers and others interested in land, water, wildlife, and cultural resources can use to adapt to climate change.

Our research directions are determined by representatives of federal, state, tribal, and regional organizations. We aim to meet high-level climate science priorities while ensuring this science also is pertinent to and addresses management needs.

Learn more at www.akcasc.org.

**EA Engineering, Science and Technology, Inc., PBC**

A leading provider of interdisciplinary environmental services, EA has worked to improve natural environments since our founding in 1973. Rooted in this experience is our philosophy that solutions needed to solve environmental challenges are meant to be part of holistic approach that take both natural and community-based elements into account as we guide our partners towards targeted nature-based responses to address challenges related to a changing climate. Our partners benefit from proven tactics for reducing life-cycle protection costs by focusing on the most sustainable long-term solutions. A 100% employee-owned public benefit corporation, EA employs more than 575 professionals through a network of 26 commercial offices including Fairbanks and Anchorage. In business for more than 48 years, EA has earned an outstanding reputation for technical expertise, responsive service, and judicious use of client resources. For more information about EA, visit EA's website at www.eaest.com. You can also listen to EA in the podcast, *Building Resilience in Cold Regions with EWN® and Natural and Nature-Based Features,* or visit EA's YouTube channel to view presentations on select EA Projects, overviews of our service areas, and other corporate activities.

For more information, contact Samuel Whitin, CERP, Vice President and Coastal Resilience Director, swhitin@eaest.com, 401-465-2549.

Also supported by

**NATIONAL PARKS CONSERVATION FOUNDATION**

National Parks Conservation Association (NPCA) is an independent, nonpartisan membership organization devoted to advocacy on behalf of the National Parks System. Our mission is to protect and enhance America's National Park System for present and future generations. In Alaska, NPCA works to protect park landscapes and ecosystems, enhance visitor experience of national parks, and ensure adequate funding for the parks and the people who work in them.

For more information, contact Jim Adams, Alaska Regional Director, jadams@npca.org, 907-538-5898.

# APPENDIX III: RESIST-ACCEPT-DIRECT FRAMEWORK

The Resist-Accept-Direct (RAD) decision framework is a solution-oriented approach to adapting to ecological changes in a rapidly warming climate (Lynch et al. 2021, Thompson et al. 2021, Schuurman et al. 2022). Unlike other planning approaches (e.g., scenarios planning, open standards), RAD squarely assigns the response (three action verbs) to climate-induced directional change to a tribal organization or land management agency. Many changes will be resisted to maintain ecological processes, functions or composition toward a historical baseline. Many changes will be accepted because they may be infeasible to be managed (e.g., warming air temperatures), insufficiently impactful to warrant a response (e.g., shrubline rise), acceptable to (or even desirable by) some stakeholders (e.g., longer growing season), or unknowingly occurring. Finally, some changes will be directed towards a future state because resisting is untenable and there is a feasible opportunity to steward the change towards a more desirable outcome than what is arising from acceptance. In a perfect world, the goal is a self-sustaining, self-organizing system that does not require continual intervention (at least for a reasonably long time).

The three decision pathways collectively encompass the entire decision space (i.e., there are no other choices), are mutually exclusive, and do NOT represent a continuum. The decision will be based on contrasting the three choices (all of which involve change), rather than comparing a management action with the perception of what is "natural" as has been conventionally done in the past. Technology (or the absence of it) does not dictate whether an approach is R, A or D, nor does acceptance imply the absence of management. Decision paralysis because of uncertainty is NOT an option as, at the very least, acceptance of a climate-induced ecological trajectory becomes explicit. Scientific and managerial uncertainties can be addressed with experiments to test ecological outcomes and pilot studies of novel climate adaptation approaches (that can be scaled up if successful).

RAD was highlighted in a special issue of the scientific journal *BioScience* in 2022 (https://academic.oup.com/bioscience/issue/72/1). Here, articles can be found on the foundational thinking for successful RAD implementation (Magness et al. 2022), the science needed (Crausbay et al. 2022), the change needed in our social values (Clifford et al. 2022), and the revision in adaptive management needed for resources with non-stationary goals (Lynch et al. 2022).

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# APPENDIX IV: PRESENTER BIOGRAPHIES

The following speaker biographies are presented in the order of their presentation during the workshop, with the title of the presentation replicated before their biography.

***Resist-Accept-Direct (RAD): A way of thinking about climate change*** (by John Morton)

Dr. John Morton is Vice President of the Alaska Wildlife Alliance. He retired from the USFWS in 2019 after 32 years working in Alaska, California, Maryland, Virginia, Wisconsin and the Mariana Islands. John was most recently the supervisory biologist at Kenai National Wildlife Refuge where he and his staff engaged in research on climate change effects and adapting to them. He worked with the two interagency groups that have been developing RAD for several years.

***RAD what? Climate-driven regional and landscape trajectories in Alaska*** (by Jeremy Littell)

Dr. Jeremy Littell is a USGS research ecologist (climate impacts) at the Alaska Climate Adaptation Science Center. He conducts research on climate impacts on terrestrial ecosystems and works to provide climate information and projections for use in planning, vulnerability assessment, and adaptation. He has a background in paleoclimatology and wildfire research.

***'Natural' colonization of novel areas in Alaska*** (by Tom Paragi and Kimberlee Beckmen)

Tom Paragi is a wildlife biologist with ADF&G in Fairbanks. His work has included research on habitat management and moose ecology and the monitoring of Intensive Management programs. Tom also worked as a furbearer biologist and on fire research with the USFWS in Alaska. Dr. Kimberlee Beckmen, M.S., D.V.M., Ph.D., is the Wildlife Health Veterinarian for ADF&G.

***Evidence of change in Alaska's marine ecosystems and fisheries*** (by Doug Limpinsel)

Doug Limpinsel earned BS and MS in Biology from Niagara University. His graduate research focused on toxicology studies to assess pollution impacts on Great Lakes salmonids. He expanded his experience at Massachusetts Maritime Academy, Woods Hole Oceanographic Institution and the Marine Biological Laboratory before conducting watershed habitat assessments and fisheries surveys for the USFWS. Doug now works in the NOAA Alaska Region as a Fisheries Biologist in the Habitat Conservation Division.

***Taking the long view: reflections on long-term ecological monitoring in Alaska*** (by Jim Lawler and Diane Granfors)

Jim Lawler is the National Park Service, Alaska Region lead for the Inventory and Monitoring program. Jim's work experience includes serving as the program manager for ecological monitoring in the five northern most Parks, and as a wildlife biologist for Gates of the Arctic National Park and Preserve and Yukon Charlie National Preserve. Dr. Diane Granfors is the I&M Coordinator for Alaska Refuges. With roots in

avian ecology and spatial analysis, Diane is interested using landscape level planning to address biodiversity and ecological integrity in the Anthropocene.

***Preparing for a response: Inventorying species diversity by metabarcoding*** (by Matt Bowser)

Matt Bowser serves as a Fish and Wildlife Biologist at Kenai National Wildlife Refuge, where he pursues entomology, botany, ecology, non-native species management, and biological inventory and monitoring.

***Managing connectivity to accept change*** (by Dawn Magness)

Dr. Dawn Robin Magness is a landscape ecologist at the Kenai National Wildlife Refuge. She is interested in climate change adaptation, landscape planning, social-ecological systems, and spatial modeling. She earned her MS in Wildlife and Fisheries Sciences at Texas A & M University and her PhD in the interdisciplinary Resilience and Adaptation Program at the University of Alaska, Fairbanks.

***What does management of threatened and endangered species in Alaska look like in the face of climate change?*** (by Erin Knoll)

Erin is the Regional Endangered Species Coordinator for the Alaska Region of the US Fish and Wildlife Service. She's spent most of her career in the endangered species world since after spending a year working with Attwater's Prairie Chickens in Texas she realized endangered species was where she wanted to work. Before moving to Alaska to work in the Anchorage Field Office in 2015, she worked in the Arkansas Field Office as an endangered species biologist, where her days were spent crawling on river bottoms looking for mussels and crawling around caves counting bats.

***Changes to ocean systems and management goals for Alaska commercial salmon fisheries*** (by Bill Templin)

William (Bill) Templin is the Chief Fishery Scientist for Salmon at the Alaska Department of Fish and Game, Division of Commercial Fisheries where he oversees the division's statewide salmon research and stock assessment programs and helps ensure that research is well integrated with fisheries management.

***Tundra ecosystem change as a consequence of permafrost degradation: Using a novel field experiment to simulate a future warmer world*** (by Ted Schuur)

Dr. Ted Schuur is a Regents' Professor in the Center for Ecosystem Science and Society at Northern Arizona University. He participates in multiple national and international science meetings, workshops, panels, and steering committees on the topic of ecology and the environment, including most recently as a lead author for the Intergovernmental Panel on Climate Change (IPCC) Special Report on Oceans and Cryosphere in a Changing Climate. He is the also the lead investigator for the Permafrost Carbon Network. He graduated Magna Cum Laude with a BS from the University of Michigan and he received a PhD from the University of California-Berkeley. In 2019, he was elected a fellow of the American Geophysical Union.

***Pilot studies to assess feasibility of intervention/assisted adaptation: thin-layer sediment augmentation at the Seal Beach National Wildlife Refuge*** (by Andy Yuen)

Andy Yuen began his career with the USFWS in 1984 as a Cooperative Education Program student at the Pacific Islands Office in Honolulu. He worked on wetland and stream conservation and planning for new National Wildlife Refuges (NWR) throughout Hawaii and the western Pacific including Kealia Pond, Guam, Kona Forest, and Palmyra Refuges. In 1996, he became the deputy project leader for the San Diego NWR Complex. He returned to Ecological Services in 1998 as the deputy field supervisor at the Carlsbad Fish and Wildlife Office. In 2005, he became the project leader for the San Diego NWR Complex, which includes Seal Beach NWR, San Diego Bay NWR, Tijuana Slough NWR and San Diego NWR.

***State wildlife management in Alaska: scope, scale, and process*** (by Chris Krenz, Tony Kavalok, Ryan Scott and Tom Paragi)

Chris Krenz is the Wildlife Science Coordinator at the Alaska Department of Fish and Game, Division of Wildlife Conservation where he oversees the division's programs for marine mammals; threatened, endangered, and diversity species; wildlife habitat enhancement and spatial analysis; and wildlife health and disease surveillance. He also helps coordinate research across the Division and ensure it is integrated with wildlife management. Tony Kavalok is an ADF&G Assistant Director, Ryan Scott is an ADF&G Assistant Director, and Tom Paragi is the ADF&G Intensive Management Coordinator.

***Offshore rafts as artificial haul-outs for walrus in absence of sea ice*** (by Rick Steiner)

From 1980–2010, Dr. Rick Steiner was a marine conservation professor with the University of Alaska, stationed in the Arctic (Kotzebue 1980-1982), Prince William Sound (Cordova 1983-1997), and Anchorage (1997-2010). He commercially fished in Alaska in the 1970s and 1980s, and has floated and hiked thousands of miles across Arctic wilderness. Today, through his independent "Oasis Earth" project, he provides scientific advice to NGOs, governments, the United Nations (UN), and civil society organizations globally on environmental issues.

***Active forest management as a means for climate change adaptation in the boreal forest*** (by Will Putman)

Will Putman is the Forestry Director at Tanana Chiefs Conference (TCC), a non-profit tribal organization serving 42 tribal communities in interior Alaska. He has a BS in Forestry from the University of Montana and an MS in Natural Resource Management from the University of Alaska Fairbanks. He has worked as a forester at TCC since 1985, helping to deliver a variety of forest and fire management services to rural interior Alaska tribes and communities.

***Experimental approaches to resisting and redirecting high-latitude terrestrial feedbacks to climate*** (by F. Stuart "Terry" Chapin, III)

Dr. Chapin's research addresses the effects of changes in climate and wildfire on Alaskan ecology and rural communities. He explores ways that communities and agencies can increase sustainability of ecosystems

and human communities over the long term despite rapid climatic and social changes. In this way, society can proactively shape changes toward a more sustainable future. He pursues this internationally through the Resilience Alliance, nationally through the Ecological Society of America, and in Alaska through partnerships with rural indigenous communities.

***Can saving ice save our way of life? Using glass microspheres to increase surface albedo*** (by Leslie Field)

Dr. Leslie Field's work for the past 15 years has focused primarily on solving some of the world's most urgent problems in climate. She brings her love of nature and her decades of engineering experience to the pressing task of preserving a habitable world. Leslie is the Founder and CTO of the Arctic Ice Project, where she also served as the founding CEO for over a decade. She earned PhD and MS degrees in Electrical Engineering from UC Berkeley's Sensor & Actuator Center, and MS and BS degrees in Chemical Engineering from MIT

***Resist until when? Applying adaptive management*** (by Abby Lynch)

Dr. Abigail (Abby) J. Lynch is a Research Fish Biologist with the USGS National Climate Adaptation Science Center. Abby conducts science and science synthesis on the impacts of global change to inland fishes at local, national, and global scales. Her work aims to inform conservation and sustainable use and assist fishers, managers, and other practitioners adapt to change.

***If we direct change, to what ends do we direct it?*** (by Steve Jackson)

Dr. Stephen T. Jackson is Director of the Southwest and South Central Climate Adaptation Science Centers, partnerships between the U.S. Geological Survey and multi-university consortia respectively led by the University of Arizona and the University of Oklahoma. In this position, he works to foster effective engagement between researchers and resource-management decision-makers. He is also Adjunct Professor of Geosciences and of Natural Resources & Environment at the University of Arizona. Before joining USGS in 2012, he was at the University of Wyoming, where he was founding Director of the Program in Ecology and is now Professor Emeritus of Botany.

***Nature in the Anthropocene: What it no longer is, will never again be, and what it can become*** (by Roger Kaye)

Dr. Roger Kaye has worked for the USFWS in Alaska for 43 years, as a planner, pilot, Native liaison, and in recent years, as the agency's Alaska wilderness coordinator. He has a PhD from the University of Alaska where he has taught courses on wilderness, environmental psychology, and the Anthropocene. He is the author of *Last Great Wilderness: The Campaign to Establish the Arctic National Wildlife Refuge* and numerous journal and popular articles related to Wilderness and the Anthropocene.

***The way forward through Indigenous traditional ecological knowledge (TEK) and western systems of knowledge (TECH): Values, principles, practices and teachings to heal systemic trauma inflicted on humanity and the planet*** (by Meda DeWitt)

Meda DeWitt's Tlingit names are Tśa Tsée Naakw, Khaat kłaat, adopted Iñupiaq name is Tigigalook, and adopted Cree name is Boss Eagle Spirit Woman "Boss." Her clan is Naanyaa.aayí and she is a child of the Kaach.aadi. Her family comes from Shtuxéen kwaan (now Wrangell, AK). Meda's lineage also comes from Oregon, Washington, and the British Columbia/Yukon Territories. Currently she lives on Dena'ina lands in Anchorage, Alaska with her fiancé James "Chris" Paoli and their eight children. Meda's work revolves around the personal credo "Leave a world that can support life and a culture worth living for." Her work experience draws from her training as an Alaska Native traditional healer and Healthy Native Communities capacity building facilitator.

***Biogeography, time lags, and forest responses to rapid environmental changes: lessons for interior Alaska from studies of lodgepole pine*** (by Jill Johnstone)

Dr. Jill Johnstone is a plant ecologist based in Whitehorse, Yukon, Canada, where she conducts research on plant ecology in affiliation with the University of Alaska Fairbanks, Yukon University, and University of Saskatchewan. Much of her research focuses on northern ecosystems, such as boreal forest and tundra, that are currently experiencing rapid rates of climate change. She uses field measurements and experimentation combined with statistical or simulation modeling to examine the dynamics of plant community responses to environmental change. She is particularly interested in how disturbances may catalyze ecosystem changes and the role of plant-soil interactions in stabilizing different potential configurations of ecosystems.

***Science to inform directing ecological transition in Acadia National Park*** (by Abe Miller-Rushing)

Abe Miller-Rushing is the Science Coordinator at Acadia National Park, where he has worked for 11 years. In his position he oversees research in the park and helps to lead the park's work to adapt resource management practices for changing climate conditions. His own research focuses on climate change ecology, phenology, citizen science, and conservation.

***Planting at the margins: Helping species move*** (by Scott McFarland)

Scott McFarland is the former Chief of Resource Management at Bandelier National Monument and currently serves as the Field Program Lead with the NPS Natural Sounds and Night Skies Division. He grew up in Montana and Oregon and currently resides in Fort Collins, Colorado with his wife, two pups, and an ornery cat.

***What is a nonnative species in a novel assemblage? Rethinking invasive species management*** (by John Morton)

Dr. John Morton is Vice President of the Alaska Wildlife Alliance. He retired from the USFWS in 2019 after 32 years working in Alaska, California, Maryland, Virginia, Wisconsin and the Mariana Islands. He has managed many invasive biota from brown tree snakes and mute swans to bird vetch and Elodea. John was most recently the supervisory biologist at Kenai National Wildlife Refuge where he and his staff engaged in research on climate change effects and adapting to them.

***Do we need new practices to direct change?*** (by Dawn Magness)

Dr. Dawn Robin Magness is a landscape ecologist at the Kenai National Wildlife Refuge. She is interested in climate change adaptation, landscape planning, social-ecological systems, and spatial modeling. She earned her MS in Wildlife and Fisheries Sciences at Texas A & M University and her PhD in the interdisciplinary Resilience and Adaptation Program at the University of Alaska, Fairbanks.

# APPENDIX V: POST-WORKSHOP BRAINSTORM SESSION NOTES

Immediately after the formal workshop concluded, participants were invited to attend a one-hour informal brainstorming session on needs, ideas, and next steps. Participants were asked "What can we do?" and given the ability to place their thoughts on virtual "sticky notes" into a shared, online idea board. The following are the participants' comments as they wrote them on those "sticky notes", organized into themes. Some participants added their contact information to share, which is reflected in their comments below, as well as on the screenshot of the contacts page in the virtual "sticky notes" idea board.

## What can we do? Working groups, committees, forums or workshops

- "Considering the capacity needed to organize 'us' and the ideas to promote proposals, etc., consider using existing forums to expand this workshop to the action stage. The Wildlife Society, Society of American Foresters, and likely other organizations like the Northwest Boreal Partnership may be options to support a working group of this interdisciplinary nature."
- "Working group for interdisciplinary studies in SE AK to support communities. Research co-produced by Alaska Native people."
- "Conduct research into the ultimate driver of env change: human understanding & motivation. We rely too much on intuition as to how to meaningfully inform & engage in the issue. We study endlessly how the env is changing, but we know very little about ourselves in relation to it."
- "Change is happening way faster than we can keep up with, we should be having annual meetings."
- "Training and Outreach to agencies and policy makers, utilize Doug Limpensel's suggestion for quick graphic communication."
- "Annual/bi-annual meeting on applied adaptation."
- "Present a summary of our discussions to AFN and provide attendees with questions?"
- "Protecting permafrost interagency think tank that can link the work of scientists like Ted with the need for RAD strategies and implementation. If it starts dumping carbon, I worry that we won't react."
- "Adaptation listserve to share info, funding sources, publications, etc. Similar to AKISP."
- "Leslie Field, working on preservation of ice, snow, water cooling, and possibly permafrost. Seeking collaborations. Contact info given on the contact info page. Our work may be of help to ice roads as well."
- "For the Kenai peninsula, engage with Renew Kenai on renewable energy projects and climate mitigation measures."
- "Managing for landscape connectivity across various Federal, State, private and possibly International boundaries. "
- "Follow-up workshops (a statewide annual workshop? Alternative natural resource governance?)"
- "Marine mammal ice alternative haulout working group."
- "Outreach to public - especially native communities - for input on their values, what is important to them, what are the biggest threats they see, what should we be studying or monitoring, etc."

- “Start local chapters of Alaska Wildlife Alliance throughout the state to further this discussion on a local level and to build community.”
- “Take time up front to engage diverse knowledges & identify key actors at all levels: state, federal, private, Alaska Native community, science community, landowners and managers, resource managers, policy-makers, etc. when developing working groups etc. Focus on diversity, equity & inclusion.”
- “ANILCA impacts conservation throughout the state and the balance between conservation and development Congress strove to incorporate affects most all lands either directly or indirectly. To bridge understandings, it must be meaningfully incorporated to understand the differing perspectives from land and resource managers, local communities, and users of the landscape, etc. Engage various federal, state, and public actors with knowledges to share, e.g., ADF&G, DNR, Statewide ANILCA programs, Institute of the North ANILCA resources, etc.”
- “We could easily have a separate sub working group to develop public friendly graphics and language to inform an interested public.”
- “WG to address the problem of "talking to ourselves" and how to reach those in the middle of the ideological spectrum. Social science/science communication.”
- “Adaptation practitioners forum to facilitate discussions.”
- “Workshop on science communication/outreach/public engagement.”
- “Incorporate more social diversity into the pathways for adaptation. We tend to look at universal and generalized solutions.”
- “Nest authorities at different scales- polycentric governance system are deliberately redundant in order to maintain adaptiveness.”

## What can we do? White papers or publications

- “Integration of IK and WK “
- “Highlight what Alaska species are most threatened by climate change and assess the prospects for doing something about it.”
- “Provide lists of species that would represent range extensions to Alaska and would be more appropriate for introduction, and less invasive.”
- “Assess connectivity barriers in Alaska and promote solutions.”
- “Look at how citizen science could help with these issues.”
- “Further develop climate impact needs to aquatic and marine resources.”
- “Inventory potential partners and funding sources and link to working group topics.”
- “TEK/TECH: Facilitated Cultural Adaptation. Coming 2022/2023 PhD completion”
- “RAD (and not so RAD) ALASKA: motivations for, information needs, and potential consequences of a radical range of management actions to confront rapid change and transformation.”
- “New evtl gov models that promote inclusivity and shared power in conservation (co-production through implementation) towards diverse values and goals/objectives; shared stewardship.”

- "There needs to be communication w/ Indigenous Peoples and some of their traditional practices with fire suppression and other land/water/air practices. Co-production with including Indigenous Peoples at the ground level - when applying for research grants etc. "

## What can we do? Regulatory or legislative actions

- "Restore the ESA to consider loss of habitat by climate change in species designation and recovery."
- "We need permissions to do field work, even at the small scale we pilot things at."
- "Greater opportunities for co-management with Tribes and financial support for program vs. project-based positions within Tribes, especially around natural resource management and climate adaptation. Grant programs that allow more flexibility in how money is spent that is culturally appropriate (e.g., door prizes are often not allowed under federal funding but go a long way to attracting public engagement in Tribal communities). Allow grant programs to provide monetary compensation for wisdom keepers who share TEK as part of a planning process - valuing different types of knowledge the same as western scientific input."
- "The biggest detriment in maintaining forward momentum in understanding, planning and preparing for change, or implementing a RAD approach is; 1) constant shifts in administrations (go/no go), 2) lack of continuity in federal and state policy and funding efforts, and 3) a poorly informed and misinformed public. The larger body of the public is interested, they just don't have the time to dig into this."
- "Acknowledge Indigenous rights to traditional use of fish and wildlife resources in Alaska as a central component of Tribal resilience."

## What can we do? Other

- "I find it interesting that managers running national and international fiduciaries and investment funds, the military, auto companies and the Oil and Gas industry are all "preparing" to become more "resilient" and "adaptive" to the future condition under a changing climate. Why isn't our ability to address these issues. https://www.cnbc.com/video/2020/01/14/blackrock-ceo-larry-fink-explains-his-decision-to-prioritize-sustainability.html"
- "Network/community of people/entities/agencies engaging in adaptation trialing efforts."
- "Form a statewide climate adaptation partnership to advance ideas, legislation, etc. (again, similar to AKISP) to do all of the above."
- "Yearly summary of what we have learned about the range of plausible ecological trajectories by ecoregion and RAD implementation in Alaska. This could be a write up and a webinar modeled after how fire science is summarized for practitioners each year."
- "Collaboration between state and federal land managers to apprentice Tribal employees and build management capacity in rural communities."

## Funding Opportunities

- "National Fish and Wildlife Foundation (NFWF) Funding for Coastal Resilience can be accessed for the upcoming round this spring. https://www.nfwf.org/programs/national-coastal-resilience-fund. Feel free to contact me (field liaison) for more details about this fund.
- Funding RAD pilot projects."
- "We need funding if possible for the initial small-scale field research - and we need to build local and indigenous collaborations to codevelop and test the solutions."
- "Program personnel! Too much funding is tied to projects, not enough to programs and program managers for climate adaptation."
- Jana Doi (National Fish and Wildlife Foundation); jana.doi@nfwf.org: Alaska Fish and Wildlife Fund - https://www.nfwf.org/programs/alaska-fish-and-wildlife-fund

## What else do you need to make decisions?

- "Synthesis of ideas, data, and options (known information)"
- "When thinking about applying frameworks like RAD at landscape scales, I believe it's important to think more holistically by considering land use in a general context that includes all ways we use or depend on lands (e.g., urban, ag, wilderness) to meet basic human needs and wants (i.e., values) now and in the future. Since its origin, humankind has adapted to and endured changing environments through, among other things, innovation, migration, and evolving values. Embracing a perspective that we will always face changing environmental conditions and must adapt our behavior accordingly opens new opportunities and challenges to considering how human values influence land use decisions vary across different spatial and temporal scales. For example, the future distribution of the human population will most likely be quite different depending on the future distribution of habitable places and resource availability. How that redistribution reshapes human values for particular places may have substantial impacts on land use planning and decisions. Previous physical and environmental barriers to human development may subside on some lands, whereas new barriers may arise on other lands. Such changes may lead to or require complete re-designation of land use priorities over large areas in response to the redistribution of humans across the landscape and the values they possess. All that said, I believe an important question to ask is: "How do we integrate broader land use values and challenges into the decision contexts for resource management on federal lands and maintain consistency at the various scales those decisions are made?"
- "Federal land management stations need capacity. Seriously."
- "Clear statements and prioritization of research/science needs for decision making/action - we can bend the direction of funded science toward these if we know the specific needs."
- "A better understanding of potential costs (literal and figurative) and benefits of different courses of action."

- “Better understanding of the social science issues involved with land management. An example is what shifts may occur in subsistence uses in a changing environment when some current resources may become less available.”
- “Better general public understanding of connections between physical and mental health and climate change - adaptation and resilience are not just infrastructure.”
- “More capacity - more people familiar with state and federal agencies and able to navigate the sometimes byzantine bureaucracies around climate. Also more funding, particularly for experimental projects or implementation of projects. “

# Contact Information

# ALASKA WILDLIFE ALLIANCE

The Alaska Wildlife Alliance is a 501c3 organization (EIN: 92-0073877) advocating for healthy ecosystems in Alaska, scientifically and ethically managed to protect our wildlife for present and future generations.

To learn more

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