Scenario Planning
Managing for a Range of Possible Futures

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National Park Service, Northeast Region

With special thanks to:
Erika Rowland
Jonathan Star
Gregor Schuurman
Cat Hawkins-Hoffman
Rowland et al. (2014)
We’re bad at predicting the future
Fortunately, there are tools that help people make decisions in the face of uncertainty...

1. Expert elicitation
2. Scenario planning
3. Structured decision making
4. Adaptive management
5. Robust decision making

Build uncertainty into our decisions rather than wait for a single “most likely” scenario to emerge.
What *is* Scenario Planning?

**Forecast Planning**
One Future

-10%  +10%

What we know today

**Scenario Planning**
Multiple Futures

Uncertainties

What we know today
Simply put, it helps to answer:

What could happen?
What might happen?

Considering multiple plausible futures
What kinds of questions can we address with scenario planning?
In the military...

Cold War (1963)

Scenarios helped the military consider what might happen in the event of nuclear war.
Shell & the 1973 Oil Crisis

Scenarios helped Shell foresee the 1973 Oil Crisis and thus respond more swiftly than its competitors.
In climate change adaptation...
Consider these threats here in the Northeast...

• Warmer springs, summers, etc.
• Warmer days, nights
• More intense storms
• More severe droughts
• Sea level rise
• Shorter winters
• Less snow, no snow
• Shorter-lived snowpack

How *might* these impact your system?
Developing the scenarios is both an **art** AND a **science**!

Step back. Question your assumptions. Think creatively.
It’s a process...

Three broad phases

1. Preparation

2. Scenario Building & Refining

3. Using: Planning & Implementing

Revisit Scenario Process

Modified from Wiseman et al. 2011, courtesy of Erika Rowland
The structure is flexible.

"Matrix" approach

"Least change" approach

Free-form

Tailor it in a way that is most useful to you.
Which 2 drivers *most* affect your system?
Identify climate drivers
An example with Assateague Island National Seashore

Sea-level rise

Low/moderate
Same strength/less frequent

Significant
More intense/frequent

Storms
Build a matrix...

- Low/moderate
- Significant
- More intense/frequent
- Same strength/less frequent
- Sea-level
- Storms
- rise
Add narratives...

Storms:
- Low/moderate:
  - Fronts, less frequent
  - Islands:
    - Dynamic barrier island
    - Island size ↓; estuary ↑
- Significant:
  - More intense, frequent
  - Islands:
    - Island smaller and shifts toward land
    - Saltwater intrusion (widespread)

Sea-level:
- Low/moderate:
  - Dune erosion & overwash ↑
  - Island size ↓; estuary ↑
  - High infrastructure impacts
- Significant:
  - Fragmentation: island → sand bar
  - High impacts to aquatic, terrestrial, & salt marshes

Sea-level rise:
- Low/moderate:
  - Dune erosion & overwash ↑
  - Island size ↓; estuary ↑
  - High infrastructure impacts
- Significant:
  - Fragmentation: island → sand bar
  - High impacts to aquatic, terrestrial, & salt marshes

Sea-level fall:
- Low/moderate:
  - Dune erosion & overwash ↑
  - Island size ↓; estuary ↑
  - High infrastructure impacts
- Significant:
  - Fragmentation: island → sand bar
  - High impacts to aquatic, terrestrial, & salt marshes
Add clever names...

**Moving Target**
- Dune erosion & overwash ↑
- Island size ↓, estuary ↑
- High infrastructure impacts

**Shifting Sands**
- Dynamic barrier island but with more intense pressure than in the past
- Island size ↓, estuary ↑

**Sand Bar**
- Fragmentation: island → sand bar
- High impacts to aquatic, terrestrial, & salt marshes

**Drowning Island**
- Island smaller and shifts toward land
- Saltwater intrusion (widespread)

**Storms**
- More intense/frequent
- Same strength/less frequent

**Sea-level rise**
- Low/moderate
- Significant
Nested scenarios

Lack of senior commitment
Varied approaches/alignment
Short-term concerns

Broad Understanding
Heightened Urgency

Nature of Leadership

Societal Concern

Widespread indifference
Competing concerns

Is Anyone Out There?...

Riots and Revolution...

Big problems, Big solutions...

Senior commitment
International alignment
Long-term perspectives

Moving Target
Intense Storms
Sand Bar
Drowning in Place

Moving Target
Intense Storms
Sand Bar
Drowning in Place

Moving Target
Intense Storms
Sand Bar
Drowning Island

Assateague Sand Bar

Sea-Level Rise

Parched Ponies

Parched

Shifting Sands

Parched

Wheel-Spinning...
“Least-change” approach...

An example from Isle Royale National Park

<table>
<thead>
<tr>
<th>Climate Driver</th>
<th>Least Change</th>
<th>Summer Drought, Wind, and Fire</th>
<th>Warmer than Duluth</th>
<th>Isle Savanna</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean annual temperature</td>
<td>increase 3.4 °F</td>
<td>same as Least Change</td>
<td>increase 6.5 °F</td>
<td>increase 5 °F</td>
</tr>
<tr>
<td>Cold days (&lt; 32° F)</td>
<td>15 fewer days</td>
<td>same as Least Change</td>
<td>up to 30 fewer days</td>
<td>up to 30 fewer days</td>
</tr>
<tr>
<td>Hot days (&gt; 95 °F)</td>
<td>increase of &lt; 5 days</td>
<td>same as Least Change</td>
<td>increase of 5 days</td>
<td>same as Least Change</td>
</tr>
<tr>
<td>Growing season</td>
<td>2 weeks longer</td>
<td>same as Least Change</td>
<td>4 weeks longer</td>
<td>3 weeks longer</td>
</tr>
<tr>
<td>Annual precipitation</td>
<td>+5% (up Winter, down Summer)</td>
<td>same total as Least Change</td>
<td>same as Least Change</td>
<td>10-15% increase</td>
</tr>
<tr>
<td>Intense precipitation</td>
<td>20% increase in number of days with &gt;1 inch precip</td>
<td>same as Least Change</td>
<td>same as Least Change</td>
<td>summer: sporadic extreme events, 30% increase in &gt; 1” events</td>
</tr>
<tr>
<td>Snow</td>
<td>snow days -25%</td>
<td>same as Least Change</td>
<td>snow days -50%</td>
<td>snow days -40%</td>
</tr>
<tr>
<td>Wind</td>
<td>20th century conditions</td>
<td>Increased probability of large wind events (derechos)</td>
<td>same as Least Change</td>
<td>same as Least Change</td>
</tr>
<tr>
<td>Lake levels</td>
<td>20th century conditions</td>
<td>same as Least Change</td>
<td>same as Least Change</td>
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</tr>
<tr>
<td>Lake temperature</td>
<td>+3.6 °F in warm season temp, &gt;50 °F water temp for 25 more days</td>
<td>same as Least Change</td>
<td>+8.3 °F in warm season temp, &gt;50 °F water temp for 60 more days</td>
<td>+6.0 °F in warm season temp, &gt;50 °F water temp for 45 more days</td>
</tr>
<tr>
<td>Lake ice cover</td>
<td>12 fewer days</td>
<td>same as Least Change</td>
<td>45 fewer days</td>
<td>30-40 fewer days</td>
</tr>
<tr>
<td>Climate variability</td>
<td>20th century conditions</td>
<td>Punctuated dry summer periods</td>
<td>Greater variability in seasonal and annual temperature</td>
<td>Greater variability in seasonal and annual precipitation</td>
</tr>
<tr>
<td>Arctic Oscillation</td>
<td>20th century conditions</td>
<td>same as Least Change</td>
<td>same as Least Change</td>
<td>Predominance of positive phase (7 out of every 10 years)</td>
</tr>
</tbody>
</table>
Scenarios should be:

- **Plausible** – believable, realistic
- **Challenging** – provocative, thought-provoking
- **Relevant** – significant and demonstrable
- **Divergent** – different from each other
Scenario exercise: Creating divergent futures

Instructions:

● Work with your neighbor(s) in groups of 2-3 for the next 10 minutes

● Fill out one (or more) of the scenario matrix sheets, focusing on a real or hypothetical issue associated with a region of your choice:
  ● for each axis, choose a high-impact aspect of climate change with high uncertainty

● name and describe each of the four scenarios
<table>
<thead>
<tr>
<th>Drivers</th>
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**Scenario Names**
Some possible drivers

- sea-level rise
- water flow seasonality
- precipitation
- permafrost
- drought
- water availability
- temperature
- climatic variability
- sea ice
- ocean acidification
- lake levels
- storms
- changing seasonality
- regional climatic features*
- [non-climate driver]

* El Nino or PDO, for example

**Plausible?** – believable, realistic

**Challenging?** – provocative, thought-provoking

**Relevant?** – significant and demonstrable

**Divergent?** – different from each other
1. Which framework did you choose (if any)?

2. If matrix, which 2 drivers did you choose? Why?

3. Describe each scenario
Integrating science into the scenarios
An example from Acadia National Park
Where is Acadia?
3,000,000+ visitors annually
Cadillac Mountain Restoration
Acadia’s Carriage Roads
Undersized culverts
Thunder Hole
3 management concerns

Coastal & inland infrastructure
- Motor/carriage road systems
- Hiking trails

Staffing & park operations
- Visitor support
- Maintenance
- Budget

Ecosystem restoration
- Cadillac Mountain
- Cromwell Brook

Climate Drivers
- Storms & flooding
- Sea level rise
- Storm surge
- Warmer conditions
- Longer warm season
- Storms & flooding
- Warming ➔ pests
- Droughts/floods
Cool first?

Aerosols?  Natural cycle?  Fernandez et al. 2015
Calm Before the Warm
-shift to cool phase of AMO early in scenario, causing slight cooling
-then shift to warm phase and strong warming acceleration
Not only more extreme — more variable too?

Ning et al. 2015
Calm Before the Warm
- shift to cool phase of AMO
  - early in scenario, causing slight cooling
  - then shift to warm phase and strong warming acceleration

Middle of the Roller Coaster
- mid-range changes for temperature and precipitation
  - strong interannual variability
Seasonal variability?

Kunkel et al. 2013
Calm Before the Warm
-shift to cool phase of AMO early in scenario, causing slight cooling
-then shift to warm phase and strong warming acceleration

Sizzlin’ Summer, Floodin’ Fall
-hot summers
-frequent summer droughts
-fall storms

Middle of the Roller Coaster
-mid-range changes for temperature and precipitation
-strong interannual variability
More episodic, extreme rainfall events

Northeast Extremes in 1-Day Precipitation (Step 4*)
Annual (January-December) 1910-2016

9-Point Binomial Filter  Mean  Actual Percent

Percent (%)
Calm Before the Warm
-shift to cool phase of AMO early in scenario, causing slight cooling
-then shift to warm phase and strong warming acceleration

Sizzlin’ Summer, Floodin’ Fall
-hot summers
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Middle of the Roller Coaster
-mid-range changes for temperature and precipitation
-strong interannual variability

We’re going to need a Bigger Boat
-warming continues
-precipitation at high end of projections
-frequent storms and major flooding events
Data integration: Science for Temperature and Precipitation
Science for Sea Level Rise and Storm Scenarios

- Integrated multiple sources to span **divergent** range across SLR scenarios
  - Low from NPS Caffrey et al – IPCC based
  - Medium and high National Climate Assessment – NOAA based
  - Art of matching each with scenario emphasis

- **Storms**
  - Hurricanes/tropical storms started from historical occurrence, changed between scenarios based on NCA – except used frequency not intensity indicators
  - Nor’easters started from historical occurrence – increased in number based on scenario emphasis, identified research need
  - Scenario indicator of frequency didn’t match up with mapping tools (e.g. by Hurricane category) but still useful in discussion
### Final scenarios

<table>
<thead>
<tr>
<th>Driver</th>
<th>Calm Before the Warm</th>
<th>Middle of the Roller Coaster</th>
<th>Sizzlin' Summer, Floodin' Fall</th>
<th>Bigger Boat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of 'hot' summer days (&gt;90 °F); length of frost-free season</td>
<td>Early - Late</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of 'cold' winter days (&lt;32 °F)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Summer precipitation</td>
<td></td>
<td></td>
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<tr>
<td>Inland and coastal storms</td>
<td></td>
<td></td>
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<tr>
<td>Sea level rise</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climate Variability Emphasis</td>
<td>Inter-decadal (AMO*)</td>
<td>Inter-annual (seasonal)</td>
<td>Intra-annual</td>
<td>Episodic events</td>
</tr>
</tbody>
</table>

### Change in number of 'hot' summer days (>85 °F) (last 20 years = 11 days)
- Early → Late
  -2 → +42
  +16
  +42
  +16

### Change in number of 'cold' winter days (<32 °F) (last 20 years = 78 days)
+2 → -40
-18
-40
-18

### Summer precipitation (compared with past 20 years)
-6%
-6%
-32%
+18%

### Hurricane/ExtraTropical storm frequency (per decade; 0-1 /dec since 1842)
0-1 → 3-4
0-3
3-4
3-4 including Cat. 1 hurricane

### Nor’easter frequency (annual strong events; ~3/yr from 1951-1997)
0-1 → 2-3
0-5
2-3
2-5

### Sea level rise (over 2015)
+13.4 in (+34 cm)
+4.3 in (+11 cm)
+8.7 in (+22 cm)
+4.3 in (+11 cm)
<table>
<thead>
<tr>
<th>Outcomes: Management Considerations</th>
<th>Coastal &amp; Inland Infrastructure</th>
<th>Staffing &amp; Park Operations</th>
<th>Ecosystem Restoration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calm before the Warm</td>
<td>Stock road material reserves in advance</td>
<td>Stick with current ratio of FTE vs seasonal employees</td>
<td>Seed banking</td>
</tr>
<tr>
<td>budget requests</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Middle of the Roller Coaster</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Sizzlin’ Summer, Floodin’ Fall</td>
<td>Earlier spring maintenance</td>
<td>Begin hiring more FTEs</td>
<td>Plant more drought tolerant species</td>
</tr>
<tr>
<td></td>
<td>More hiking trail usage &amp; repairs</td>
<td>Push to open park earlier?</td>
<td></td>
</tr>
<tr>
<td>Bigger Boat</td>
<td>Increase stocks of road material</td>
<td>Increase budget for maintenance</td>
<td>Bigger culverts</td>
</tr>
<tr>
<td></td>
<td>Replace undersized culverts</td>
<td>Hire more maintenance staff</td>
<td>Protection against salt-water intrusion</td>
</tr>
</tbody>
</table>
Scaling climate change adaptation in the northern Great Plains through regional climate summaries and local qualitative-quantitative scenario planning workshops

Amy Symstad, Brian Miller, Nicholas Fisichelli, Gregor Schuurman, Andrea Ray, Jonathan Friedman, Erika Rowland

Funded by:
Key Issues

• Key issues:
  – Erosion
  – Grasslands
  – Grazing
  – Road maintenance
Table 1. Climate drivers for the next 35 years (through 2050) for the southwest South Dakota scenarios. Arrow size and direction denote trends compared with the past (1950-1999). Down arrows denote decreasing trends, up arrows increasing or earlier trends, and sideways arrows indicate no change from recent conditions. Arrow size denotes the magnitude/rate of change.

<table>
<thead>
<tr>
<th>Climate Driver</th>
<th>Rather Hot</th>
<th>Awfully Dry</th>
<th>Wet in Bursts</th>
<th>The Jungle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>![Arrow]</td>
<td>![Arrow]</td>
<td>![Arrow]</td>
<td>![Arrow]</td>
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<tr>
<td>Last spring freeze date</td>
<td>![Arrow]</td>
<td>![Arrow]</td>
<td>![Arrow]</td>
<td>![Arrow]</td>
</tr>
<tr>
<td>April-June precipitation</td>
<td>![Arrow]</td>
<td>![Arrow]</td>
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<tr>
<td>Spring-Summer soil moisture</td>
<td>![Arrow]</td>
<td>![Arrow]</td>
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<tr>
<td>One-day heavy rain events</td>
<td>![Arrow]</td>
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Scenario Implications (working in mixed groups of experts & managers)
-effects to cultural, geological, and natural resources
-effects to facilities and infrastructure

Building out the scenarios – adding to the climate skeletons
**Scenario Implications** (working in mixed groups of experts & managers)
- effects to cultural, geological, and natural resources
- effects to facilities and infrastructure

<table>
<thead>
<tr>
<th>Developments and Implications</th>
<th>Rather Hot</th>
<th>Awfully Dry</th>
<th>Wet in Bursts</th>
<th>The Jungle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultural Resources (incl. archeological sites)</td>
<td>More archeological sites exposed</td>
<td>Less erosion from water, more from loss of vegetation (bare ground) and wind</td>
<td>Major erosion exposes many sites</td>
<td>Lose archeological sites to erosion and vegetation growth</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increased fire danger to archeological sites</td>
<td>Increased poaching and vandalism</td>
<td>Culturally significant trees persist</td>
</tr>
<tr>
<td></td>
<td></td>
<td>More educational opportunities, enhances individual responsibility</td>
<td>Water damage to historical structures</td>
<td></td>
</tr>
</tbody>
</table>

Building out the scenarios – adding to the climate skeletons
Testing Decisions and Options
Aligning Goals and Actions in Climate Adaptation

* Review and revise as needed, based on climate change assessments.

Adapted From Climate-Smart Conservation
Testing Decisions and Options

Paleontology / Archeology
# Testing Decisions and Options

**Paleontology / Archeology**

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<tbody>
<tr>
<td>Awfully Dry</td>
<td>Goal: Preservation and protection Actions:</td>
<td>Short term – yes Long term – yes</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>• Survey</td>
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<td></td>
<td>• Site stabilization</td>
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<td>• Salvage / data recovery</td>
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<td>• Law enforcement to mitigate theft / looting</td>
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<td></td>
<td>• Interpretation education</td>
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- Fewer opportunities for fossil / site discovery
- Less opportunity for theft or looting
# Testing Decisions and Options

## Paleontology / Archeology

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- Fewer opportunities for fossil / site discovery
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## Testing Decisions and Options

**Paleontology / Archeology**

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### Business as Usual

- Current goals
- Current actions
|------------|------------------------------------------------------------------------------------------------|--------------------------------------|---------------------------------|--------------------------------|--------------------------------------------------------------------------------------|
| The Jungle | • Maintain optimal health and genetically diverse bison population—approximately 1000 animals existing—approximately 17 genetic groups | • Short term — yes with action revisions  
• Long term — yes with action revisions | • Bison may not be drawn to water, may need alternative round-up strategies  
• Distribute more bison to tribes  
• Mechanism to transfer; tribes ready  
• Pest and disease monitoring  
• Drone observation  
• Develop new vaccines for new diseases |                                                | • Across scenarios: managers need to be as adaptive and accommodating as bison already are |
## Testing Decisions and Options

### Bison

<table>
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## Testing Decisions and Options

### Bison

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**Climate Retrofit**

• Current goals

• Revised actions*
## Testing Decisions and Options

### Infrastructure

|---------------|--------------------------------|-------------------------------------|--------------------------------|--------------------------------|----------------------|
| Wet in Bursts | • Maintain safety and usability of current transportation system  
• Fixing as needed – status quo | • Short term – yes  
• Long term – no |                                | • Sustainable transportation options  
• Re-align roads  
• Re-engineer roads (add culverts)  
• Update current drainage systems  
• Invest in equipment versus contracting | • More frequent maintenance  
• Budget pressure  
• Staffing levels and workloads  
• Management priorities  
• Review weight limits  
• Controlled transportation access  
• Short- and long-term visitor inconveniences |
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• Short- and long-term visitor inconveniences |
## Testing Decisions and Options

**Infrastructure**

|-------------------|------------------------------------------------------------------------------------------------|-------------------------------------|------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|---------------------------------------------|
| Wet in Bursts     | • Maintain safety and usability of current transportation system  
                   • Fixing as needed – status quo
                                                                                       | • Short term – yes  
                   • Long term – no
                                                                                       |                                                                                   | • Sustainable transportation options  
                   • Re-align roads  
                   • Re-engineer roads (add culverts)  
                   • Update current drainage systems  
                   • Invest in equipment versus contracting
                                                                                       |                                                                                   | • More frequent maintenance  
                   • Budget pressure  
                   • Staffing levels and workloads  
                   • Management priorities  
                   • Review weight limits  
                   • Controlled transportation access  
                   • Short- and long-term visitor inconveniences |

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**Climate Rebuild**

- Revised goals*
- Revised actions*
### Aligning Goals and Actions

<table>
<thead>
<tr>
<th>Resource</th>
<th>Rather Hot</th>
<th>Awfully Dry</th>
<th>Wet in Bursts</th>
<th>The Jungle</th>
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<td>Business as Usual</td>
<td>Retrofit/Rebuild</td>
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<td>Business as Usual</td>
<td>Retrofit/ Rebuild</td>
<td>Retrofit/ Rebuild</td>
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</tbody>
</table>
Thanks to all the workshop participants and the project team

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²USGS Northern Prairie Wildlife Research Center
³NOAA Earth System Research Lab, Physical Sciences Division
⁴Colorado State University, Natural Resource Ecology Laboratory
⁵North Central Climate Science Center
⁶Wildlife Conservation Society
⁷Schoodic Institute at Acadia National Park
Follow-up discussion

• You developed these scenarios. How do you see yourself using these to adapt your own management practices?

• Questions?