

Climate Change Scenario Planning

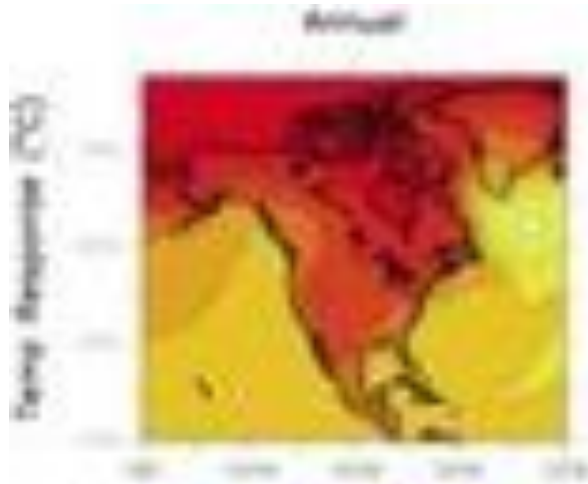


Crown Managers
Partnership



CMP Annual Forum Rockies
4/14/2010

Climate Predictions for North America

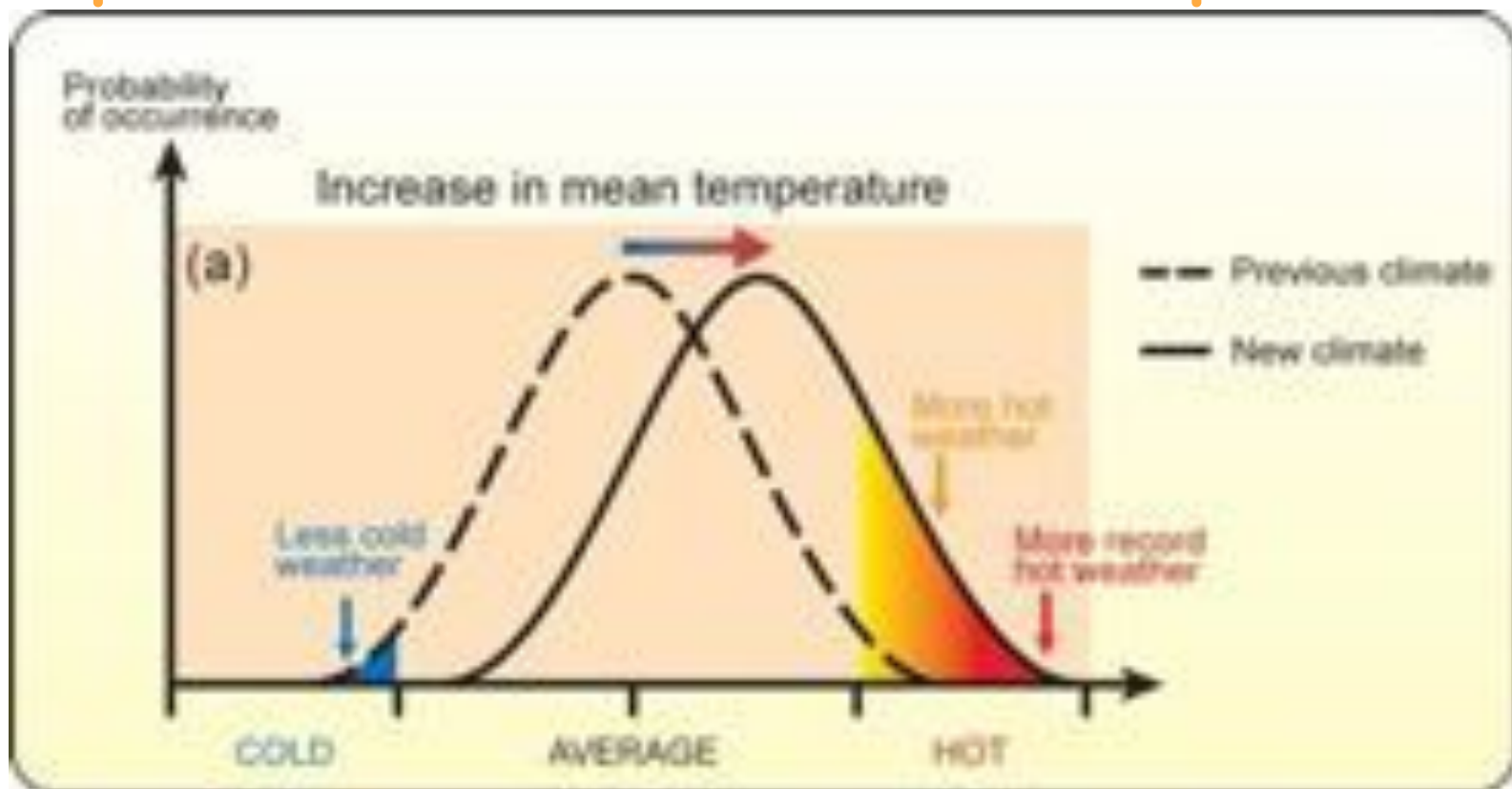


Continued temperature increases **highly likely** (“virtually certain”) in western North America based on agreement among models runs and fundamental knowledge of key physical processes.



Relatively **low confidence** in forecast precipitation changes because of disagreement between models and the complexity of underlying processes. For CoC—more confidence in winter predictions, less in spring/summer/fall.

Expect Increases in Extreme Temperatures



More hot days, fewer cold days
More heat waves, fewer cold outbreaks

Mountain pine beetle will dramatically alter Western conifer forests



Widespread epidemics driven by warmer temperatures
Tree's natural defenses reduced by drought
Unprecedented (?) in extent, rate of spread and severity



Warmer temperatures increase wildfire

- 6x increase in area burned since 1986
- Higher spring and summer temp plus earlier snow melt
- New paradigm for wild land fire

Westerling et al. 2006;
see also McKenzie et al. 2004

Grinnell Glacier

from the summit of Mt. Gould

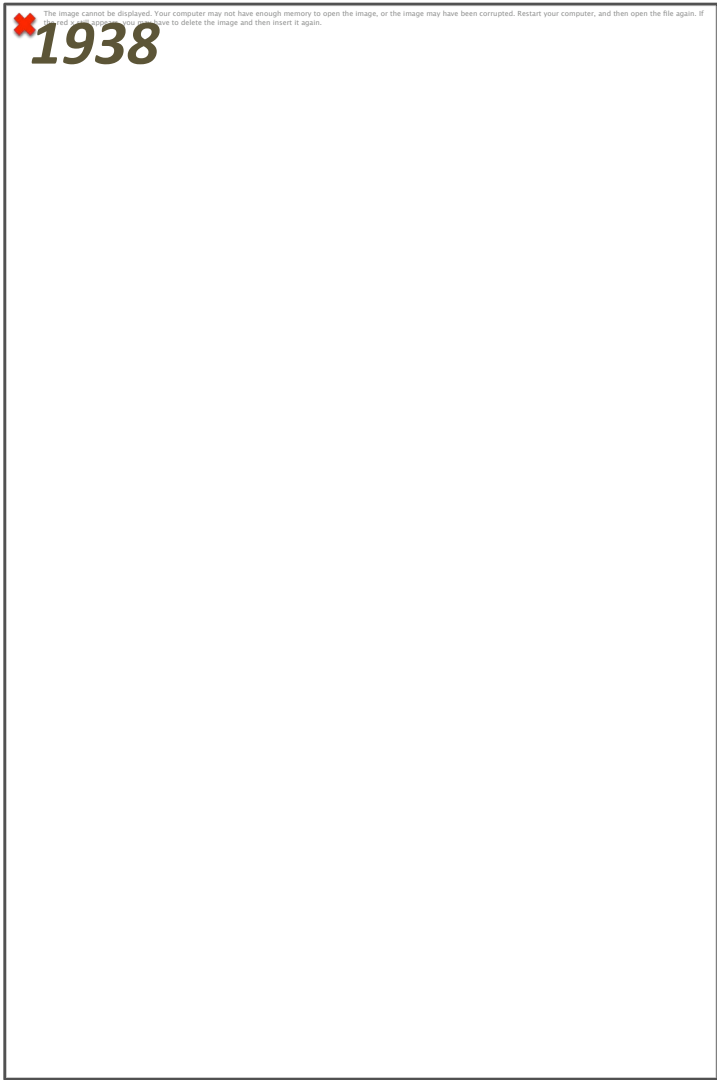


Photo by TJ Hileman, GNP Archives

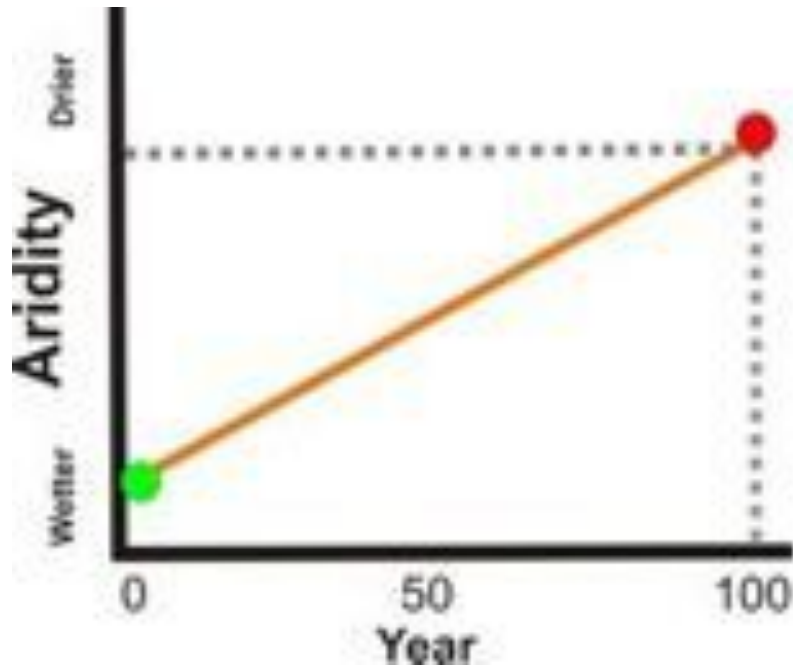


photo by L Bengtson, USGS

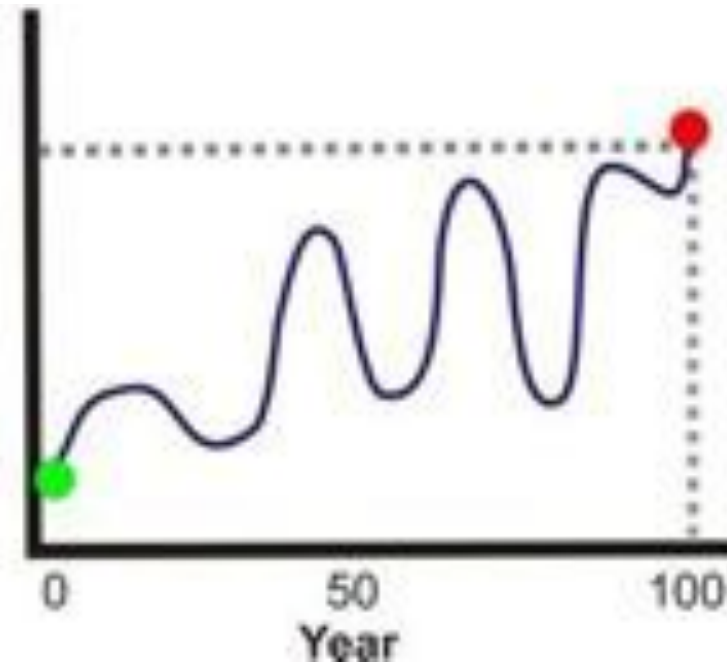


What do we know?

Future Climate = Natural Variability + Warming



We tend to think of future climate change as a simple linear trend...



Future climate will be a combination of human-induced trends and natural variability

Definitions: Mitigation vs Adaptation

Mitigation = intervention to reduce the anthropogenic forcing of the climate system; includes reducing GHGs and emissions and enhancing GHG sinks

Adaptation = Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.



Definitions: Mitigation vs Adaptation

Mitigation = removing the cause of a problem. For CC, any action that reduces the concentration of GHGs in the atmosphere

Adaptation = an adjustment or coping strategy. For CC, actions that allow organisms or humans systems to endure or survive

- **Organisms** can *adapt in place* by evolving new capacities or changing behaviors OR they can *move to a new location*
- **Human adaptation** involves making different choices to protect what's important to us

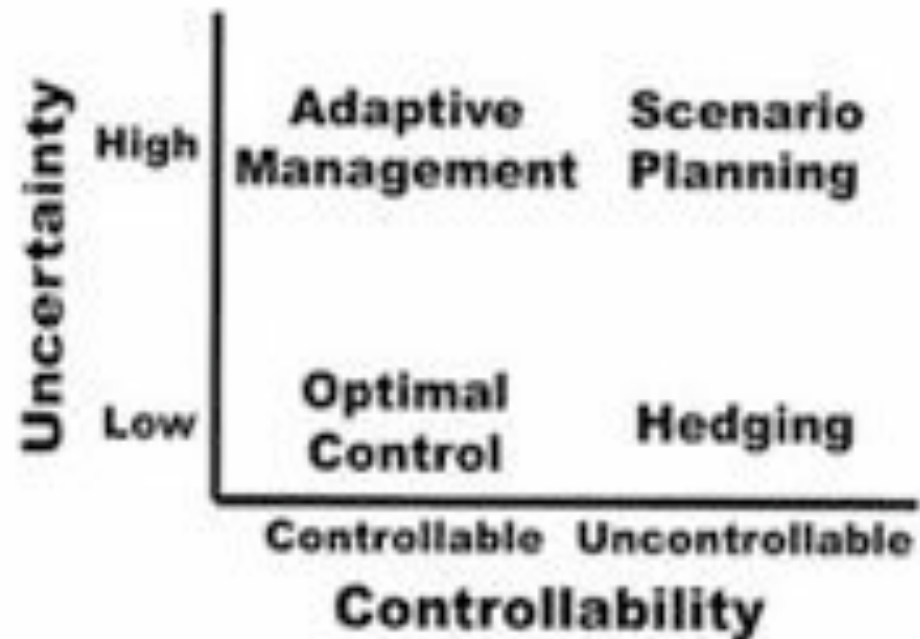
Facilities / structures → protection / rethinking design; location

Landscape / ecosystems → protection / promoting resilience

Adaptation Planning: Building a management toolkit

Begin looking at how to incorporate climate change into landscape planning

- Scenario Planning as a tool for evaluating where you are and where you want to go – long-term strategic planning
- Scenarios are not predictions or forecasts, nor a method for arriving at the most likely future
- Adaptive Management and Hedging options for helping to get there

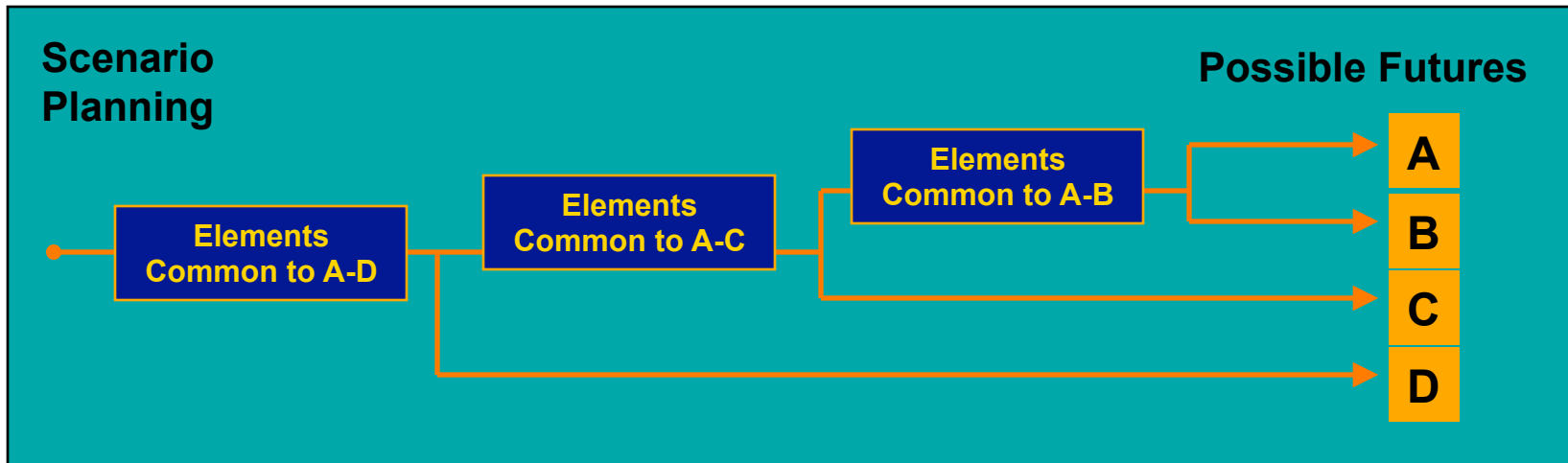
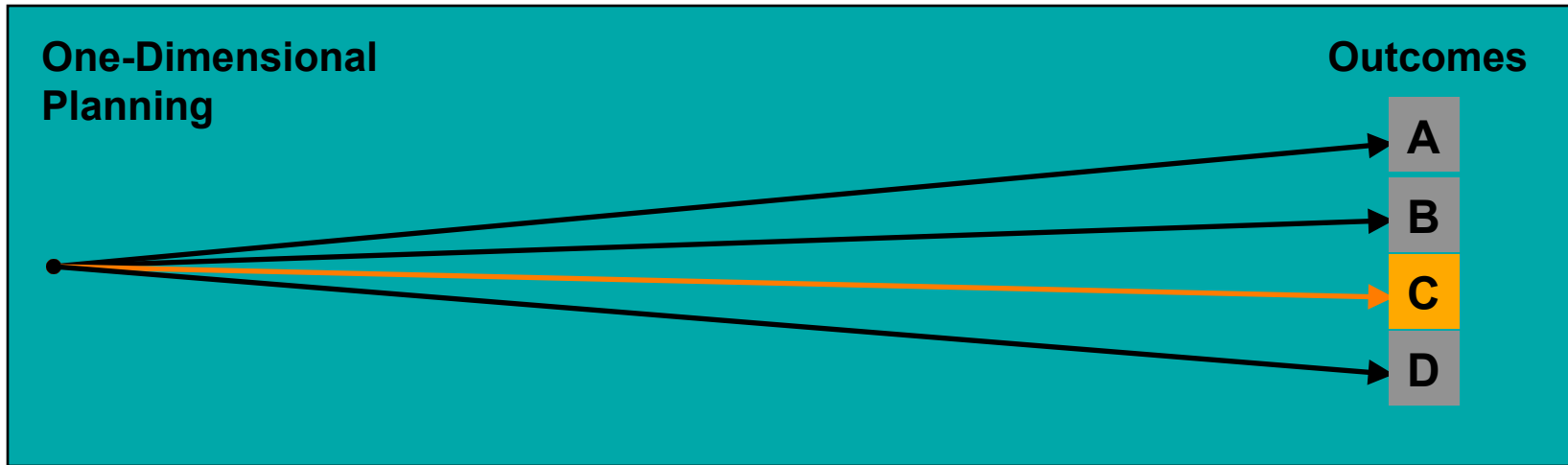


Explaining Scenarios: Description

- **Scenarios are stories about tomorrow that can help you make better decisions today**



One-Dimensional Planning vs. Robust Planning



What are Scenarios?

Scenarios Are:

- A tool for long-term strategic planning
- Compelling narratives of alternative environments in which decisions may be played out
- Coherent, internally consistent, and plausible

Scenarios Are Not:

- Predictions or Forecasts
- A method for arriving at the “most likely” future

Climate Change Drivers

Climate Variable	Source of Change	Change in Variable	Change in Variable	Change in Variable	Conditions
Temperature	Greenhouse effect	Global warming	Global warming	Global warming	Global warming is expected to continue, with the most significant increases occurring in the tropics and at night.
Sea Level Rise	Thermal expansion of water and melting of glaciers and ice sheets	Sea level rise	Sea level rise	Sea level rise	Sea level rise is expected to continue, with the most significant increases occurring in the tropics and at night.
Extreme Events	Changes in weather patterns	Increased frequency and intensity of extreme events	Increased frequency and intensity of extreme events	Increased frequency and intensity of extreme events	Changes in extreme events are expected to continue, with the most significant increases occurring in the tropics and at night.
Acid Rain	Increased emissions of sulfur dioxide and nitrogen oxides	Increased frequency and intensity of acid rain	Increased frequency and intensity of acid rain	Increased frequency and intensity of acid rain	Changes in acid rain are expected to continue, with the most significant increases occurring in the tropics and at night.

Climate Change Drivers

SUMMARY OF PROJECTED CLIMATE CHANGES FOR THE COURSE OF THE CENTURY					
Climate Variable	Observed Change Expected	Range of Change Expected at Different Probabilities	Expected Change Midpoint in 2050	Range of Change Expected at Different Probabilities	Implications
Annual Mean Temperature	Annual Mean Increase of 1.0 to 2.0°C	Annual Mean Increase of 0.5 to 3.0°C	1.5°C	Annual Mean Increase of 0.5 to 3.0°C	Over the next several decades, annual temperature trends could become increasingly variable, ranging from decreases in winter to increases in summer. There may be a net annual temperature increase, but the timing of that increase may differ in different regions.
Annual Mean Precipitation	Annual Mean Precipitation Change of 0.5 to 1.0% per decade	Annual Mean Precipitation Change of 0.5 to 1.0% per decade	Annual Mean Precipitation Change of 0.5 to 1.0% per decade	Annual Mean Precipitation Change of 0.5 to 1.0% per decade	Annual precipitation will generally increase in winter and decrease in summer. Precipitation trends may vary by region and season. Precipitation trends may also vary by region and season. Precipitation trends may also vary by region and season.
Annual Mean Snow	Annual Mean Snow Decrease of 10 to 20% per decade	Annual Mean Snow Decrease of 10 to 20% per decade	Annual Mean Snow Decrease of 10 to 20% per decade	Annual Mean Snow Decrease of 10 to 20% per decade	Annual snow cover will decrease in most regions. Annual snow cover will decrease in most regions. Annual snow cover will decrease in most regions.

The Adaptation Challenge



CLIMATE DRIVERS IN $^{\circ}\text{C}$

High

I
M
P
A
C
T

Low

Low

UNCERTAINTY

High

Temperature increases

Shifts in temperature extremes

Changes in seasonal hydrology/
Seasonal water balance

Winter precipitation increase

Fire frequency and severity

Summer precipitation increase/decrease

Rate of temperature change

Crossing environmental temperature thresholds

Timing and type of precipitation

Shifts in other extremes:
Precip, Wind

CoC Climate Axes

- PDO moderation in early decades
- warmer, more humid & dynamic system
- increased storminess
- droughts are generally intra-annual
- overall increase in productivity
- fires more isolated in time, space

SSR
precip
increase

PRECIPITATION

- dynamic and volatile climate: intra- and inter-annual
- hydrologic flashiness: rain-on-snow; storms year-round
- water stresses often moderate at local levels
- significant chances of intense intra-annual drought
- rapid ecological responses
- emergence of novel ecosystems

Climate Complacency

Volatile Surprise

Gradual/
Uniform

RATE OF CHANGE OF TEMPERATURE INCREASE

Rapid /
Abrupt

Colorado Creeps North

Race to Refuge

- overall drier climate in non-winter months
- recurring summer/fall moisture stress: streams, meadows, wetlands
- fire regime changes: higher severity, extent, frequency
- with every disturbance, shift to drier ecosystems
- eventual regional change favoring shrubs and grasslands

NON-WINTER

SSR
precip
decrease

- rapid warming & decrease in non-winter precipitation
- rain/snow ratio changes dramatically at low- & mid-elevations
- substantial risk of rain-on-snow events
- water stress severe, region-wide, unrelenting
- epic fire regimes: region-wide, firestorms
- ecosystems in great transition: drought, fire, disease, pests, exotic species
- unrelenting assault on infrastructure: rain-on-snow, fire, rain-on-snow after fire

FOR ALL QUADRANTS: Temperatures increasing; Temperature extremes increasing; Environmental thresholds exceeded; Winter precipitation stable or increasing ; Earlier spring runoff; Growing season & Fire season extended; Phenological mismatches

Case Study: Growth of the Continent (CoC)

Combining local and high level technology requirements -> "Academy of Innovation"

Local
Innovation

High level
Academy of Innovation



Local
Innovation

High level
Academy of Innovation

Simple Scenario Descriptions

Race to refuge – rapid temp rise, decrease in summer precip, strong leadership, strong societal concern

Colorado creeps north – moderate temp. rise, increase in non-winter precip; strong leadership, weak societal concern

Climate complacency – moderate temp rise, increase in non-winter precip; weak leadership, weak societal concern



One-Dimensional Planning vs. Robust Planning

