Lecture 4: Scenario Planning

April 19, 2022

Lecture Objectives

- Planning under uncertainty
- The limits of predictions
- Strategic foresight and scenario planning
- Case study: Snohomish basins 2060
- Lessons learned

Planning for What Future(s)

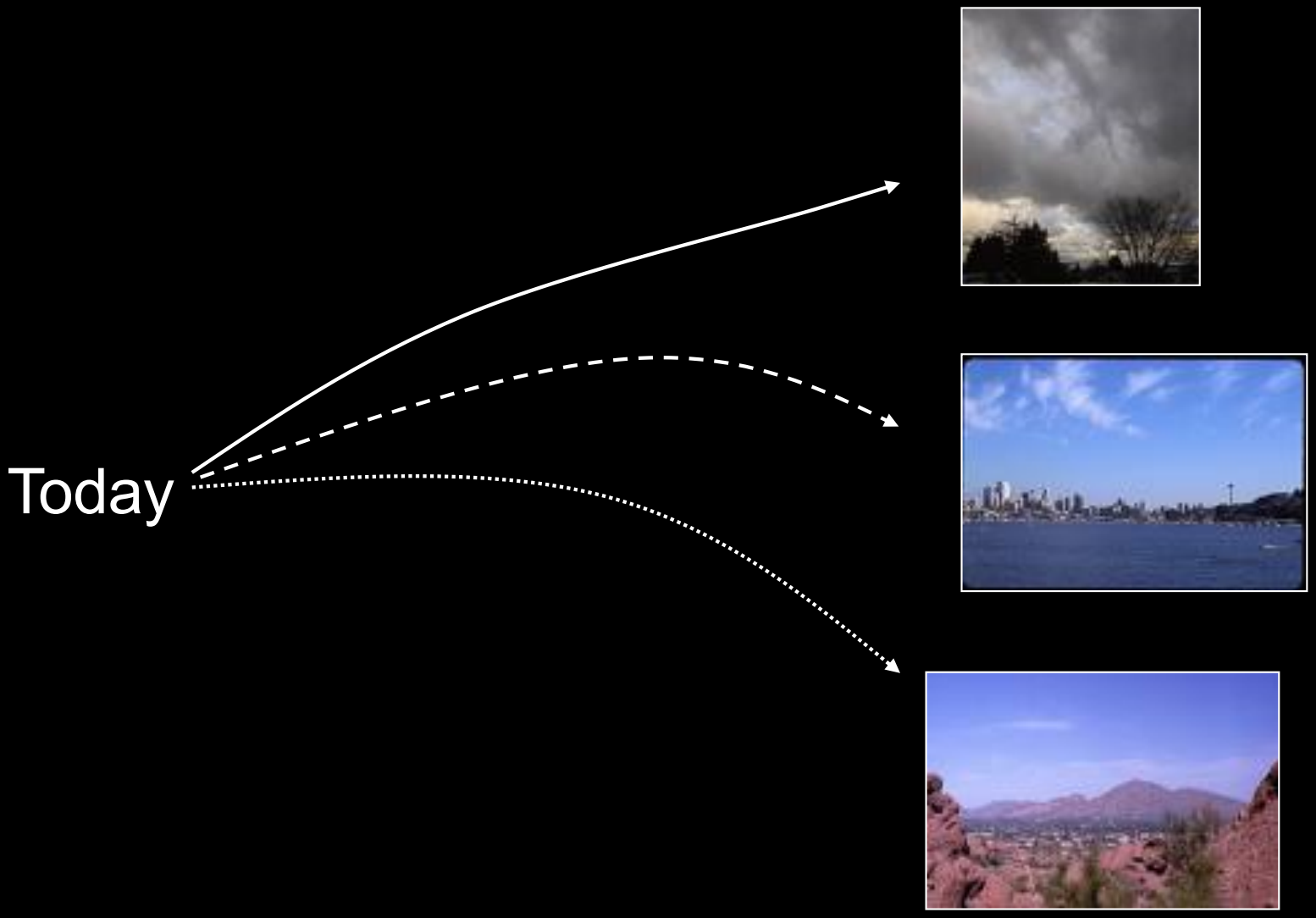
Key Questions

1. What are major trajectories and key uncertainties that will affect the urban resilience over the next 50 years?
2. What impacts, feedbacks, thresholds and critical transitions may emerge from their interactions?
3. How might alternative future scenarios affect social well-being, economic assets, and ecosystem services?
4. How can we identify robust strategies to reduce vulnerabilities and increase resilience to maintain these conditions, assets and services in the long term?

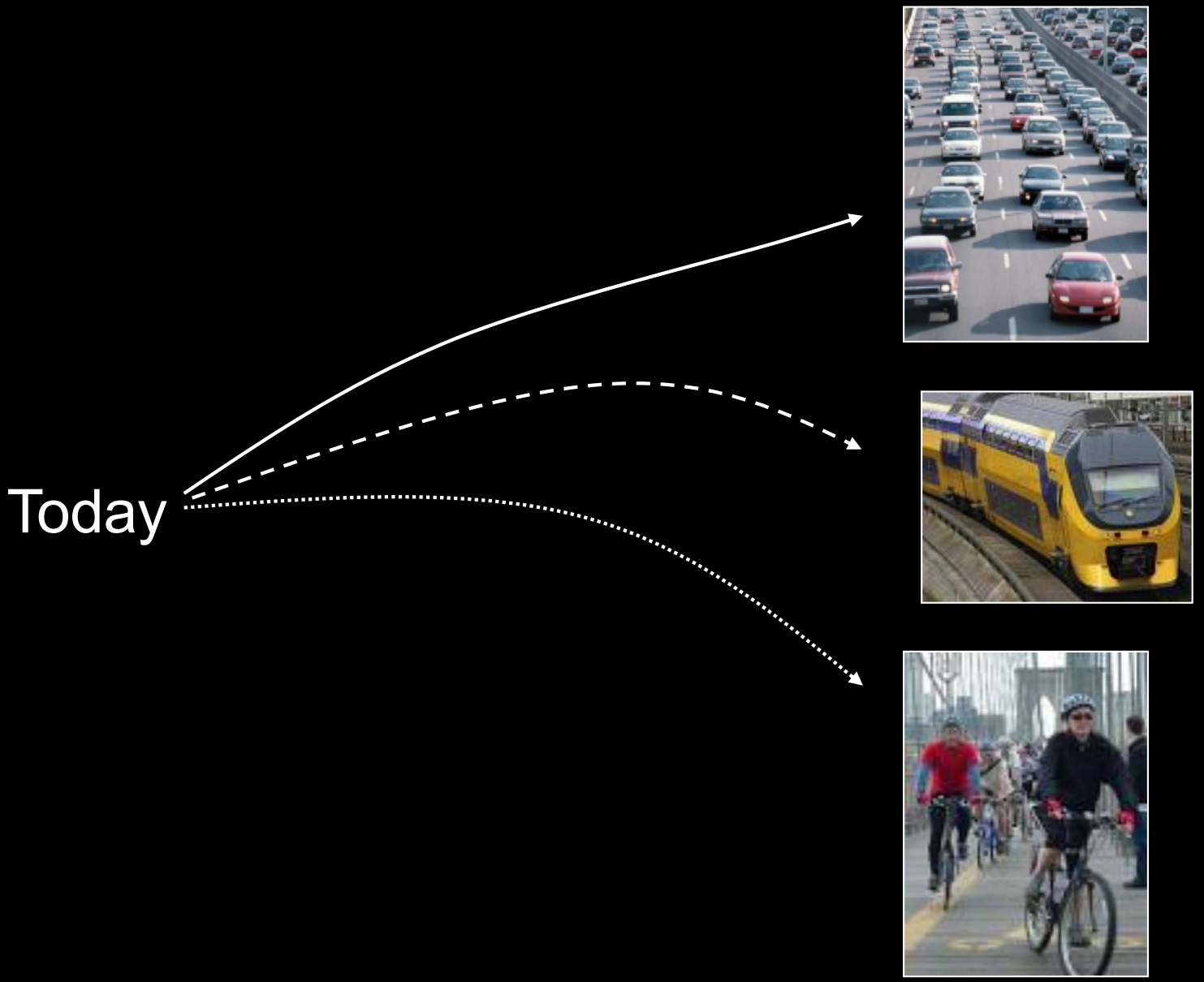
Change emerges from complex interactions among multiple uncertain drivers



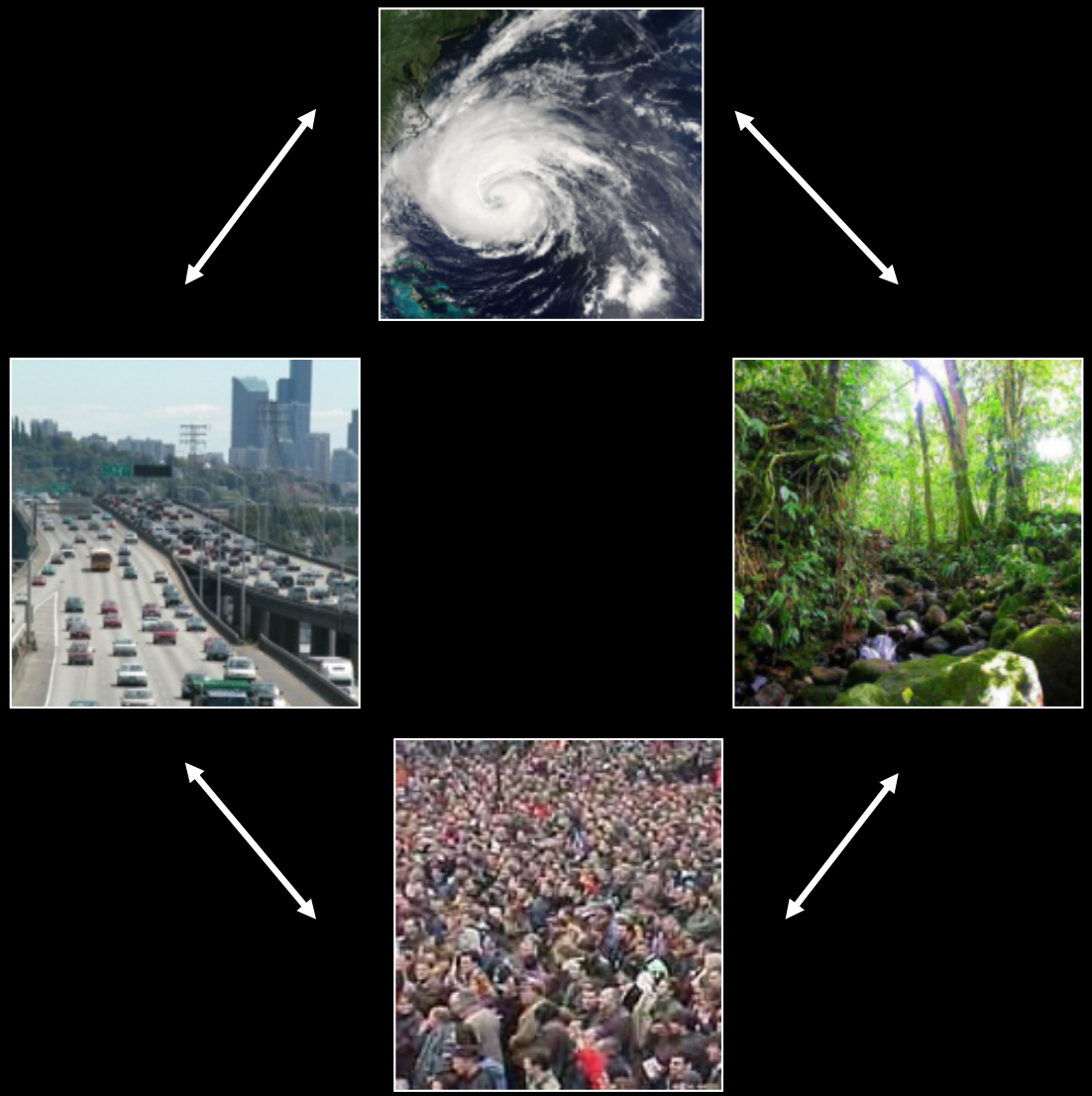

Uncertain Trajectories: Climate Change



Uncertain Trajectories: Transportation



Trajectories are interconnected



Types of Change

Change	Type of Change	Example
gradual or incremental	predictable	gradual responses to trends in ecological and human drivers.
random events	unpredictable	increasing variability of climate or technological innovations.
regime shifts	change to a different set of dominant feedbacks	critical points in land use change for maintaining ecosystem function.
transformations	change to a fundamentally new system and rule sets	new management institution or regulation

Alternative Future Approaches

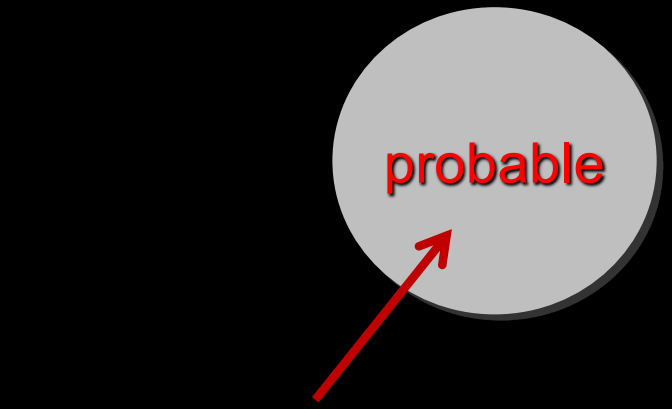
Scenario planning

how do iffer?

Visioning

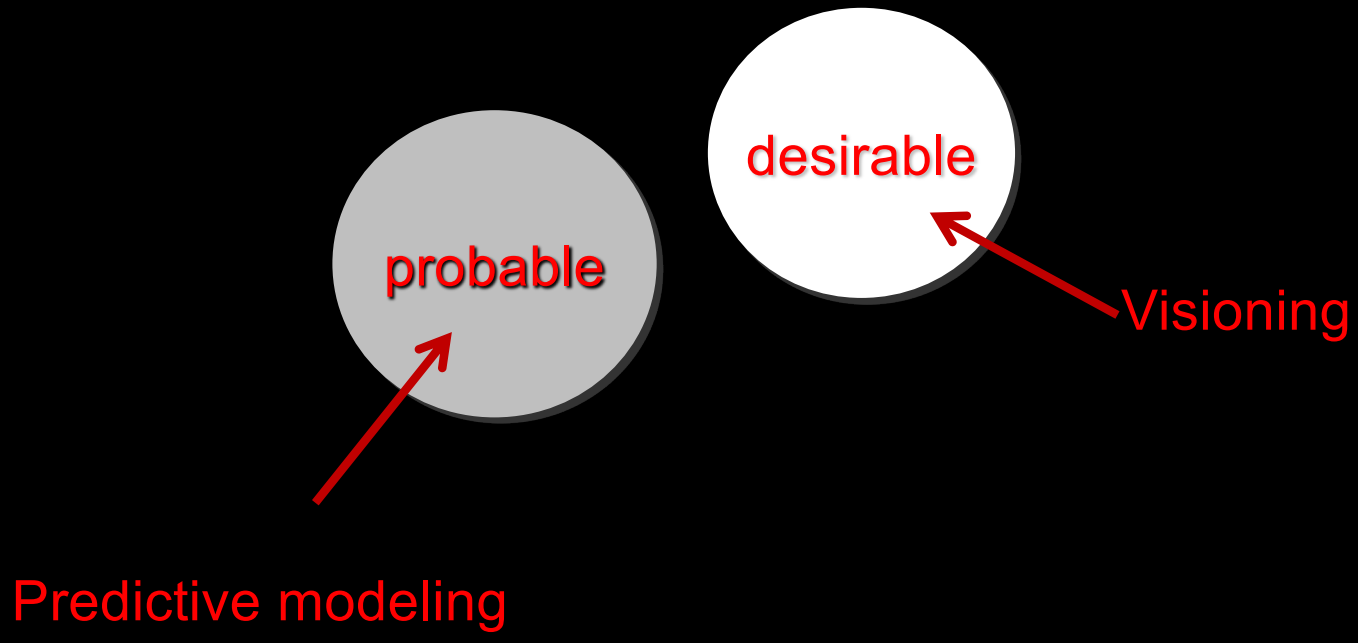
Predictive modeling

Alternative Future Approaches

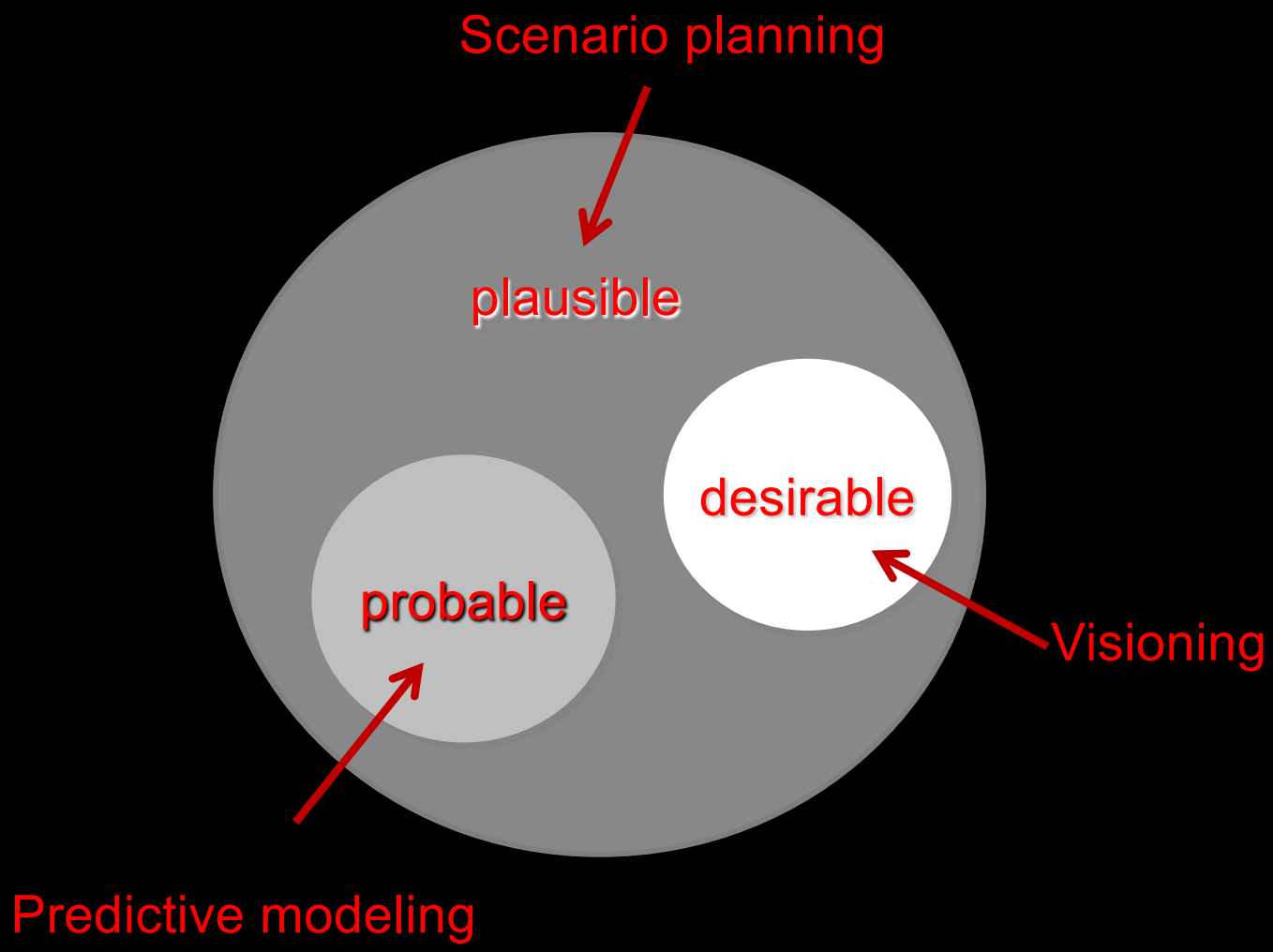


Predictive modeling

Alternative Future Approaches



Alternative Future Approaches



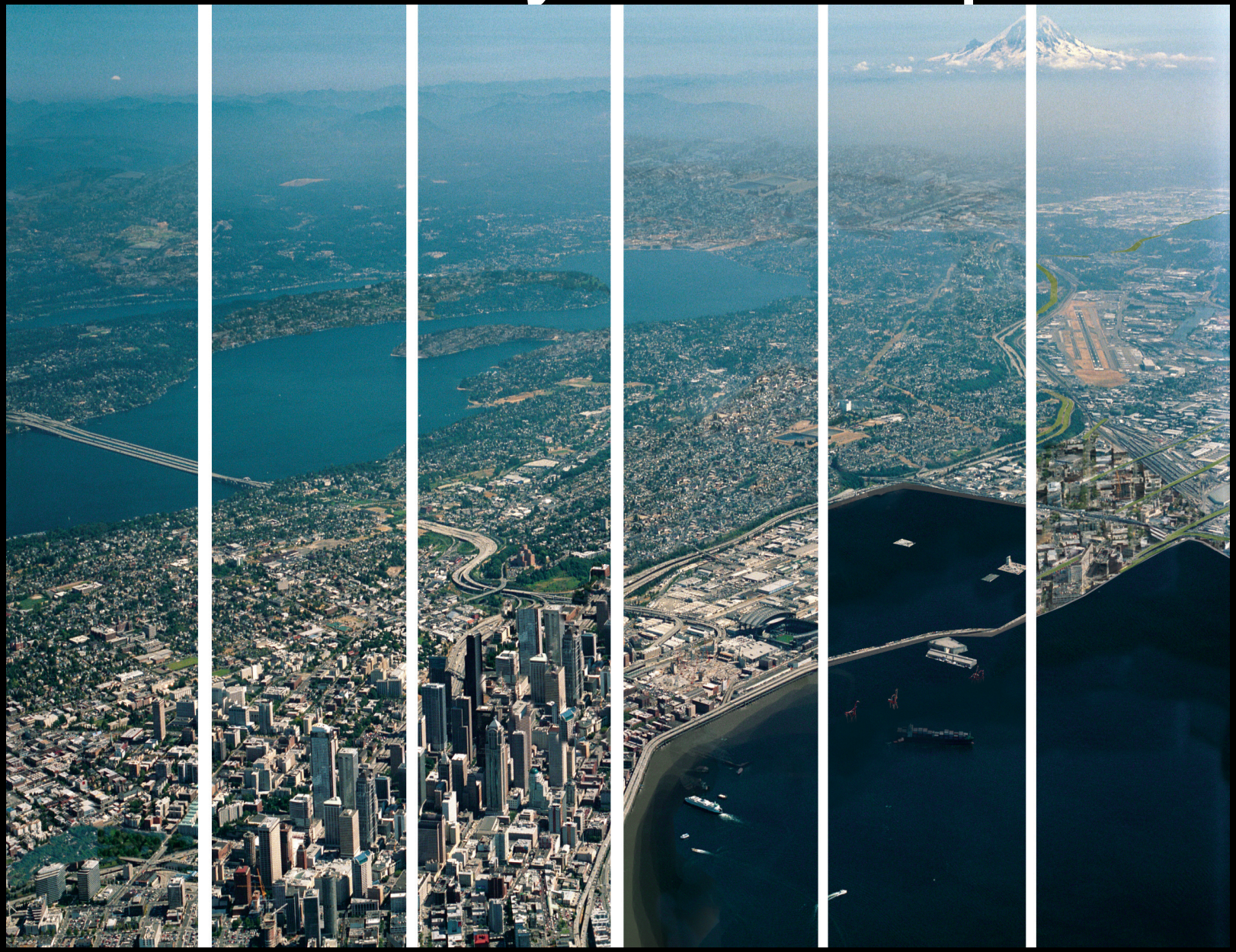
Futures Approaches

Futures	Forces	Thinking	Techniques
Visions *preferable*	Choices Images	Visionary Normative	Visioning Planning
Extrapolations *probable*	Constants Trends	Definite Probabilistic	Historical Extrapolation
Scenarios *plausible*	Uncertainty Discontinuities	Complexity Imaginative	Scenarios Simulation

Bishop (2004) modified

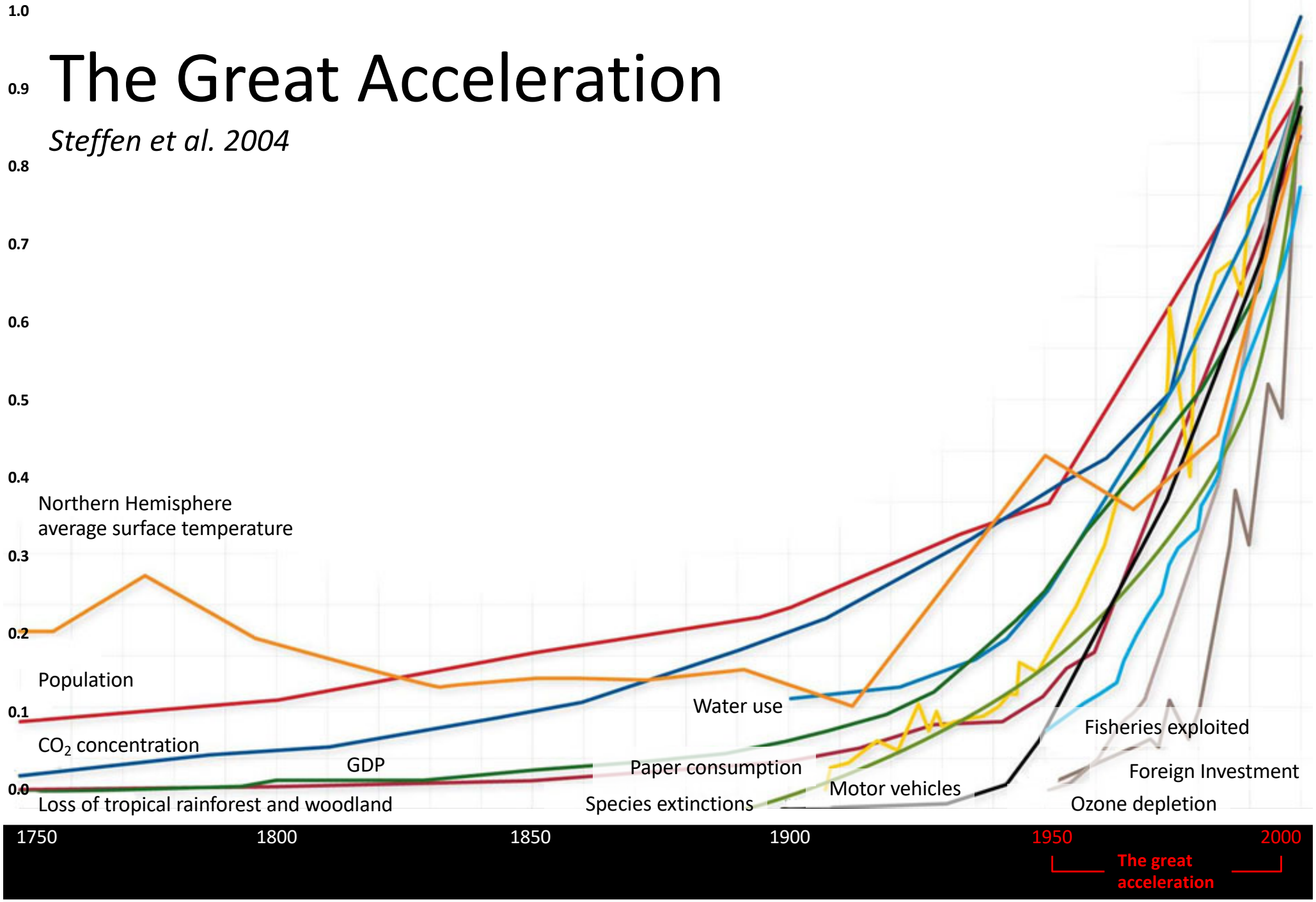

Imagine Seattle 50 years from now…

Uncertainty and Surprise

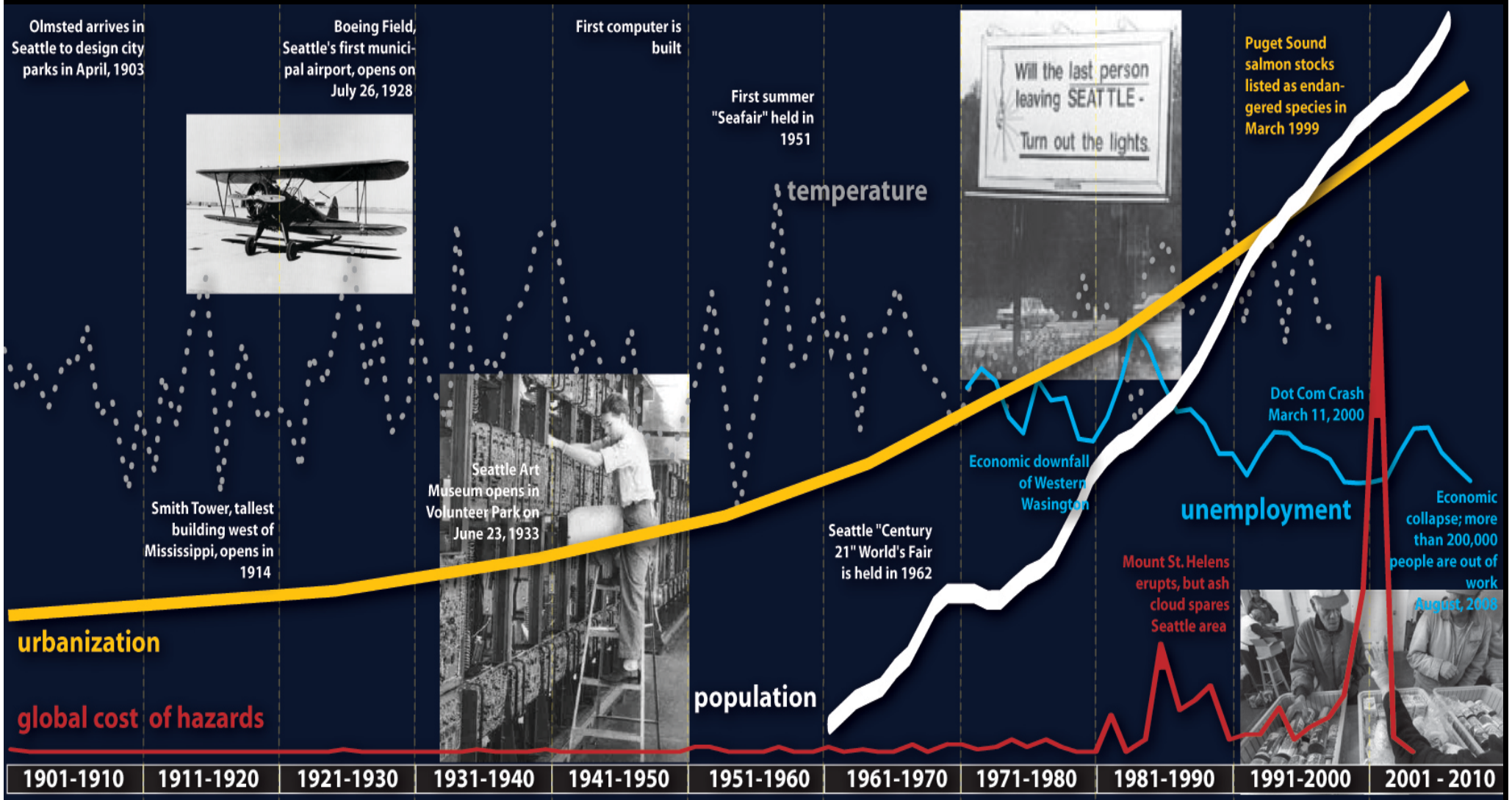


The Great Acceleration

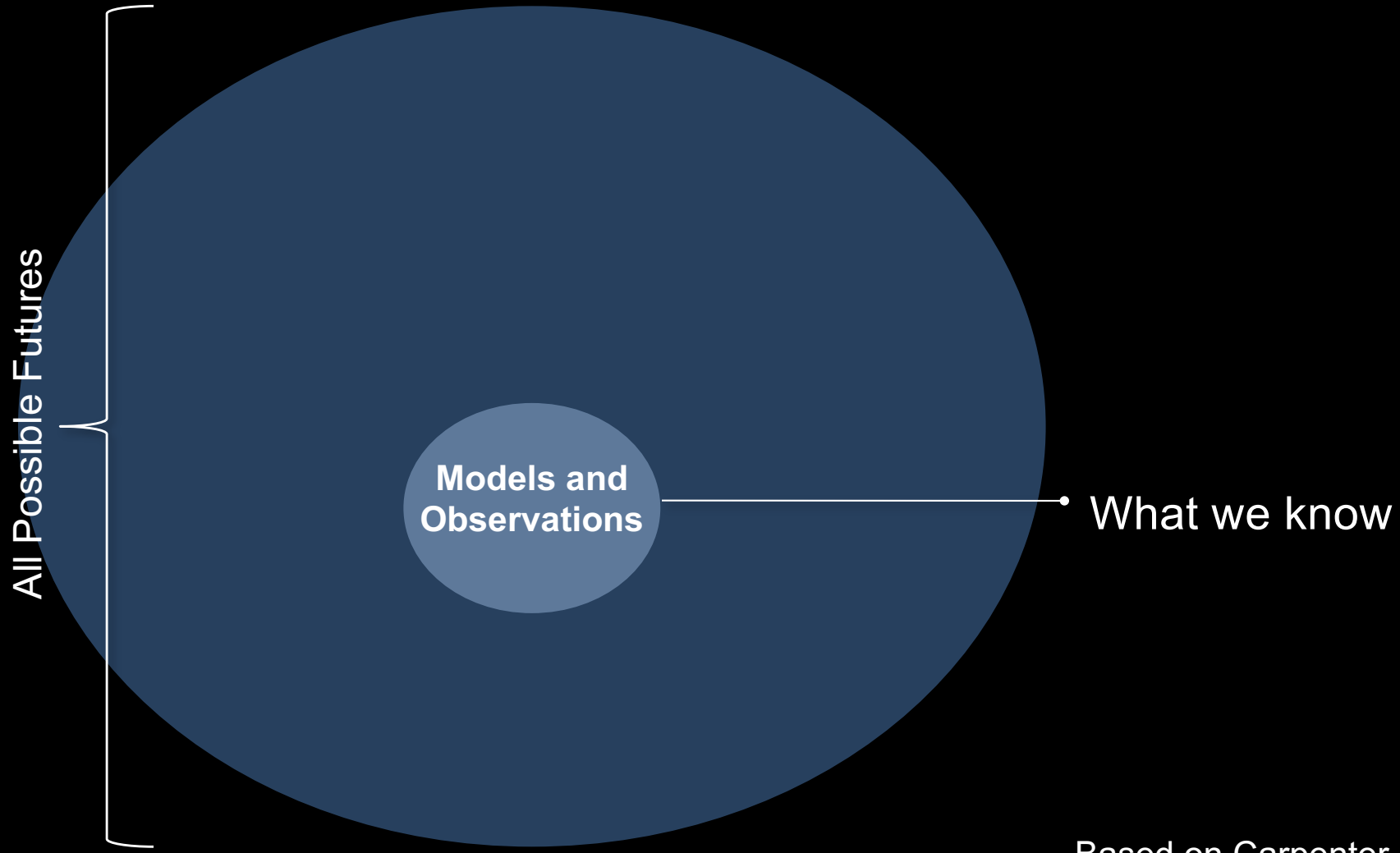
Steffen et al. 2004



How the past can bias our view of the future

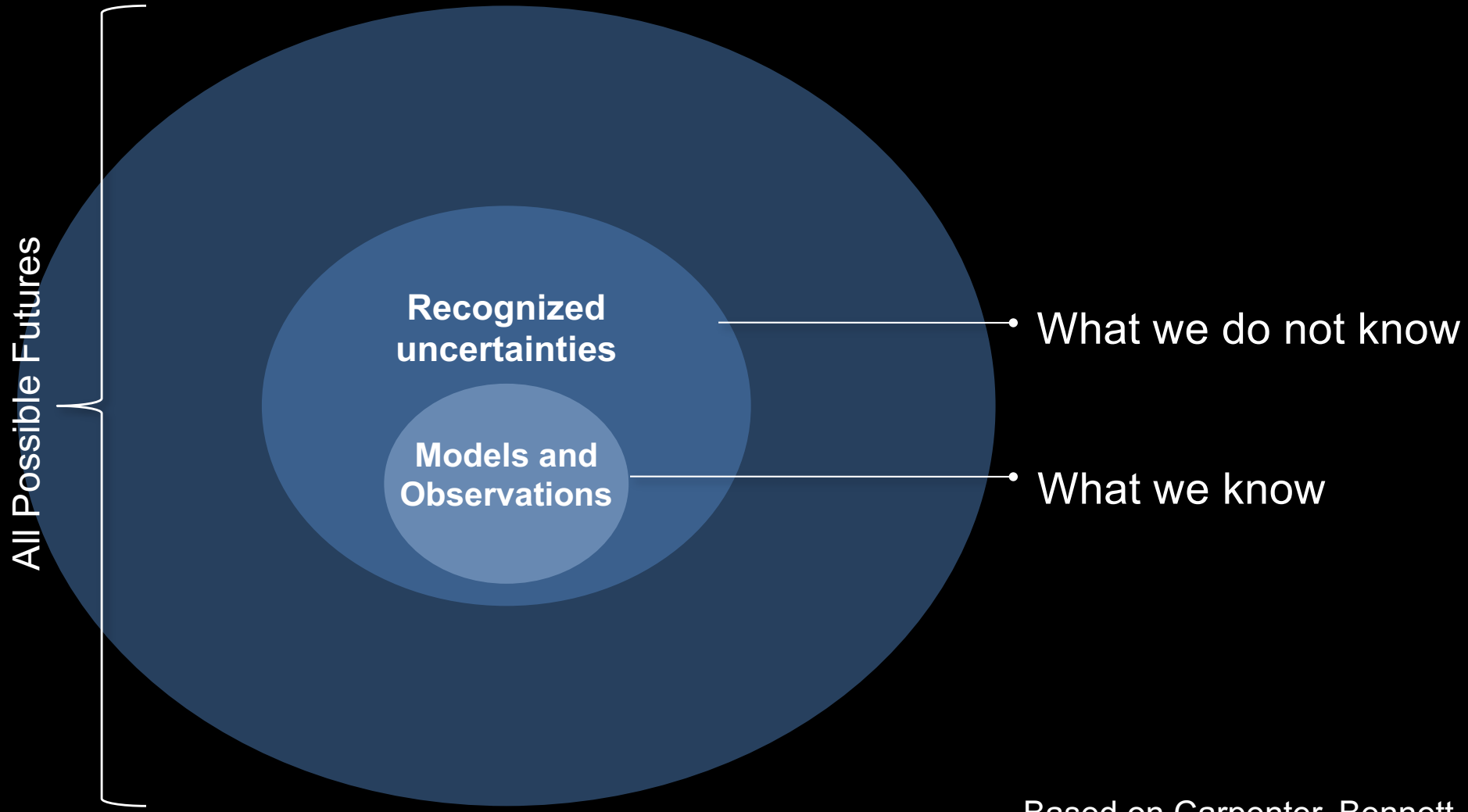


Predictability and Uncertainty



Based on Carpenter, Bennett & Peterson, 2006.

Predictability and Uncertainty



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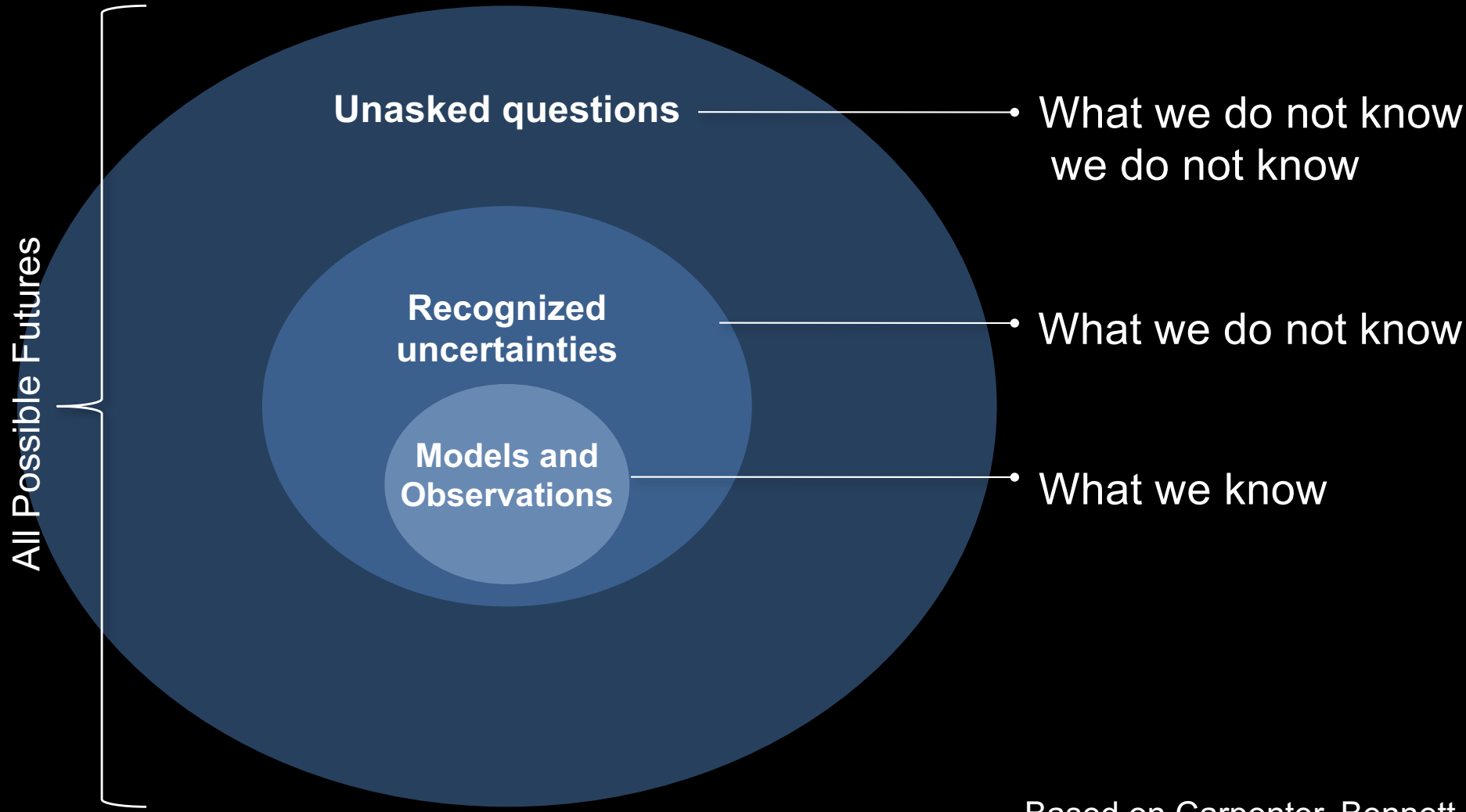
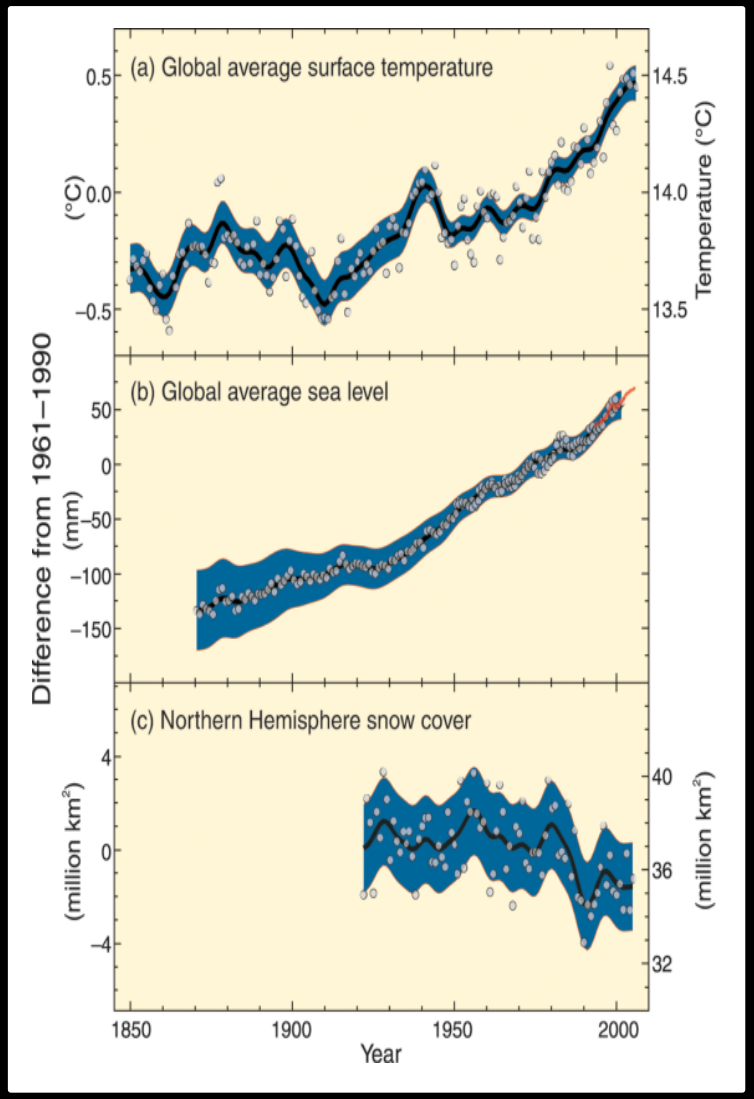
Predictability and Uncertainty



Based on Carpenter, Bennett & Peterson, 2006.

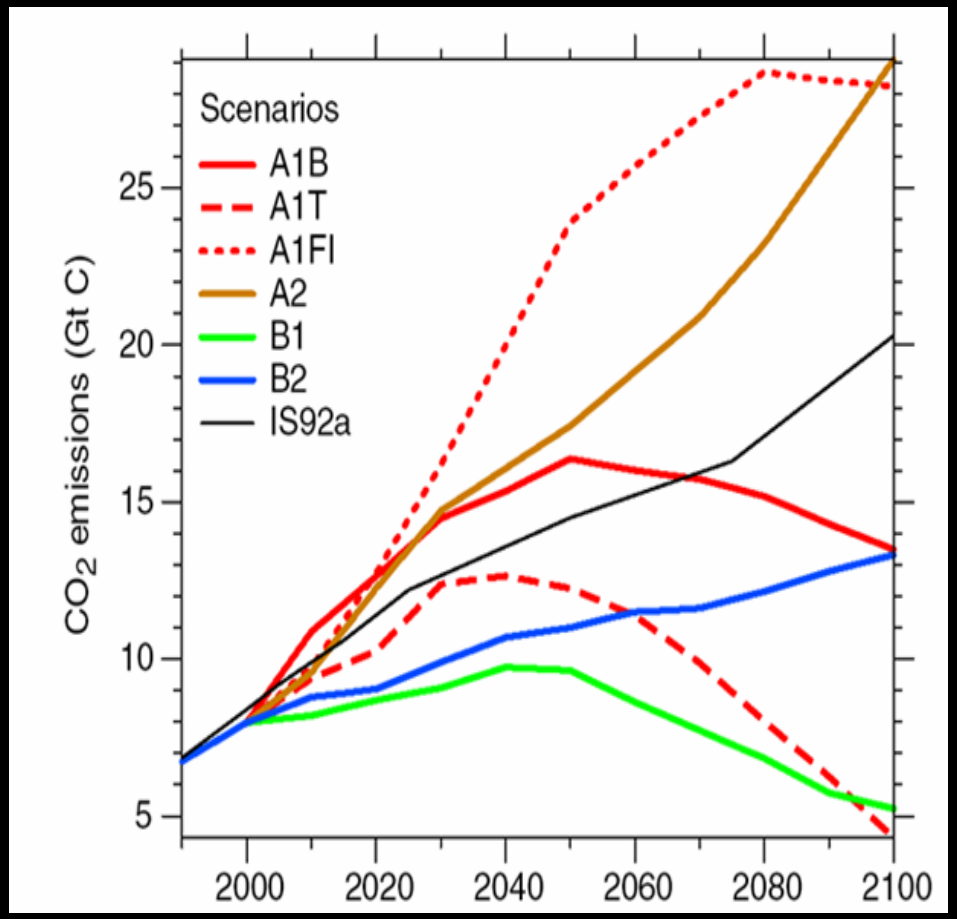
What we know: Observations

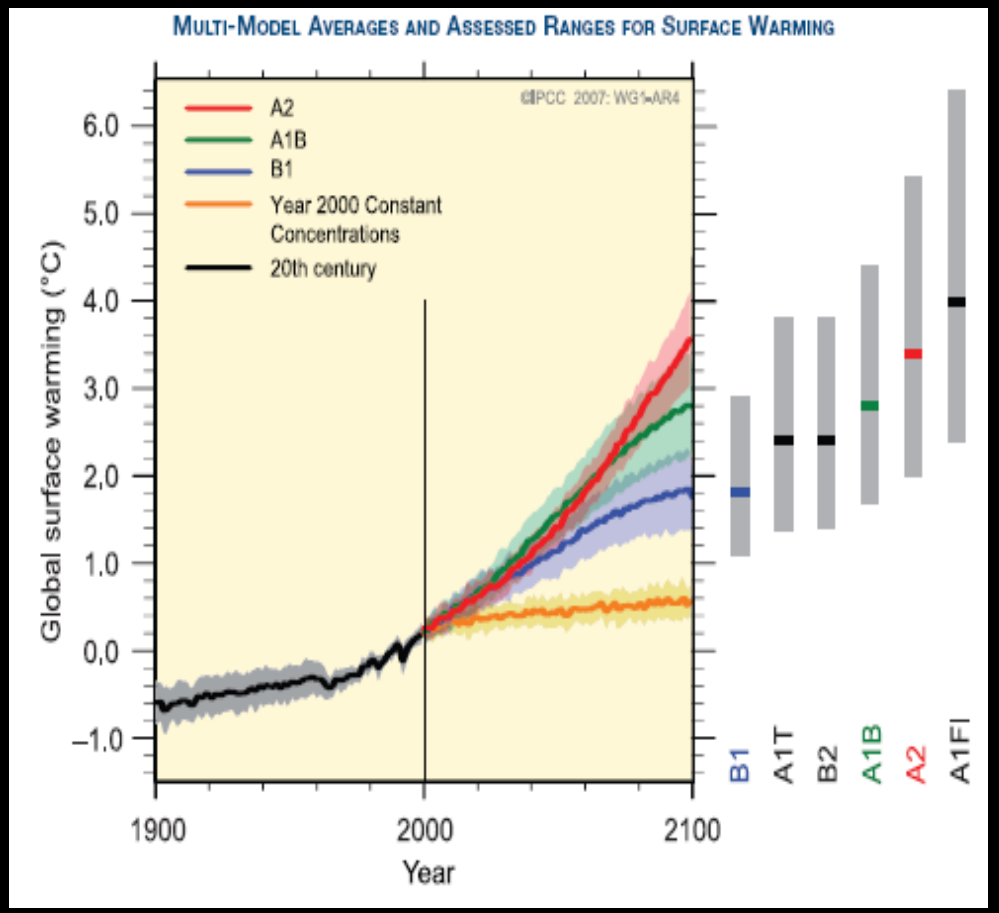
IPCC, 2007



- Human actions since the industrial age have contributed significant atmospheric emissions leading to changes in the global climate pattern.
- Instrumental observations over the past 157 years show that temperatures at the surface have risen globally, with important regional variations.
- The scientific community agrees that climatic variations will increase in magnitude and fluctuation over the next century.

What we predict: Models





IPCC 2007

What we do not know:
Accounted uncertainty

Scenario	Population	Economy	Environment	Equity	Technology	Globalisation	Climate
A1FI	↗↘	↗	↘	→	↗	→	↑
A1B	↗↘	↗	→	→	↗	→	↗
A1T	↗↘	↗	↗	→	↗	→	→
B1	↗↘	→	↗	→	↗	→	→
A2	↗	→	↘	↘	→	↘	↗
B2	→	→	↗	→	→	↘	→

Viner and Sayer, 2004

What factors control the risks associated with climate change?

What are the computable uncertainties?

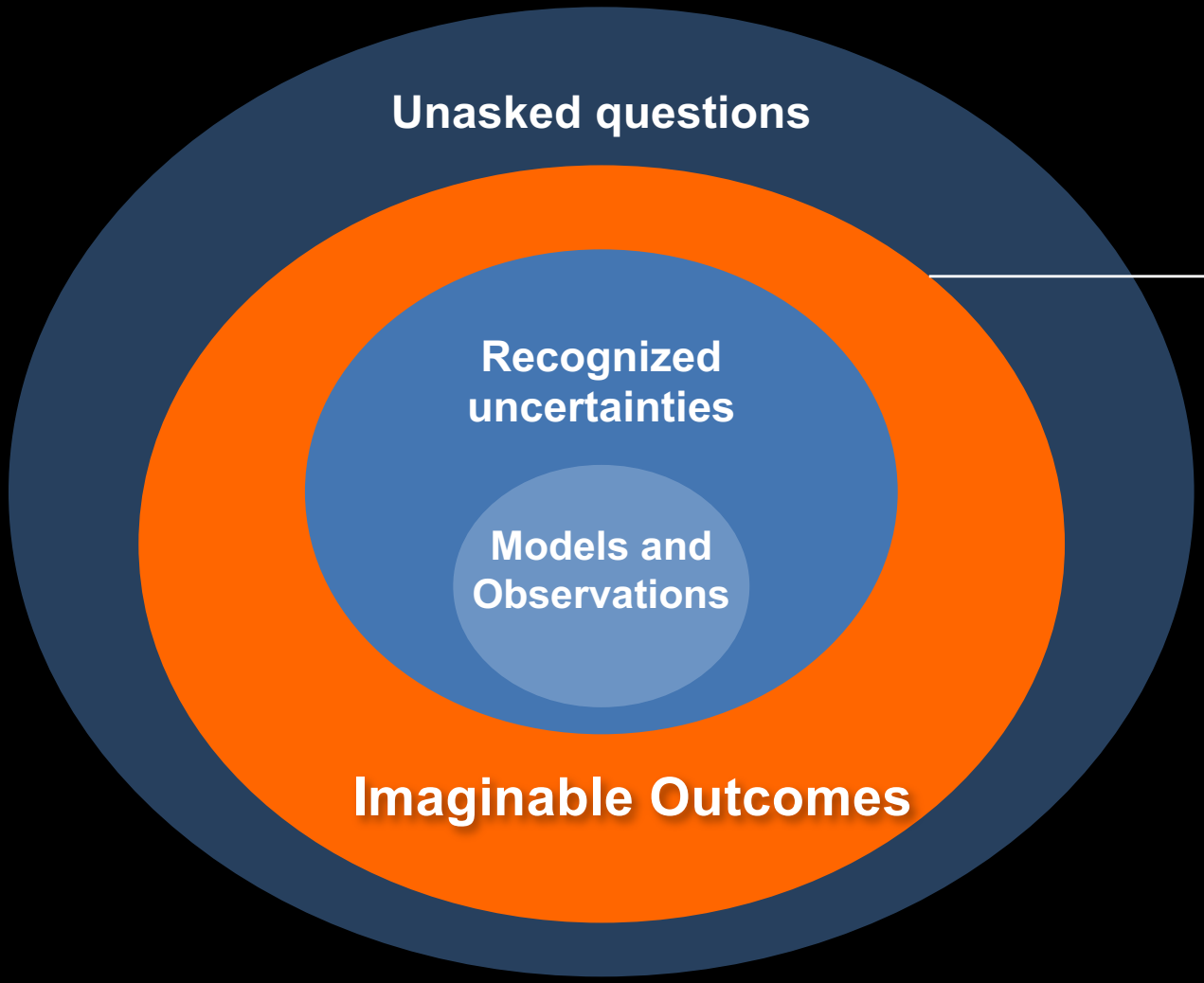
"…we do not know, over the longer term, how the oceanic biological system in the southwest Pacific will be influenced by the interaction of ENSO events with the overall warming trend…"

IPCC, 2007

What we do not know, we do not know:
Unasked questions

- What lies beyond our predictions and models?
- What synergistic outcomes have we not anticipated?
- Which critical thresholds have we ignored?
- How can the future surprise us?

What we can imagine based on our best available information



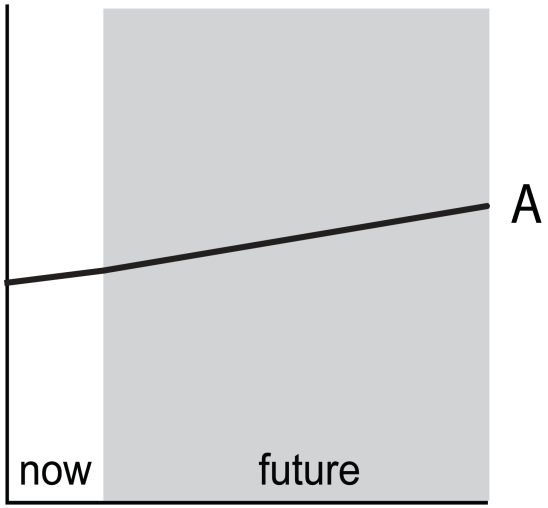
Where scenarios can help us the most

Based on Carpenter, Bennett & Peterson, 2006.

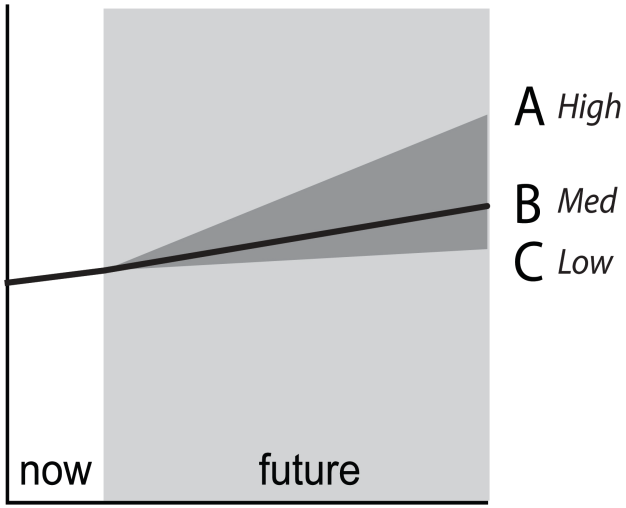
How Scenarios Work

- **Multiple Drivers:** Scenarios explore the interaction between significant uncertain drivers

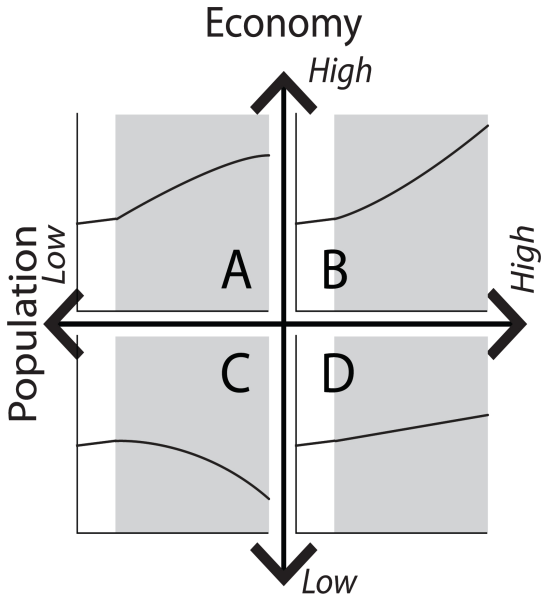
Singular Prediction



One Variable



Multiple Drivers



Scenarios

- Scenarios are hypotheses of alternative futures that highlight the *risks* and *opportunities*.
- Scenarios focus on interactions among uncertain drivers and expand the assumptions of predictive models.
- Scenarios direct our attention towards the most relevant uncertainty dimensions.
- Scenarios ask: How robust are alternative strategies under plausible future conditions

Why Scenarios

- **Complexity** of coupled human-natural systems (heterogeneity, non-linearity and emergent properties) make them highly unpredictable.
- **Limited knowledge** many of the processes underlying climate change are still poorly understood, further limiting the predictability of system response
- **Reflexivity** we must incorporate an understanding of reflexive human decision-making and behavior into the evaluation of the strategies.
- **Uncertainty** increases the further out we look

Redefining the Question

How can we minimize uncertainty about future changes to select the most optimal strategies?

Redefining the Question

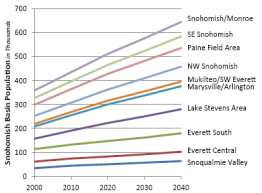
How can we minimize uncertainty about future changes to select the most optimal strategies?

How can we characterize uncertainty about future changes to inform the choice of the most robust strategies?

Observations & Forecasts

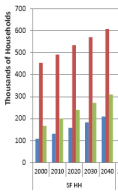
Demography *published data*

Population Growth / Decade



PSRC 2006 trends are based on declining rates of growth in both King and Snohomish Counties. While the growth rate was 9% in King and 21% in Snohomish County between 2000-2010, the rate is forecasted to decrease to 7.5% and 12%, respectively, between 2030-2040. If 2000-2040 trends were extended linearly to 2060, the Basin could be forecasted for an additional 350,000 people in the Basin (2010-2060)

Household Growth

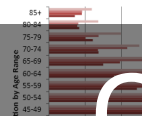


In 2010, 25% of the Basin households lived in multiple-family units. By 2040, the percentage is forecasted to rise modestly to 26.7%. In King County, during the same time frame, the percentage of MF units is expected to rise from 38% to over 45%.

Ethnicity and Race in WA

In 2000, 7.5% percent of the State was of Hispanic Origin. By 2030, the percentage is forecasted to rise to 12.9%.

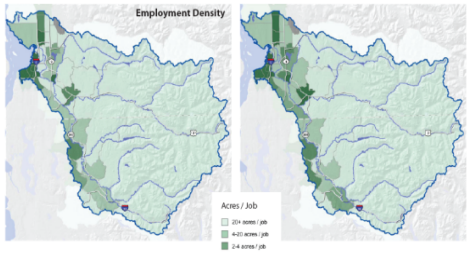
Age Structure in Washington State



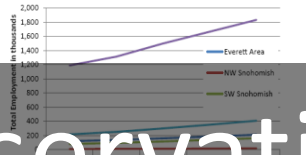
In 2000, the median age in the State was 35. By 2030, the median age is forecasted to rise to 39.
In 2000, 19% of the population was school aged (5-17). By 2030, only 16.7% of the population will be school aged. However, there will be over 300,000 more students in the system.
In 2000, 11% of the State population was of retirement age. By 2030, an additional 1 million people will be of retirement age (65+), one fifth of the total population.

In 2010, the Basin's population represented ~6.5% of the State's population. If growth trends in the Basin remained fairly consistent with the State's growth trends, the Basin can be forecasted to grow by an additional 20,000 students and 65,000 retirees by 2030.

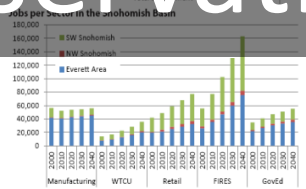
Economy *forecast data*



Total Number of Jobs in the Snohomish Basin



Jobs per Sector in the Snohomish Basin



Employment Trends

Between 2010 and 2040 the King and Snohomish Counties are forecasted to grow by an additional 520,000 jobs and 160,000 jobs, respectively.

The majority of these jobs will be within the financial, professional, business and educational services sectors (FIRES).

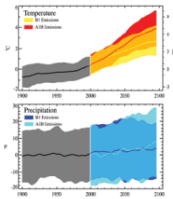
The Basin is forecasted to increase by an additional 150,000 jobs between 2010 and 2040, 57% of these additional jobs are forecasted for the

Manufacturing is forecasted to grow by 17,000 jobs

Note: PSRC's forecast was updated in 2006. Since the release of the forecasts, important changes to underlying planning assumptions and trends have occurred, an updated release is slated for Spring 2012.

Climate *forecast data*

Simulation of Annual Changes in Temperature and Precipitation

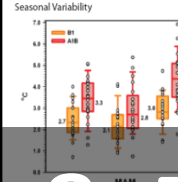


Simulated temperature change and percent precipitation change for the 20th and 21st century global climate model simulations for the Pacific Northwest. The black curve for each panel is the weighted average of all models during the 20th century. The colored curves are the weighted average of all models in that emissions scenario ("low" or B1, and "medium" or A1B) for the 21st century. The colored areas indicate the range (5th to 95th percentile) for each year in the 21st century. All changes are relative to 1970-1999 averages.

	Temperature Change degF	Precipitation Change (%)
2020's	+2.0 (+1.1 to +3.3)	+1.3 (-9 to +12)
2040's	+3.2 (+1.5 to +5.2)	+2.3 (-11 to +12)
2080's	+5.3 (+2.8 to +9.7)	+3.8 (-10 to +20)

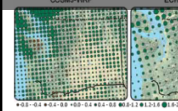
(39 combinations averaged for each cell in the table). The ranges for the lowest to highest projected change are in parentheses.

Seasonal Variability



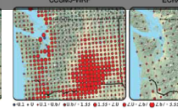
Extreme Events

Change in the number of heat wave events



A heat wave is an episode of three or more days where the daily heat index (HUMIDEX) exceeds 32°C. The CCSM3-WRF shows considerable increase in heat waves in the lowlands of western Washington.

Change in the fraction of daily precipitation exceeding the 20th century 95th percentile (95t)



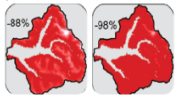
An increase reflects that a greater percentage of precipitation occurs during extreme precipitation events. Both models show increases, with CCSM3-WRF showing considerably more change.

Hydrology *forecast data*

Snowpack Loss (SWE)

The hydrology of the Pacific Northwest (PNW) is particularly sensitive to changes in climate because seasonal runoff is dominated by snowmelt from cool season mountain snowpack, and temperature changes impact the balance of precipitation falling as rain and snow.

Projected changes in snow water equivalent (SWE) in the Sultan Watershed for 2040 and 2080 according to the A1B SRES scenario compared with simulated mean historical April 1 SWE (1916-2006) as simulated by DHSVM (below). By 2040, the Sultan is forecasted to lose 88% of April 1 SWE, by 2080 nearly all of the snow (98%) will be gone by the first of April. In the Tolt watershed (not pictured) 79% is forecasted to be lost by 2040, and 95% lost by 2080.



Groundwater

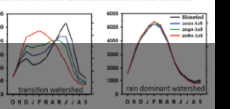
The literature review indicates that a wide range of groundwater impacts could result from climate change. Some studies indicate negative impacts to groundwater recharge related to climate change, while other studies predict increased groundwater recharge. In general, results suggest that changes in precipitation, caused by different emissions of greenhouse gases in the future, influence the amount of recharge. However, in some situations, local conditions, such as evapotranspiration, surface water exchanges, and changes to groundwater pumping, are more significant to groundwater systems than changes in climate. many studies indicate the relative importance of hydraulic conductivity to rivers and changes in river flows to groundwater levels.

Watershed Transitions

Historically, both the Skykomish and the Snoqualmie were transition watersheds. By 2020, under both the A1B and B2 scenarios,the Snoqualmie would become a rain dominant watershed. By 2040 under the A1B scenario, and by 2080 under the B2 scenarios, the entire Basin would become rain dominant.

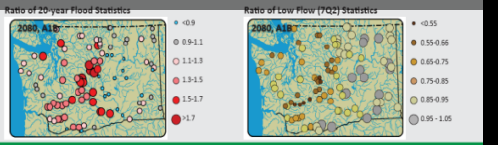
Streamflow Changes

Transient basins will likely experience significant streamflow shifts, becoming rain dominant as winter precipitation falls more as rain and less as snow. The characteristic double-peak hydrograph of the transition watersheds will shift towards a single-peak characteristic of rain-dominant watersheds (left below). Watersheds that are rain dominated will likely experience higher winter streamflow because of increases in average winter precipitation, but overall will experience relatively little change with respect to streamflow timing. These changes are important because they determine when water is available and how it must be stored.

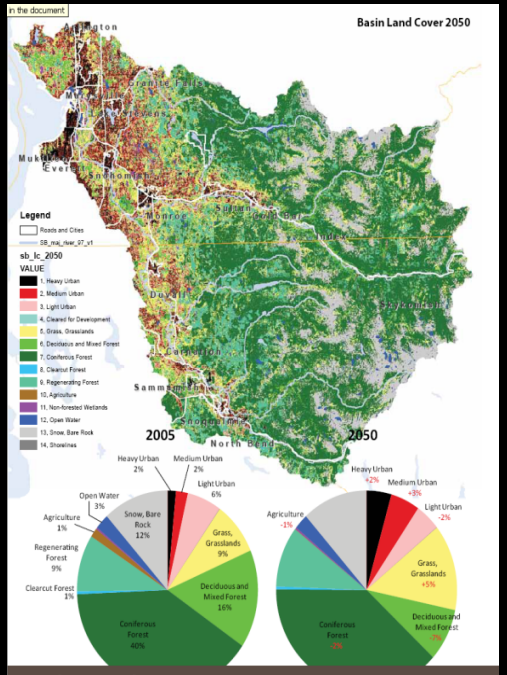


Flow Statistics

Reductions in the magnitude of summer low flows are predicted to be widespread for Washington State's rain dominant and transient runoff river basins. Future estimates of the annual average low flow magnitude (7Q2, which is the 7 day average low flow magnitude with a 2 year return interval) are projected to decline by 0-50% by the 2080s under both the A1B and B1 emissions scenarios (see 2080, A1B above). The reduction in streamflow for more extreme (7Q10) low flow periods in rain dominant and transient runoff basins is also predicted to change by a similar amount, ranging from 5-40% (not shown). Further, the duration of the summer low flow period is projected to expand significantly

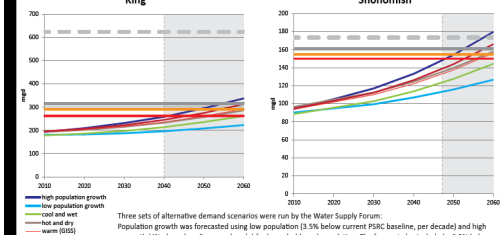


Land Cover Change *published data*



Infrastructure *published data*

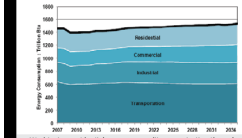
Water Supply and Demand



Three sets of alternative demand scenarios were run by the Water Supply Forum: Population growth was forecasted using low population (3.5% below current PSRC baseline, per decade) and high growth (4% above baseline, per decade) for households and population. The forecast also included a 2.5% below baseline and 3.5% above baseline employment growth.
Weather Forecast utilized historic temperature and precipitation data to forecast alternative future weather parameters. Hot-dry conditions had 4% hotter temperatures and 38% less precipitation than average. Cool and wet had 5% cooler than average and 29% wetter than average weather.
The projected impacts of climate change utilized the A2 and B1 SRES emissions scenario. With A2 representing the warmest (IPSL) scenario and B1 representing the warm (GISS) scenario.
Changes to existing supply was explored. Included in the above diagrams are current water rights
In addition to demand, supply was explored. The total amont of supply is dictated by water rights.
Surface water supply is forecasted to change as a result from the expected seasonal shift in streamflow, with less runoff in late spring and early summer months, which have traditionally marked the reservoir refill period of the region's supply reservoirs. As with demand, the warm scenario represent SRES emissions scenario B1 while the warmest scenario represents A2. The above graphic does not represent new planned or proposed projects which will increase water supply in each County.

Energy Supply and Demand

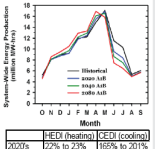
Forecast primary energy consumption in Washington, by end use sector



Washington residential energy expenditures projection through 2035. Expenditures are expected to decline primarily driven by improving efficiency in transportation standards, but also partly due to more purchases of efficient appliances, electronics and heating systems.

Climate impacts on Hydropower Supply

Hydropower accounts for roughly 70% of the electrical energy production in the Pacific Northwest and is strongly affected by climate-related changes in annual streamflow amounts and seasonal streamflow timing.



Climate impacts on energy demand due to changes in heating and cooling days

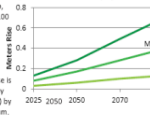
Combining the effects of warming with population growth

	HEDI (heating)	CEDI (cooling)
2020's	22% to 23%	165% to 201%
2040's	35% to 42%	363-565%
2080's	56% to 74%	981-1845%

Sea Level Rise *forecast data*

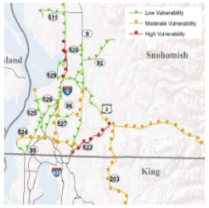
Pacific NW Seal Level Rise

Medium projections of sea level rise for 2100 are 2 inches to 13 inches (depending on location) in Washington State. Substantial variability within the region exists due to coastal winds and vertical land movement. The small possibility of substantial sea level rise from the melting of the Greenland ice cap lead to projections as high as 35 inches to 50 inches for 2100 (depending on location).The IPCC Sea Level Rise projections for moderate A1B scenario, range across the next 100 years and under a minimum, mean or maximum trajectory (see below). In WRIA 7 (Coast from Everett – Marysville) sea level rise is projected to increase by 0.36 meters (14 inches) by under the A1B Maximum.



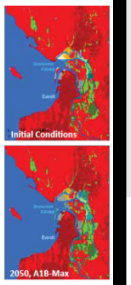
Transportation Vulnerability Assessment

- Northwest Region Area 3 consists predominantly of urban and suburban roads in Snohomish County and US 2 to the region boundary and SR 203 in northern King County. In general, most climate impacts would result in either reduced capacity or temporary road closures due to heavy rain events.
- US 2 has impacts now from flooding and debris moving down the Skykomish River. If sea level rises 2 feet, US 2 could see more log jams collecting on bridge piers, but they would be easier to reach. With 4- and 6-foot sea level rises, the river could overtop the dikes and the water would spread, easing pressure on the bridge.
- US 2 is the sole mountain pass in this Maintenance Area. Climate impacts are anticipated to result in temporary closures rather than closures lasting over 60 days.
- SR 104 at the intersection to the Edmonds ferry terminal already has flooding during high tides and during average tides in heavy rain events. This is expected to increase with higher sea levels. Low-lying roads will be impacted by higher sea levels.
- SR 203 is impacted now by high winds coming off the Cascades. Winds may increase with more extreme weather events.
- In general, with increased heavy rain events, existing drainage ditches and culverts may be undersized for larger events. Roads at the base of steep slopes may see more landslides, but these are not anticipated to close the road for more than 60 days.

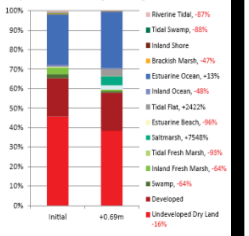


Habitat Vulnerability Assessment

Extensive dikes protect the low-lying dry land and marshes within Everett. This reduces the predicted effects of sea-level rise for this site. Assuming that dikes in this area are able to withstand the predicted increases in sea level rise, the most significant prediction at this site is the inundation of brackish marsh and inland fresh marsh north of Smith Island and west of Marysville. However, it is not unreasonable to suggest that, because many of the dikes in this area were constructed with wood waste from lumber mills and other degradable materials, they may be vulnerable to damages associated with sea-level rise. The Tulalip Tribe and other stakeholders in the region are currently working to remove some of the region's dikes to restore habitat.

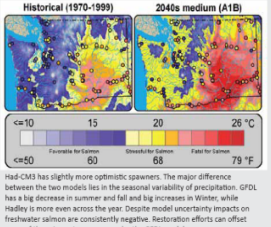


Projections for Habitat Changes for Everett Area, Site 4 Projections for Habitat Changes Assuming no Dikes



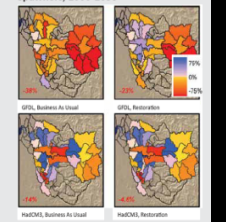
Salmon *forecast data*

Aug. Mean Surface Air + Maximum Stream Temperature



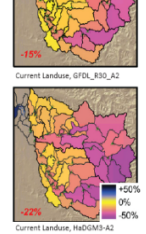
Had-CM3 has slightly more optimistic spawners. The major difference between the two models lies in the seasonal variability of precipitation. GFDL has a big decrease in summer and fall and big increases in Winter, while Hadley is more even across the year. Despite model uncertainty impacts on freshwater salmon are consistently negative. Restoration efforts can offset some of these impacts, more so under the GFDL model.

Change in Mean Returning Chinook Spawners, 2000-2050

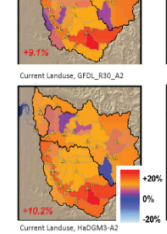


Results of Hydrologic Model on Key Salmon Survival Limiting Factors

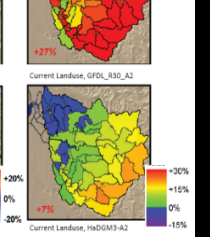
2000-2050 Percent Change in Minimum Spawning Flows.



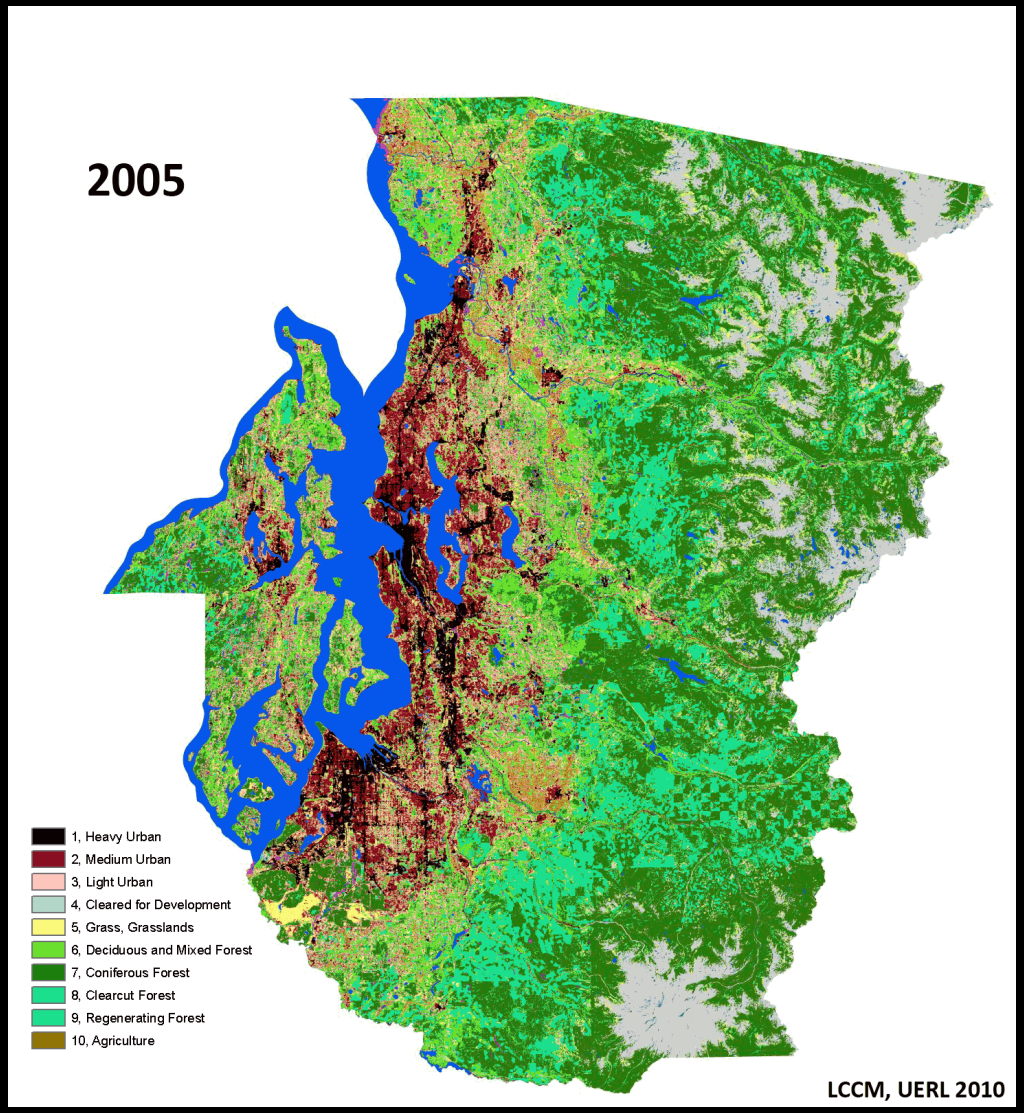
2000-2050 Percent Change in Average Daily Maximum Pre-Spawning Temperature



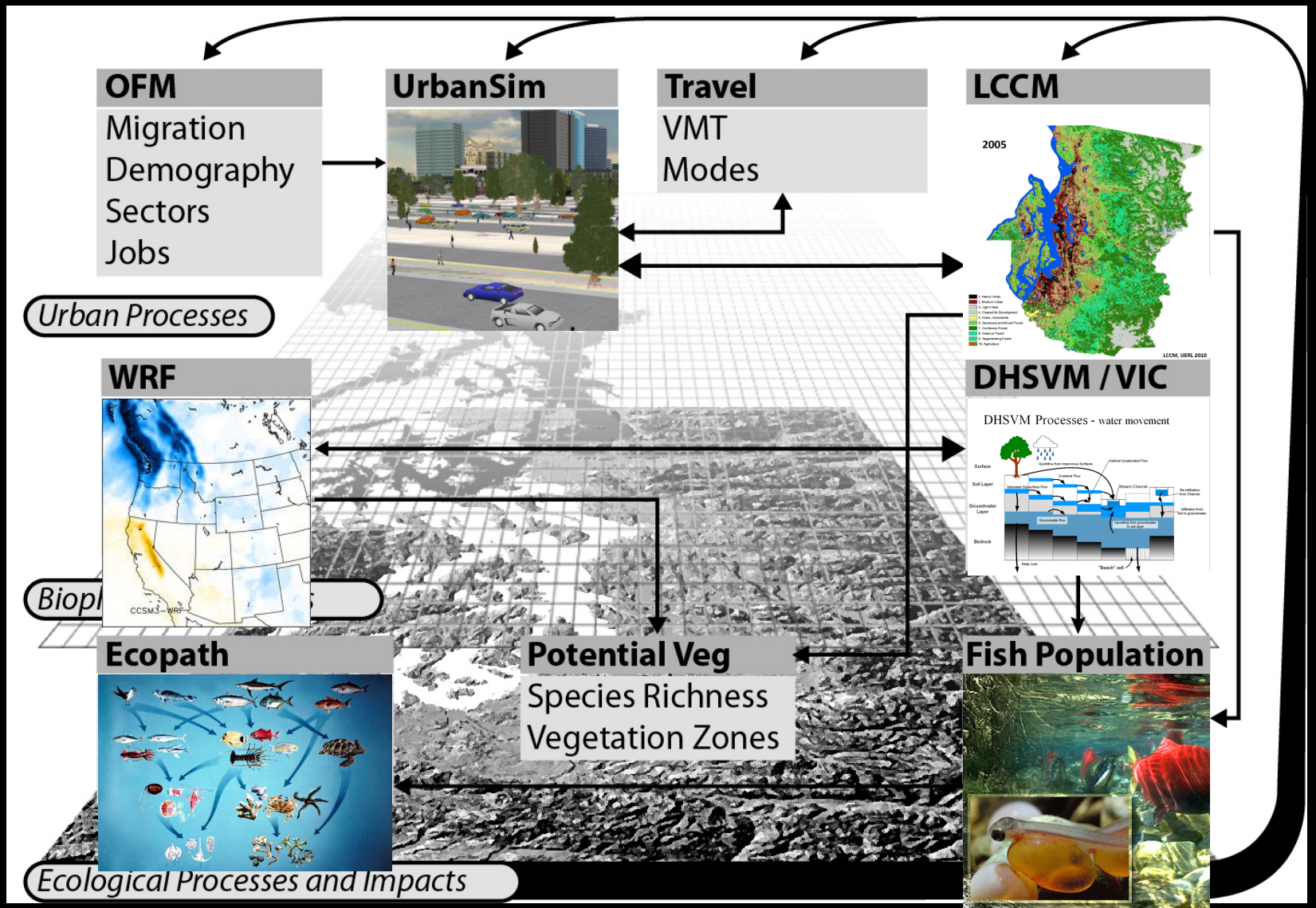
2000-2050 Percent Change in Incubation Flows



Land Cover Change Model



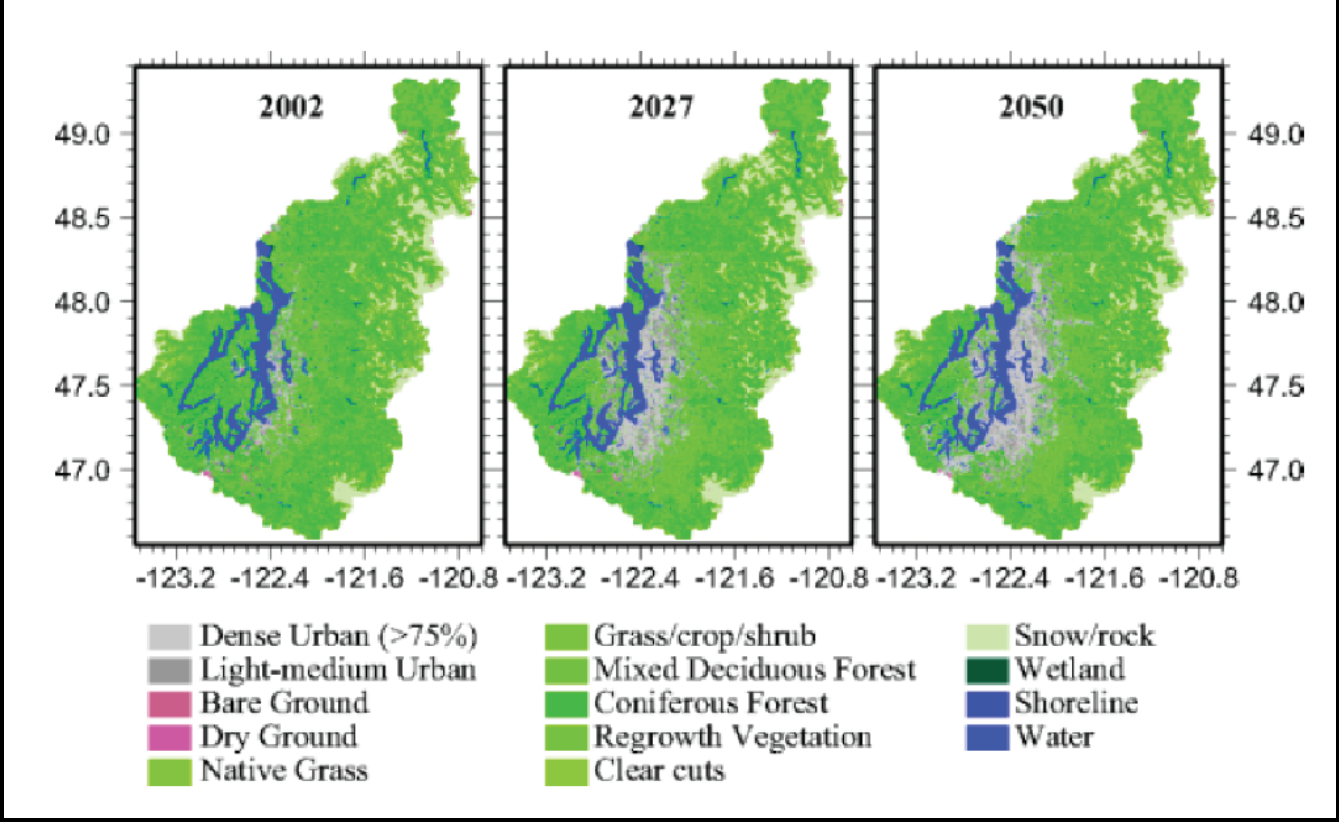
Integrated Geo-Spatial Models



Alberti and Waddell 2001.

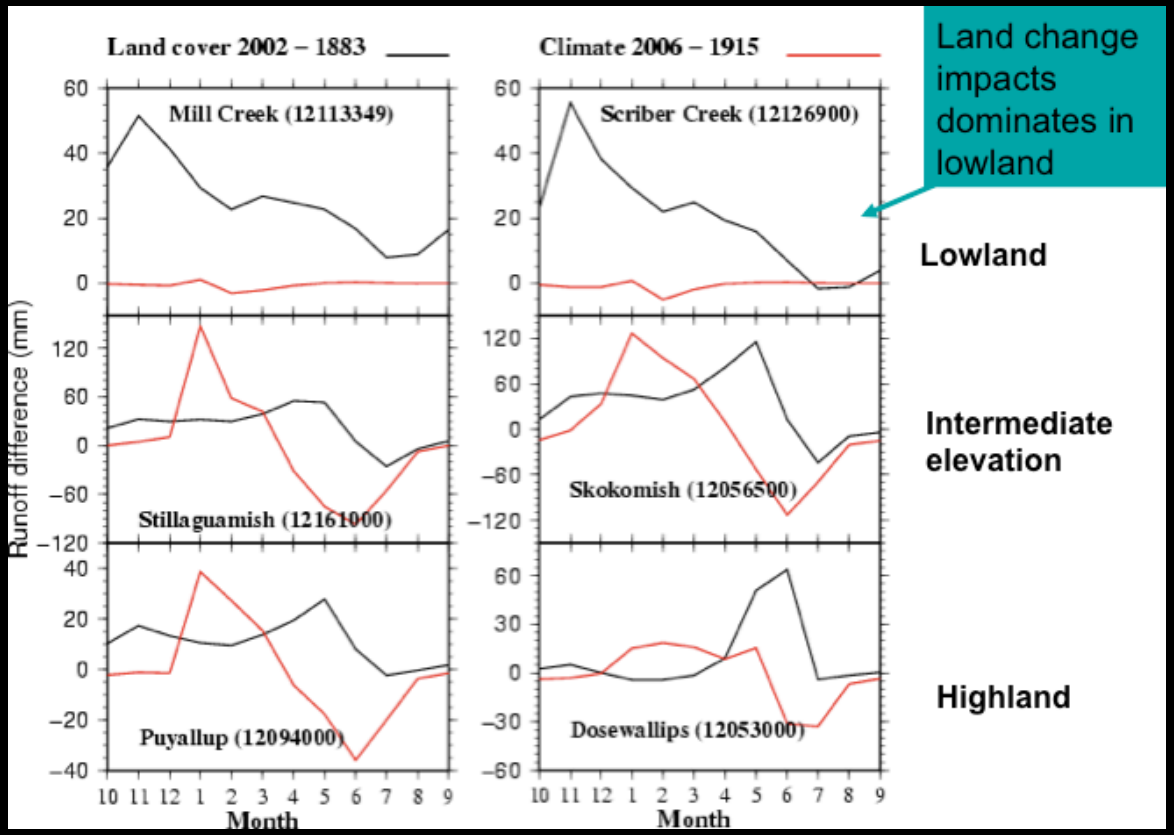
Effects of mid-twenty-first century climate and land cover change on the hydrology of the Puget Sound basin, Washington

Cuo, L., Lettenmaier, D.P., Alberti, M., Richey, J.E. 2011.



Land Cover maps for 2002, projected land cover in 2027, and constructed 2050 land cover.

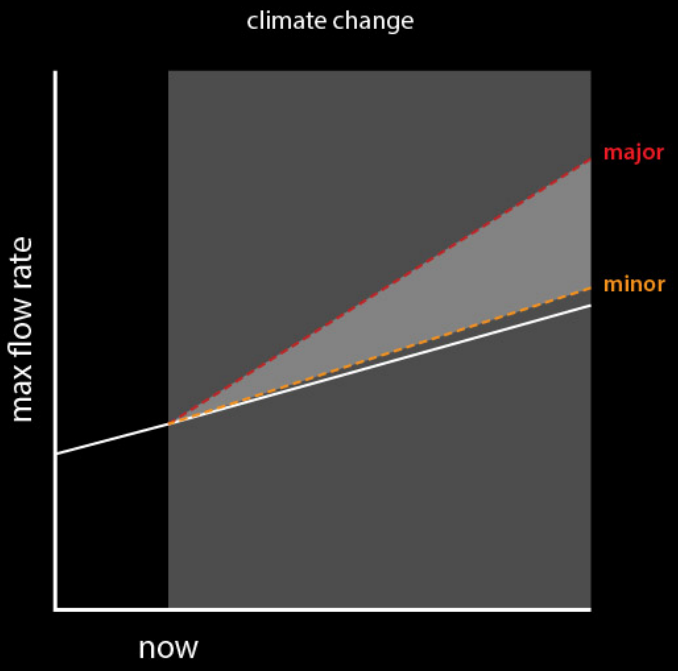
Land cover change Impacts dominate in urbanizing lowlands

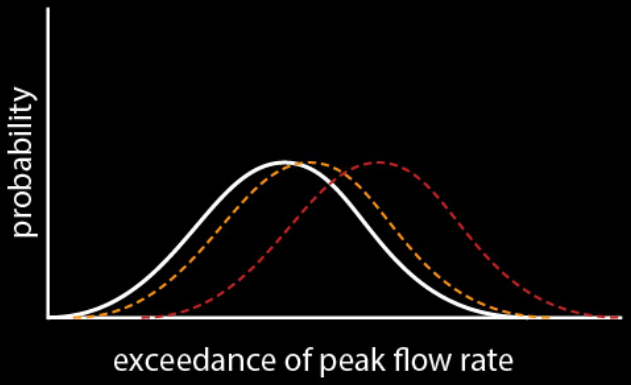


Cuo, L., Lettenmaier, D.P., Alberti, M., Richey, J.E. 2011.

Predictive Models under Uncertainty

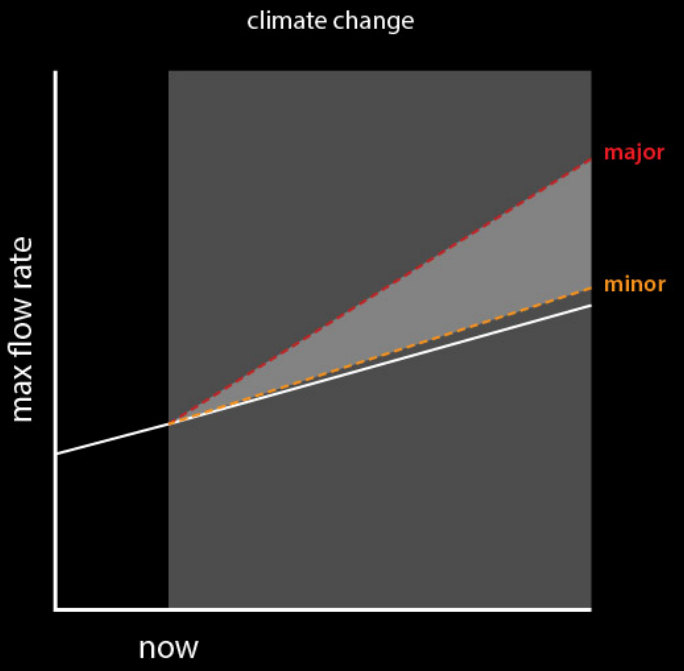
single driver

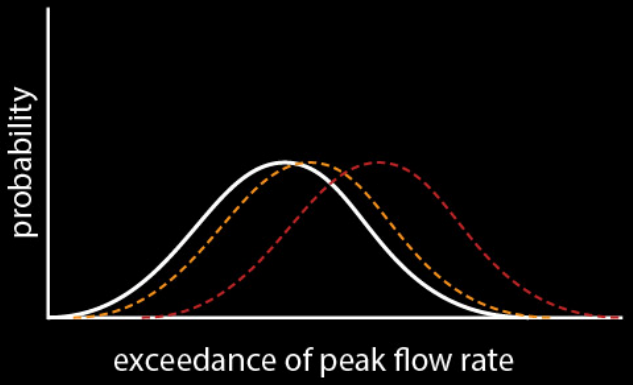




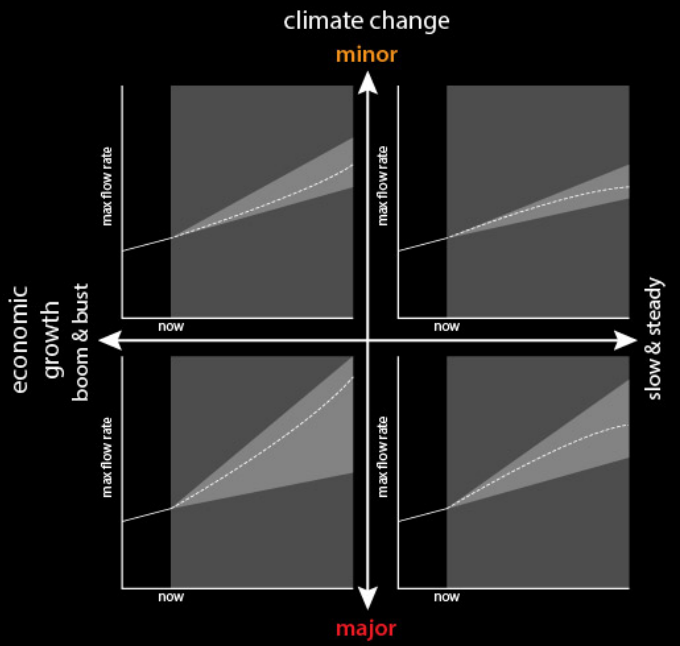
Predictive Models under Uncertainty

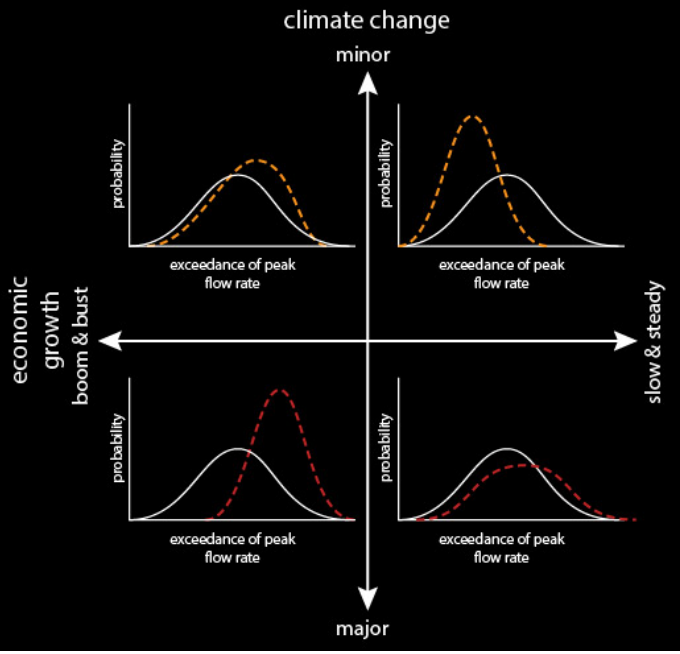
single driver

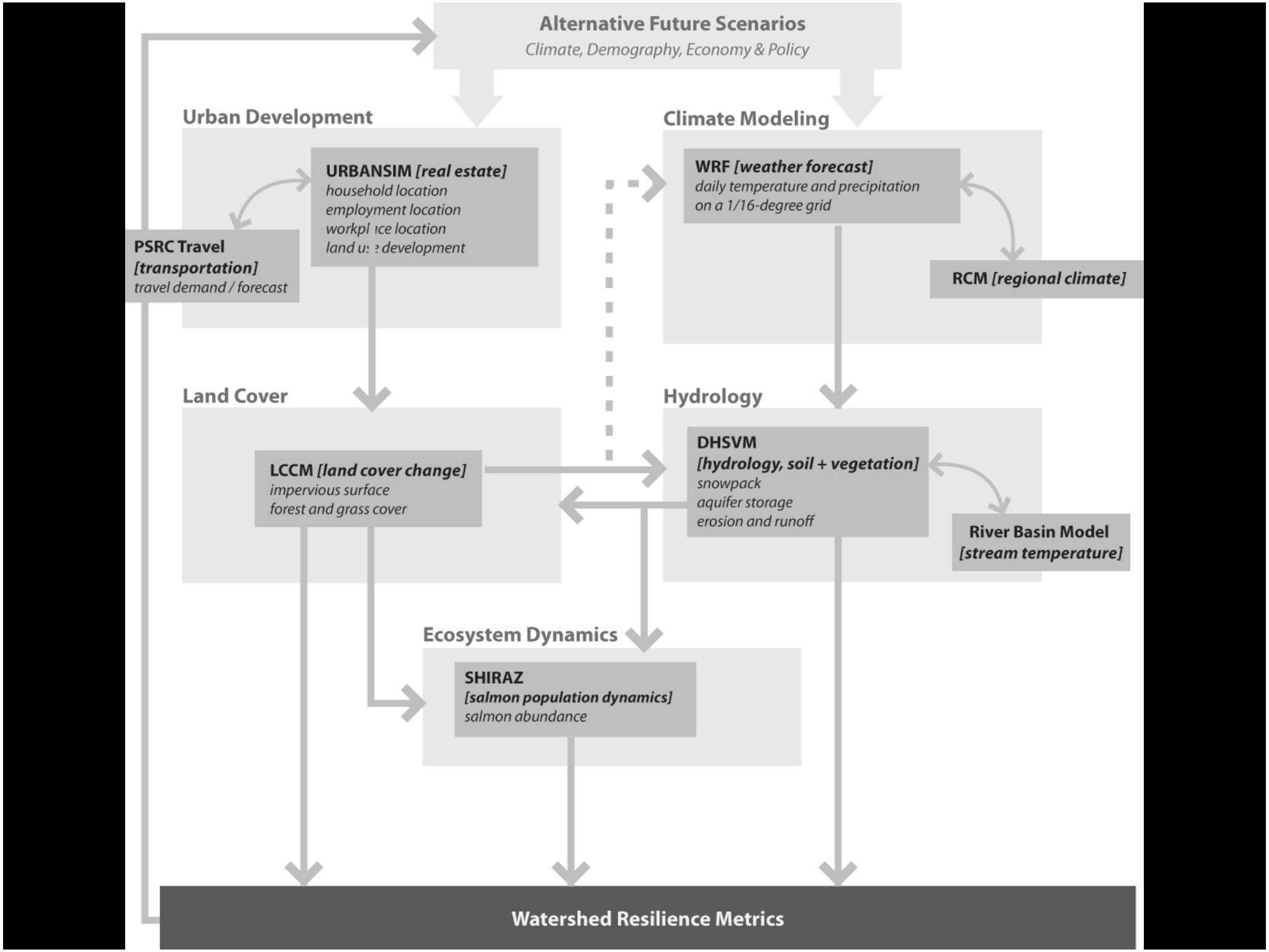




multiple drivers

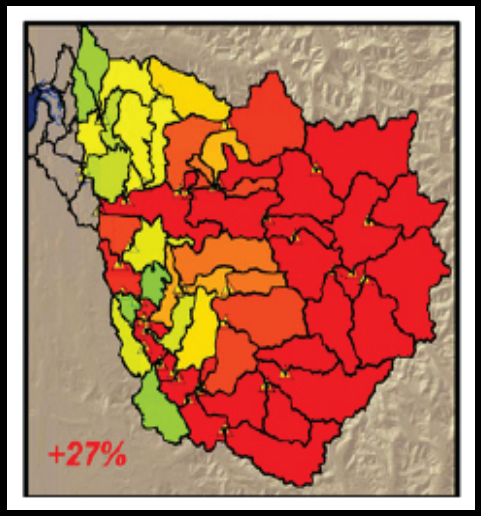




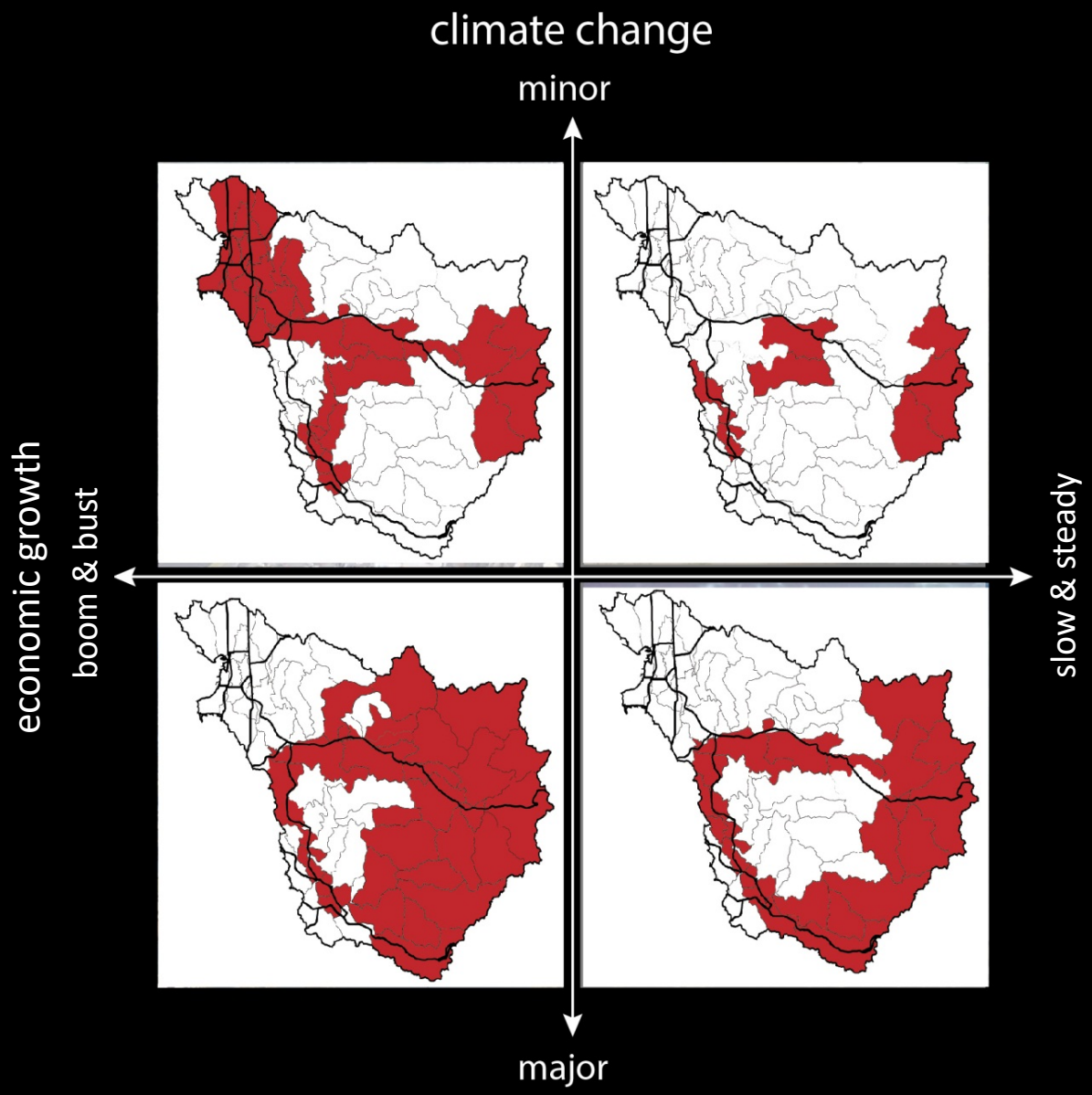

Alternative Future Scenarios
Climate, Demography, Economy & Policy
Urban Development
URBANSIM [real estate]
household location
employment location
workpl ıce location
land u: : development
PSRC Travel
[transportation]
travel demand / forecast
Climate Modeling
WRF [weather forecast]
daily temperature and precipitation
on a 1/16-degree grid
RCM [regional climate]
Land Cover
LCCM [land cover change]
impervious surface
forest and grass cover
Hydrology
DHSVM
[hydrology, soil + vegetation]
snowpack
aquifer storage
erosion and runoff
River Basin Model
[stream temperature]
Ecosystem Dynamics
SHIRAZ
[salmon population dynamics]
salmon abundance
Watershed Resilience Metrics

scenarios

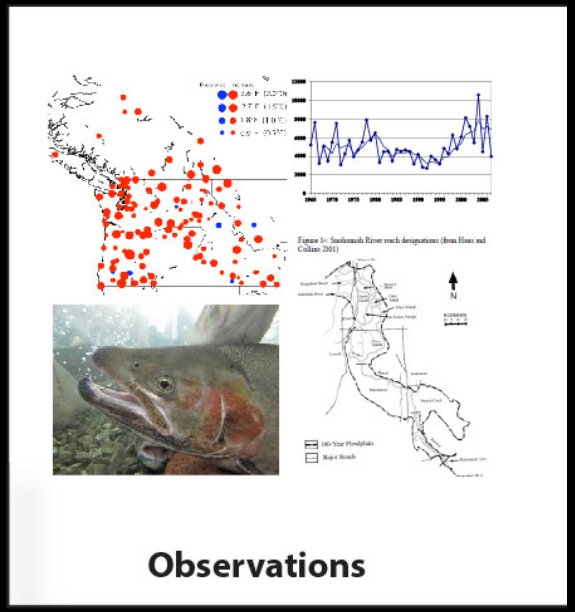
Incubation Peak Flows



J. Battin *et al.* Climate Impacts on Salmon Recovery in the Snohomish River Basin



Linking Observations, Models and Scenarios



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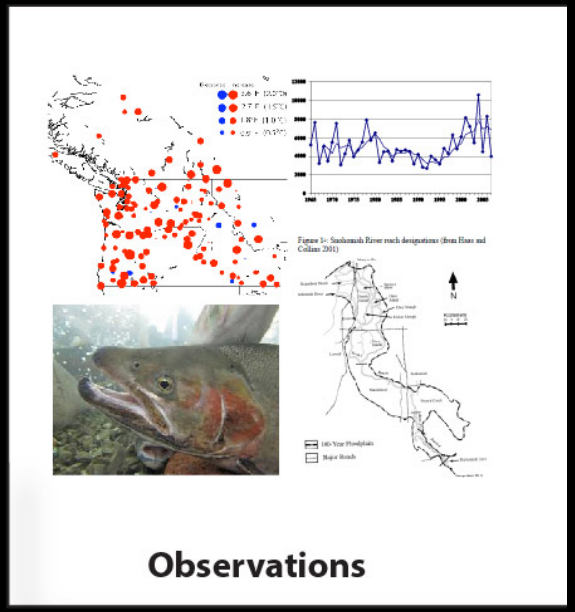

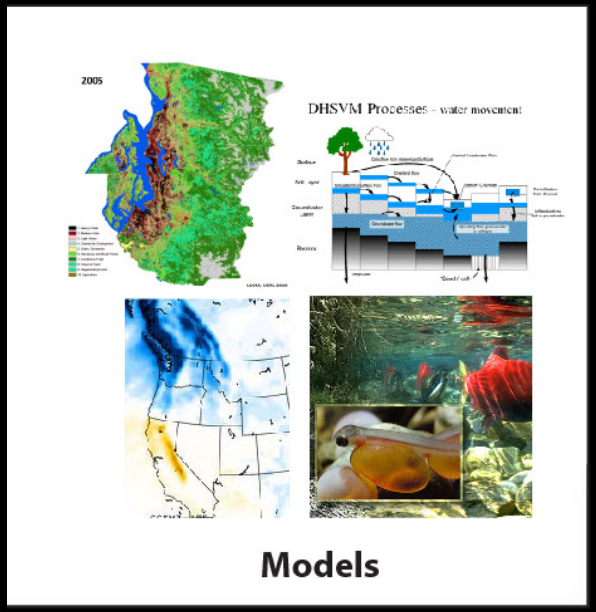

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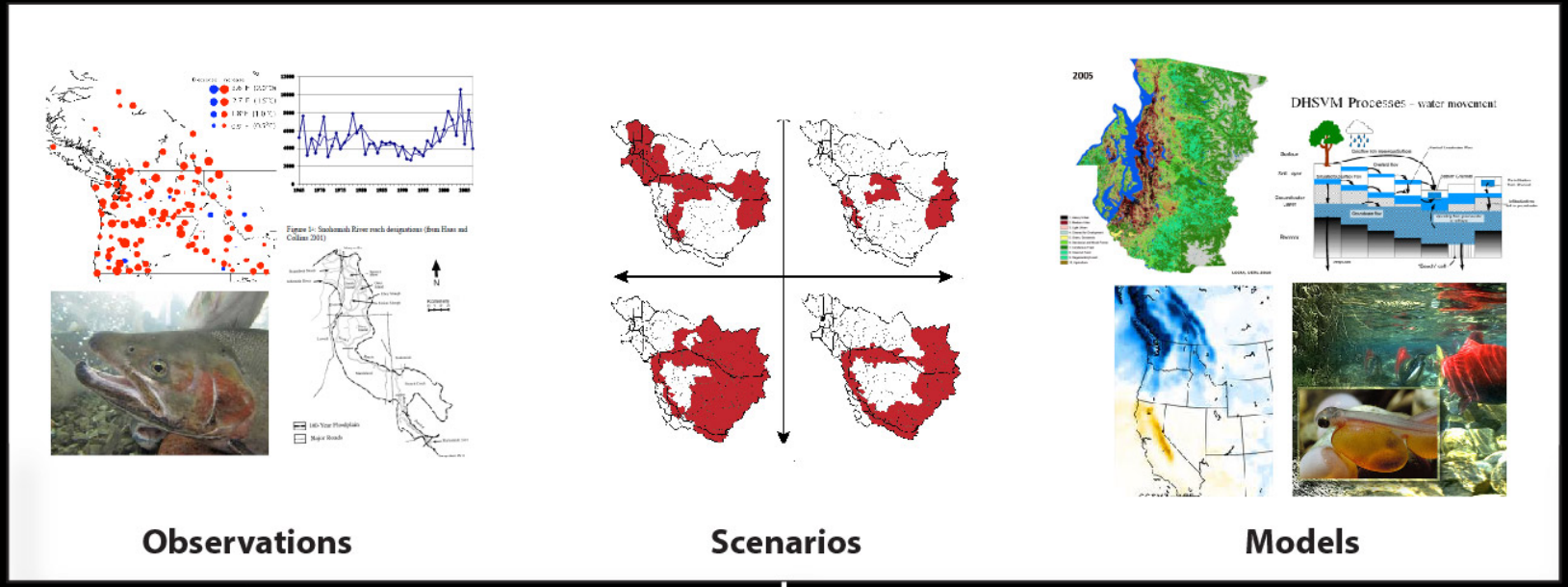
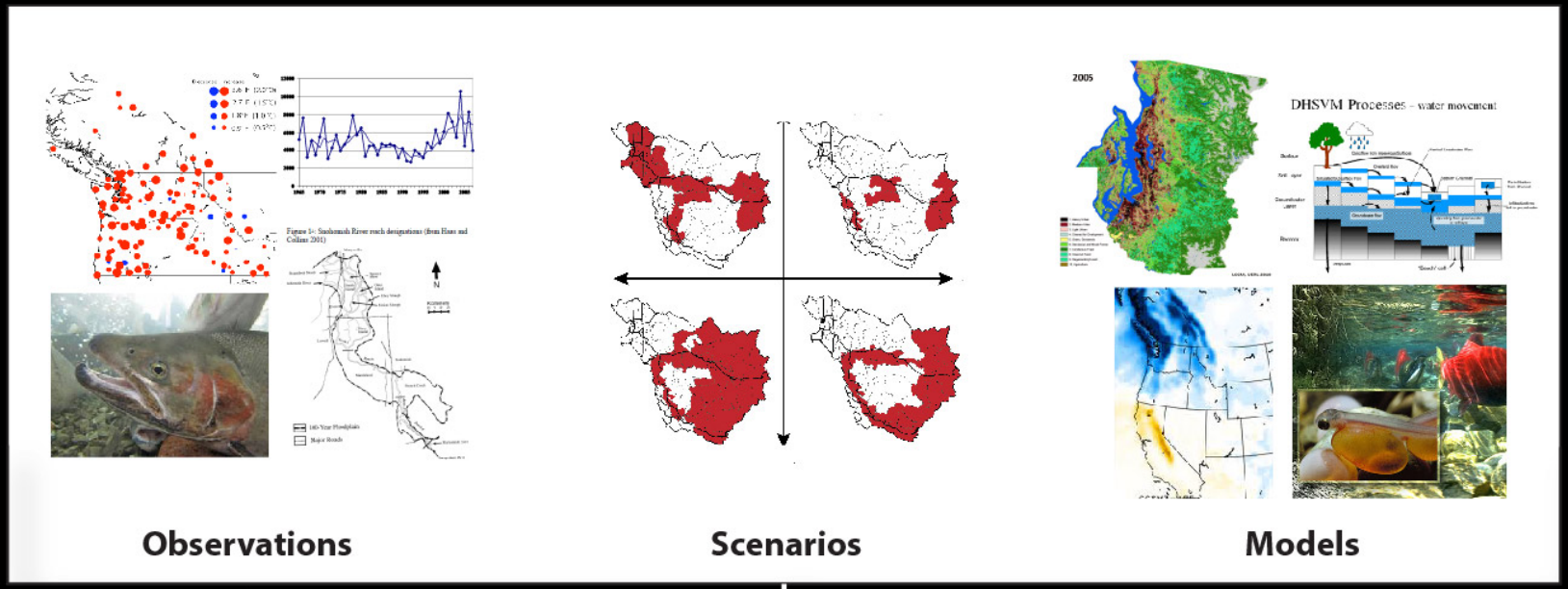
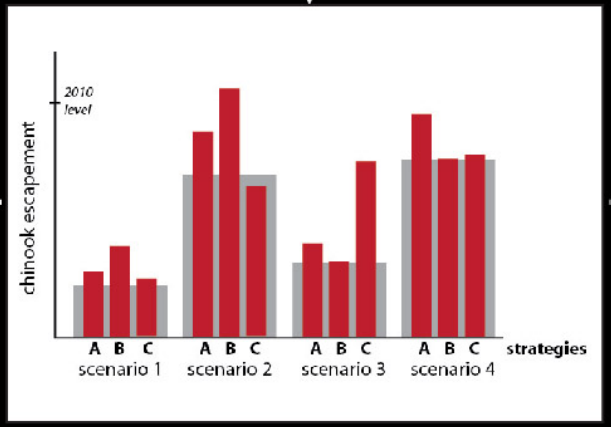


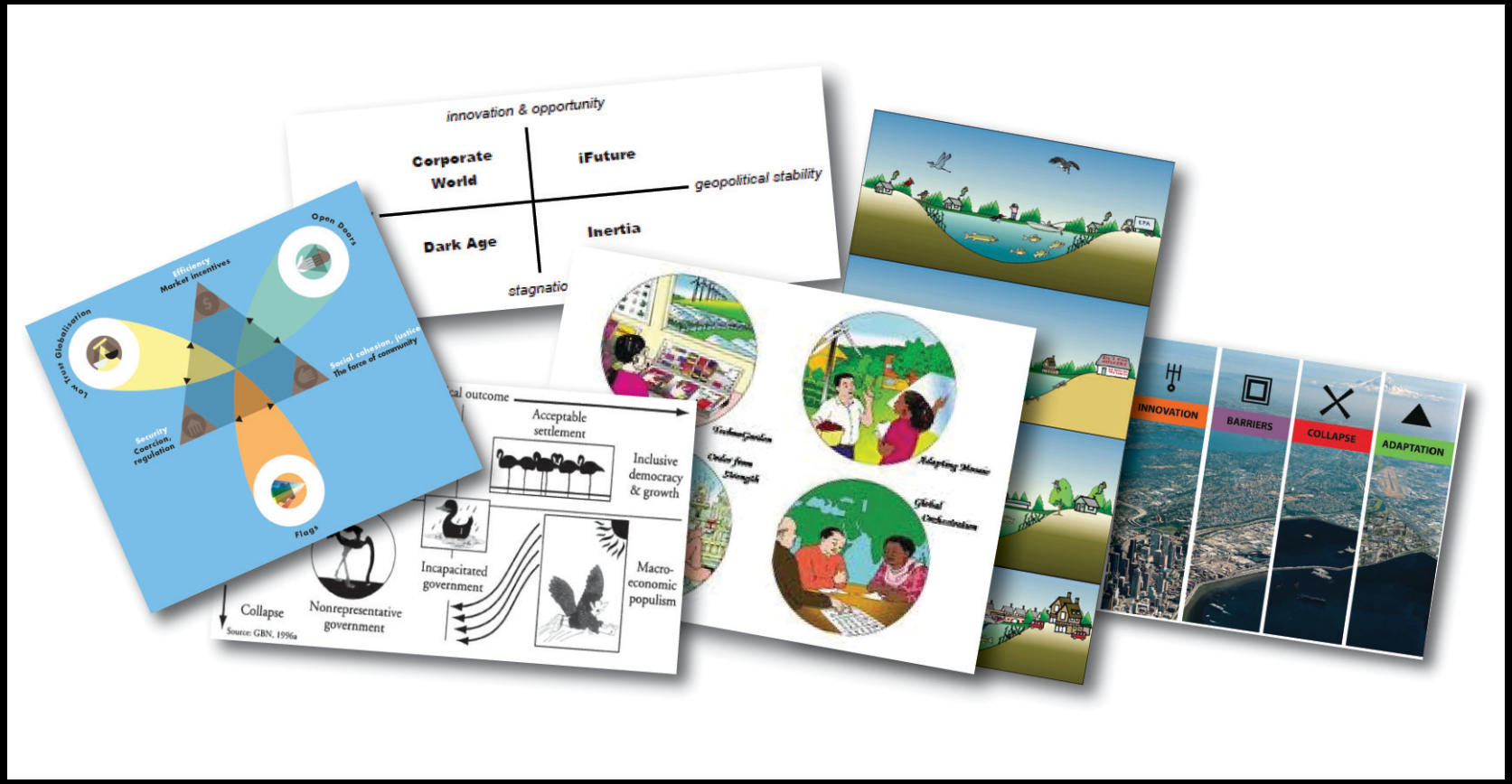
Linking Observations, Models and Scenarios





Strategic Assessment

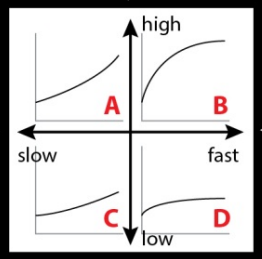
How do scenarios work?



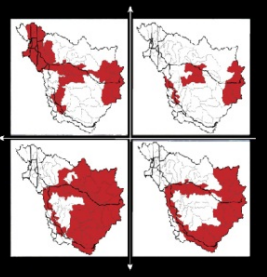
Key elements of scenario planning

1) Define focal issue

2) Identfiy and rank key uncertain driving forces



3) Develop scenario logics and Narratives

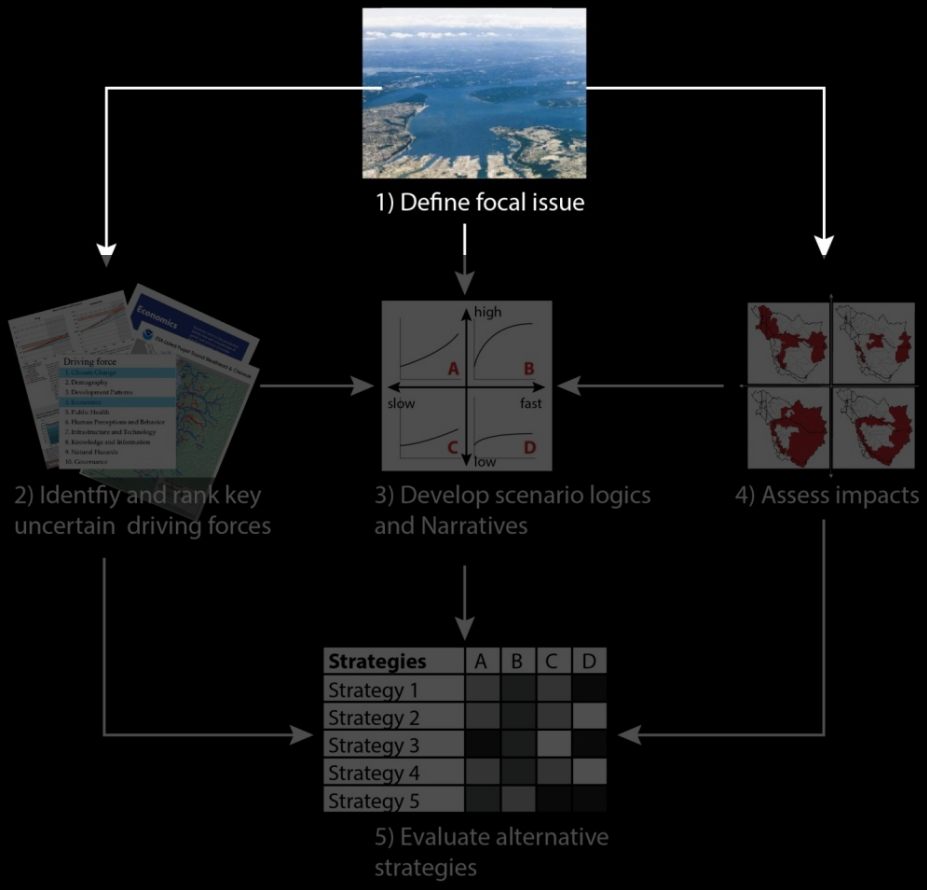


4) Assess impacts

Strategies	A	B	C	D
Strategy 1				
Strategy 2				
Strategy 3				
Strategy 4				
Strategy 5				

5) Evaluate alternative strategies

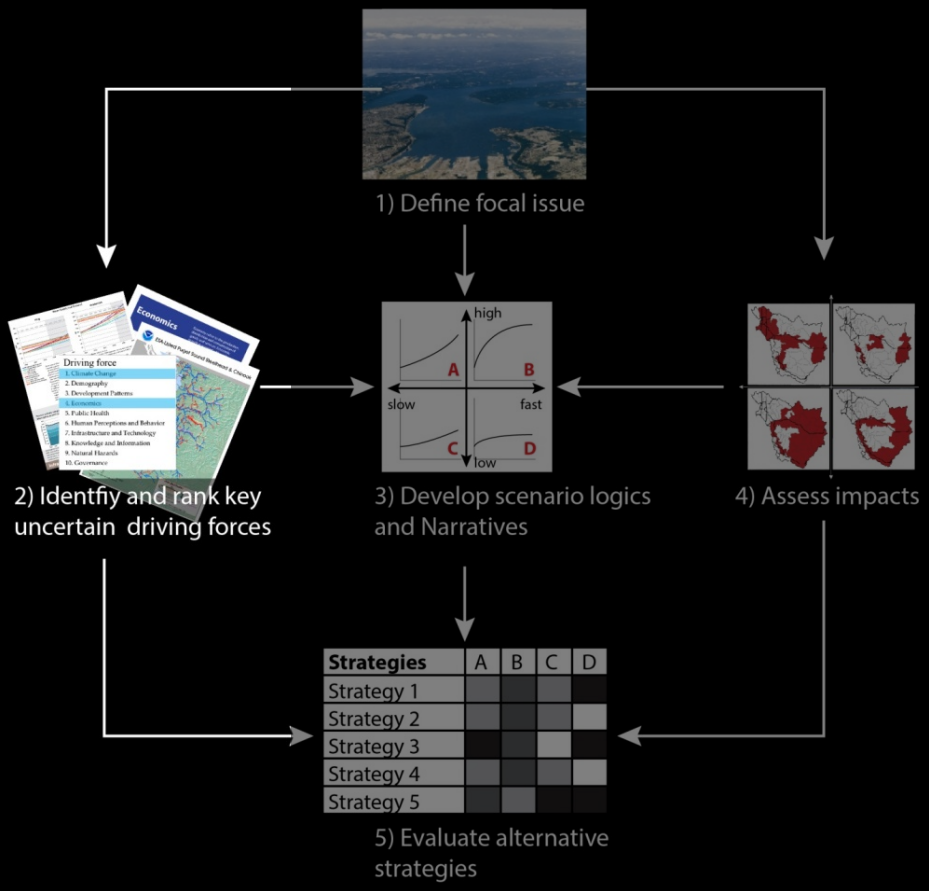
Key elements of scenario planning



1. Define focal issue

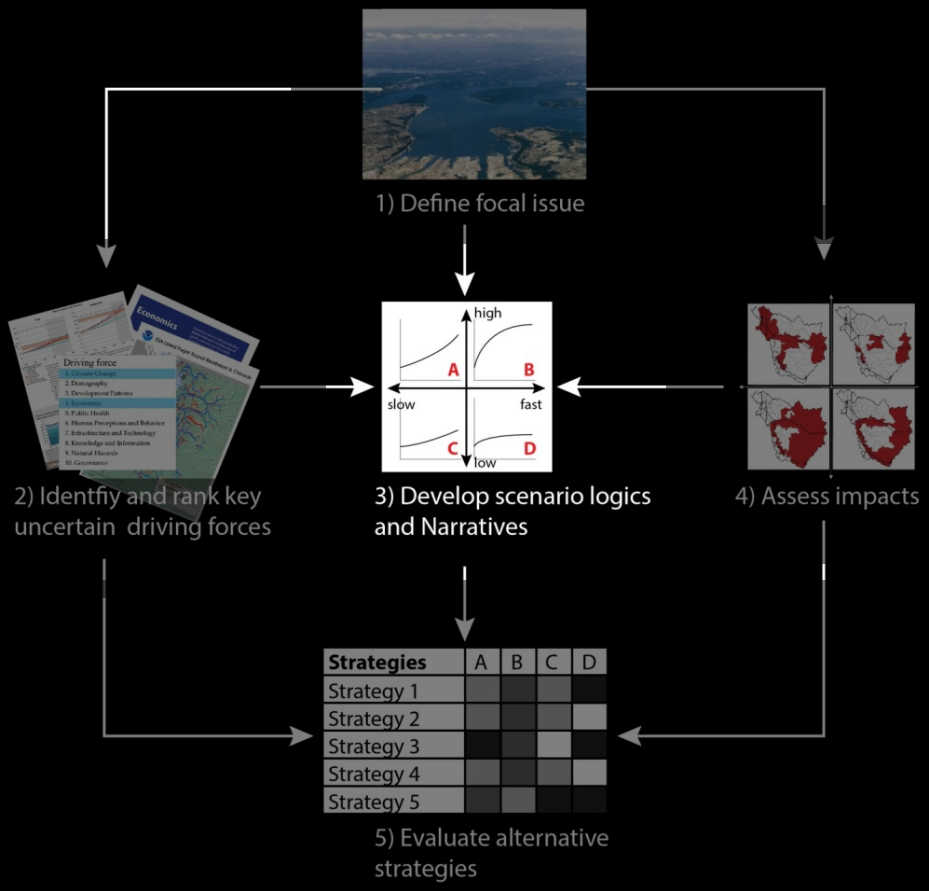
- Data and observations
- Historical documents
- Expert knowledge
- Conceptual models

Key elements of scenario planning



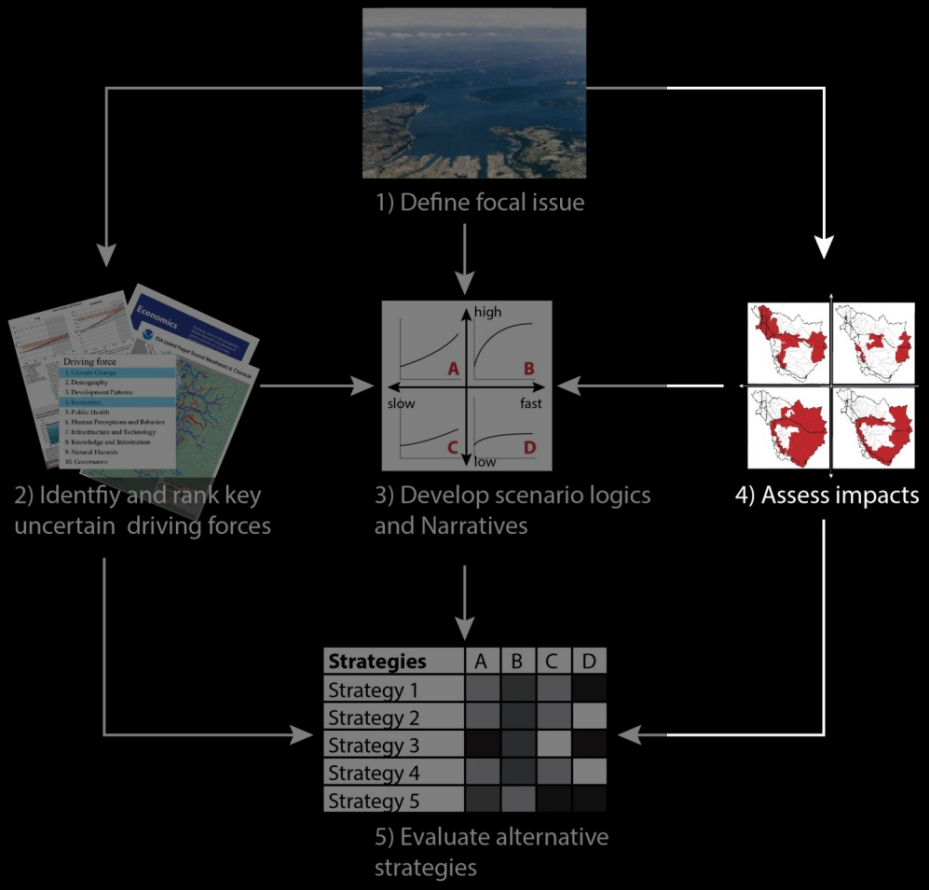
2. **Identify and rank driving forces**
   - Identify key driving force
   - Rank their importance
   - Rank their uncertainty
   - Select most important & uncertain

Key elements of scenario planning



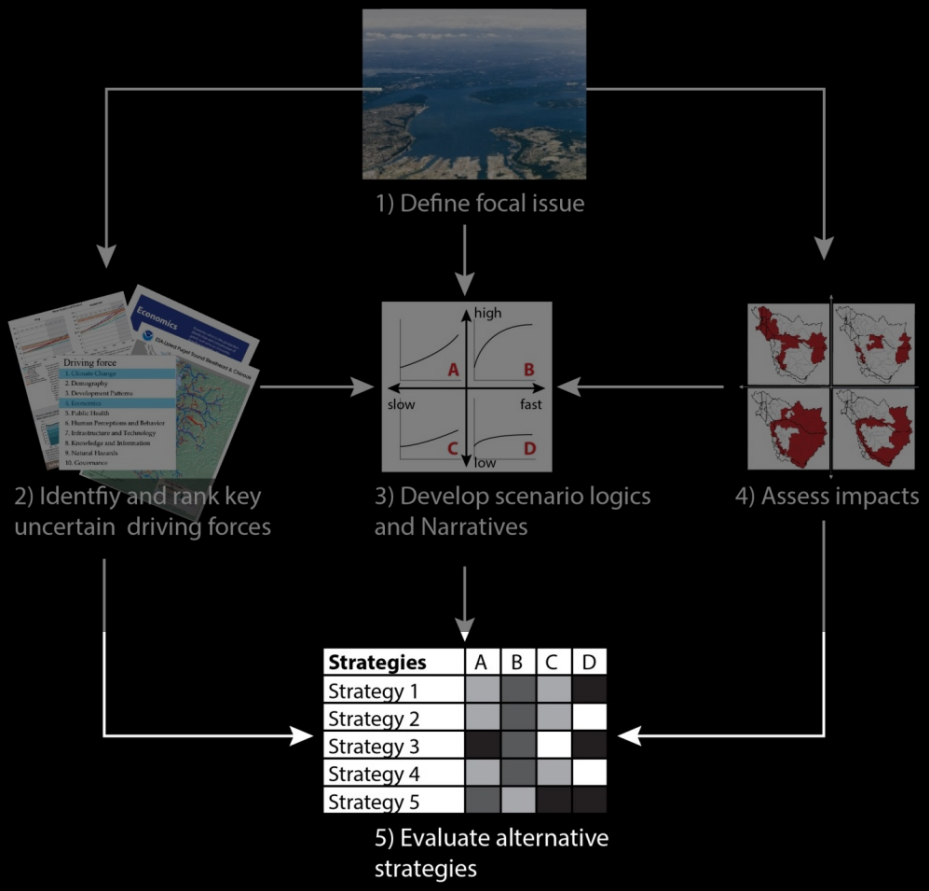
3. **Develop scenario logics and narratives**
   - Selected driving forces create the frames for scenario logics
   - Participants develop the story lines and narratives

Key elements of scenario planning



4. **Assess Impacts**
   - Identify indicators
   - Apply predictive models
   - Assess impact of future conditions

Key elements of scenario planning

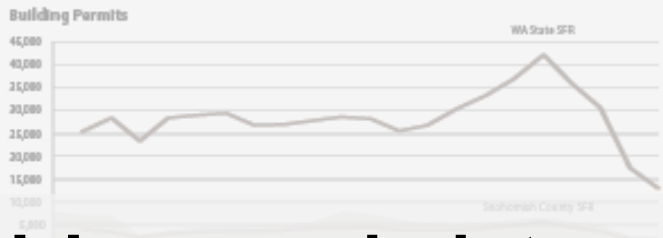


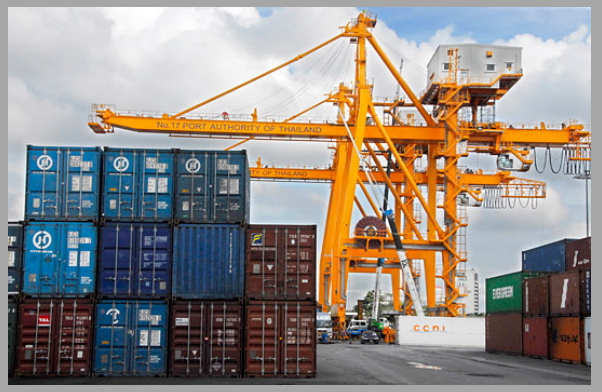
5. Evaluate alternative strategies

- Use indicators to evaluate alternative strategies (their efficacy and robustness) under alternative scenarios.

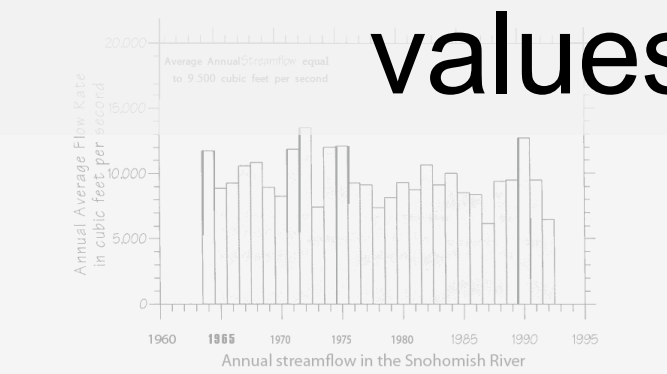
Snohomish Basin Scenarios

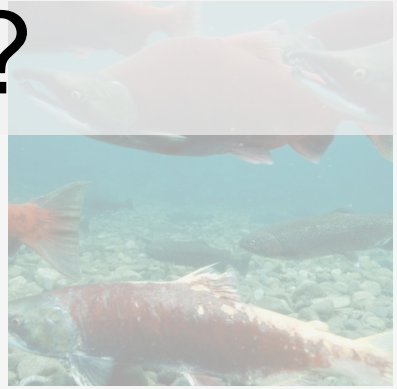
support critical decisions that aim to maintain ecosystem service provision in the Snohomish Basin out to 2060 despite irreducible future uncertainty





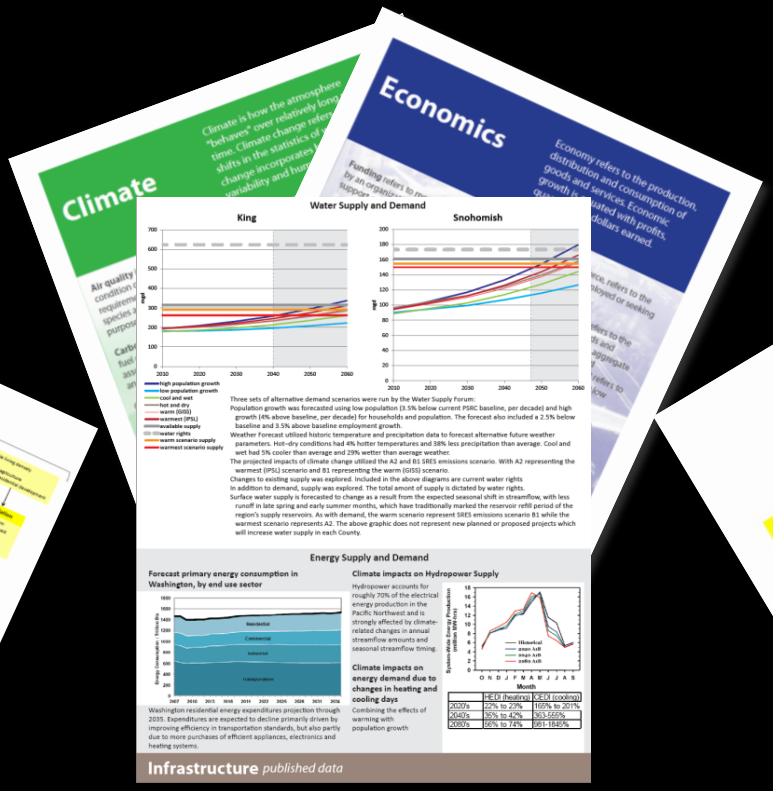
How might we change our strategies if critical uncertainties shift trends and values?

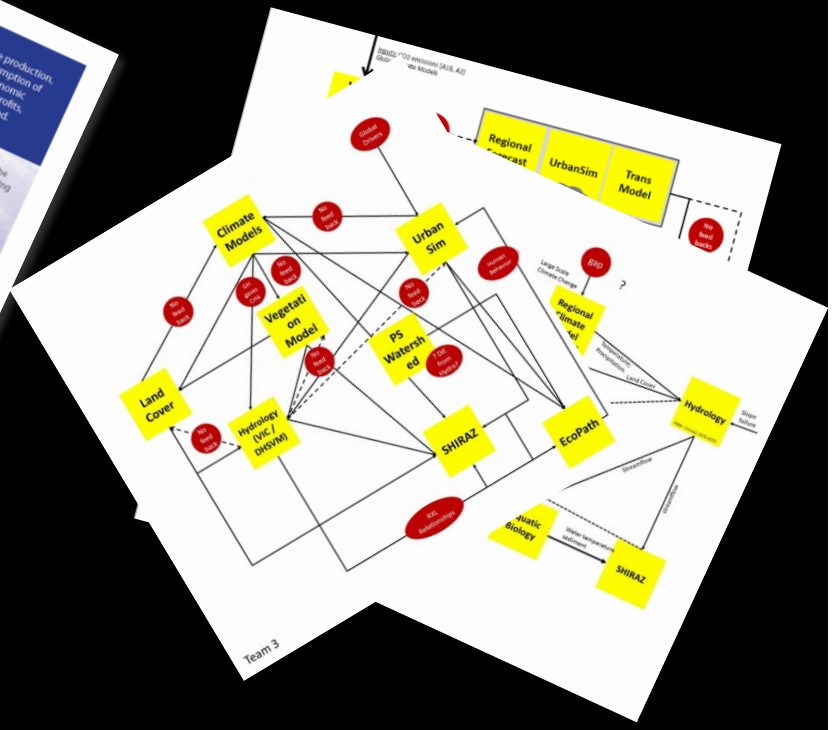




trends **value** **strategies**

Scenario Development

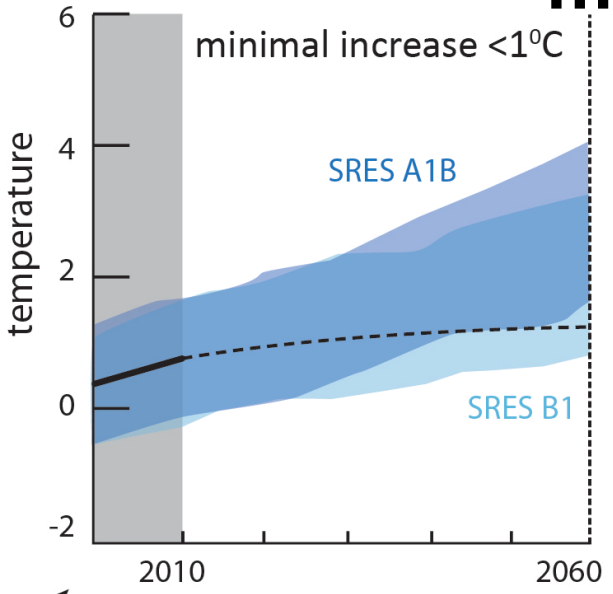


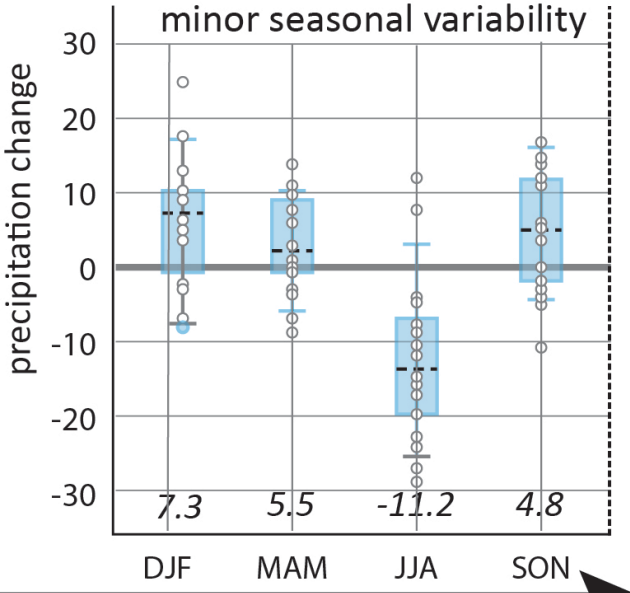


conceptual models **driving forces** **predictive models**

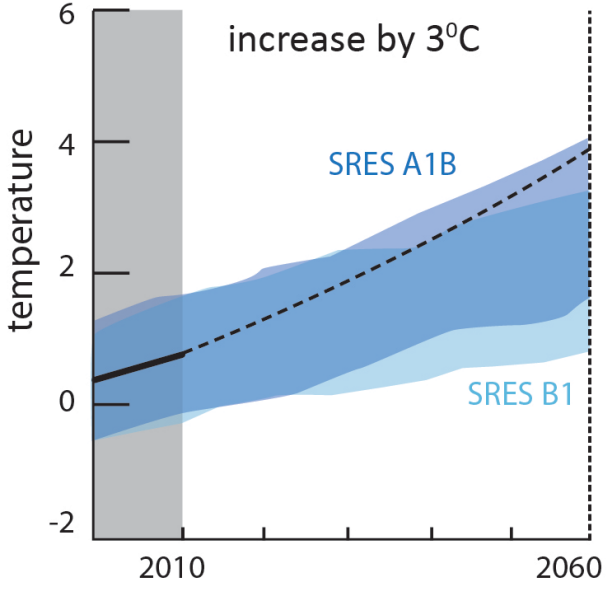
CLIMATE CHANGE

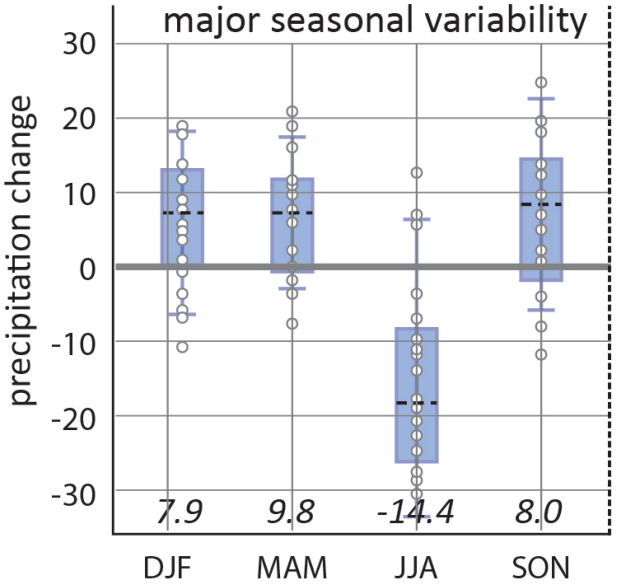
minor





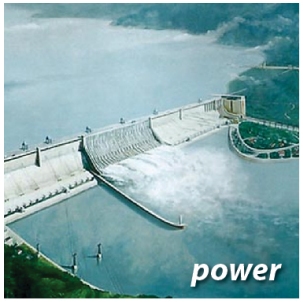
alu

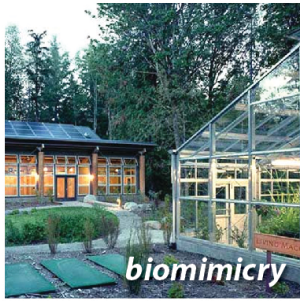


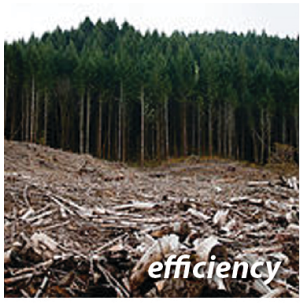


major

SOCIAL VALUES







mastery

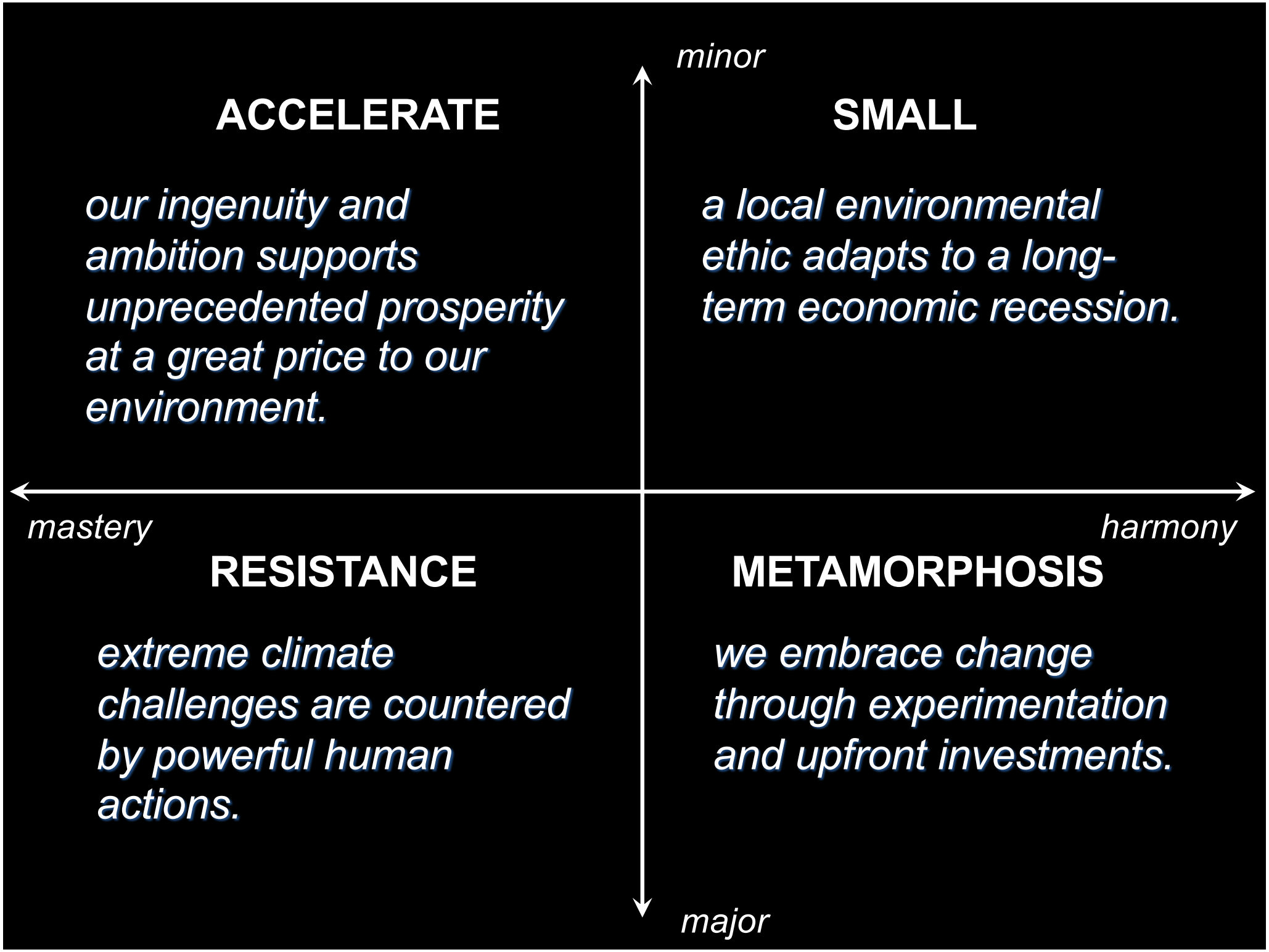
master and change the world, to assert control, bend it to our will, and exploit it in order to further personal or group interests

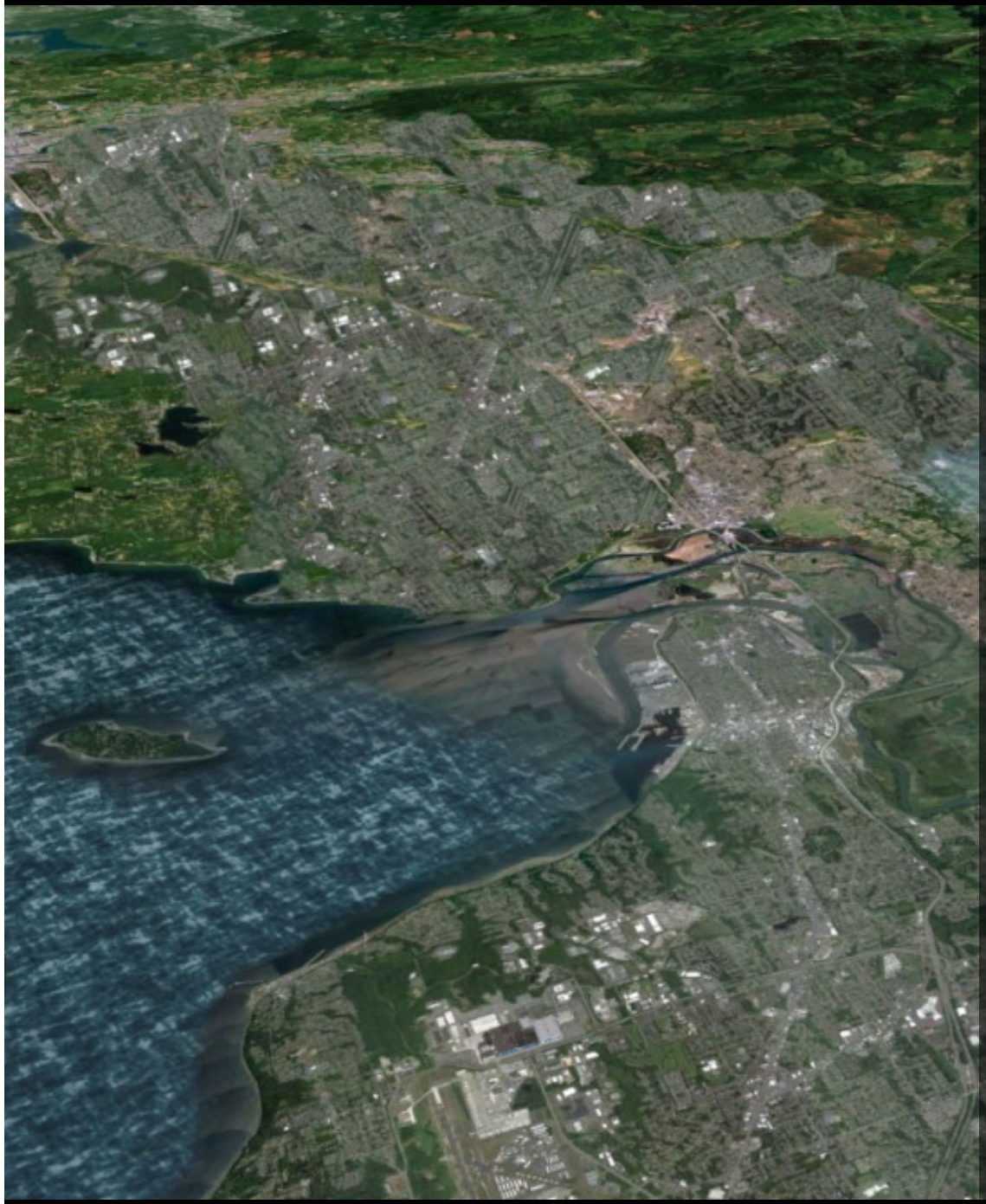
ambition, success, control, competence

harmony

accept the world as it is, trying to fit in rather than to change or exploit it

peace, interdependence, equity, environmental protection


minor
ACCELERATE
our ingenuity and ambition supports unprecedented prosperity at a great price to our environment.
SMALL
a local environmental ethic adapts to a long-term economic recession.
mastery
harmony
RESISTANCE
extreme climate challenges are countered by powerful human actions.
METAMORPHOSIS
we embrace change through experimentation and upfront investments.
major



ACCELERATE

- Accelerated economic growth & wealth accretion
- Accelerated technological innovation & implementation
- Accelerated development with limited regulation
- Minor climate impacts
- Accelerated resource depletion and control

SMALL

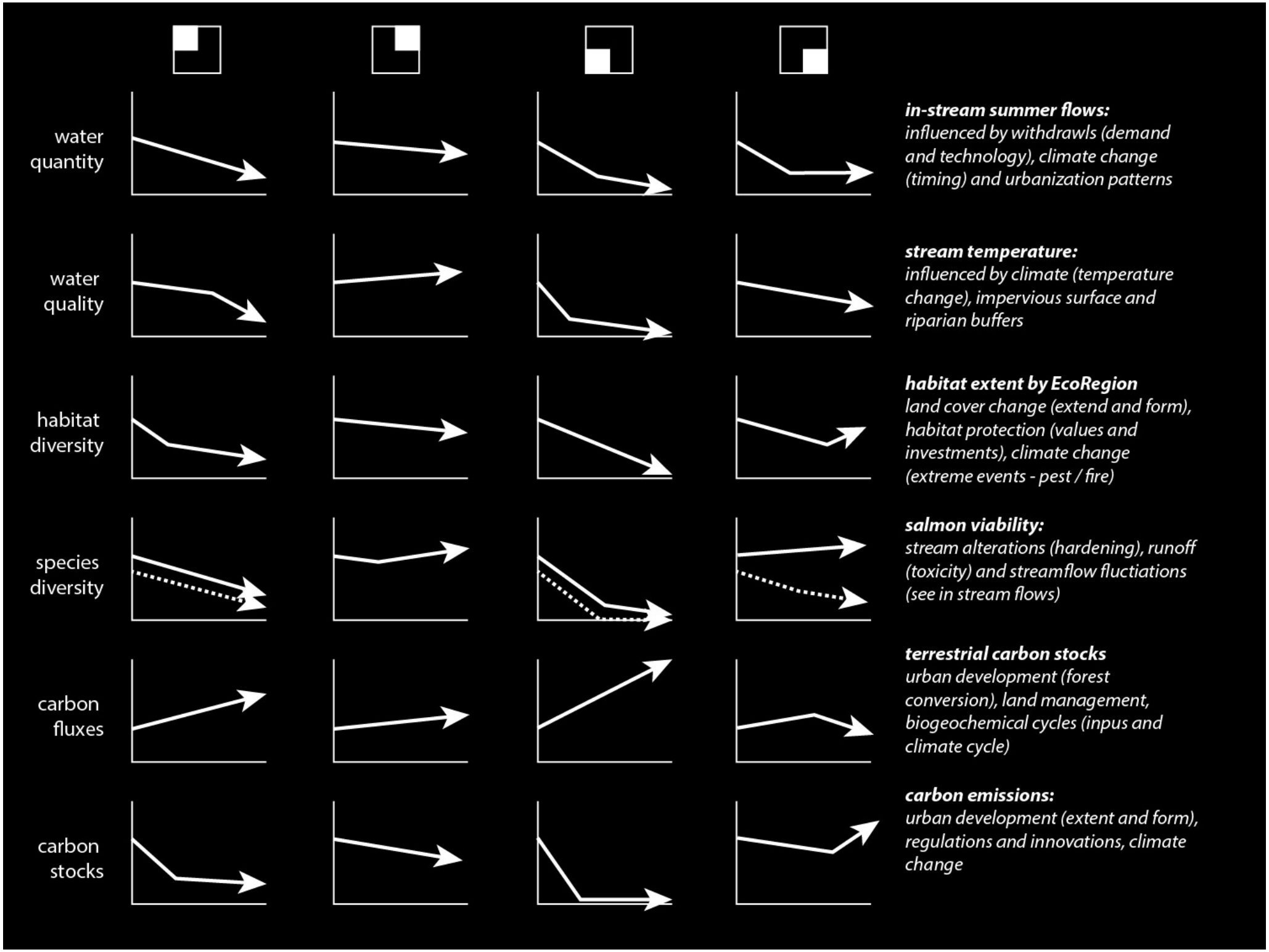
- Long term economic recession
- Minor climate change
- Shift in power to many small entities
- Environmental / land focus
- Few investment opportunities

RESISTANCE

- Strong and rapid climate impacts
- Risk averting engineering responses
- Heavy government control
- Distributional inequities
- System failures

METAMORPHOSIS

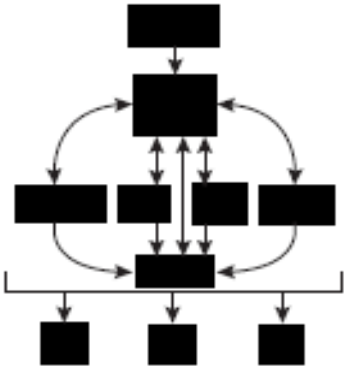
- Significant climate impacts
- Prioritization of equitable, flexible and natural capital investments
- High initial investments and initial error rate
- Networked & coordinated governance structure
- Diverse and stable growth


water quantity
water quality
habitat diversity
species diversity
carbon fluxes
carbon stocks
in-stream summer flows:
influenced by withdrawls (demand and technology), climate change (timing) and urbanization patterns
stream temperature:
influenced by climate (temperature change), impervious surface and riparian buffers
habitat extent by EcoRegion
land cover change (extend and form), habitat protection (values and investments), climate change (extreme events - pest / fire)
salmon viability:
stream alterations (hardening), runoff (toxicity) and streamflow fluctiations (see in stream flows)
terrestrial carbon stocks
urban development (forest conversion), land management, biogeochemical cycles (inpus and climate cycle)
carbon emissions:
urban development (extent and form), regulations and innovations, climate change

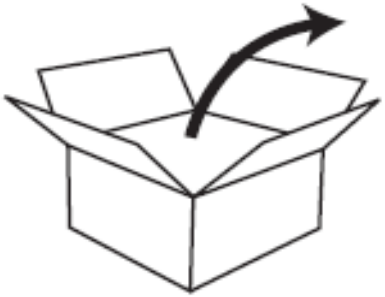
Lessons Learned

Shift Focus to Resilience

Redefine Decision Context

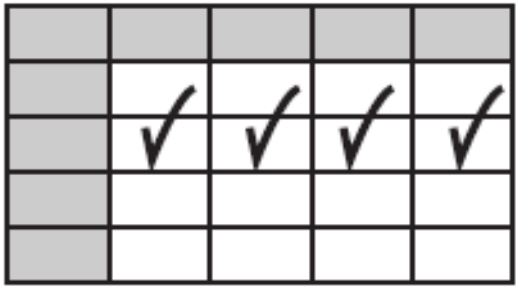


Integrate Predictive Models



Highlight Risks and Opportunities

Illuminate Warning Signals

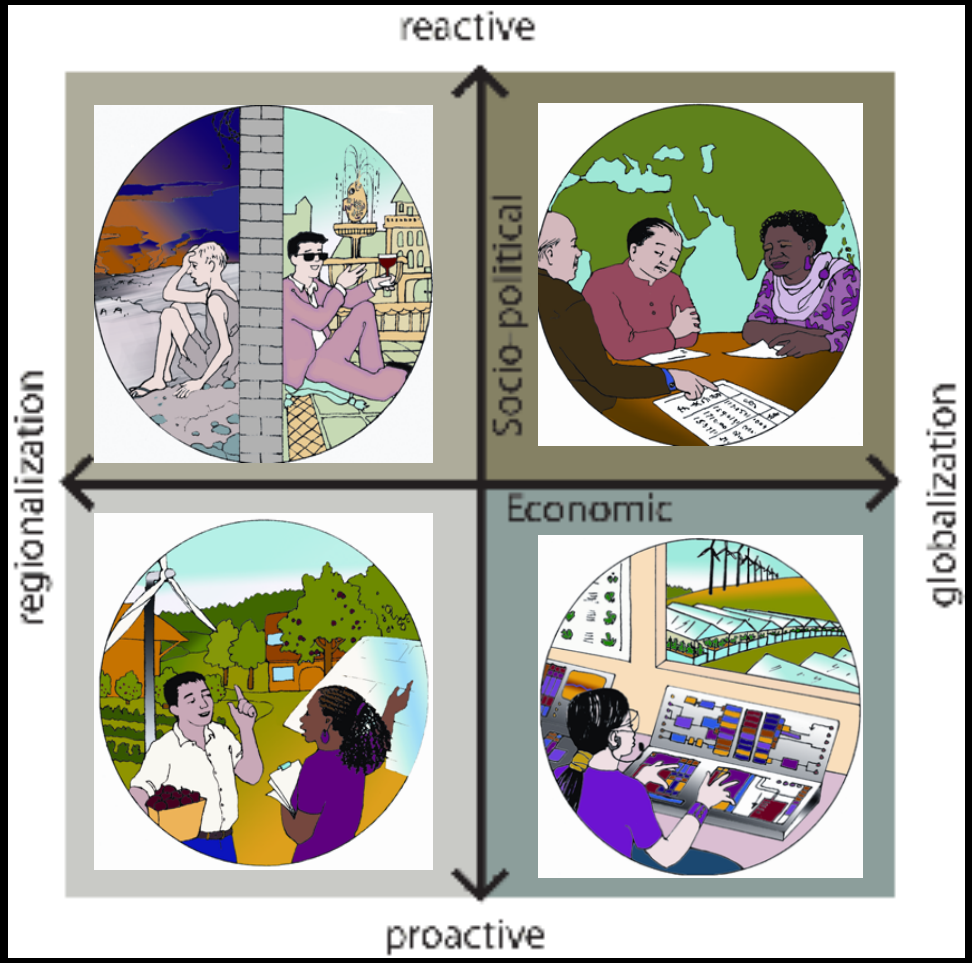


Identify Robust Strategies

Yahara 2070

MEA Scenarios

- Four scenarios based on Socio-political and Economic Drivers.
  - [TL] Order from Strength
  - [TR] Global Orchestration
  - [BL] Adapting Mosaic
  - [BR] Techno Garden



Take Home Messages

- Complexity and uncertainty make long term predictions of social and ecological impacts highly unpredictable
- Observations from the past are not sufficient to make reliable predictions about the future
- Unpredictable transitions associated with environmental change are expected to become more common in shaping the future
- Scenario planning provides a systematic framework to explore plausible futures and assess potential risks
- **SUMMARY:** By using scenarios, we will be able to develop more robust adaptation strategies for reducing vulnerability and increasing resilience in the face of irreducible uncertainties.