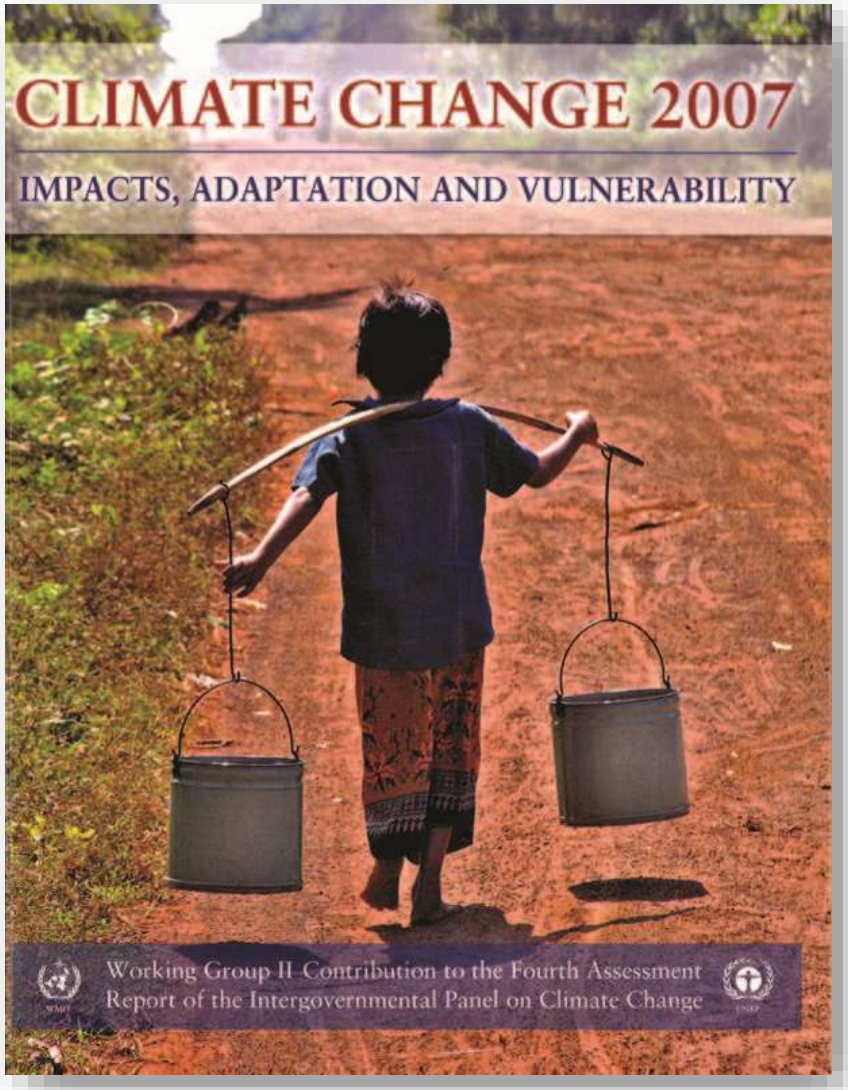
Resisting, Accepting or Directing Change:
A new way to think about climate adaptation

John Morton
Kenai National Wildlife Refuge

Adaptation is…

“an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities”

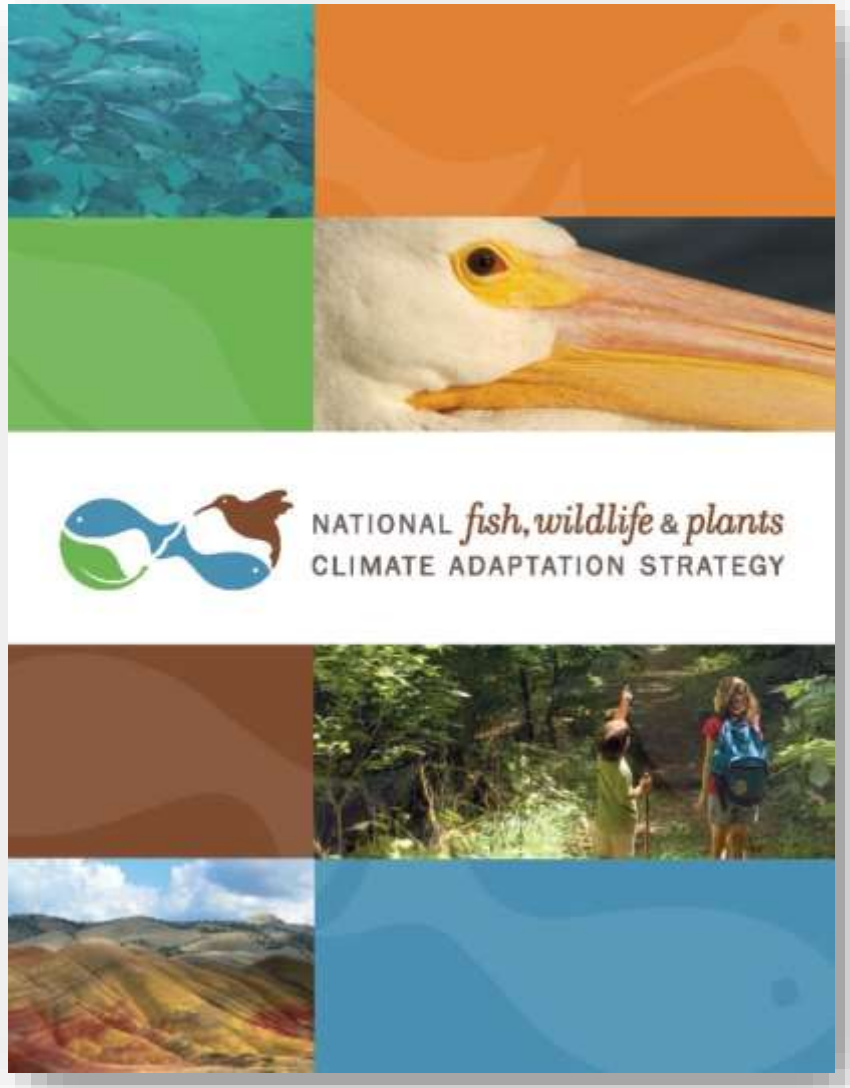


—Intergovernmental Panel on Climate Change (2007)

Resistance vs Resilience vs Transformation

NFWPCAS developed to promote unified agency responses to climate change impacts

— National Fish, Wildlife, and Plants Climate Adaptation Strategy 2012

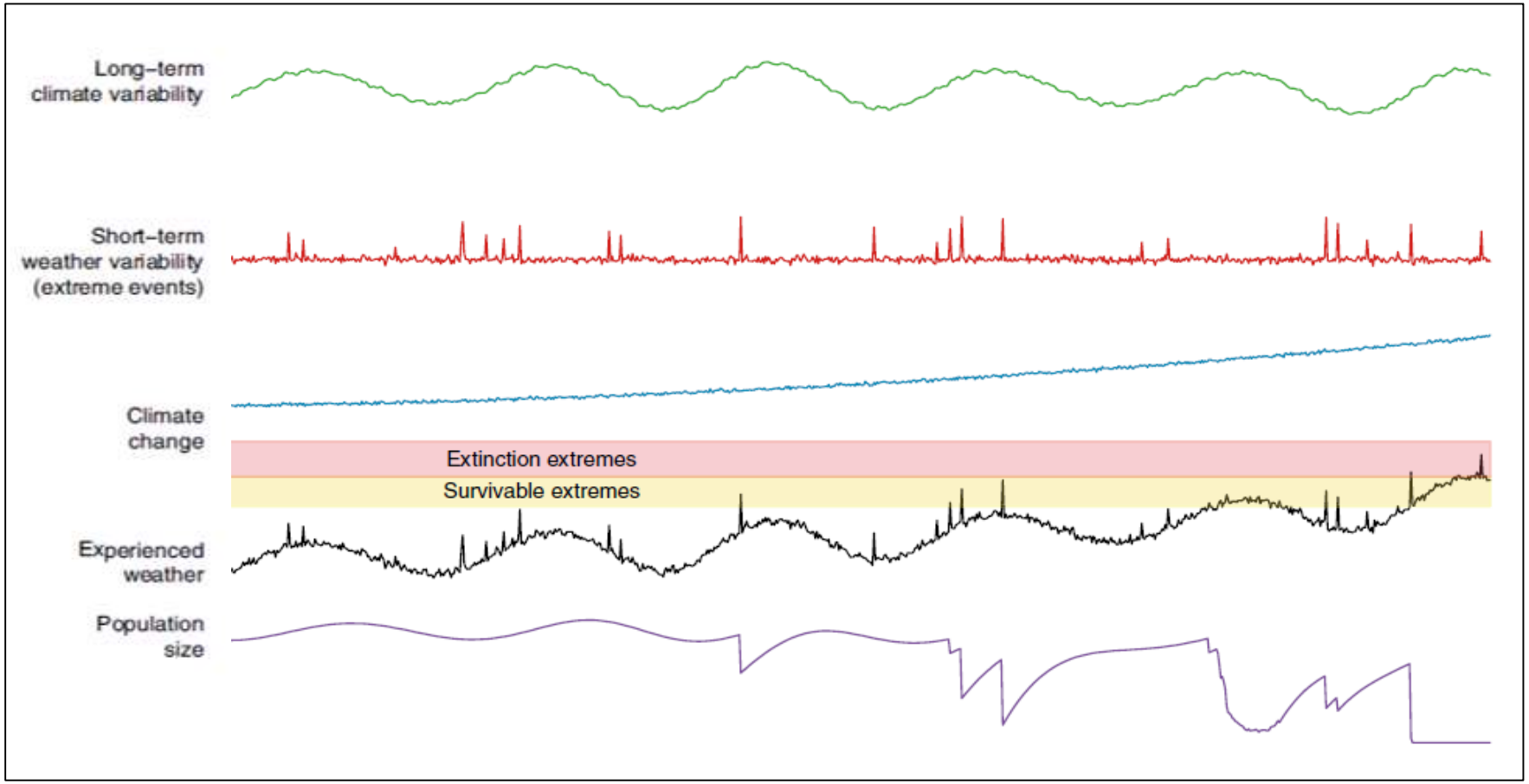


RAD framework squarely assigns the adaptation response to a managerial decision

RESIST	ACCEPT	DIRECT
Many changes will be **RESISTED** by managers, to maintain ecosystem processes, function, and composition toward a historical baseline	Many changes will be **ACCEPTED** by managers, perhaps because… • Infeasible to be managed • insufficiently impactful to warrant response • acceptable to (even desirable by) stakeholders • unknowingly occurring • lack of will or impetus despite sufficient knowledge or resources	Some changes will be **DIRECTED** by managers toward a specific future state because… so dramatic that resisting is untenable and there is a feasible opportunity to steward change towards a more desirable outcome than what would be achieved with acceptance

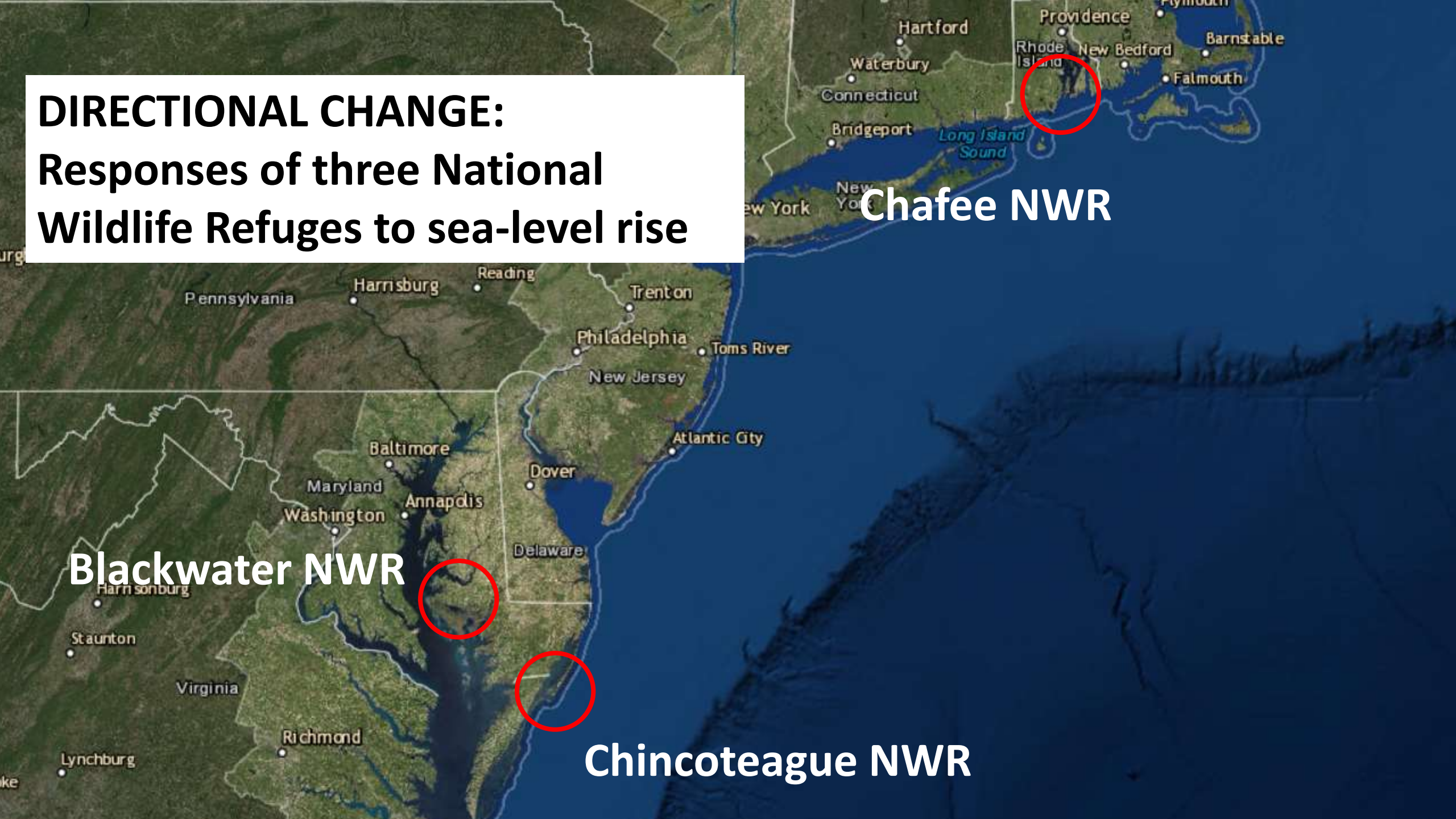
…with the goal of a self-sustaining, self-organizing system

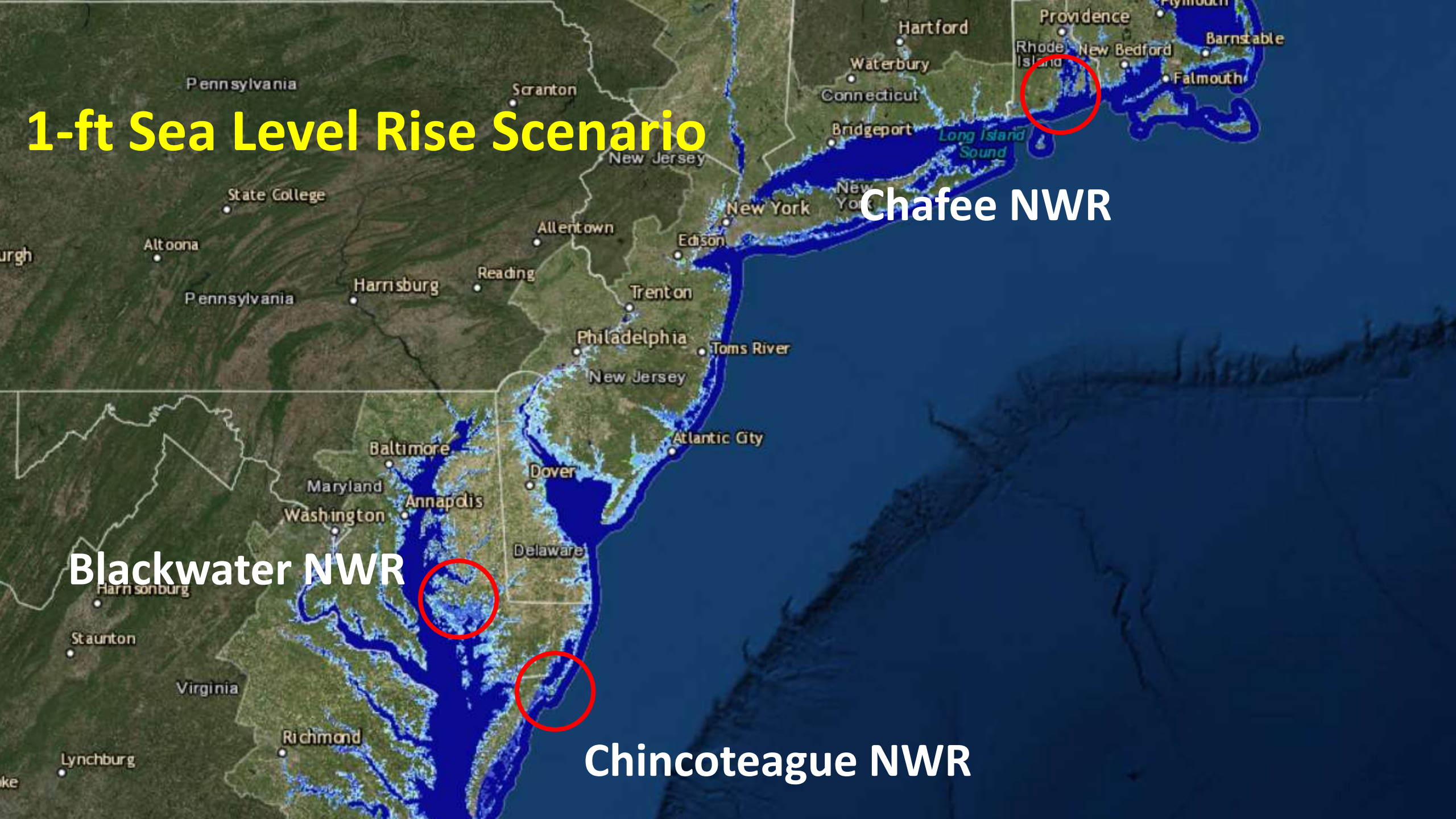
RAD addresses Directional Change and Ecological Transformation



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

Ecological Transformation
"a dramatic, persistent, and statistically 'extreme' shift in multiple ecological characteristics, the basis of which is dramatic changes in species composition"


DIRECTIONAL CHANGE:
Responses of three National Wildlife Refuges to sea-level rise
Chafee NWR
Blackwater NWR
Chincoteague NWR
Providence
Hartford
Rhode Island
New Bedford
Barnstable
Falmouth
Waterbury
Connecticut
Bridgeport
Long Island Sound
New York
Pennsylvania
Harrisburg
Reading
Trenton
Philadelphia
Toms River
New Jersey
Atlantic City
Baltimore
Dover
Maryland
Annapolis
Washington
Delaware
Harrisonburg
Staunton
Virginia
Richmond
Lynchburg


1-ft Sea Level Rise Scenario
Chafee NWR
Blackwater NWR
Chincoteague NWR
Pennsylvania
Scranton
New Jersey
State College
Altoona
Harrisburg
Reading
Allentown
New York
Edison
Trenton
Philadelphia
Toms River
New Jersey
Atlantic City
Baltimore
Maryland
Annapolis
Washington
Dover
Delaware
Harrisonburg
Staunton
Virginia
Richmond
Lynchburg
Hartford
Waterbury
Connecticut
Providence
Rhode Island
New Bedford
Barnstable
Falmouth
Bridgeport
Long Island Sound

RESISTING CHANGE: Chafee National Wildlife Refuge

- ✓ **$1.4 million project to use thin-layer deposition to keep *Spartina patens* saltmarsh in situ**
- ✓ **3,000 bags of clam and oyster shells to sediment and water on the marsh platform**
- ✓ **Amphibious excavator to disperse sediment**

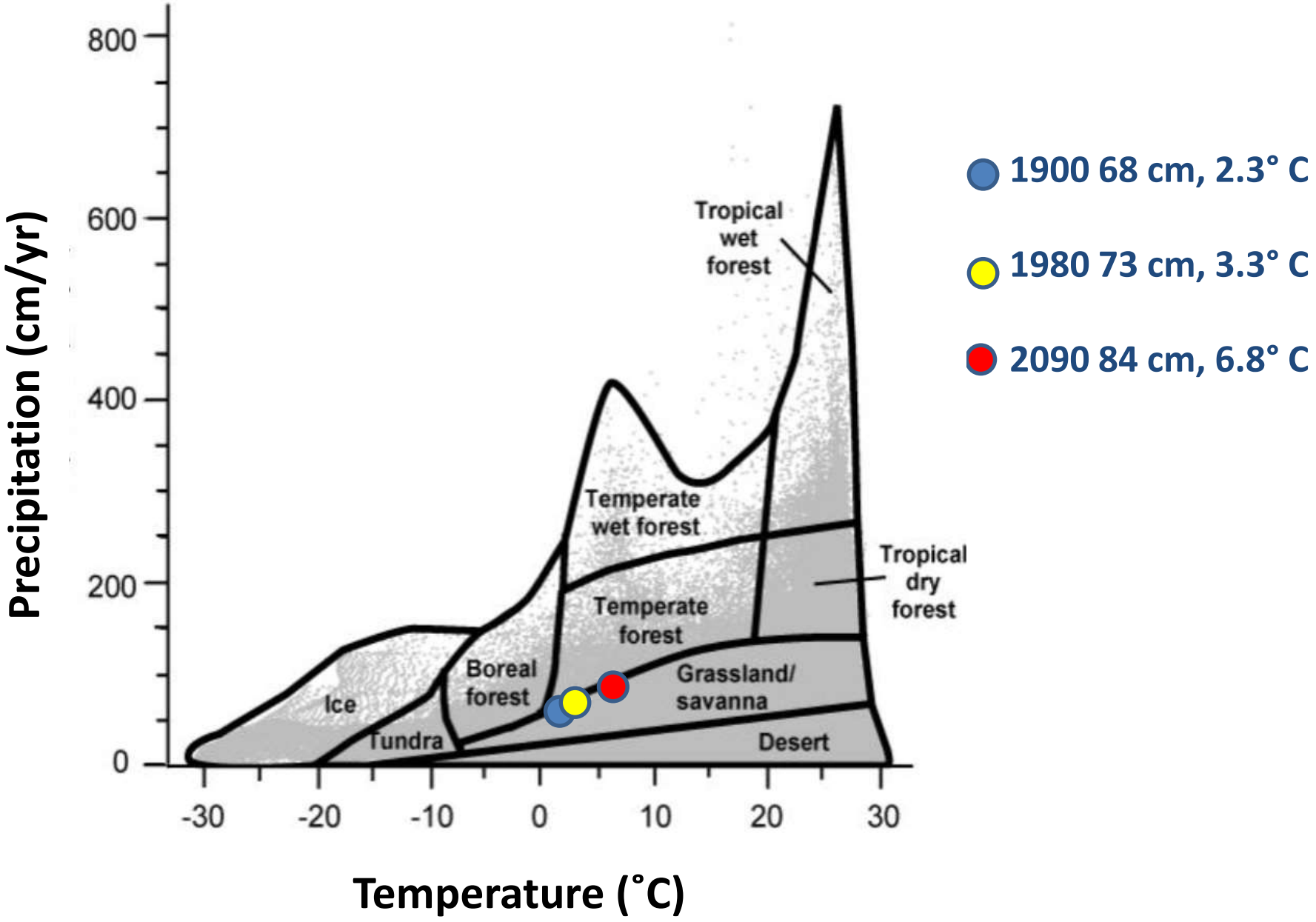
ACCEPTING CHANGE: Chincoteague National Wildlife Refuge and Assateague Island National Seashore

- ✓ After 6 decades of maintaining artificial dunes, the island will be allowed to overwash during storm events and migrate in response to long-shore current
- ✓ Since 2003, increasing storm damage to infrastructure (visitor center, roads, parking lots) has cost $3.5 million
- ✓ NPS beach facilities have been moved inland and two refuge waterfowl impoundments will be allowed to deteriorate

DIRECTING CHANGE: Blackwater National Wildlife Refuge

- ✓ **Since 1938, 5,000 acres of tidal wetlands converted to open water, but 2,700 acres of new marsh created by upslope migration**
- ✓ **A partnered $475K demonstration project to facilitate marsh migration by extending the head of a tidal creek with a low-ground-pressure excavator (DIRECT)**
- ✓ **Thin-layer deposition to hold some marsh in situ (RESIST)**

TRANSFORMATIONAL CHANGE:
Could this novel system be stewarded towards one that is more diverse?



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

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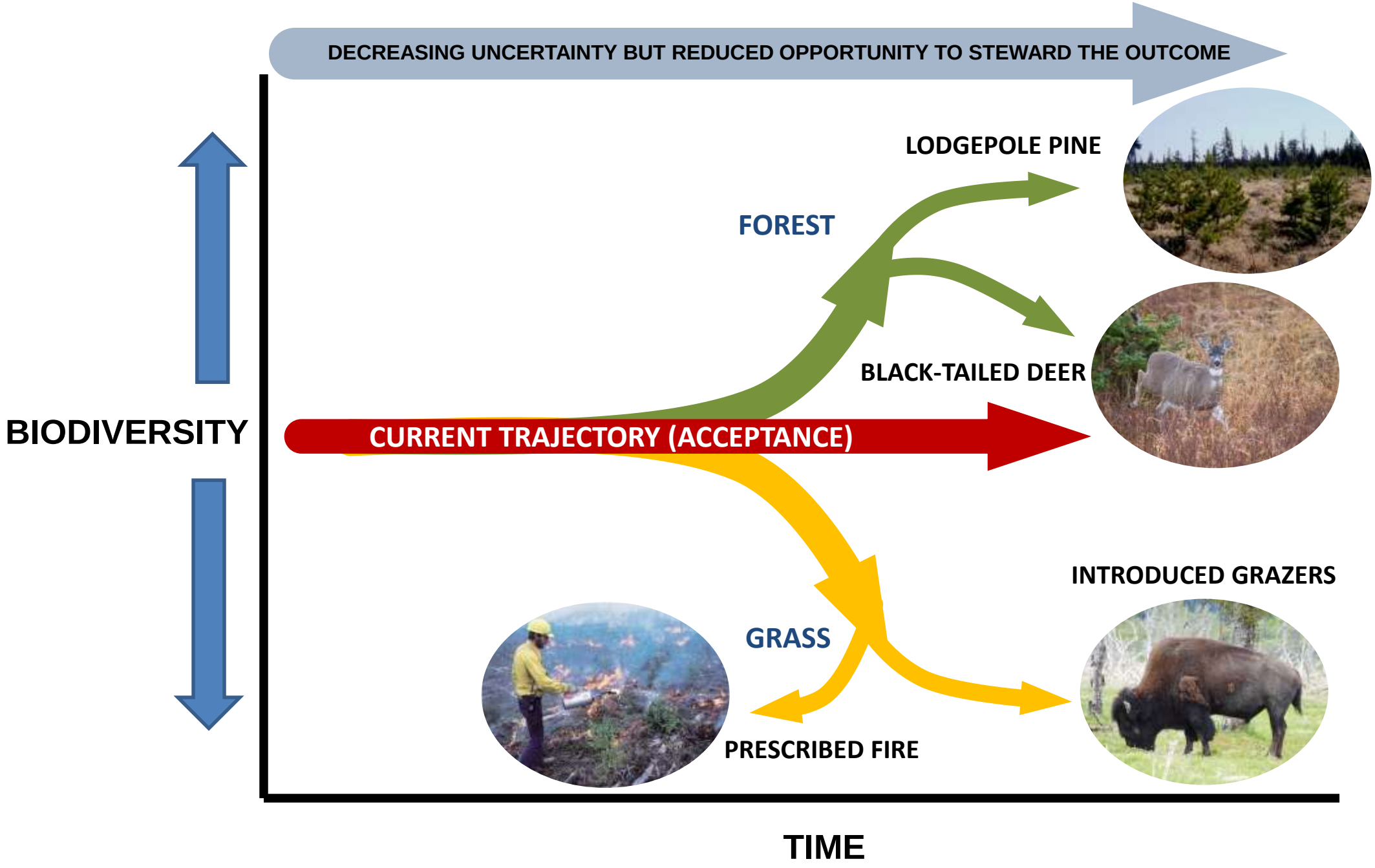
BIODIVERSITY

CURRENT TRAJECTORY (ACCEPTANCE)

TIME


DECREASING UNCERTAINTY BUT REDUCED OPPORTUNITY TO STEWARD THE OUTCOME
LODGEPOLE PINE
FOREST
BLACK-TAILED DEER
BIODIVERSITY
CURRENT TRAJECTORY (ACCEPTANCE)
INTRODUCED GRAZERS
GRASS
PRESCRIBED FIRE
TIME

	Human-influenced stressors	Change	Management Responses	
			Kenai NWR	Other entities
Ecological Processes	fire regime	increased ignition rates, spring grassland fires, fires in hemlock	RESIST/ACCEPT	RESIST
	spruce bark beetle	15-yr outbreak on ~ 1 million acres	ACCEPT	ACCEPT/RESIST (KPB, NNAI)
	subalpine tree/shrub line	1 m per yr (trees), 2.8 m per yr (shrub)	ACCEPT	ACCEPT
	glaciers	Harding Icefield lost 5% surface area, 21m elevation; glacial thinning increased 55%	ACCEPT	ACCEPT
	wetlands	6–11% loss per decade in surface area	ACCEPT	ACCEPT
	nonglacial anadromous streams	17 of 48 streams reach sublethal temperatures in July	ACCEPT	ACCEPT/RESIST (Cook InletKeeper, KHLT)
Species	American marten	recent colonization of Kenai Lowlands	ACCEPT	ACCEPT
	Elodea spp.	accidentally introduced by aquarium dumps and floatplane	RESIST	RESIST
	northern pike	transplanted from interior Alaska	RESIST	DIRECT/RESIST (private landowners)
	Sitka black-tailed deer	translocated from SE Alaska	ACCEPT	DIRECT (Cordova Chamber of Commerce)
	earthworms	accidentally/deliberately introduced	ACCEPT	DIRECT (gardeners, anglers)
	Mycoplasma ovipneumoniae	introduced disease in mountain goats	ACCEPT	ACCEPT

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Could engineering by beavers and humans recharge drying peatlands?

Journal of Hydrology

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

Michael B. Graze, Mary F. Moffett, Donald L. Siegel, Paul H. Glaser

Peatlands represent 55% of streamflow during low flow

Journal of Hydrology: Regional Studies

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

Kathleen Feiner, Christopher S. Lowry

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

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Ice911 is a “Silicon Valley moonshot aiming to stabilize climate by restoring ice in the Arctic”

AGU100 ADVANCING EARTH AND SPACE SCIENCE

Earth's Future

RESEARCH ARTICLE

Special Section:

Increasing Arctic Sea Ice Albedo Using Localized Reversible Geoengineering

L. Field[1,2], D. Ivanova[3], S. Bhattacharyya[4], V. Mlaker[4], A. Sholtz[1], R. Decca[1,2], A. Manzara[4], D. Johnson[1], E. Christodoulou[1], P. Walter[1,2], and K. Katuri[1]

Abstract The rising costs of climate change merit serious evaluation of potential climate restoration solutions. The highest rate of change in climate is observed in the Arctic where the summer ice is diminishing at an accelerated rate. The loss of Arctic sea ice increases radiative forcing and contributes to global warming. Restoring reflectivity of Arctic ice could be a powerful lever to help in the effort to limit global warming to 1.5°C. Polar ice restoration should be considered in planning of 1.5°C pathways. In this paper, a novel localized surface albedo modification technique is presented that shows promise as a method to increase multiyear ice using reflective floating materials, chosen so as to have low subsidiary environmental impact. Detailed climate modeling studying the climate impact of such a method reveals more than 1.5°C cooler temperatures over a large part of the Arctic when simulating global sea ice albedo modification. In a region north of Barents and Kara Seas temperatures have been reduced by 3°C and in North Canada by almost 1°C. Additionally, there are notable increases in sea ice thickness (20–50 cm Arctic wide) and ice concentration (>15–20% across large parts of central Arctic). These results suggest that the geoengineering technology proposed in this study may be a viable instrument for restoring Arctic ice.

Plain Language Summary This paper describes a method to preserve and restore ice in the Arctic in order to reduce the effects of climate change. This method is benign by design, developed to restore ice in

Could Ice911 stabilize ice in the Harding Icefield?

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It’s not rocket science…

…it’s harder