Cumulative Effects Assessment & Management Workshop: Sharing Knowledge and Building Capacity in the North Coast

10-11 December 2015

SPEAKER BIOS

Jamie Afflerbach

Jamie is a research assistant working on the Arctic Options project and the Ocean Health Index. She earned her B.Sc. from the University of Miami and a Masters degree from the Bren School of Environmental Science and Management at University of California, Santa Barbara (UCSB). Previously Jamie has worked on projects in coral reef ecology, small scale fisheries and marine mammal conservation. At the National Centre for Ecological Analysis and Synthesis (NCEAS), Jamie uses open-source analytical tools to explore and synthesize spatial data to better understand human impacts to the global oceans.

Dave Daust

Dave and his partner Karen are consultants, based in Telkwa but often found at their Francois Lake cabin. Dave has been playing around with landscape models for the last quarter century, exploring the ecological and social consequences of resource use policies. More formally (and pompously), playing around includes timber supply analysis, risk assessment, impact assessment, cumulative effects assessment and climate change vulnerability assessment. He occasionally dabbles in "reality" in the woodlot. Dave holds an MSc degree and is a Registered Professional Forester (RPF) in British Columbia.

Darrell Desjardin

Darrell Desjardin is a senior environmental scientist and project manager with Hemmera Envirochem Inc. with over 28 years of experience in the environmental, ports and marine and the oil and gas sector. Darrell has led multi-disciplinary teams of engineers, scientists and engagement professionals conducting major environmental assessments, marine impact assessments, air quality inventories and emission reduction strategies, contaminated sites assessment, management and remediation projects, and Corporate Social Responsibility initiatives. His skill set has delivered projects that have required complex federal, provincial and municipal government approvals and First Nations and community support. Darrell has a successful track record of providing environmental, regulatory and stakeholder support for a range of infrastructure and resource development projects in BC, Alberta and Washington State and is experienced at directing complex and controversial environmental assessments processes, advising government and private sector executives on strategic environmental issues.

Kevin Hanna

Kevin Hanna grew up on his family's ranch in the southern interior of British Columbia. He is an alumni of the University of British Columbia (UBC), and the University of Toronto — where he obtained his PhD. Dr. Hanna has served as a policy advisor and analyst at Environment Canada for the Ontario Region. A past faculty member at the University of Toronto and Wilfrid Laurier University, he now works at UBC where he teaches environment and natural resources policy and environmental impact assessment. Kevin Hanna's research centres broadly on integrated approaches to natural resource management, the effectiveness of environmental impact assessment, and the implementation of cumulative effects assessment. Dr. Hanna leads the new UBC Centre for Environmental Assessment Research and he also heads the National Municipal Adaptation Project, which is examining Canadian local government planning and policies needs for addressing climate change adaptation.

In addition to many peer reviewed papers, he has published four books: the most recent is the fourth edition of *Environmental Impact Assessment: Practice and Participation*; he is co-author of *Community Forestry, Local values, Conflict and Forest Governance*; and co-editor of *Fostering Integration: Concepts and Practice in Resource and Environmental Management* and *Parks and Protected Areas: Design and Policy*. Dr. Hanna's current projects are: Effectiveness and Canadian Environmental Impact Assessment (*Is environmental impact assessment (EIA) an effective instrument for environmental management in Canada?*) and the National Municipal Adaptation Project.

Steve Kachanoski

Steve is an Integrated Resource Specialist and Planner for the Ministry of Forests, Lands, and Natural Resource Operations in Victoria. He has been involved in numerous land planning and management initiatives during his 15 years with the provincial government. Recently, Steve was the provincial lead on the development of the MaPP North Coast Marine Plan and currently, he is the provincial project manager for the development of "core values" to support the implementation of BC's Cumulative Effects Framework. Steve lives in Victoria and enjoys spending time on and off the water with his wife and 3 children.

Katerina Kwon

Katerina Kwon is a Master's student in the School of Resource and Environmental Management (REM) at Simon Fraser University. Her research group in REM has an ongoing partnership with the Metlakatla First Nation to develop and implement a cumulative effects management (CEM) framework in their traditional territory. For her Master's research, she proposes an improved methodology for identifying and selecting biophysical valued components for the assessment and management of cumulative effects in a First Nation context. She collaborated with the Metlakatla Stewardship Society to apply this methodology in the CEM initiative. Katerina continues to work with the Metlakatla Stewardship Society to advance the CEM initiative through the collection of baseline information and development of management triggers and actions.

Will McClintock

Will McClintock is a Project Scientist at the University of California Santa Barbara, Marine Science Institute. The McClintock Lab develops software for marine planning, monitoring and assessment. Their flagship application, SeaSketch (www.seasketch.org) is used for the collaborative geodesign of marine spatial plans in New Zealand, the US, Canada, the South Pacific, Montserrat, Barbuda, Curaçao, the Galapagos Islands and other geographies. Will received his B.S. in Biology from Earlham College, M.S. in Animal Behavior from the University of Cincinnati, M.A. in Counseling Psychology from Pacifica Graduate Institute, and Ph.D. in Ecology, Evolution and Marine Biology from the University of California Santa Barbara.

Don Morgan

Don Morgan is a Natural Resource Management and Systems Researcher with the Ministry of Environment. Don's main area of research is describing and analyzing socio-ecological systems with an emphasis on wildlife habitat supply. He has also applied innovative methods to explore uncertainty, particularly the impact of climate change on ecological processes and its interaction with resource management decisions. Don has also served as Project Coordinator of the Northwest Cumulative Effects & Assessment Management Framework Demonstration Project (MFLNRO), the goal of which was to develop and test methods to improve information sharing with policy-makers and Ministry staff so cumulative effects from land-use activities can be proactively mitigated or avoided. Don is a Registered Professional Biologist in British Columbia. He also has a BSc in Wildlife Biology and Computational Mathematics from Trent University, a BSc (Hon.) from Carleton University in Quantitative Ecology and Computer Science, and an MSc in Natural Resources and Environmental Studies - Biology at the University of Northern British Columbia.

Peter Nagati

Peter Nagati is a professional forester turned auditor. He's spent a good part of his career travelling the province to assess the British Columbia's management of its natural resources. Four years ago, Peter joined the Office of the Auditor-General of British Columbia, as a director of performance audit.

Jennifer Natland

Jennifer Natland is Manager, Planning & Development with Port Metro Vancouver, Canada's largest and busiest port. In her role, Jennifer leads multidisciplinary teams to prepare strategies and plans for the optimal development of Port lands to best accommodate growing trade demand. She also oversees a team of professional planners who administer a comprehensive review process for development applications. Jennifer continues to lead the Port 2050 initiative that uses scenario planning to set a strategic direction for the Port in anticipation of a transition to a lower-carbon economy. Prior to joining the Port, Jennifer spent five years with the City of New Westminster working in both long-range and current development planning. She holds a Master of Urban Studies degree from Simon Fraser University and remains involved with the program as a member of its advisory council. She is a member of the Canadian Institute of Planners, a Registered Professional Planner and past Vice-Chair of the Vancouver City Planning Commission.

Karen Price

Karen is a consultant, based near Telkwa, but often found at her cabin at Francois Lake. She works at the interface of science and management, enjoying the challenges of research, teaching and—of most relevance here—trying to increase the knowledge content in resource decision-making. Karen enjoys analysing and synthesising scientific data and, more generally, learning about the world around her. She believes that sustainability requires a strengthening of connections between people and ecosystems; hence, she enjoys sharing with and learning from people with diverse backgrounds, experience and knowledge.

Stella Swanson

Stella Swanson is an aquatic ecologist and risk assessment specialist. Stella's 35-year career has included management of the Aquatic Biology Group at the Saskatchewan Research Council, and consulting positions with SENTAR Consultants (now Stantec) and Golder Associates Ltd. (where she attained the position of Principal). She now owns and operates Swanson Environmental Strategies out of Calgary and Fernie. Stella's experience spans work for a wide range of industries as well as federal, provincial and territorial governments, First Nations, and NGOs. She has worked on all types of ecosystems, from small saline lakes on the prairies to subarctic watersheds and marine systems off both the east and west coasts of Canada. Stella's work in ecological risk assessment has included large, landscape-scale assessments in environments such as the Bay of Fundy, the Queen Charlotte Basin, and the Columbia River. Stella facilitated the development of the Elk Valley Cumulative Effects Management Framework (CEMF) from 2012-2015. A goal of CEMF is the production of a practical framework that supports decisions related to the management of cumulative effects in the Elk River Valley of British Columbia.

Stella is currently the Chair of the Joint Review Panel for the Deep Geologic Disposal of Low and Intermediate Nuclear Waste. She is also a member of the Royal Society of Canada's Expert Panel on the Behaviour and Environmental Impacts of Crude Oil Released into Aqueous Environments. Stella's focus is on strategic environmental planning, public consultation and engagement, and expert review. She is committed to the vision of collaborative decision-making.

Spencer Wood

Spencer Wood is a Research Associate at the Stanford Woods Institute for the Environment and a Senior Scientist at the Natural Capital Project. Spencer works directly with partner organizations in Canada and Belize who are revising and evaluating their coastal management plans, using tools produced by the Natural Capital Project. His scientific research focuses on empirical and mathematical approaches to understanding interactions between humans and the environment in complex socio-ecological networks. This includes studies on patterns of tourism in Belize, ancient human settlement in the Aleutian Islands, and distributions of species interactions in New Zealand and British Columbia. Previously, Wood participated in a variety of ecological studies on intertidal biodiversity, nearshore wave transformation, coastal sedimentation, and fire recovery. He earned his PhD from the University of British Columbia and is currently based in Seattle, WA.

Taylor Zeeg

Taylor Zeeg co-ordinates the Cumulative Effects Management (CEM) initiative on behalf of the Metlakatla Stewardship Society. MSS has placed great emphasis on addressing cumulative effects over the last several years, recognizing it is an important element of effective stewardship. Phase 1 of the initiative is complete and included developing a values foundation and implementation plan for a range of biophysical, socioeconomic and cultural values. A phase 2 pilot project is underway, with a focus on gathering baseline information and identifying management triggers for a subset of Metlakatla values. The MSS participates with neighbouring First Nations on cumulative effects through the Cumulative Effects Monitoring Initiative (CEMI) and the emerging Tsimshian Environmental Stewardship Authority (TESA).

SESSION I PRESENTATIONS – VALUES AND INDICATORS

Grounded in values, informed by science: Value and indicator selection in a First Nation CEM framework

Presented by:

Katerina Kwon, *Simon Fraser University (REM)*

Taylor Zeeg, *Metlakatla Stewardship Society*

WWF CEAM Workshop

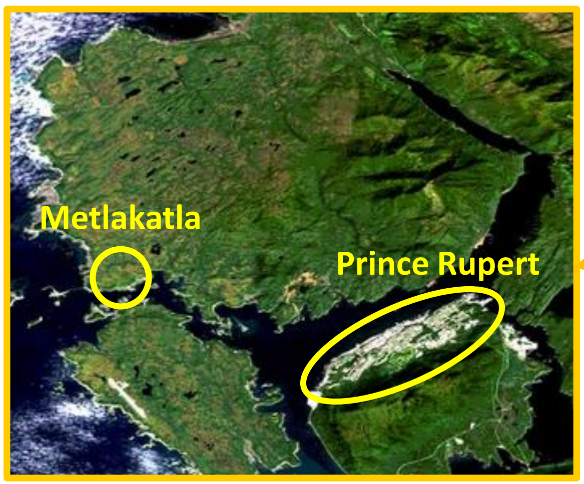
Workshop Session 1 – Values and Indicators: Dec. 10, 2015

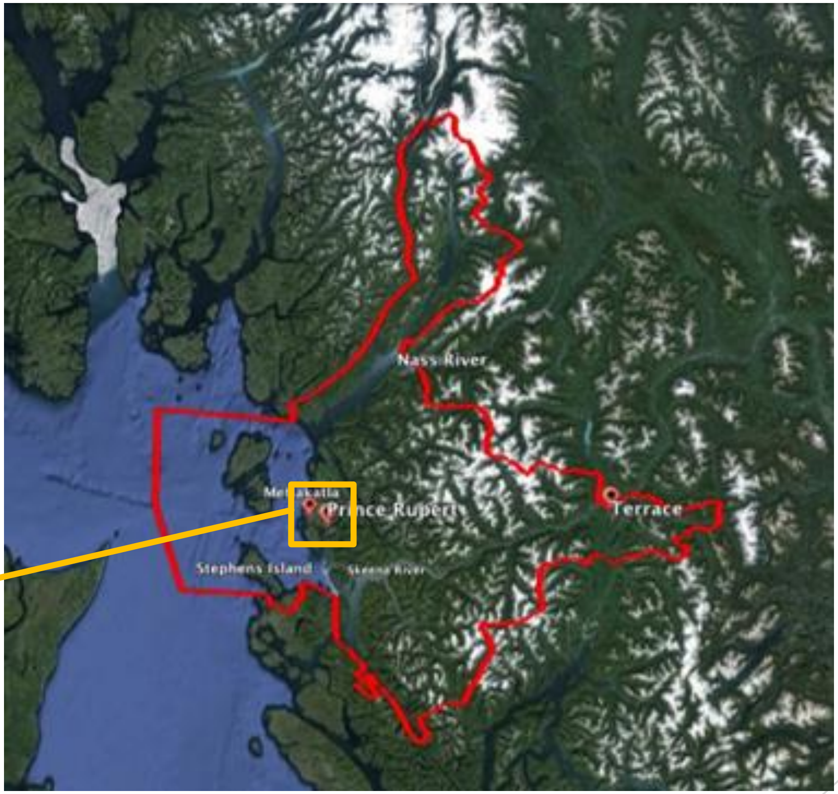
Metlakatla First Nation

Territory: ~19,000 km^2

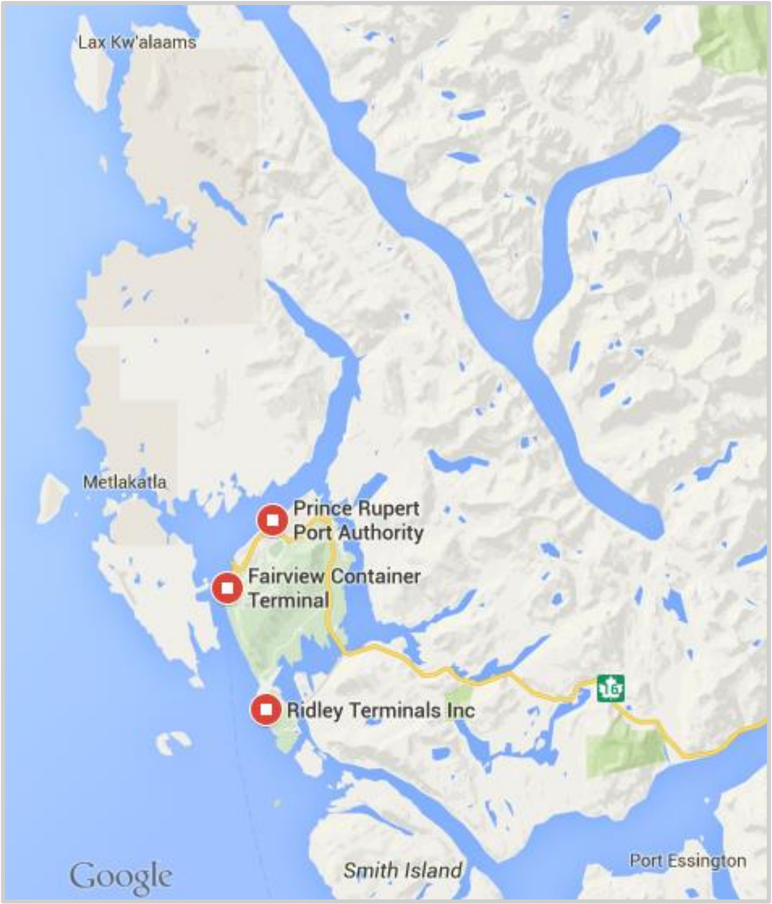
Membership: 800+

Metlakatla: 80 residents



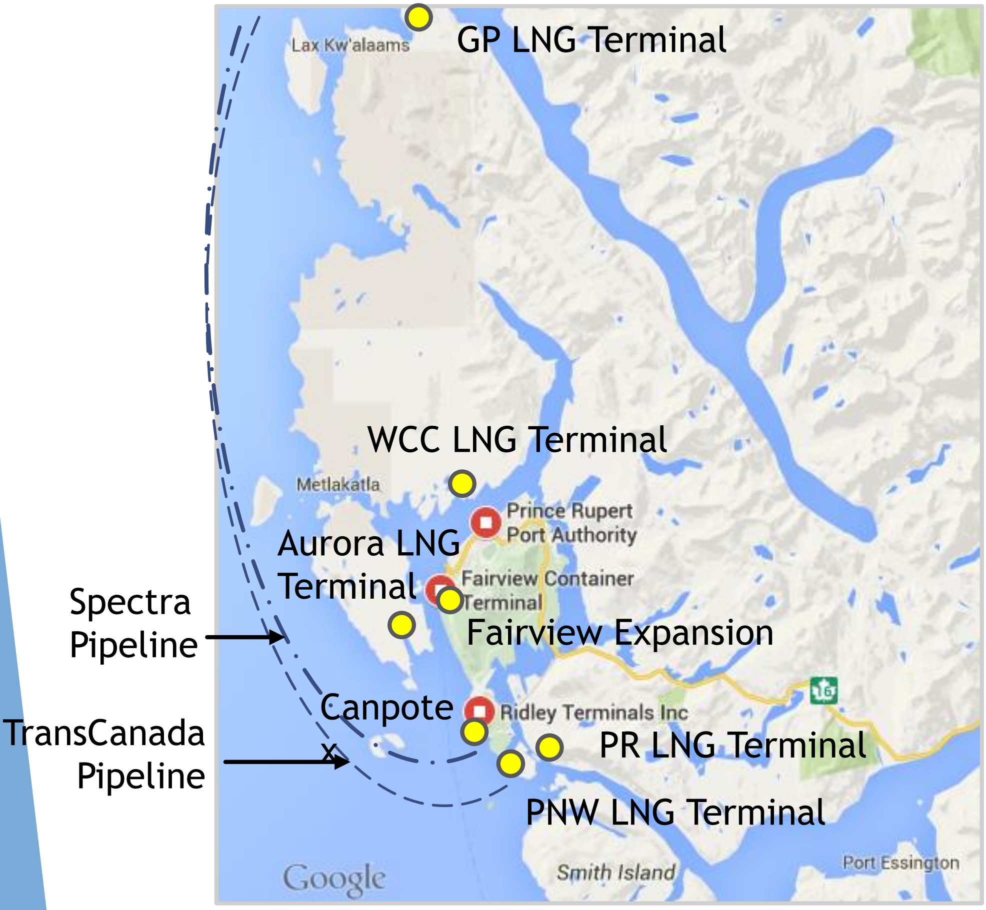


Rationale for Cumulative Effects Management



Prior to 2012

Rationale for Cumulative Effects Management



Post 2012

Projects:

- LNG terminals
- LNG pipelines
- Port facilities
- Shipping
- Linear infrastructure

Activities:

- Commercial and recreational fishing
- Commercial and rec. marine traffic
- Forestry activities

Metlakatla Cumulative Effects Management (CEM) Project

The CEM initiative:

1. Tracks the condition of priority Metlakatla values over time

2. Develops monitoring, mitigation and management strategies to maintain or improve condition of priority values

Cultural

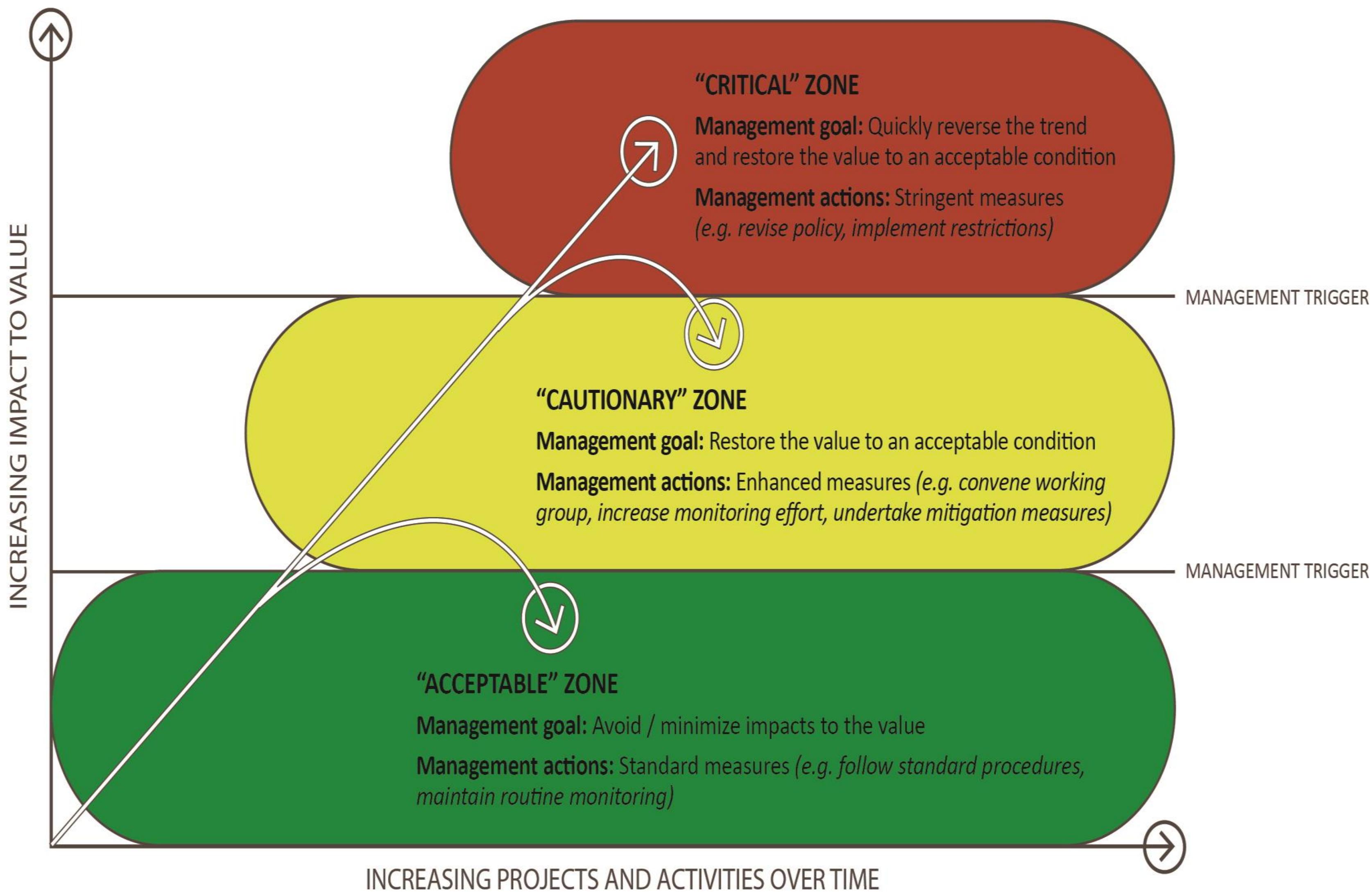
Environment

Governance/ Stewardship

Health

Economic Prosperity

CUMULATIVE EFFECTS MANAGEMENT CONCEPT



Current VC Selection Method

- VC selection process itself, its principles and rationale have not been extensively studied
- CEA is currently conducted at the project level scale as part of project review processes
  - Challenges to identify well-defined values that are both responsive and measureable at an appropriate regional scale
- Current practices do not explicitly incorporate local knowledge and Aboriginal values

Improved Value Selection Method

BASIS:

1. **BCEAO *GUIDELINES FOR VC SELECTION***
2. **BC FLNRO *CONSISTENT APPROACH TO DESCRIBING VALUES***

MODIFICATIONS

DESIGN:

- KEY DEFICIENCIES WITH CURRENT APPROACH
- CEM CONTEXT
- PRINCIPLES FOR ABORIGINAL-LED RESEARCH AND ENGAGEMENT
- METLAKATLA VALUES AND LOCAL KNOWLEDGE

IN PRACTICE:

- IMPLEMENTATION PLANNING – IDENTIFICATION OF BARRIERS
- NO SET FORMULA FOR SELECTING VALUES AND INDICATORS – INFORMED BY VALUES AND SCIENCE

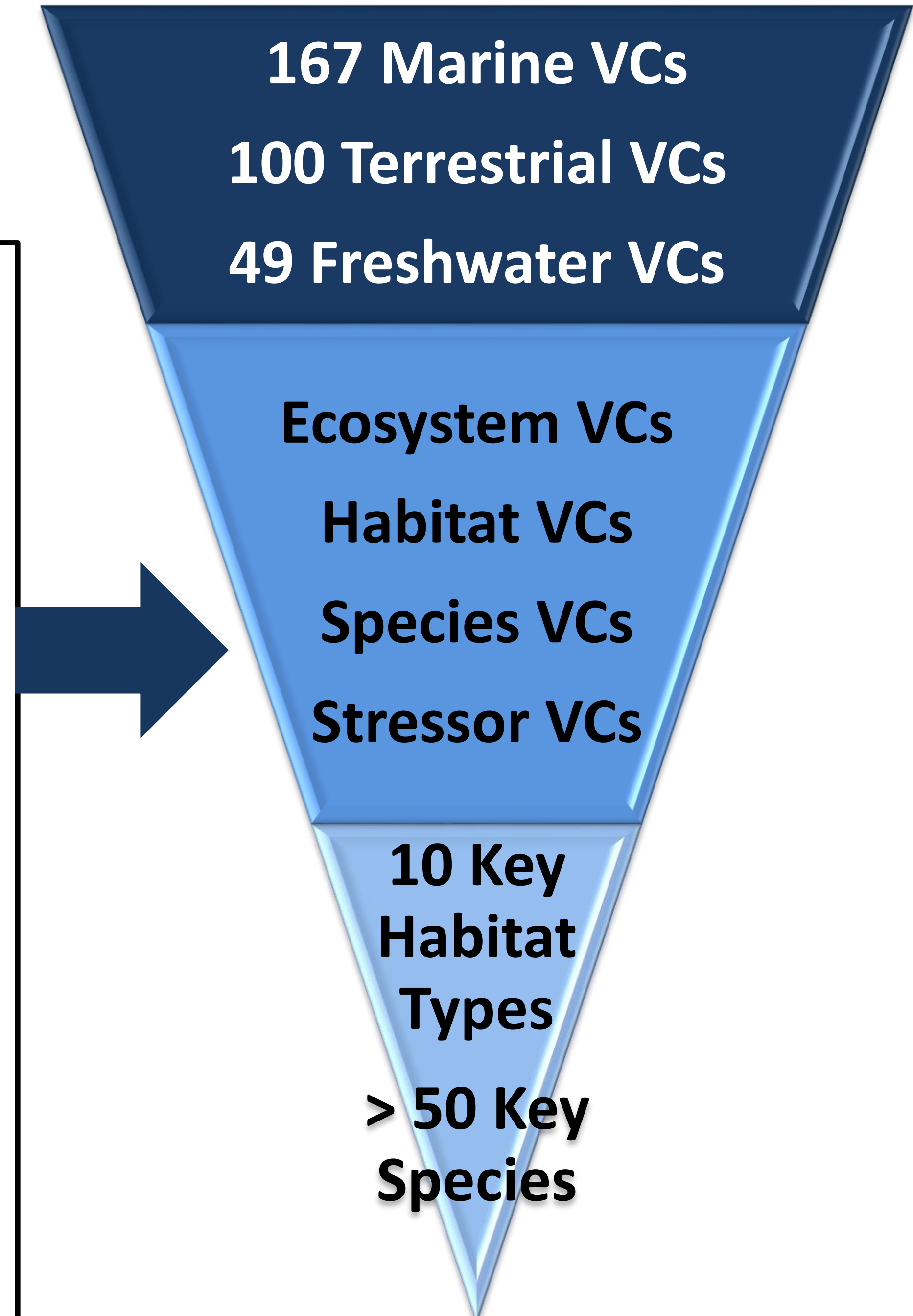
Selection of Values and Indicators

1.
   - Comprehensive review of relevant documents
   - Compile an extensive inventory of values
2.
   - Identify value and indicator selection criteria
   - Identify candidate list of values
3.
   - Working sessions, interviews with content experts
   - Refine candidate list of values
4.
   - Workshops with Metlakatla managers and decision-makers
   - Final priority list of values

1

Biophysical Values Inventory

- Metlakatla planning documents
- Traditional use studies
- Socioeconomic studies
- Government planning documents
- Other organizations' planning documents
- Proponent EA applications
- Academic literature



2 Biophysical Value Selection Criteria

BC EAO Criteria	Modified Criteria
• Relevant • Comprehensive • Representative • Responsive • Concise	• **Traditional Importance** • **Sensitive to Development** • **Responsive and practical indicators** • Key Role in Ecosystem – Keystone Species / Umbrella Species • Representative of Key Habitats • Species at Risk

2

Biophysical Indicator Selection Criteria

BC EAO Criteria

- Relevant
- Practical
- Measureable
- Responsive
- Accurate
- Predictable

Modified Criteria

- **Relevant** – can inform work of Metlakatla departments and reflects cultural values
- **Practical**
- **Measureable**
- **Sensitive** - to development expected in region
- **Accurate**
- **Manageable**

2

Biophysical Values List

VALUE CATEGORY	BIOPHYSICAL VALUES	
FOCAL SPECIES	**PRIORITY**	**SECONDARY**
	SOCKEYE SALMON	CHINOOK SALMON
	EELGRASS	PACIFIC HALIBUT
	RED LAVER	CLAMS & COCKLES
	EULACHON	RED SEA URCHIN
	NORTHERN ABALONE	RHINOCEROS AUKLET
	PACIFIC HARBOUR PORPOISE	
ENVIRONMENTAL QUALITY	MARINE BIODIVERSITY	
	CLEAN WATER	
	PRIMARY PRODUCTION	

3

Candidate List of Biophysical Values

Biophysical Values	Indicators
Chinook Salmon	Population abundance
	Critical juvenile habitat (eelgrass)
Bivalves (Clams & Cockles)	**Population density**
Eulachon	Population abundance
Dungeness Crab	Population abundance



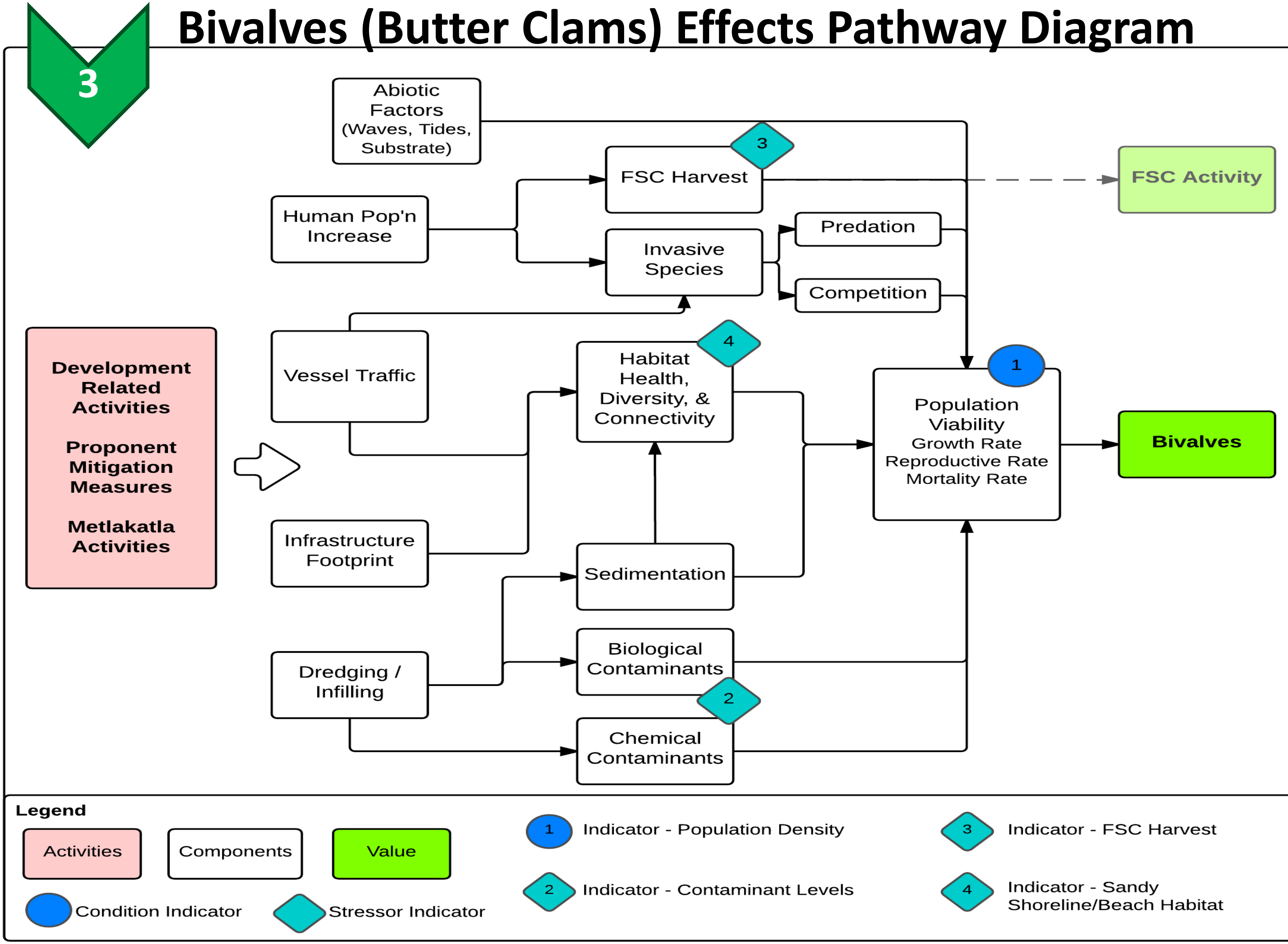

3

Bivalves (Butter Clams) Selection Rationale

Value	Indicator	Metric(s)
Bivalves (Butter Clams)	Butter Clam Population Density	• # individuals/m^2 • Includes both adults & juveniles

- Identified as an important traditional resource
- Clam gardens are an important historical resource
- Priority goal in Integrated Marine Use Plan
- Bivalves are sensitive to environmental change
- Timely opportunity with new sewage facility next year
- Can extend to other bivalve species in future phases

Bivalves (Butter Clams) Effects Pathway Diagram



Barriers to Successful Implementation

Mandate

Priority

Capacity

Ability to Influence

4 Priority List of Biophysical VCs

- Final workshop with Metlakatla managers and decision-makers
  - Prioritizing exercise to identify priority list of VCs for Pilot Project

Biophysical VCs	Indicators
Chinook Salmon	Population abundance
	Critical juvenile habitat (eelgrass beds)
Butter Clams (Bivalves)	**Population density**

Bivalves (Butter Clams)

4

- **Implementation Challenges**
  - No available baseline population density
  - Important biological & environmental considerations – natural inter-annual variability, cold weather freeze outs

- **Management Considerations**
  - Butter Clam monitoring can be managed internally
  - Partnerships can be useful when developing the protocol & methodology
  - Capacity requirements will depend on the number and location of survey sites
  - Technical working group to identify program goals and determine what stable population density should be for each surveyed beach

Next Steps: Butter Clam

- Established working group to determine monitoring program objectives and confirm indicator choices
  - Composed of Metlakatla Fisheries Department, Metlakatla Stewardship Office and harvesters
  - Invited experts in the field (DFO, NCSFNSS) to provide guidance from their experiences
  - Ongoing engagement with Metlakatla managers and community members is a crucial component of this process

Butter Clam Working Group Discussion

Monitoring Program Goals	Indicators				
	Population Density	Growth Rate	Condition Index	Recruitment	Contaminant Levels
Harvesting	X		X		
Marine Health (water quality, pollution)			X		X
Stable Bivalve Population	X	X		X	
Short-term responses		X	X		
Long-term responses	X	X	X	X	X

Next Steps: Butter Clam

- Working with NCSFNSS to develop a butter clam monitoring framework / plan:
  - Measure and monitor a broader suite of indicators
  - Condition indicator: population density and size/age structure
  - Stressor indicator: contaminant levels
  - Hope to collect baseline data next summer
  - Then identify management triggers / responses

Next Steps: Socio-economic Values

- The Census was identified as a need for the Metlakatla Cumulative Effects Management (CEM) project
- General lack of baseline information for Metlakatla socioeconomic VCs

METLAKATLA MEMBERSHIP CENSUS

Metlakatla Membership Census

Cultural	Governance	Economic Prosperity	Health
FSC Participation	Ability to Steward	Individual Self-Sufficiency	Physical, Mental & Emotional Health
		Economic Resiliency	Housing
		Wealth Distribution	Access to Health Services

- **Census categories based on CEM indicators**
- **Using census results to further refine some indicators (e.g. FSC participation)**

Metlakatla Membership Census

- Huge success!
  - 66% response rate
- Collected previously unavailable data on status of Metlakatla membership (using CEM indicators)
- This information can help Metlakatla in many ways, including helping managers meet community and stewardship goals

Key Messages

1. **Value and indicator selection is an iterative and adaptive process**
   – Development context and actors change
   – Need to be willing to adapt and change initial choices based on new information
2. **Implementation feasibility planning is a critical component of selection process**
   – Explicit consideration of management and implementation barriers (capacity, resources, etc.)
   – Balance comprehensiveness and practicality
   – Either enable or constrain value and indicator selection

Key Messages

3. **Value and indicator selection is inherently a deliberative process**
   - Requires ongoing engagement with community managers and members, stakeholders and content experts
4. **Lack of baseline data can restrict value and indicator selection**
5. **Some values and indicators benefit greatly from coordinated action (TESA, CESI, etc.)**
   - Shared values among stakeholders
6. **First Nations have a key role to play in CEM**

Acknowledgements

- Metlakatla First Nation
- Compass Resource Management
- SFU and School of Resource and Environmental Management
- MITACS

Thank you

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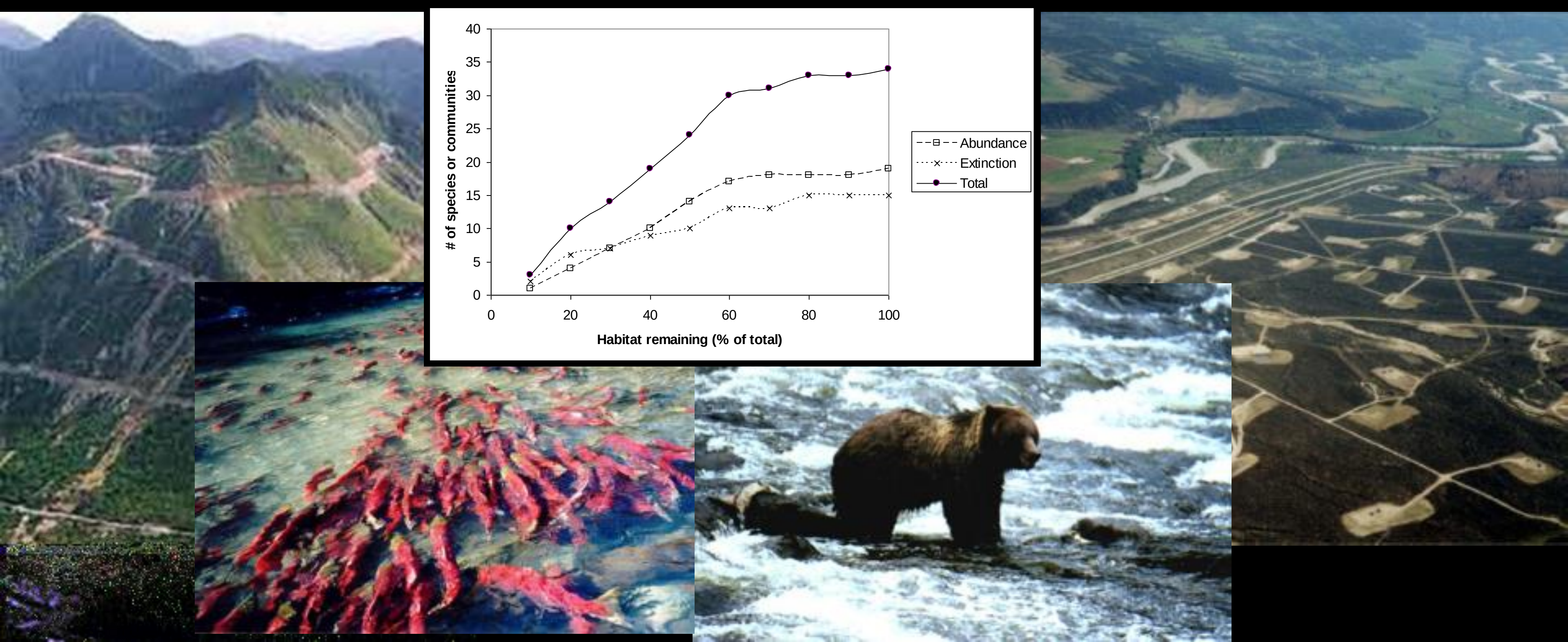
compass

Mitacs
Accelerate

Values and Indicators: What Matters and How do we Measure it?



Risk assessment

Adaptive environmental assessment

Vulnerability assessment

Structured decision-making

Cumulative effects assessment

Environmental impact assessment

Ecosystem-based management

Monitoring

Adaptive management

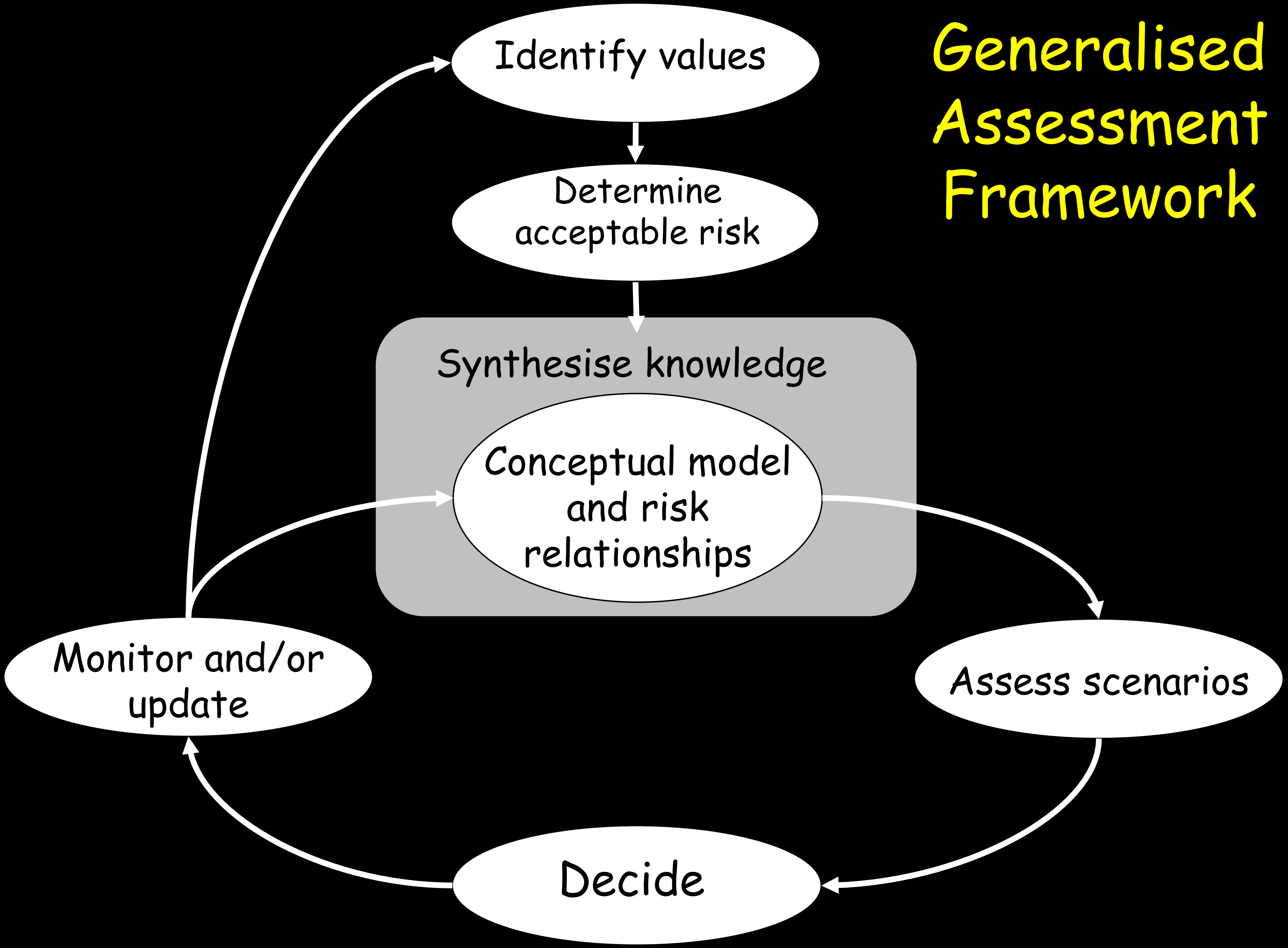
Risk management

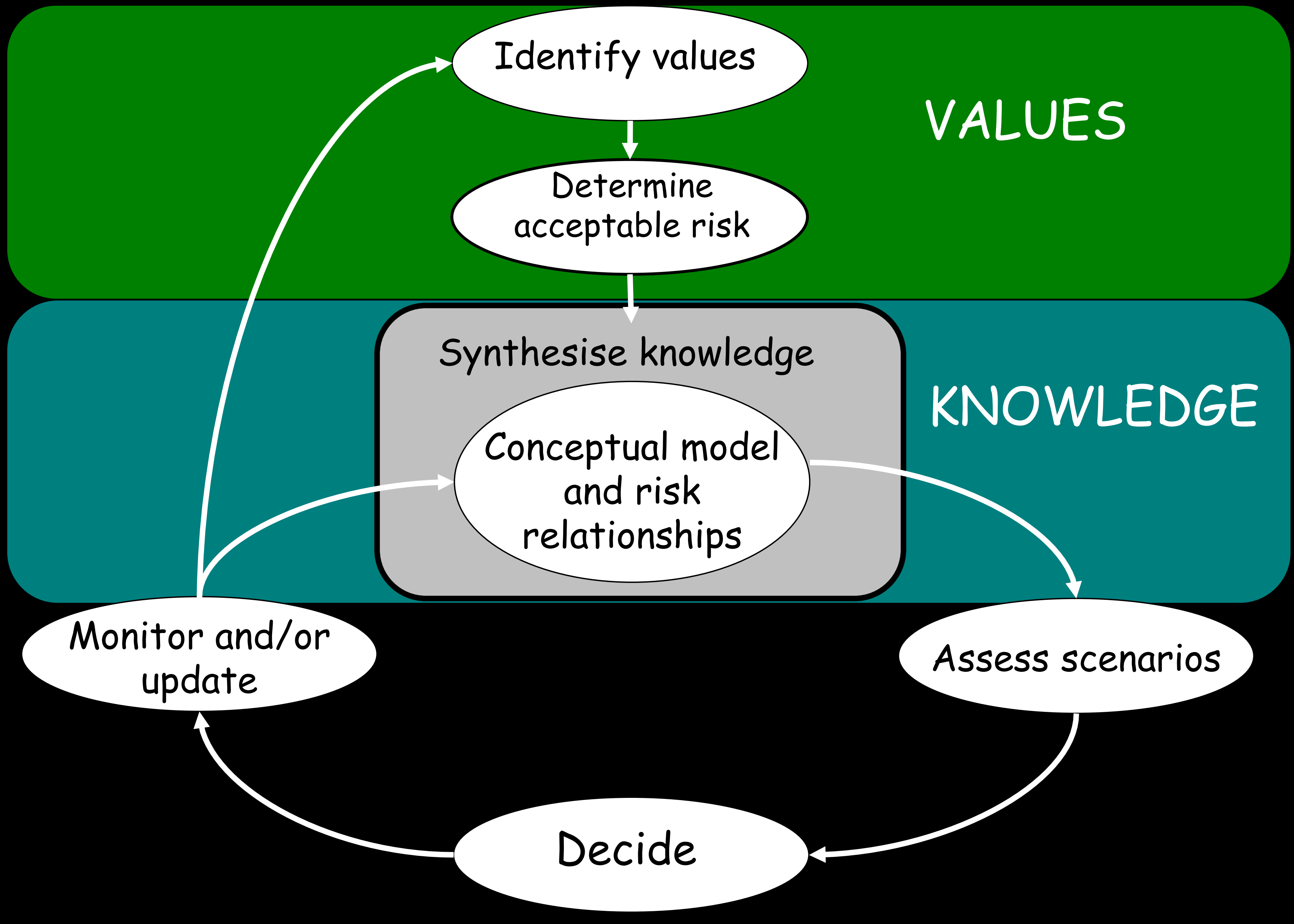
All basically the same!*

- Focus on values
- Estimate consequences to values using knowledge about risk and uncertainty
- Use assessment to inform decisions
- Transparent
  - knowledge-based decisions rather than manufacturing decision-based knowledge

* Done properly

Generalised Assessment Framework




Identify values
VALUES
Determine acceptable risk
Synthesise knowledge
KNOWLEDGE
Conceptual model and risk relationships
Monitor and/or update
Assess scenarios
Decide

Identify Values

- What matters?
  - Principles (e.g., fairness, intergenerational equity, collaboration)
    - E.g. EBM is "*an adaptive approach to managing human activities that seeks to ensure the coexistence of healthy, fully functioning ecosystems and human communities*" (GBR)
  - Valued components or services (e.g., salmon, clean water)

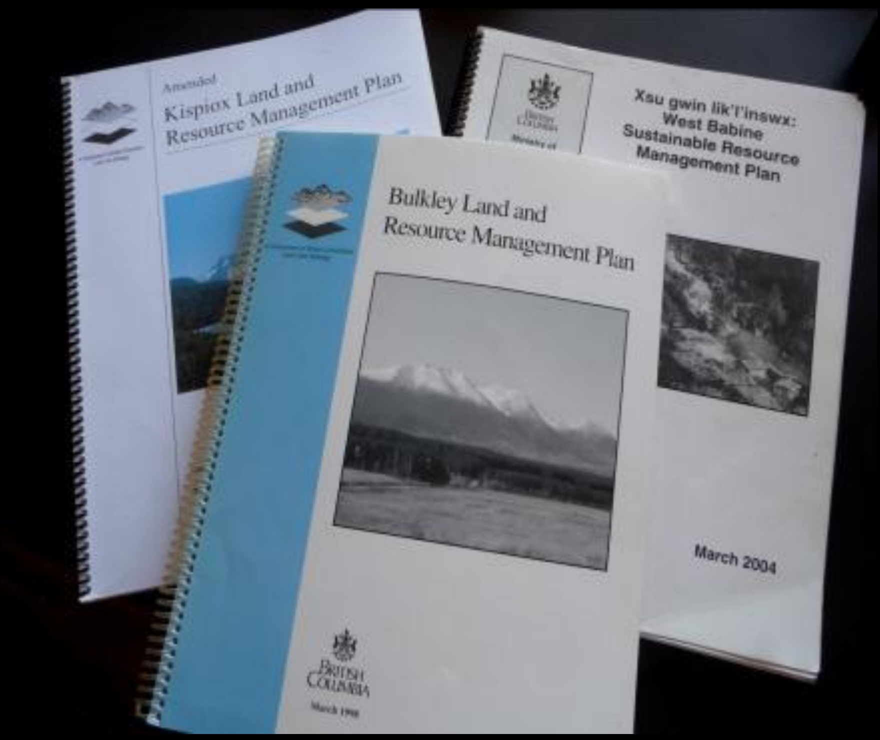
Identify Values

- What matters?
- To whom?

Best available information on values

- Public survey
- Consensus or consultation process
- Elected government representatives

Good sources already exist



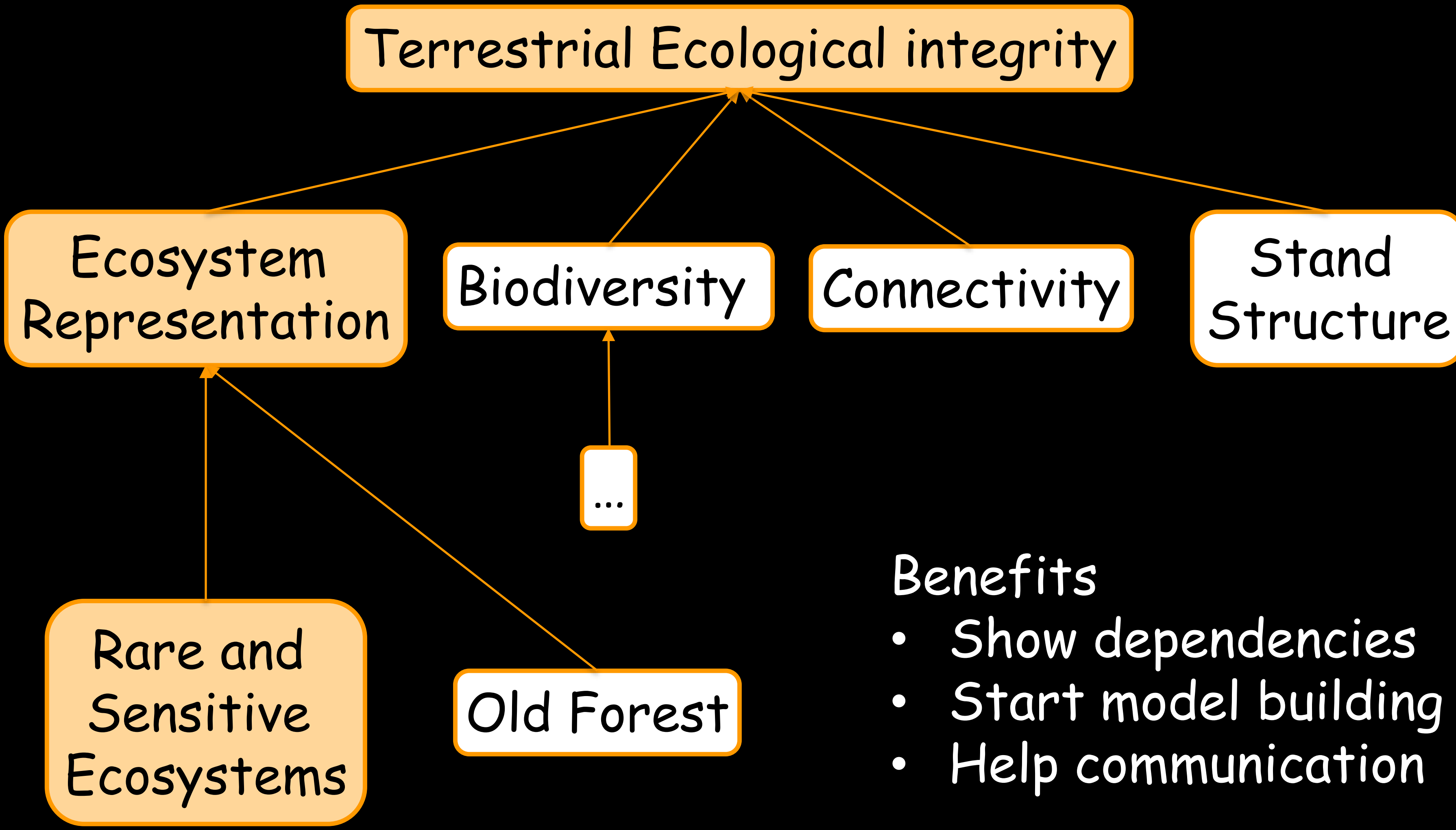
- Land-use plans (FN and/or provincial)
- Consensus values and objectives
  - Local people
  - Multiple interests
  - Long-term
  - Big-picture
- Supplement as needed
  - Missing voices (many FN)
  - Missing values (e.g., CC)

Summarise values: table

Terrestrial Ecological Integrity	
Terrestrial ecological integrity	• Maintain ecological integrity (NC p43) • Maintain the natural diversity of species, ecosystems and seral stages (EBMH p32) • Preserve the integrity of ecological values and physical features in areas used for tourism (NC p147)
Ecosystem representation	• Manage the amount of early seral … consistent with natural disturbance (CFN B p7, GX F p7) • Conserve the diversity of … ecological communities and their ability to adapt (PNC p 26) • Maintain a range of seral stages across the landscape (KA p34)
Rare and sensitive ecosystems	• Maintain the structural and functional integrity of red-listed and selected blue-listed plant communities (CFN B p8, GX F p8) • Protect known red- and blue-listed and regionally rare ecosystems (EMBH p23)

- Document source for transparency
- (Skeena Estuary, WWF)

Summarise values: concept maps



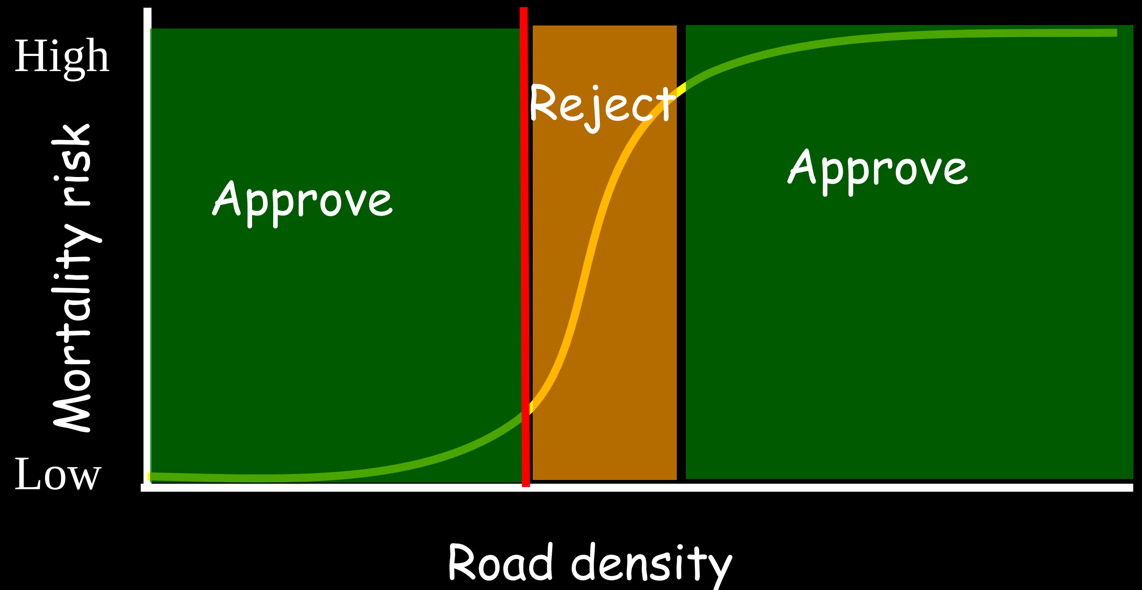
Benefits

- Show dependencies
- Start model building
- Help communication

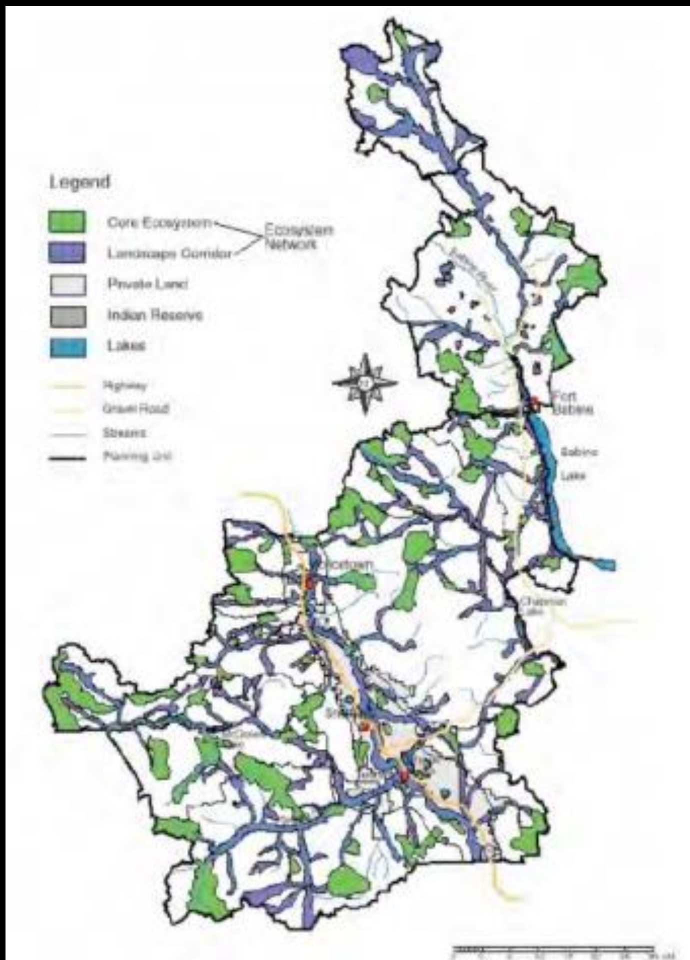
Determine acceptable risk

- List (or map) of values not sufficient
- Need objective for each value
  - What/how much to maintain? What risk?
- Without limits, focus on incremental change moves all projects to approval

e.g., grizzlies

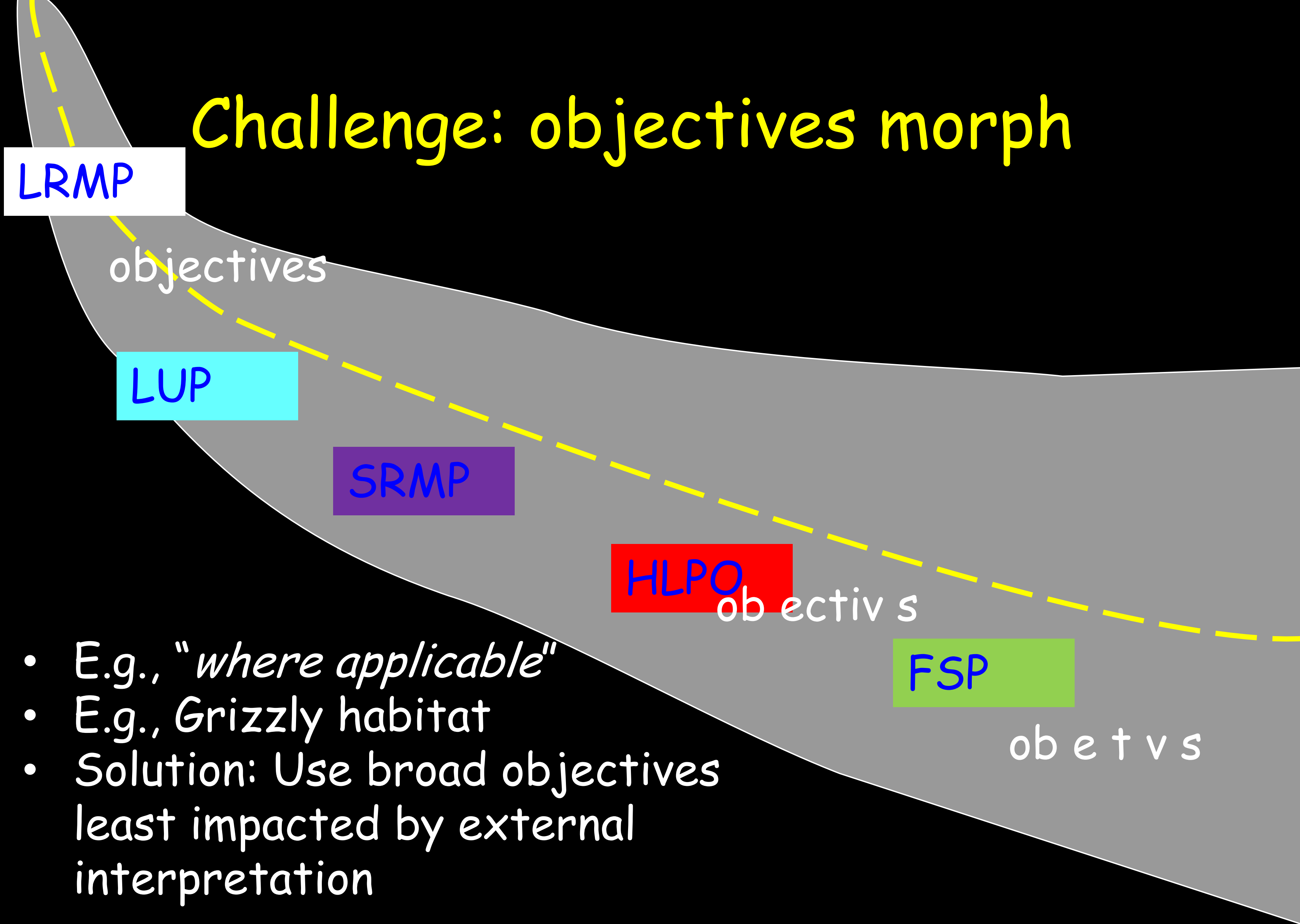


Challenge: objectives vary



- Target: "*Maintain water quality and quantity within its natural range*" (Babine SRMP 2004)
- Specific zones: strategy to maintain biodiversity (Bulkley LRMP 1998)
- General: "*minimize the risk of grizzly bear displacement and human induced mortality*" (Morice LRMP 2007)

Challenge: objectives morph



- E.g., "*where applicable*"
- E.g., Grizzly habitat
- Solution: Use broad objectives least impacted by external interpretation

Principles can help (e.g., GBR)

- Ecosystem-based management: ecosystem integrity and human wellbeing
- Decisions based on independent science
- Low risk as guiding principle
- So “maintain ecosystem integrity” means acceptable risk is low

Use other sources to clarify

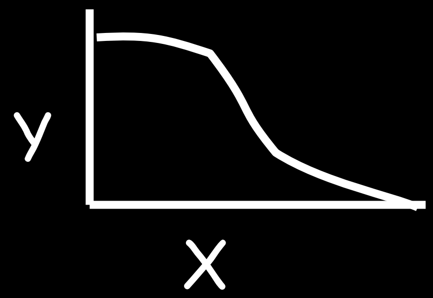
- Record objectives for each value
  - Maintain grizzly bears
- Clarify objectives from other sources
  - Maintain ecological integrity
  - Other sources of evidence (e.g., hunting, viewing)
- Translate to acceptable risk

Low risk of population decline

How do we measure impacts to values? Indicators

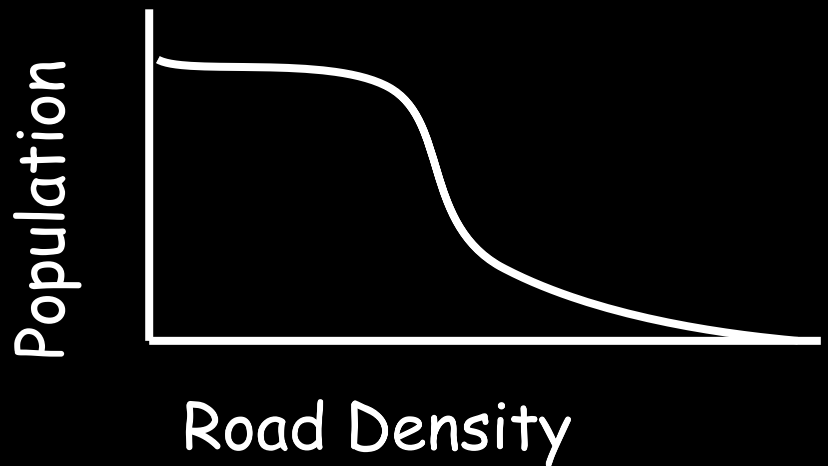
Type	Measures	Variable	Monitors
State or condition	Value	Dependent (Y)	Effectiveness
Pressure or stressor	Impact	Independent (X)	Implementation

- Variety of terms
- Essentially variables in model (story): pressure indicator X affects state indicator Y



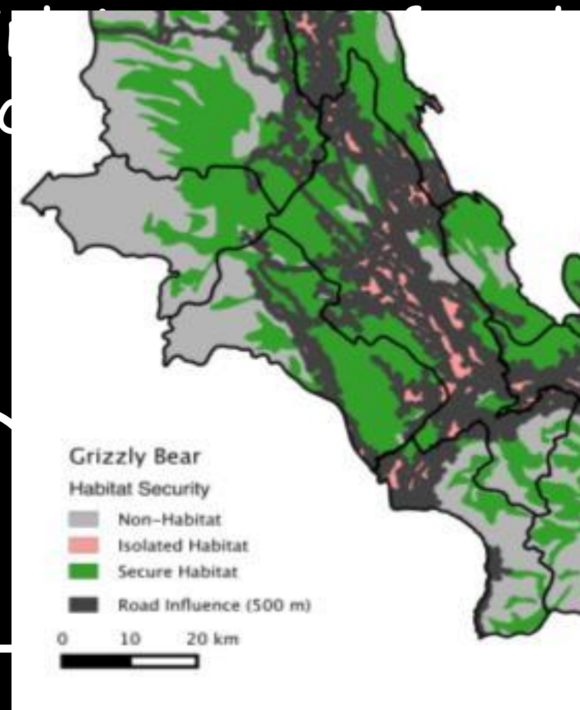
Indicators: Grizzly Bears

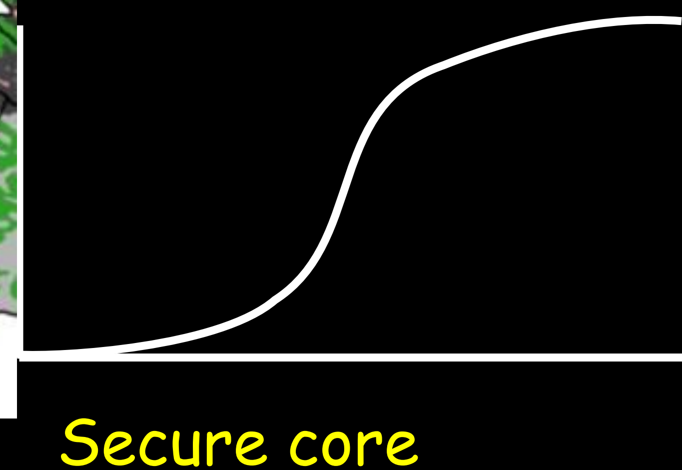
Type	Measures	Variable	Indicators
State or condition	Value	Dependent (Y)	Population size Growth rate
Pressure or stressor	Impact	Independent (X)	Road density



Challenge: complex indicators

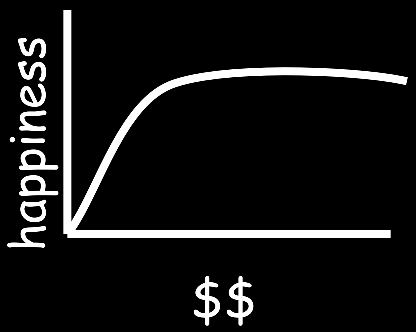
- Secure core habitat
- Can indicate habitat condition or pressure on bear population
- Solution: Thi … el (or story): road density affec … itat AND secure core affects … rowth rate



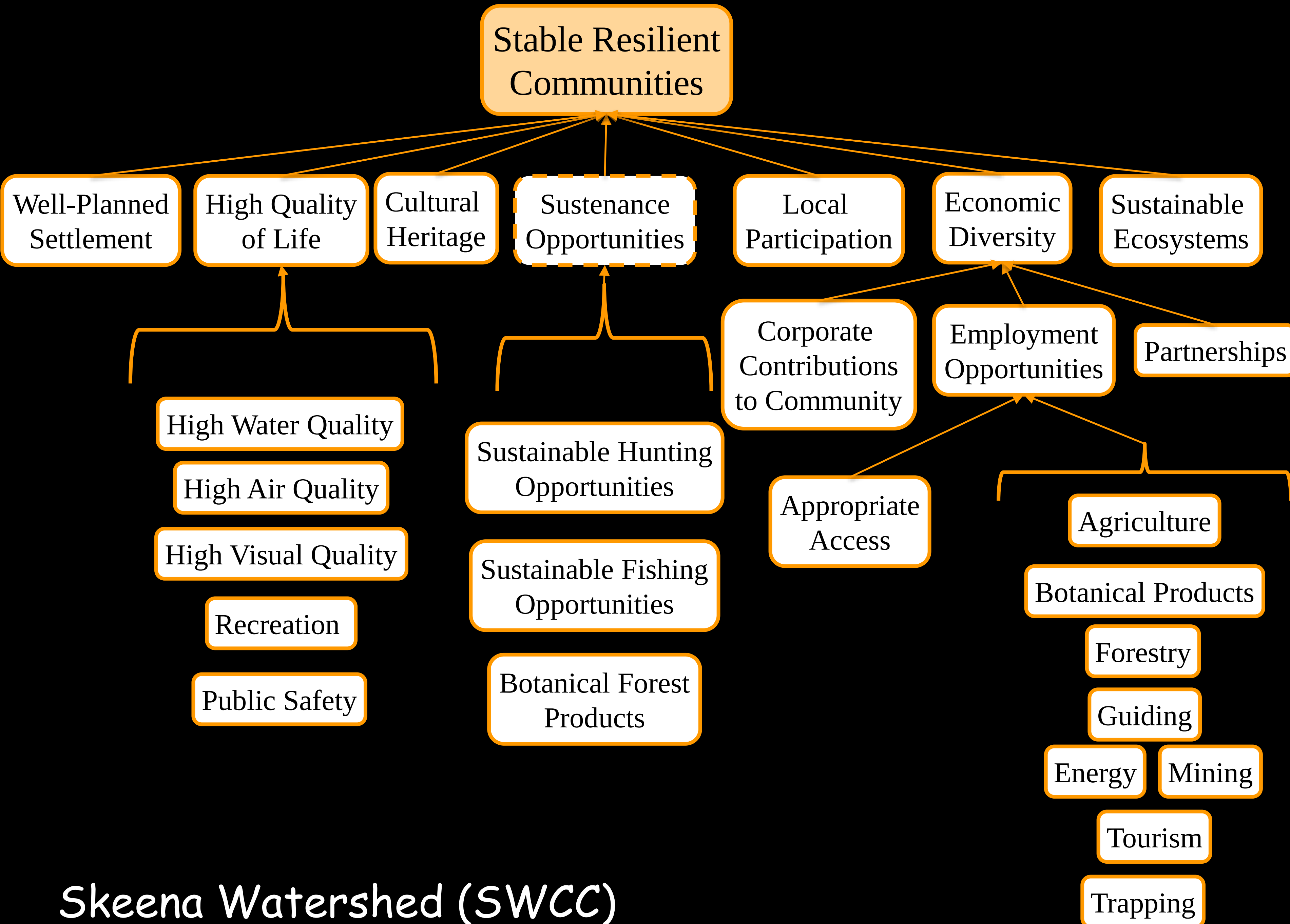


Challenge: unclear indicators

- Human wellbeing
  - Jobs or $$
- Wellbeing ≠ $$
  - Poor Y-axis indicator
  - Rate of change is critical
  - Boom-and-bust towns are not stable



- Solution: learn more about human wellbeing



Skeena Watershed (SWCC)

Challenge: which acceptable risk?

- Public consensus or legal objectives?
- E.g., Government/industry assessments say "*no loss of identified wildlife habitat*" concluding that risk is acceptable
  - Meets legal objectives
  - Implies habitat is ultimate state indicator
  - BUT people care about the wildlife, not just the habitat—doesn't represent public values
  - Does maintaining habitat maintain wildlife?

- Top-level state indicators must represent broad public values

Recommendations for Values

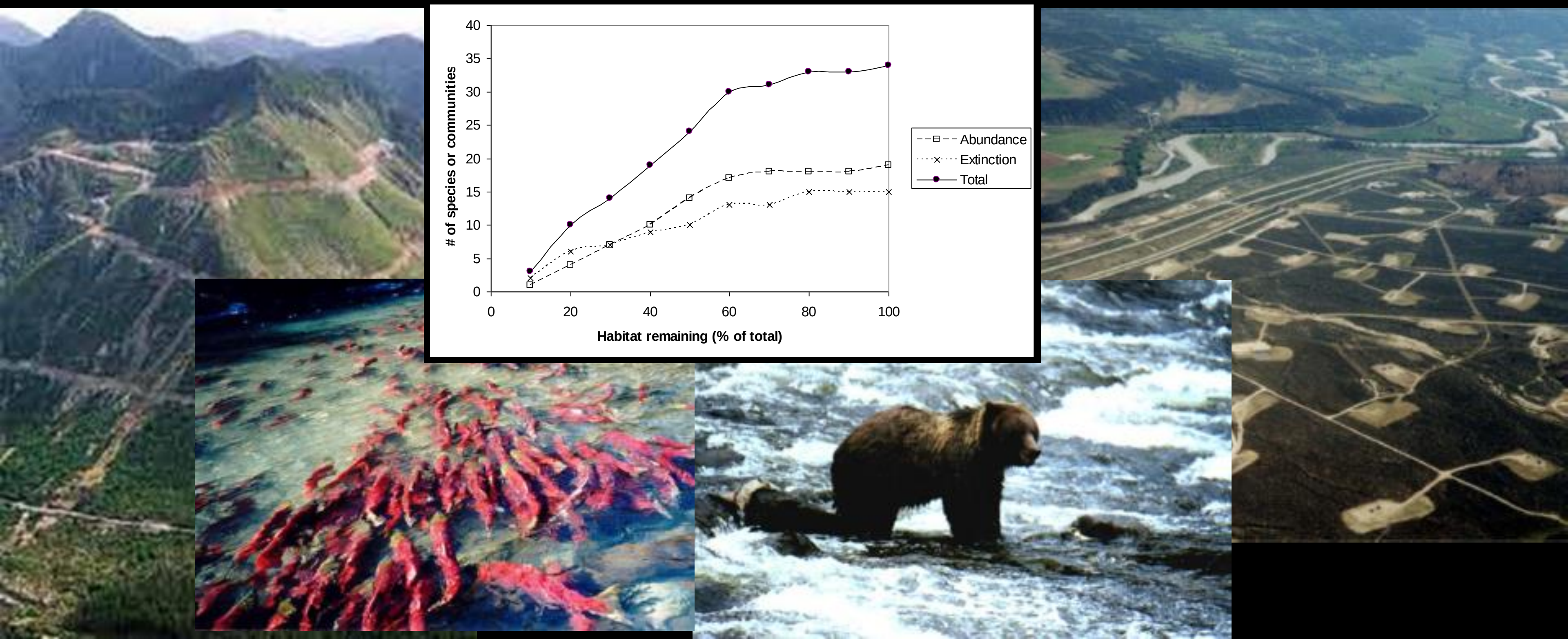
- Start with existing sources
  - Add missing voices
  - Add missing values
- Use broad values that represent public agreement
- Build concept maps
  - Assist communication
  - Start model building
- Define acceptable risk before assessment
- Don't worry about terms, just build the model!

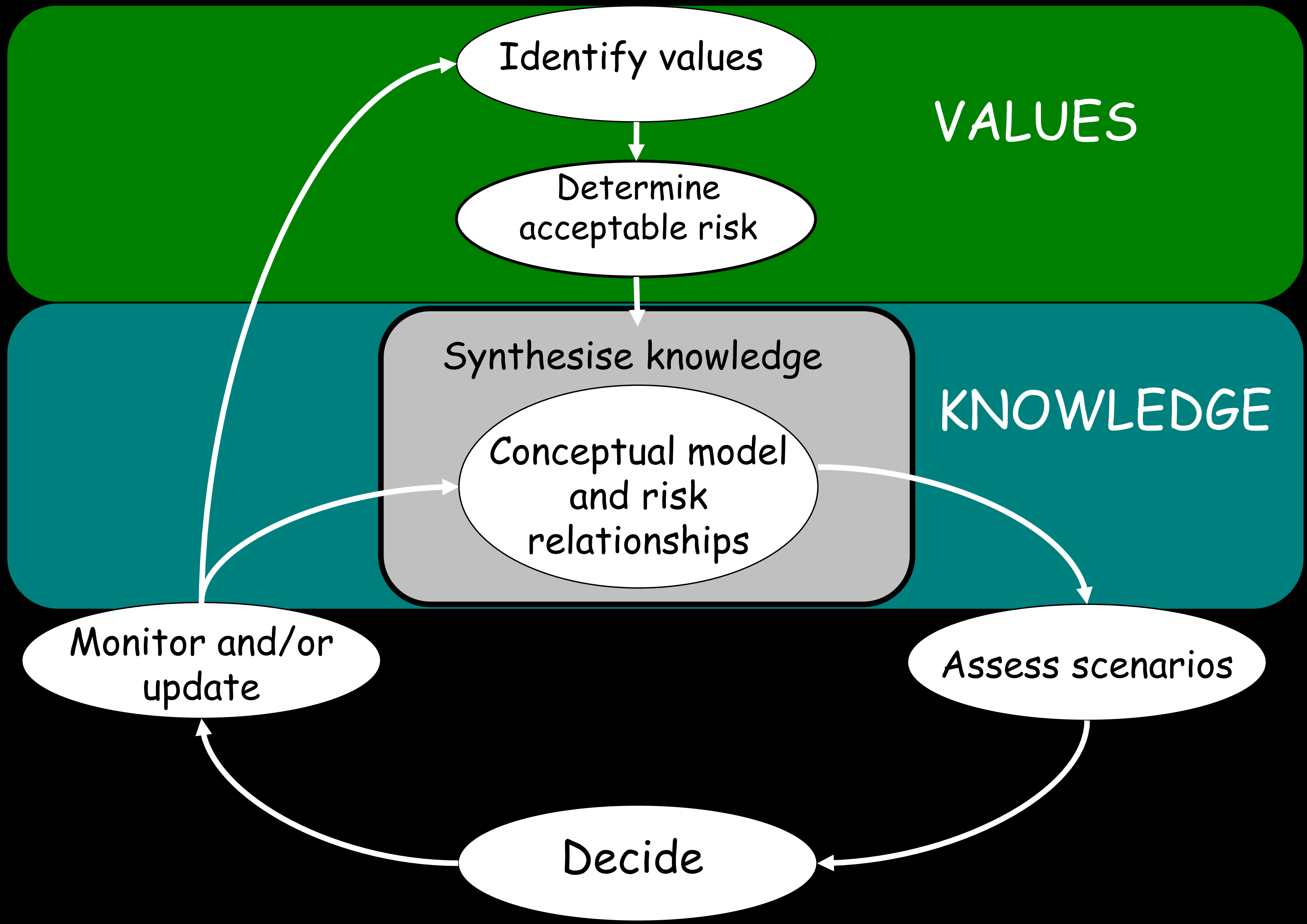
Values Matter




SESSION II PRESENTATIONS – BENCHMARKS & THRESHOLDS

Thresholds and Benchmarks: Setting Limits Based on Knowledge

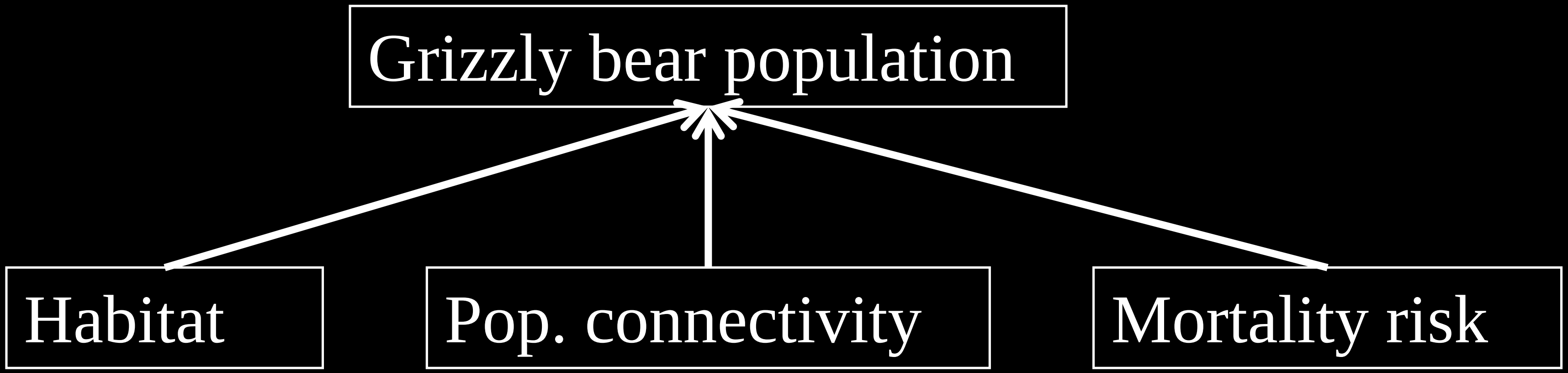



Identify values
VALUES
Determine acceptable risk
Synthesise knowledge
KNOWLEDGE
Conceptual model and risk relationships
Monitor and/or update
Assess scenarios
Decide

How to summarise knowledge

1. Conceptual Models (Concept Maps)
   – What factors influence a value?
2. Explicit Risk Hypotheses
   – What risk is posed by each factor?

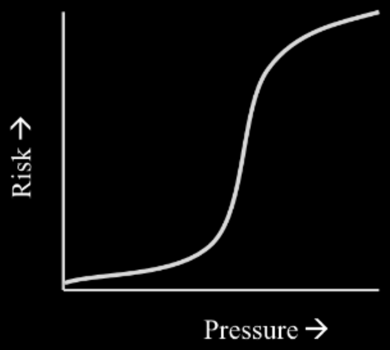
Conceptual Model



1. Describe big picture
2. Show all variables—helps define uncertainty
3. Explicit and transparent
4. Facilitate discussion

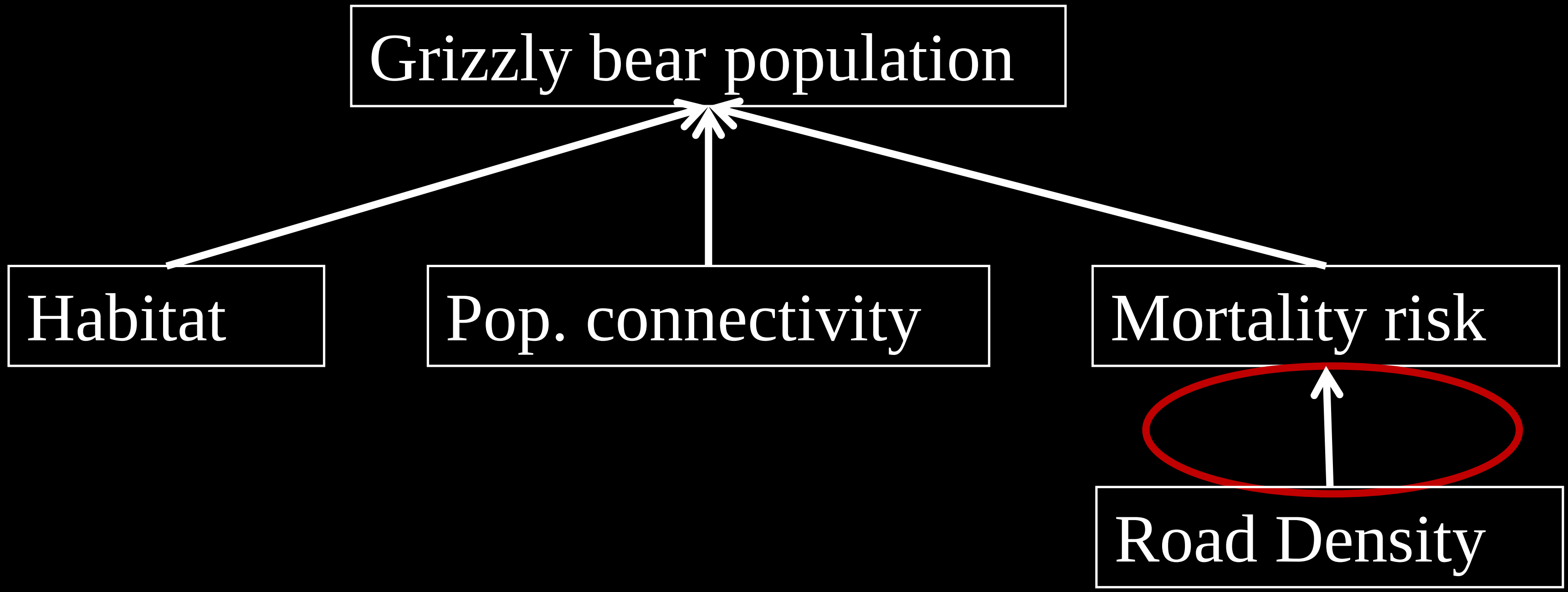
Risk Hypothesis: Risk Curve

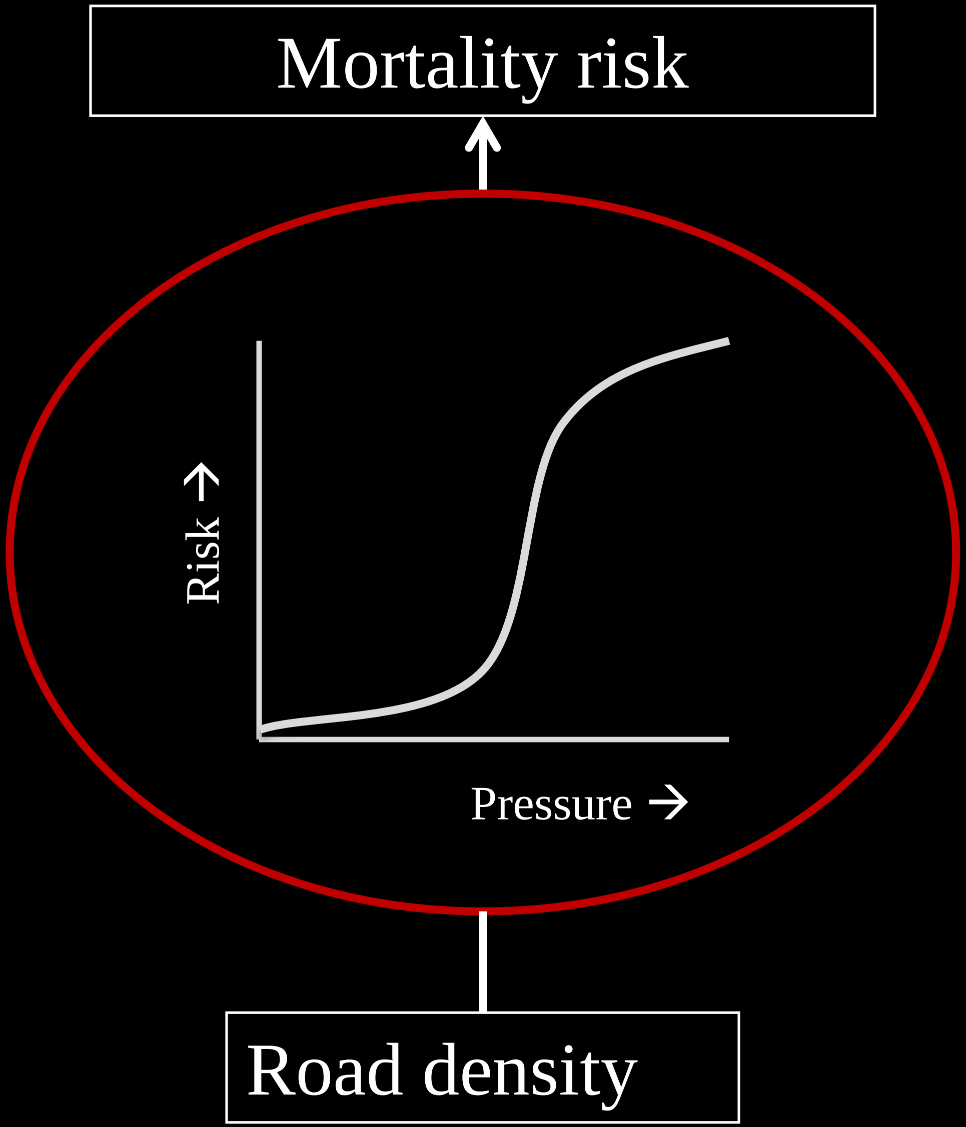
Explicit graphical hypothesis about relationship between risk and indicator



- Estimates risk over a range of indicator values
- Considers probability and uncertainty of one relevant outcome (i.e., one severity level)
- Documents benchmarks, thresholds and management targets

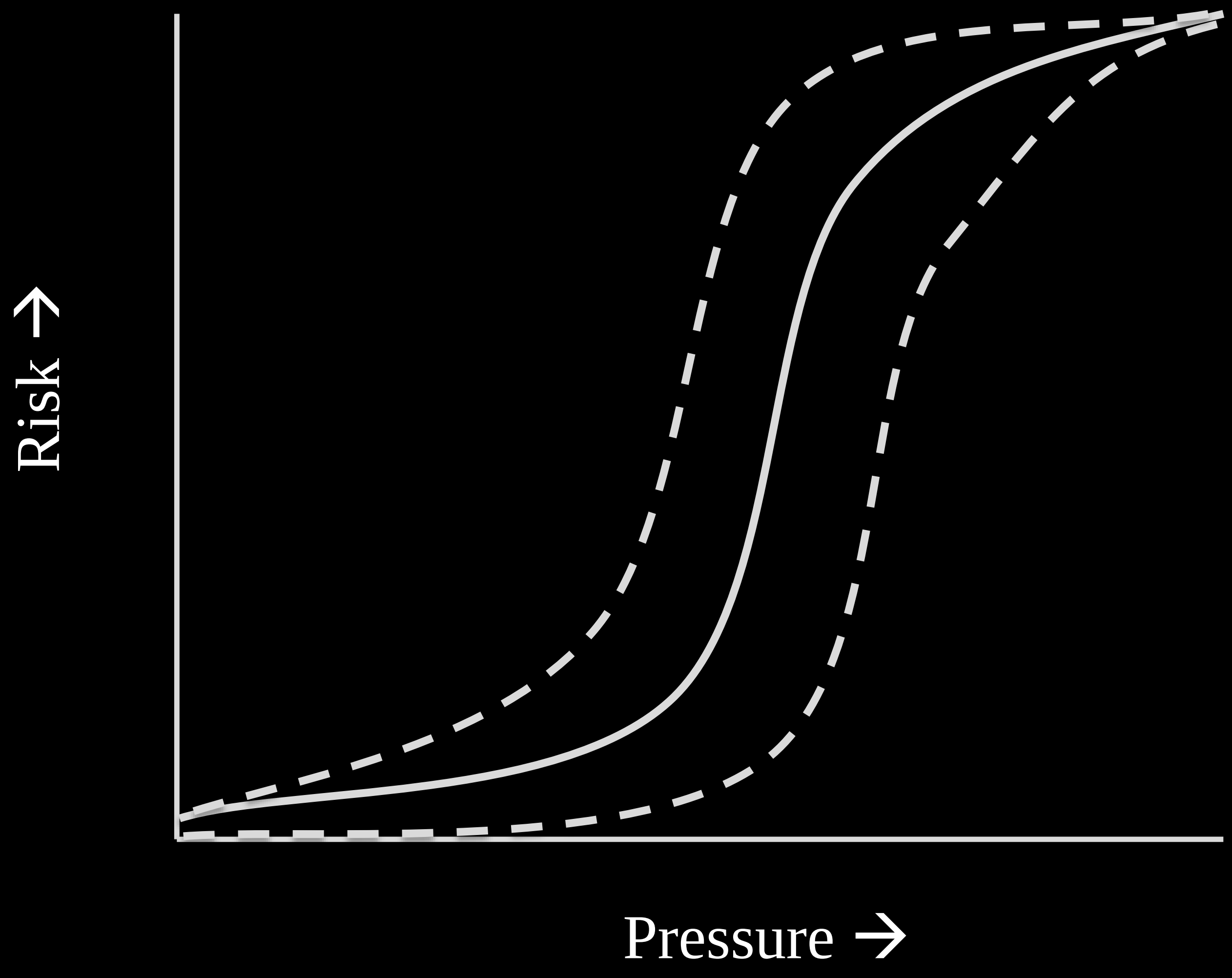
Expanding the arrows





Risk Hypothesis

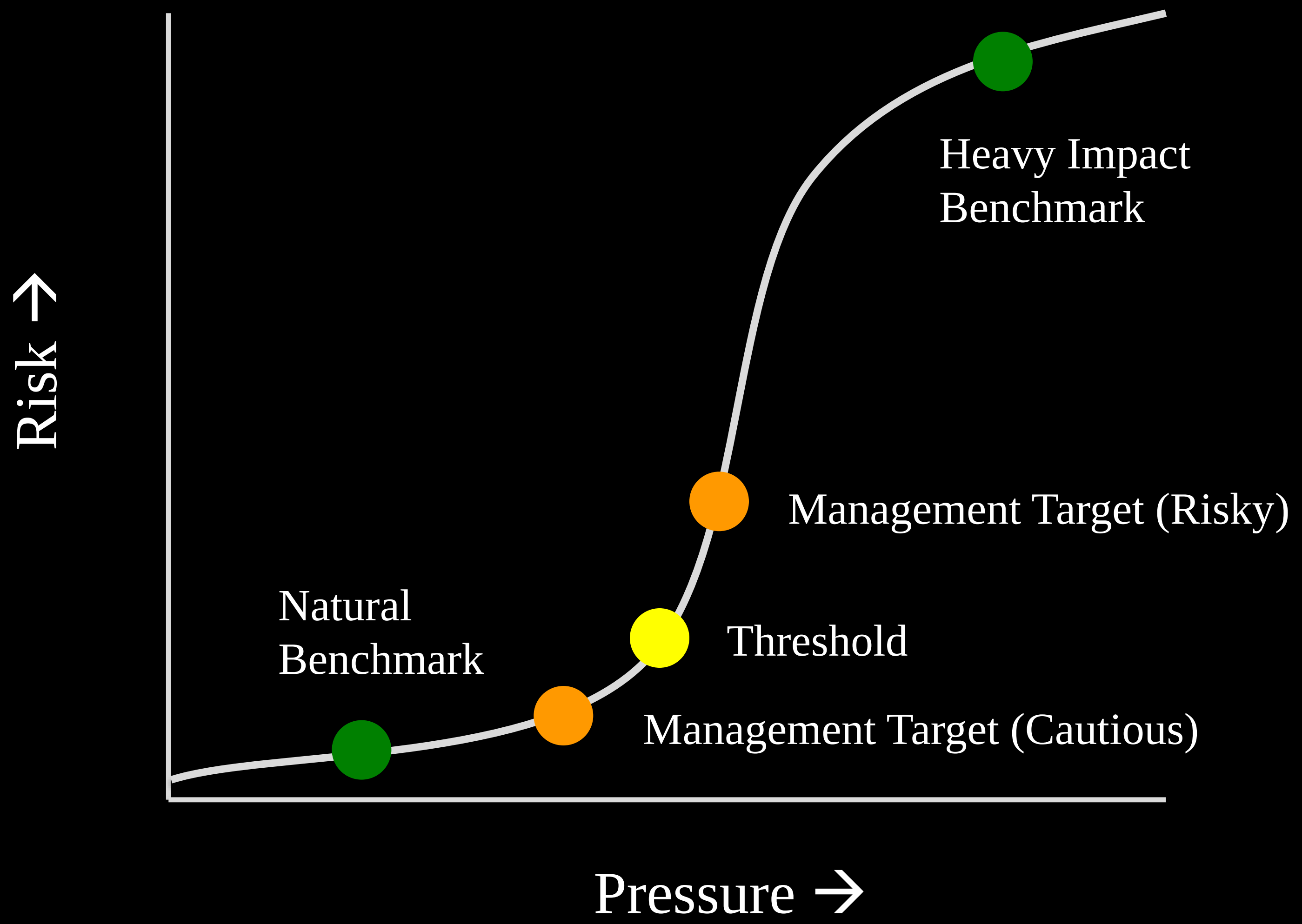
Risk AND UNCERTAINTY!!!



Thresholds and benchmarks

- Thresholds
  - Knowledge-based changes in the slope of a relationship (e.g., 0.6km/km2 for grizzly bears)
- Benchmarks
  - Known points in the relationship (e.g., natural benchmark: population under historic disturbance)

- Management Targets
  - Chosen points in the relationship
  - NOT KNOWLEDGE


Heavy Impact
Benchmark
Risk →
Management Target (Risky)
Natural
Benchmark
Threshold
Management Target (Cautious)
Pressure →

Case Studies

- Ecological Integrity in Great Bear Rainforest
  - Based on literature
- Grizzlies in the Great Bear Rainforest
  - Based on expert workshops
- Salmon in the Morice Watershed
  - Based (in part) on past assessments

Ecological Integrity in the Great Bear Rainforest

- Recall: clear values and principles…
  - Ecosystem-based management
  - Decisions based on independent science
  - Low risk to ecological integrity as guiding principle

- All we had to do was to summarise what "independent science" documented as "low risk" to ecological integrity

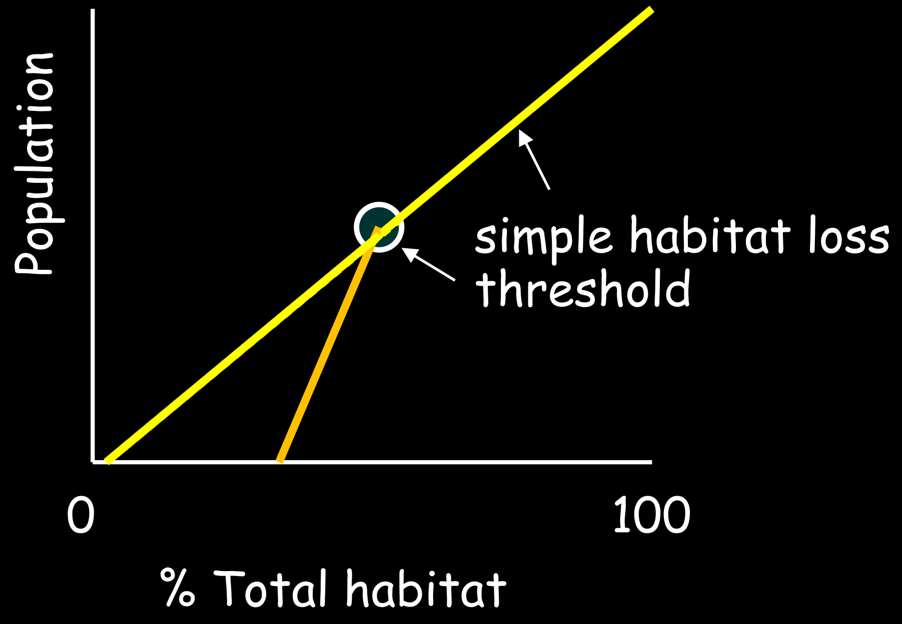
Used thresholds to ask "How much is enough"

- How much of each ecosystem is needed to maintain ecological integrity?
- Insufficient knowledge
- Meta-analysis of published studies on ecological thresholds related to habitat amount

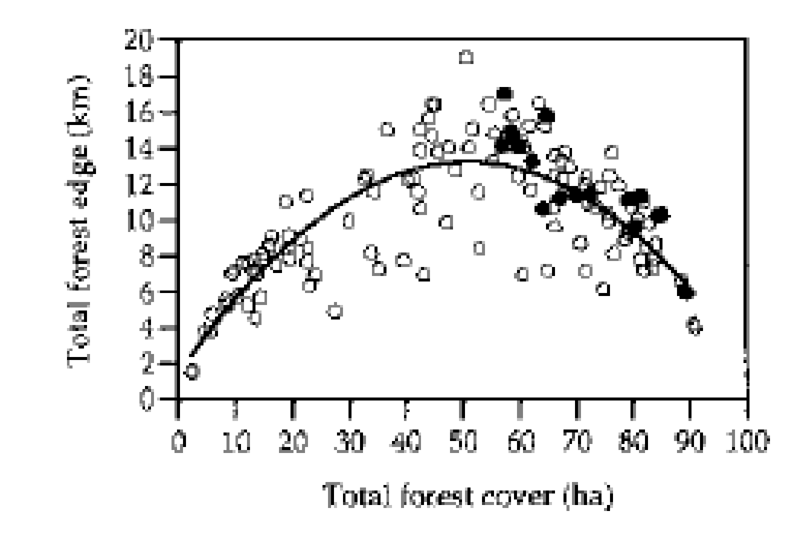
Habitat thresholds

- Assume: thresholds indicate potential change to ecological function
  - (e.g., connectivity, predator/prey, pollination…)
- Indicate where risk and uncertainty increases

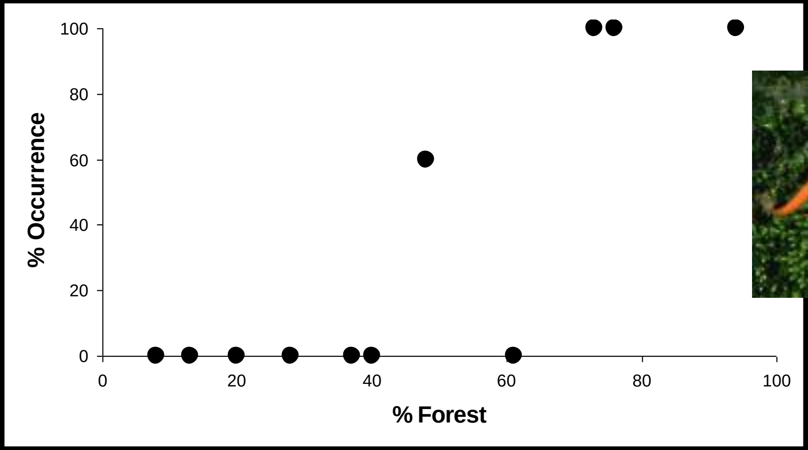
- Change in the rate of loss



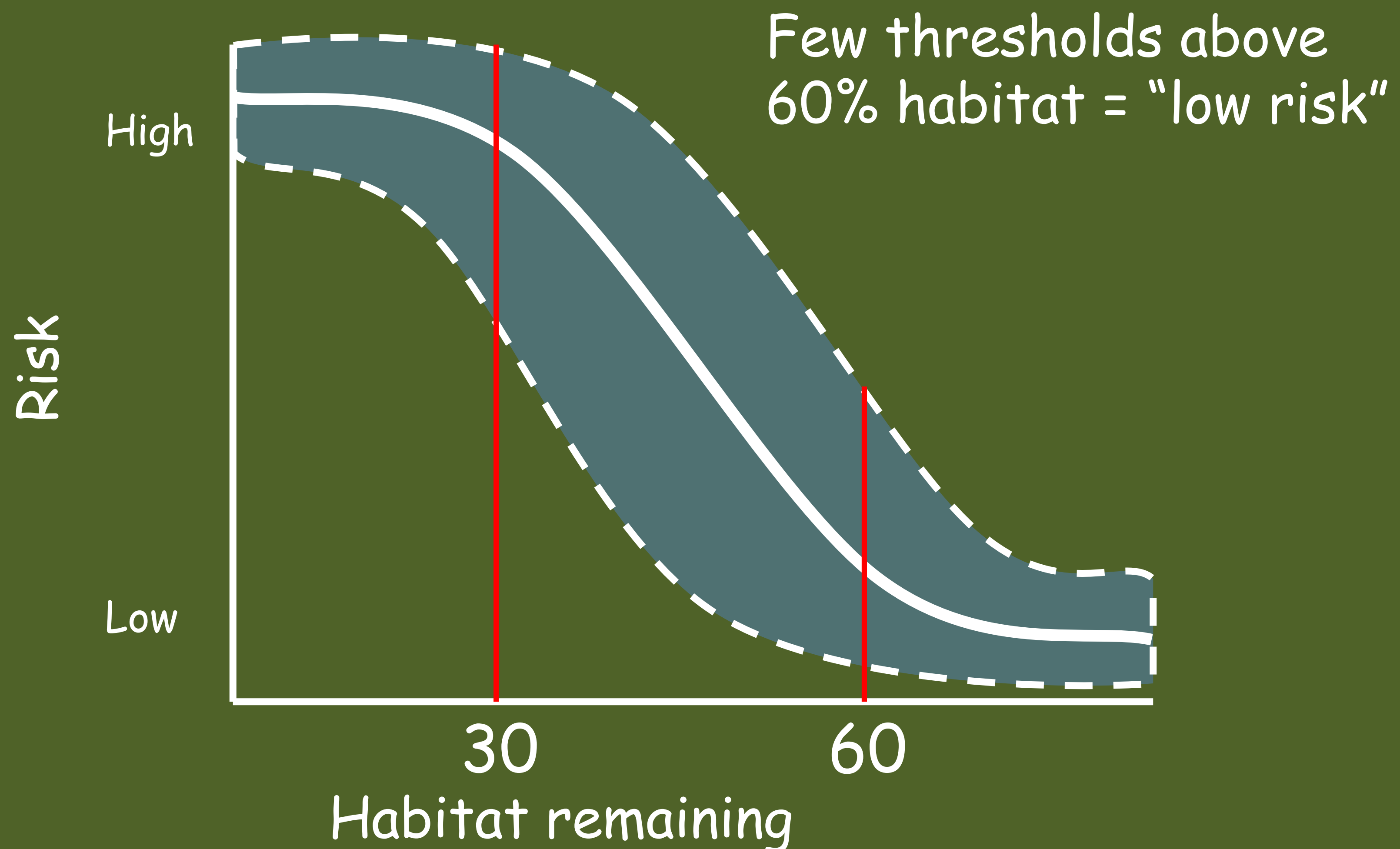
Sample studies



- No occupancy below a threshold
  - E.g. bay-breasted warbler (Drolet et al. 1999); red-spotted newt (Gibbs 1998)



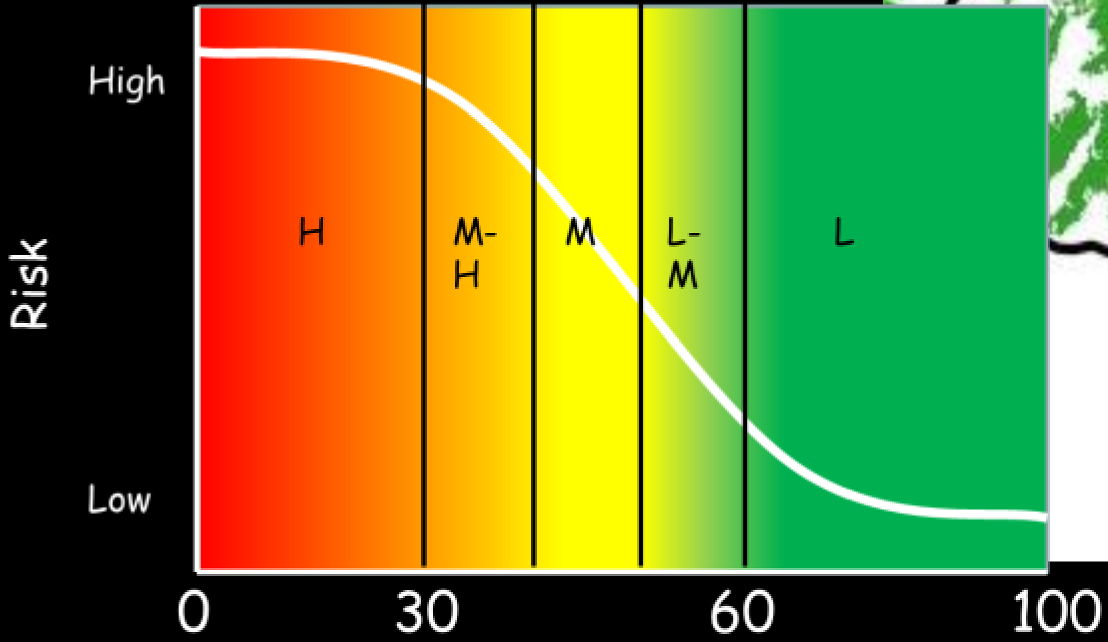
Risk to ecological integrity

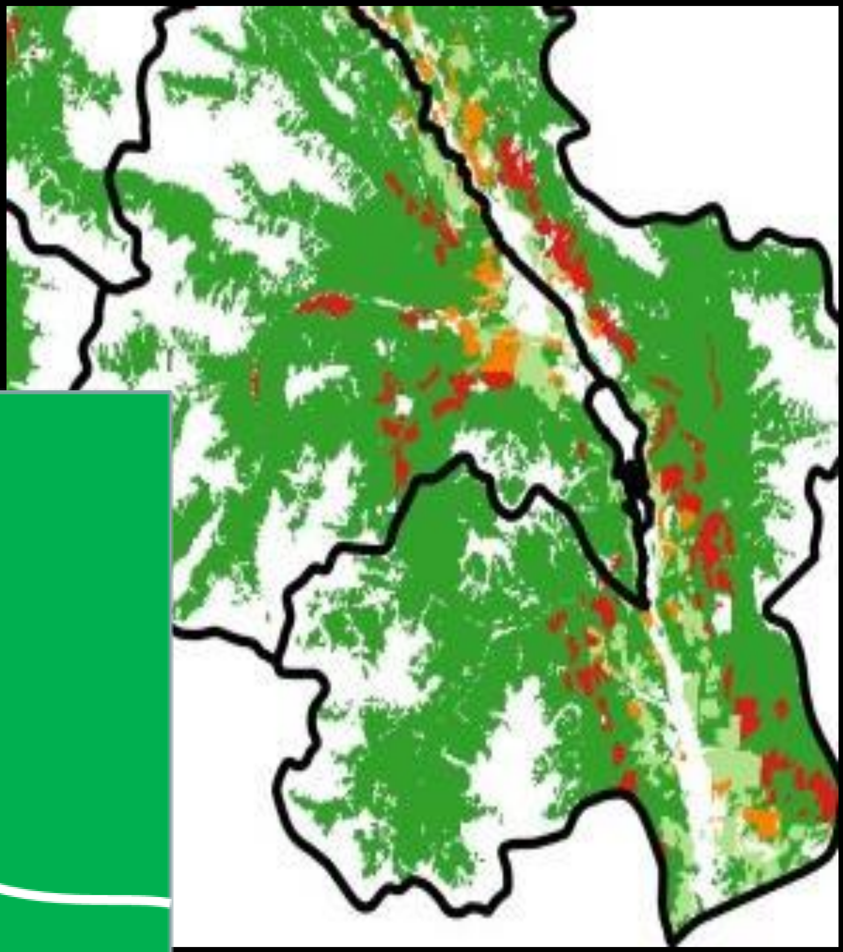


Price K, Roburn A, MacKinnon A 2009 Ecosystem-based management in the Great Bear Rainforest. Forest Ecology and Management 258:495-503.

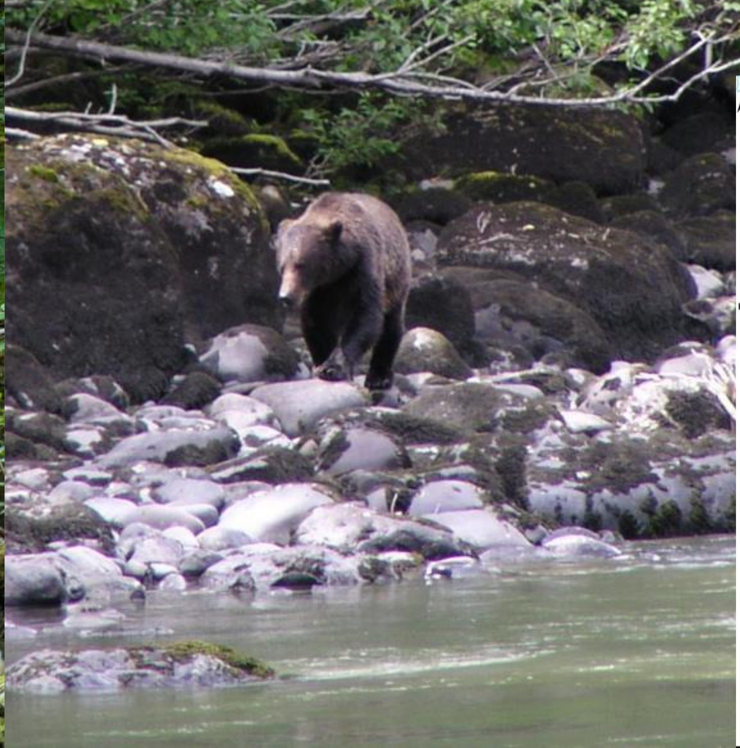
Use thresholds to map risk

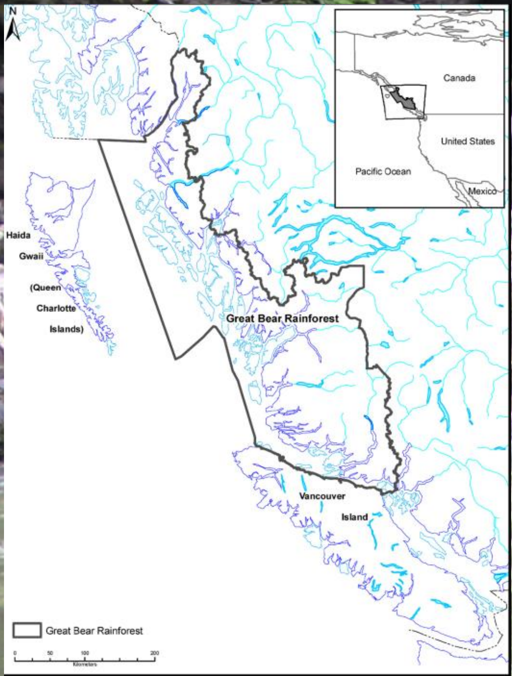
- High productivity ecosystems are at high risk (Gitanyow)



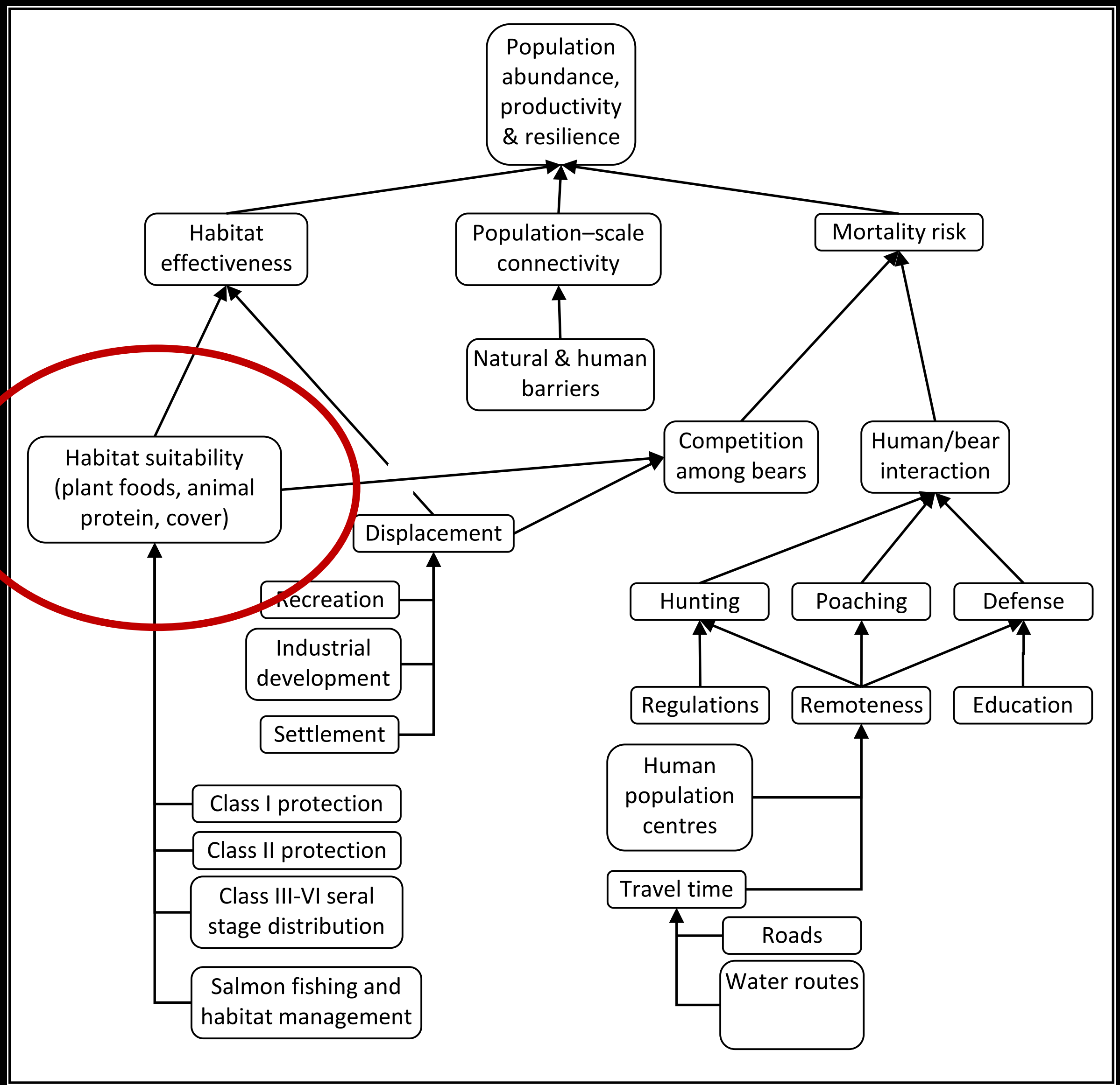


Grizzly Bears in the Great Bear Rainforest (EBM Area)





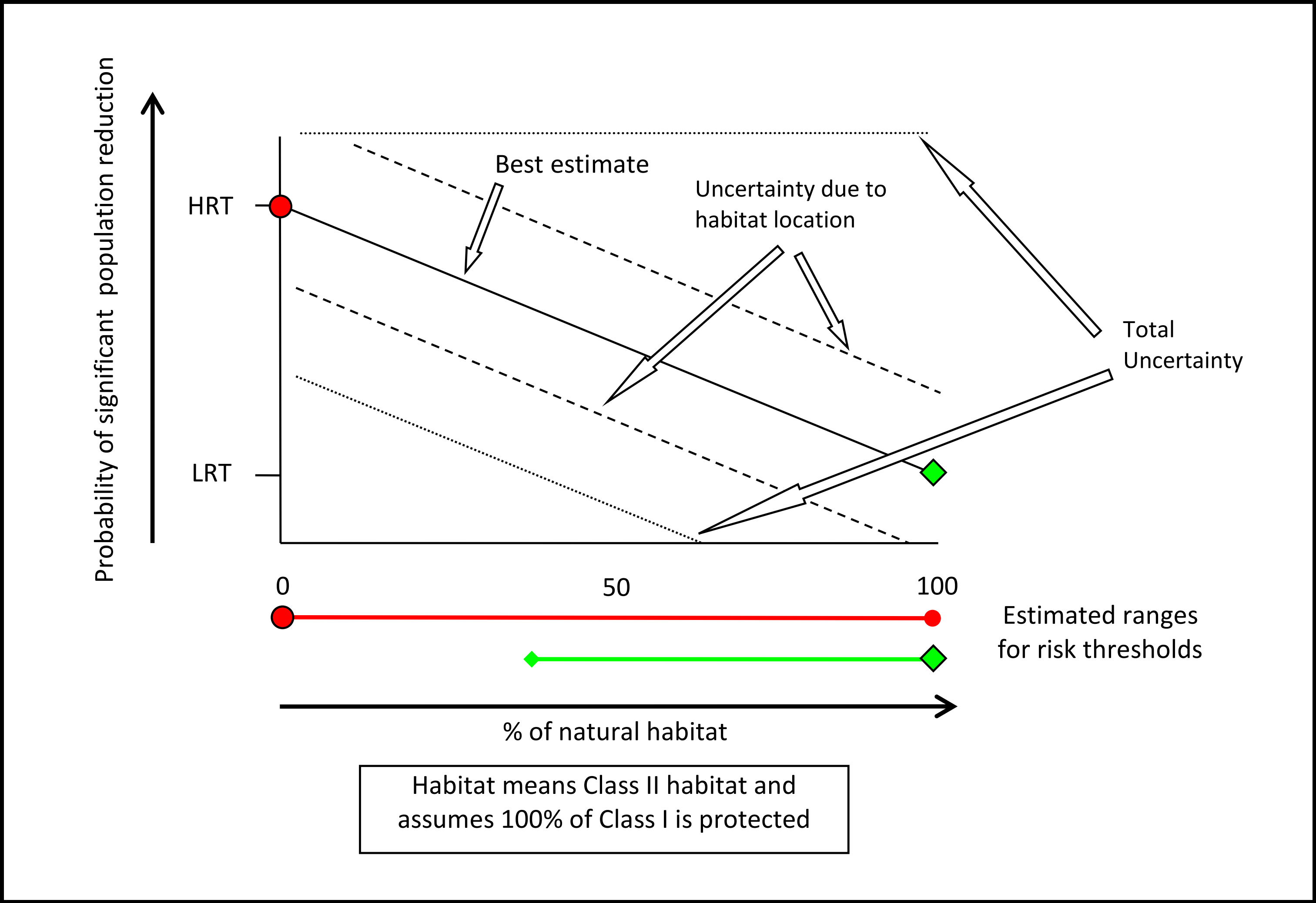
Conceptual Model



Pre-defined Thresholds

- Low Risk Threshold
  - Population deviates from natural abundance beyond threshold
- High Risk Threshold
  - Population loses viability beyond threshold

Risk Hypothesis



Sources of Uncertainty

Source of Uncertainty	Effect on risk
Improved habitat maps	↓↑
Poor protection of Class I	↑↑
Best or worst Class II habitat selected for protection	↓↑
Better or worse seral stage distribution	↓↑
Substantial increase in human-bear interaction (access)	↑↑↑↑
Increased habitat fragmentation at population scale	?
Declining salmon stocks	↑↑↑
Social interactions among bears that increases mortality	↑↑
Climate Change	?

Habitat is much less influential than access!!
Knowledge hampered by process.

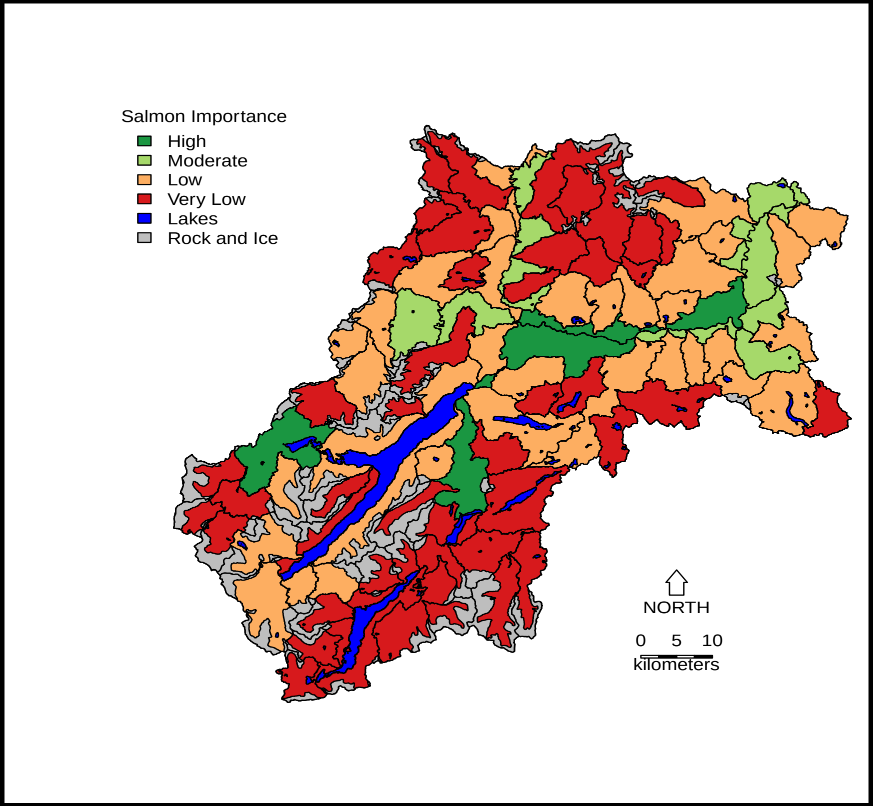
Salmon in the Morice Watershed

Core Team: Don Morgan, MoE Research
Dave Daust, Andrew Fall

Technical Experts: Scott Jackson, MoE, Matt Sakals & Dave Wilford FLNRO, Greg Utzig, Martin Carver

Context

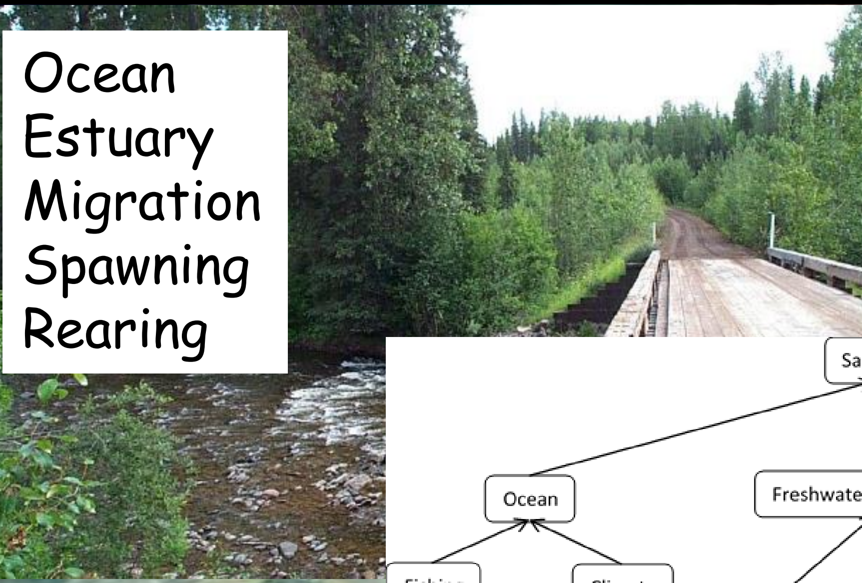
Habitat

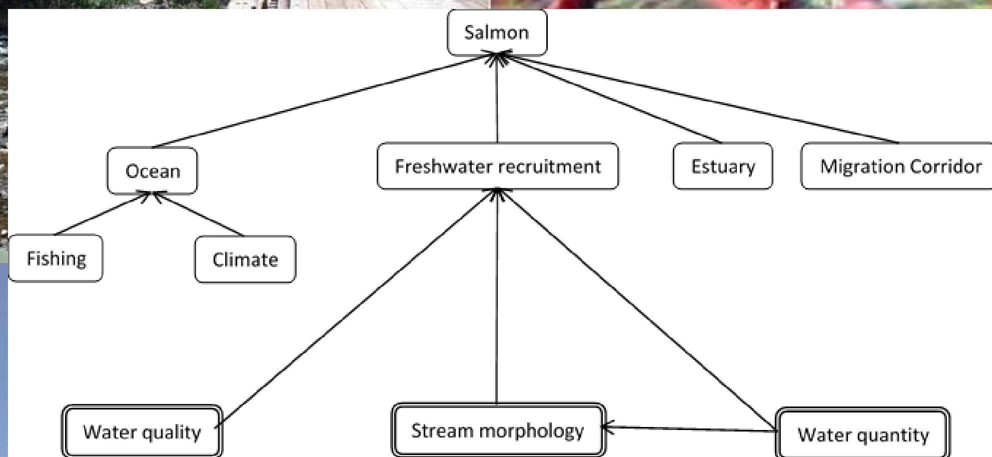


Development

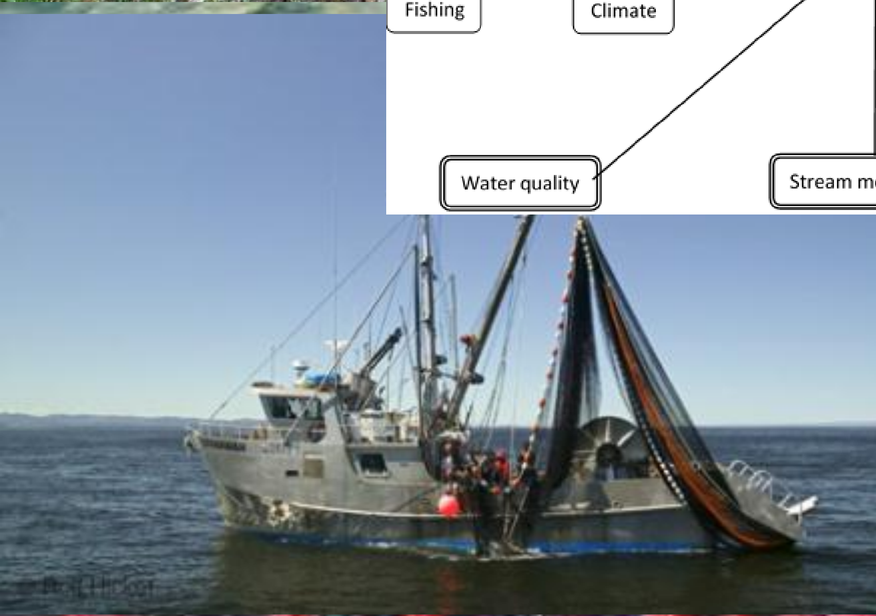
Full Conceptual Model

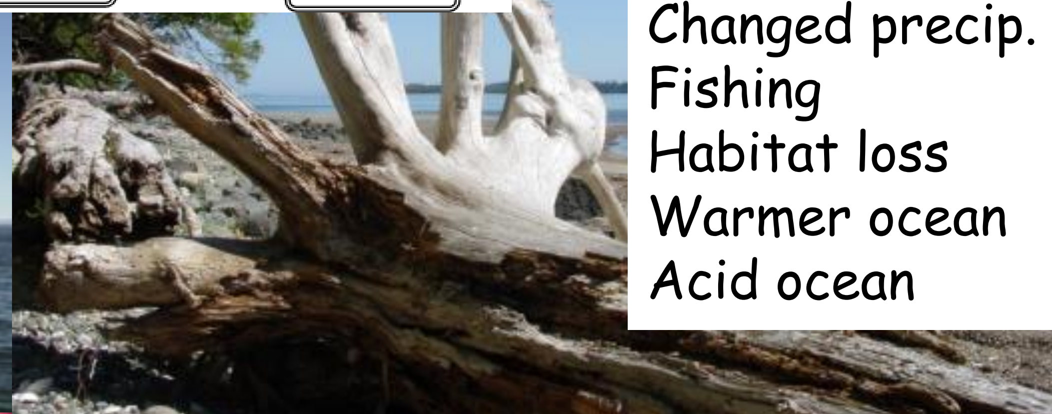
Ocean
Estuary
Migration
Spawning
Rearing



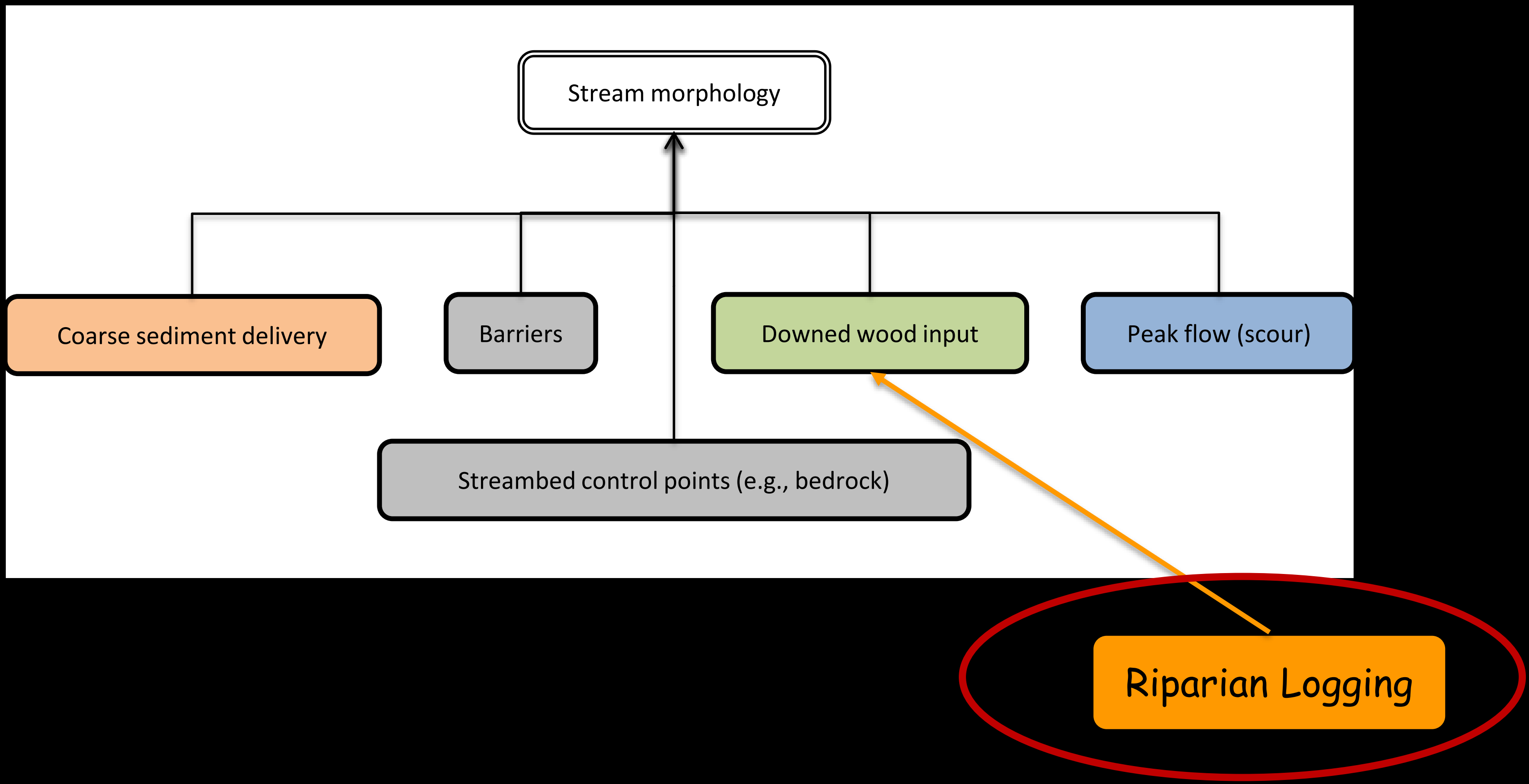


Urban
Industrial
Agriculture
Roads
Logging
Pollution
Warmer air
Melting glaciers
Changed precip.
Fishing
Habitat loss
Warmer ocean
Acid ocean

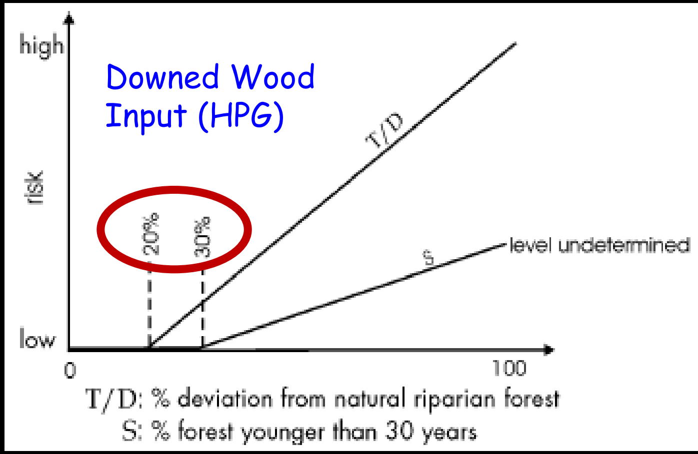




Stream Morphology

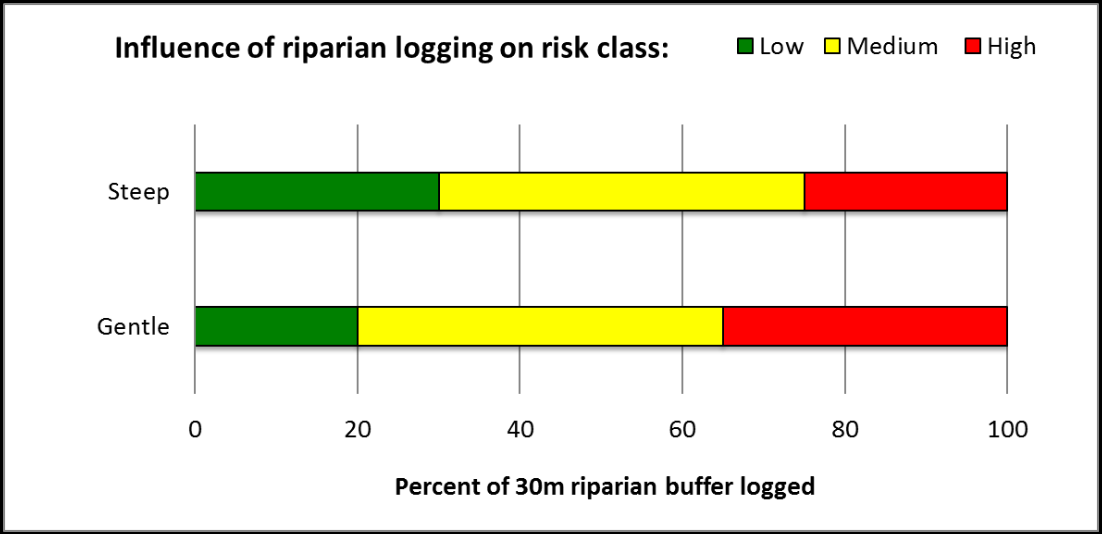


Simple indicator calculation: riparian logging

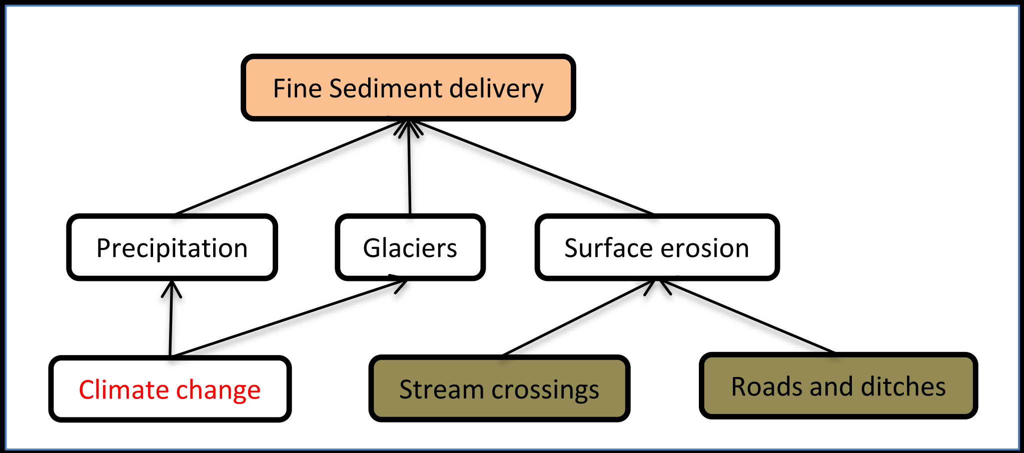


Risk based on thresholds from existing Assessments

Based on Hydroriparian Planning Guide



Complex indicator calculation: fine sediment model



Sediment model: precipitation, glaciers, water flow and roads

Risk based on BCMELP Ambient Water Quality Guidelines for Turbidity

Challenge 1: complex concept map

- One indicator, many effects
  - E.g., riparian logging → downed wood, shade, streambank erosion, litter-fall
- Many indicators, one effect
  - E.g., air temp + glacier melt + riparian logging + ditch pools → water temperature

Solution: choose carefully

- One indicator, many effects
  - E.g., riparian logging → downed wood, shade, streambank erosion, litter-fall
  - Pick one or two most sensitive

- Many indicators, one effect
  - E.g., air temp + glacier melt + riparian logging + ditch pools → water temperature
  - Pick most influential or add if possible

Challenge 2: Cumulative Impacts

- How do we accumulate impacts from several indicators?

Solution: math

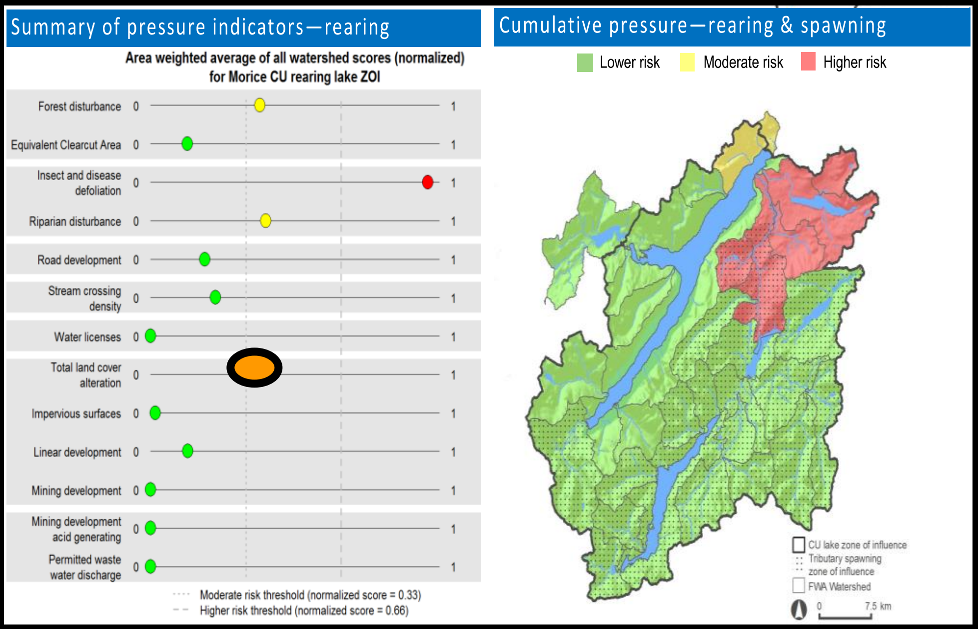
Need

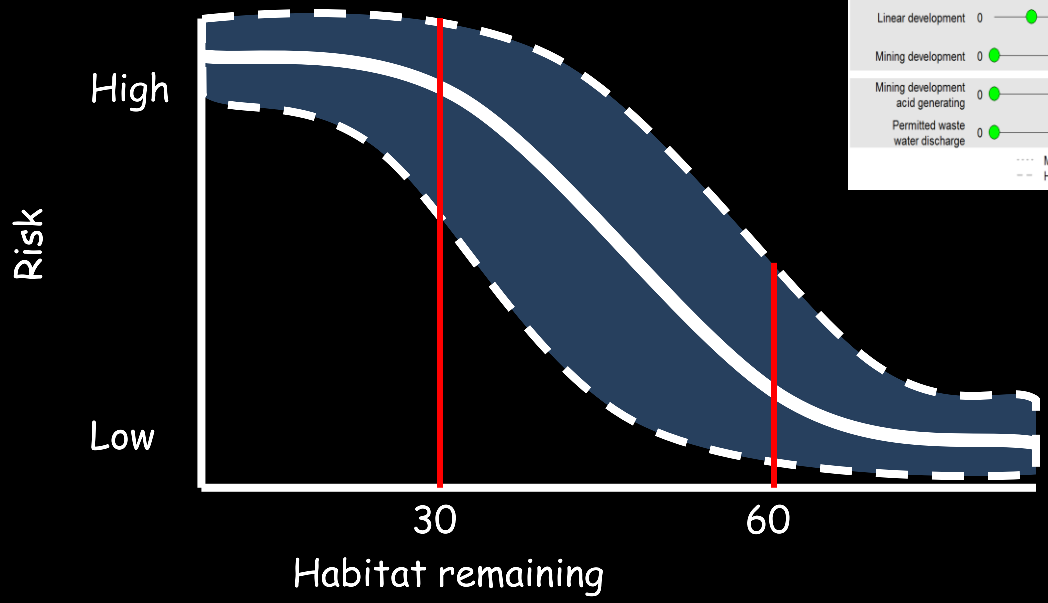
- Same risk definition for all indicators
  - E.g., probability of salmon decline
- Indicator Independence
  - I.e., different pathways of influence

Cumulative risk = 1 – (avoiding all risks)

Solution: meta-indicator

http://skeenasalmonprogram.ca
PSF and ESSA





Total land cover alteration

Challenge 3: relying on existing curves

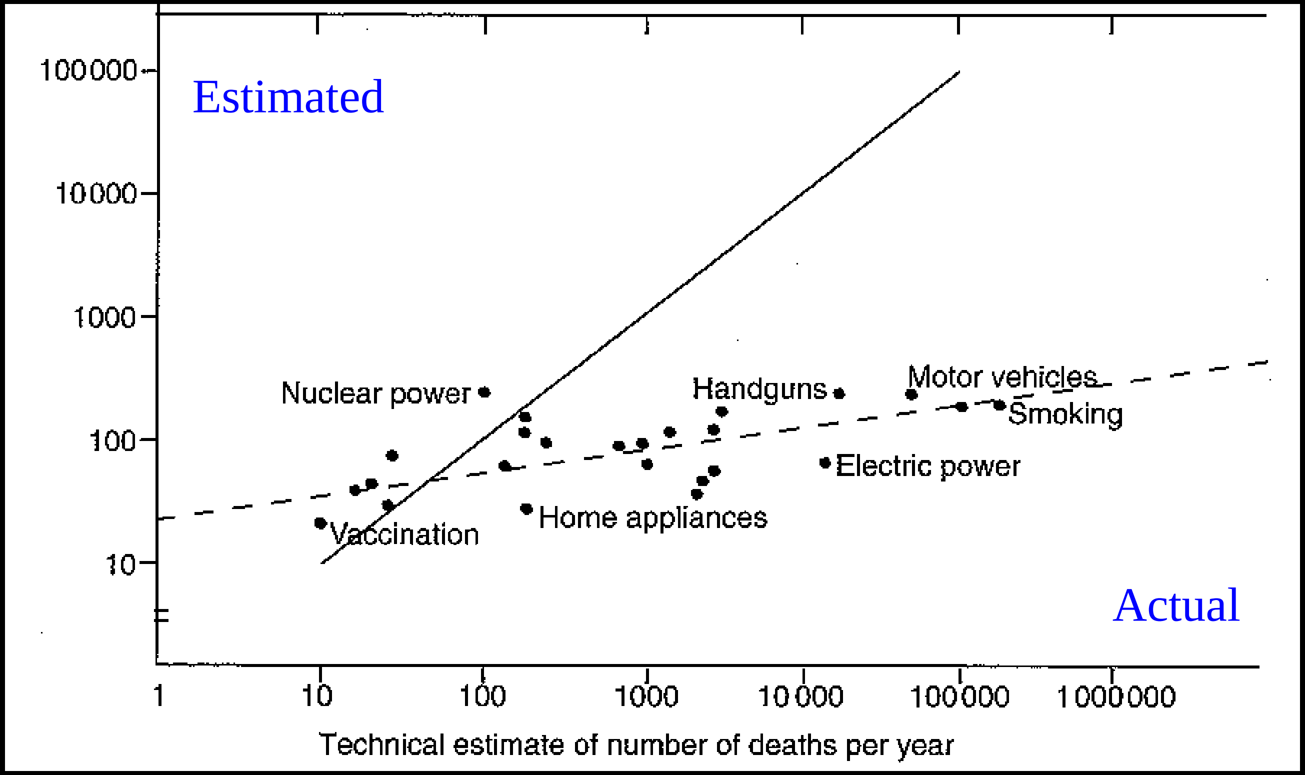
E.g., Watershed Assessment Procedure

- Effort, experts and literature not recorded
- Risk is not clearly defined

Solution

- Compare assessments
- Contact original experts
- Back up with literature

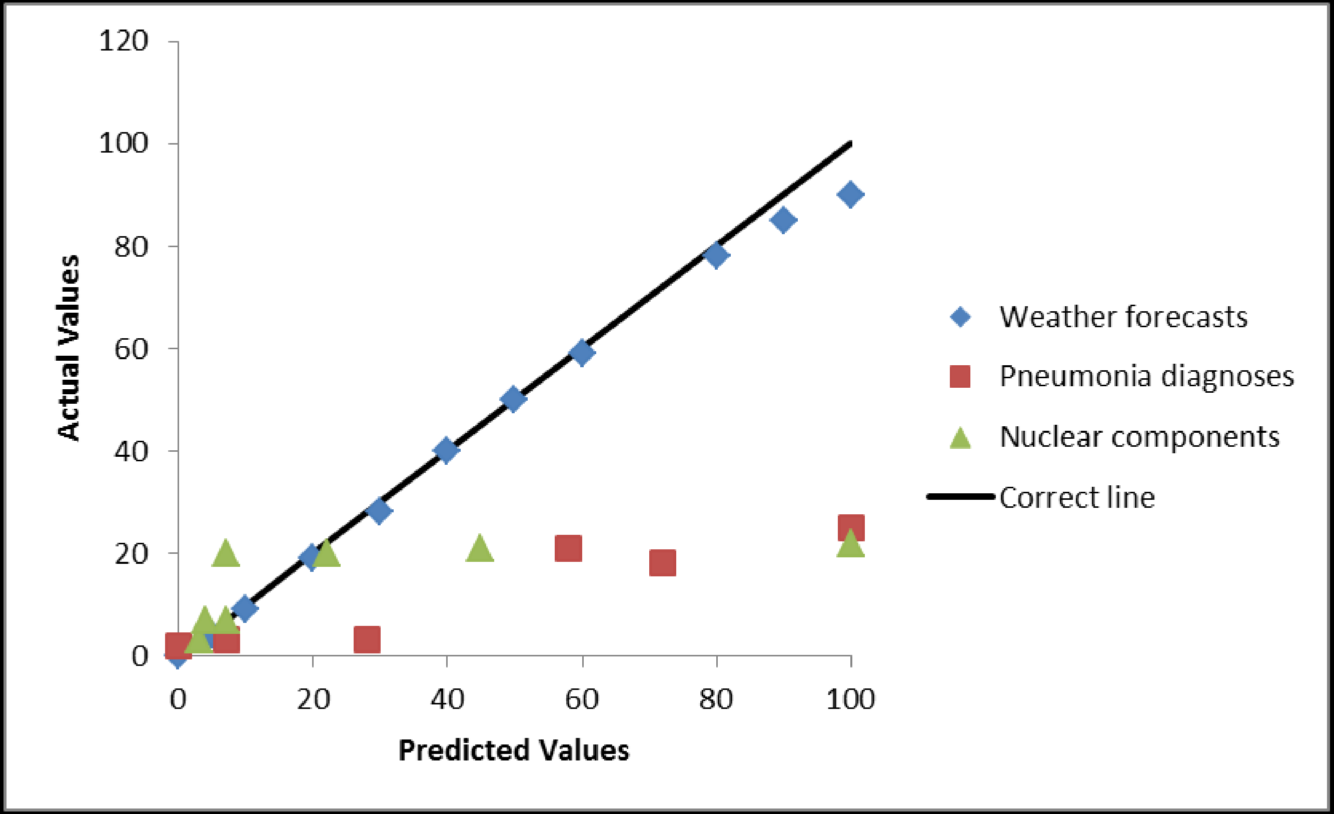
Challenge 4: we're bad at estimating risk



- Underestimate big risks; overestimate small ones

Slovic et al 1979 and Fischhoff et al 1982 in Burgman M 2005

Experts aren't great either



Weather forecasters did better than doctors or engineers

Burgman M 2005 Fig 4.14

Solution: debate and transparency

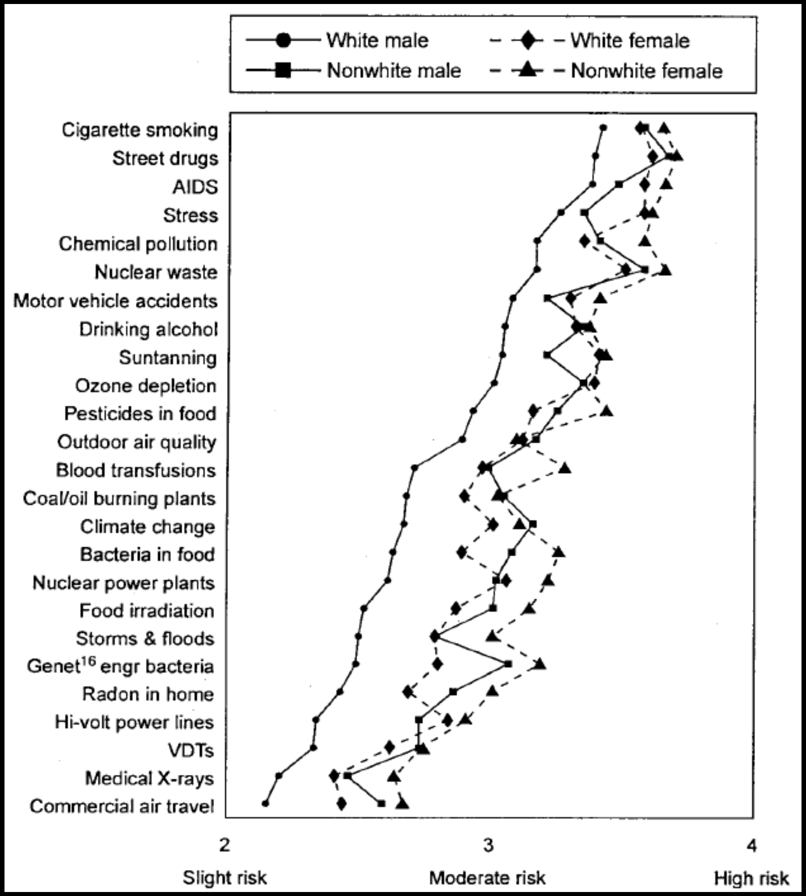
- Workshops, multiple perspectives
- External reviews
- Explicit risk curves and uncertainty
- Data where possible (MONITOR)
- Reputable experts

BIG challenge

- Informing decision-makers
- General solution: engage them from the start
- But…

Challenge: Risk Takers

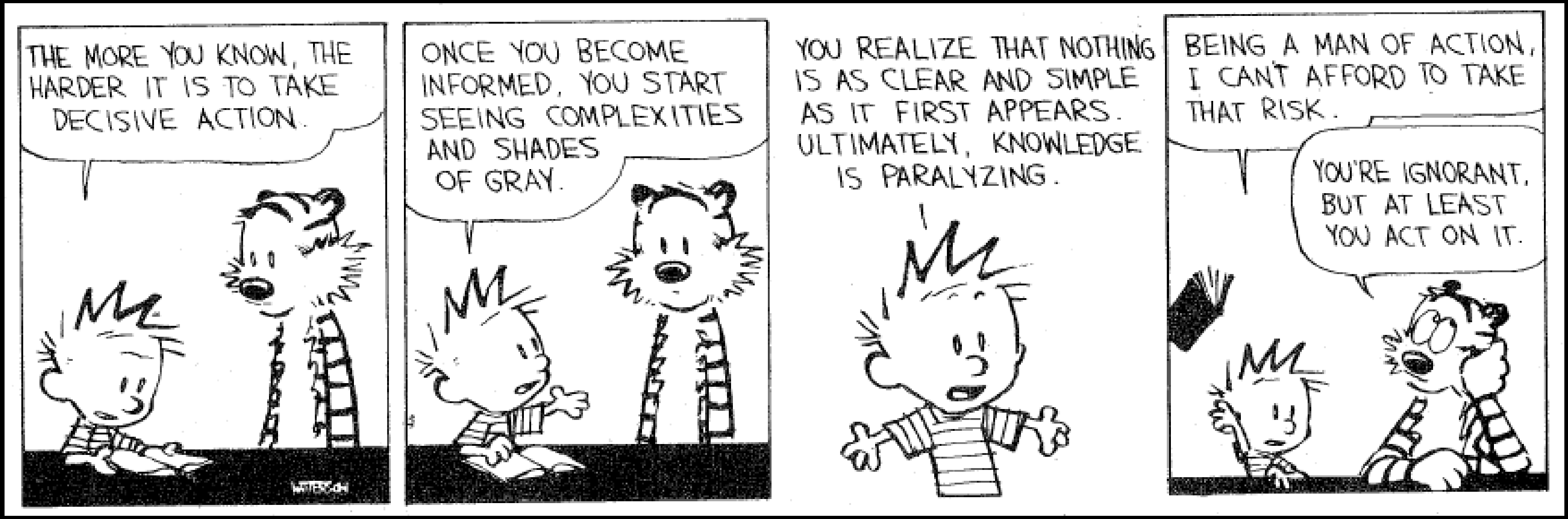
- White males perceive lower risk
- 30% of white males judge risks to be very low
- Tend to be
  - Well educated
  - Wealthy
  - Politically conservative



Solution: Don't let white males make decisions?
Clearly described values and knowledge

Flynn et al. 1994 cited in Finucane et al. 2000. Gender, race and perceived risk: the white male effect. Healthy risks and society 2: 159-172

Challenge: Decisive Leadership



Arrogance + ignorance = poor decisions

Calvin and Hobbes Bill Watterson

Swanson Environmental Strategies

Thirty Years of Experience in Environmental Services

How Much is Too Much?

Effects-Based versus Stressor-Based Benchmarks and Thresholds and Some Examples from the Elk Valley in the East Kootenays

www.swansonenviro.ca

Outline

1. Effects-based versus stressor-based indicators, thresholds and benchmarks

2. Thresholds, Benchmarks and Targets for the Elk Valley

3. The Importance of Collaboration in the Development of Thresholds and Benchmarks

Start with Indicators*

Indicators: Surrogate measures used to represent, monitor, or assess condition, state, change in or stress to a Valued Component

"Tell us something about something for some reason"

Measurement → something
Valued Component → something
Management, Monitoring, Research → some reason

* Adapted from Presentation by Bram Noble

Two Types of Indicators

Outcome (i.e. effects-based):

- Provide measure of the effects on VCs
  - e.g. fish abundance

Input (i.e. stressor-based):

- Provide measure of the condition of / trends in stress, disturbance, or risk to the VCs
  - E.g. % disturbed riparian area

Characteristic of Good Indicators

"Good indicators for cumulative effects must be indicative of the cause(s) of change/sources of stress, <u>not only the existence of change".</u>

Bram Noble

Is this ↓ related to this? ↓

Some Definitions

- **Thresholds** are based on **benchmarks** established from laboratory testing or field observations of past or current "reference conditions" or trends – thus they are knowledge based.
- **Targets** incorporate desired state or condition of a VC. Targets are established as a matter of policy or as legal requirements, and thus must be met.

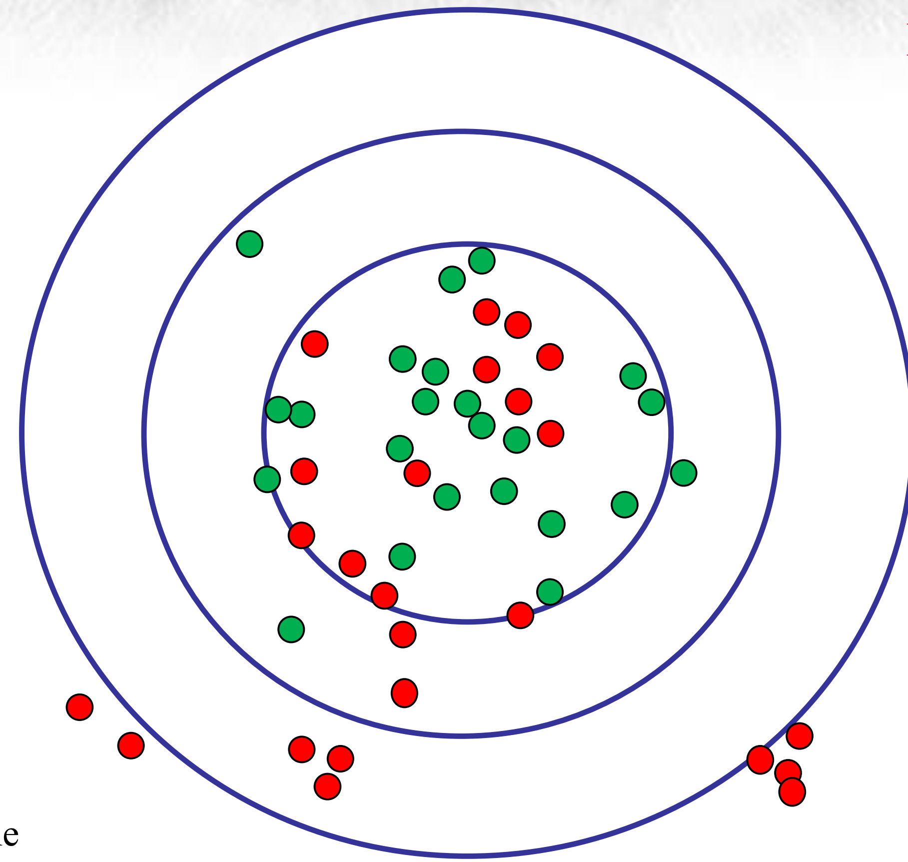
Effects-Based vs Stressor-Based Thresholds

- Which are most useful to decision-makers?
- Which are the most well understood?
- Which are useful across different types of human activities?
- Which are reliable over time?

Effect Threshold:

Benthic Invertebrate Community Structure

Green dots = reference
Red dots = mine-exposed

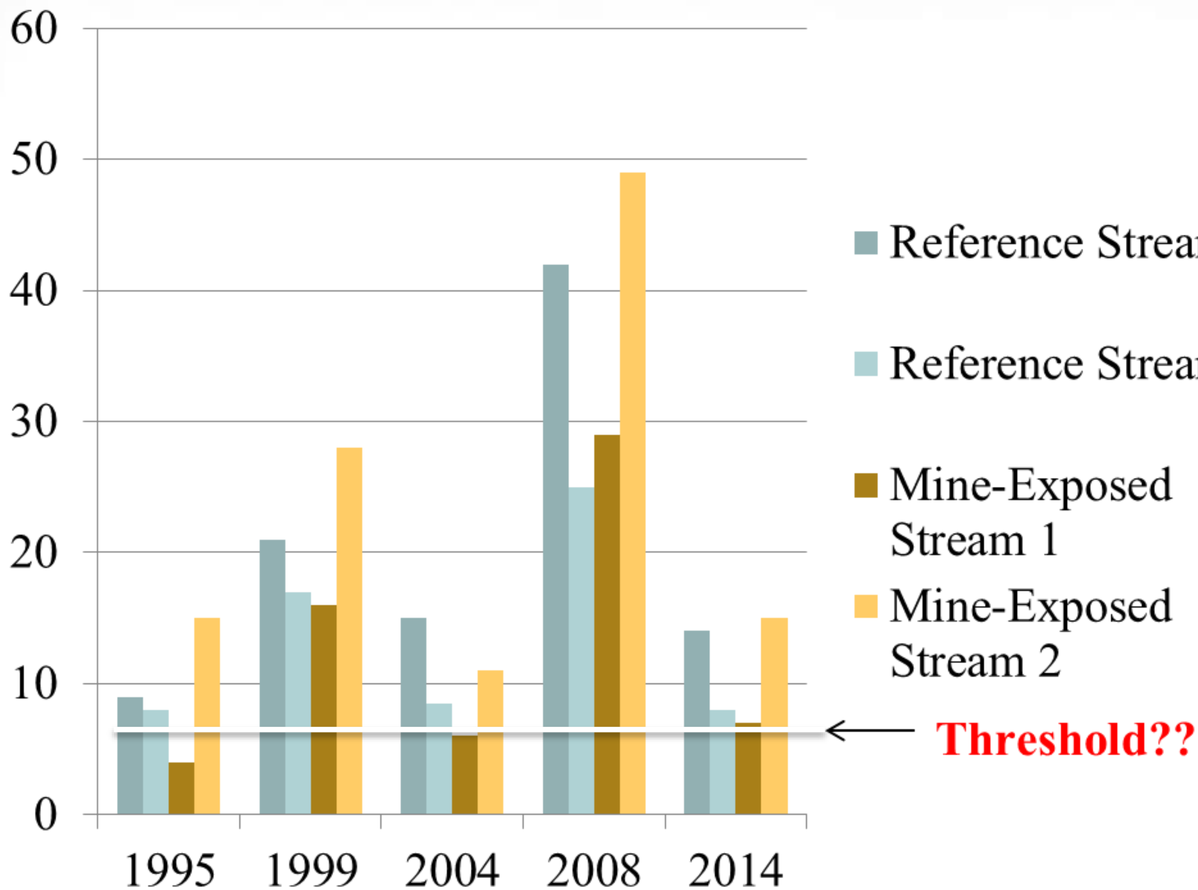


Threshold: 90th percentile? 99th percentile?

Moving outward from the centre circle, sampling sites are increasingly divergent from the reference condition

Effect Threshold:

Number of Westslope Cutthroat Trout > 300 mm/km*



How low is too low?

Natural variability versus effects?

*Hypothetical data; not from actual studies

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Pros and Cons of Effects-Based Thresholds

Pros	Cons
• Meaningful because they are direct measurements of the valued component • Can integrate effects across many human activities	• Not as useful to decision-makers because there may be prolonged scientific debate due to poorly-understood cause/effect linkages • Data intensive and can be highly specific to location • "After-the-Fact"

Stress Indicators:
Watershed Habitat*

Habitat Indicator	Moderate Risk Benchmark	High Risk Benchmark
Road density for entire watershed	0.6 km/km^2	1.2 km/km^2
Road density less than 100 m from a stream	0.08 km/km^2	0.16 km/km^2
Stream crossing density (interior watersheds)	0.16/km^2	0.32/km^2
Stream crossing density (coastal watersheds)	0.40/km^2	0.80/km^2
Portion of fish-bearing streams logged	0.10 km/km	0.20 km/km
Peak flow index (proportion of basin that has been clear-cut)	0.12	0.24

* From Porter et al. 2015 Watershed Status Evaluation: An Assessment of 71 Watersheds Meeting BC's Fisheries Sensitive Watershed Criteria

Pros and Cons of Stressor-Based Thresholds

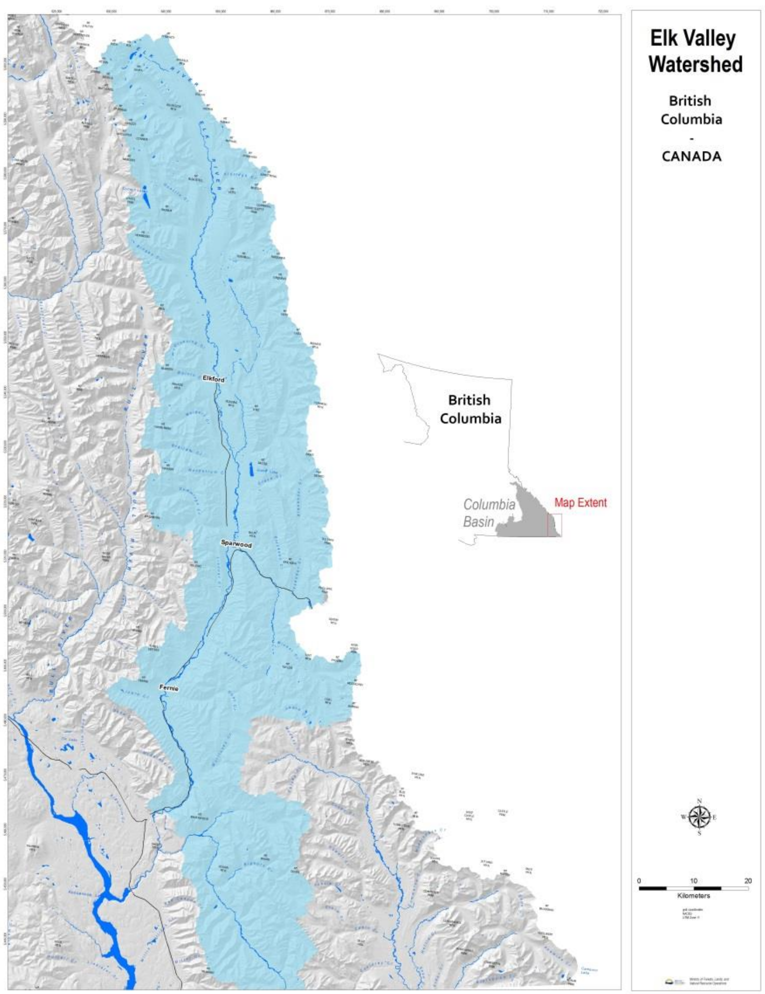
Pros

- Useful to decision-makers because easily linked to land use management
- Usually well understood and can be efficiently measured
- Reliable over time –thus useful for examining trends in accumulated stress

Cons

- Not always applicable across several human activities
- Correlations with effects can be complex and confounded by other variables
- Don't capture total effects, only the stressors we choose to measure

Elk Valley Cumulative Effects Management Framework (CEMF)



"Provide a practical, workable framework that supports decisions related to assessment, mitigation and management of cumulative effects in the Elk Valley"

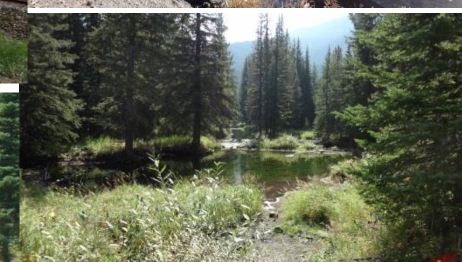
www.elkvalleycemf.com

CEMF Riparian Habitat Indicators

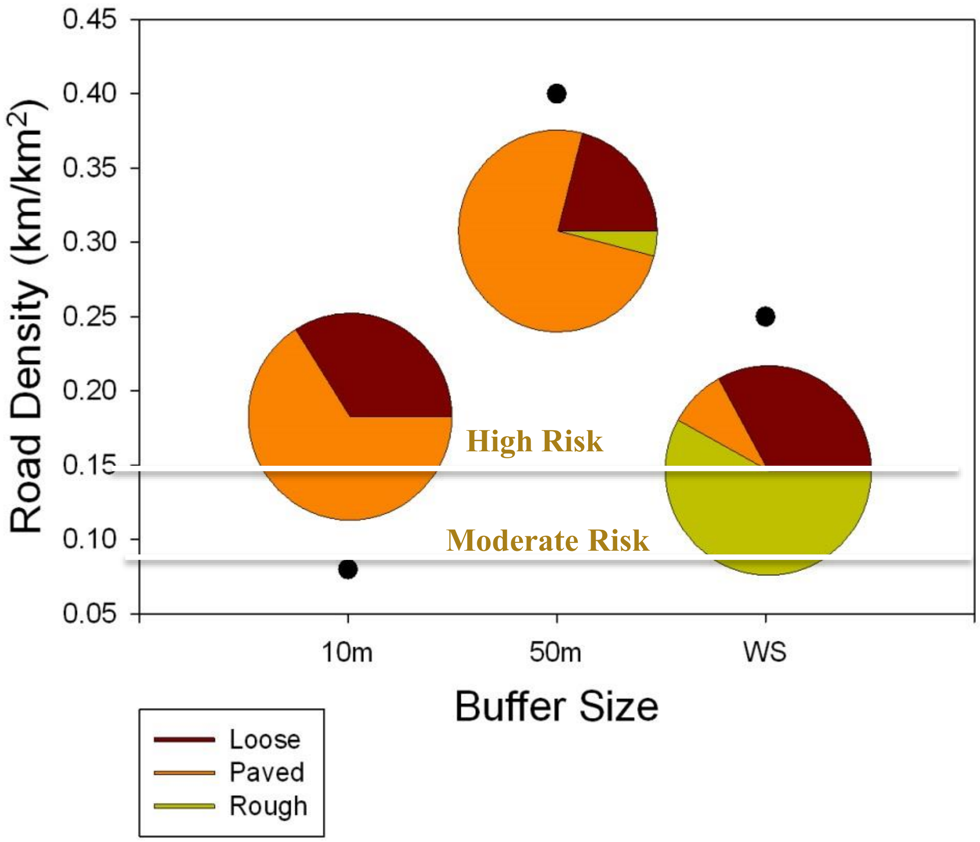
1. Road density within riparian buffers
2. Disturbance (logging, fire history, etc.)
3. Stream crossings and cattle access points





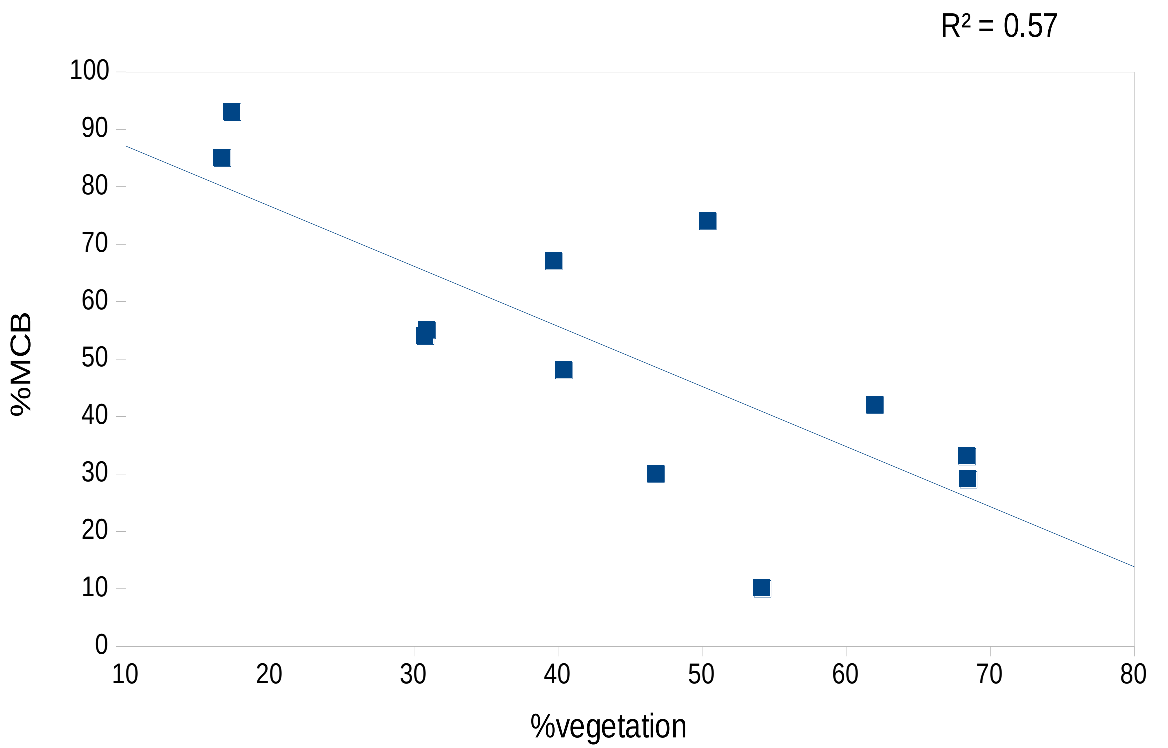
Road Density in the Michel Creek Watershed



Road density and classification for 10m buffer, 50 m buffer and watershed. The black dots represent road density in km/km^2 and the pie charts show the distribution of road type.

Road density within 50m of Michel Creek as well as for the entire watershed exceeded the "high risk" threshold presented in Porter et al. 2015

Retrospective Channel Morphology Assessment



More riparian vegetation = better channel condition

Example of Targets: The Elk Valley Water Quality Plan

Teck Coal Ltd. was required by BC MOE to develop the plan in consultation with regulators, the Ktunaxa and the public. The plan sets water quality targets for 5 water quality parameters, including selenium. The plan was adopted by the Province and Ktunaxa as policy and as such the targets must be met by Teck and all others seeking permits

Selenium Targets from the Elk Valley Water Quality Plan

Fish Species	Benchmark (10% effect)	Short-term Target			Long-Term Target		
		Upper Fording	Lower Fording	Elk	Upper Fording	Elk	Lake Koocanusa
Cutthroat Trout	70	63 (2019)	51 (2019)	19 (2023)	57 (2022)	19 (2023)	2 (2014)
Brown Trout	19						

Do Water Quality Targets Adequately Address Cumulative Effects in the Elk River?

NO, because cumulative stressors go beyond 5 parameters

- Land use (CEMF indicator)
- Riparian habitat degradation (CEMF VC with a suite of indicators)
- Effects on stream flow, channel morphology, erosion, landslides, climate change (CEMF indicators)
- Effects of recreational fishing
- Municipal discharges, etc.

The Importance of Collaboration

If there is:

- No meaningful discussion
  - Causing violation of interests or values
- Perceived or real unfairness
- Low trust

There can be deadlock when trying to deal with cumulative effects

Collaboration Regarding Thresholds and Targets

Accessible science

Inclusive discussion

Open dialogue about acceptable risk and how to deal with uncertainty

Can contribute to broadly-accepted thresholds and targets

Principles of Good Collaboration

Transparency – how did we derive benchmarks, thresholds and targets?

Engagement - did we engage early and often regarding how much is too much?

Accountability – is it clear who is accountable for which decisions?

Policy Coherence – is there consistency across levels of government and are policies applied uniformly across the province?

Discussion

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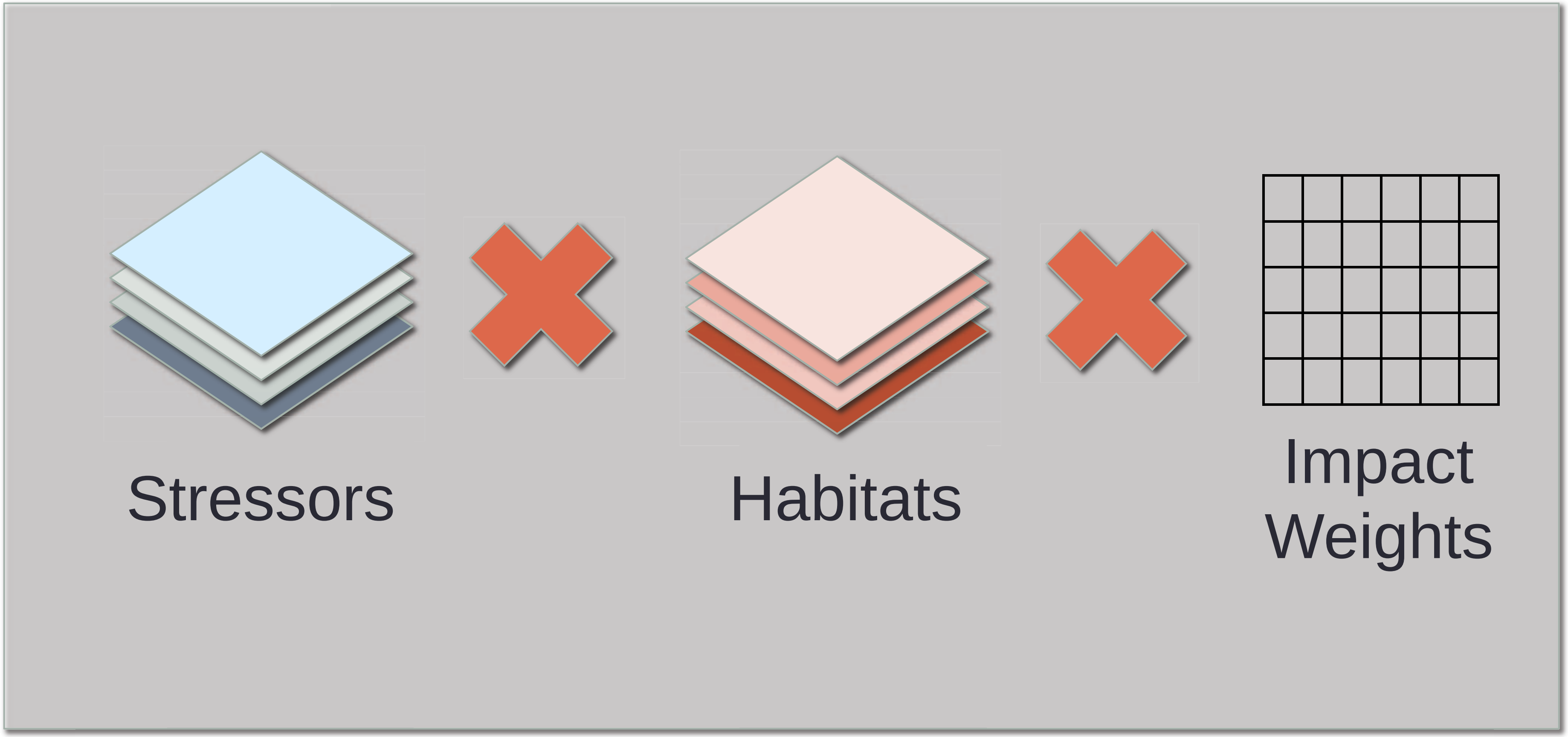
SESSION III PRESENTATIONS – SPATIAL ANALYSIS

Cumulative Human Impacts in the Bering Strait Region

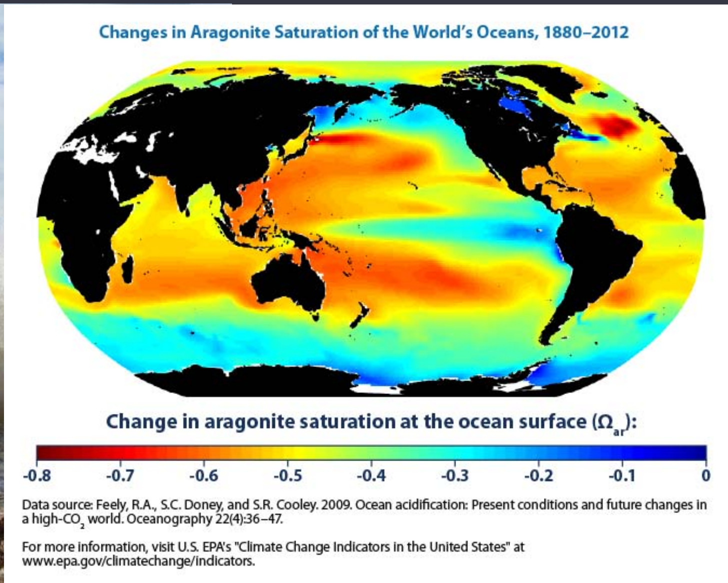
Jamie Afflerbach

National Center for Ecological Analysis and Synthesis
University of California, Santa Barbara

Cumulative Impacts Framework

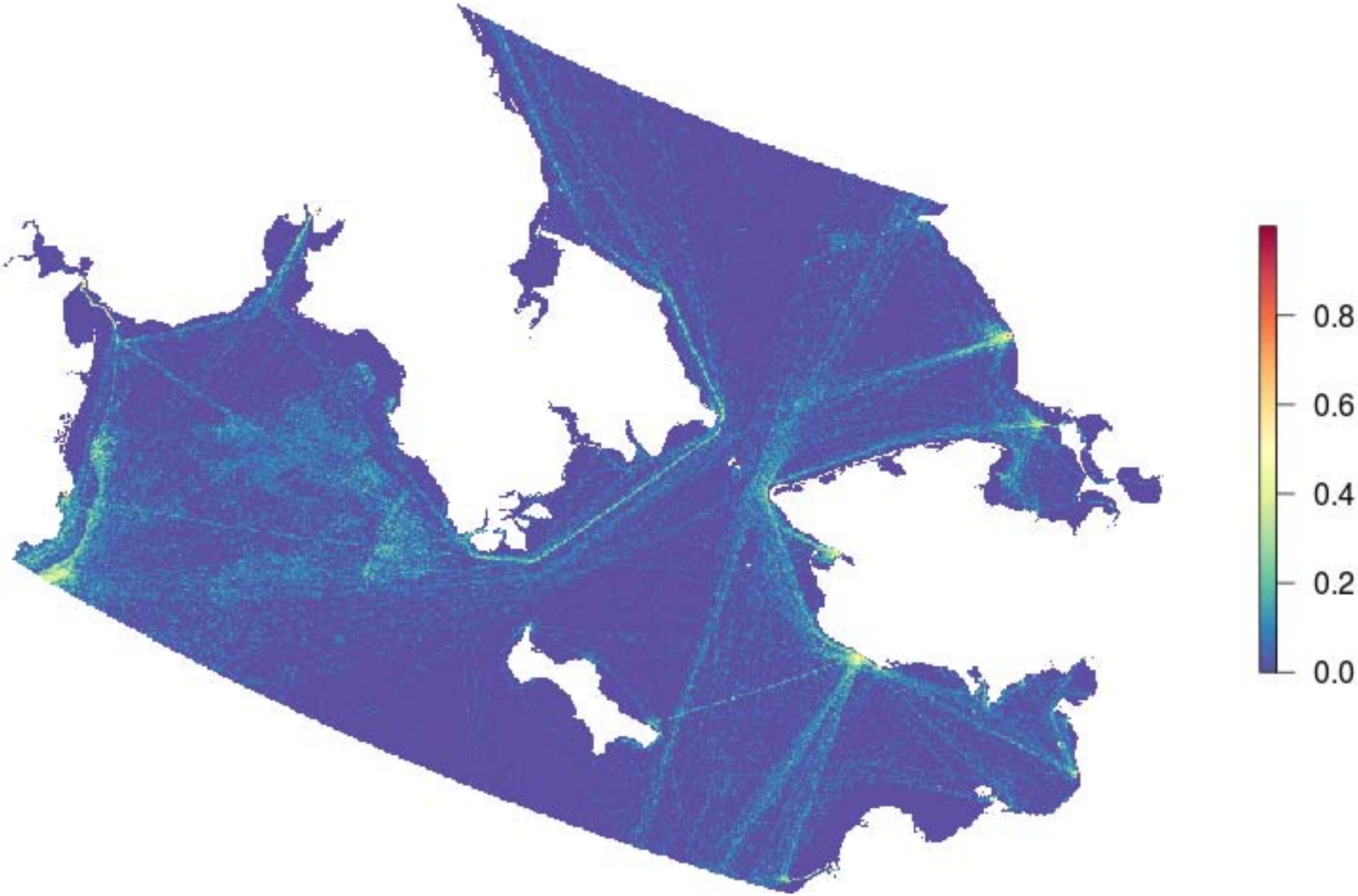



Chukchi
Sea
United States
Bering
Sea
Gulf of
Alaska
Esri, GEBCO, DeLorme, NaturalVue | Esri, GEBCO, IHO-IOC GEBCO, DeLorme, NGS
POWERED BY esri

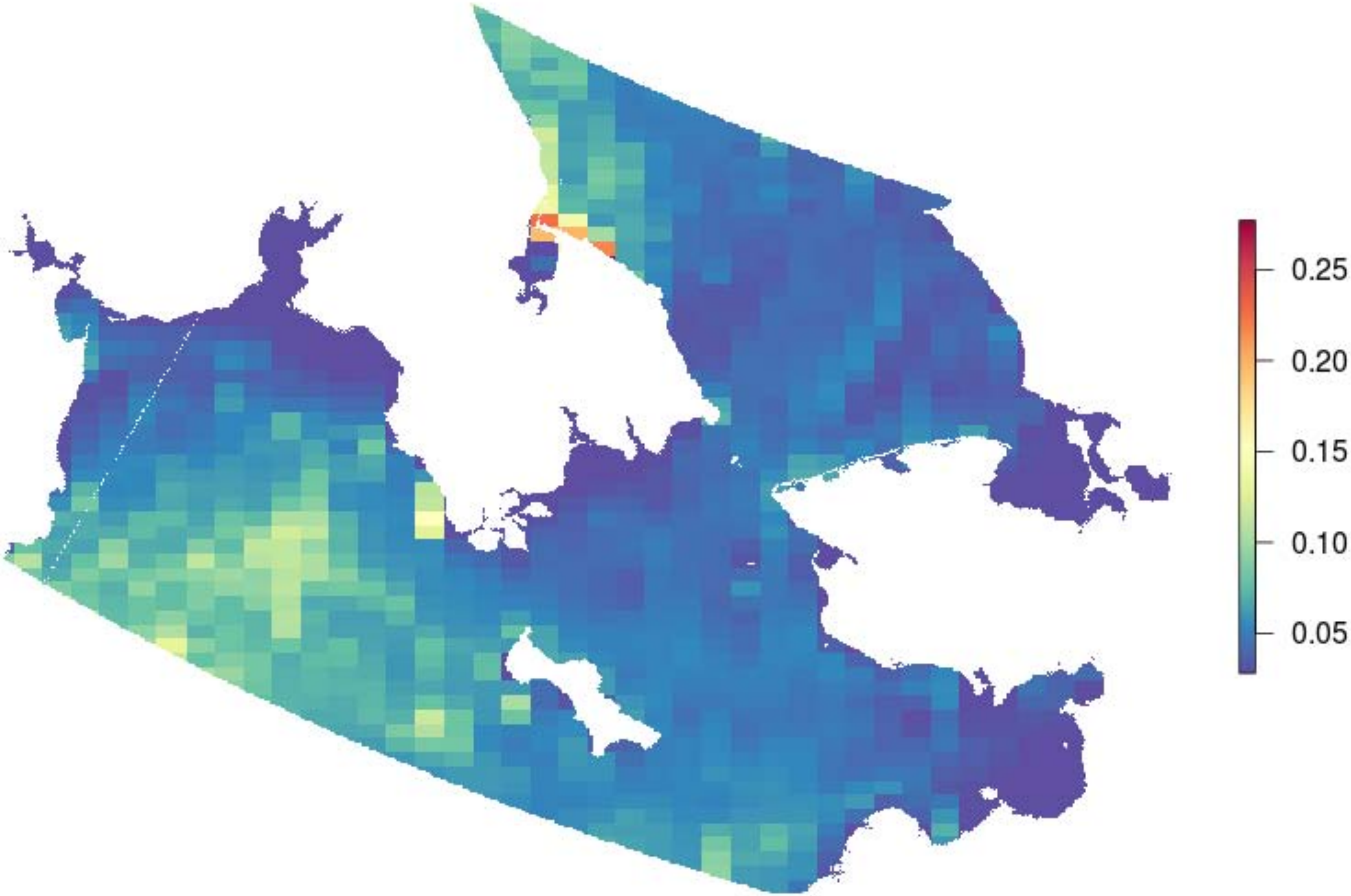

Changes in Aragonite Saturation of the World's Oceans, 1880–2012
Change in aragonite saturation at the ocean surface (Ω_{ar}):
-0.8 -0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0
Data source: Feely, R.A., S.C. Doney, and S.R. Cooley. 2009. Ocean acidification: Present conditions and future changes in a high-CO_2 world. Oceanography 22(4):36–47.
For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climatechange/indicators.


MSC

Shipping



Marine Debris





Number of habitats per cell

Weights

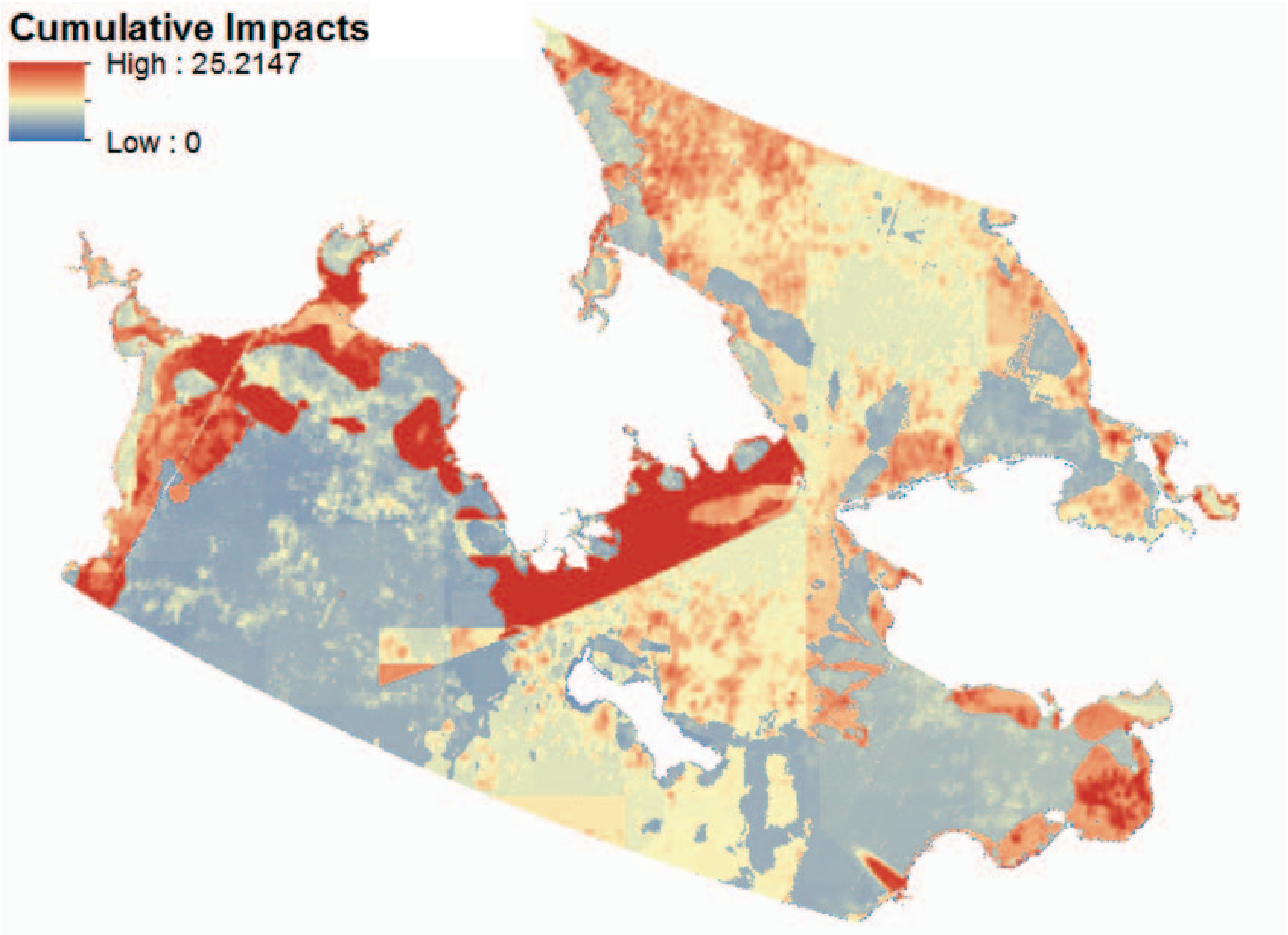
HABITATS

STRESSORS

	Rocky Reef	Hard Shelf	Subtidal soft bottom	Soft Shelf	Surface waters	Deep waters	Beach	Salt Marsh	Rocky Intertidal	Intertidal Mud
Demersal Destructive Fishing	2.9	3.2	2.4	2.5	0	0	0	0	0	0
Demersal nondest low bycatch	2.7	2.8	1.7	1.8	0	0	0	0	0	0
Demersal nondest high bycatch	2.8	3.1	2.1	2.2	0	0	0	0	0	0
Pelagic low bycatch	2.6	2.6	0.6	0.8	2.2	0.6	0	0	0	0
Fertilizer	1.7	1.7	1	1	1.4	0.5	1.9	3	2.3	1.9
Pesticide	1.5	1.5	0.8	0.8	1.2	0.3	1.7	2.8	2.1	1.7
Marine plastic	0.9	1	0.4	0.8	1	0.8	1.2	1.2	0.9	1
Ocean acidification	2.5	2.5	1.7	1.7	1.8	1.8	1	1.3	1.6	1
Sea level rise	0	0	0	0	0	0	2.1	3	2.8	3
Shipping	1.9	0.9	0.5	0.3	1	0	0	0	0	0
SST	2.5	1.7	2	1.7	3.3	1.6	0.6	1.4	1.4	1.4
UV	0.7	0	0.3	0	1.5	0	0	1.1	0.9	1.3

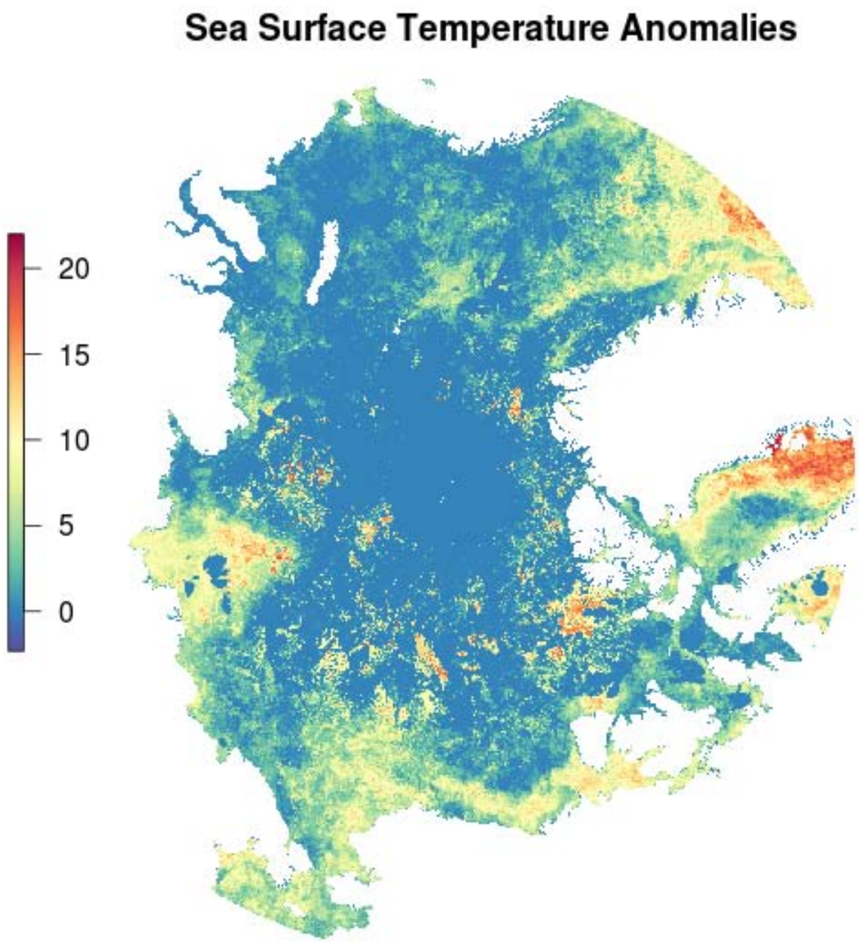
For detailed methods see Halpern et al. (2007)

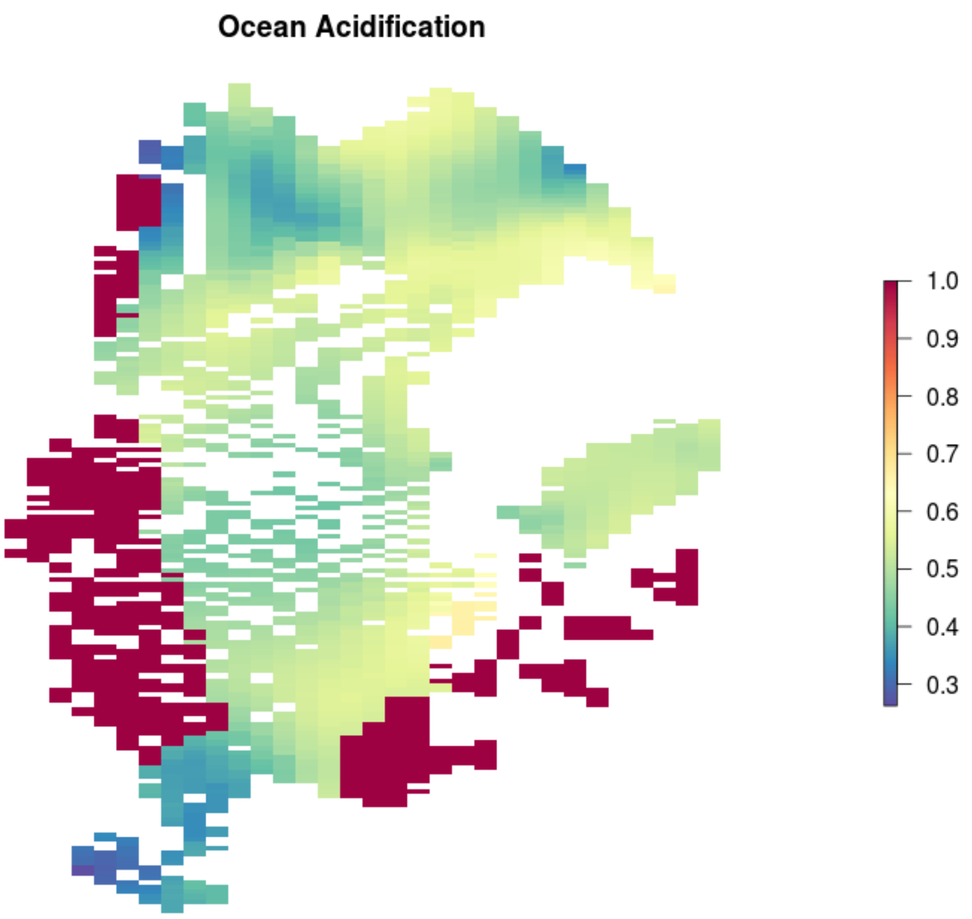
Preliminary Results



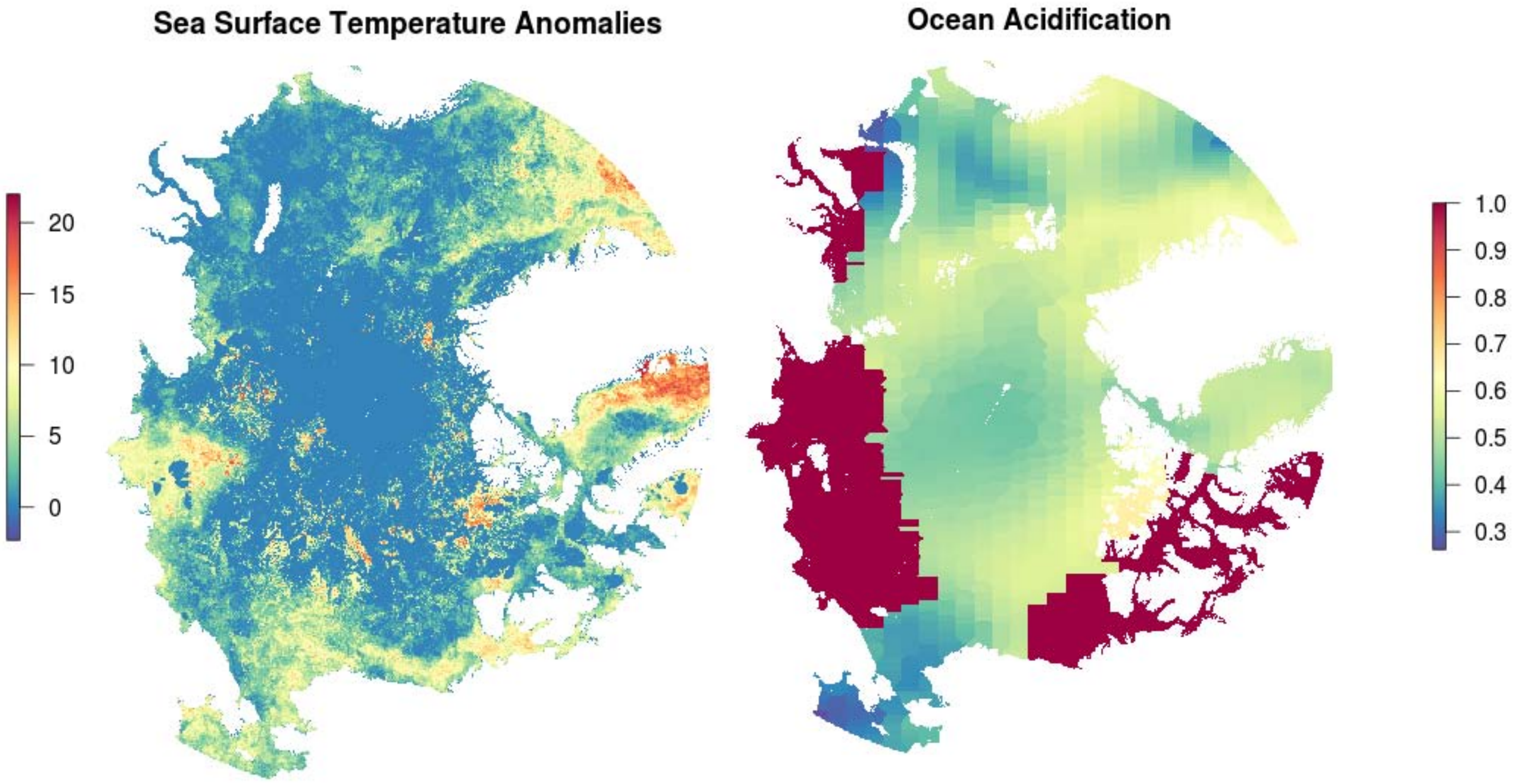
Data Limitations & Solutions

Cell Resolution and Gaps



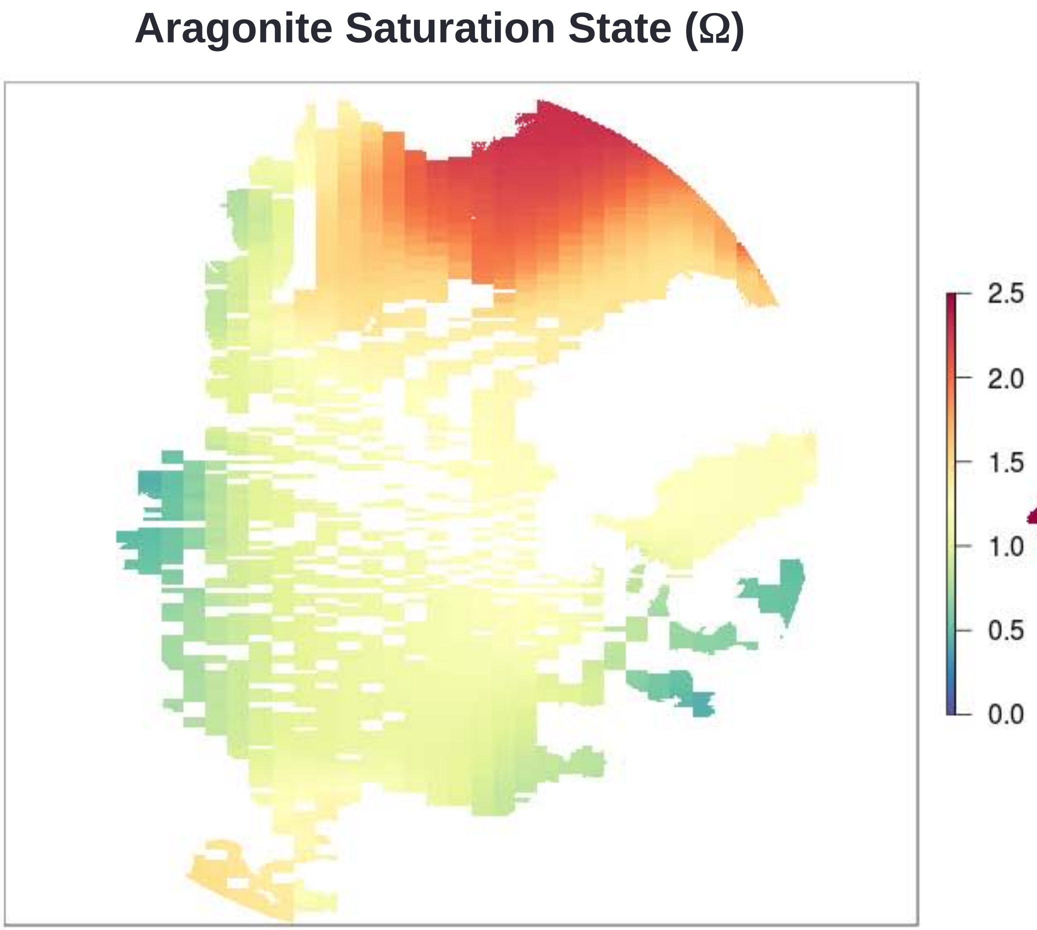


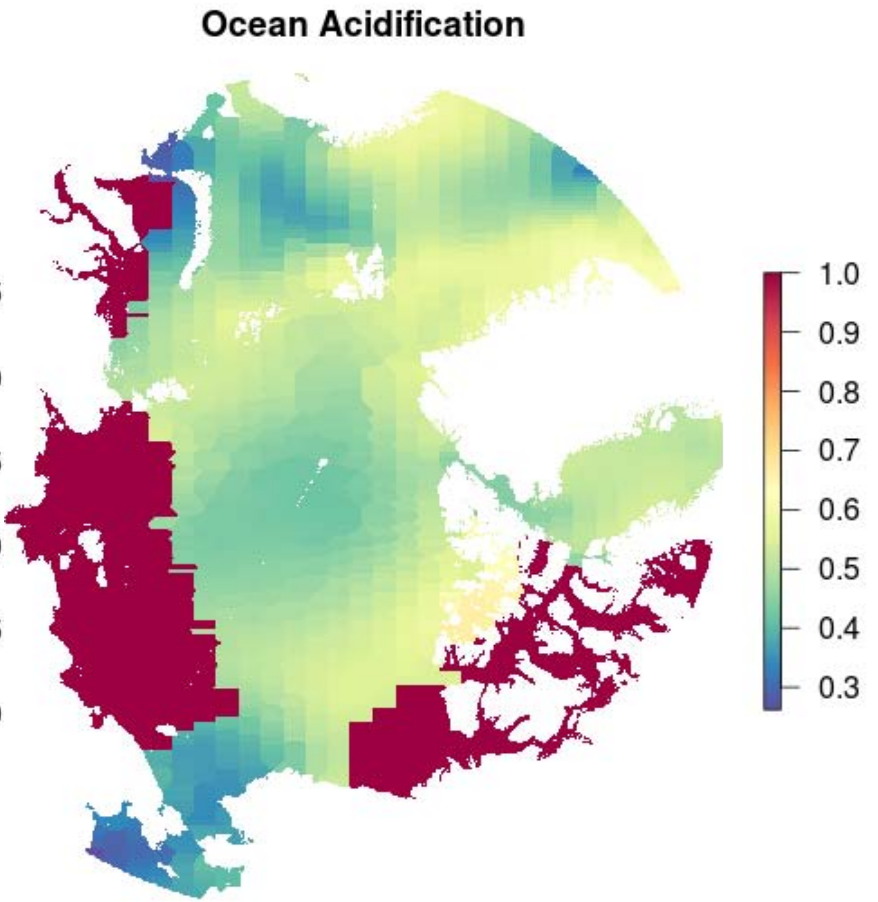
Cell Resolution and Gaps



Rescaling

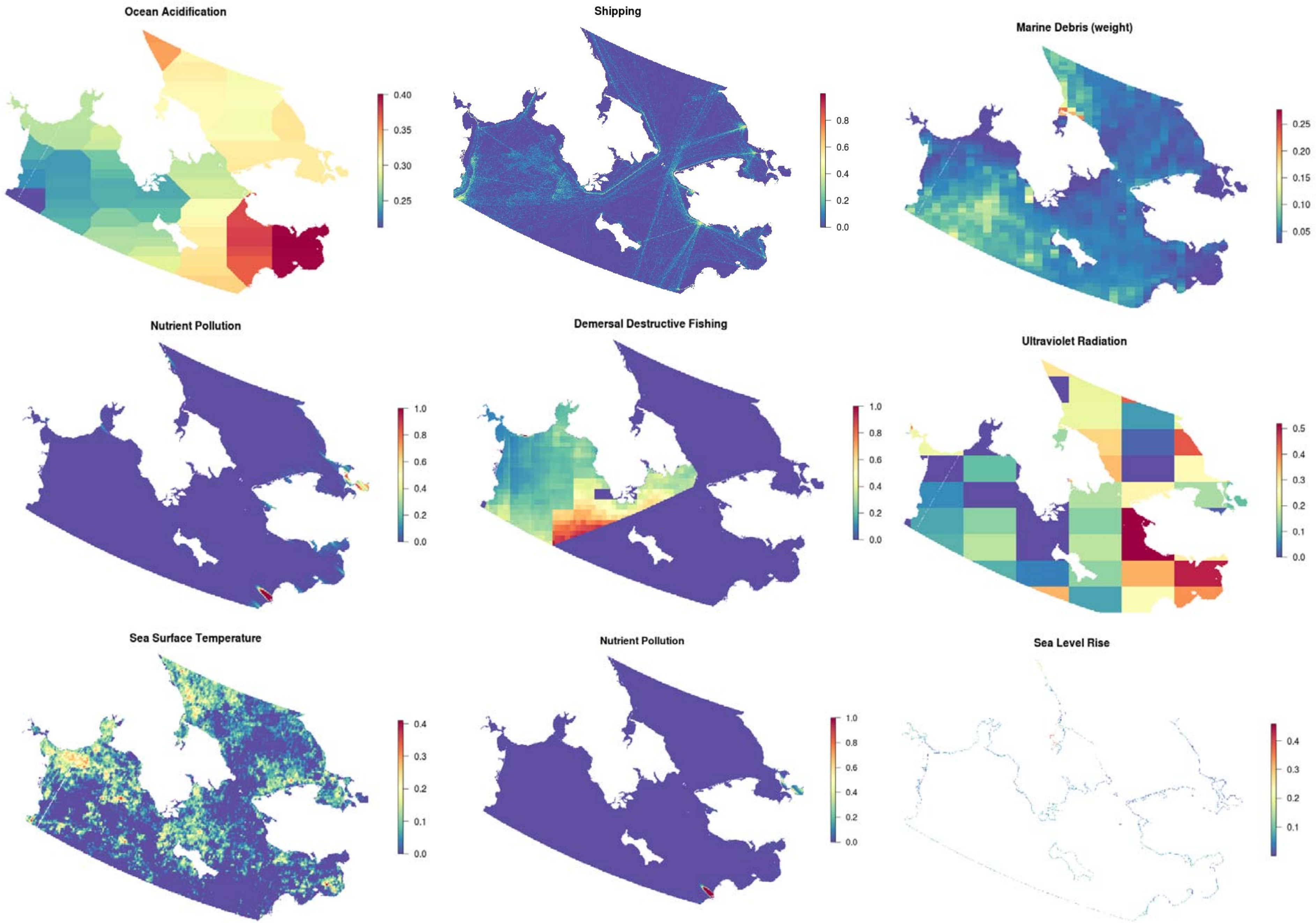
- Biological Threshold



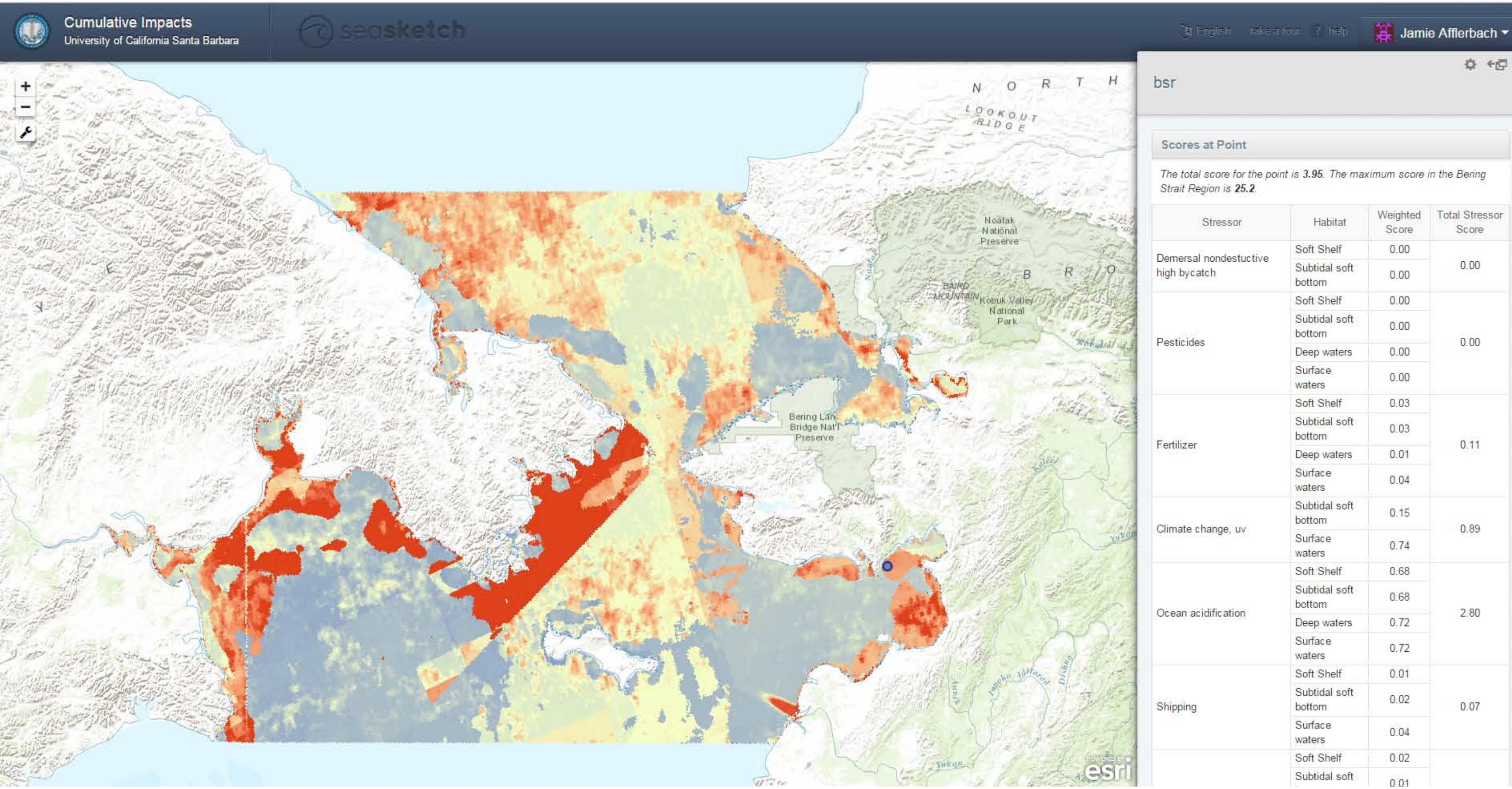


Rescaling

- Biological Threshold
- Maximum value = 1
- Quantile (99^{th}, 95^{th})


Ocean Acidification
0.40
0.35
0.30
0.25
Shipping
0.8
0.6
0.4
0.2
0.0
Marine Debris (weight)
0.25
0.20
0.15
0.10
0.05
Nutrient Pollution
1.0
0.8
0.6
0.4
0.2
0.0
Demersal Destructive Fishing
1.0
0.8
0.6
0.4
0.2
0.0
Ultraviolet Radiation
0.5
0.4
0.3
0.2
0.1
0.0
Sea Surface Temperature
0.4
0.3
0.2
0.1
0.0
Nutrient Pollution
1.0
0.8
0.6
0.4
0.2
0.0
Sea Level Rise
0.4
0.3
0.2
0.1

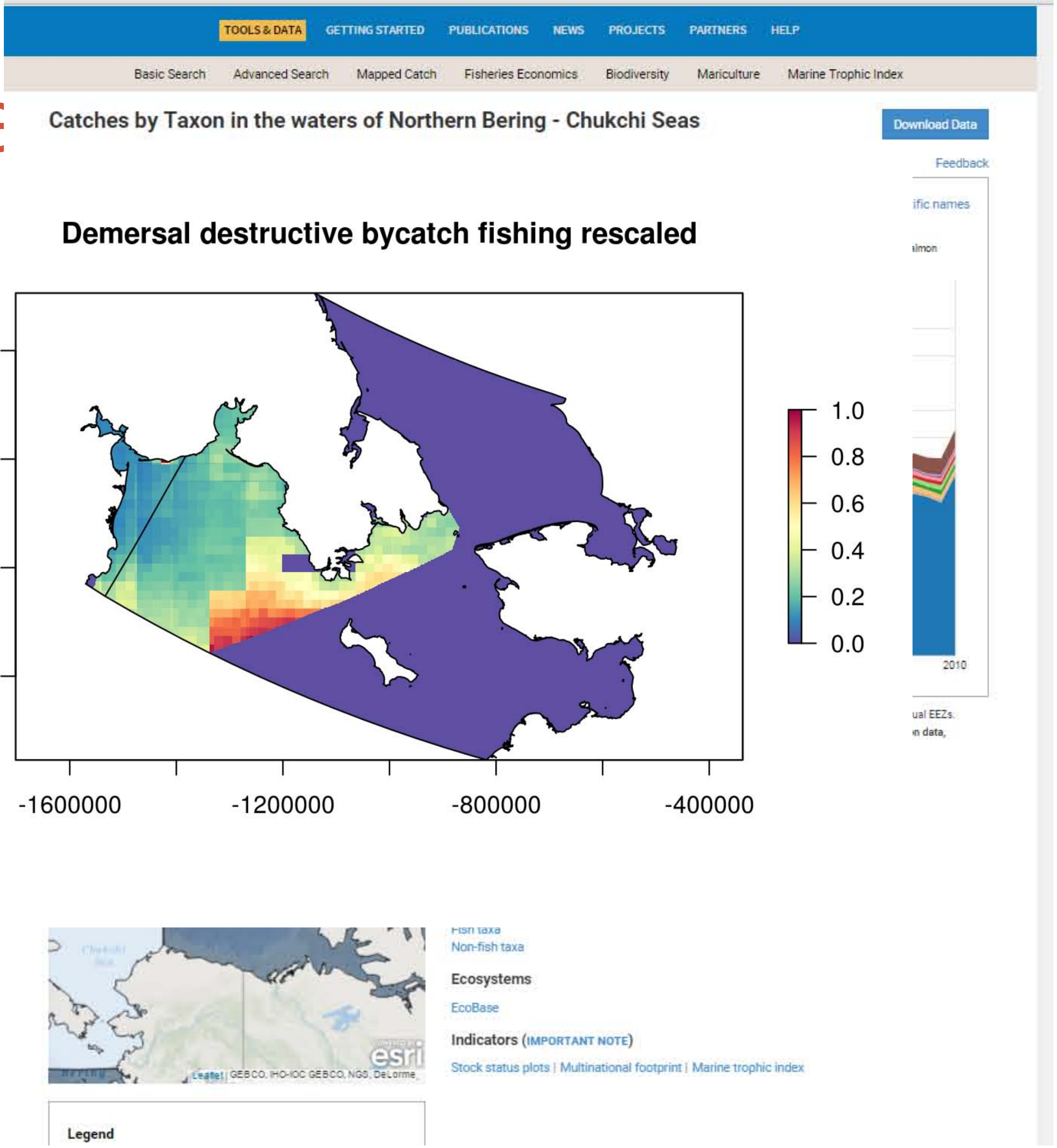
Seasketch



Stressor	Habitat	Weighted Score	Total Stressor Score
Demersal nondestuctive high bycatch	Soft Shelf	0.00	0.00
	Subtidal soft bottom	0.00	
Pesticides	Soft Shelf	0.00	0.00
	Subtidal soft bottom	0.00	
	Deep waters	0.00	
	Surface waters	0.00	
Fertilizer	Soft Shelf	0.03	0.11
	Subtidal soft bottom	0.03	
	Deep waters	0.01	
	Surface waters	0.04	
Climate change, uv	Subtidal soft bottom	0.15	0.89
	Surface waters	0.74	
Ocean acidification	Soft Shelf	0.68	2.80
	Subtidal soft bottom	0.68	
	Deep waters	0.72	
	Surface waters	0.72	
Shipping	Soft Shelf	0.01	0.07
	Subtidal soft bottom	0.02	
	Surface waters	0.04	
	Soft Shelf	0.02	
	Subtidal soft	0.01	

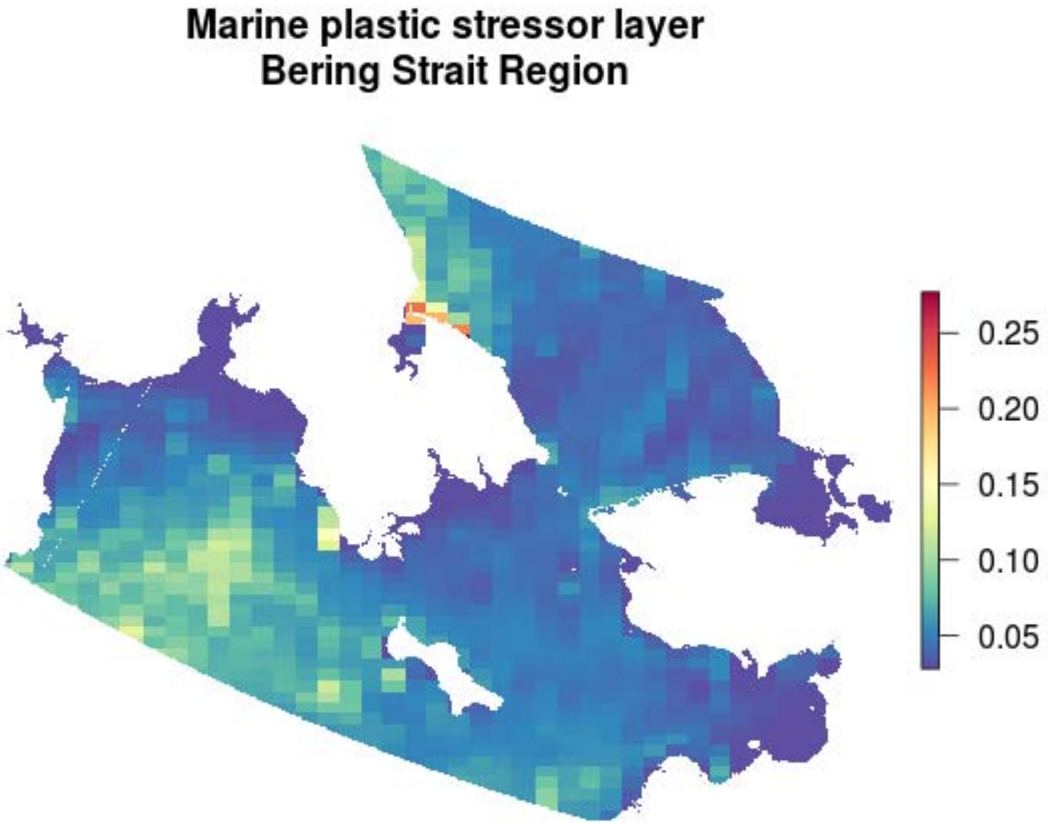
Thank you!

Non-raste



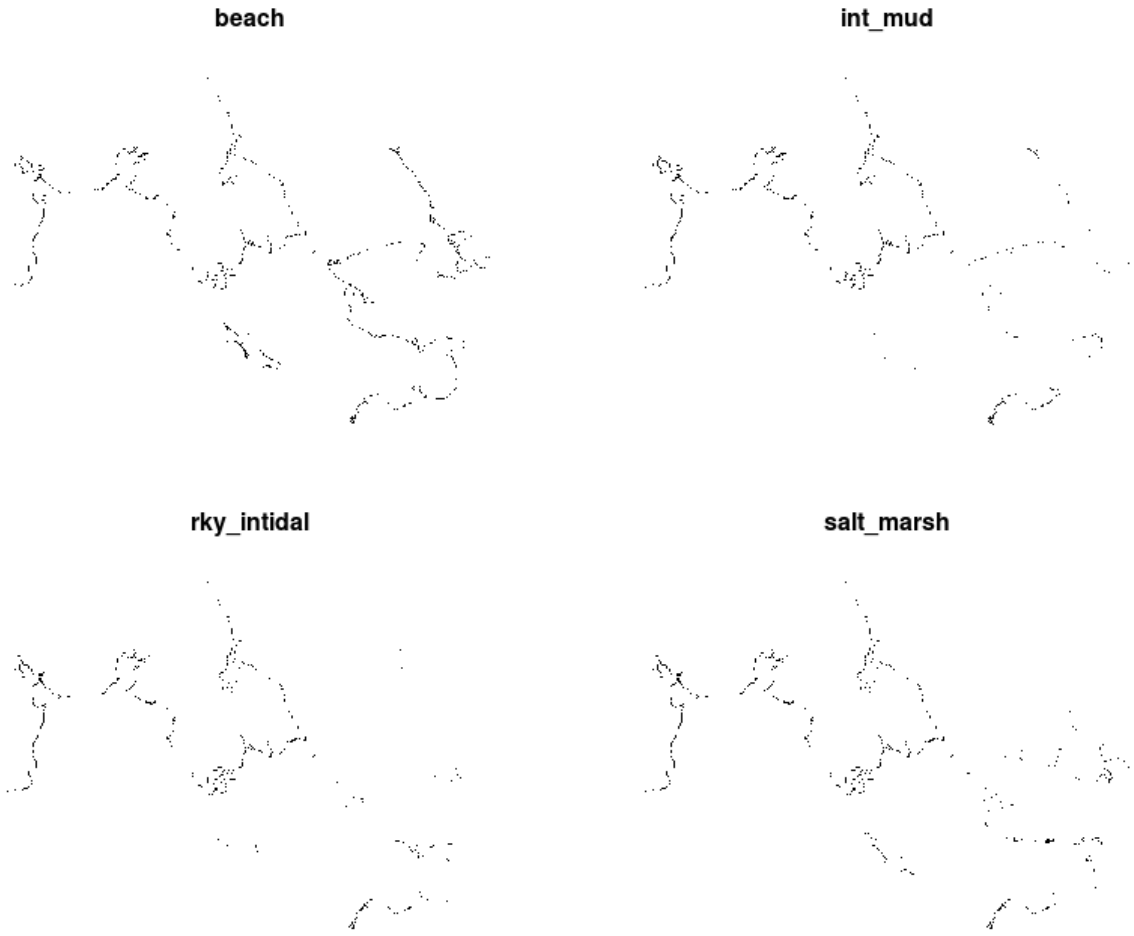
TOOLS & DATA
GETTING STARTED
PUBLICATIONS
NEWS
PROJECTS
PARTNERS
HELP
Basic Search
Advanced Search
Mapped Catch
Fisheries Economics
Biodiversity
Mariculture
Marine Trophic Index
Catches by Taxon in the waters of Northern Bering - Chukchi Seas
Download Data
Feedback
Demersal destructive bycatch fishing rescaled
-2400000
-2800000
-1600000
-1200000
-800000
-400000
1.0
0.8
0.6
0.4
0.2
0.0
2010
Non-fish taxa
Ecosystems
EcoBase
Indicators (IMPORTANT NOTE)
Stock status plots | Multinational footprint | Marine trophic index
Legend

Rescaling



Marine plastic stressor layer
Bering Strait Region
0.25
0.20
0.15
0.10
0.05

Habitats






Ecosystem Modeling – Fundamentals, Concepts and Use in Environmental and Cumulative Effects Assessment in Coastal Ecosystems

Darrell Desjardin VP, Port & Infrastructure

December, 2015

HEMMERA

Hemmera Lines of Business

Planning and Management

- Environmental impact assessment
- Cumulative effects assessment
- Terrestrial ecology
- Marine and aquatic ecology

Community Engagement and Social Sciences

- First Nations consultation
- Community engagement
- Socio-economic assessments

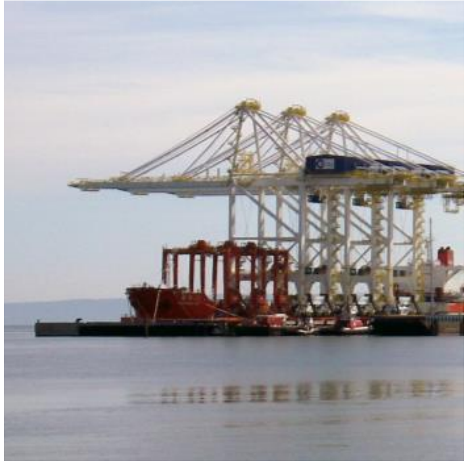
Site Assessment and Remediation

- Environmental engineering
- Hydrogeology
- CS Assessment and Remediation
- Ecological risk assessment
- Human health risk assessment
- Environmental effects monitoring

Overview

- Why use an ecosystem based approach?
- How to use an ecosystem model to inform cumulative effects assessments?
- What variables can you assess?
- How can this inform resource managers and stakeholders?

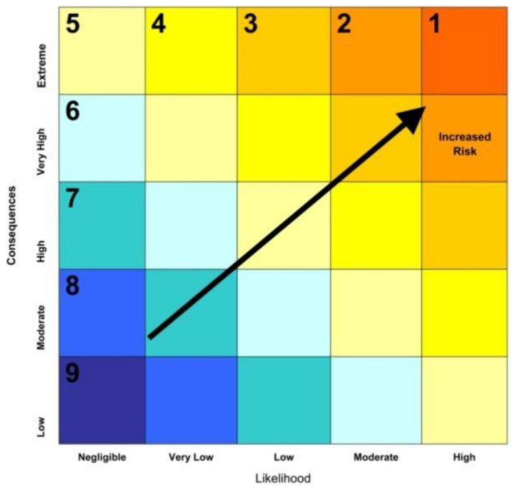
Cumulative Effects



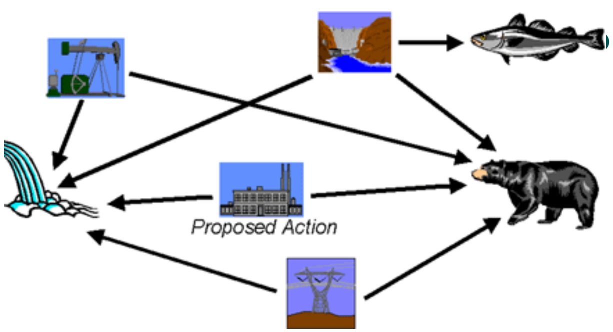
- Cumulative effects
  - are changes to the environment that are caused by an action in combination with other past, present and future human actions. *CEAA 1999*
  - can occur when impacts are: (1) additive (incremental); (2) interactive; (3) sequential; or (4) synergistic.

Cumulative Effects

How has it been done



- Historical review of past projects
- Qualitative estimate of future effects on project's residual effects – risk matrix
- Additive approach rather than integrated
- Typically single species models – simplistic and do not address change in interactions or multiple stakeholders interests



Ecosystem Based Approach

What is it and why use it

- Examines species interactions with multiple other species and the environment at a regional level
- Allows for coordination among multiple interest stakeholders
- Can be expanded to address social and economic values
- Can be used with other methods to build certainty in results (e.g. groundtruthing, coastal geomorphological models)

Ecosystem-Based Approach
How can we do it

- Willingness of stakeholders to work at a regional scale
- Meta analysis – summarize effects from the historical studies (Data sharing)
- Gap analysis (targeted environmental studies to fill gaps)
- Integrated and spatial analysis tools (GIS, InVEST)
- Ecosystem models (EwE, Atlantis, ERSEM)

Ecosystem Models

K. Hyder et al. / Marine Policy 61 (2015) 291–302

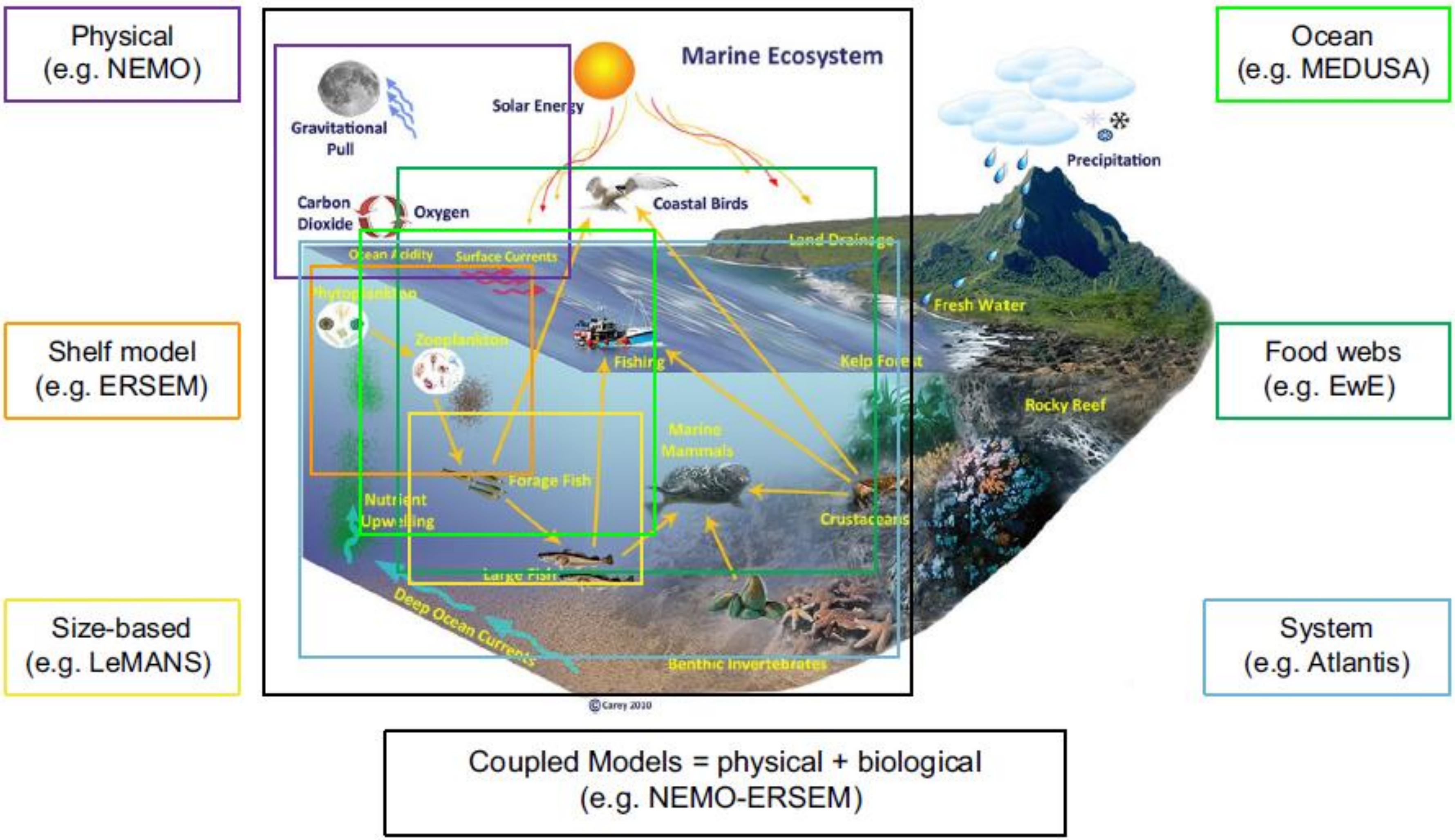


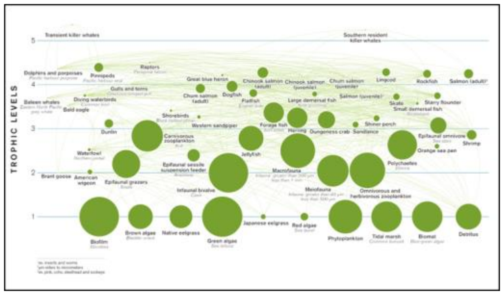
Fig. 1. Categories of ecosystem models and the parts of the ecosystem that they include.

Ecosystem Modelling – Ecopath with Ecosim and Ecospace (EwE)

- Ecosystem Model (EwE)

  500+ research based publications
- Can model food webs, fisheries, plus…changes to environment, infilling, dredging, structures, marine protected areas, ocean acidification, sea level rise
- Scientifically defensible and integrates fisheries, wildlife, habitat, environment
- Used in major EAs in Canada (BC Hydro, PMV), accepted in Europe

How to build Ecosystem Model



Spatial data

Environmental data

Baseline Conditions

Run Model

Desired Scenarios

PRODUCTIVITY
WITHOUT PROJECT

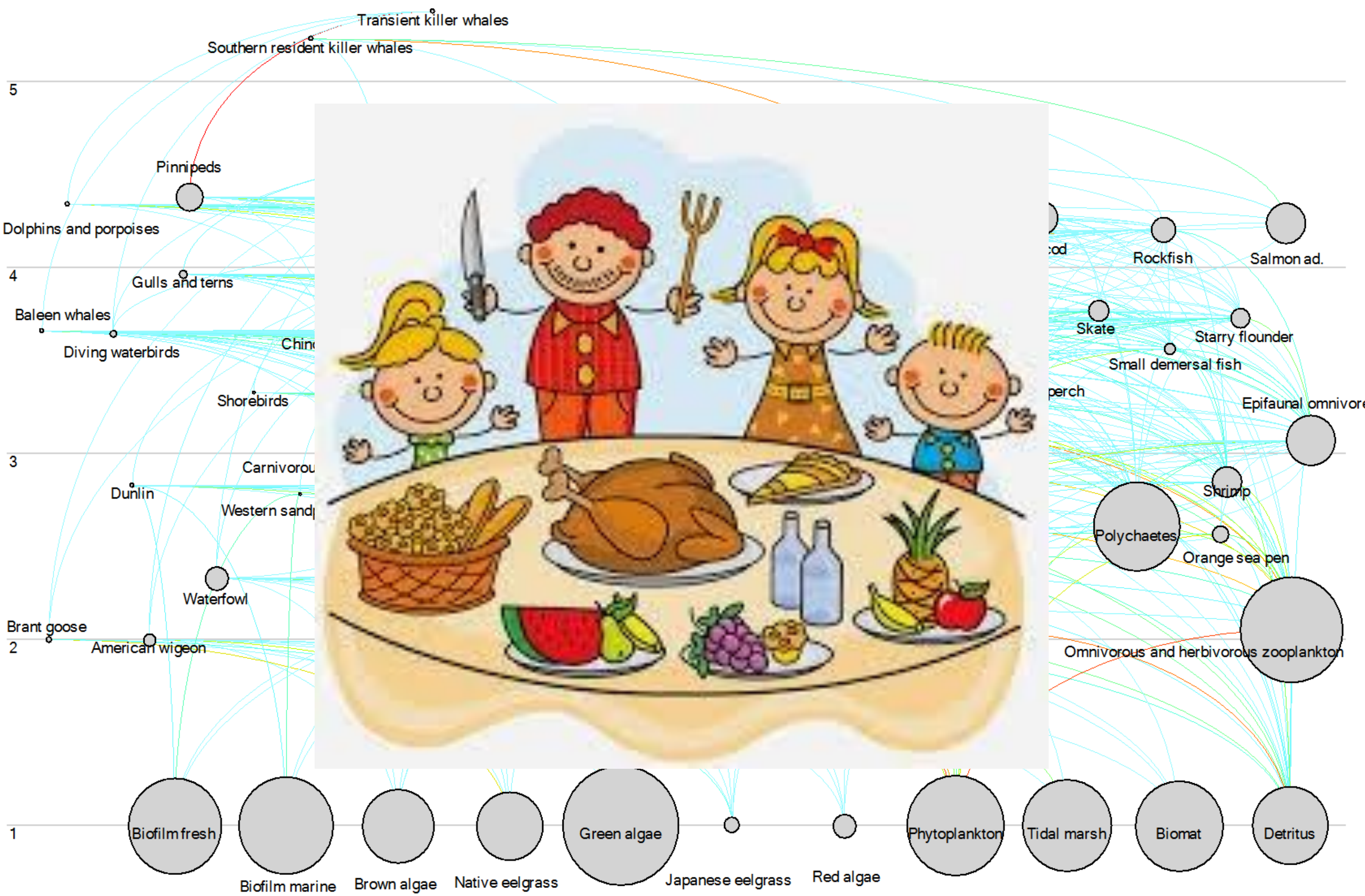
PRODUCTIVITY
WITH PROJECT

1. Choose objectives and spatial area
2. Construct food web
3. Inform environment
4. Determine drivers of change
5. Run Model without and with effects drivers
6. Examine results
7. Address uncertainty

Choose Objectives and Study Area

- Use whole basins, all areas that impact study area if possible (i.e., Hecate Strait)
- Consider range of key species (whales, birds, fish, invertebrates)
- Region of planning and extent of past, present and proposed projects
- Available information

ECOSYSTEM MODEL: FOOD WEB BALANCING



Construct Food Web – who and how

Who

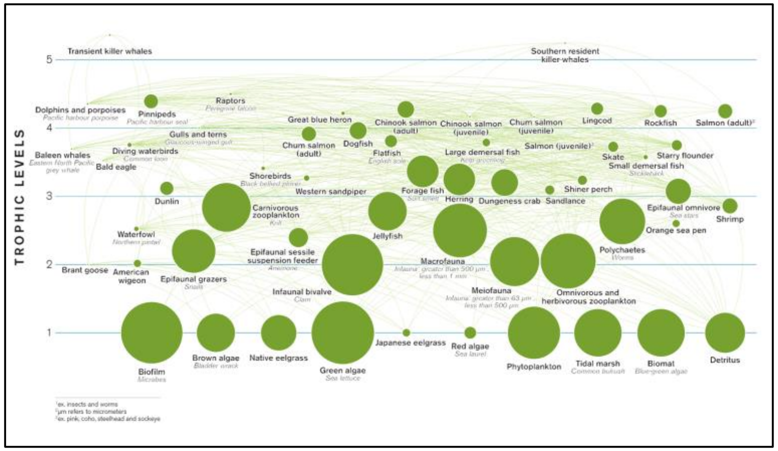
Biologists

Local Experts

First Nations

Regulators

Stakeholders



Literature

Expert Input

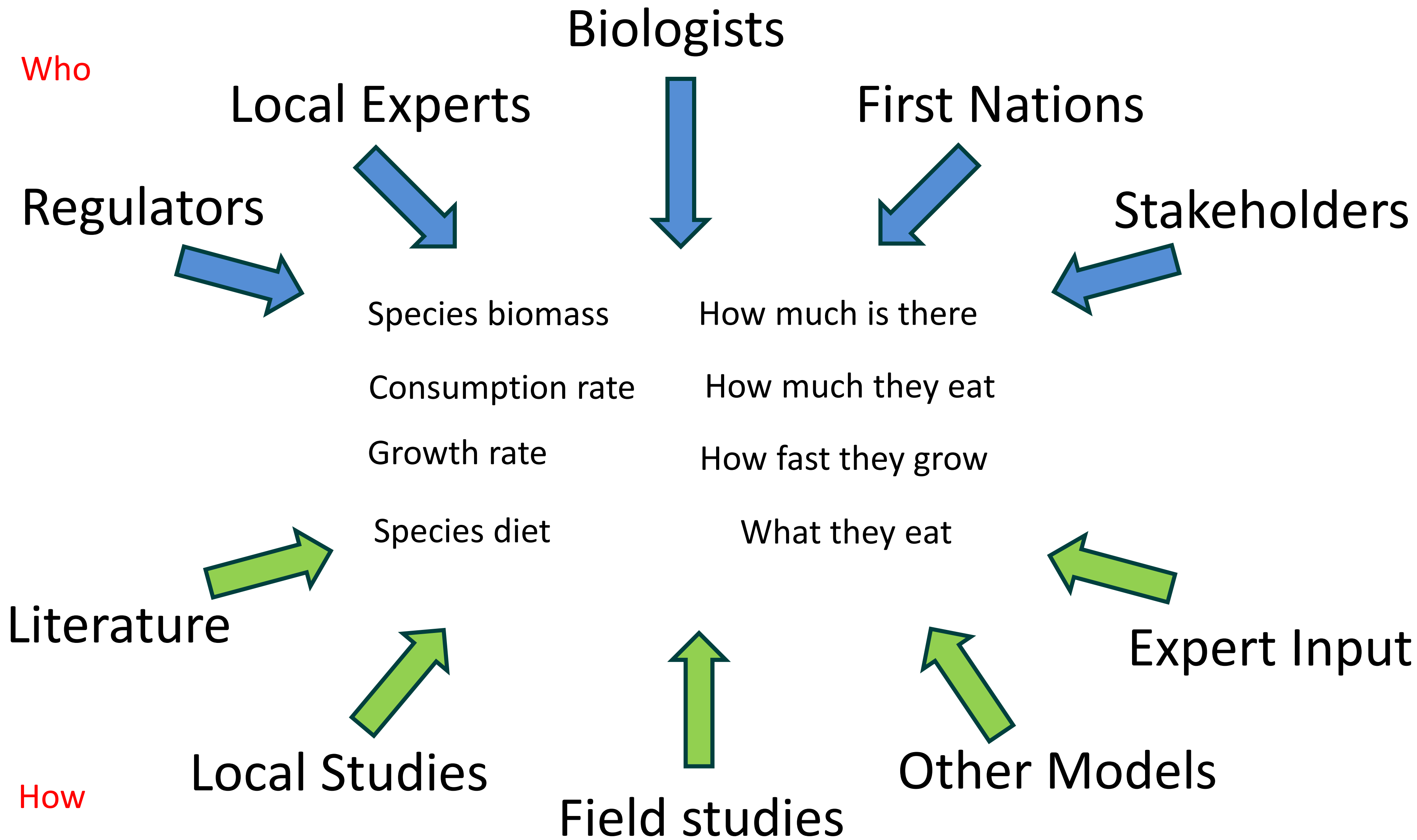
Local Studies

Field studies

Other Models

How

Construct Food Web – what inputs

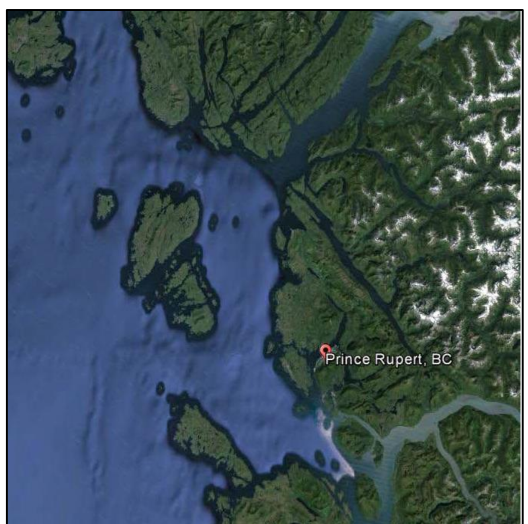


Inform Existing Environment and Species Preferences

Choose variables that:

- are altered by your scenarios – currents/waves, pH, sea level
- affect changes in species abundance
- that can be realistically informed/ modelled

Temperature
Waves
Salinity
pH
Depth
Substrate
Nutrients
Currents



Fieldwork

Literature

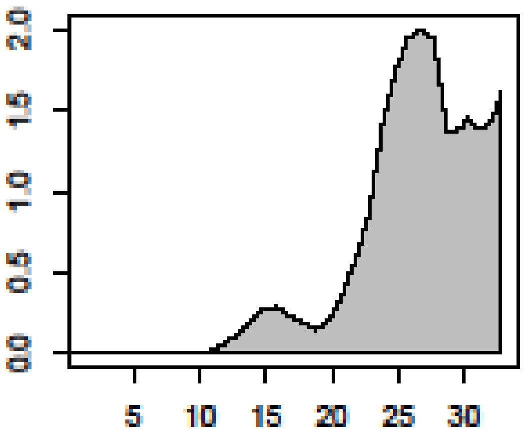
Physical modelling

Local experts

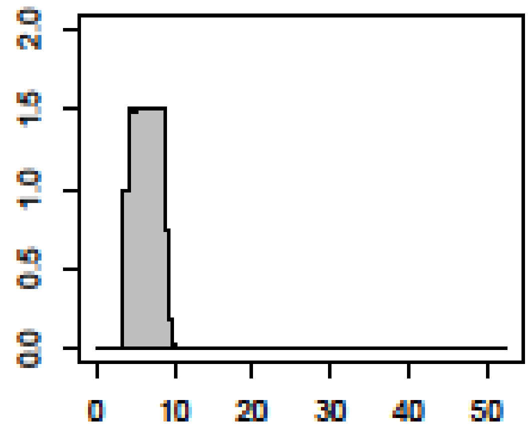
Traditional Knowledge

Inform Existing Environment and Species Preferences

Salinity

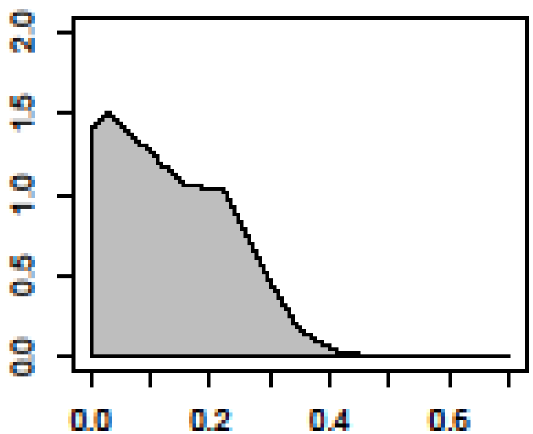


Depth

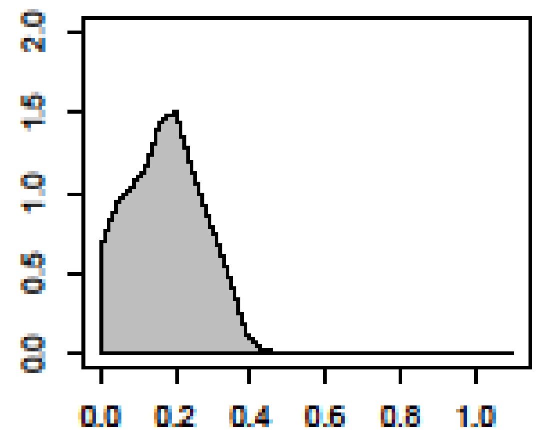


- Inform where a species occurs
- Data from literature or field data

Wave



Current



What Can We Model

Scenario		Model approach
Infilling & development	→	Change spatial design of land form
Fisheries policy	→	Alter fishing pressure
Protected areas	→	Add exclusion areas
Habitat quality	→	Change in productivity
Ocean acidification	→	Change pH levels
Sea level rise	→	Change water depth

Uncertainty

- Important to quantify uncertainty and confidence for regulators
- Uncertainty addressed through Monte Carlo simulations informed by confidence in inputs
- Uncertainty also reduced by using ecosystem approach in tandem with other methods for comparison of results – precautionary principle

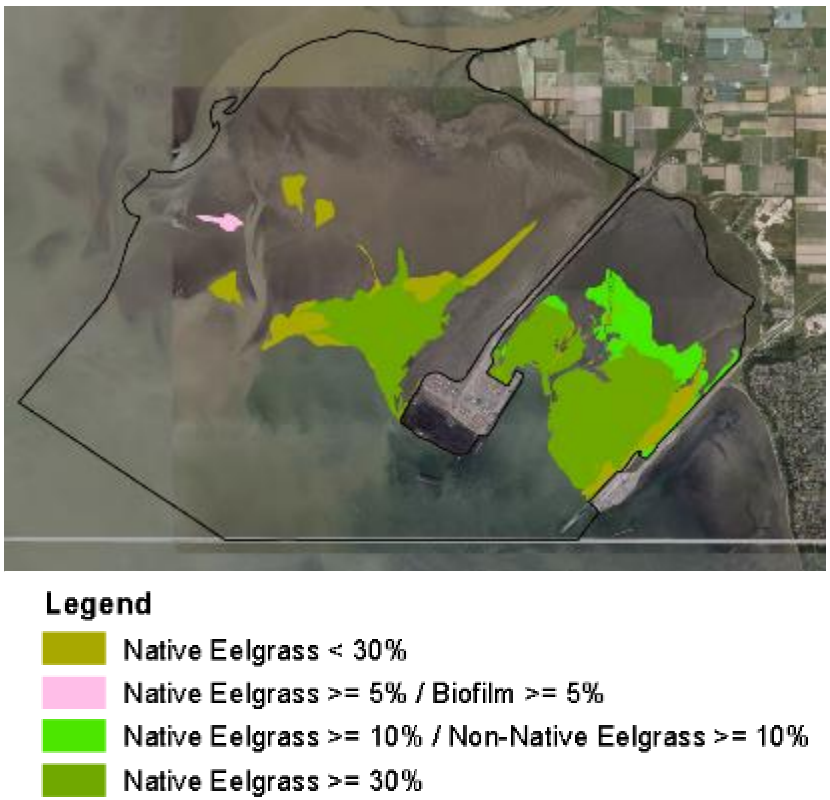
Sensitivity Analyses and Cause

- Model is easily and quickly rerun to allow for many scenarios to be feasibly examined
- Add substrate environmental layers to identify key drivers
- Can chose the number effects to be examined through multiple models or rerunning and excluding specific affects

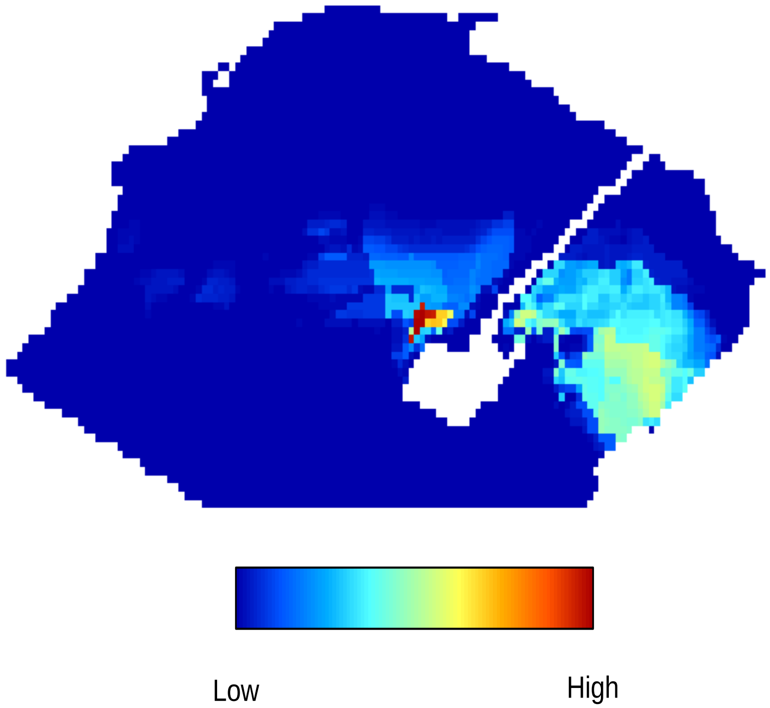
Native Eelgrass habitat – model validation

Model Validation: EwE Model generally predicts current species' distribution and abundance as observed in the field

Based on field studies



Predicted by EwE Model (without Project)

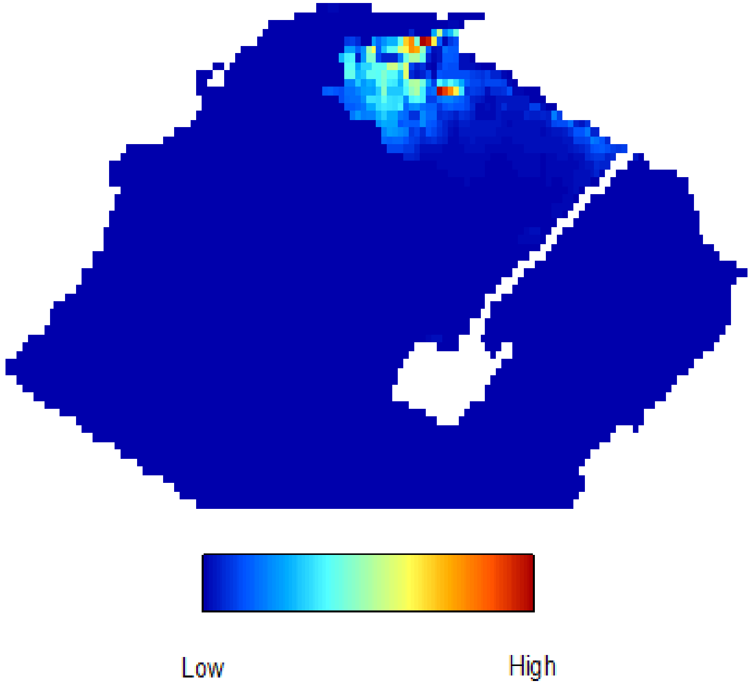


PRELIMINARY INFORMATION
SUBJECT TO REVISION

Tidal Marsh habitat – model validation

Based on field studies

Predicted by EwE Model (without Project)



Summary

- Ecosystem-based approach to assessing cumulative environmental effects is efficient for medium to large projects and medium to large areas
- Scientifically defensible and integrates multiple disciplines
- Informs environmental assessment and offsetting requirements
- Removes subjectivity and allows for uncertainty analyses


Thank you. Questions?
Darrell Desjardin
P: 604.669.0424 ext 210
Hemmera Envirochem Inc.
18th Floor, 4730 Kingsway
Burnaby, BC V5H 0C6
HEMMERA

SESSION IV PRESENTATIONS – SCENARIO DEVELOPMENT

PORT METRO vancouver

Charting a Course to a Sustainable Gateway: Scenario Planning as a Strategic Tool

December 11, 2015

Jennifer Natland
Manager,
Planning & Development

Agenda

- About Port Metro Vancouver
- Port 2050 Scenario Planning
- Business Plan Integration

Our Mandate

- Facilitate Canada's trade
- Balance efficient port operations with community concerns and environmental protection
- Work for the benefit of all Canadians

PORT METRO
vancouver

Jurisdiction

PORT METRO vancouver

CONNECTING CANADIANS TO OVER

160

TRADE ECONOMIES

FACILITATING TRADE OF

140 million

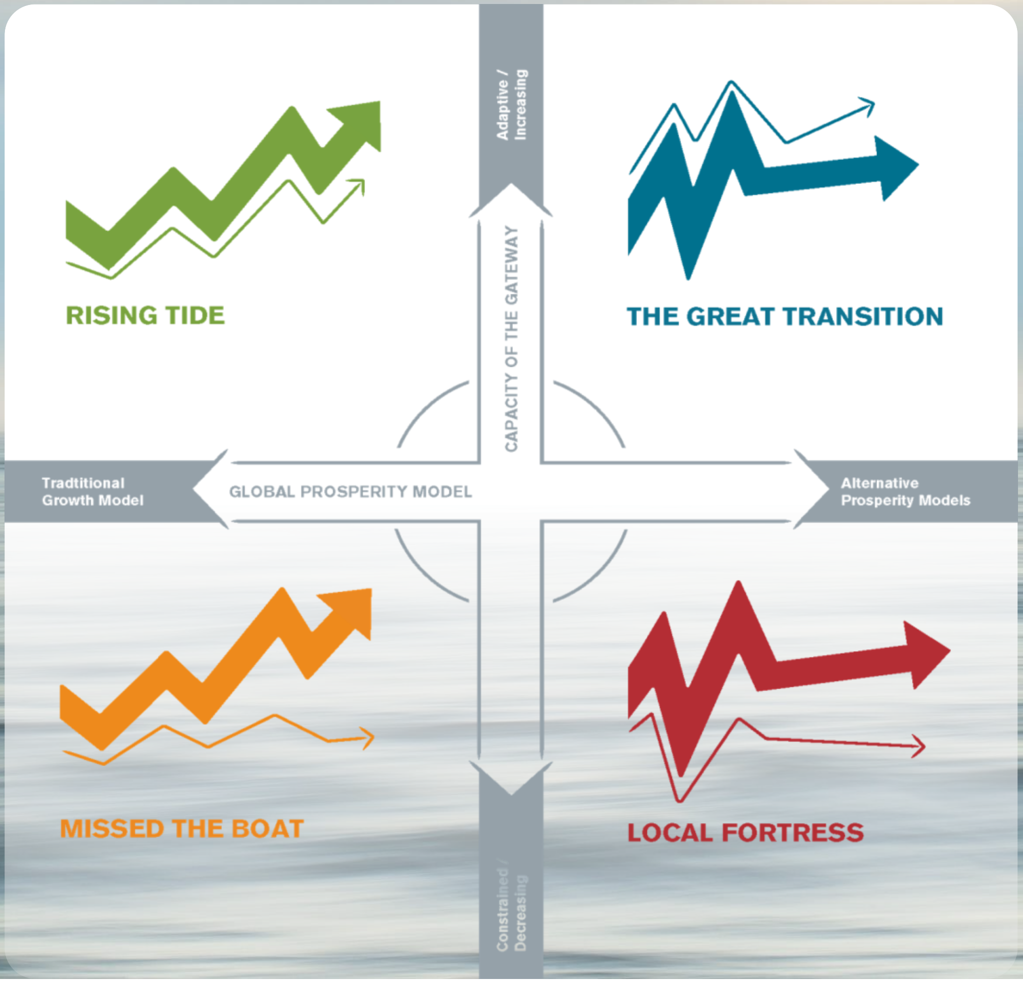
TONNES OF CARGO ANNUALLY

PORT METRO vancouver

Our Vision

To be recognized as a world-class gateway by efficiently and sustainably connecting Canada with the global economy, inspiring support from our customers and from communities locally and across the nation.

Port 2050 Scenario Planning



PORT METRO vancouver

A Sustainable Gateway for a Great Transition

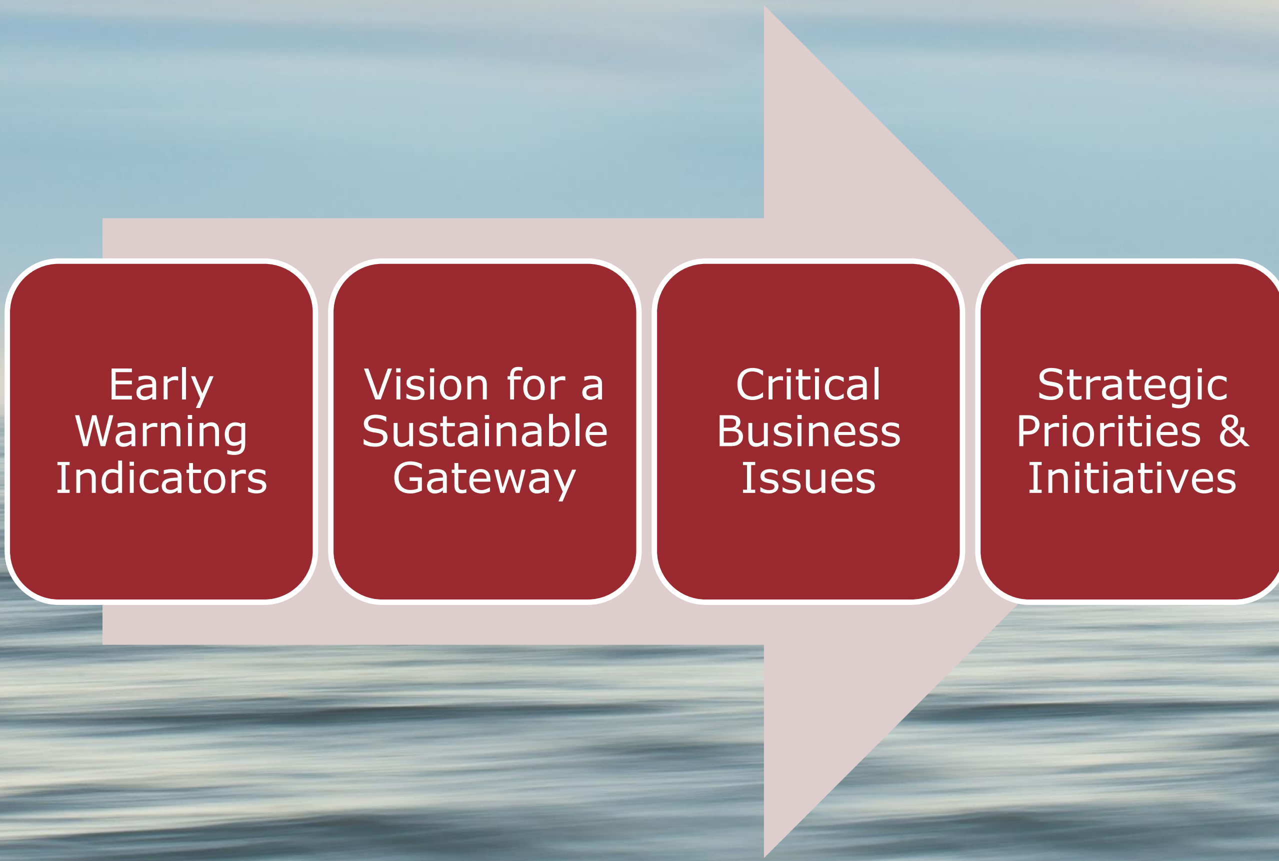
- ECONOMIC PROSPERITY THROUGH TRADE
- HEALTHY ENVIRONMENT
- THRIVING COMMUNITIES

PORT METRO vancouver

Key Drivers of Change

- Capacity to Grow
- Demographics & Shifting Social Values
- Energy Transition
- Gateway Competitiveness
- Geopolitical Stability
- Patterns of Production & Consumption
- Technological Innovation

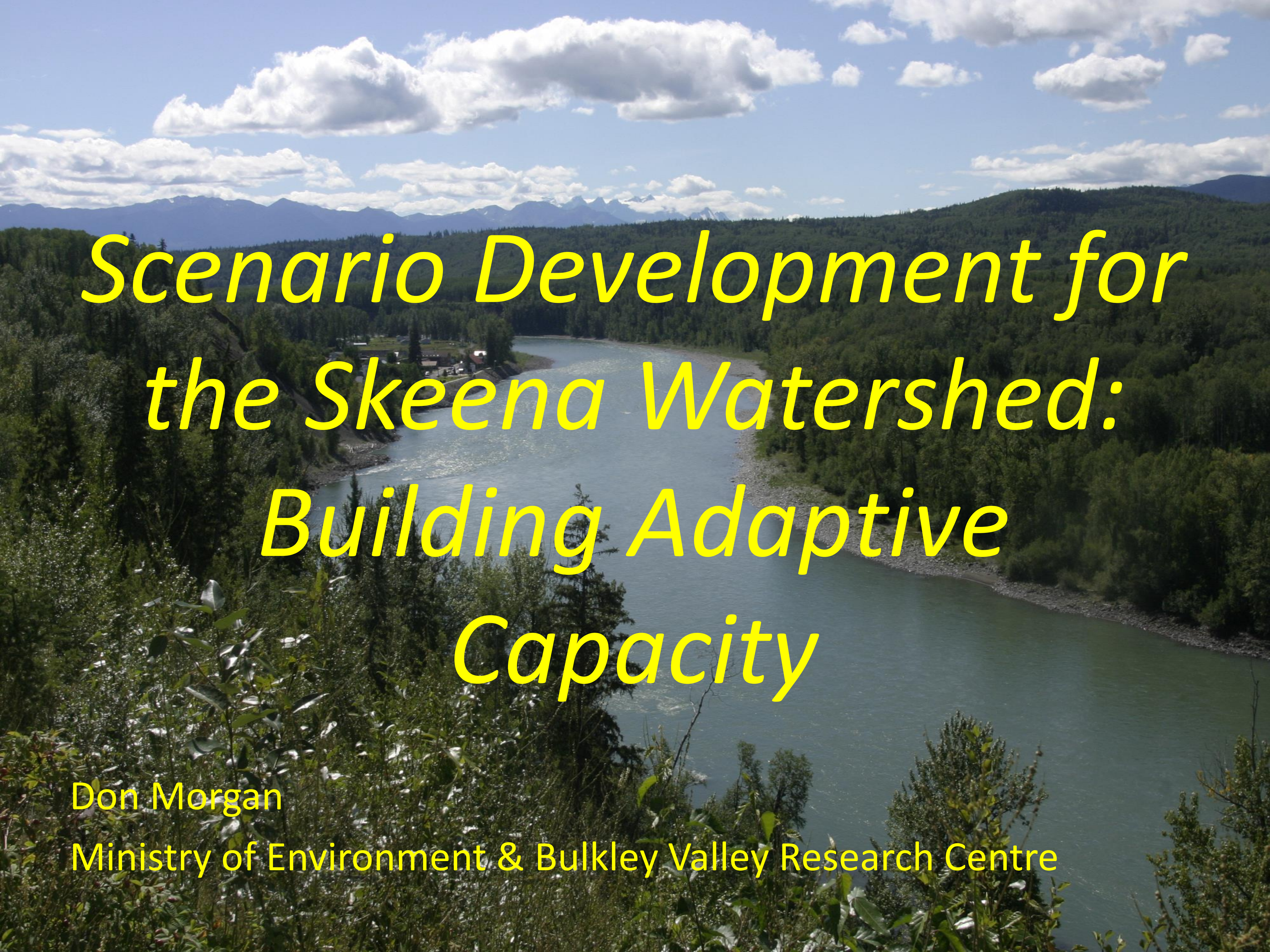
Annual Business Planning Cycle



Charting a Course to a Sustainable Gateway: Scenario Planning as a Strategic Tool

December 11, 2015

Jennifer Natland
Manager,
Planning & Development


Scenario Development for the Skeena Watershed: Building Adaptive Capacity
Don Morgan
Ministry of Environment & Bulkley Valley Research Centre

Outline

1. Context
2. Scenario approach
3. Scenario tools
4. Scenario case study
5. Global scenarios
6. Interpreting global scenarios for the Skeena
7. Feedback

Managing Resource Systems is Complex!

Landscapes are complex systems

⇒ many elements, multi-scale interactions and lags

Emerging issues increase complexity

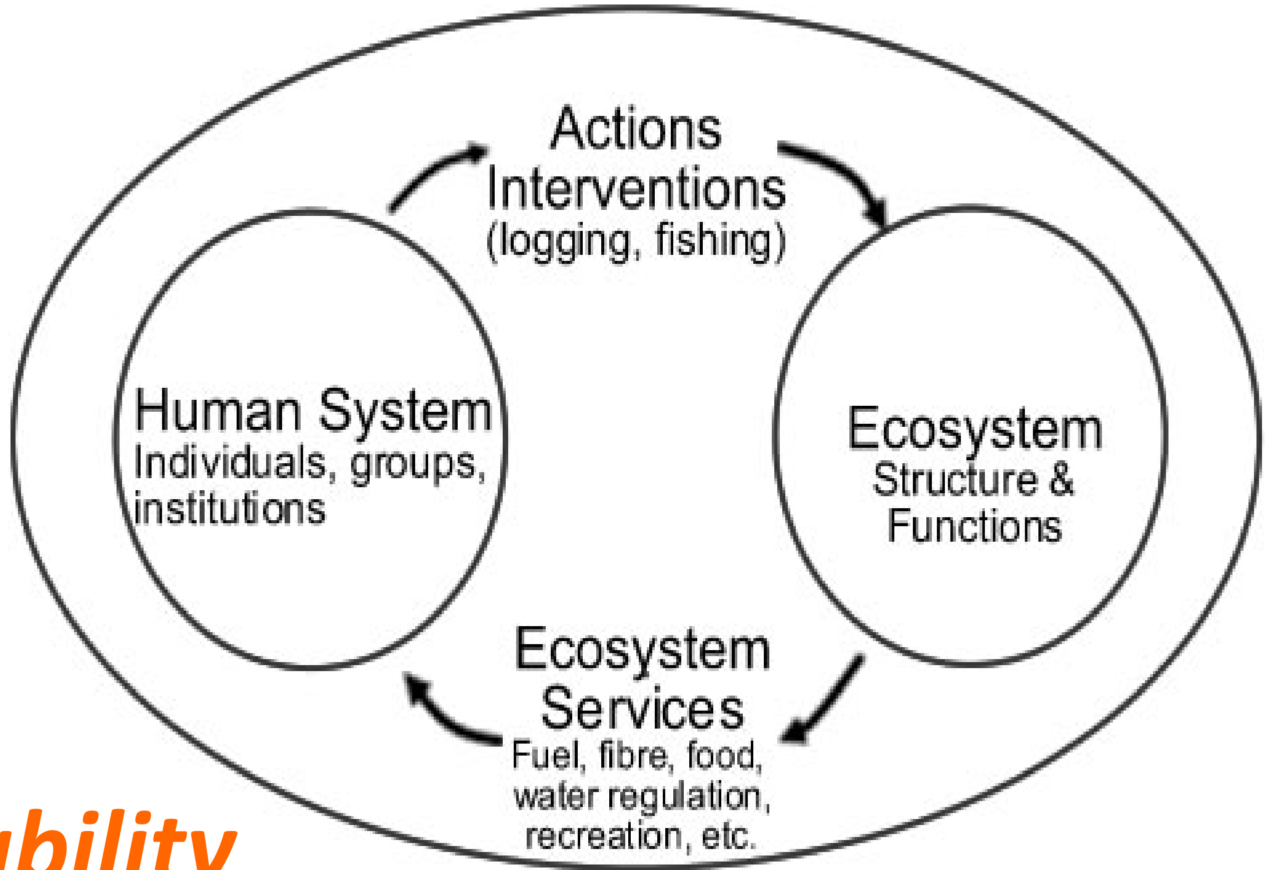
⇒ cumulative effects & climate change

Complex Decision-making

⇒ Multiple agencies responsible for regulating impacts

Social-Ecological System

Resilience

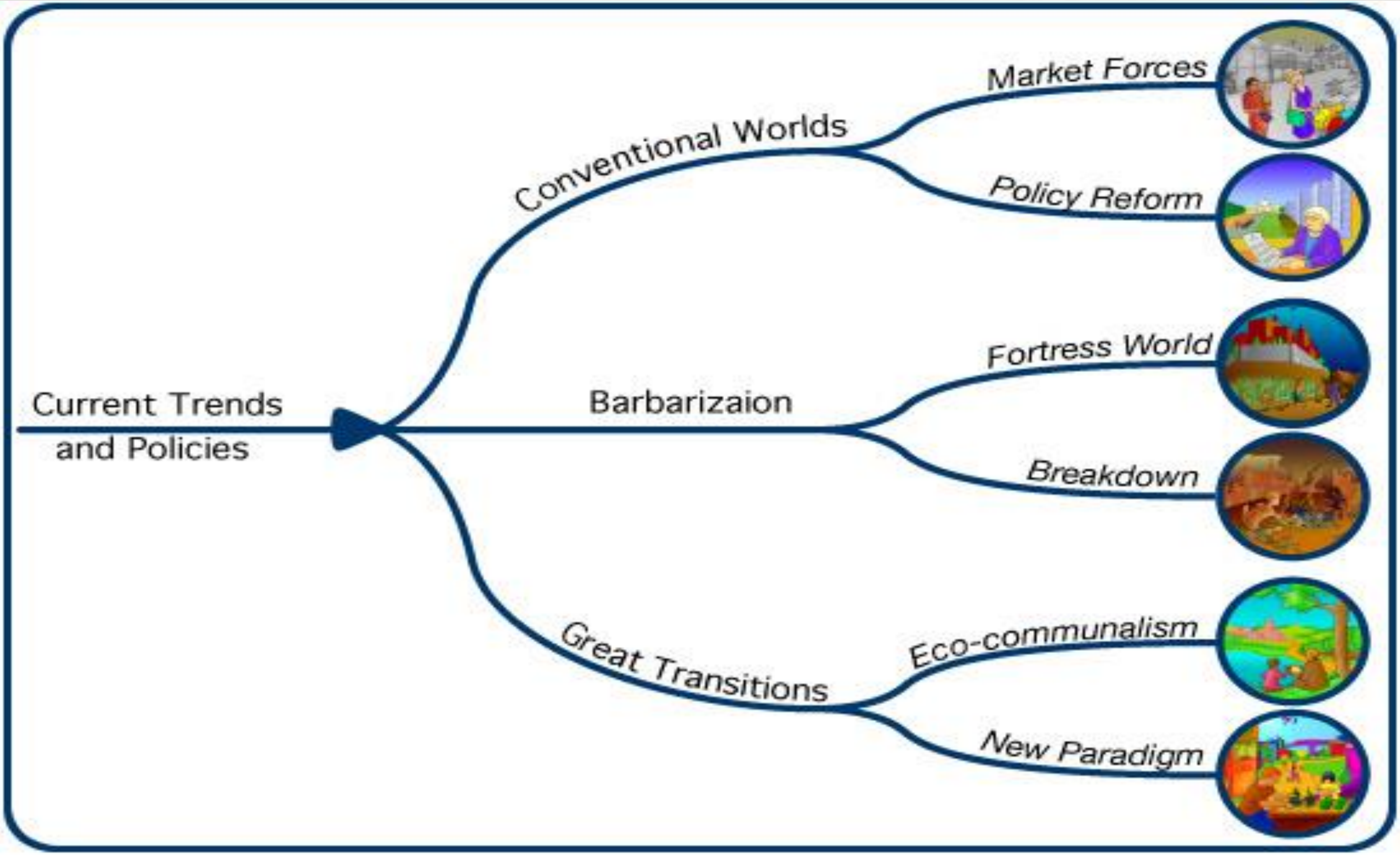


Adaptability

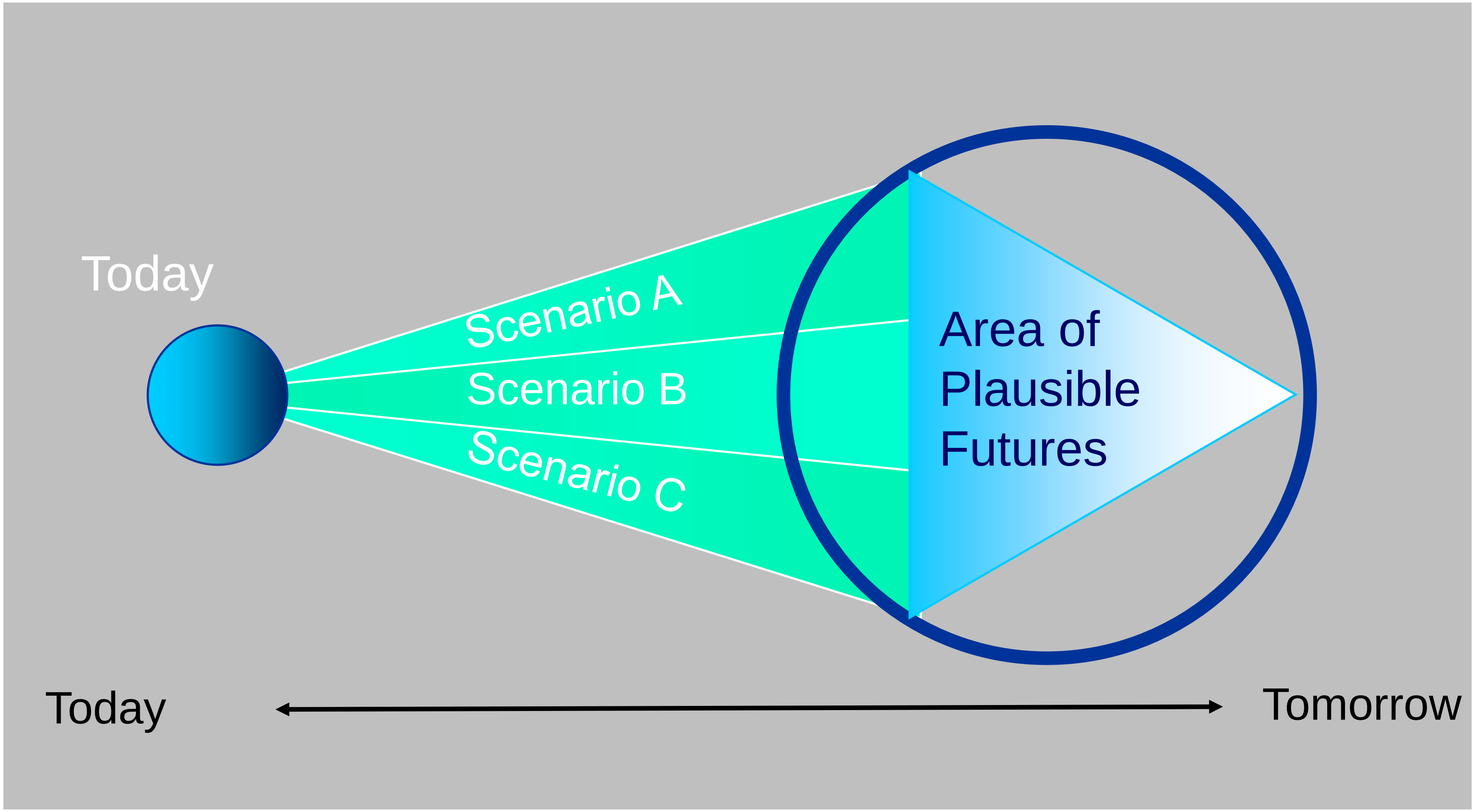
Transformability

Social-ecological systems are complex, integrated systems in which humans are part of nature (Resilience Alliance 2012).

Scenarios


Market Forces
Conventional Worlds
Policy Reform
Fortress World
Current Trends and Policies
Barbarizaion
Breakdown
Eco-communalism
Great Transitions
New Paradigm

Building Scenarios



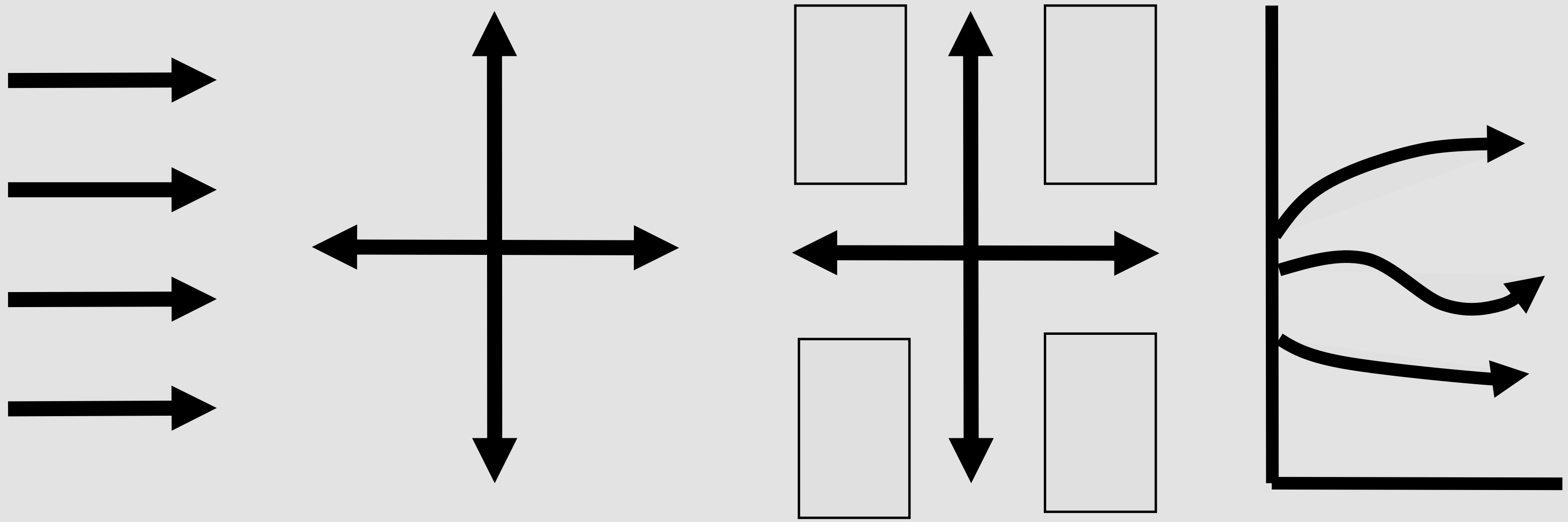
Building Scenarios

Identify Driving Forces

Define Critical Uncertainties

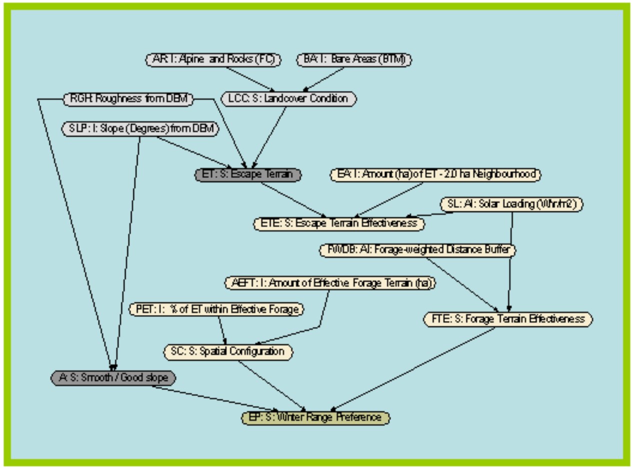
Describe Major Characteristics

Develop Logical Paths

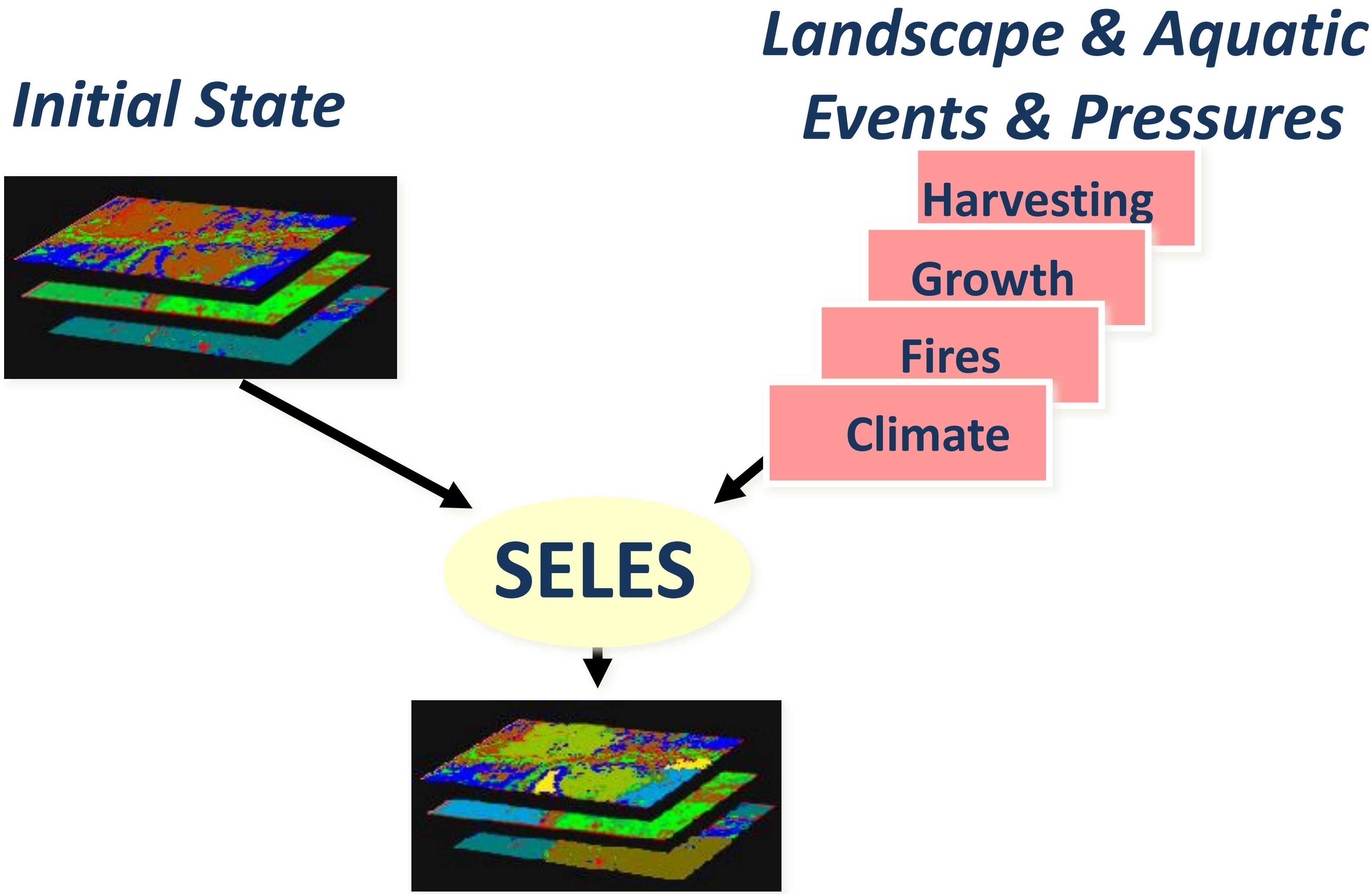


Types of Scenarios

- ***Qualitative***
  - Scenario Narratives
- ***Quantitative***
  - analytical
  - formal model

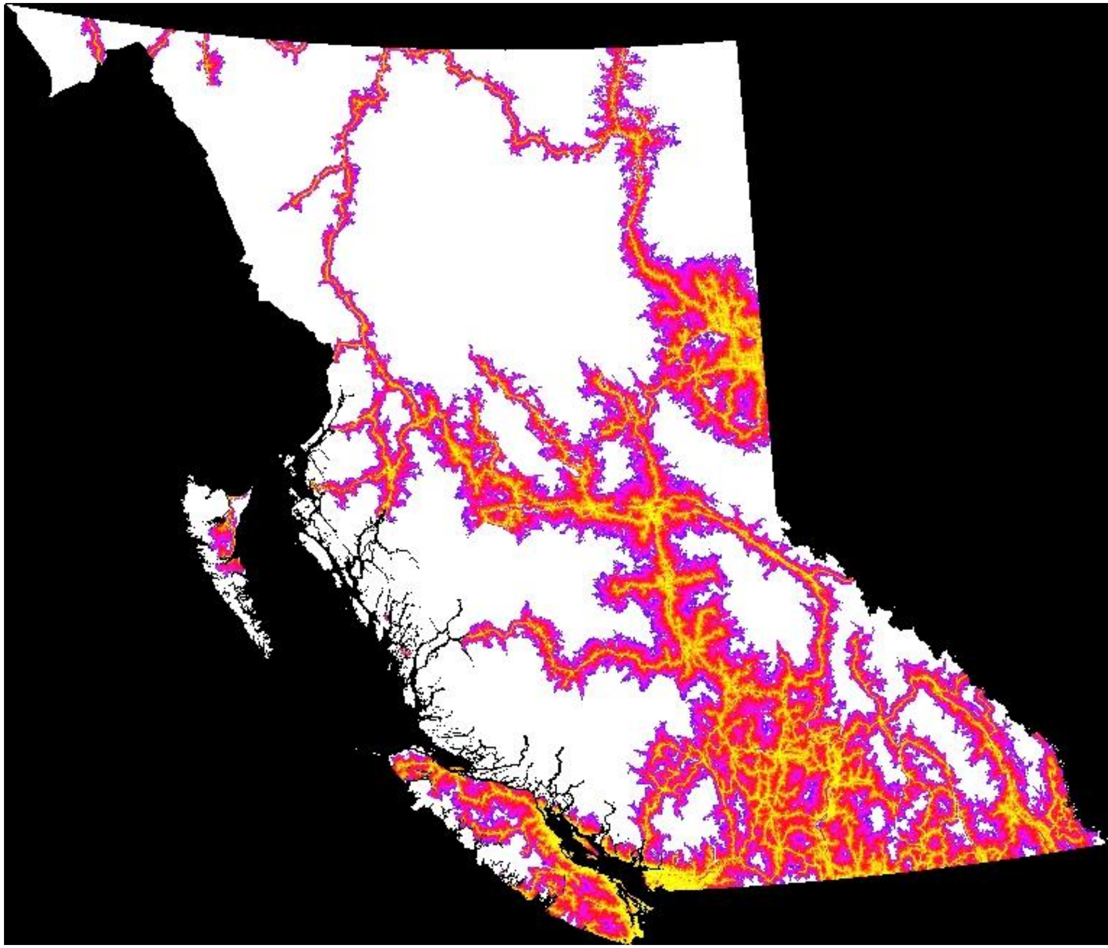


Scenario Modelling

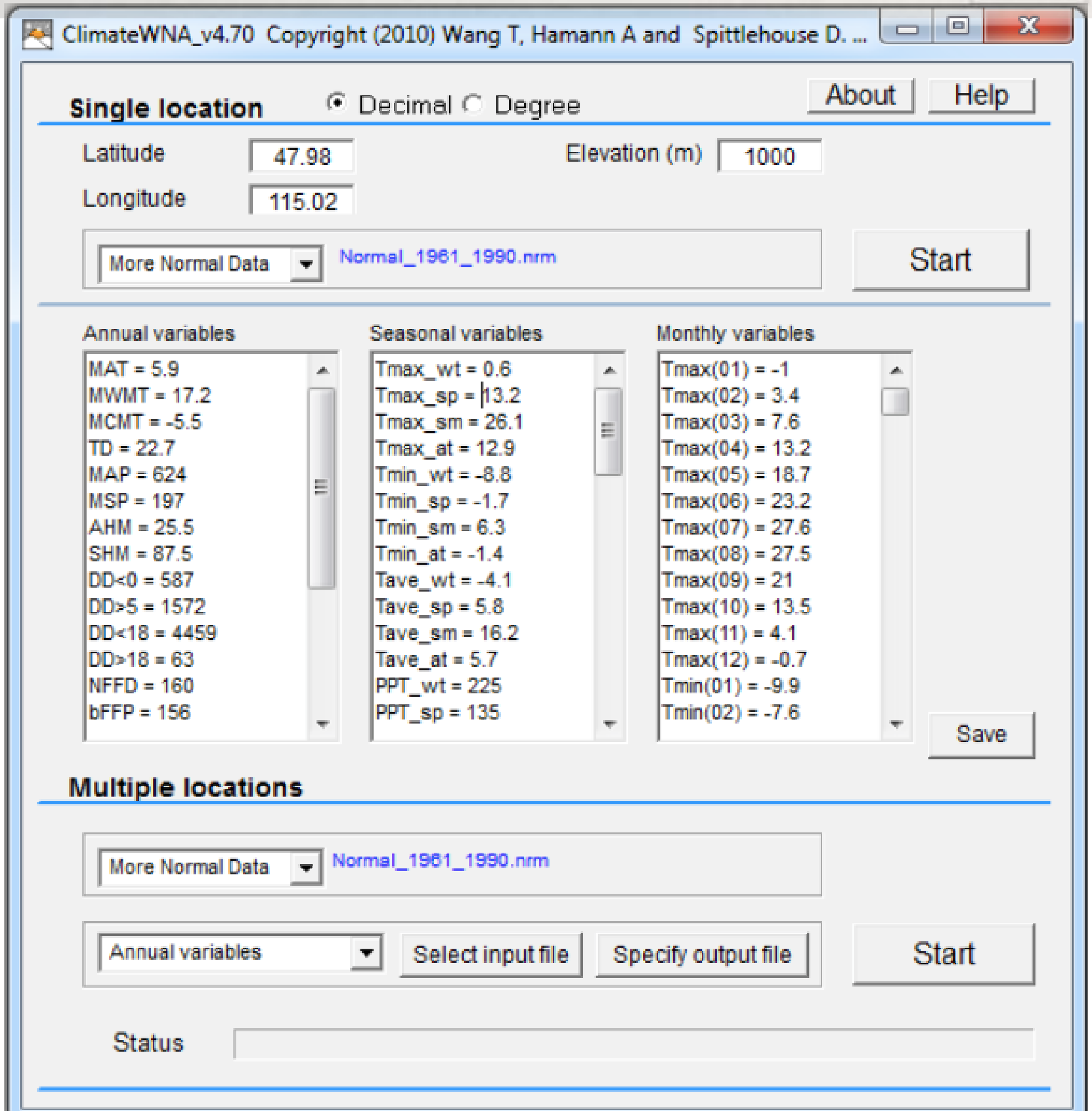


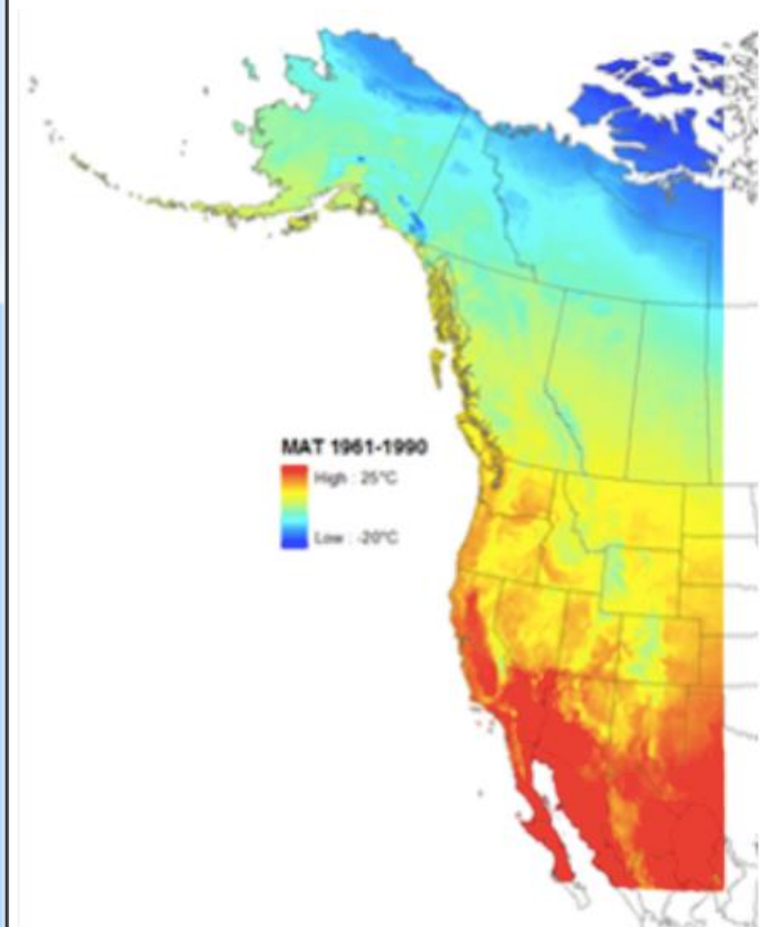
Scenario Toolkit

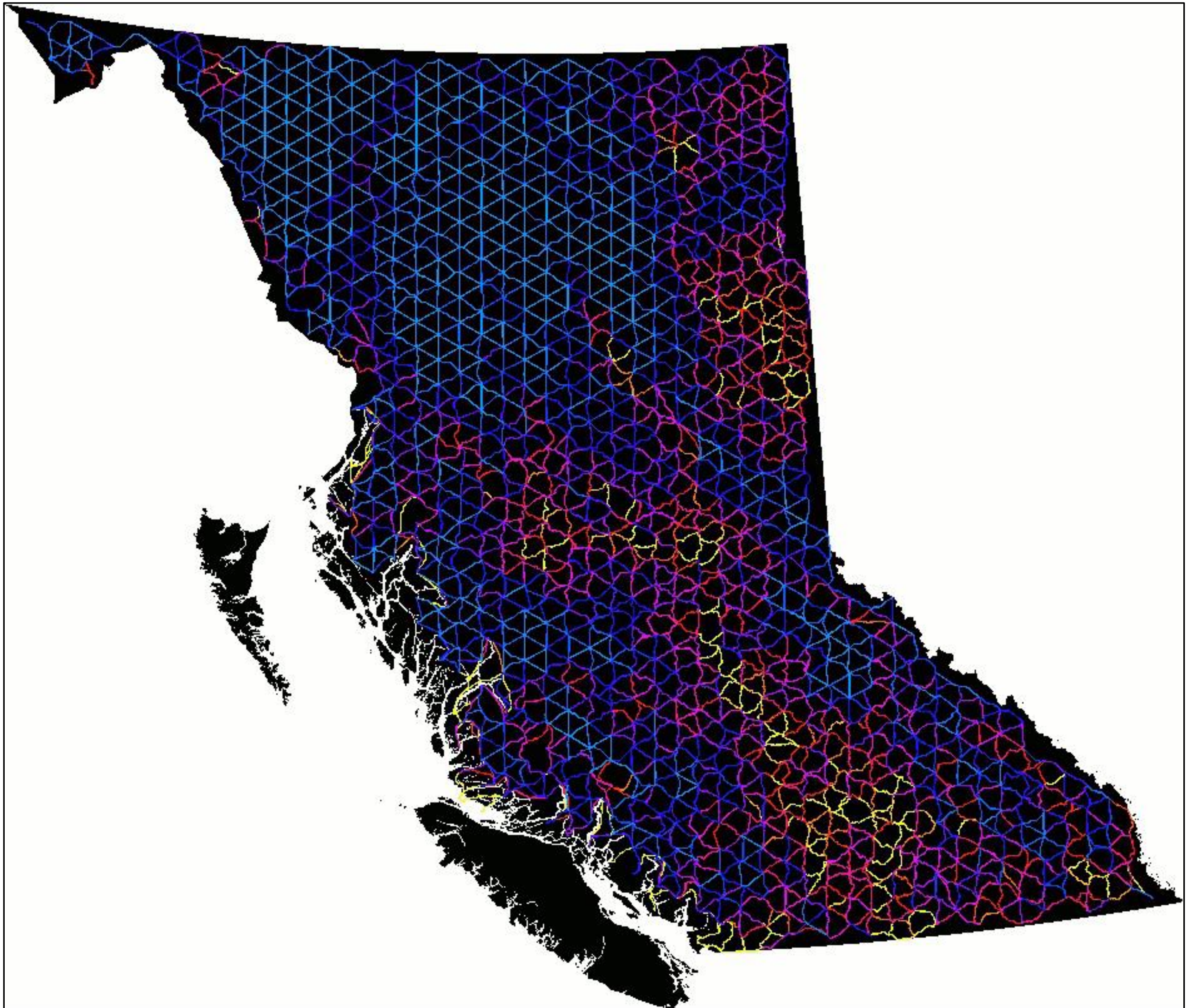
- Landscape Models:
  - Timber Supply
  - Road construction
  - Pipelines
  - Mines
  - Natural Disturbance
  - Hydrology & Glaciers
  - Wildlife
  - Human pressure



Scenario Toolkit

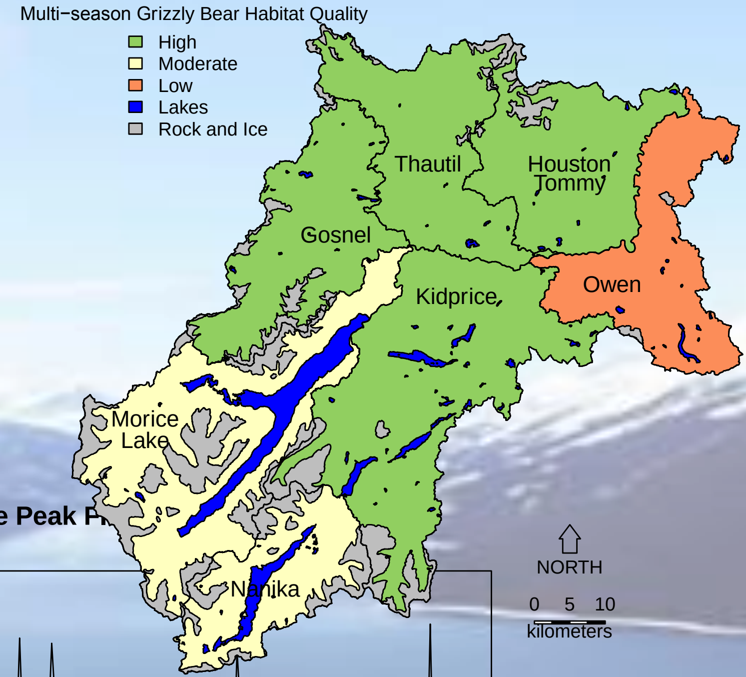


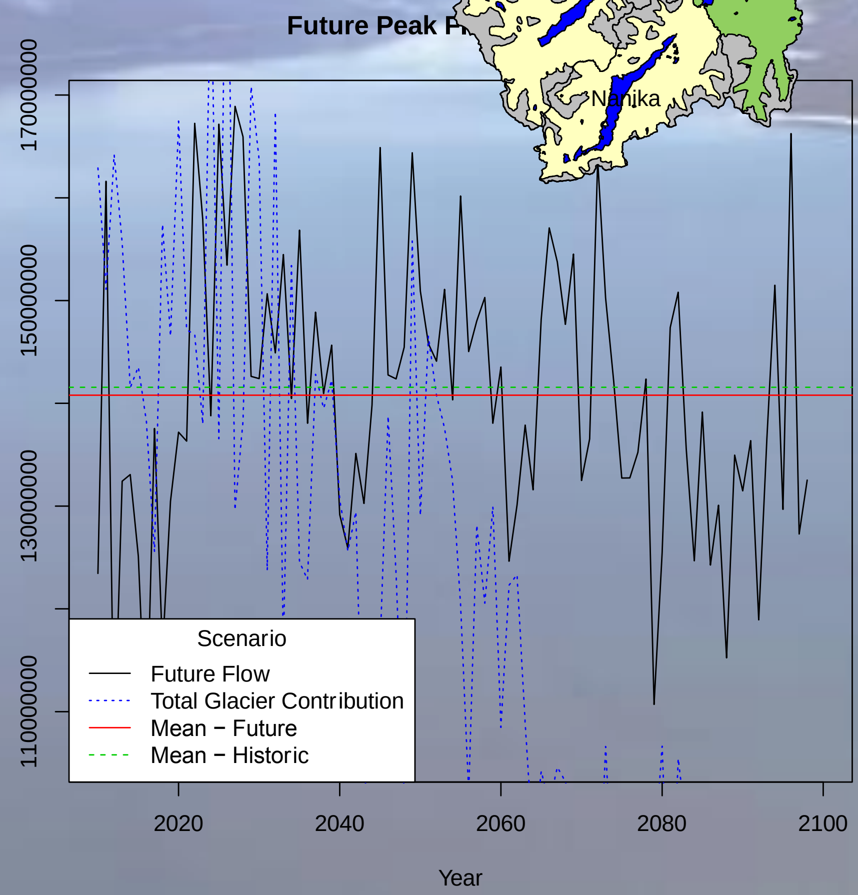




Morice Watershed Case Study

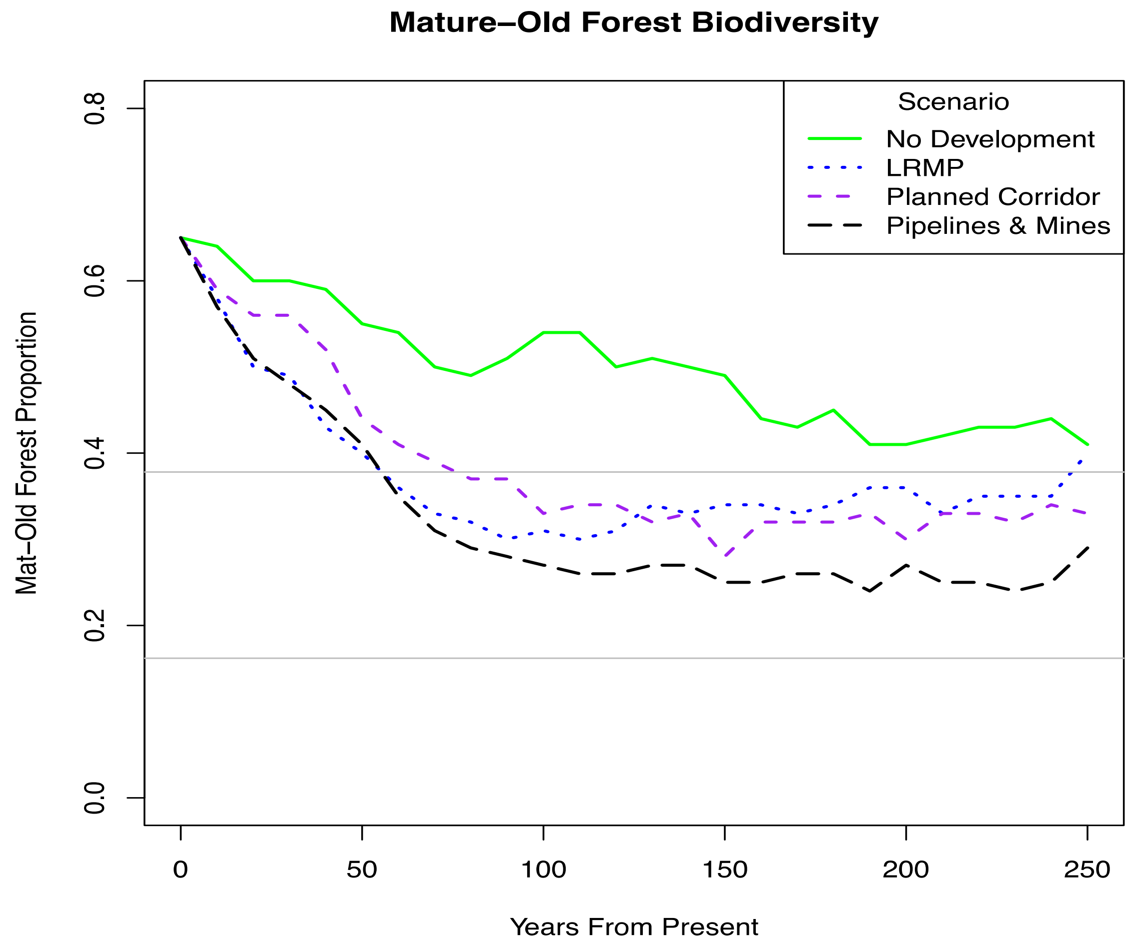
- **Values:**
  - Grizzly Bears
  - Moose
  - Forest Biodiversity
  - Salmon Habitat
    - Water Quality
    - Water Quantity
    - Stream Morphology
- **Drivers of Change:**
  - Climate change
  - Forestry
  - Human access



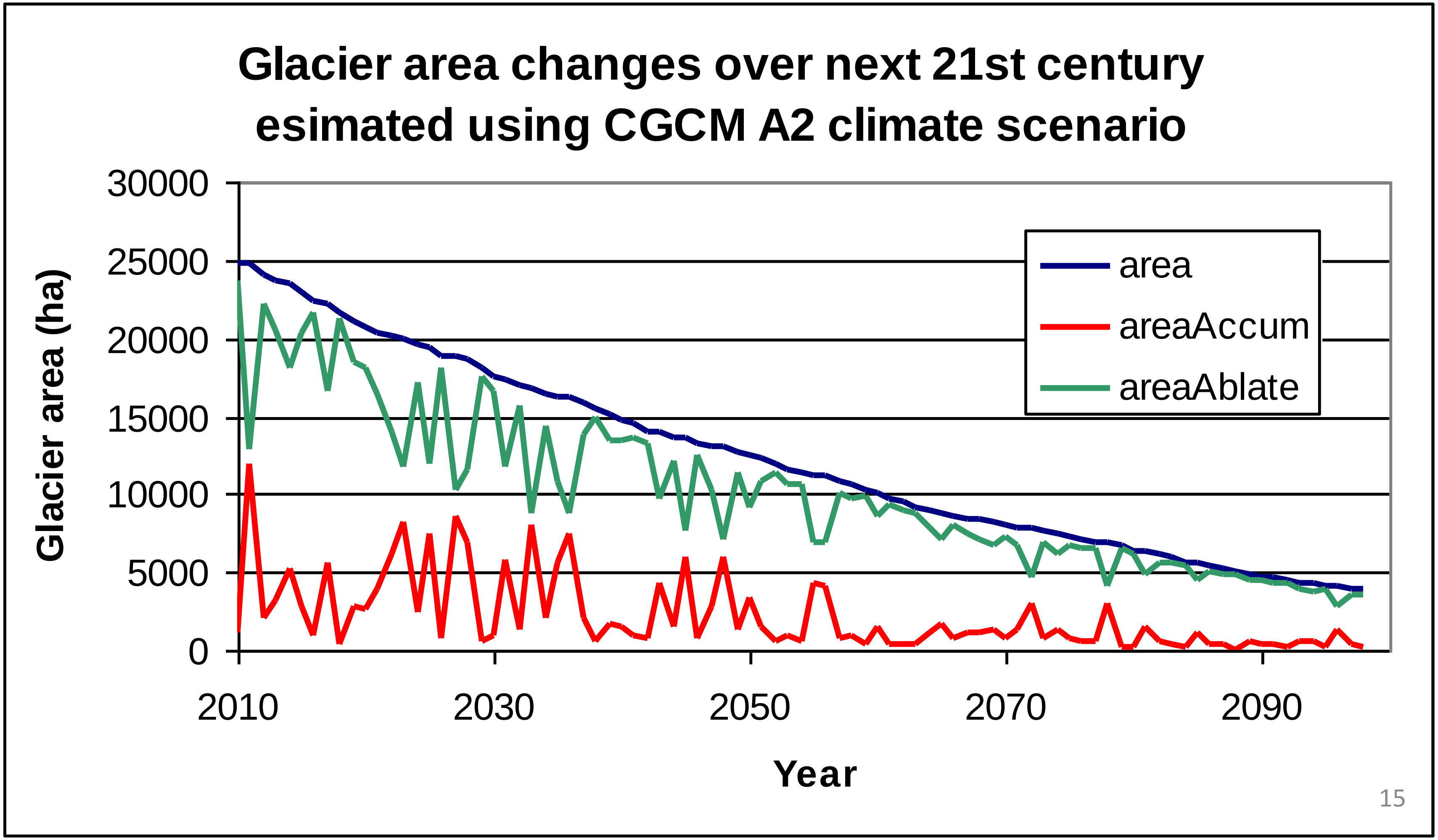


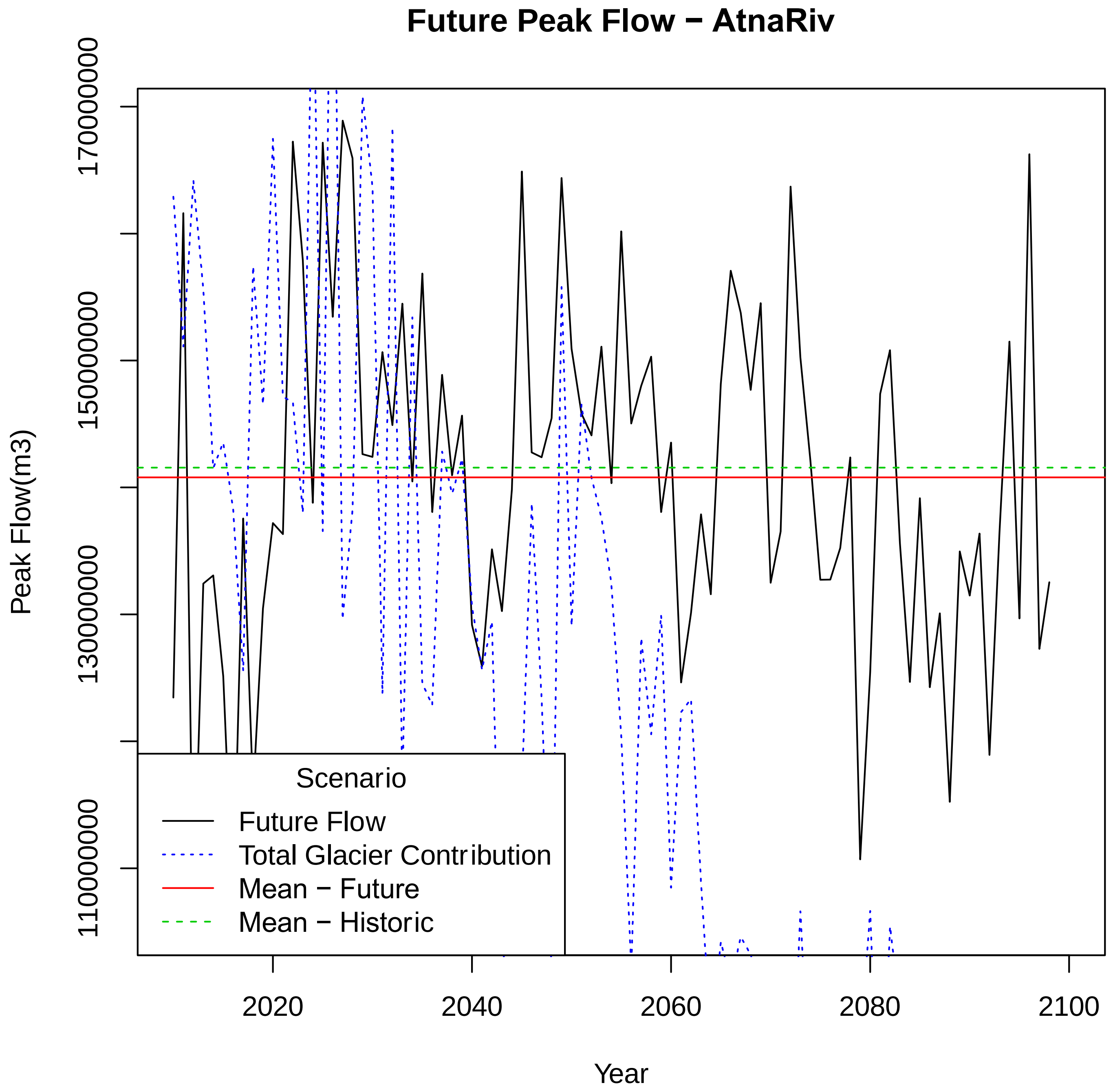
Biodiversity

Assessment Component	Indicator name
Importance	Special features in a landscape unit
Risk	Mature-old forest remaining Unroaded mature-old forest Air temperature increase
Mitigation	No-logging zones No-access zones



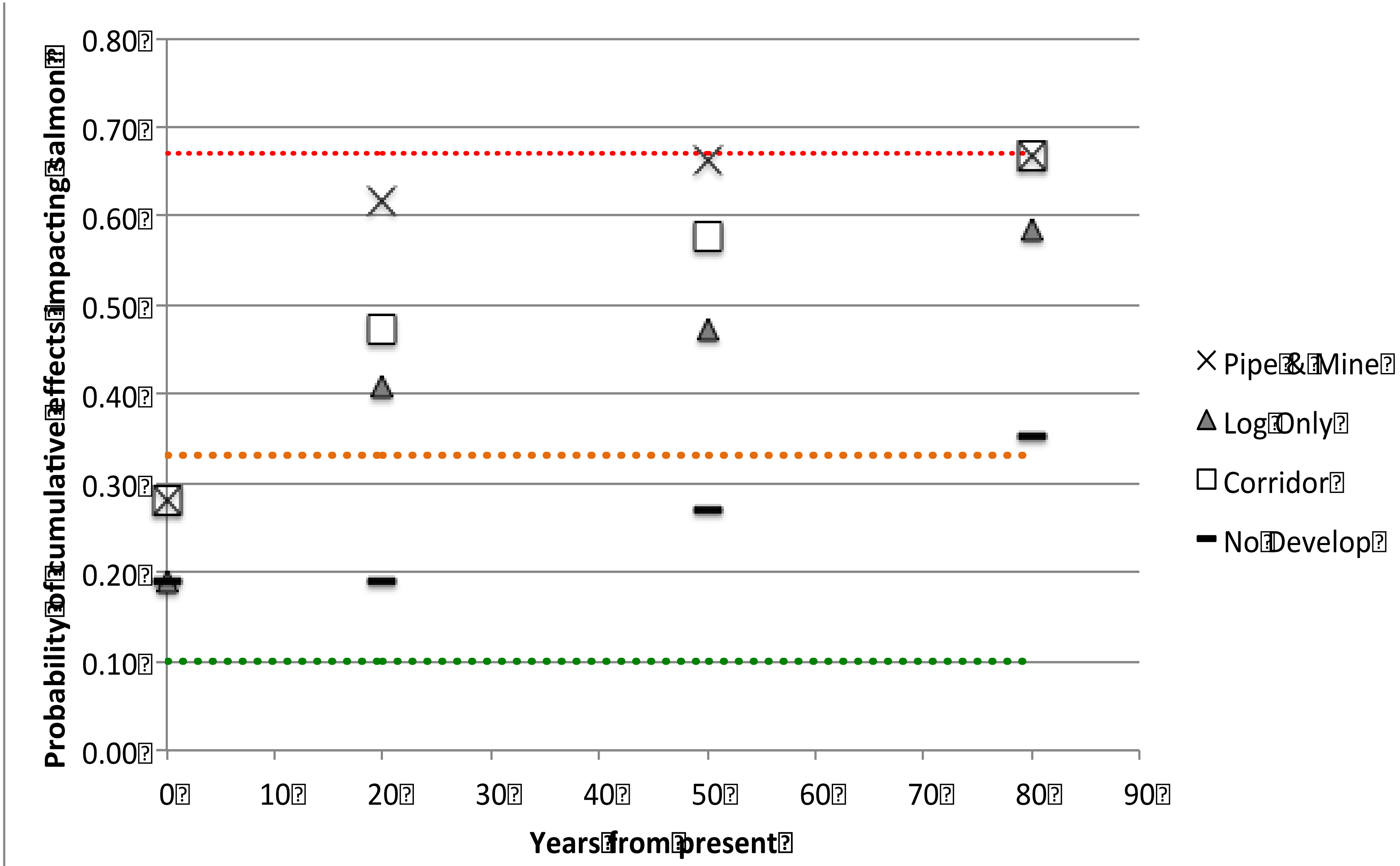
Climate Change Glacier Mass Balance



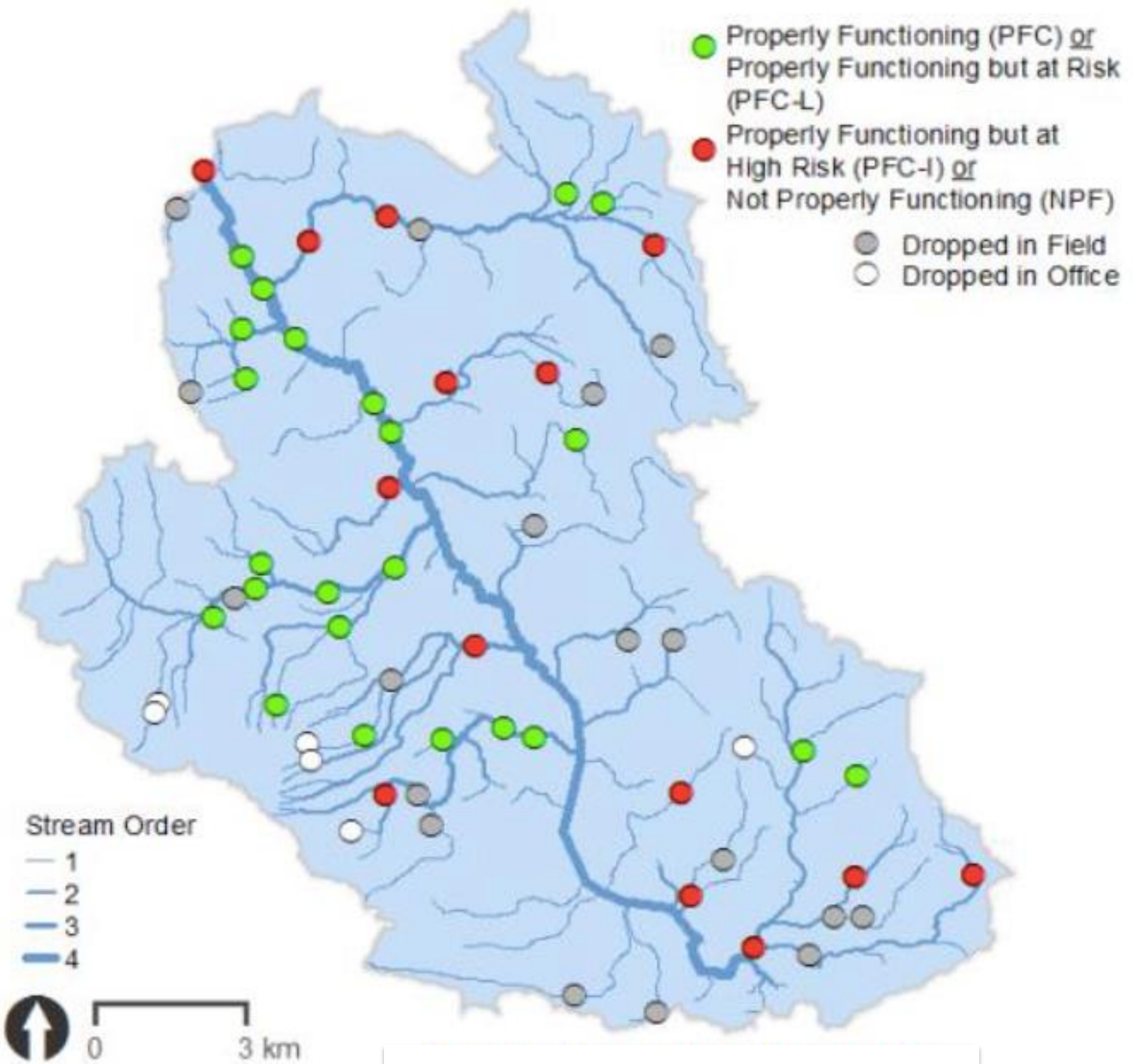


Future Peak Flow − AtnaRiv
Peak Flow(m3)
170000000
150000000
130000000
110000000
2020
2040
2060
2080
2100
Year
Scenario
Future Flow
Total Glacier Contribution
Mean − Future
Mean − Historic

Scenarios & Salmon Habitat

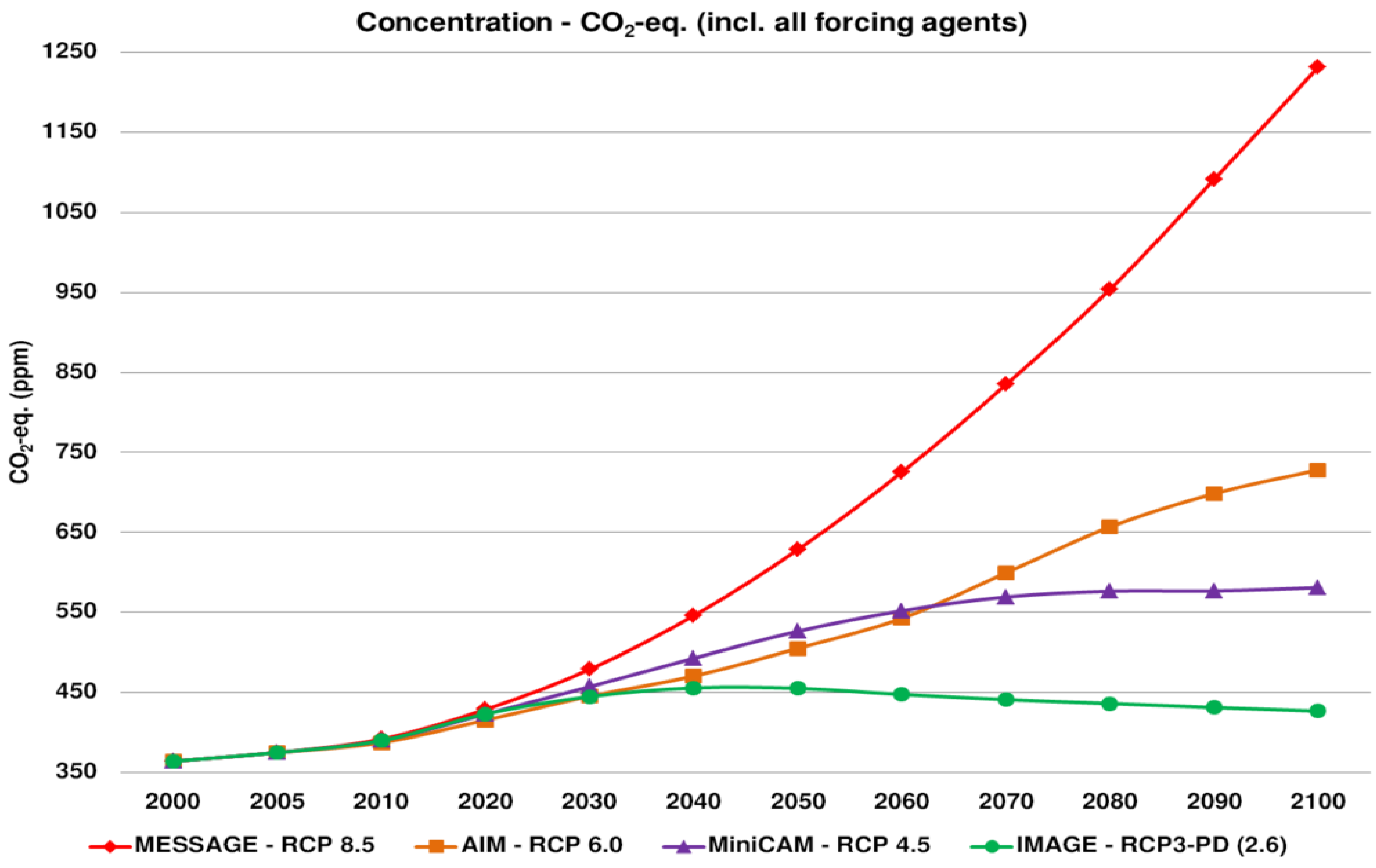


Owen Riparian Condition




Global
Scenarios

Representative Concentration Pathways - RCP



Global Scenarios

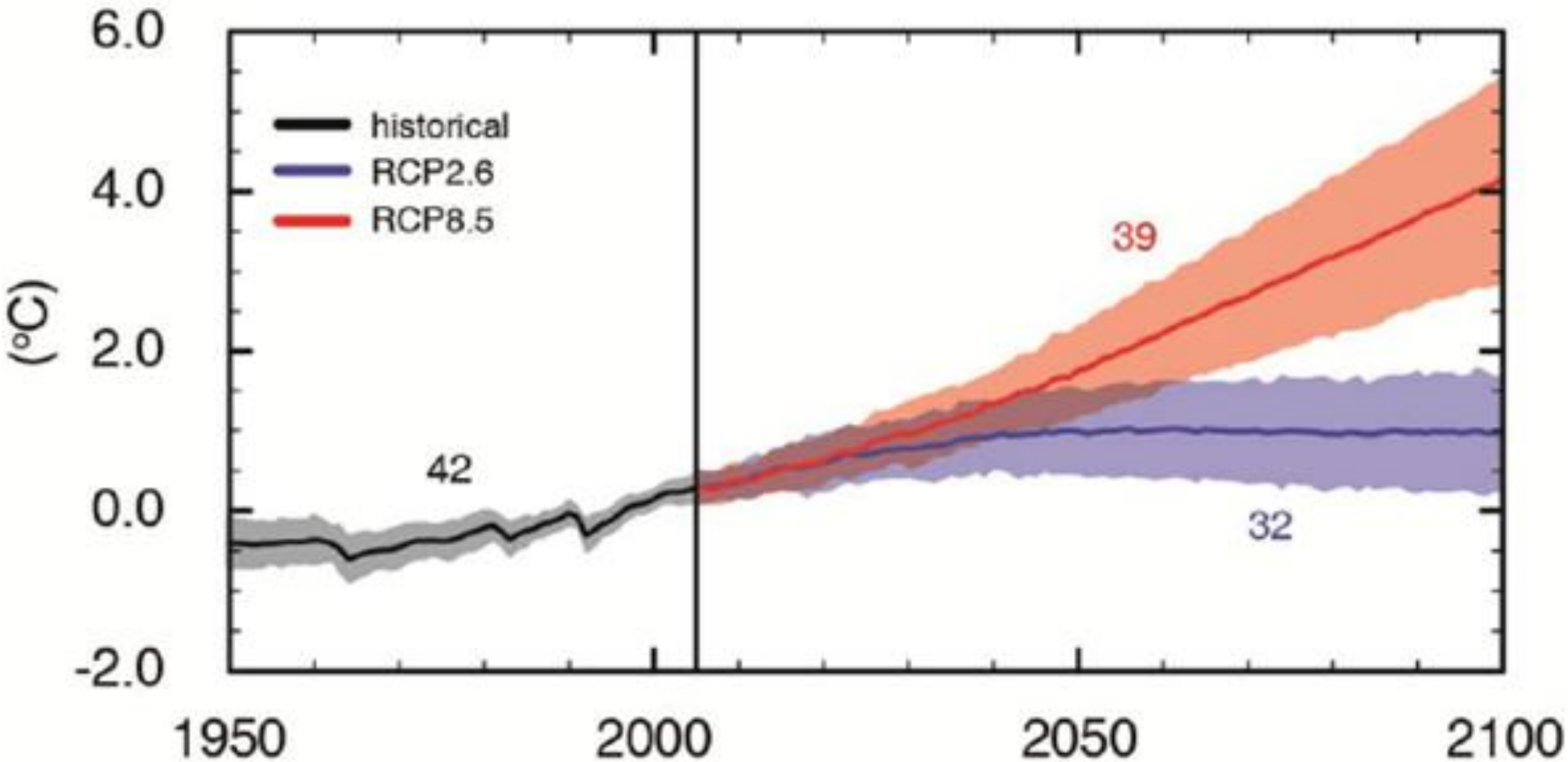
Year / RPC (w/m^2)	2046-2065 (C^o)	2081-2100 (C^o)	Trend
2.6	0.4-1.6	0.3-1.7	Peak 2020
4.5	0.9-2.0	1.1-2.6	Stabilize 2040
6.0	0.8-1.8	1.4-3.1	Stabilize 2080
8.5	1.4-2.6	2.6-4.8	Rising

Global Scenario Plot Lines

- ***SSP Elements:***
  - Demographics (e.g. population growth);
  - Human development (e.g. skills training);
  - Economy and lifestyle (e.g. economic growth, inequality, globalization);
  - Policies and institutions (e.g. international cooperation);
  - Technology (e.g. geo-engineering); and
  - Enviornment and natural resources (e.g. land use).

Shared Socio-Economic Pathways

Global Temperature Increase



Shared Socio-Economic Pathways

Shared Socio-Economic Pathways

Shared Socio-Economic Pathways

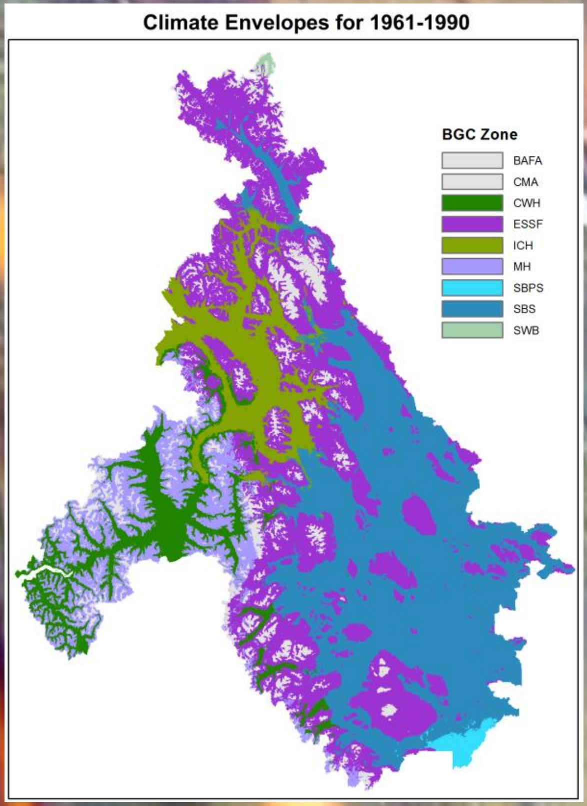
Shared Socio-Economic Pathways

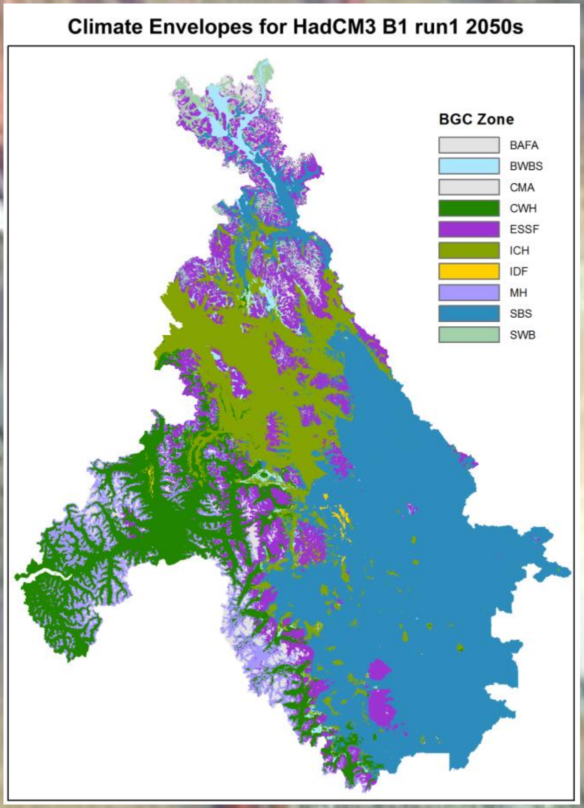
Shared Socio-Economic Pathways

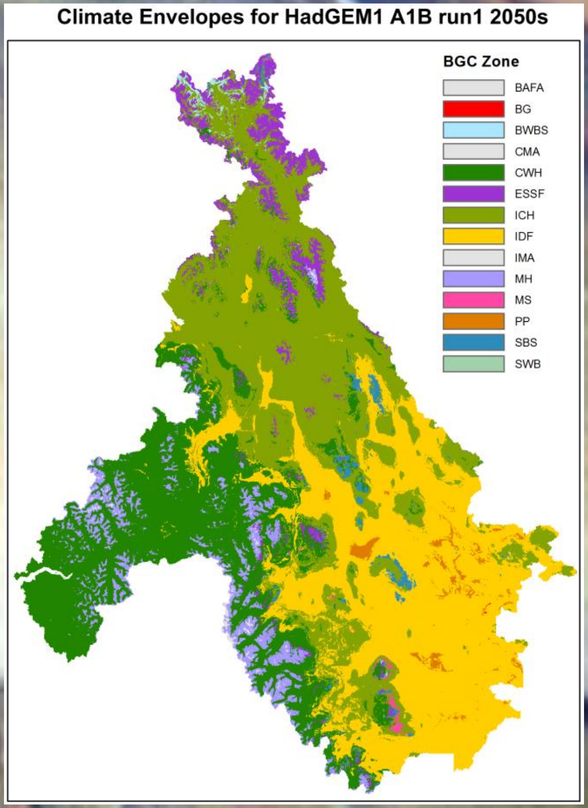
Global SSP Elements

	Environmnt	Population	Human Developmnt	Economy & Life Style	Policies & Institutions	Technology
Sustainability (SSP1) -	↗	↗	↗	↗	↗	↗
Middle of the road (SSP2) +	↘	↗	↗	↗	↘	↗
Regional Rivalry (SSP3) ++	↘	↗	↘	→	↘	↗
Inequity (SSP4) -	→	↗	↘	↘	↗	↗
Engineered (SSP5) -	↗	↗	↗	↗	↗	↗

Skeena Scenarios

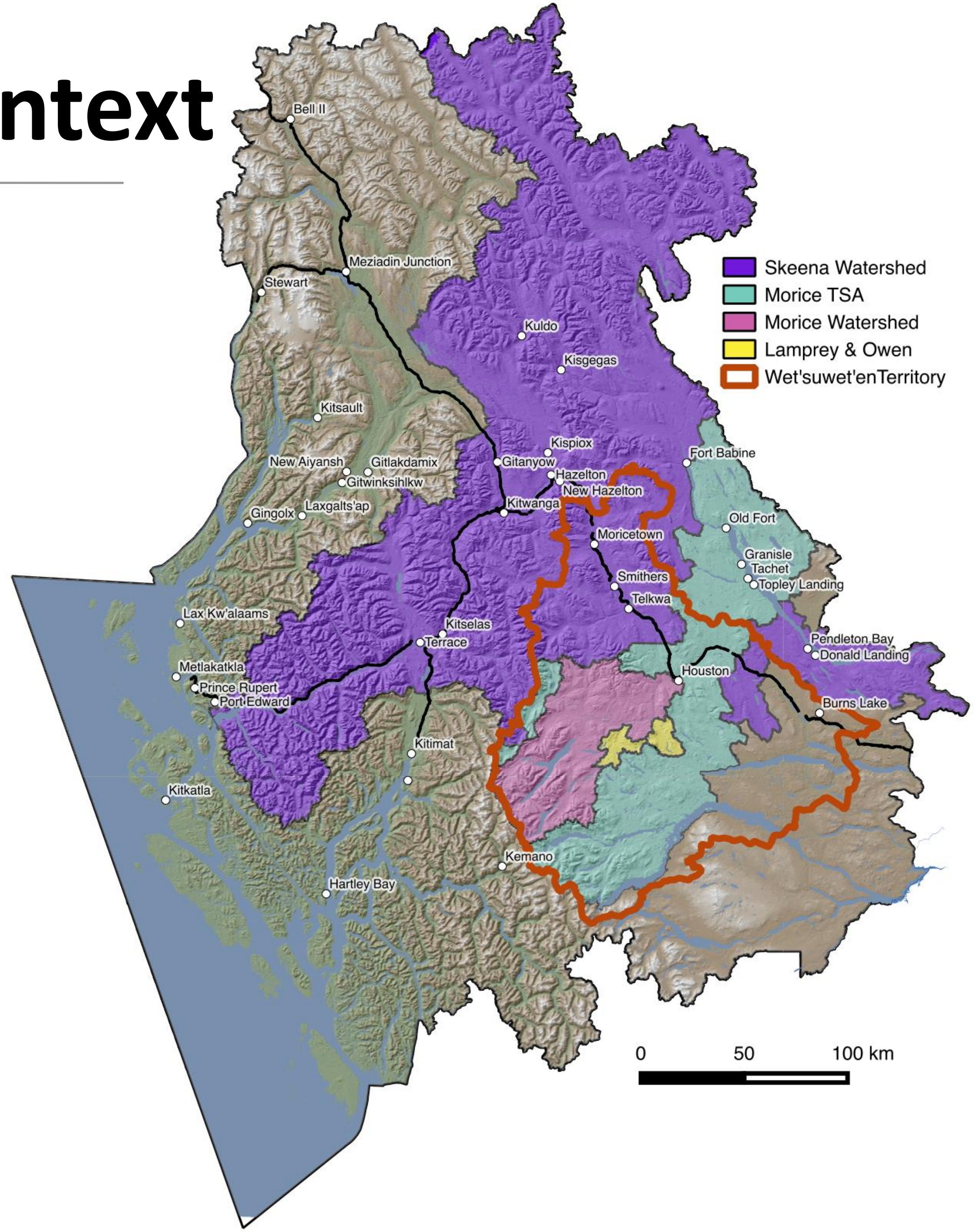






Geographic Context

- Morice:
  - Watershed
  - Water Management Area
  - Owen & Lamprey
- Morice Timber Supply Area
- Skeena Watershed

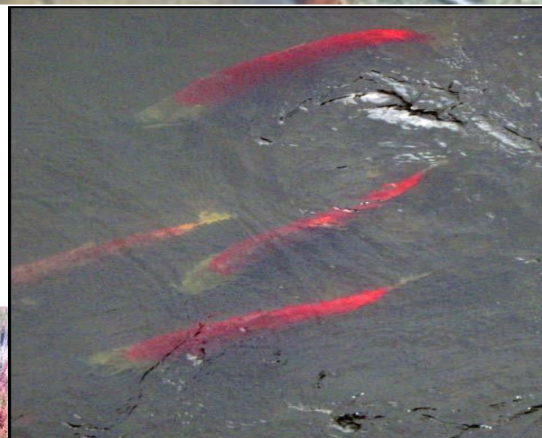


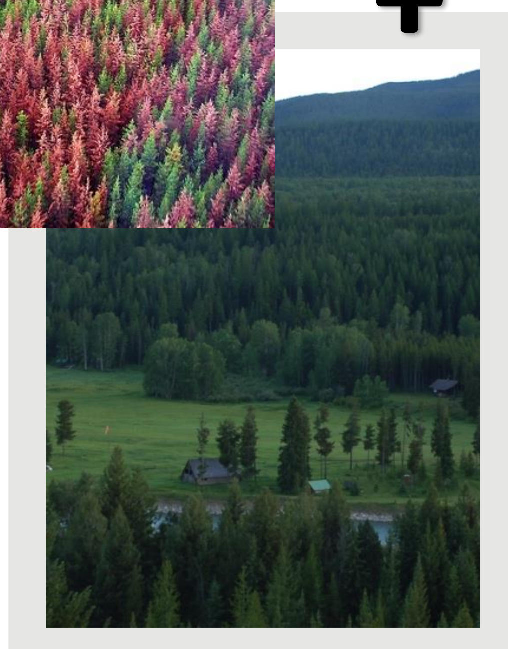
Skeena – Key Drivers

Key System Drivers

- Human:
  - Roads
  - Logging
  - Energy Development
  - Settlement
  - Land Use
- Ecological:
  - Climate Change
  - Peak/Low flow
  - Fire
  - MPB
  - Floods

Skeena Shared Socio-Economic Pathways





Elements

- Enviornment and natural resources:
  - Biodiversity
  - Water & Fish habitat
  - Grizzly Bears
  - Timber
- Socio-economic:
  - Demographics
  - Human Development
  - Economy and lifestyle
  - Policies and institutions
  - Technology

Skeena Scenarios

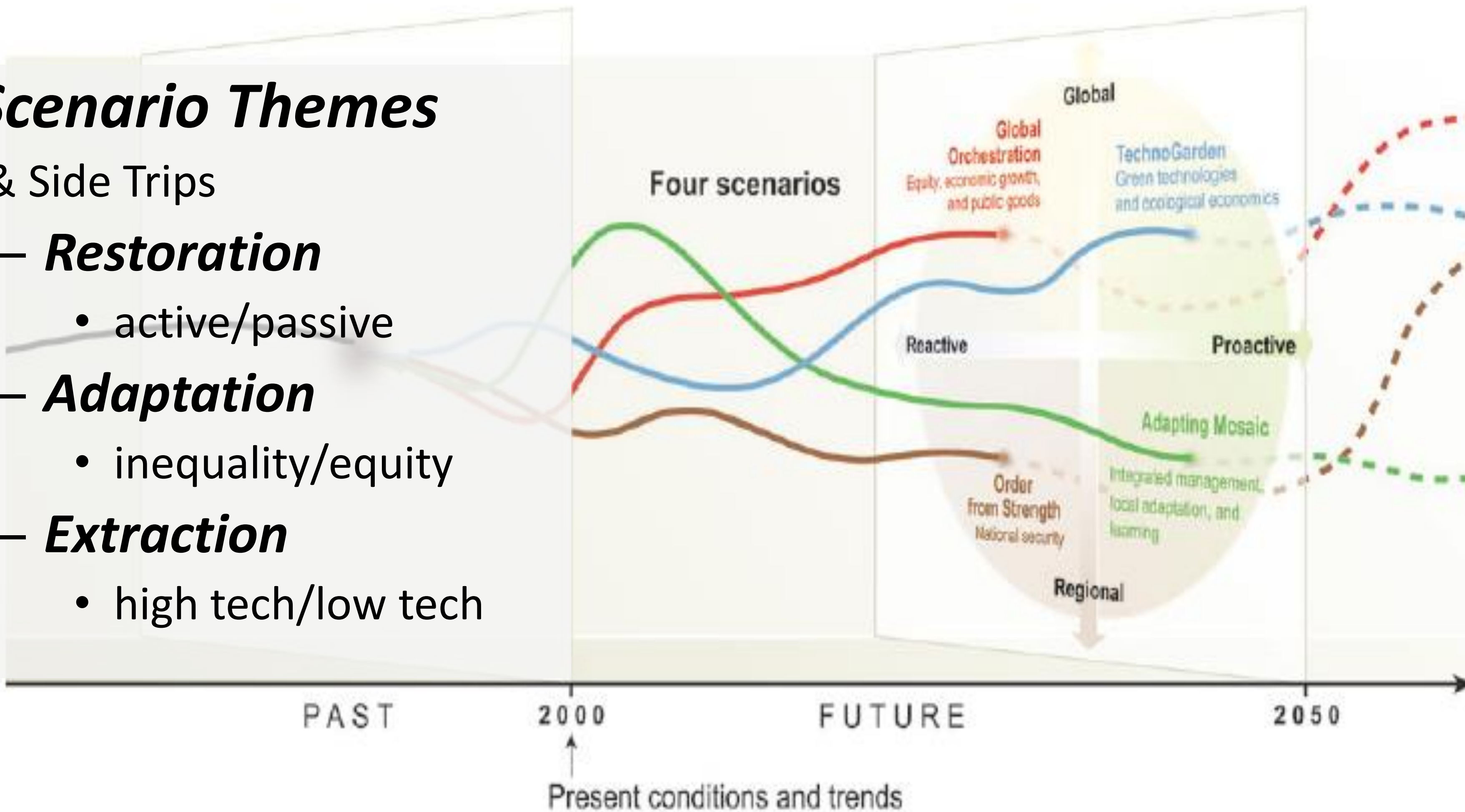
- ***Scenario Themes***

  & Side Trips

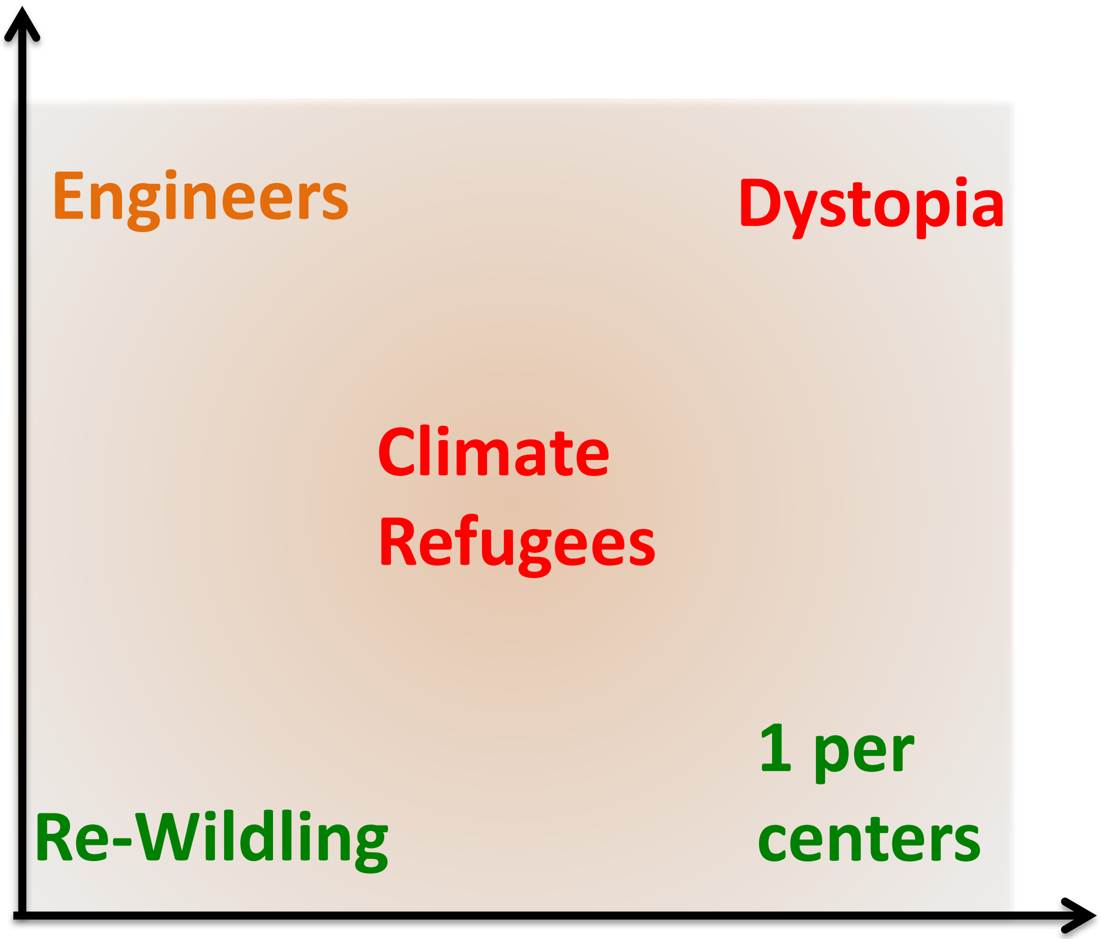
  – ***Restoration***
    - active/passive

  – ***Adaptation***
    - inequality/equity

  – ***Extraction***
    - high tech/low tech

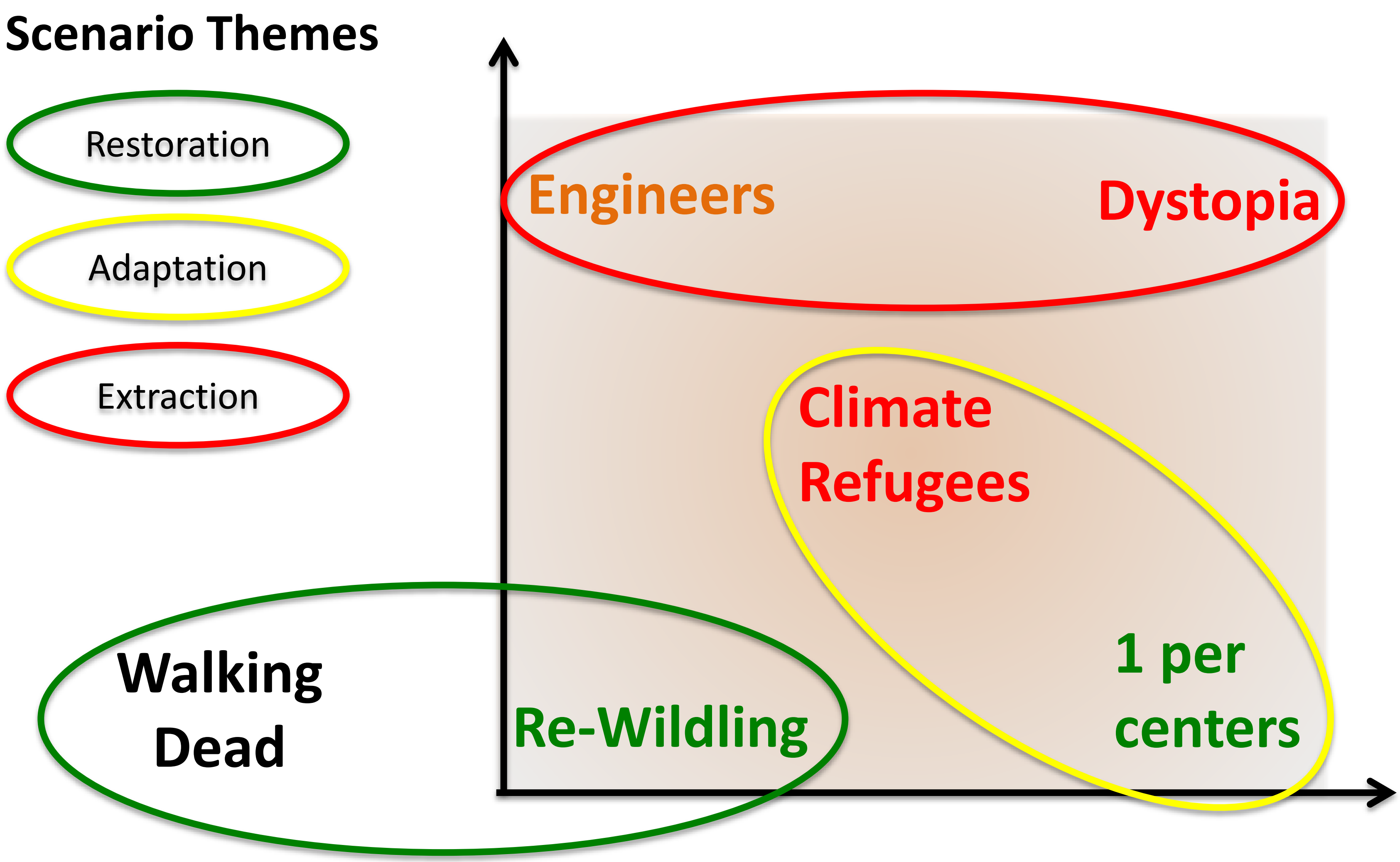


Skeena Scenario Space

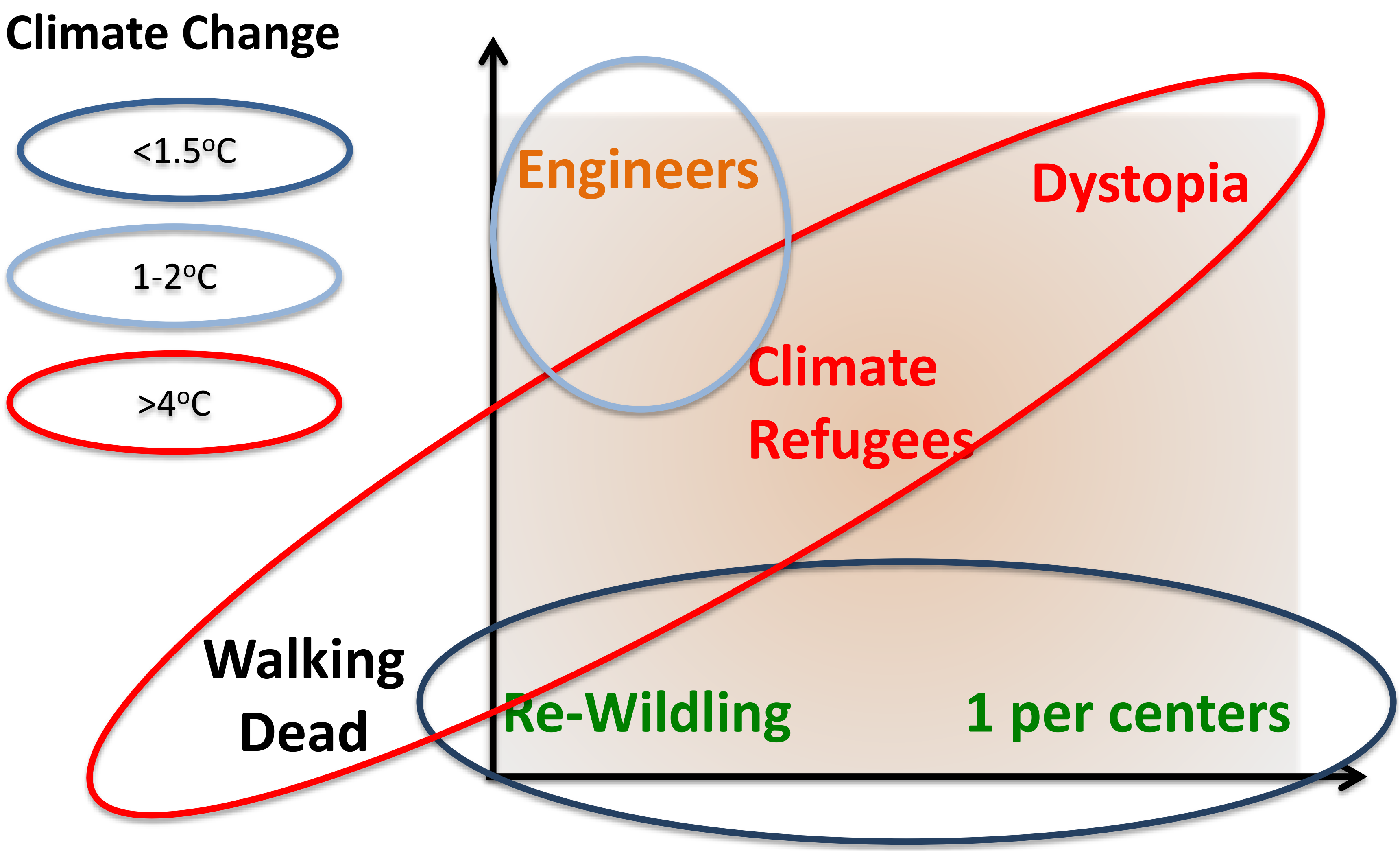


Walking Dead

Skeena Scenario Space



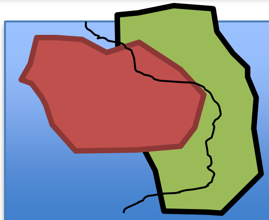
Skeena Scenario Space



Skeena SSP Elements

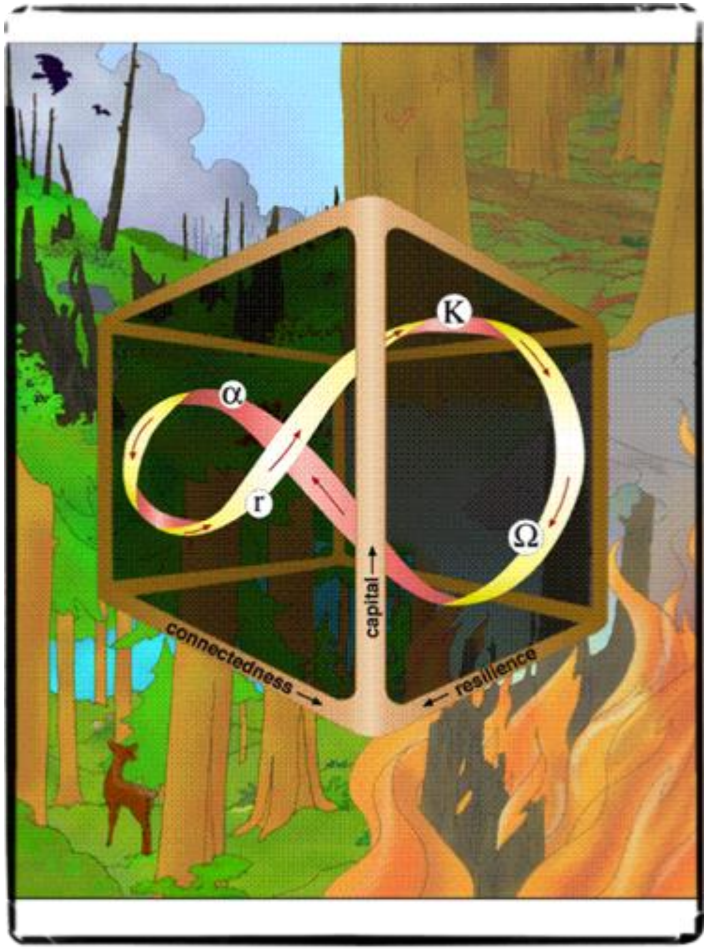
	Environmnt	Demo-graphics	Human Developmnt	Economy & Life Style	Policies & Institutions	Technology
Re-Wildling (SSP1) -	↗	↗	↗	↗	↗	↗
Climate Refugees (SSP2) +	↘	↗	↗	↗	↘	↗
Dystopia (SSP3) +	↘	↗	↘	→	↘	↗
1 per centers (SSP4) -	→	↗	↘	↘	↗	↗
Engineers (SSP5) -	↗	↗	↗	↗	↗	↗

Skeena Integrated Assessment

Step	Activities	Examples
Define Scenarios	Development Activities & Natural Events	climate change, fire, hydrology, forestry, energy corridors
System Dynamics	Landscape/Water, Social & Economic Dynamics	 landscape change
Effects	Land/Water, Social & Economic Change	Stream flow, wildlife movement, human access, land cover
Interpretation	Valued Service Specific Assessment	salmon habitat, grizzly bear, biodiversity, timber supply, population

System Drivers → Models

- Climate change
  - Terrestrial
  - Aquatic ecosystem change – glacial melt, stream flow
- Regulation
  - Forestry
  - Energy Corridors
  - Road building and deactivation
- Population
  - Settlement expansion
  - Land Use – agriculture, grazing.
  - Hydrology



Skeena Scenarios

	Skeena	Global	Theme	CC	Regultn	Popn	Equity
Restoration	*Re-wildling*	Taking the Green Road-SSP1	Sustainability	-	+	-	++
	Walking Dead	NA	No people	+	NA	NA	NA
Adaptation	*1 per centers*	A Road Divided-SSP4	Inequality - 1 per centers dominate, but global agreements	-	+	++	-
	Climate Refugees	Middle of the Road-SSP2	Future resembles past	+	-	+	+
Extraction	*Engineers*	Taking the High Way-SSP5	Fossil-fueled Development with geo-engineering to dampen temp increase	-	+	-	++
	Dystopia	Rocky Road-SSP3	Regional rivalry, no agreements, no rules	+	-	++	-

Emissions ➡ Global SSP ➡ Skeena SSP

Year / RPC	2046-2065 (C°)	2081-2100 (C°)	Trend
2.6	0.4-1.6	0.3-1.7	Peak 2020
4.5	0.9-2.0	1.1-2.6	Stabilize 2040
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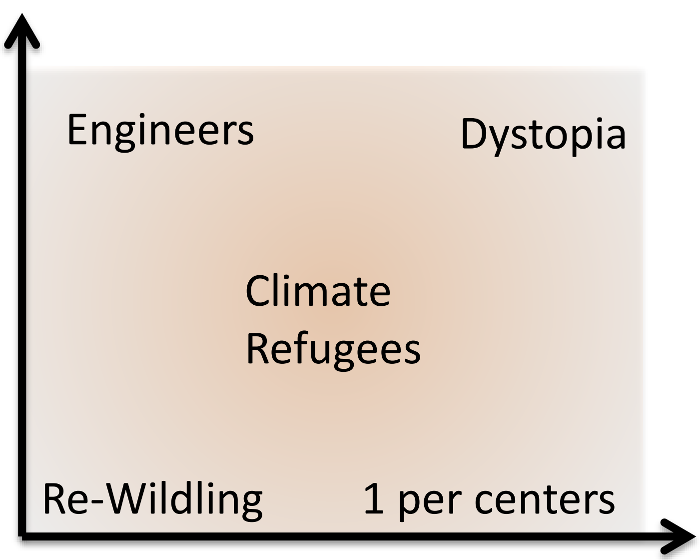


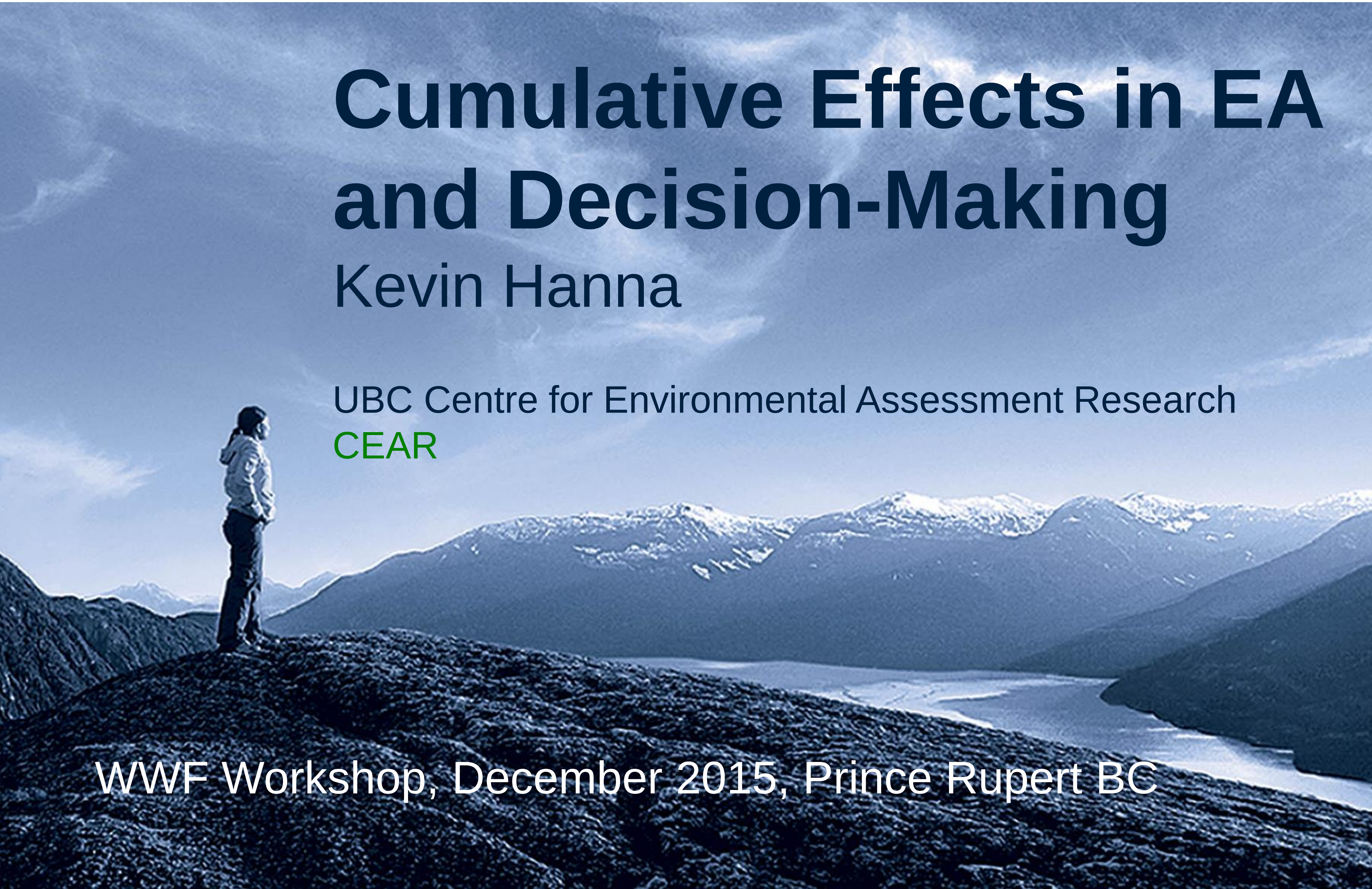
Acknowledgements

– Ministry of Environment
– Bulkley Valley Research Centre
– Ministry of Forests, Lands and Natural Resource Operations

– Dave Daust
– Gowland Technologies
– Moore Foundation


Questions

SESSION V PRESENTATIONS – CUMULATIVE EFFECTS IN ENVIRONMENTAL ASSESSMENT & DECISION-MAKING



Cumulative Effects in EA and Decision-Making

Kevin Hanna

UBC Centre for Environmental Assessment Research
CEAR

WWF Workshop, December 2015, Prince Rupert BC

Outline for today

1. EA and CEA
2. Terms and definitions
3. The need for CEA?
4. Three uncertainties
5. The link to decision making
6. Doing something new

Environmental Assessment

- Environmental Impact Assessment, Impact Assessment, Environmental Assessment
- Process to identify impacts that may come from an action… options to eliminate, mitigate, or accept
- Systematic process
- Does not make a decision
- Informs decision-maker

The objective of environmental assessment

Assessment terms

- Project-based assessment
  - One project, assessment is bounded by time, space, issues (significant issues?)
- Risk Assessment, ERA, TIA
- Social and/or economic impact assessment
- Health impact assessment
- Cumulative effects/impact assessment

Cumulative Effects Assessment

1. The incremental impact of an action when added to other past, present, and reasonably foreseeable future actions…
2. Cumulative effects/impacts can result from individually minor but collectively significant actions taking place over time
3. Effects/impacts resulting from the interaction of the proposed project with other (‘significant’) projects in the same area during a set time period

Characteristics

- Action is assessed relative to other past, present and foreseeable actions
- The temporal scale is longer (than single EIA)
- The number and type of actions considered is greater
- Spatial scales are broader
- An action is evaluated beyond local boundaries

Temporal and spatial scales

- Individual assessment might conclude that the impacts of an individual project are insignificant because of confined temporal and spatial scales. But…
- changes from repeated, or multiple actions may accumulate over time and then become significant.

- Combined SO_2 emissions within a region from 1 then 2 then 3 operating natural-gas processing plants…
- Combined reductions in flow volumes within a watershed from irrigation, municipal, and industrial water withdrawals, then we add pollution…
- Grizzly bear decline from logging, habitat change, food loss, roads are built, more access, road kills, other activities, hunting…

The objective of cumulative effects assessment

Link to EA

- As part of EA practice, a form of EA
- Applied to project-based EA as a regulatory requirement
  - May be not too useful here?
- Provider of data and analysis
- Predictive tool
- A strategic planning tool

So.. Why are you interested in CEA?

- What is the question you want it to answer?
- Is it meant to solve a problem, a conflict, or help make a decision?
- Is it a replacement for something else?
- Is it simply fashionable, the next wave in the progression of land use planning approaches?

Three uncertainties

1. Institutional arrangements are central to effective CEA. Are existing arrangements adequate?

Agencies, other organizations, industry.

Institutional arrangements are essential for connection data and analysis to needs and decision-making.

2. CEA needs to be technically strong and data-rich. But how such tools and data are used to actually support policy, planning and decision-making, and how well they reflect values is a challenge – there is a risk of data that has no place to go.

3. There is uncertainty about the relationship between new CEA frameworks and existing land use planning and regulatory EA processes – whether CEA should be integrated into such, or if each functions better separately?

I think this poses a major policy challenge.

If you want to inspire confidence, give plenty of statistics – it does not matter that they should be accurate, or even intelligible, so long as there is enough of them.

LEWIS CARROLL, *Three Months in a Curatorship*

The link to decision-making

- What is the decision need?
- Who is making it?
- What information do they need?
- What are the capacities of the decision-making structures?
- What are the uncertainties?
- How do we communicate risk?

- EA does not make the decision, it is a tool, it informs the decision (ideally?).
- CEA will do the same. It is a mechanism for provide good information (better information?).
- There is no guarantee that good information will result in a good decision.

Change is always a challenge

41% of change projects fail. Of the 59% that 'succeed' only half meet the expectations of senior management.[1]

Why?[2]

1.	Competition for resources	48%
2.	Functional boundaries (silos)	44%
3.	Lack of change mngt skills	43%
4.	Middle management	38%
5.	Long IT lead times	35%
6.	Communication	35%
7.	Employee opposition	33%
8.	HR (training) issues	33%
9.	Initiative fatigue	32%
10.	Unrealistic timetables	31%

Source: 1: CSC Index/AMA Survey noted in PWC Change and Effectiveness Programme, 2014;
2: PWC-MORI Survey, 1997.

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Source: 1: CSC Index/AMA Survey noted in PWC Change and Effectiveness Programme, 2014;
2: PWC-MORI Survey, 1997.

“Would you tell me, please, which way I ought to go from here?
That depends a good deal on where you want to get to, said the Cat.
I don't much care where - said Alice.
Then it doesn't matter which way you go, said the Cat.
- so long as I get SOMEWHERE,' Alice added as an explanation.
Oh, you're sure to do that, said the Cat, if you only walk long enough.”

CEAR

UBC Centre for Environmental Assessment Research

Kevin Hanna, The University of British Columbia, CEAR Director
kevin.hanna@ubc.ca

SESSION VI PRESENTATIONS – CUMULATIVE EFFECTS IN PLANNING

BRITISH COLUMBIA | Natural Resource Sector Transformation Secretariat

BC's Cumulative Effects Framework

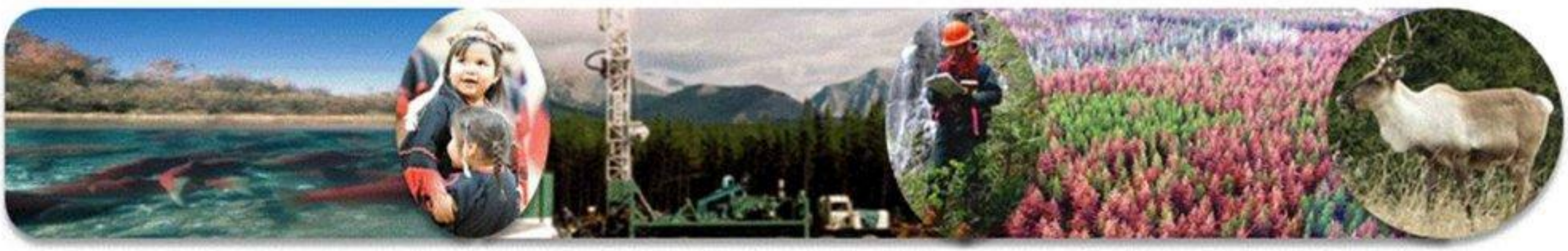
Cumulative Effects Assessment & Management Workshop:

Sharing Knowledge and Building Capacity in the North Coast

10-11 December 2015

Steve Kachanoski – Cumulative Effects Project Manager

BC Ministry of Forests, Lands, and Natural Resource Operations



Cumulative Effects Framework

Assessing and Managing Cumulative Effects in British Columbia

The Framework

BRITISH COLUMBIA

The Cumulative Effects Framework (CEF) is intended to improve environmental outcomes and support enhanced economic and social benefits derived from resource use.

- To be successful, the framework includes policy, procedures and decision support tools to improve the assessment and management of cumulative effects
    - Overview of cumulative effects framework
    - Core elements of the CEF
        - Focus on Values, Assessment, and Decision Support
    - Timelines and linkages

Cumulative Effects Framework

Assessing and Managing Cumulative Effects in British Columbia

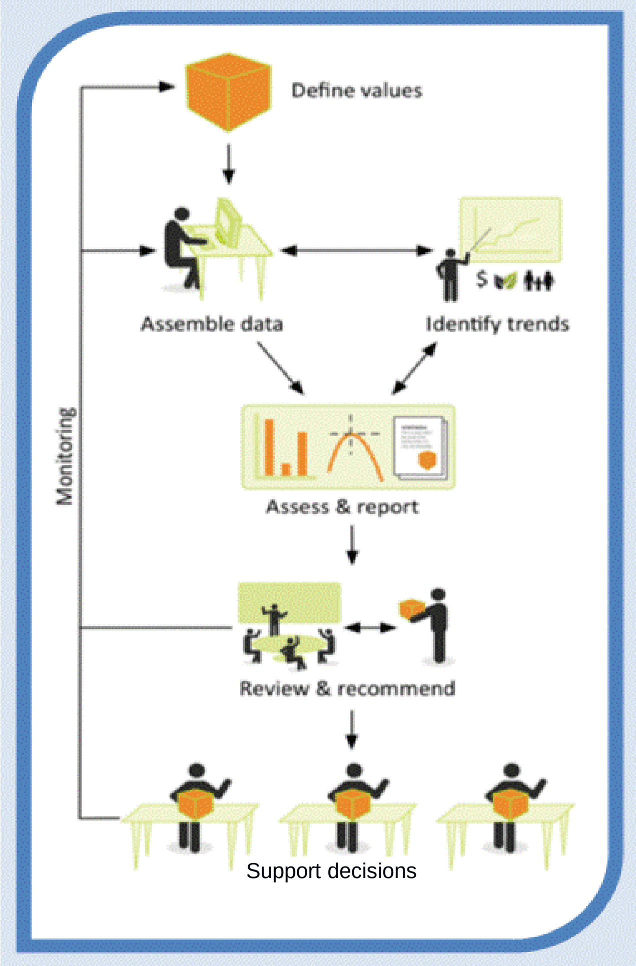
Elements of the Cumulative Effects Framework

Core Elements

Common Values & Objectives

CE Assessment

CE Management & Decision Support



Enabling Elements

First Nations & Stakeholder Engagement

Research & Monitoring

Legislation & Policy

Values:
How were the initial values for the CEF selected?

Criteria for Selection

- ❑ Existing Objectives (Legal & Policy)
- ❑ Support for Aboriginal/Treaty Rights
- ❑ Coarse Filter/Represents Nested Values
- ❑ Spatially Mappable
- ❑ Available Data

Proposed Values

- Forest Ecosystem Biodiversity
  - *seral distribution, old growth*
- Aquatic Ecosystems
  - *watershed condition, riparian*
- Water Quantity and Quality
- Priority Fish and Wildlife Species
  - *Caribou, grizzly, moose, deer*
- Marine
- Air Quality
- Cultural Heritage
- Visual Quality
- Resource Capability (e.g., timber)
- Economic & Social Wellbeing

5 Initial Values

- Forest Biodiversity
- Old Growth
- Aquatic Ecosystems
- Grizzly Bear
- Moose

Framework approach & Current Condition Assessments

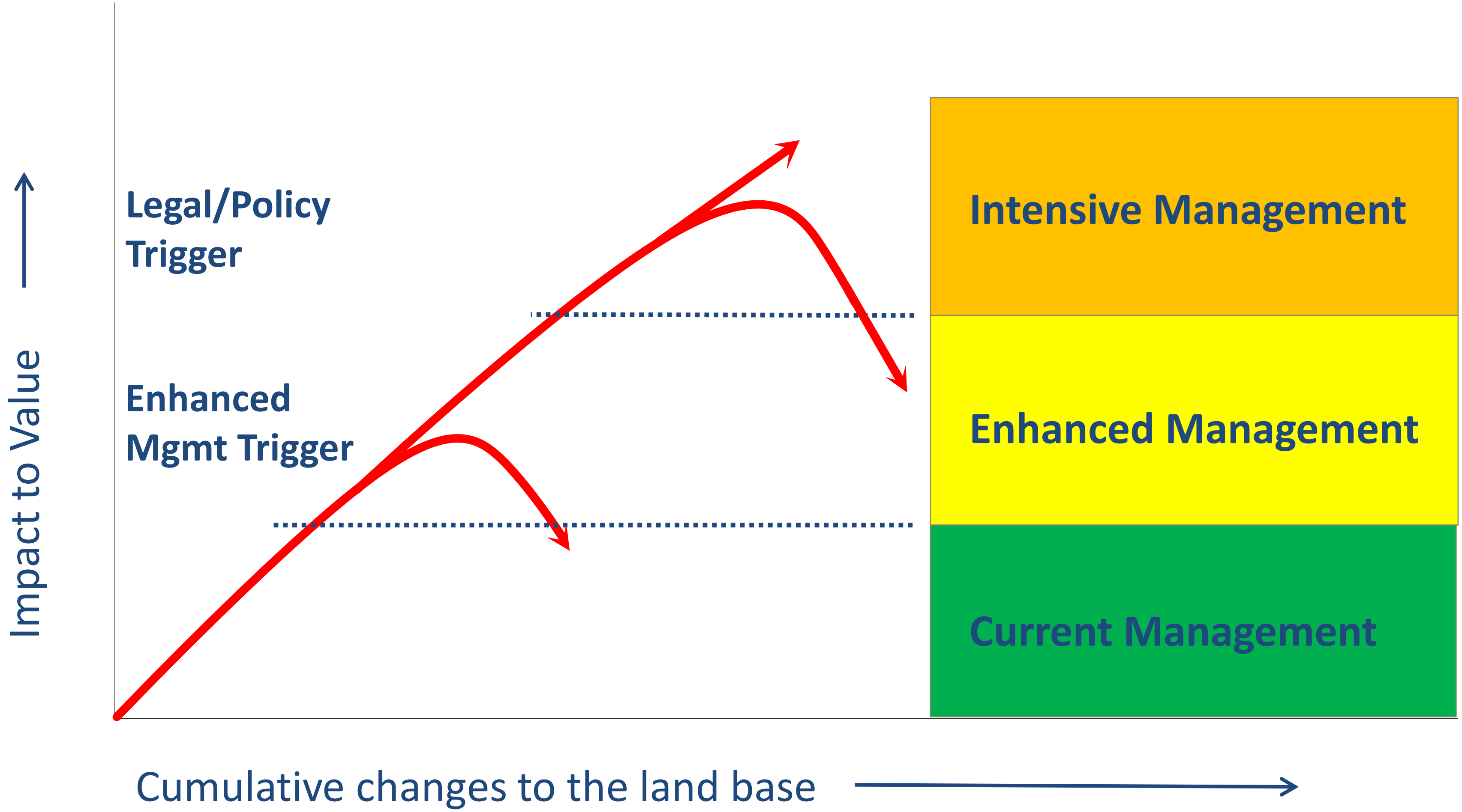
Priority Values:

1. Aquatic Ecosystems
2. Forest Biodiversity
3. Old Forest
4. Grizzly Bear
5. Moose

For Each Value :

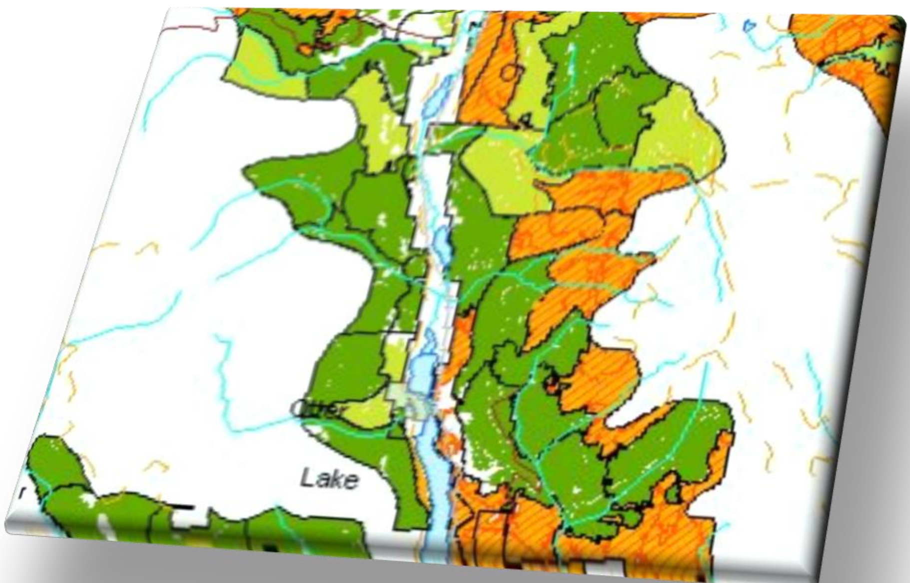
1. **Policy & Knowledge Summaries**
2. **Standard Assessment Procedure**
   -components, indicators
   -data sources
   -assumptions & uncertainty
3. **Current Condition Assessment**
   -current conditions for indicators
   -maps, reports

CEF considers the condition of values relative to management targets and triggers

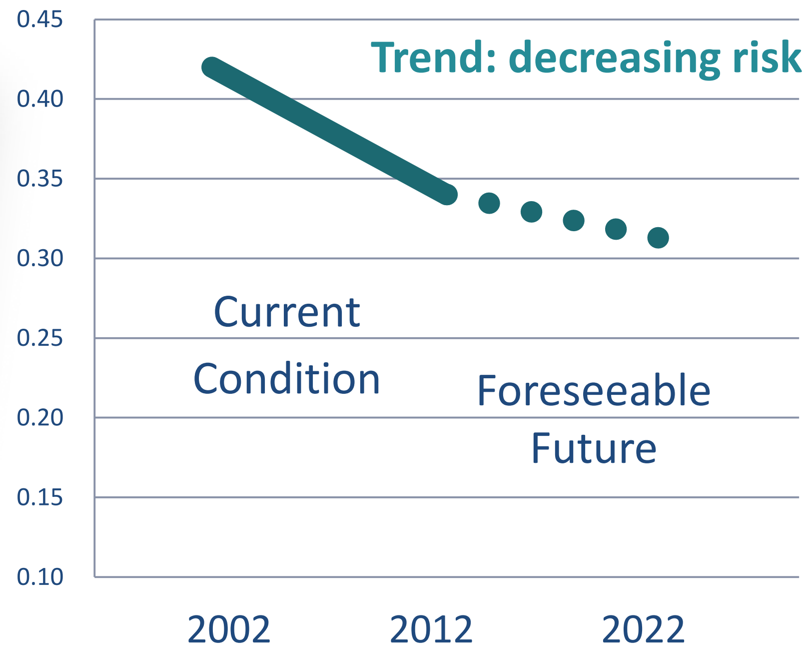


Sample: Cumulative Effects Assessment data for mule deer habitat

Current and potential future condition



Mule Deer Habitat Condition



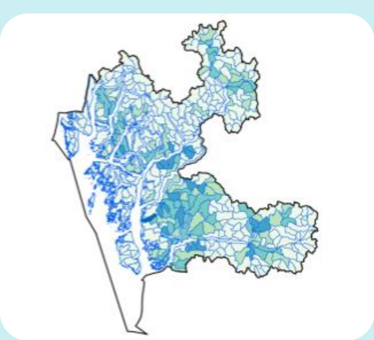
From Provincial Value Assessments to Regional CEAs

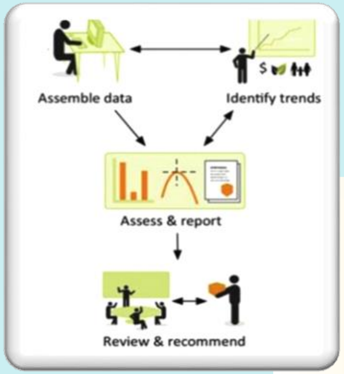
Provincial Assessments

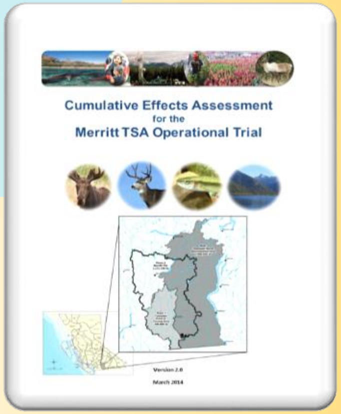
- Standardized *procedures* for assessing condition of provincial CEF values
- Current condition assessment / periodic update
- Standard techniques for communication and display of results

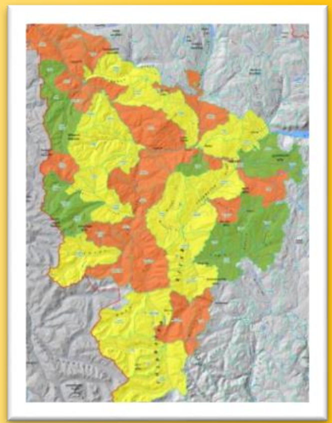
Regional Cumulative Effects Assessments

- + Regionally specific objectives
- + Foreseeable future condition / scenario development
- + Interpretation of conditions
- + Management Responses









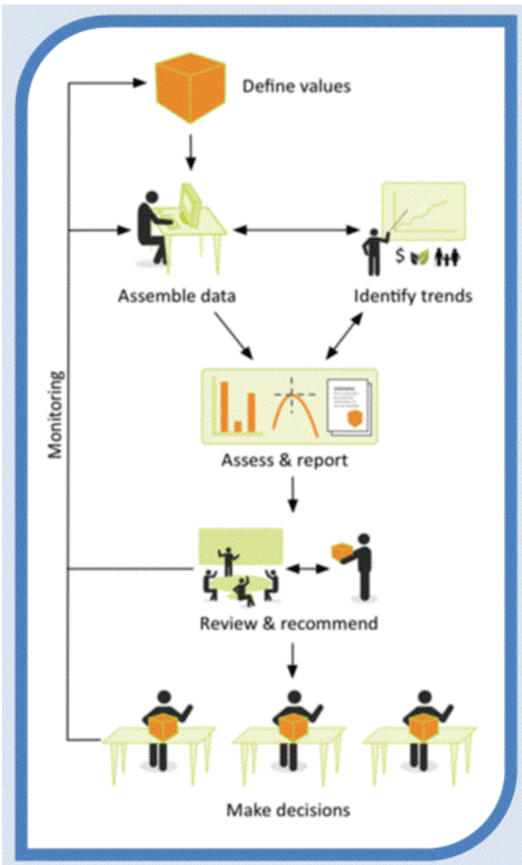
How will the CEF support decision making?

Strategic Decisions

Tactical and Operational Decisions

First Nation Rights & Interests

CE Policy Overview



Staff Responsible for Assessments

Regional CE Management Committees

Individual Decision-Makers

Policy and Procedures for:

A. Cumulative Effects Assessment

*Defining values, components, indicators
*Defining management targets, triggers
*CE assessment and reporting

B. Cumulative Effects Management

*Regional CE management process
*Considering CE in decision-making and reporting

Cumulative Effects Framework
Assessing and Managing Cumulative Effects in British Columbia

Key Considerations for Values

- Data quality, gaps, and scale of data and assessments
- Knowledge
- Defendable and repeatable procedures
- Consistent and consumable communication strategies (maps, report cards, online GIS, etc)

Linkages to Skeena Region

- Provincial assessment for core values include the Skeena region, with the intent to update periodically.
- Regional efforts are intended to build the cumulative effects knowledge through more localized activities.
- MaPP and other initiatives can borrow upon the framework to either directly apply, or use as a starting point, to help develop localized assessments.

- Expert workshops such as this
    - **Workshops and efforts such as this 2 day workshop have tremendous value to bring experts together, share information, and explore opportunities and linkages.**

2015-16 Timelines for Provincial Values Assessments

Standards & Current Condition Assessments

Assessment Procedure Development

Regional Internal Engagement

Technical Review
assessment methods, alignment across values

External Engagement

May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March

- **Policy & Knowledge Summaries**
- **'Beta' assessment procedures** ***-Aquatic, Biodiversity, Old Forest***
- **'Beta' assessment procedures** ***-Grizzly, Moose***
- **Version 1 Assessment Procedures**
- **Final Approval of provincial values**

2015-16 Timelines for Cumulative Effects Policy

Phase 1 Engagement (Internal & External)
- NRS Policy for Considering CE

Phase 2 Engagement
- NRS Policy

May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March

- **Draft CE Policy**
- **Revised Draft CE Policy**
- **Approved Policy**

Key next steps - Phased Implementation Vision

South Peace
Cariboo
Merritt

+ North Area
+ Howe Sound
+ Elk Valley

Benefits increasing over time

- Efficient, streamlined decision-making
- Better information to consider Aboriginal and Treaty rights
- Achieving desired outcomes for values
- Durable decisions and reduced litigation

Phase 2

2016 onward

- Condition of 10 core values assessed
- Decision makers using CEAs
- Policy in place for consistent provincial implementation
- Continuous improvement in increasing benefits realized
- Full CEF program developed with cross-sector implementation

Condition of key values known throughout the Province

FY2014-15 | **FY2015-16** | **FY2016-17** | **FY2017-18** | **FY2018-19**

End Slide

BRITISH COLUMBIA

END

Cumulative effects for (marine) spatial planning

identify values

determine acceptable risk

synthesize knowledge

assess scenarios

decide

values

knowledge

(karen price)

identify values | determine acceptable risk | synthesize knowledge | assess scenarios | decide

values | **knowledge**

Taylor & Katarina
(Metlakatla values & indicators)

Jamie
(arctic ecological risk)

Karen and Dave
(activities > habitats > species)

Stella
(stressor-based thresholds)

Will
(data and visualisation)

Jennifer
(YVR port visioning)

Darrell
(food web modeling)

Don
(integrated scenarios for resilience)

Kevin
(cumulative EAs)

identify values | determine acceptable risk | synthesize knowledge | assess scenarios | decide

values | knowledge

a co-developed science and policy process matters

- for buy-in, consensus, transparency (Katerina, Taylor, Stella)

a wide variety of values resonate with people

- ecological and social values (Katerina, Taylor)

data, maps, and models are useful in decisions

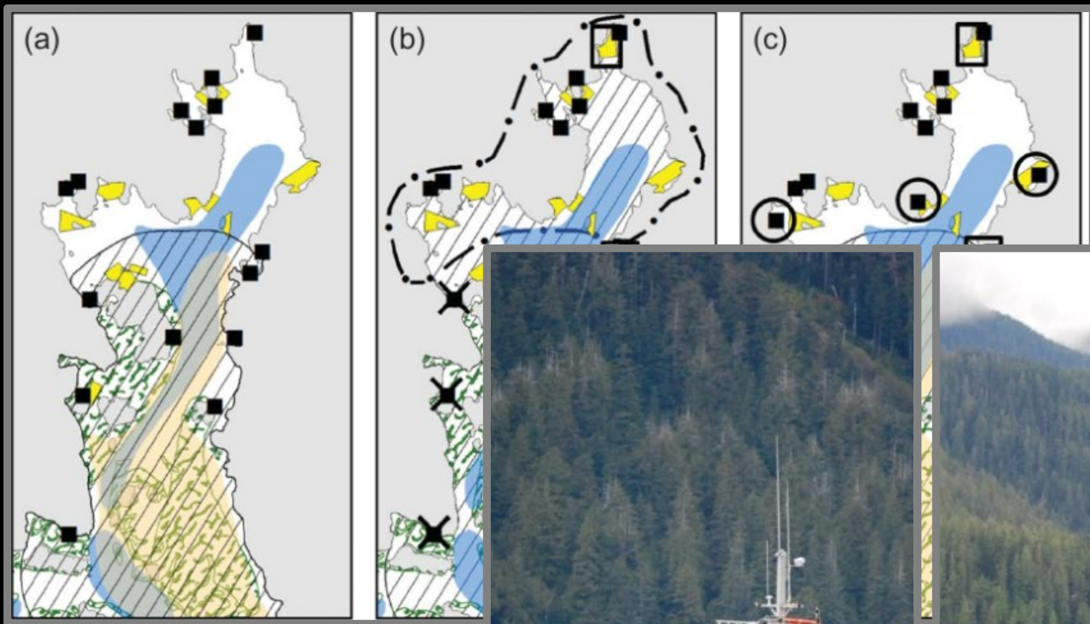
- spatial/temporal, scenarios, uncertainty (Karen, Dave, Will, Darrell)

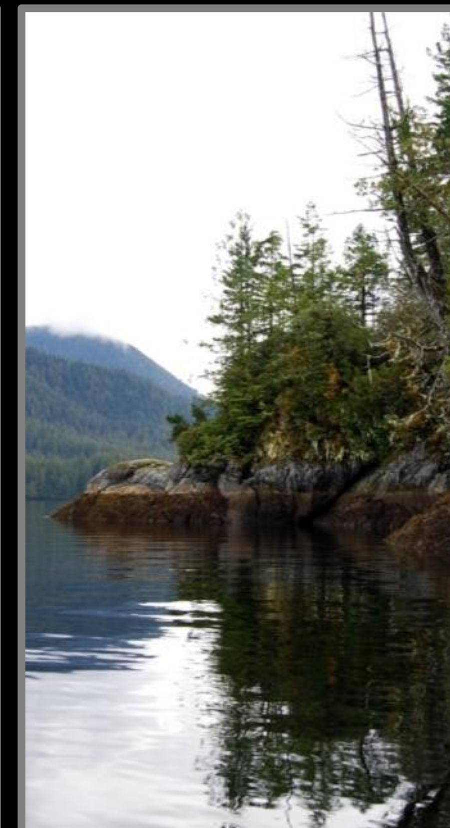
it's important to consider tradeoffs among values

- integrated assessments, multiple objectives (Don, Kevin)

Marine Spatial Planning in Clayoquot Sound

predicting change to values under alternative future scenarios





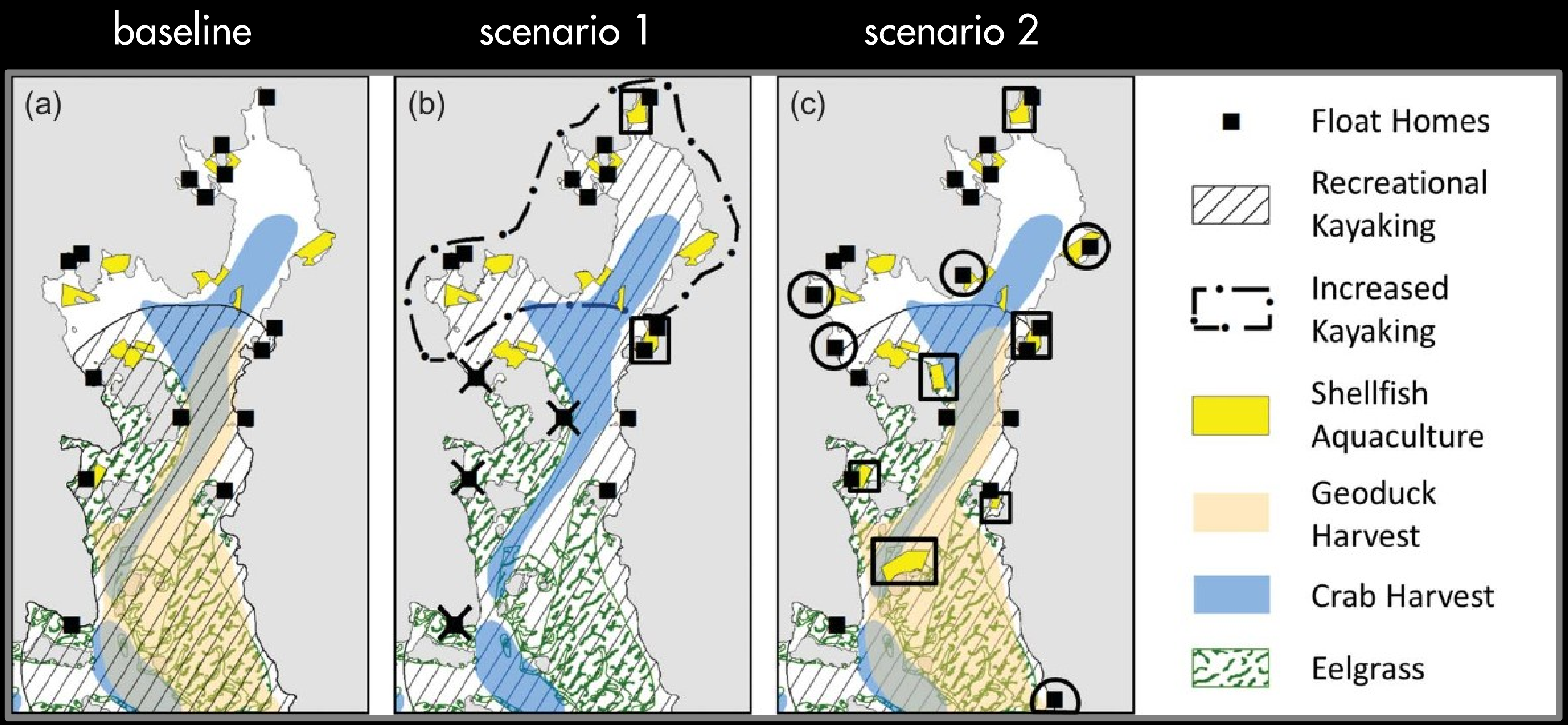
What if ...

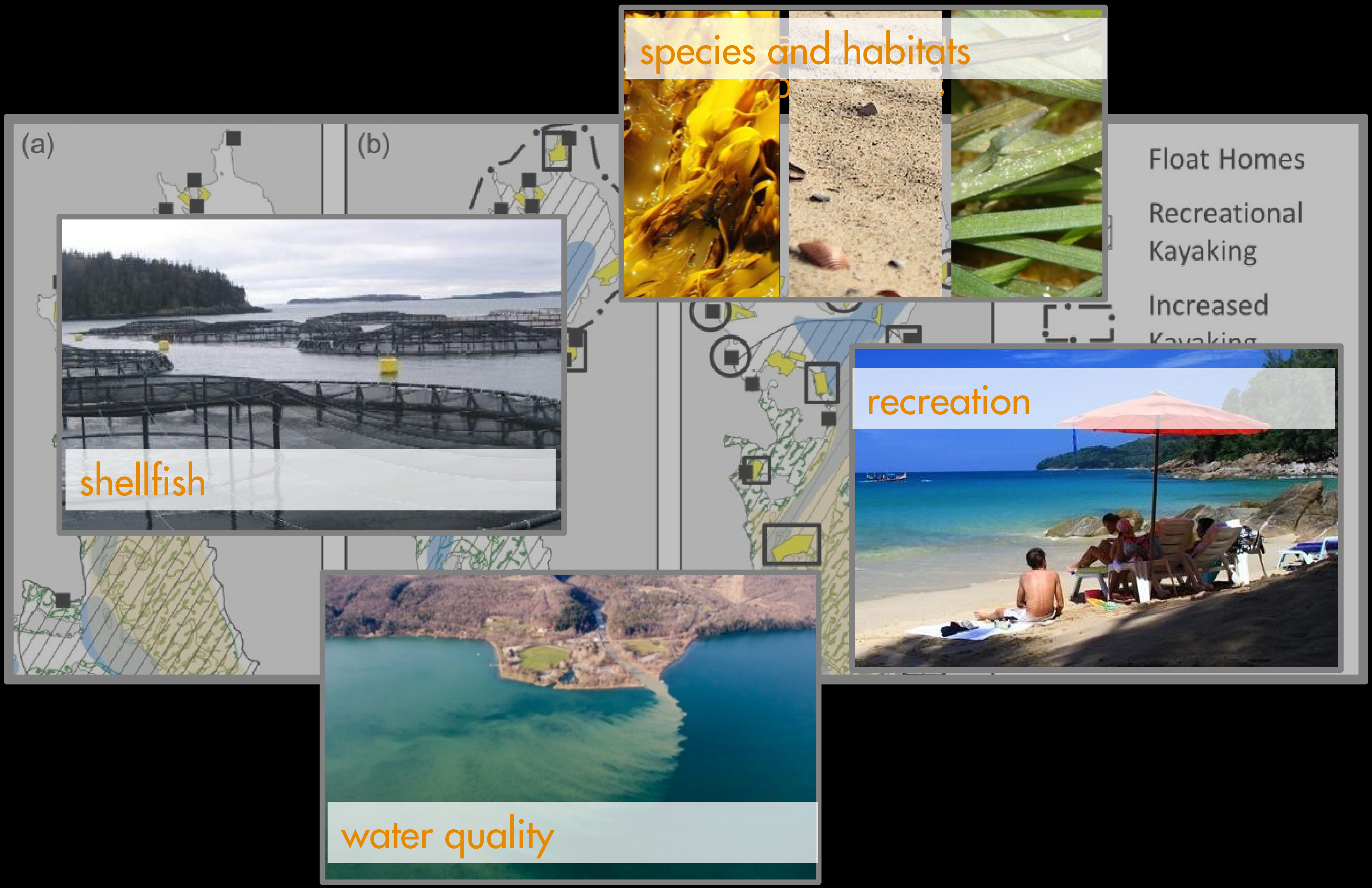
additional fishing ?

additional oyster-farming ?

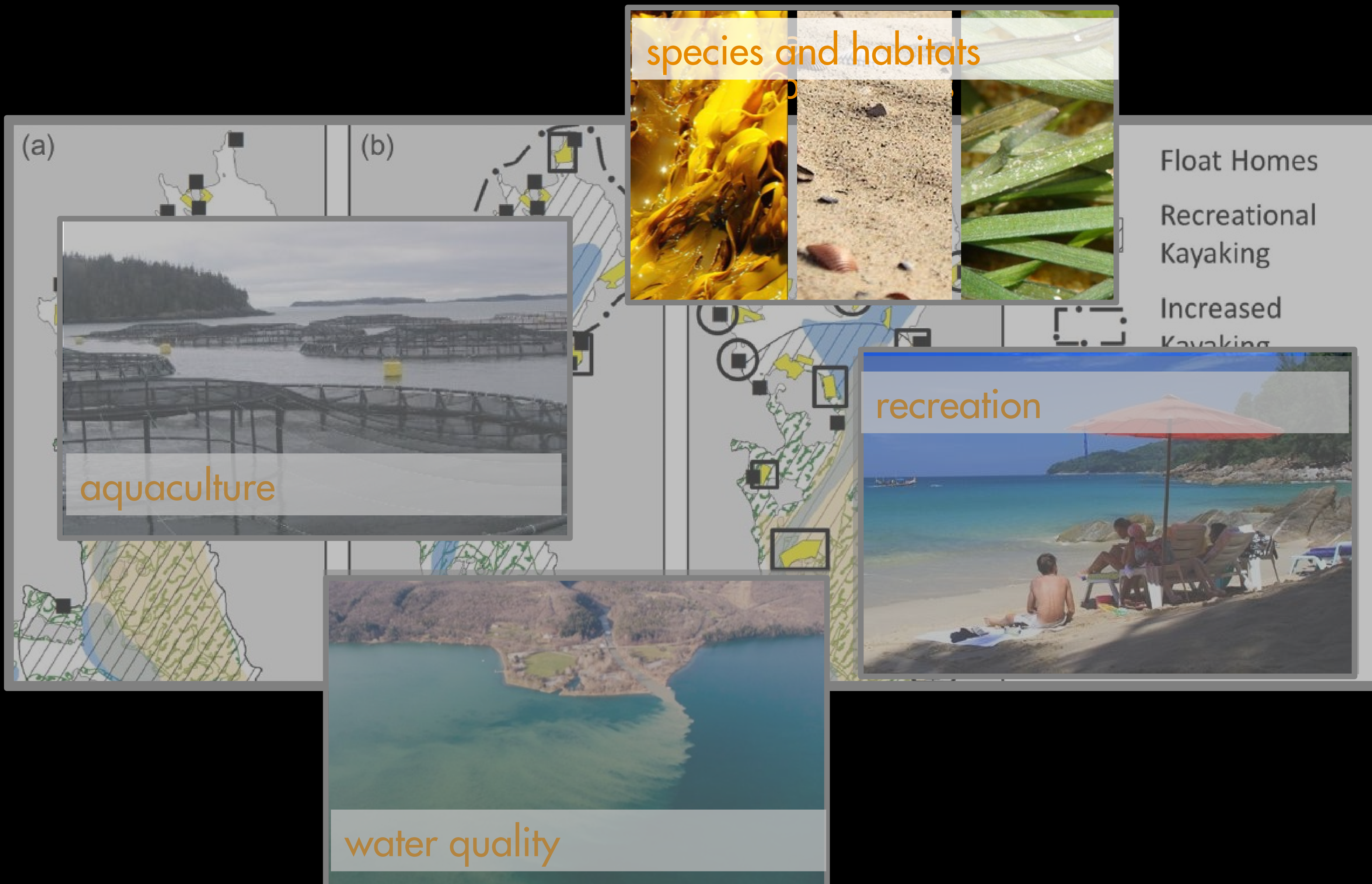
tribal marine park ?

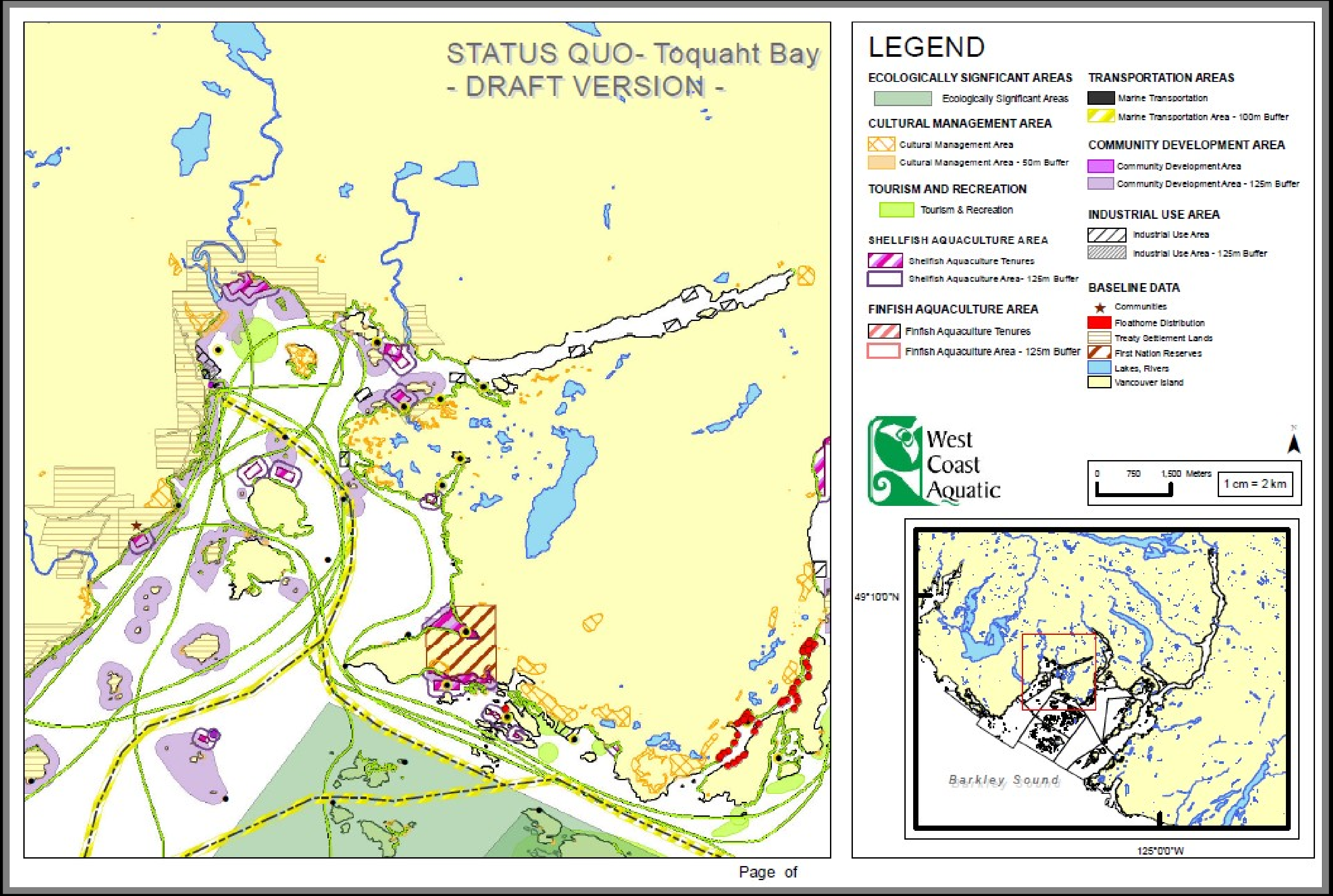
etc...


baseline
scenario 1
scenario 2
(a)
(b)
(c)
Float Homes
Recreational Kayaking
Increased Kayaking
Shellfish Aquaculture
Geoduck Harvest
Crab Harvest
Eelgrass



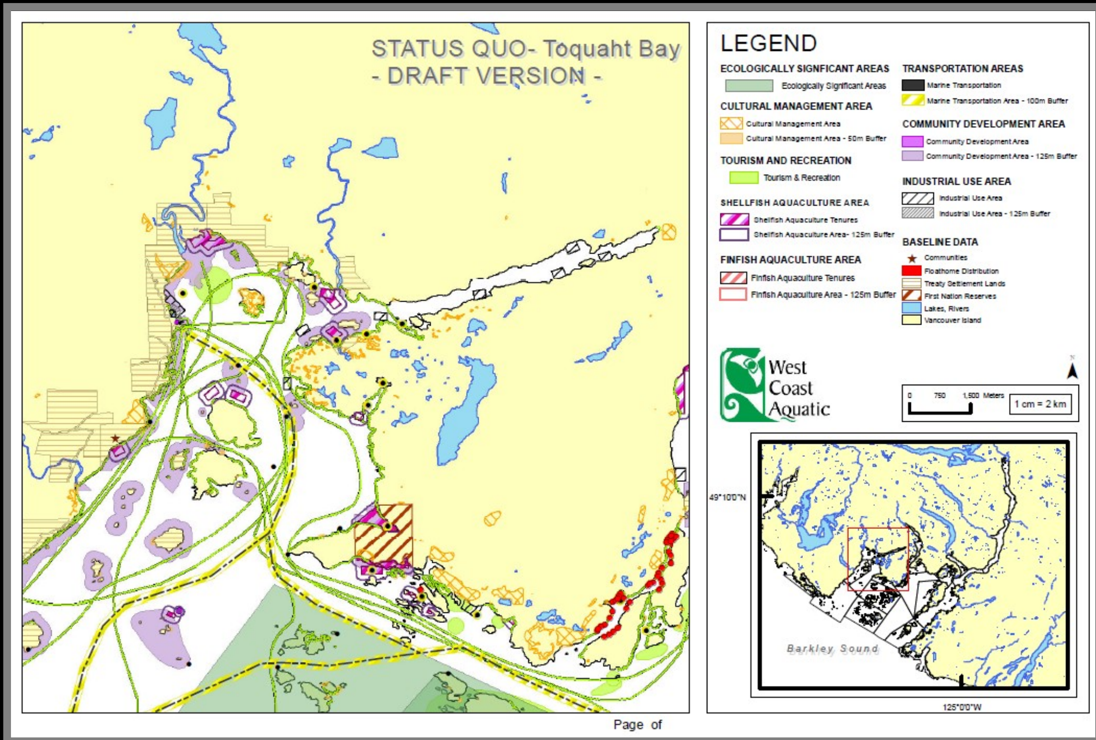
species and habitats
(a)
(b)
Float Homes
Recreational Kayaking
Increased
shellfish
recreation
water quality


species and habitats
(a)
(b)
Float Homes
Recreational Kayaking
Increased
aquaculture
recreation
water quality



which species and habitats are at risk and where ?

what types of management may reduce risk ?



consequence

change in area ?

change in structure ?

frequency ?

natural mortality ?

natural recruitment ?

recovery time ?

connectivity ?

exposure

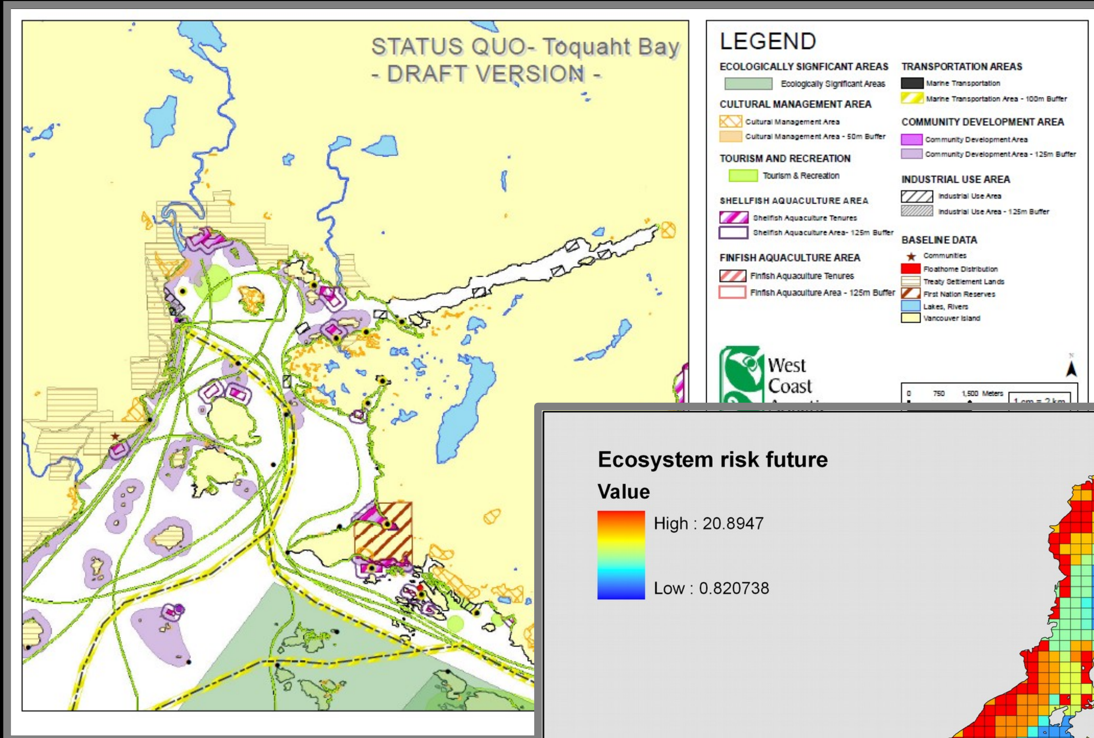
spatial overlap ?

temporal overlap ?

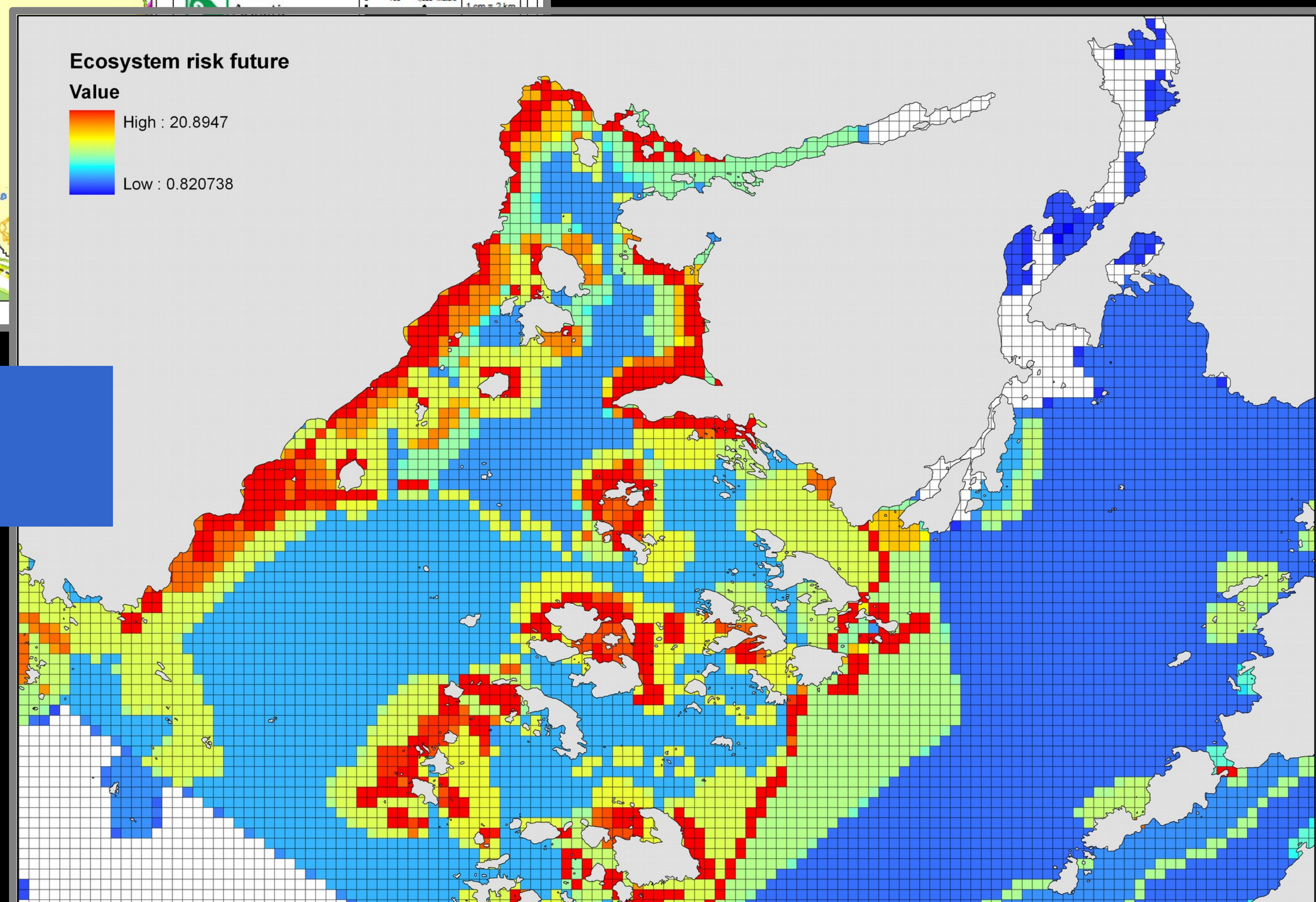
intensity ?

management effectiveness ?

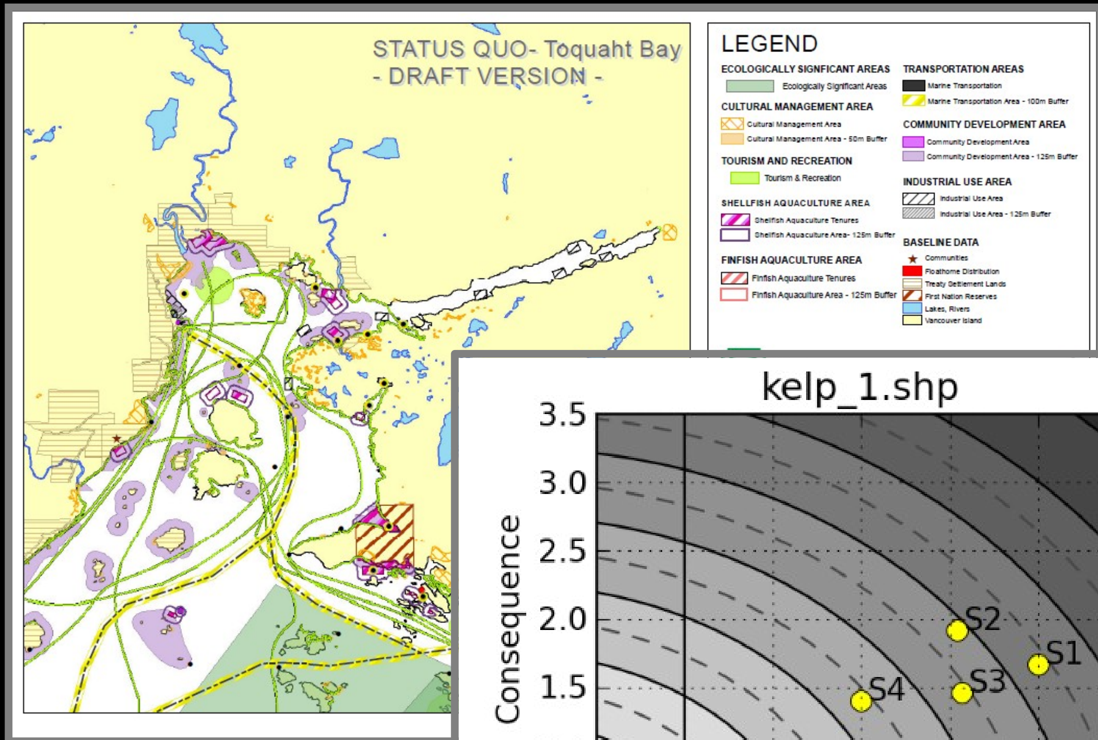
(arkema et al 2015 ERL)



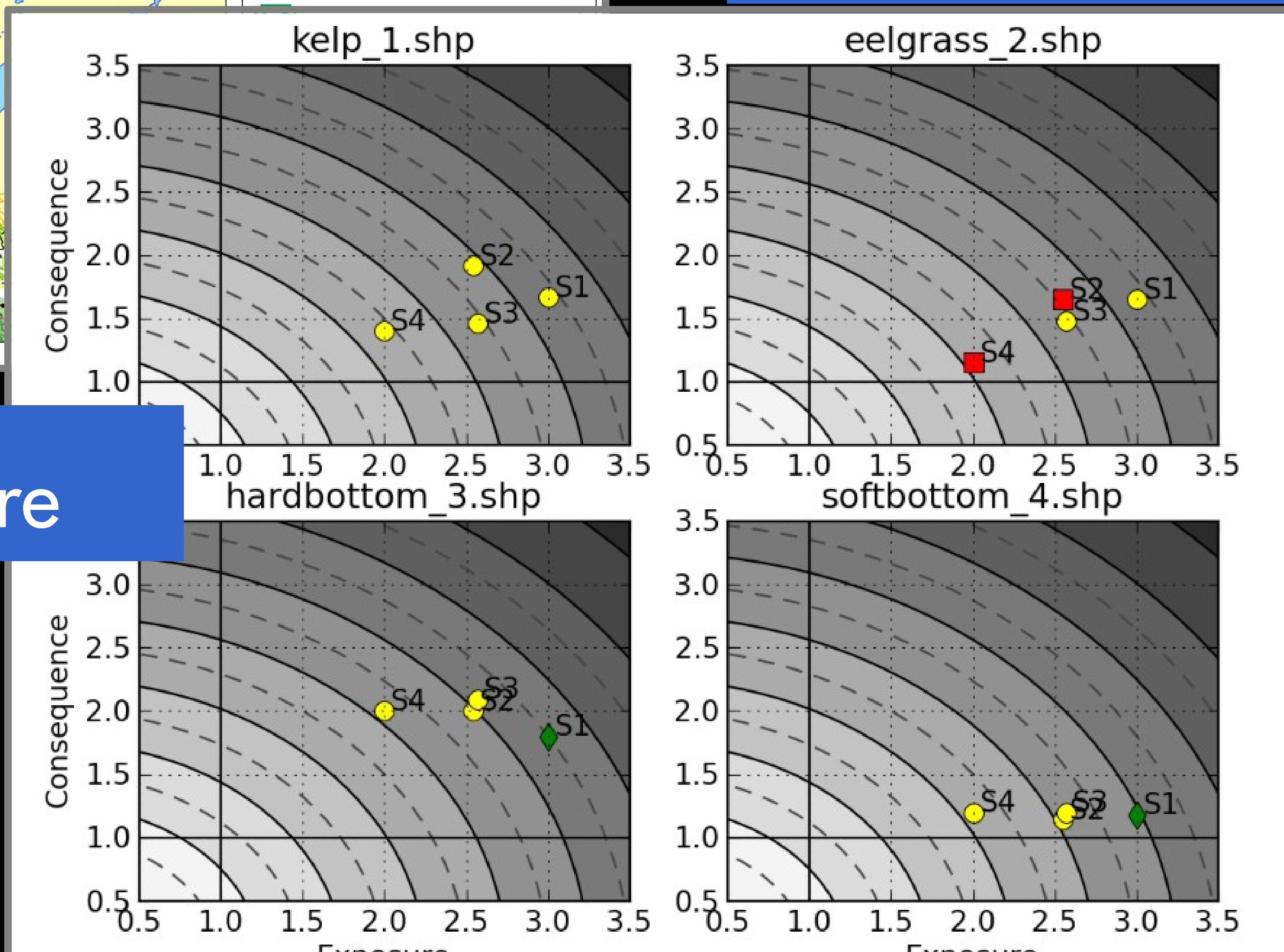
consequence



exposure



consequence



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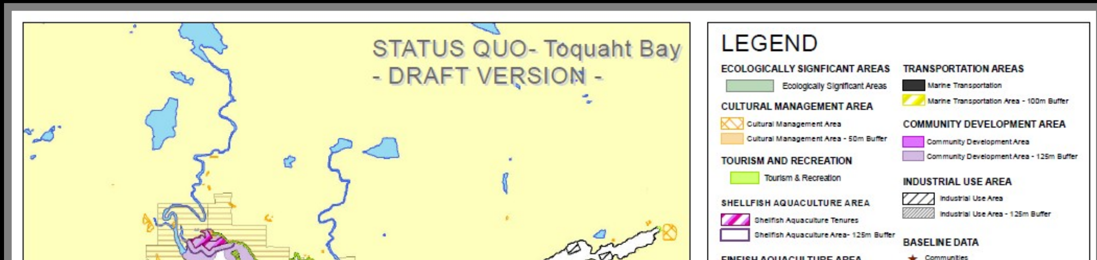
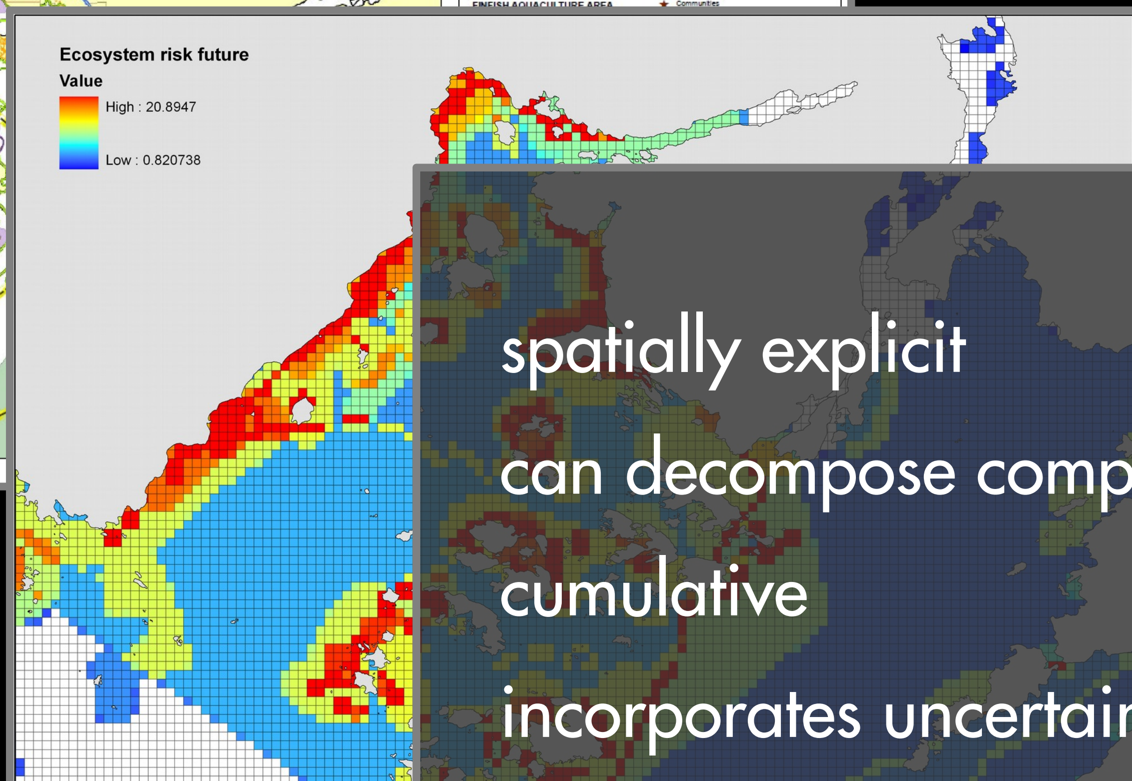




spatially explicit

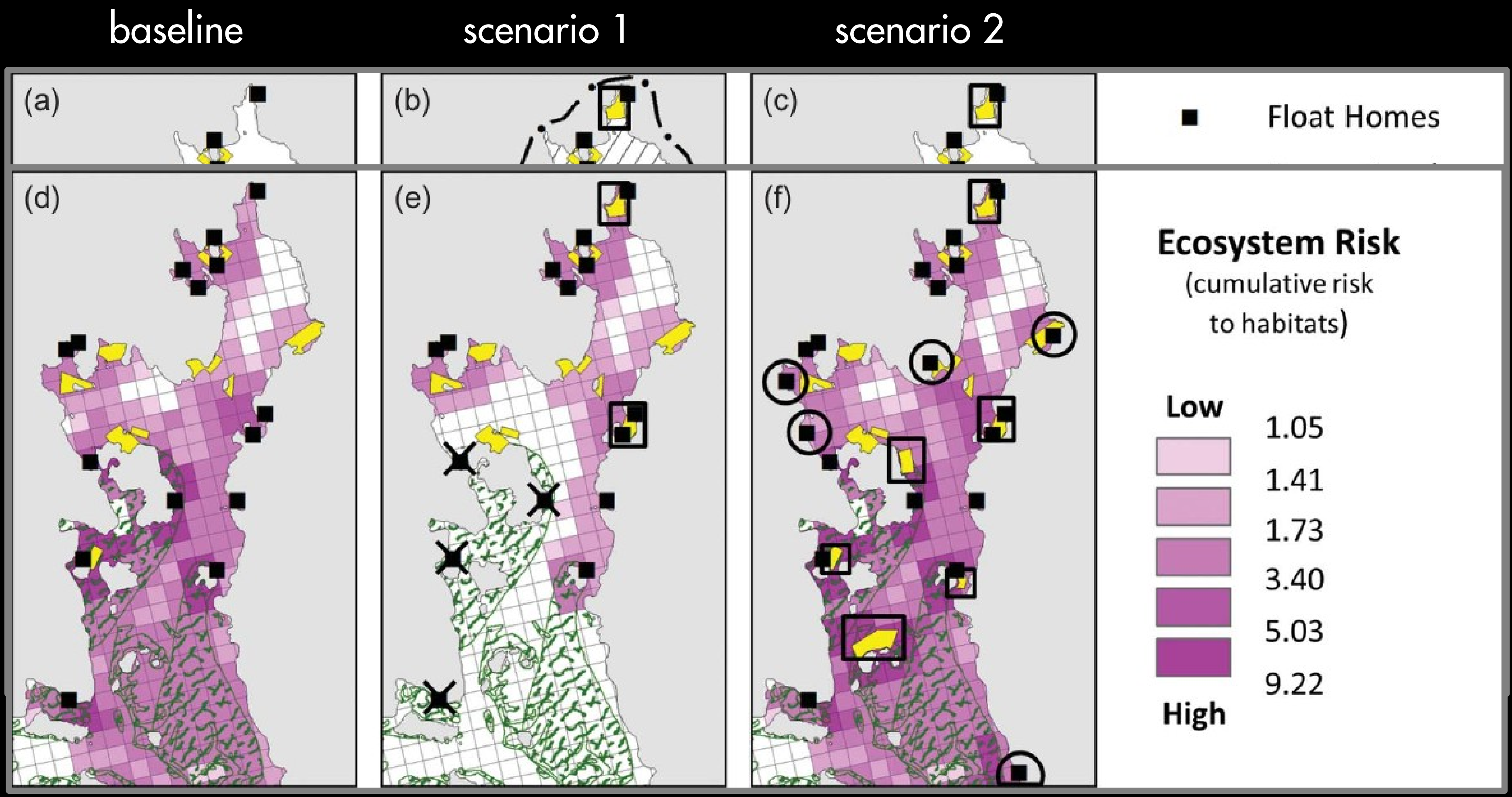
can decompose components of risk

cumulative

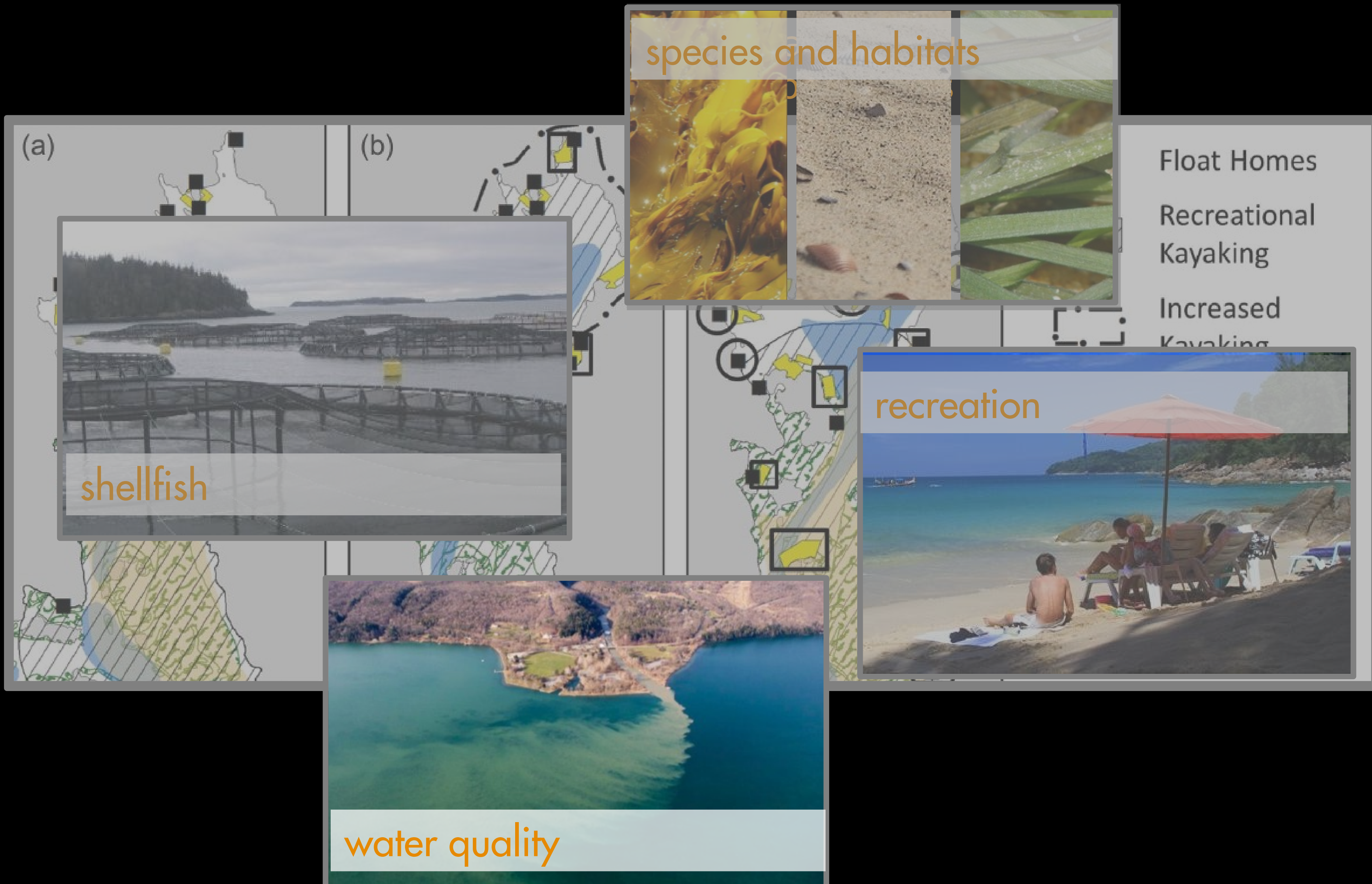
incorporates uncertainty

transparent and transferable

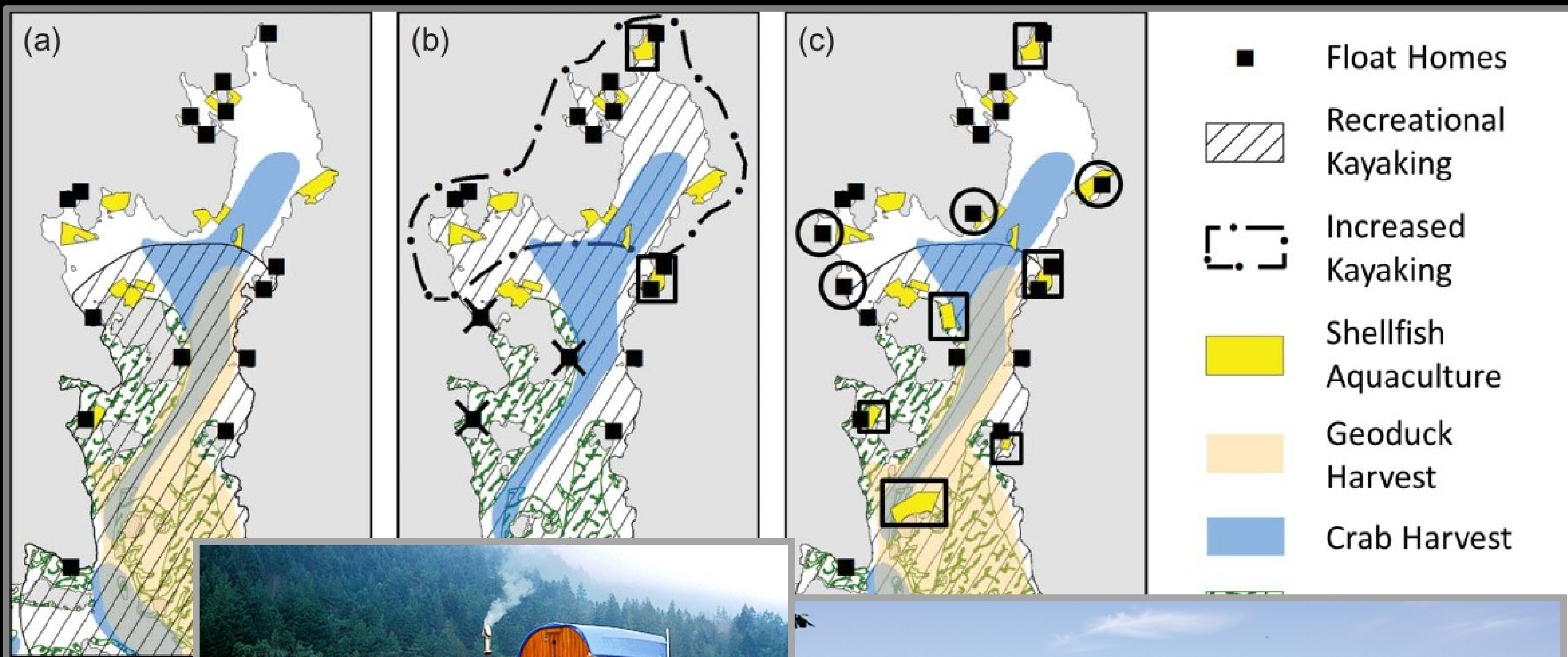
scenario-based

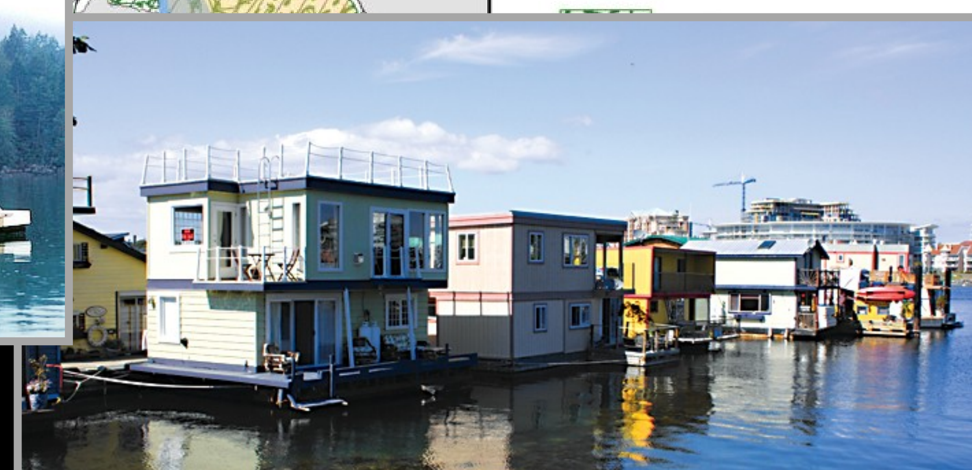


(guerry et al 2013 IJBESM)


species and habitats
(a)
(b)
Float Homes
Recreational Kayaking
Increased
shellfish
recreation
water quality

baseline scenario 1 scenario 2





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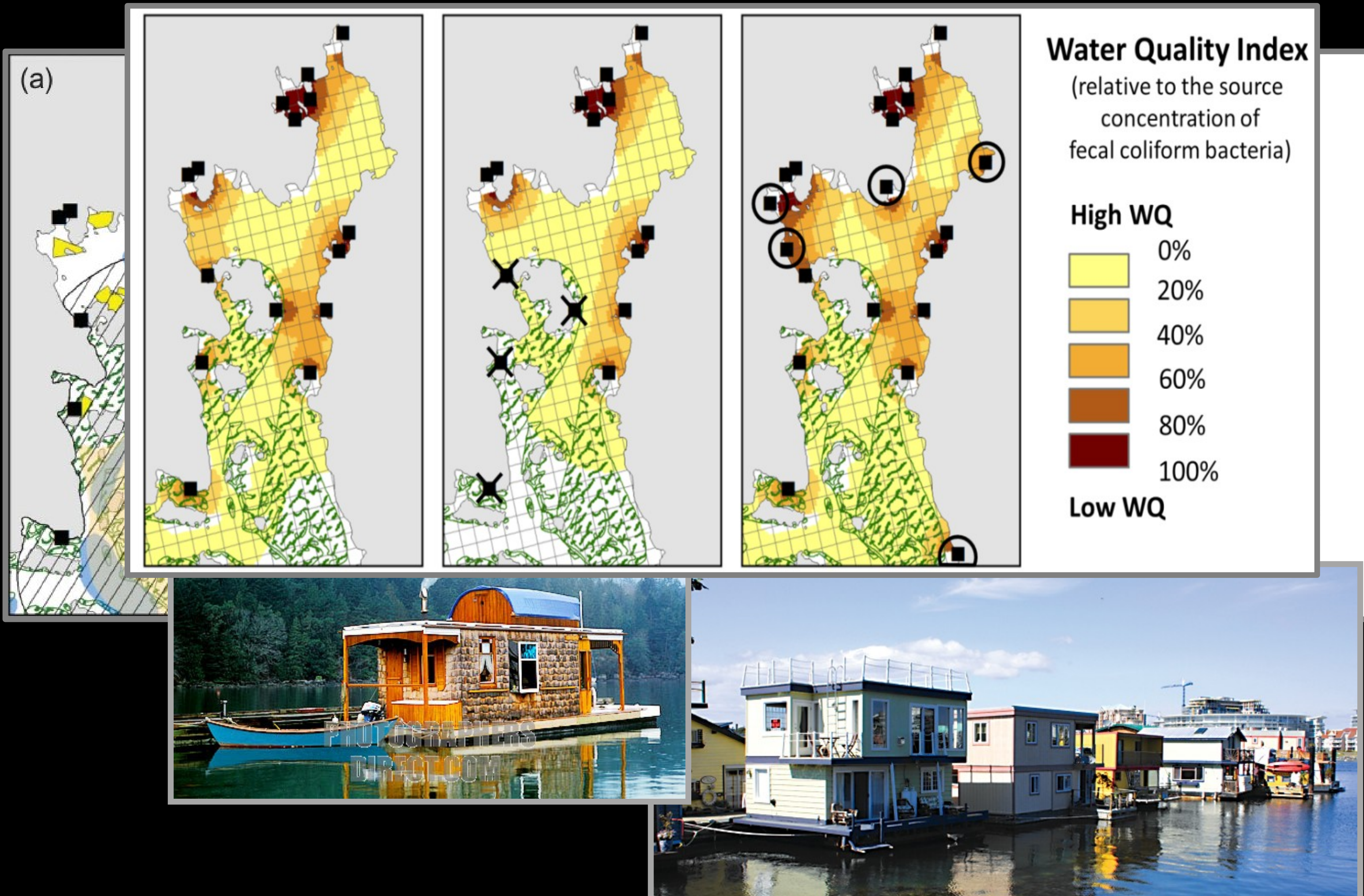

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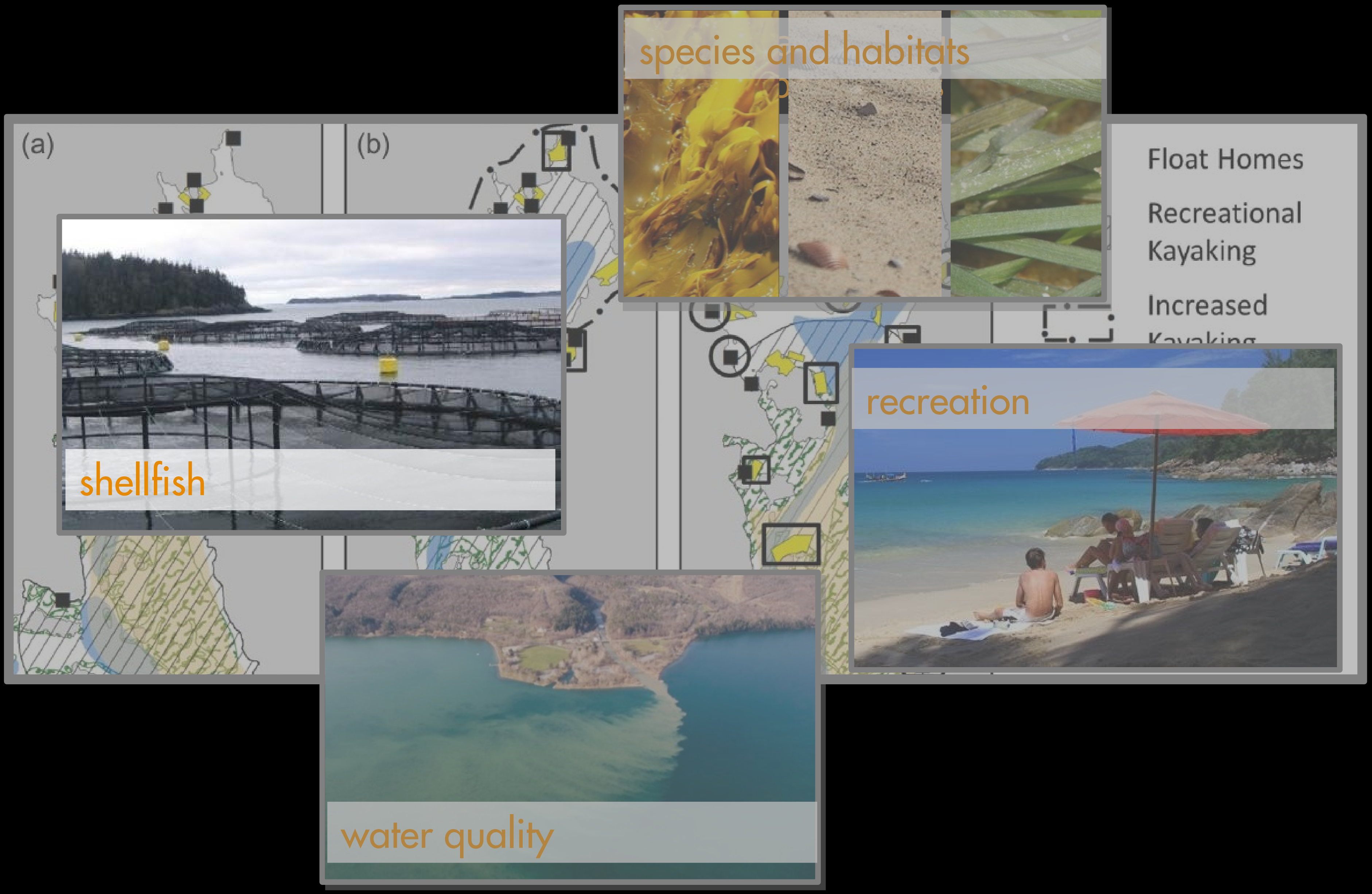
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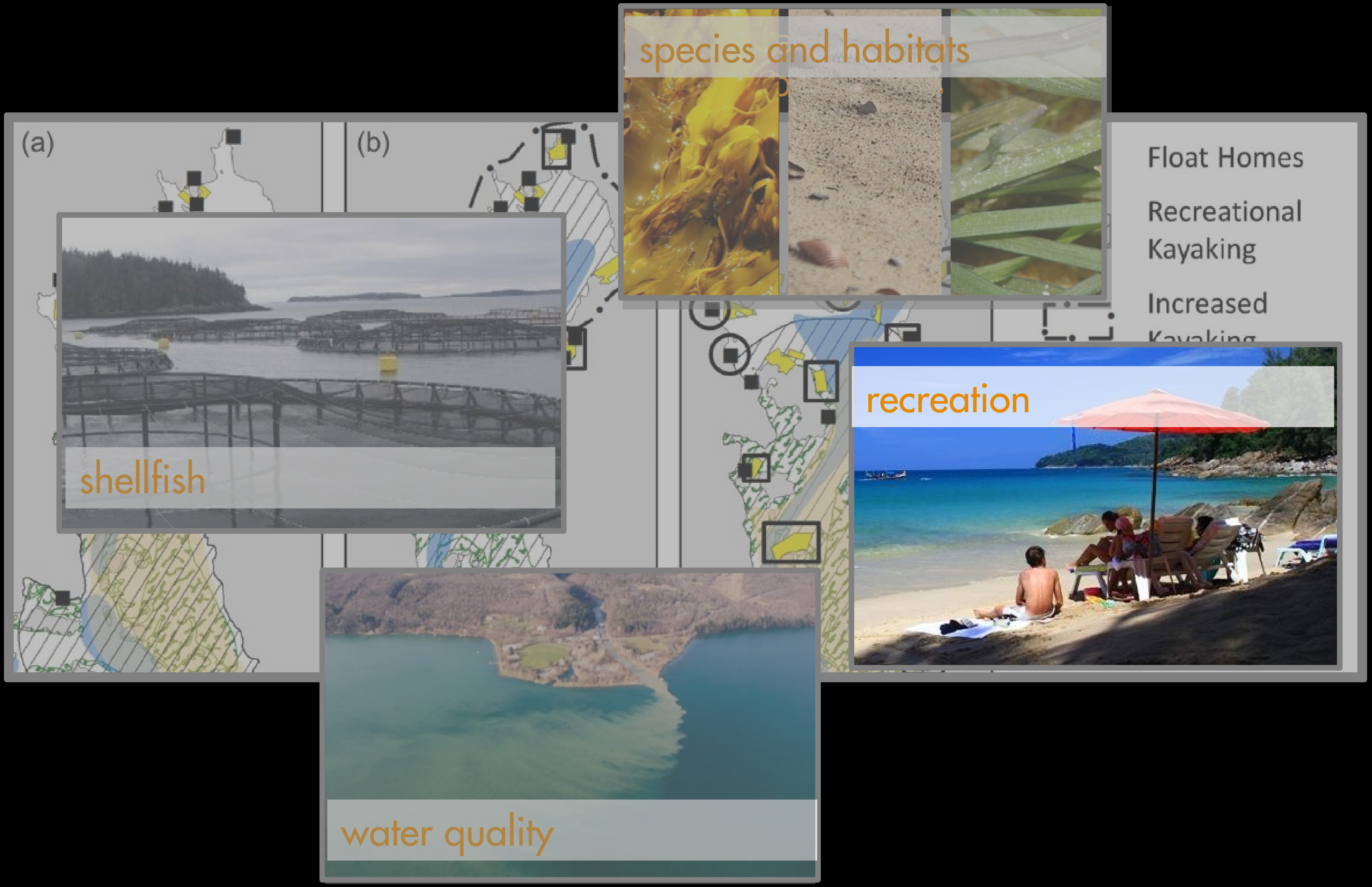
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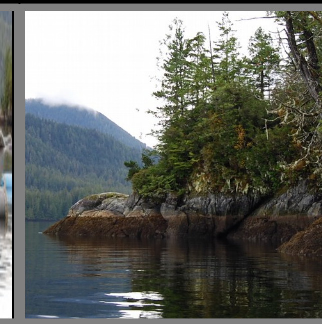
values X scenarios



planning goals

Species/Habitats

Water Quality

Clam Beach Access

Coastal Erosion

Oyster Harvest

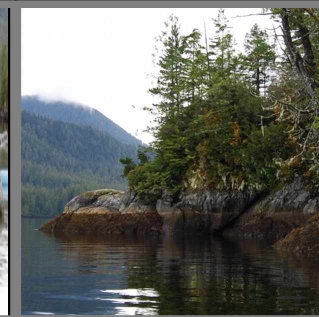
Aesthetic Quality

Crab Fishery

Recreation

etc ...

values X scenarios

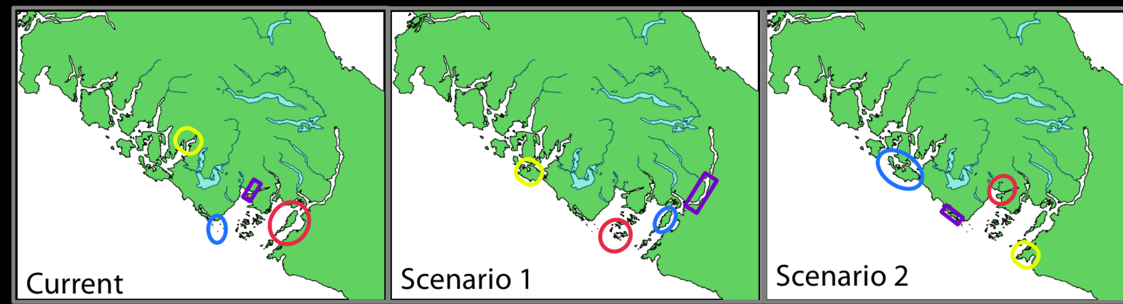



planning goals

Species/Habitats	↑	↓	(cumulative risk)
Water Quality	↓	↑	(fecal coliform)
Clam Beach Access			
Coastal Erosion			
Oyster Harvest	↑	↓	(Kg oyster harvest)
Aesthetic Quality			
Crab Fishery			
Recreation	0	↑	(number of visitors)

West Coast Aquatic

values X scenarios



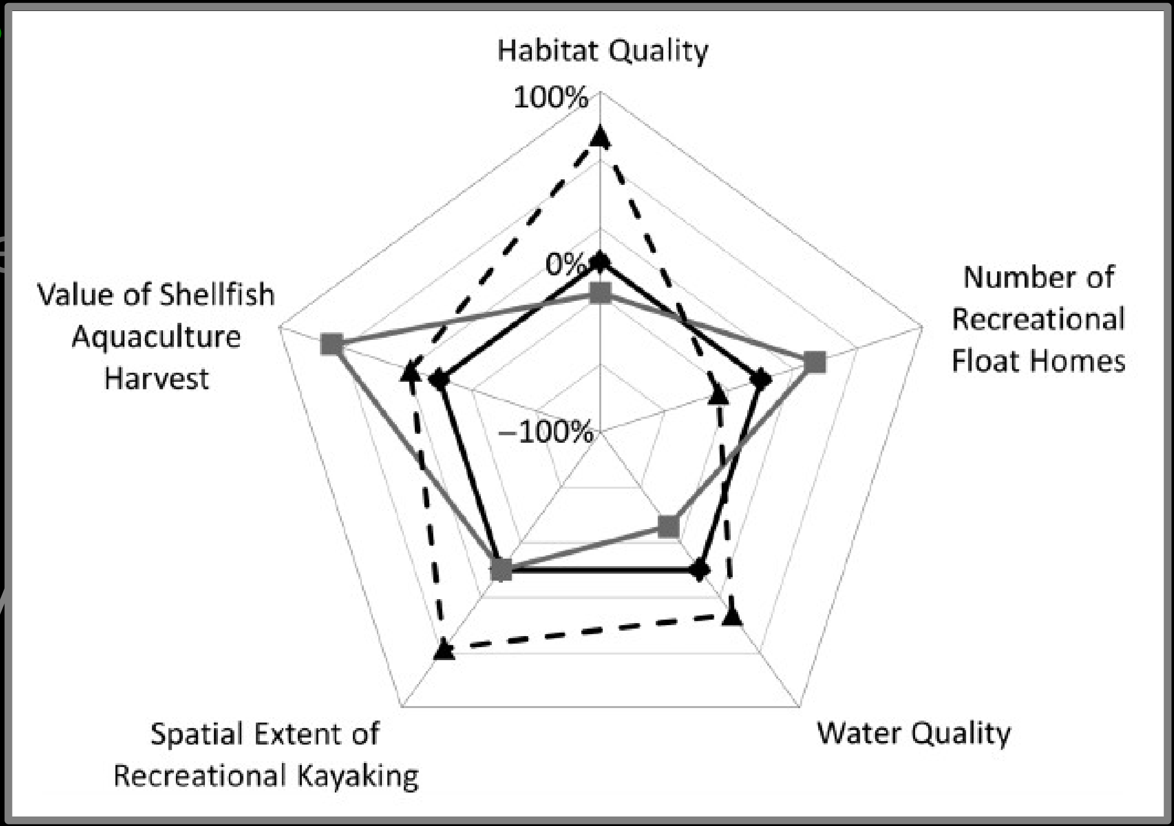
planning goals

Species/Habitats	(Km² high risk, protected area at high risk)
Water Quality	(km² safe levels of fecal coliform)
Clam Beach Access	(# of traditional beaches accessible)
Coastal Erosion	(% vulnerable shoreline)
Oyster Harvest	(kg meat harvested, $ market revenue)
Aesthetic Quality	(pristine views from villages)
Crab Fishery	(lbs caught by locals)
Recreation	(# tourist days)

values X scenarios

planning goals

- Species/Habitats
- Water Quality
- Clam Beach Acce
- Coastal Erosion
- Oyster Harvest
- Aesthetic Quality
- Fisheries
- Recreation



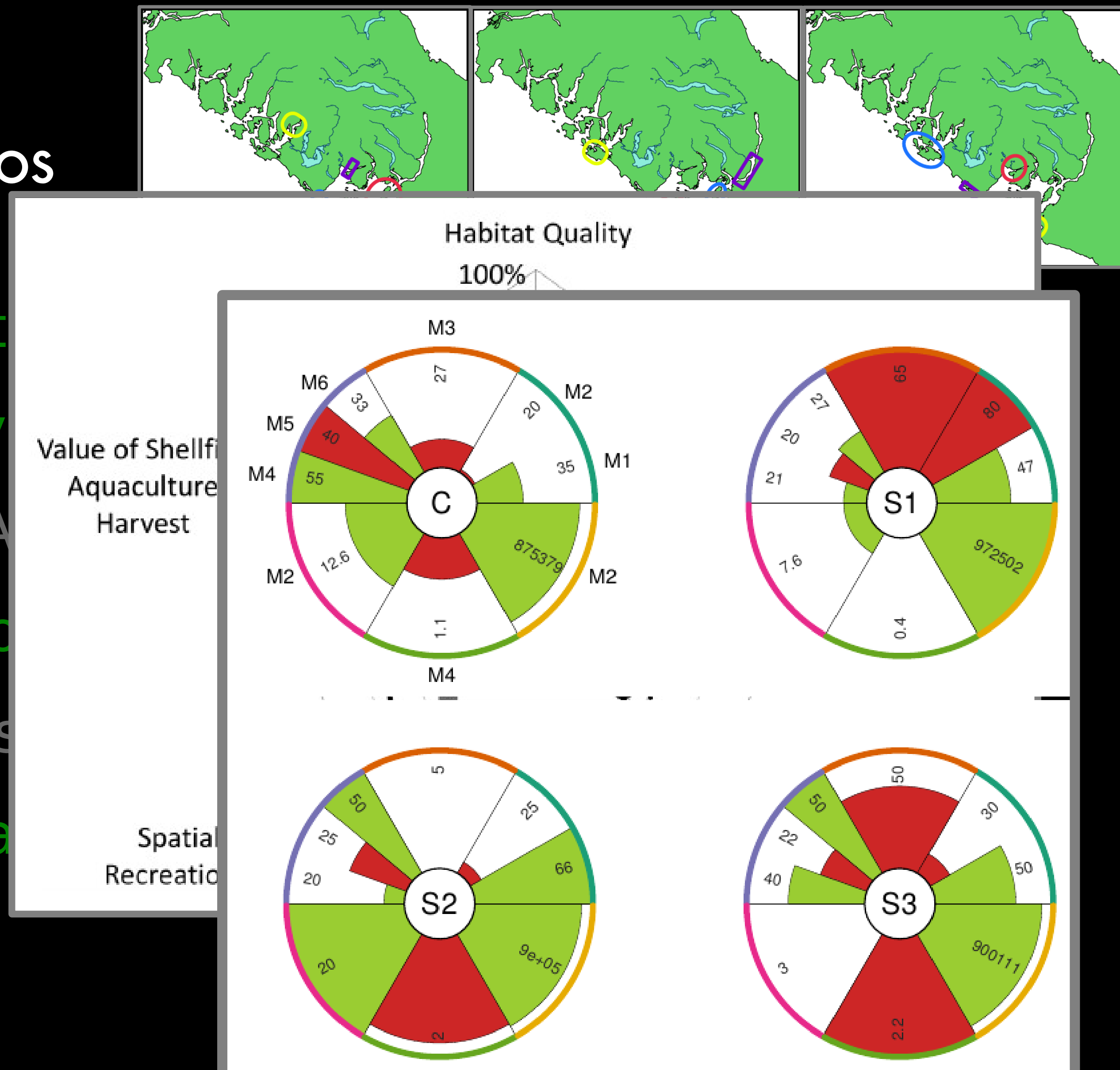
(guerry et al 2013 IJBESM)

West Coast Aquatic

values X scenarios

planning goals

- Species/Habit
- Water Quality
- Clam Beach A
- Coastal Erosio
- Oyster Harves
- Aesthetic Qua
- Fisheries
- Recreation



West Coast Aquatic

values X scenarios

planning goals

Species/Ha

Water Qua

Clam Beac

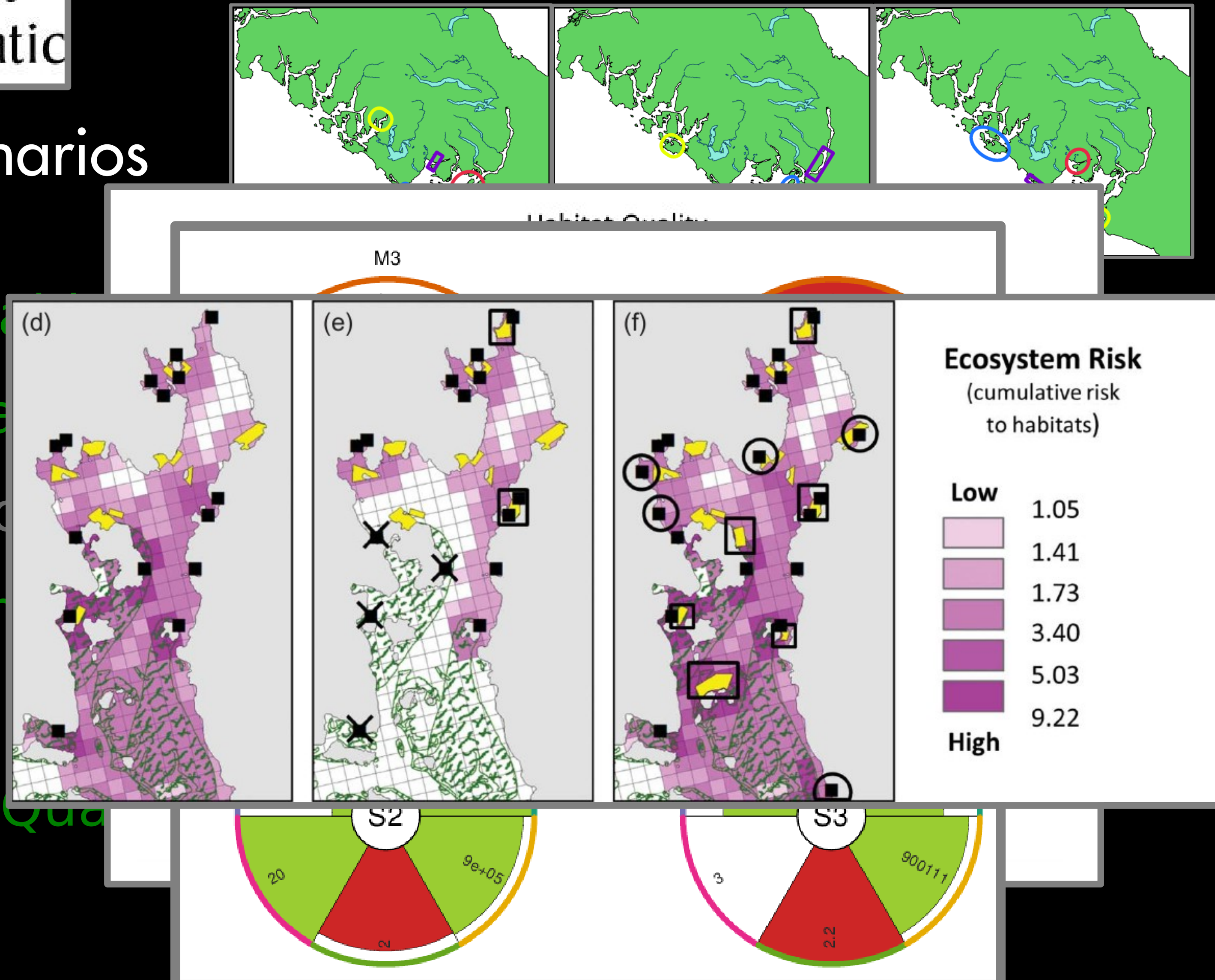
Coastal Er

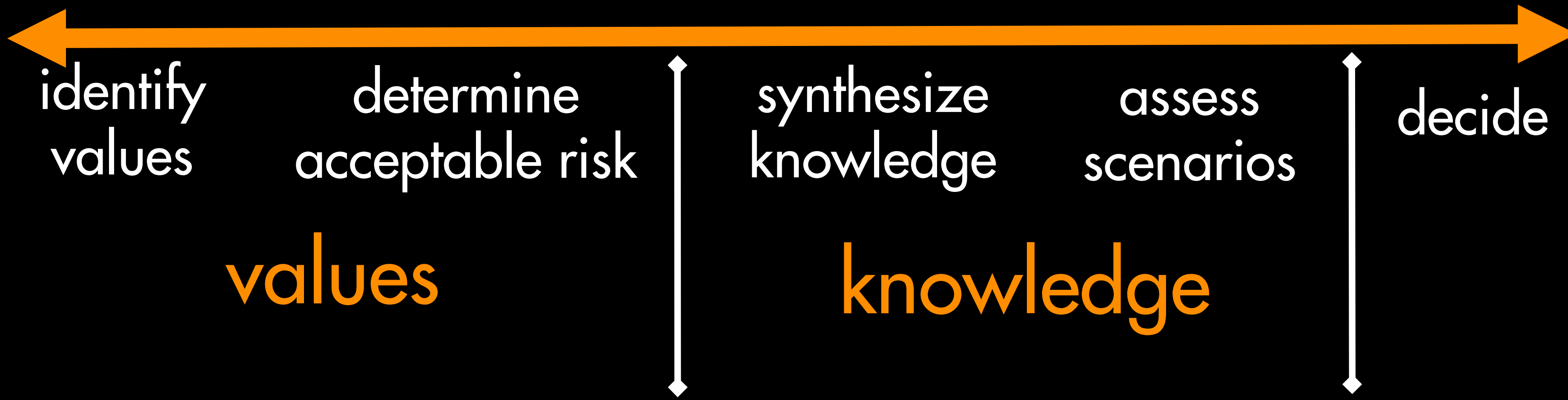
Oyster Ha

Aesthetic Qua

Fisheries

Recreation





a co-developed science and policy process matters

a wide variety of values resonate with people

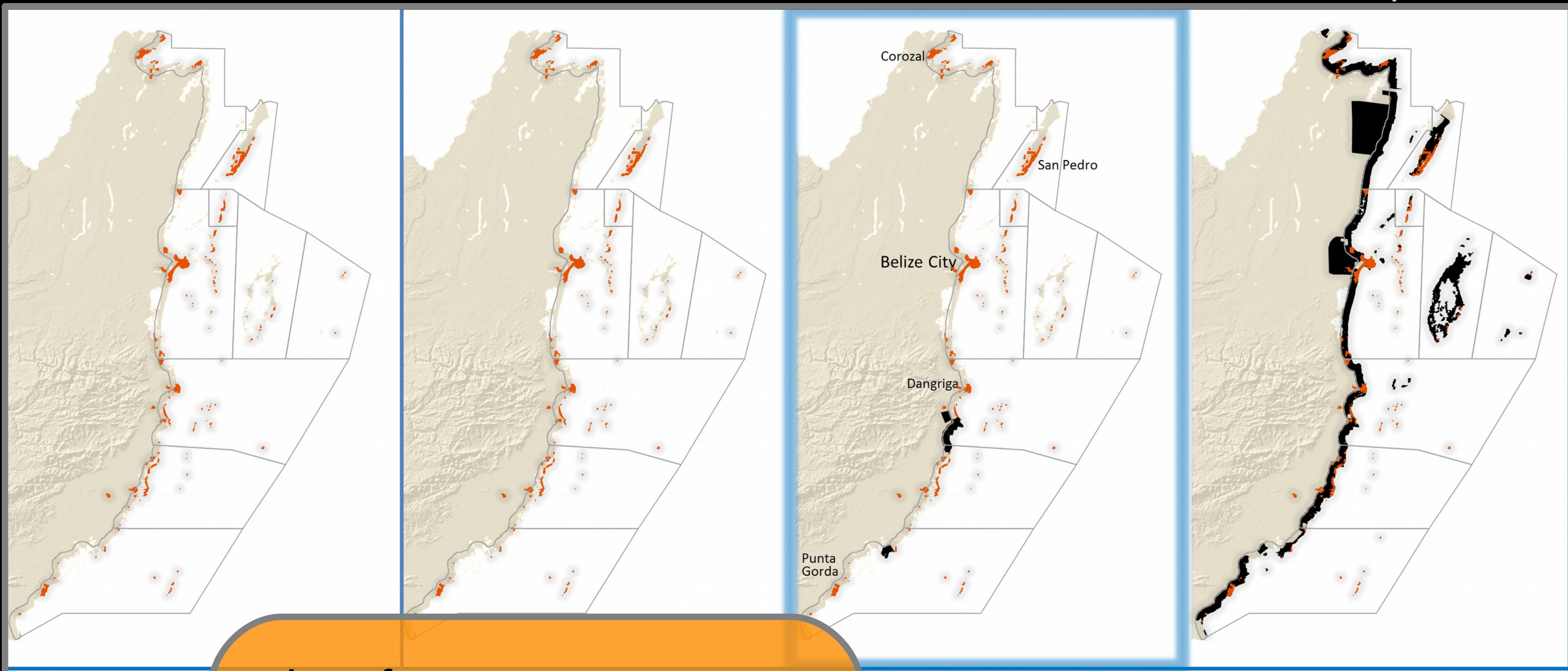
data, maps, and models are useful in decisions

it’s important to consider tradeoffs among values


Belize National Development Planning
sustainable development goals


GUATEMALA
SOUTHERN
PLANNING
REGION

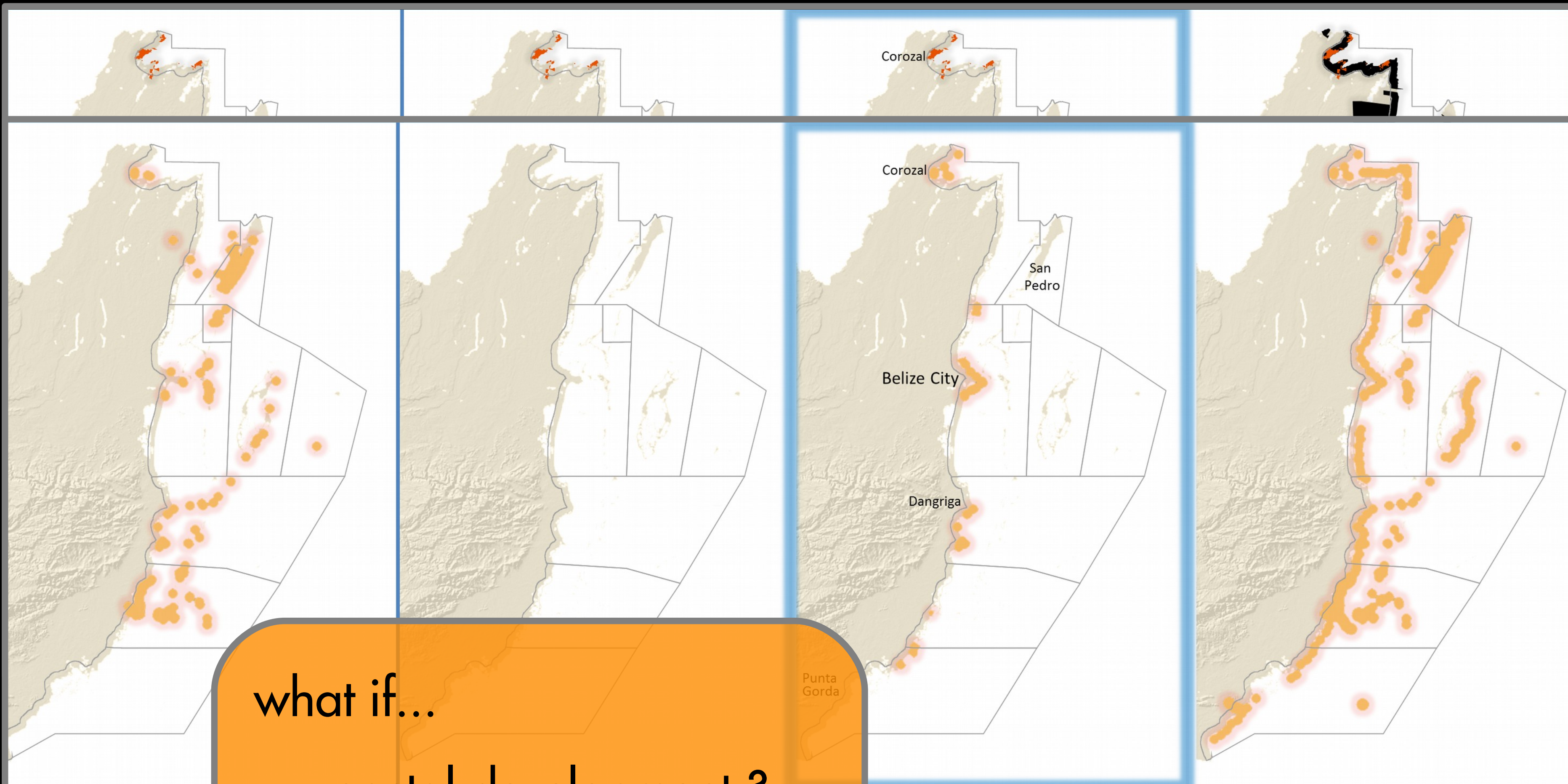
current conservation informed development



what if...

coastal development ?
ocean dredging ?
marine transportation ?
et cetera ?

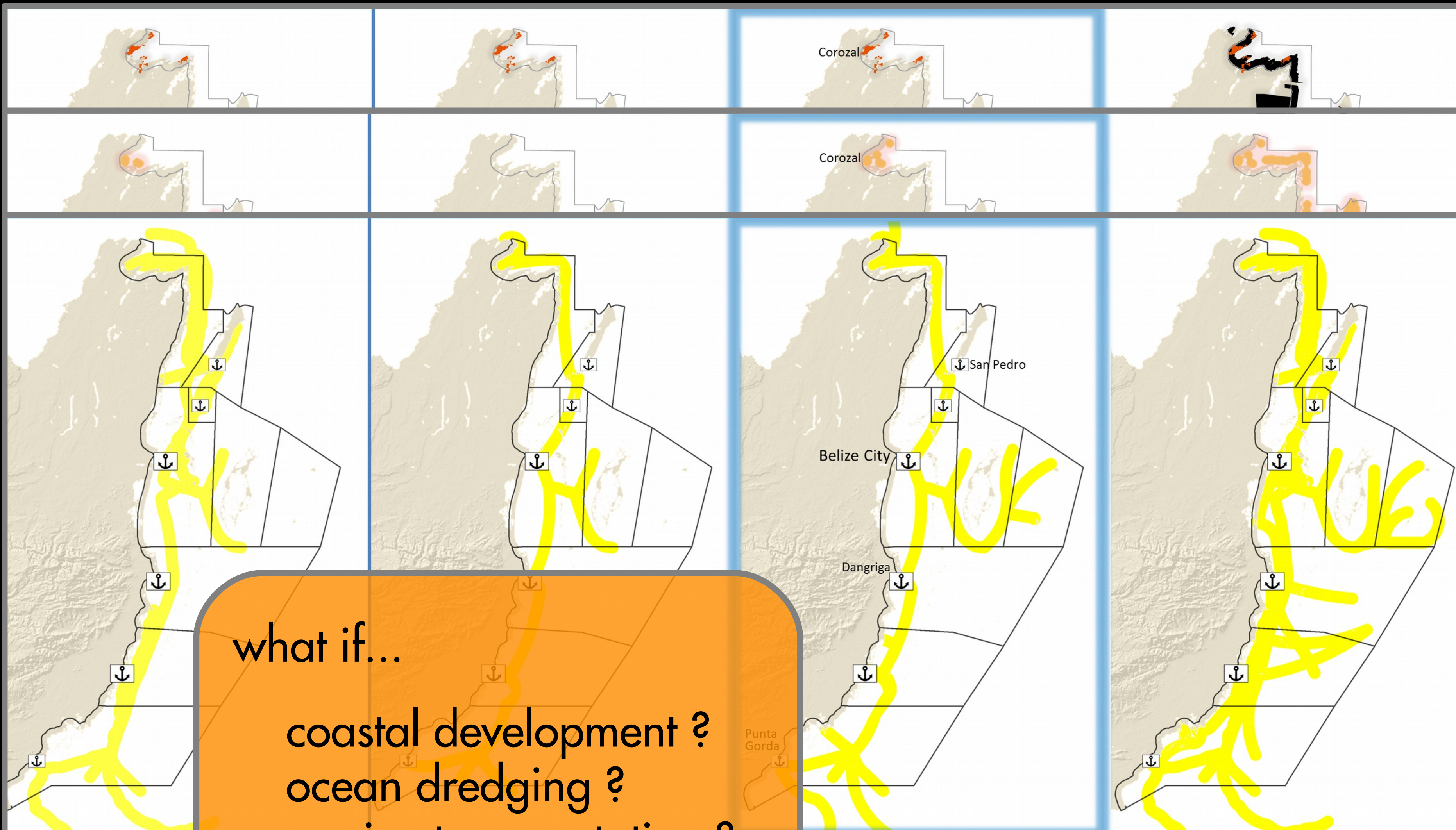
coastal development



what if…

coastal development ?
ocean dredging ?
marine transportation ?
et cetera ?

ocean dredging

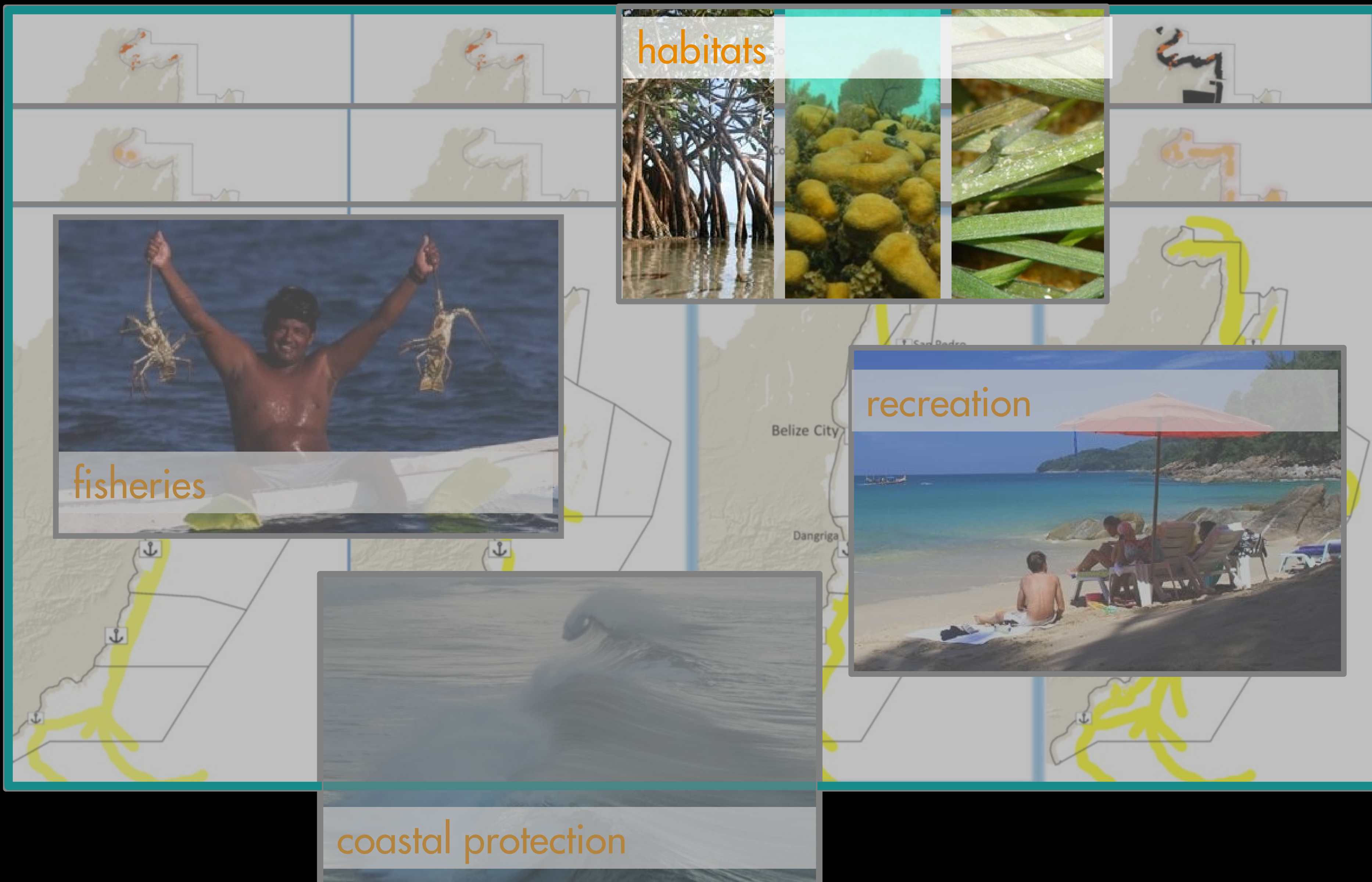


what if...

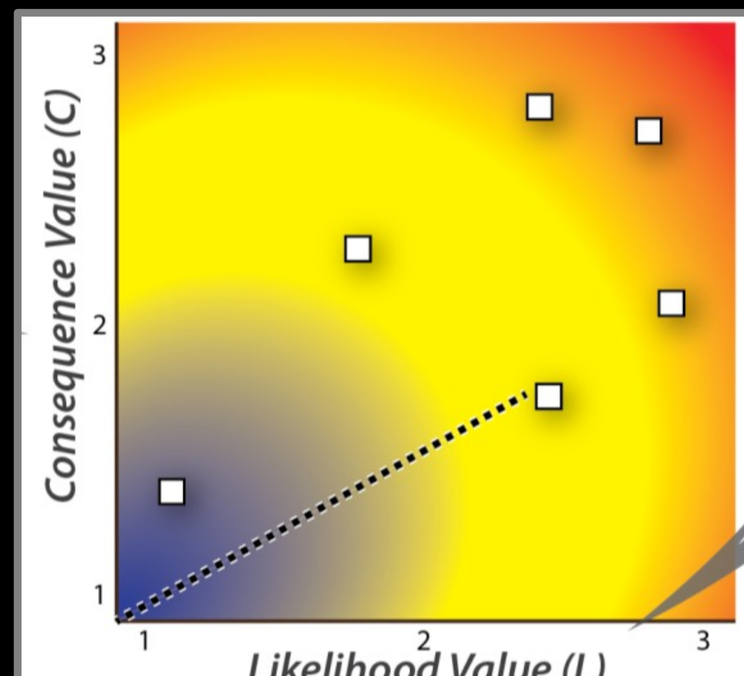
coastal development ?
ocean dredging ?
marine transportation ?
et cetera ?

marine transportation

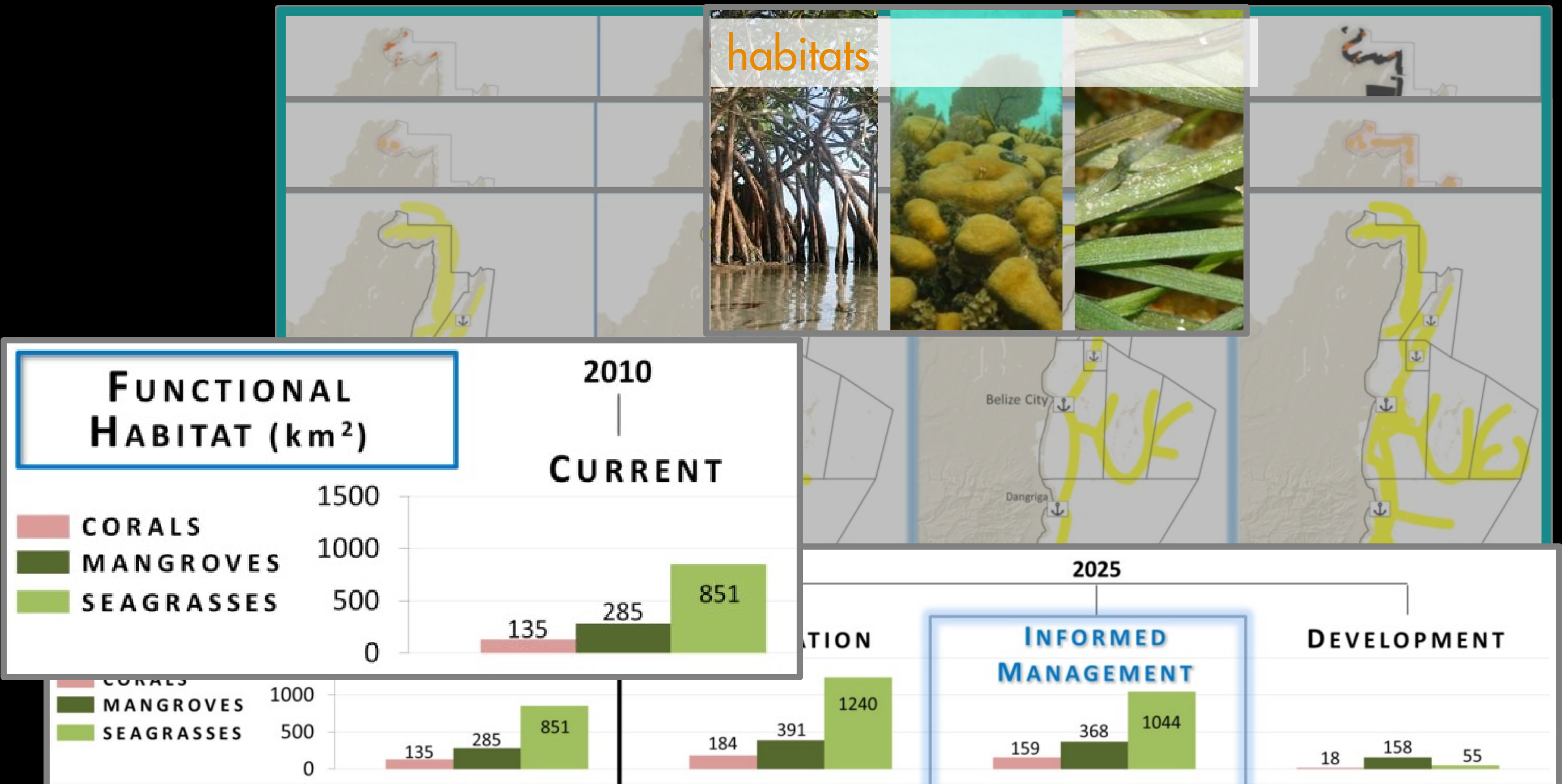

habitats
fisheries
recreation
coastal protection
Belize City
Dangriga


habitats
fisheries
recreation
coastal protection
Belize City
Dangriga

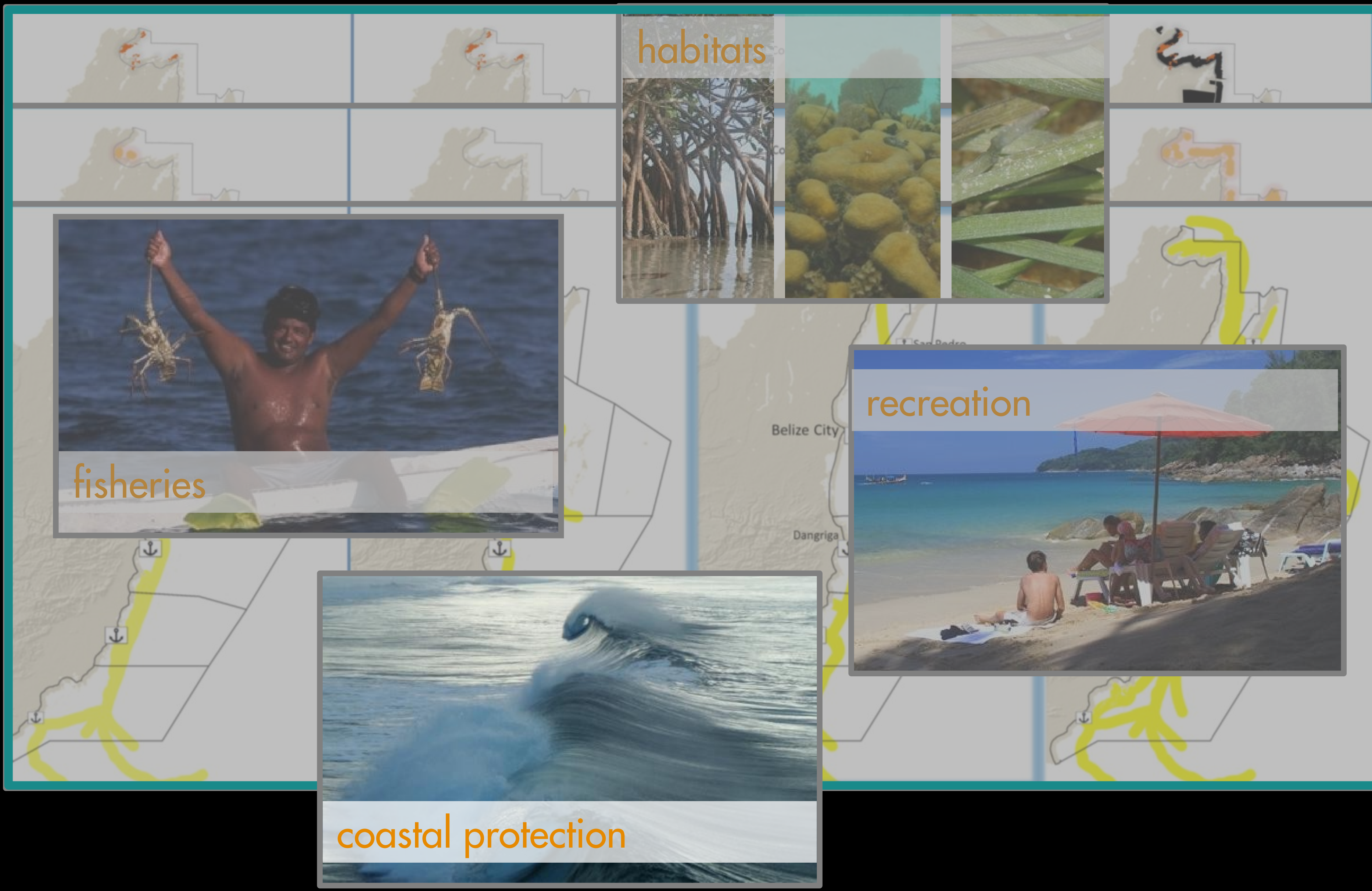
Alt. 644m 16,28.0587N 88,4.0956W



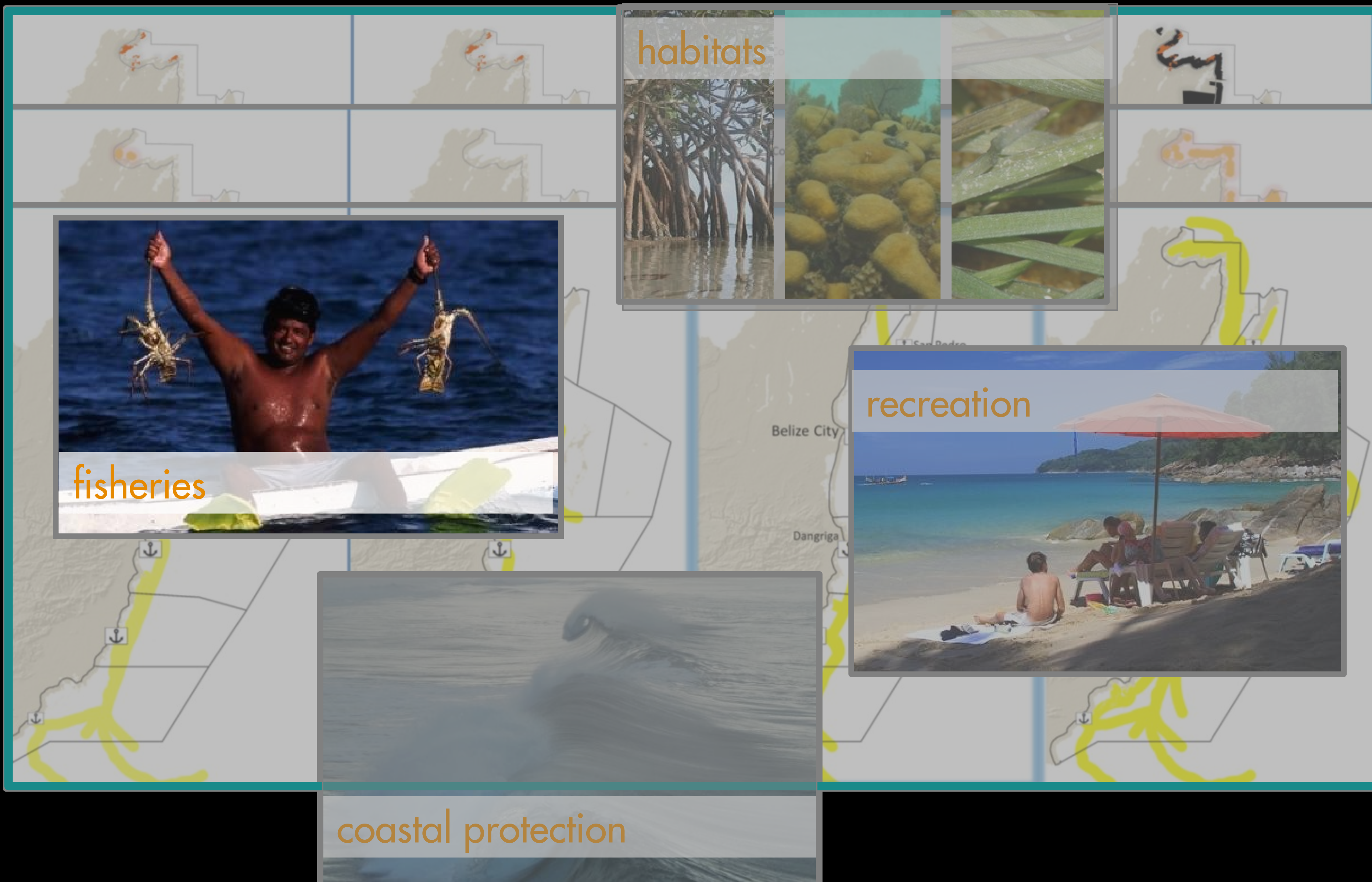
(arkema et al 2015 ERL)



(arkema et al 2015 PNAS)

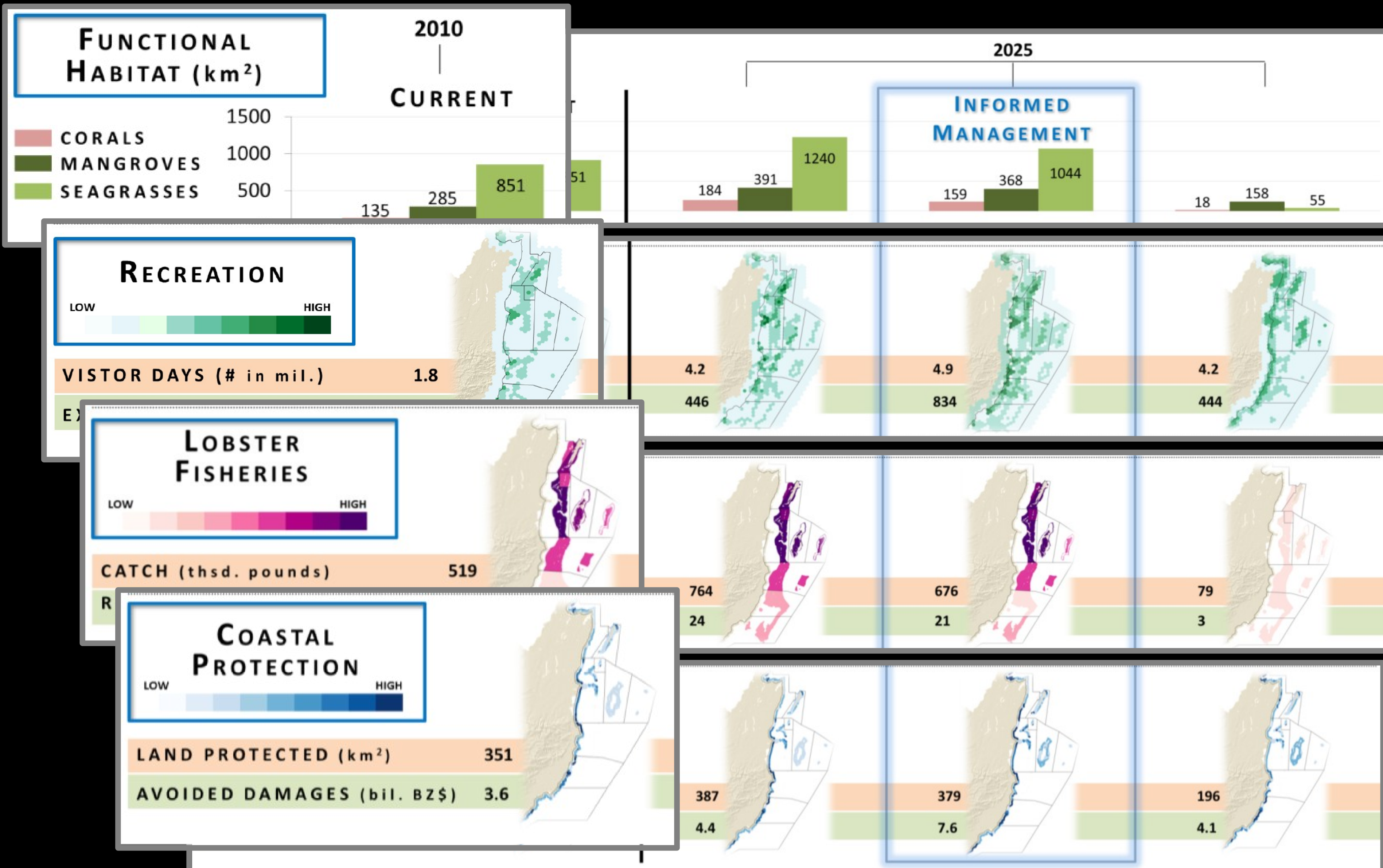

habitats
fisheries
recreation
coastal protection
Belize City
Dangriga


Habitats
Fisheries
Recreation
Storm protection
Belize City
Dangriga
San Pedro



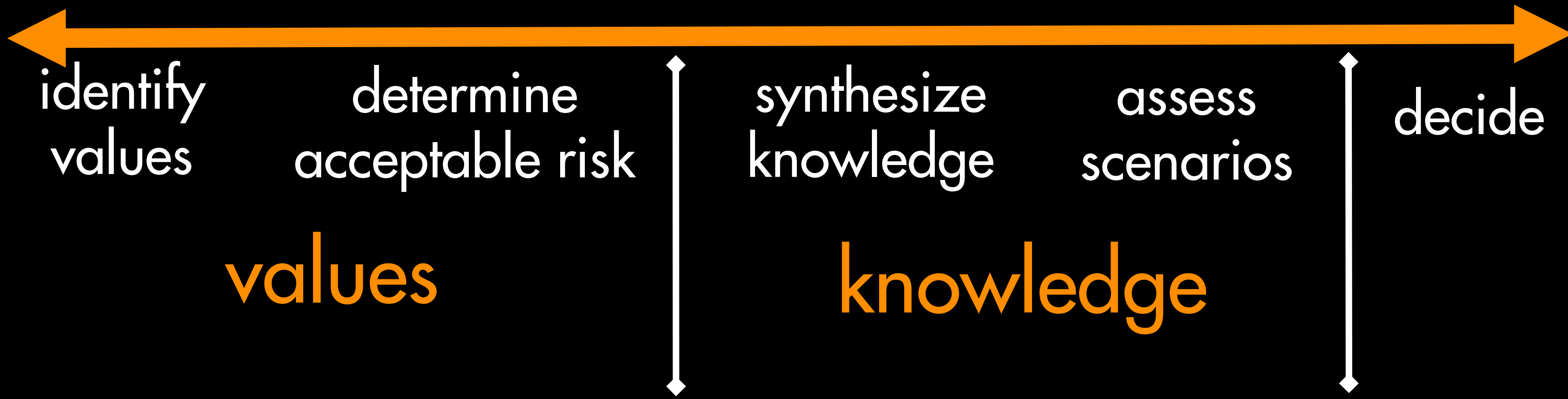
habitats
fisheries
recreation
coastal protection
Belize City
Dangriga

COASTAL PLANNING IN BELIZE



(arkema et al 2015 PNAS)

COASTAL PLANNING IN BELIZE



a co-developed science and policy process matters

a wide variety of values resonate with people

data, maps, and models are useful in decisions

it's important to consider tradeoffs among values

Broader Themes

a co-developed science and policy process matters

CEA is embedded in systems of governance and planning

a wide variety of values resonate with people

planning considers risk to ecological and social values

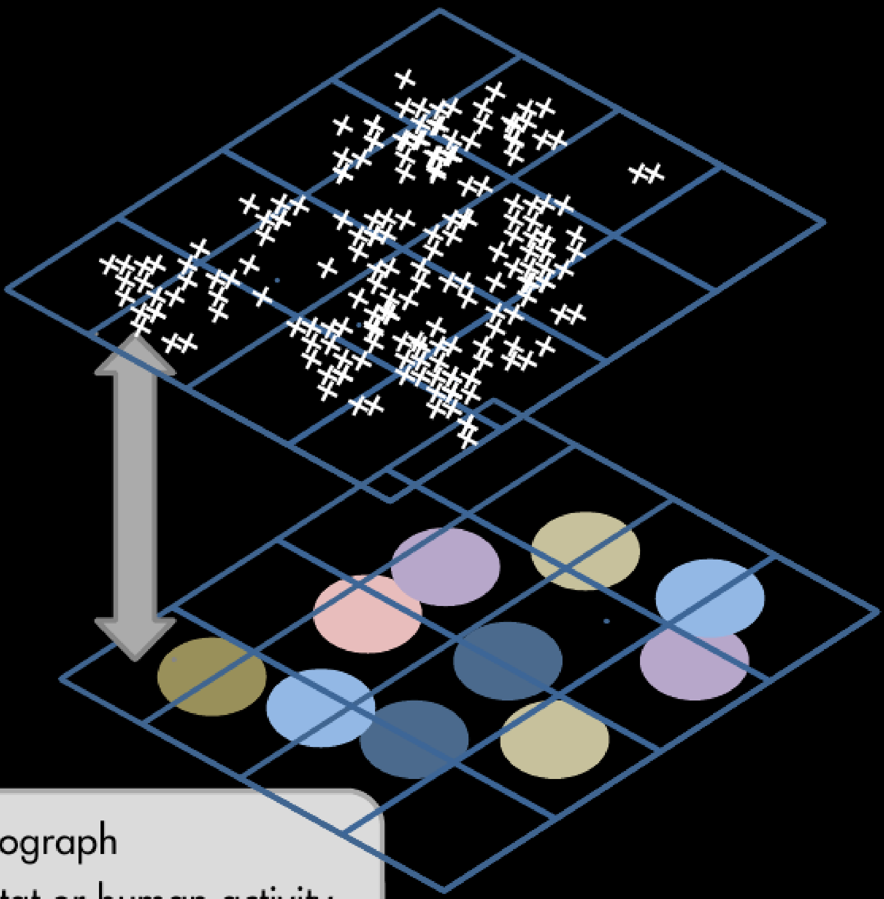
data, maps, and models are useful in decisions

but use and collection of data and models should be strategic

it's important to consider tradeoffs among values

planning for multiple (synergistic and conflicting) objectives

VISITATION RATE = f (HABITATS AND HUMAN ACTIVITIES)



× photograph

habitat or human activity
(eg, coral, aquaculture)

(wood et al 2015 Sci Rep)