



Decision-making under uncertainty: facing surprises, seizing opportunities

Peter Duinker

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Ann Chan-McLeod

Ken Zielke

Laurie Kremsater

12 June 2012



Session Overview

- Introduction – PD
- Short Presentations – Investigators
- Discussion
- Charge to working groups
- Working-group discussions
- Presentations to plenary

Speakers and Project Titles

- **Kathy Swift**
 - Reducing vulnerabilities and promoting resilience of BC's natural and human systems through adaptation of post-disturbance land management options
- **Emina Krcmar**
 - Uncertainty in adaptation to climate change in forest management
- **Ann Chan-McLeod**
 - Integrating climate change adaptation strategies with sustainability and socioeconomic objectives for the Quesnel timber supply area
- **Ken Zielke**
 - Validating impacts, exploring vulnerabilities, and developing robust adaptive strategies under the Kamloops Future Forest Strategy
- **Laurie Kremsater**
 - Monitoring forest and rangelands to anticipate and respond to climate change, phase 4

Decision-making under uncertainty?

- Isn't it always so?
- A former contextual stability becomes a moving target – damn!
- Just when it gets harder, the tools get better!
- Key – sharpen insight!
- But how?
 - More-incisive prospective analysis
 - More-rigorous retrospective analysis
- Major congrats to you BC people!

Desired Outcomes of FFESC Research

- Forest and range sectors rely on systematic climate-change-related modelling, monitoring, evaluation and learning
- PD reaction – YES!
 - That series defines Adaptive Management:
 - Modelling for prospective insight
 - Monitoring for retrospective insight
 - Evaluation for comparative insight
 - Learning for cumulative insight

Desired Outcomes of FFESC Research

- Policies and analysis (tools and processes) support interdisciplinary and cross-scale assessment.
- PD reaction:
 - Move to transdisciplinarity!
 - Multiple levels on time and space scales

Desired Outcomes of FFESC Research

- Decision-making has shifted from assuming stability and predictability to acknowledging change and uncertainty and utilizing scenarios and risk assessment.
- PD reaction – YES!
 - Scenarios are critical to insight
 - Calculate what you can . . . and then analyze the big risks!

Desired Outcomes of FFESC Research

- Proactive, science-based, long-term adaptation approaches to mid-term timber and wildlife habitat fall down in areas significantly affected by climate change (e.g., MPB areas).
- PD reaction:
 - Science-based? Only reveals potential consequences, not what one OUGHT to do – need values for that!

Desired Outcomes of FFESC Research

- Decision-making takes advantage of the best available climate-change adaptation science and assessment tools and techniques.
- PD reaction:
 - Infiltrate and subvert!



Kathy Swift

- Reducing vulnerabilities and promoting resilience of BC's natural and human systems through adaptation of post-disturbance land management options

Decision Support Framework:

A mental model for integrating the environmental and human dimensions into management decisions related to changes in natural disturbance events

Project Background

➤ Why?

- Projected climate change shifts in frequency and severity of natural disturbances
- Decision makers are making post-disturbance land management decisions to create/maintain ecosystems resilient to addressing these shifts
- Lots of information and tools available in various places
- But how to incorporate this information



Decision Support Framework

Approach

➤ Extension Project

- Utilizing existing knowledge (science, experiential, TEK)
- Bridging with other FFESC research projects (e.g., DeLong, Morgan, Chan-McLeod, Nelson, and others)

➤ Project Components

- Natural Disturbance projections
- Topical Syntheses
- Decision Support Framework



ECOLOGICAL/SOCIAL VULNERABILITY TO A CHANGING ENVIRONMENT

EXPOSURE/
EFFECTS

ADAPTIVE
CAPACITY

COMPETING
PRESSURES

ADAPTATION FRAMEWORK ACTIONS

PILLAR 1.

Provide the evidence base
(projections, opportunities, expert
opinion, trends, etc.) for need to
change

PILLAR 2.

Equip decision makers with
skills & tools (AM, risk
framework, vulnerability
assessments, etc.)

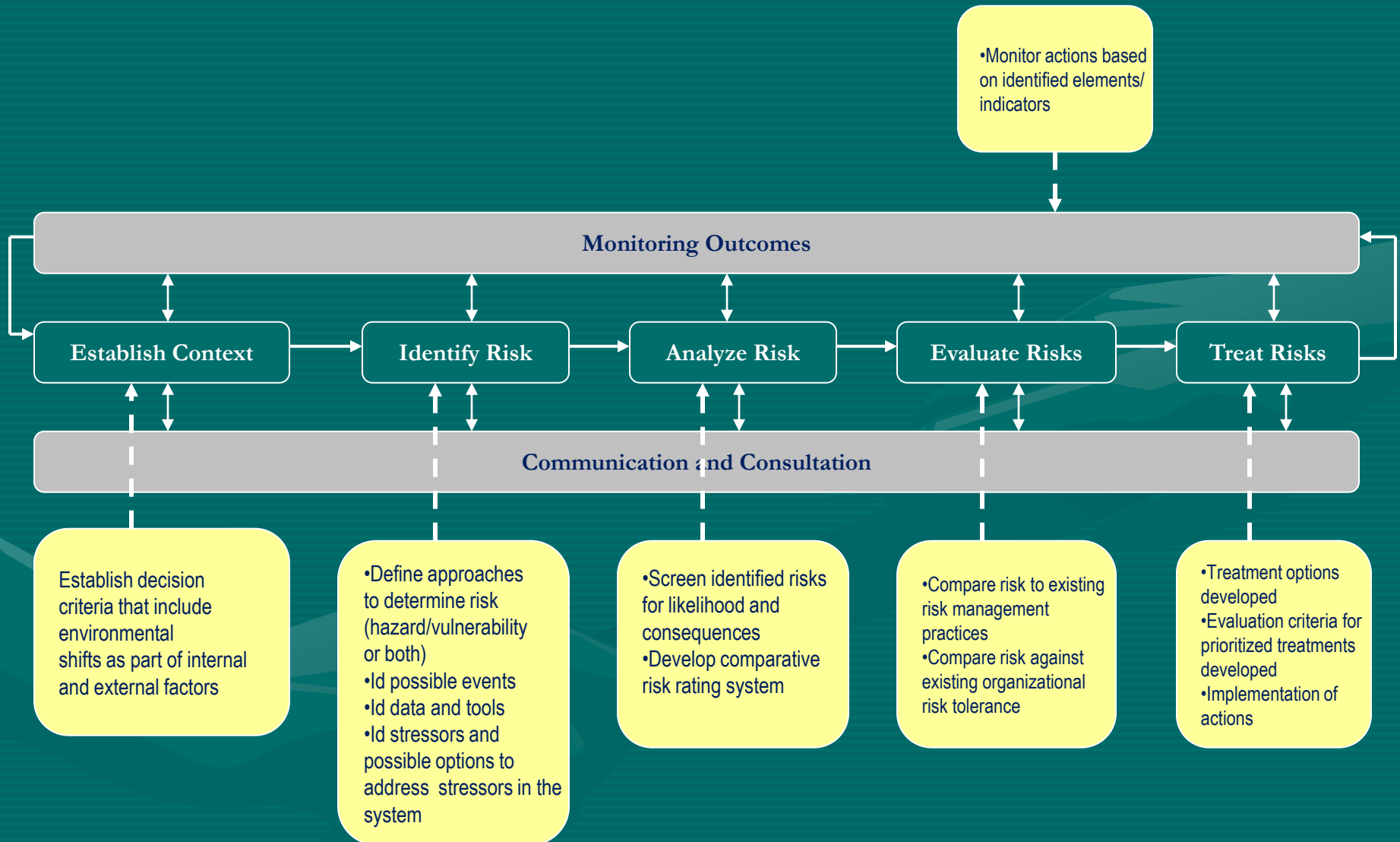
PILLAR 3.

Integrate adaptation into
local regulation and district
policy and monitor trends
(e.g., FPPR 26/5, etc.)

DELIVER ADAPTATION ACTIONS THAT ARE
SENSITIVE TO LOCAL NEEDS

RESULT: increase the resistance of the Williams Lake
TSA to the effects of environmental changes

Example of modified risk tools



PROJECTED CHANGES TO NATURAL DISTURBANCE EVENTS

EXPOSURE/
EFFECTS

ADAPTIVE
CAPACITY

COMPETING
PRESSURES

ADAPTATION FRAMEWORK ACTIONS

PILLAR 1.

Evidence supporting need for a change or adjustment to a decision or approach and the extent of that change (projections, opportunities, assumptions etc.)

PILLAR 2.

Decision support to equip decision-makers with skills & tools (AM, vulnerability assessments, risk frameworks, principles, expert opinion, etc.)

PILLAR 3.

Integrate adaptation into provincial planning/policies based on values in questions and monitor for trends and trigger points

DELIVER ADAPTATION ACTIONS THAT ARE FLEXIBLE AND
SENSITIVE TO LOCAL NEEDS

Result: informed natural resource decision-making related to adaption to projected natural disturbance event shifts as a result of a changing climate

Emina Krcmar

- Dealing with uncertainty in forest management under climate change



Dealing with uncertainty in forest management under climate change

Emina Krcmar

University of British Columbia

Vancouver, Canada

FFESC Closing Conference
Vancouver, BC, June 12, 2012

Forest decisions under uncertainty

- Forest management decisions under climate change are decisions under uncertainty
- There is no “correct” climate change scenario, only “possible” climate scenarios

Deep uncertainty

“... the climate change debate is characterized by deep uncertainty, which results from factors such as lack of information, disagreement about what is known or even knowable, linguistic imprecision, statistical variation, measurement error, approximation, subjective judgment, and disagreement about structural models, among others. [...] Moreover, climate change is not just a scientific topic but also a matter of public and political debate, and degrees of uncertainty may be played up or down (and further confused, whatever the case) by stakeholders in that debate.”

Schneider (2003)

Robust decisions under deep uncertainty

- Robust decision making is not a technique but an iterative and interactive framework to help identify and evaluate potential robust decisions
- Robust approaches search for “good-enough” strategies under a range of possible future conditions

Robust decision-making framework

Current planning horizon

- **Step 1:** Data collection: inventory, climate change, market conditions, disturbances
- **Step 2:** Define objectives and targets
- **Step 3:** Generate alternative management plans
- **Step 4:** Determine the objective values for all combinations of plans and possible CC scenarios
- **Step 5:** Select the robust plan(s)
- **Step 6:** Implement the plan
- **Step 7:** Monitor

Next planning horizon

Go to Step 1.

Characteristics

- *Iterative*: forest plans are generated iteratively over time
- *Interactive*: stakeholders' input can be included into model development and selection of the forest plan
- *Balancing* competing interests by including multiple goals
- *Dealing with uncertainty* by including a range of future climates into decision process
- *Robust* able to generate “good-enough” forest plans under the worst case climate conditions

Ann Chan-McLeod

- Integrating climate change adaptation strategies with sustainability and socioeconomic objectives for the Quesnel timber supply area

Lessons Learned on Uncertainty from FFESC Project B3

“Integrating Climate Change Adaptation Strategy
with Ecological and Socioeconomic Objectives
in the Quesnel TSA”

Presenter: Ann Chan-McLeod
Dept. of Forest Sciences, UBC

Lessons Learned on Uncertainty

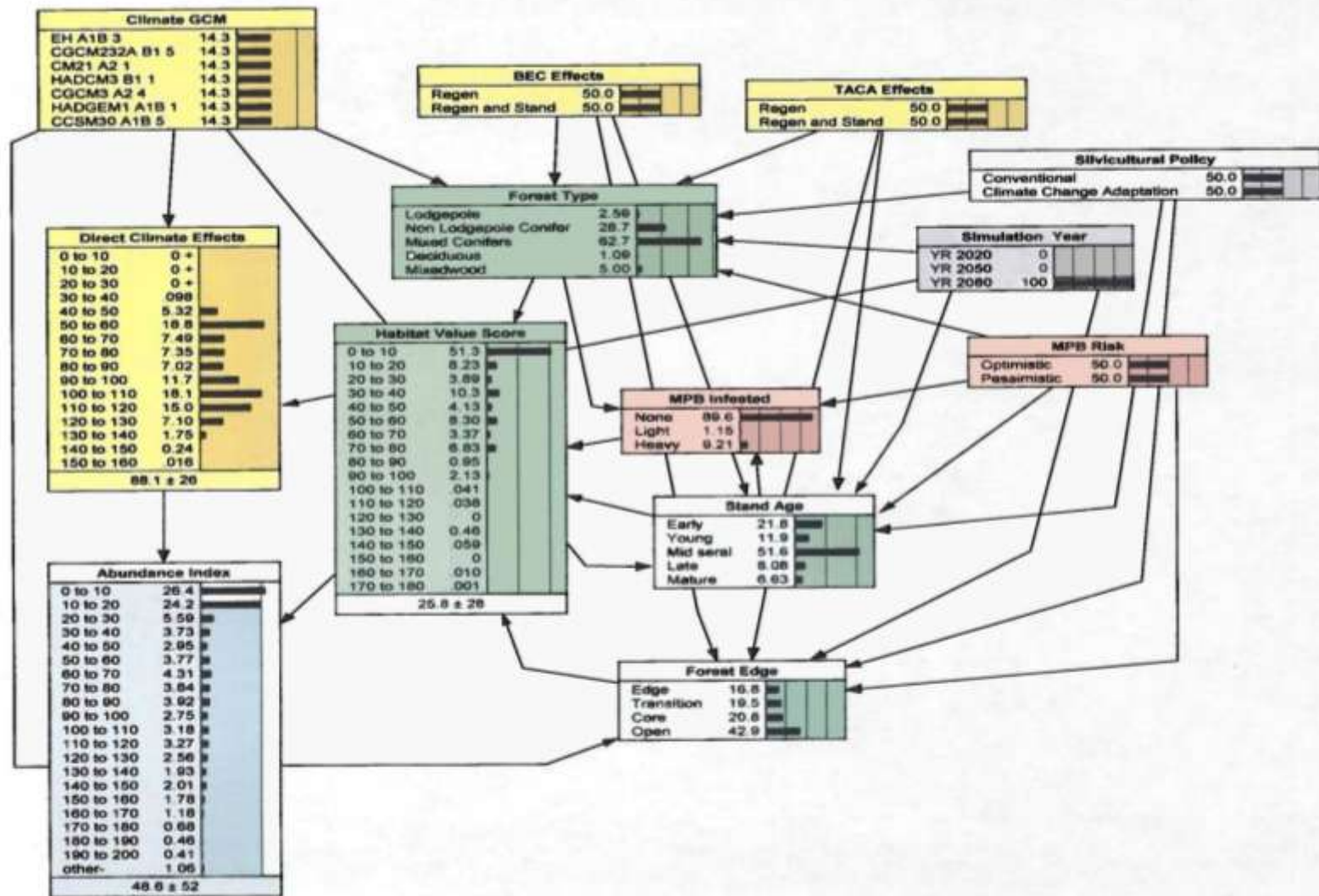
1. Remember that uncertainty is simply the variability around the value of a parameter. It is something that can be parameterized.

If we do this , we can then evaluate many things, including:

- whether the conclusions change depending on the uncertainty
- the relative importance of different types of uncertainties

How we parameterized uncertainty

Bayesian-GIS Network



Lessons Learned on Uncertainty

2. Valid conclusions can emerge despite uncertainties in input parameters.

For e.g., we were able to demonstrate that:

- the uncertainty in GCM scenario was not important to conclusions on habitat values, regardless of time horizons or modeling assumptions

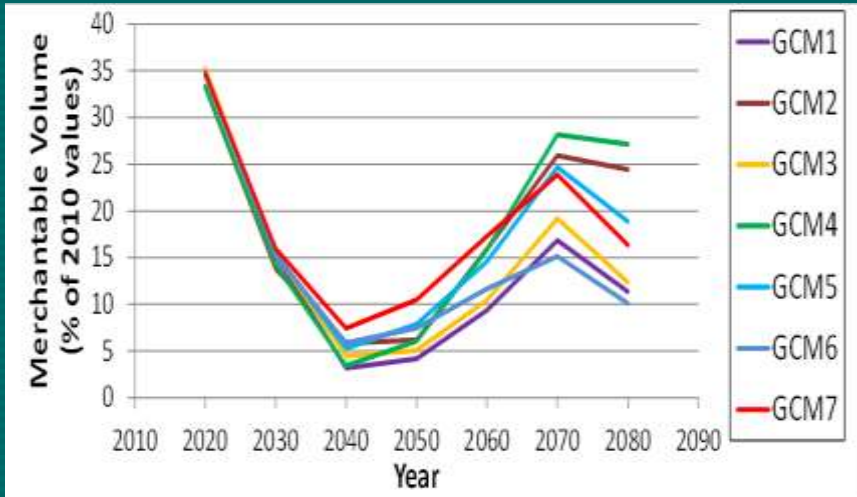
Lessons Learned on Uncertainty

3. New management principles and approaches will likely be necessary.
 - A climate change adaptation silviculture regime (assisted migration) improved all ecological and socioeconomic indicators in the long term, regardless of GCM scenario, MPB risk, and uncertainties in volume loss associated with maladapted trees
 - Changing reforestation practices was the only means to allow harvest to approach target AAC in middle term when growing stocks at lowest.

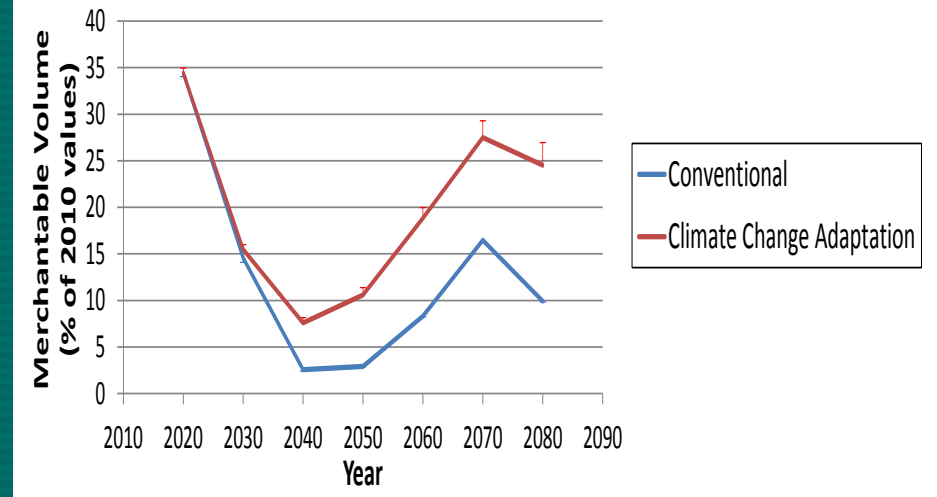
Standing Merchantable Timber

Sources of Variability

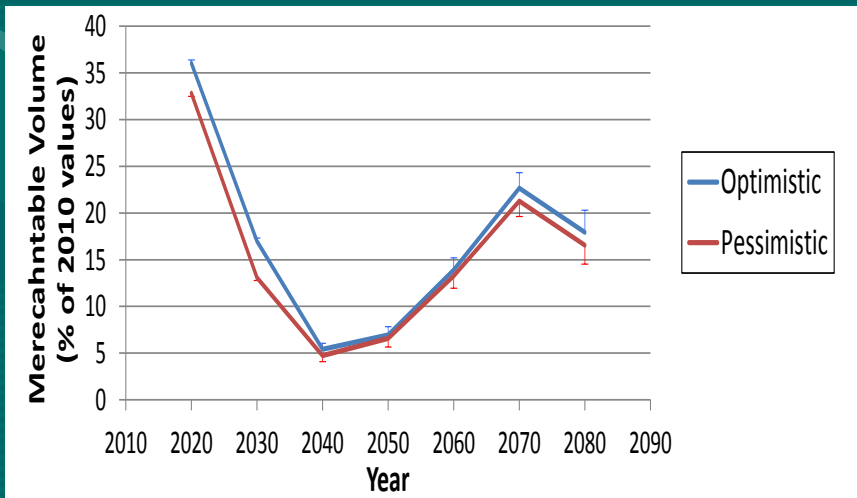
GCM



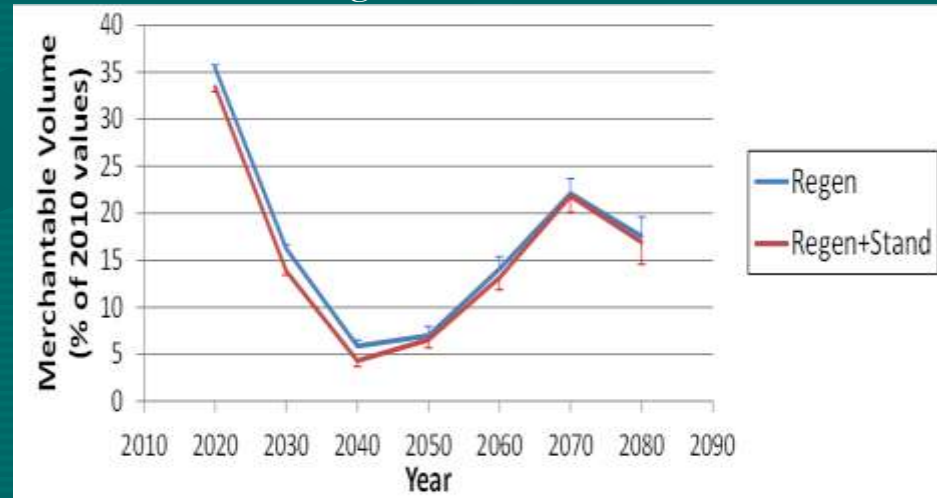
Silviculture Regime



MPB

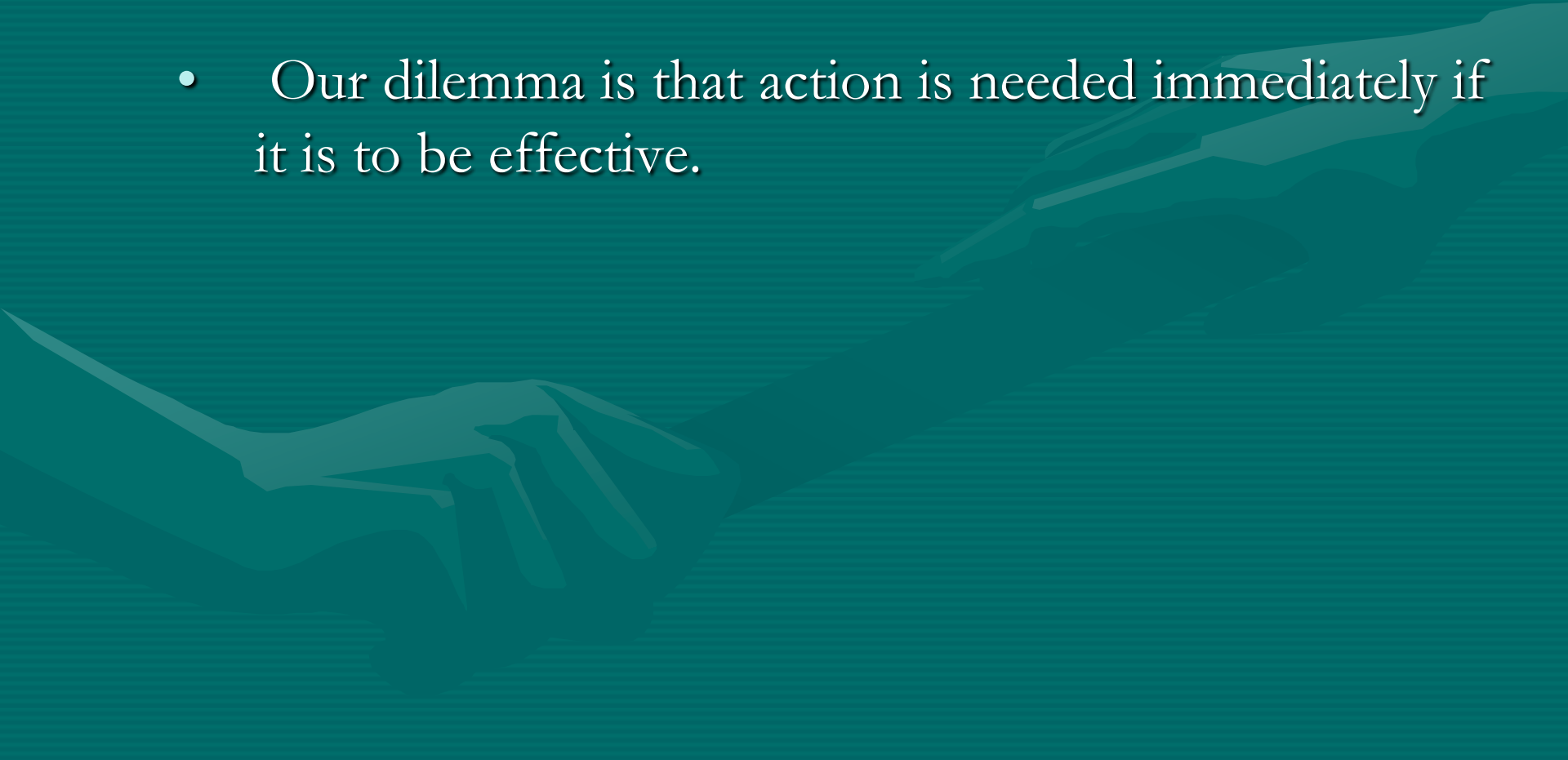


Climate Change Mechanism



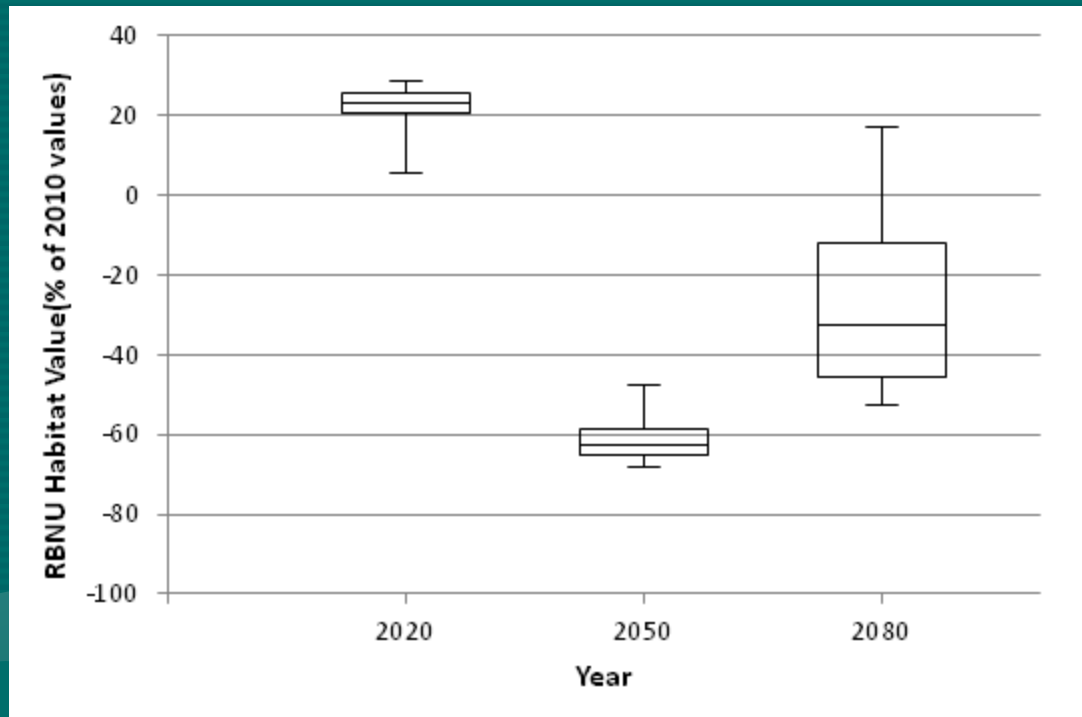
Lessons Learned on Uncertainty

4. Uncertainty is greatest in the long term.
 - Our dilemma is that action is needed immediately if it is to be effective.



How to resolve dilemma?

RBNU Habitat Values



Lessons Learned on Uncertainty

5. Direct effects of climate change on wildlife are much more uncertain than the indirect effects, which are mediated through habitat changes.
 - Magnitude of direct effects are less than indirect effects
 - However, extreme variability in indirect effects can make it a game changer
 - Need to evaluate effects of extreme weather events and not just average weather pattern



Ken Zielke

- Validating impacts, exploring vulnerabilities, and developing robust adaptive strategies under the Kamloops Future Forest Strategy

Validating Impacts, Exploring Vulnerabilities, and Developing Robust Adaptive Strategies under the Kamloops Future Forest Strategy (File: 012_Nelson)

Dr Harry Nelson and Ken Zielke
- Project Leads

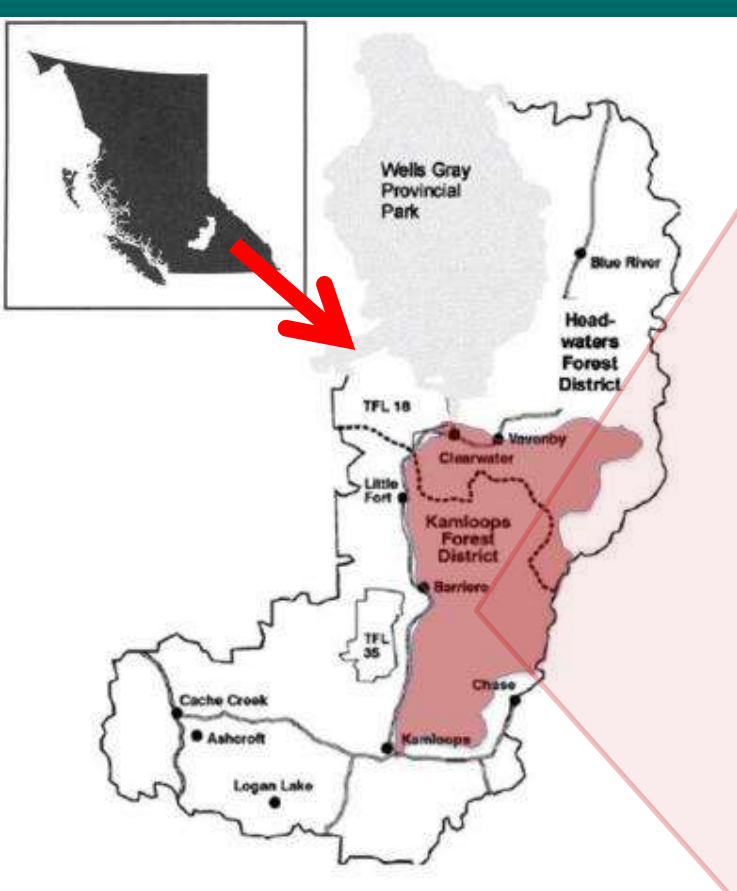


FFESC Research Project

June, 2012

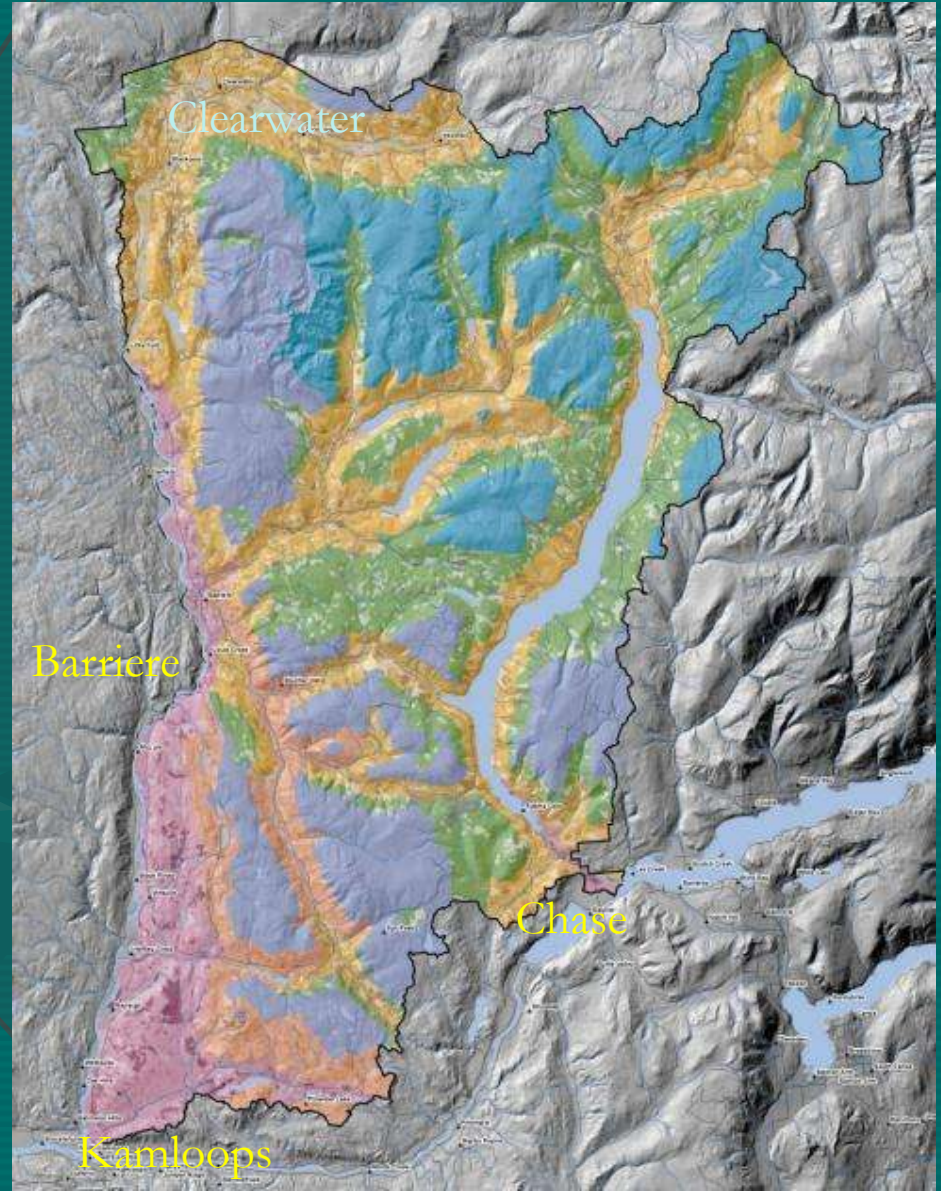


Case Study Area – the center of the TSA

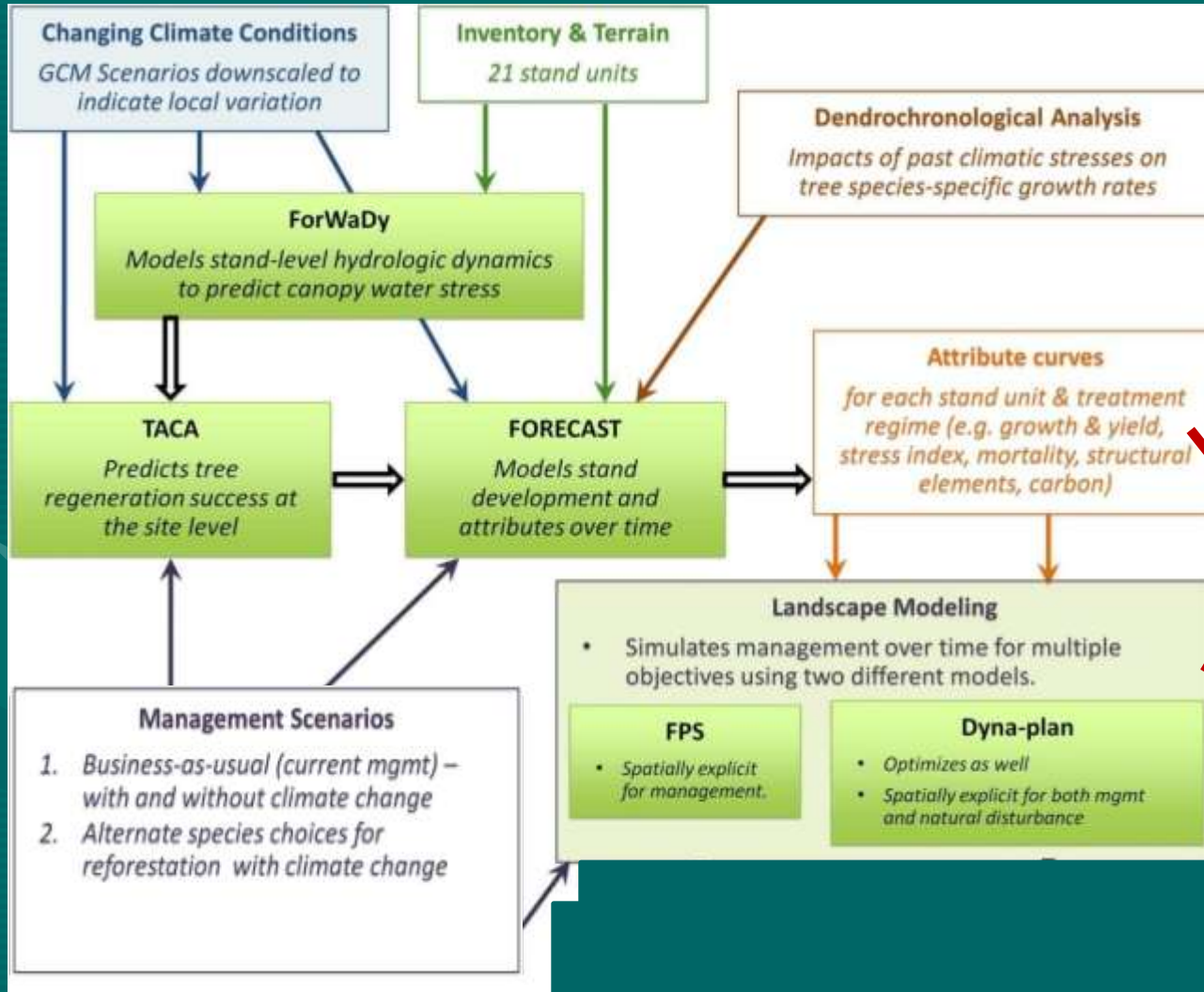


CASE STUDY AREA

- 900,000 ha
- Six Broad Eco-units



Modeling Suite and Approach

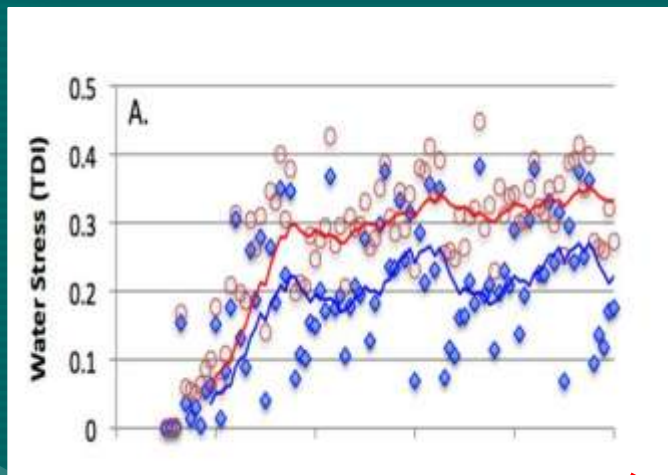
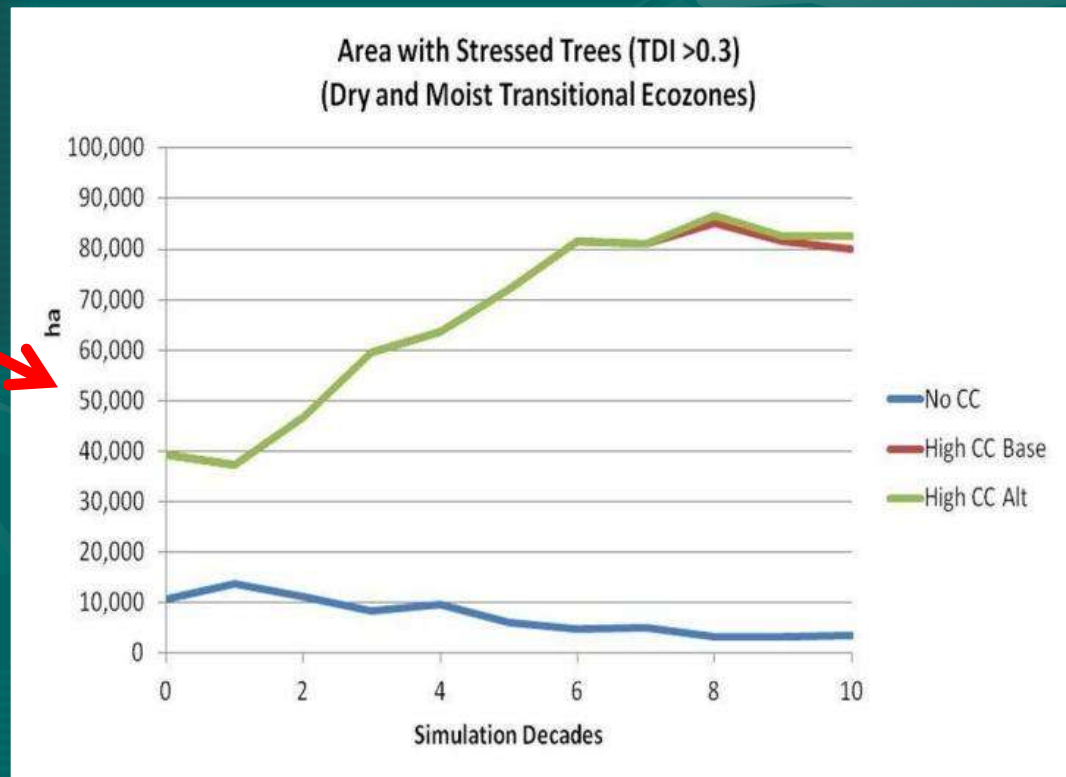


- Interpret Trends
- To refine management strategies

KEY LESSONS

Both +ve and -ve Productivity Impacts

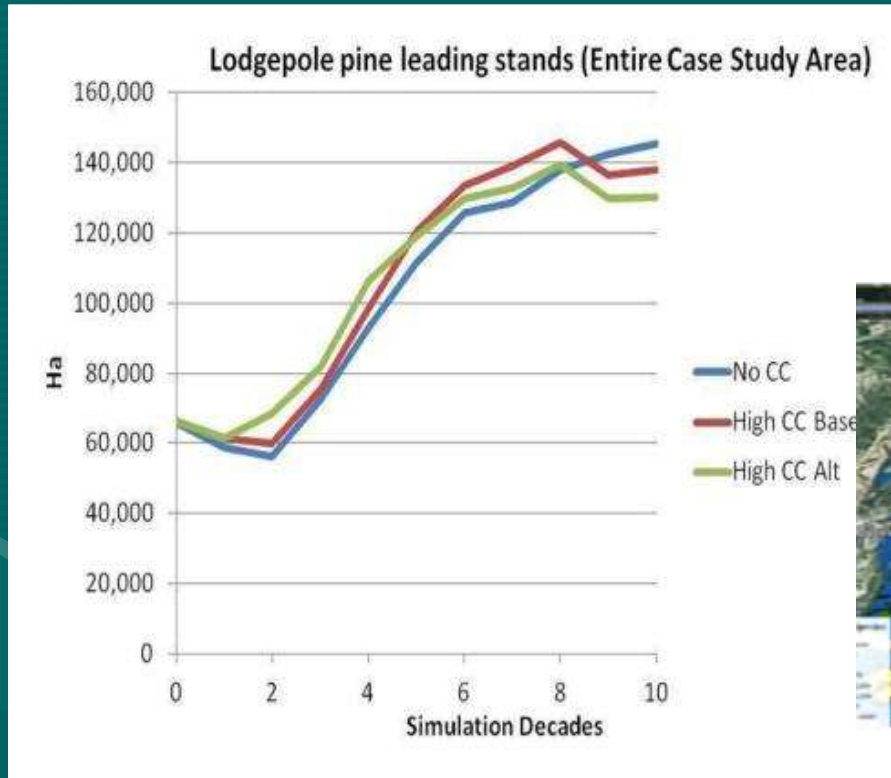
BUT - Climate change consistently led to increase in mid-growing season water stress



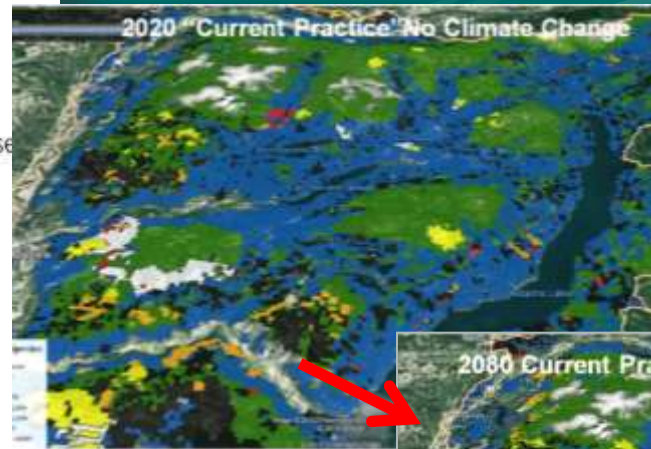
KEY LESSONS:

We are expanding lodgepole pine on the Landscape

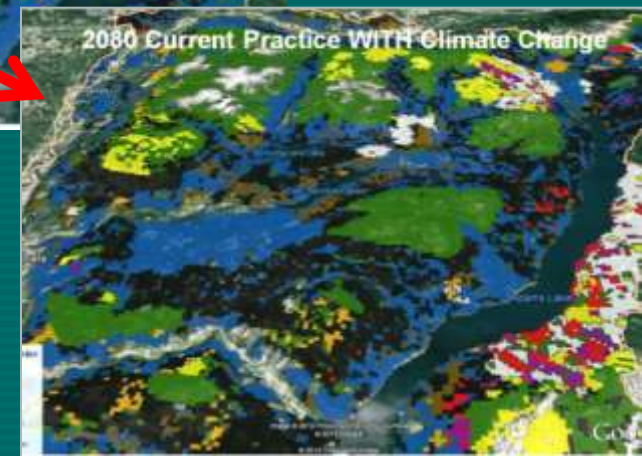
AND - Most stands are projected to have high moisture stress!



2020



2080

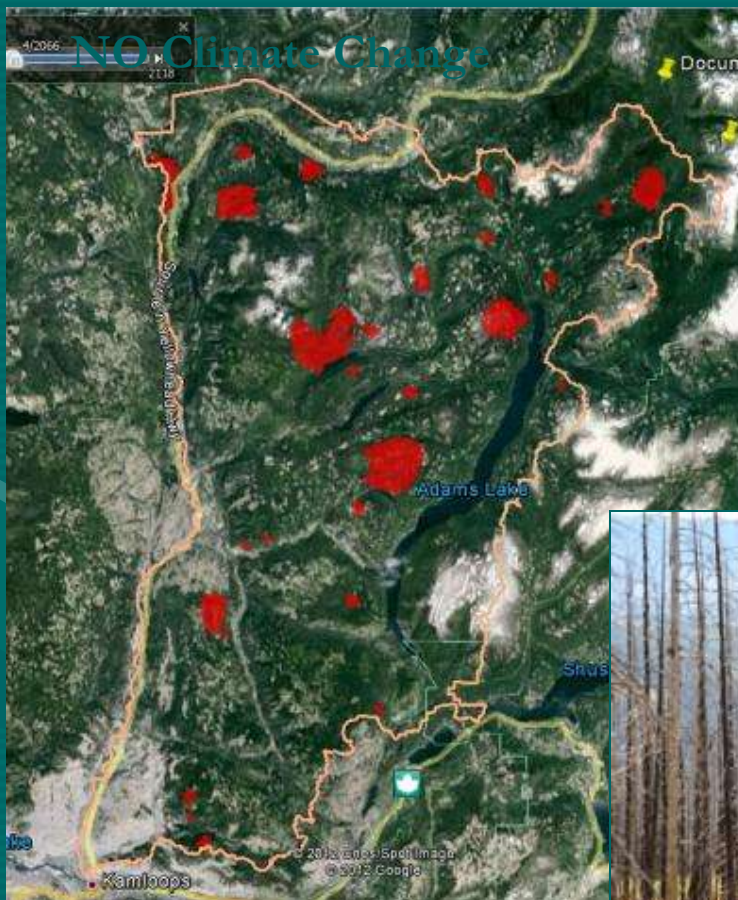


KEY LESSONS

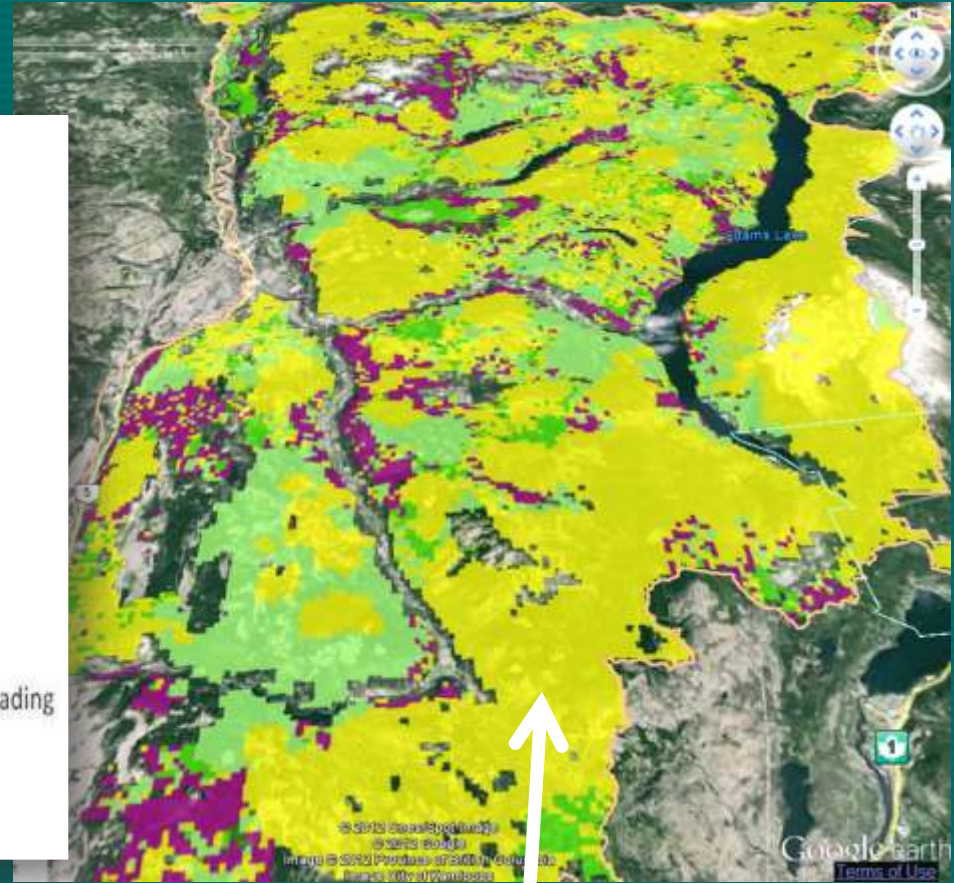
Area burned (wildfires) projected to **DOUBLE**

Spatial simulation – 2060-2070

- 10 year area burned by stand replacing fires.



Timber Supply headed for trouble? – past 2100



Management Guidance

Guidance to Adapt Forest Management for Climate Change in the Kamloops TSA.

FIRST APPROXIMATION (June 7, 2012) which should be viewed as a continuous work in progress.

Based on:

Validating Impacts, Exploring Vulnerabilities, and Developing Robust Adaptive Strategies under the Kamloops Future Forest Strategy (K2-2011) – Future Forest Ecosystems Scientific Council (FFESC) Interdisciplinary Climate Change Adaptation Research for Forest and Rangeland Ecosystems.

And

Adapting Forest Management in the Kamloops TSA to Address Climate Change – The Kamloops Future Forest Strategy (K1 – 2009)



Forest Resources Management
University of British Columbia,
Symmetree Consulting Group Ltd.,
Forsite Consultants Ltd.

Ecological Landscape (Ecozones)	Associated BEC subzones	Guidance	Details
Plateau	Transitional to higher elevations (e.g. MSdm, SBS mm ESSFdc)	Avoid conversion of Douglas-fir or Spruce leading stands to Pli leading stands	Manage for a majority of Fd, Py, Lw, Pw and other appropriate non-pine species. Restrict Pli to 20-30% of stocking or restrict to "acceptable" stocking status in silvicultural surveys.
		Encourage species diversity across the landscape.	On average across the landscape, maintain species diversity at natural / historic levels. Target warm lower elevation sites for increased amounts of Douglas-fir (e.g. 20-35%) where it is ecologically feasible.
Plateau (cont)	Transitional to higher elevations (e.g. MSdm, SBS mm ESSFdc)	Maintain presence of At on landscape for habitat and species diversity	Avoid removal of aspen (where concentrated) through brushing and other activities. Make strategic use of stratification and free-growing stocking standards.
Wet ESSF	e.g. ESSFwk	Encourage tree species diversity as much as possible across the landscape	Spruce is still a good choice for regeneration – monitor carefully for increased weevil damage at lower elevations, where redcedar should be gradually mixed in.

Harvesting:

The harvesting guidance below is strategic in nature and as such requires thoughtful strategic planning directing well-coordinated tactical plans. Work will be necessary to identify the vulnerable stand types and make appropriate decisions regarding economics and timing of treatment. Incentive and other mechanisms not yet in place may be needed.

Ecological Landscape (Ecozones)	Associated BEC subzones	Guidance	Details
Dry Fdi (Py)	IDF and PP subzones too dry for Pli	Reduce fuels with commercial thinning and/or juvenile spacing	With well designed fire management strategies encourage vigor and health and reduce fire risk by significantly reducing stand stocking densities.
Dry subzones with Pli	IDF with Pli (e.g. IDFdk) and very dry MS (e.g. MSdk)	Targeted harvesting to address high risk stands.	Target stands more vulnerable to fire (with climate change) as a priority for harvesting, retaining those stands that are less vulnerable for future passes and other objectives.

Management Guidance

HOLD IT!

This is based on data that is precise but not accurate...

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Ecological Landscape (Ecozones)	Associated BEC subzones	Guidance	Details
Plateau	Transitional to higher elevations (e.g. M50m SBS rim ESSFG)	Avoid conversion of Douglas-fir to Spruce leading stands to PI leading stands	Manage for a majority of Fir, P. Ly, Lir, P. and other appropriate non-vine species. Retain PI to 20-30% of stocking or restrict to "acceptable" stocking rates in silvicultural surveys.
Plateau (cont)	Transitional to higher elevations (e.g. M50m SBS rim ESSFG)	Encourage species diversity across the landscape.	On average across the landscape, maintain species diversity at natural / historic levels. Target lower elevation sites for increased amounts of Douglas-fir (e.g. 20-35%) where it is ecologically feasible.
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Dry Fd (Py)	DF and RP subzones too dry for PI	Reduce fuels with commercial thinning and/or juvenile spacing	With well designed fire management strategies, encourage vigor and health and reduce the risk by significantly reducing stand stocking densities.
Dry subzones with PI	DF with PI (e.g. DFd) and very dry MD (e.g. MDd)	Targeted harvesting to address high risk stands	Target stands more vulnerable to fire (with climate change) as a priority for harvesting, retaining those stands that are less vulnerable to future stresses and other objectives.



Management Guidance

HOLD IT! – This is based on data that is precise but not accurate...

AND...

- Precision allows for useful comparisons.
- Must Embrace Uncertainty – By continually:
 - Questioning and exploring assumptions, and
 - Revisiting modeling and guidance.

Guidance to Adapt Forest Management for Climate Change in the Kamloops TSA.

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A dense forest of tall evergreen trees, likely spruce or fir, fills the frame. The trees are dark green, with some lighter green foliage visible in the foreground. The text "Thank you" is overlaid in a teal color. The background is a dark, dense forest of tall evergreen trees, with some lighter green foliage visible in the foreground. The text "Thank you" is overlaid in a teal color.

Thank you

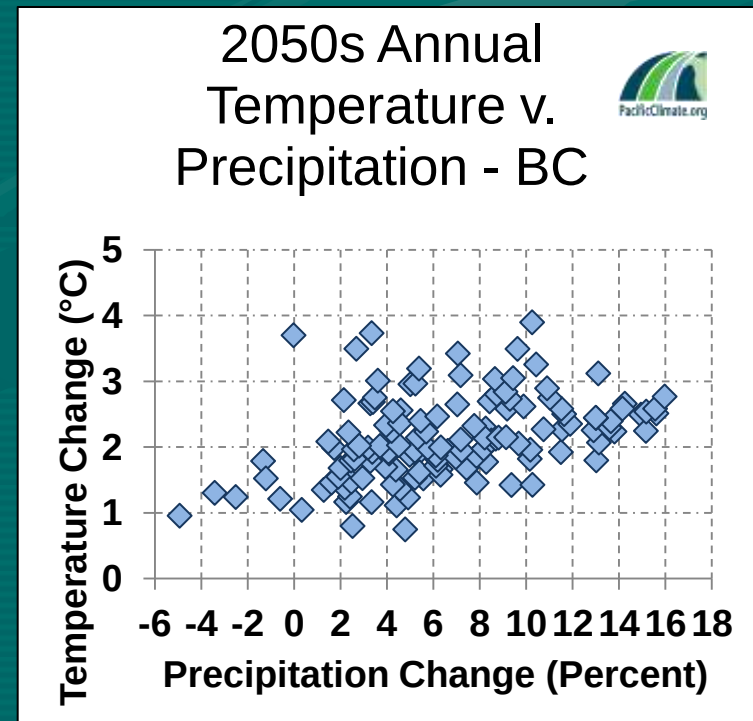
Monitoring forests to anticipate and respond to climate change in BC.

- John Innes, Margie Eddington, Laurie Kremsater
- Project in 4 phases



Rationale/Intent of Project

- While predictions can help guide management, monitoring -- tracking over time -- is a necessity to be able to react to actual changes.
- Climate change brings many uncertainties in abiotic changes
- And even greater uncertainty in ecological responses: trees, insects, diseases (and other organisms)



Tracking changes over time

- Phases 1 and 2 gathered experts and managers together to identify most useful indicators
- Phases 3 and 4 identified presently available data for the indicators and piloted indicators in South Selkirks area.

State of Information for the Indicators

- **Abiotic**
 - Temperature; precipitation
 - Snowpack; glaciers
 - Streamflow
 - Water temperature and quality
 - Extreme weather
- **Disturbances**
 - Fire, insects, pathogens, wind, mass wasting
- **Biotic**
 - Ecosystem composition, distribution, connectivity
 - Ecosystem productivity
 - Species ranges
 - Genetic changes

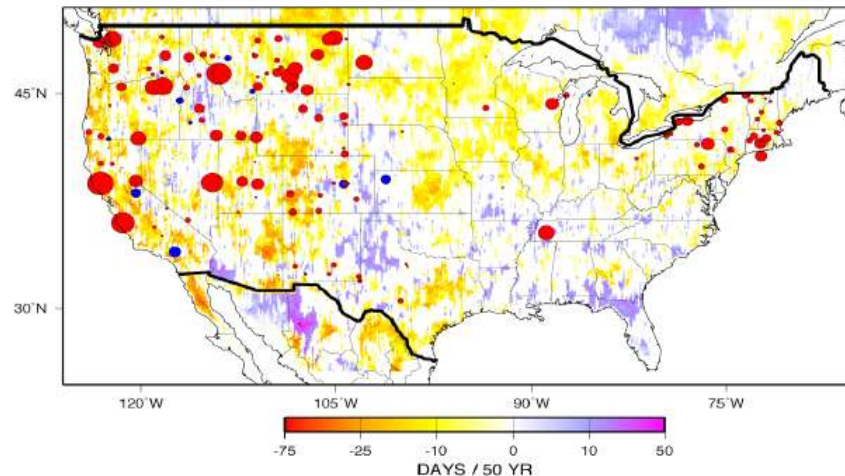
Summary

1. Some basic trends in data already are tracked and reported well, particularly for abiotic indicators:

- Temperature
- Precipitation
- Snowmelt
- Streamflow
- Glaciers
- Ice on lakes

Figure 6. Trends in Frost-Free Growing Season Length and Phenological Observation of Bud Burst

SHADES: TRENDS OF BEGIN DATE OF GROWING SEASON, 1950-99, FROM TEMPERATURES
DOTS: TRENDS IN LILAC FIRST-BLOOM DATES (Sites with 20+ yrs of record)



- **BUT** some derived indicators lacking: growing season, drought

Summary con't

2. Some abiotic indicators not tracked as well

- Extreme weather (frost, drought) – *and this is what forests respond to quickest and most strongly!*
- Water temperature
- Water quality



Summary con't

3. **Natural disturbances: fire and insects/disease tracked better than mass wasting or windthrow**
 - **Fire** (confounded with suppression so note suppression levels and which ones suppressed)
 - **Insects and disease** (FIDS, then MOF overview flights help on this, they also track windthrow and mass wasting if seen)
 - **Mass wasting** – mostly site level but for Geertsema
 - **Windthrow** – also mostly site level so confounded (but Pearson on Coast looked at landscape level)

Summary con't

4. Tracking biotic responses weakest!

- Ecosystem distribution and composition – *we have benchmarks but no plans to measure again for trend (BEC, VRI, TEM)*
 - *There are change measurements plots that are happening through NFI*
- Species distributions changes – *few data even for trees*
- Ecosystem productivity (*PSPs, other?*)
- Genetic diversity – *few data*
- Ecosystem connectivity (*useful measures?*)

Next steps

Some key holes to fill:

- Measure and report extreme weather – frost, duration of drought, growing season length, etc
- Organize water temperature and quality information
- Continue insect and disease surveys and perhaps add wind and mass wasting reporting
- Establish repeated measures for ecosystem composition and distribution (use BEC plots as PSPs?)
- Track tree productivity
- Track ranges of sensitive species
- *Measure our adaptations*



Thank You!

