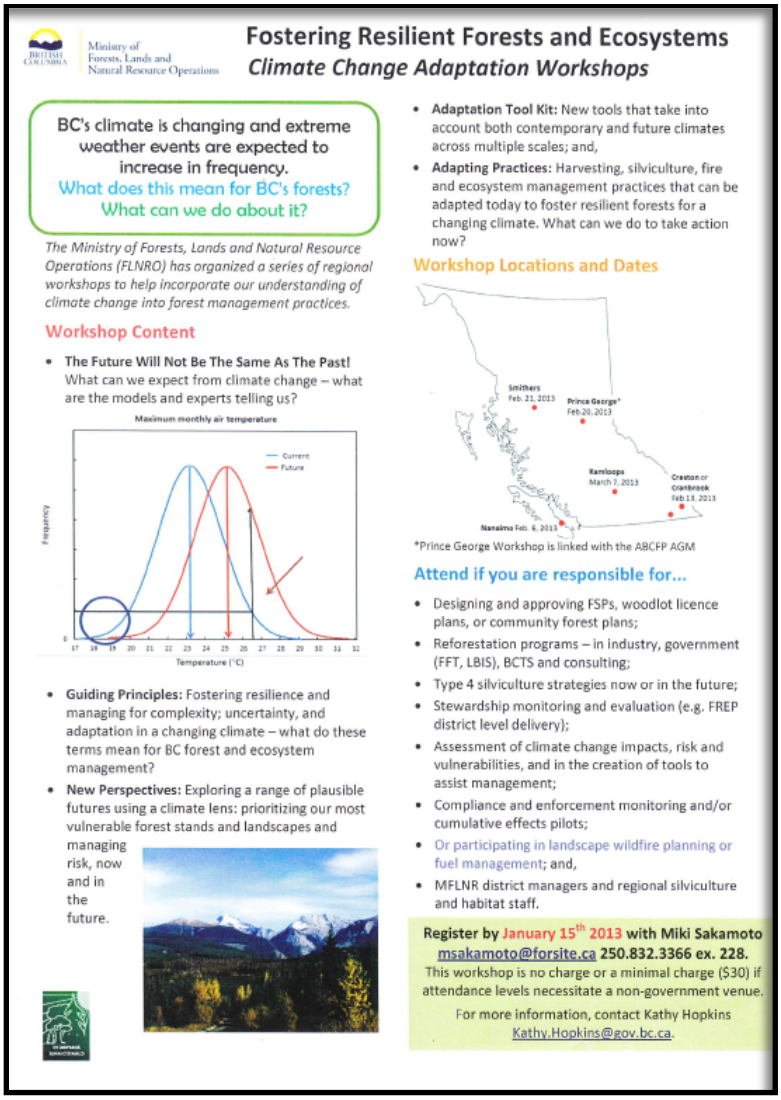
Ministry of Forests Lands and Natural Resources Operations

Climate Change Adaptation Workshop

February 13, 2013 Cranbrook, BC



Ministry of Forests, Lands and Natural Resource Operations

Fostering Resilient Forests and Ecosystems

Climate Change Adaptation Workshops

BC's climate is changing and extreme weather events are expected to increase in frequency.
What does this mean for BC's forests?
What can we do about it?

The Ministry of Forests, Lands and Natural Resource Operations (FLNRO) has organized a series of regional workshops to help incorporate our understanding of climate change into forest management practices.

Workshop Content

- **The Future Will Not Be The Same As The Past!** What can we expect from climate change – what are the models and experts telling us?

Maximum monthly air temperature

- **Guiding Principles:** Fostering resilience and managing for complexity; uncertainty, and adaptation in a changing climate – what do these terms mean for BC forest and ecosystem management?
- **New Perspectives:** Exploring a range of plausible futures using a climate lens: prioritizing our most vulnerable forest stands and landscapes and managing risk, now and in the future.

- **Adaptation Tool Kit:** New tools that take into account both contemporary and future climates across multiple scales; and,
- **Adapting Practices:** Harvesting, silviculture, fire and ecosystem management practices that can be adapted today to foster resilient forests for a changing climate. What can we do to take action now?

Workshop Locations and Dates

*Prince George Workshop is linked with the ABCFP AGM

Attend if you are responsible for...

- Designing and approving FSPs, woodlot licence plans, or community forest plans;
- Reforestation programs – in industry, government (FFT, LBIS), BCTS and consulting;
- Type 4 silviculture strategies now or in the future;
- Stewardship monitoring and evaluation (e.g. FREP district level delivery);
- Assessment of climate change impacts, risk and vulnerabilities, and in the creation of tools to assist management;
- Compliance and enforcement monitoring and/or cumulative effects pilots;
- Or participating in landscape wildfire planning or fuel management; and,
- MFLNR district managers and regional silviculture and habitat staff.

Register by January 15th 2013 with Miki Sakamoto msakamoto@forsite.ca 250.832.3366 ex. 228.
This workshop is no charge or a minimal charge ($30) if attendance levels necessitate a non-government venue.

For more information, contact Kathy Hopkins Kathy.Hopkins@gov.bc.ca.

PARTICPANT MATERIALS

Ministry of Forests, Lands and Natural Resource Operations

ASSOCIATION OF BC FOREST PROFESSIONALS

Climate Change Adaptation Workshops

Module 1
Managing for Resilient Forests and Ecosystems

Ministry of Forests, Lands, and Natural Resource Operations

2013

Module 1 Managing for Resilience

Today's agenda

Welcome and Introductions

Executive Direction

Principles of Climate Change and Adaptation

- Climate trends, terminology and risk

Lunch on our own

Resilient Forests in a Changing Climate

- Guidance from Vulnerability Assessments
- Resilience through scenario-based risk management

What can we do now? – using:

- Overview of available tools
- Locally relevant exercises
- Done throughout the day

Lessons learned

2

Module 1 Managing for Resilience

A message from our executive sponsors

Welcome from:

- Dave Peterson, ADM, Executive Sponsor
- Regional Sponsor
- Casey Macauley/Mike Larock ABCFP

3

ASSOCIATION OF BC FOREST PROFESSIONALS

Climate Change and the Forest Professional

An Era of Consequence

Fostering Resilient Forests and Ecosystems workshop series, February 2013

Mike Larock RPF, Director of Professional Practice and Forest Stewardship
Casey Macaulay RPF, Resource Operations Specialist

ABCFP 2008 Position Statement:

"There is a large body of scientific research showing that climate change will have a profound effect on BC forests. Projections of climate change and assessment of carbon cycle dynamics should be derived from the most defensible scientific evidence available. The ABCFP supports a diverse range of approaches to managing BC's forest land adaptively…"

Why is the profession concerned?

Professionals have a critical role:

Learning: professional development and innovation

Professional Reliance: application of knowledge

Managing uncertainty and risk: 'Blind corner ahead'

Stewardship mandate: managing for the long term

Of course,
forest professionals are used to dealing with some uncertainty..

To forest professionals, climate change presents another example of a non-statutory expectation..

"*Forest professionals are expected, by others, to achieve forest resource outcomes in an environment that does not always provide them the authority, control or resources to produce these outcomes..*"

(Non-Statutory Expectations Series - A Description of Non-Statutory Expectations and the Practice of Professional Forestry Sept. 2012)

What is the ABCFP doing?

CEO established the Climate Change Task Force:

- Identify and prioritize concerns for members
- Develop guidance material or advocacy papers
- Communicate best practices and research
- Provide expert advise to other committees

Work to date:

- Member survey: baseline of awareness
- Collaborating with other professions
- Working with government and the research community to foster awareness

Preliminary survey results: ABCFP climate change awareness survey (full membership) to Jan 29th

Please check any of the following items that you would identify as a threat to BC forests in a changing climate or that you have observed in your region of the province.

Response	Chart	Percentage	Count
Increased levels of natural disturbance/mortality due to wildfires		58%	754
Increased levels of natural disturbance/mortality due to insects and disease		83%	1076
Regeneration failures		42%	548
Changes in stand-level productivity		34%	441
Increase in invasive species		49%	634
Genetic maladaptation		22%	290
Biome conversion (e.g. forest to shrub, grassland, etc.)		31%	406
Business disruptions due to extreme weather		40%	521
Other, please specify...		12%	160
		Total Responses	1291

The biggest barriers I face in working to minimize the impacts of climate change in my forestry decisions are (check all that apply):

Response	Chart	Percentage	Count
Lack of employer awareness of impacts.		13%	160
Lack of employer interest in minimizing impacts.		18%	223
Lack of personal knowledge, expertise or ability.		32%	410
No authority to make adaptation recommendations/decisions.		33%	417
Lack of strategic vision or policies that support innovation/diversification of practices.		43%	543
Lack of guidance, standards or best practices.		45%	567
Costs are prohibitive.		17%	222
My workload allows little time for this.		25%	319
No barriers.		14%	181
Other, please specify...		18%	228
		Total Responses	1274

Do you have the appropriate level of training needed to make balanced, scientifically sound climate change adaptation decisions in accordance with your current scope of professional practice?

Response	Chart	Percentage	Count
Yes		41%	516
No		59%	756
		Total Responses	1272

Please indicate which, if any, adaptation practices you are currently undertaking.

Response	Chart	Percentage	Count
Research (e.g. use of climate models, projections)		10%	125
Experimentation (e.g. small scale pilots, operational trials)		12%	153
Risk, impact and / or vulnerability assessments		10%	131
Incorporating into strategic planning		15%	186
Incorporating into operational planning		16%	199
Practices on the ground (to meet obligation requirements)		19%	241
Monitoring and evaluation		23%	294
None of the above		46%	581
Other, please specify...		9%	110
		Total Responses	1262

Messages that we are working on..

- Forest professionals must develop an ongoing awareness.
- There is enough scientific data available for professionals to begin pursuing adaptation.
- Policy makers and practitioners must manage for uncertain future conditions.
- The ABCFP will advocate for and support policies that lead to improved climate adaptation.
- The ABCFP supports collaboration between governments, industry, researchers and practitioners.

ASSOCIATION OF BC FOREST PROFESSIONALS

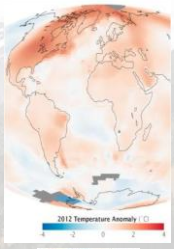
For more information, contact the Professional Practice and Forest Stewardship Team

www.abcfp.ca

Module 1 Managing for Resilience

Learning Objectives for Today

1. Understand the principles and terminology of climate change and adaptation.
2. How will climate change in your region?
3. What do we mean by resilient forests and ecosystems?
4. What can YOU do now to promote resilience!

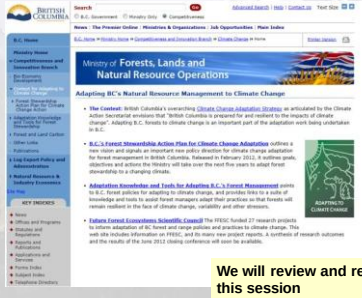


17

Module 1 Managing for Resilience

Work to date – building as we go

FLNRO initiatives to aid understanding



We will review and reference them in this session

18

Module 1 Managing for Resilience

Climate Change Adaptation Workshops Overview

Long range view for Adaptation Workshops

Modules to be created by subject area, e.g.,

- *Forest Health*
- *Hydrology*
- *Habitat*
- …
- Possible multi day field based workshop

Other modules to follow based on information availability and need – your feedback is welcome

19

Managing for Resilience

ADAPTING TO CLIMATE CHANGE

PRINCIPLES OF CLIMATE CHANGE ADAPTATION

20

Module 1 Managing for Resilience

Principles of Climate Change and Adaptatio

ADAPTING TO CLIMATE CHANGE

CLIMATE TRENDS

– what can we expect globally, regionally, locally?

21

Principles of Climate Change and Adaptation
Climate Trends

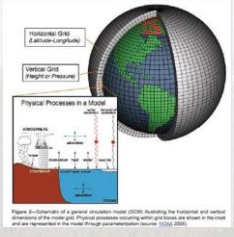
Personal observations

Turn to your Neighbour Discussion

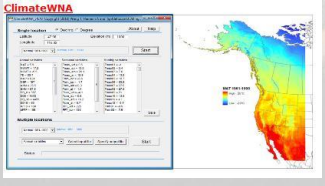
- Discuss what local or regional impacts (differences) you have observed that could be attributed to climate change.
- Debrief as a group

22

Principles of Climate Change Adaptation
Climate Trends
Global Circulation Models and Downscaling



Mathematical representation of global climate system (the physics) – takes global climate and is downscaled for interpretation – e.g. Climate WNA



23

Principles of Climate Change Adaptation
Climate Trends

Natural Variation

Climate the bigger picture

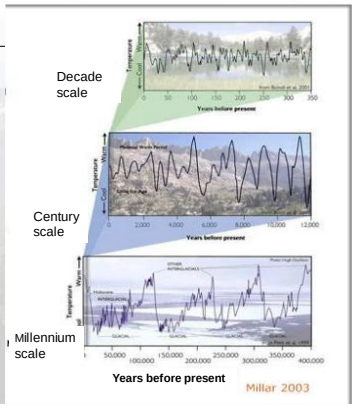
Earth's natural climate system varies over time

Climate changes over time with different patterns and modes.

Modes are nested in annual, decadal, century and millennial scales

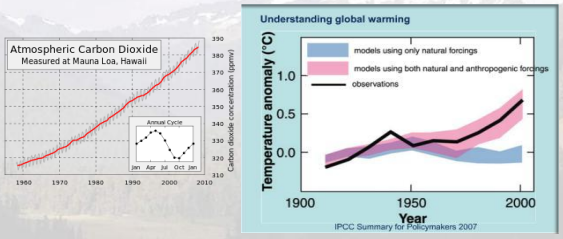
Note: Different mechanisms drive different modes

Source: Millar 2003



Principles of Climate Change Adaptation
Climate Trends

Global observations - IPCC



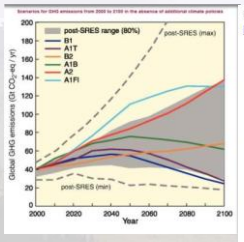
Sources: IPCC http://www.ipcc.ch/publications_and_data/ar4/syr/en/figure-3-1.html http://www.ipcc.ch/publications_and_data/ar4/syr/en/figure-1-1.html

25

Principles of Climate Change Adaptation
Climate Trends

Scenarios – IPCC

Note in 2013 moving to Representative Concentration Pathways



Note: SRES is the Special Report on Emission Scenarios.
http://en.wikipedia.org/wiki/Special_Report_on_Emissions_Scenarios

The four *SRES* scenario families[1][2][3] of the *Fourth Assessment Report* vs. projected global average surface warming until 2100

AR4 (Summary; PDF)	More economic focus	More environmental focus
Globalisation (homogeneous world)	**A1** rapid economic growth (groups: A1T; A1B; A1FI) **1.4 - 6.4 °C**	**B1** global environmental sustainability **1.1 - 2.9 °C**
Regionalisation (heterogeneous world)	**A2** regionally oriented economic development **2.0 - 5.4 °C**	**B2** local environmental sustainability **1.4 - 3.8 °C**

Sources: IPCC http://www.ipcc.ch/publications_and_data/ar4/syr/en/figure-3-1.html http://www.ipcc.ch/publications_and_data/ar4/syr/en/figure-1-1.html

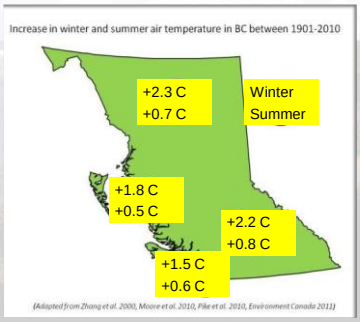
26

Principles of Climate Change Adaptation
Climate Trends

What has been observed in BC

Change in Average Temperature
1901 - 2010

- North and interior warming faster
- Winter warming faster
- Spring coming earlier
- Summer warmer but not as much change as winter



27

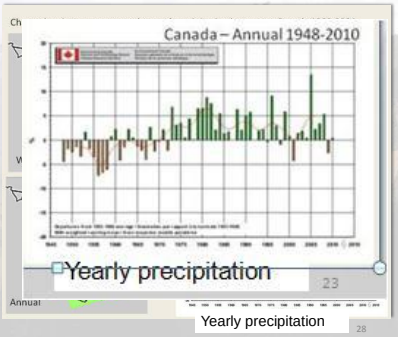
Principles of Climate Change Adaptation
Climate Trends

What has been observed in BC

Change in Average Precipitation 1900-2004

- Overall, BC has been getting wetter.
- Note the prairies are getting drier.
- Canada is overall getting wetter

(Moore et al 2010)



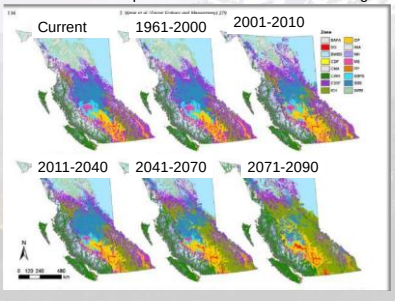
Yearly precipitation

28

Principles of Climate Change Adaptation
Climate Trends

Shifts of climate envelopes

Note: This is one representation at the zonal level using BC analogues



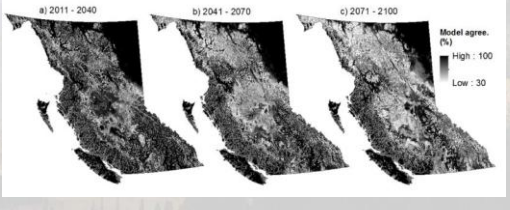
Source: Tongli Wang et al 2012

29

Principles of Climate Change Adaptation
Climate Trends

Shifts of climate envelopes

Model agreement (black) diminishes over time – (e.g., Future is more uncertain).



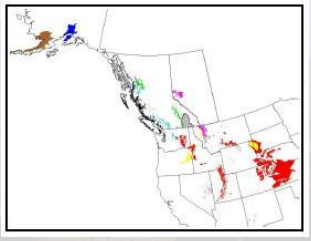
Source: Tongli Wang et al 2012

30

Principles of Climate Change Adaptation
Climate Trends

Shifts of climate envelopes

West Kootenay 2080 output - possible climate from outside BC

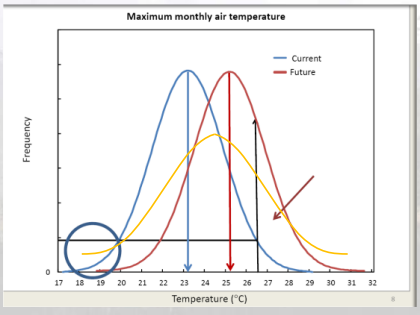


Source: http://www.kootenayresilience.org/Report5_BioclimateShift_Final.pdf

31

Principles of Climate Change Adaptation
Climate Trends

Regional plausible futures



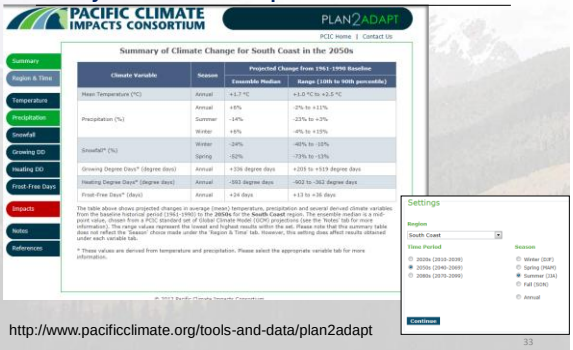
E.g., Shift of the mean and extremes

(Spittlehouse 2012)

32

Principles of Climate Change Adaptation
Climate Trends

Activity: Use of Plan2Adapt



http://www.pacificclimate.org/tools-and-data/plan2adapt

33

Principles of Climate Change Adaptation
Climate Trends

Output from Plan2Adapt – list of impacts

Shorter access season where winter access requires frozen road
- Winter logging season will likely decrease
- More logs may need to be stockpiled for break-up

Opportunities for facilitated migration of tree species
- Increased growing season and changing frost dates
- Southerly species may be more suitable

Warmer and shorter cold season
- Increased growing season for some commodities
- Heating costs in cold season may decline

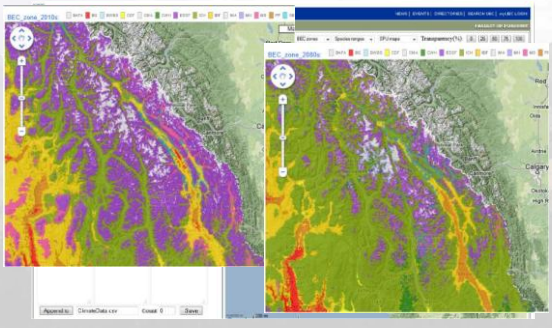
Earlier spring lake ice melt.
- Lake productivity may decline
- Inland fisheries, sport fisheries and related tourism affected
- Salmon smolt migration timing may be affected

Opportunity to for participant input and discussion

34

Principles of Climate Change Adaptation
Climate Trends

Tutorial – Climate BC map



Source: Tongli Wang et al 2012 http://www.genetics.forestry.ubc.ca/cfcg/ClimateBC40/Default.aspx

35

Principles of Climate Change Adaptation
Climate Trends

Regional plausible futures

See also PCIC summaries – tmurdock@uvic.ca

Virtually Certain
- **Temperatures will increase.**
- **Growing seasons will get longer.**
- **Nature and timing of precipitation will change.**
- **Pests and diseases will increase or become more severe.**

Very Likely
- **Frequency and size of natural disturbances will change across the landscape.**

Likely
- **Drier soils later in the growing season.**

From: Generalities in USDA GTR NRS-87 2012 p2

36

Principles of Climate Change Adaptation
Climate Trends

Why does climate change matter? (Nagel et al 2012)

20-45 days shorter

Arrives 29 days earlier

Arrives 9 days earlier

Has leaves 11 more days

Principles of Climate Change Adaptation
Climate Trends

Why does climate change matter? (Nagel et al 2012)

Stress

Disturbance

More Stress

More disturbance

Module 1 Managing for Resilience

Principles of Climate Change

Climate change terminology

- Vulnerability, risk and resilience – at relevant scales

Principles of Climate Change Adaptation
Climate Change Terminology

Vulnerability Definition (IPCC 2001)

The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change.

- *including climate variability and extremes.*

NOTE: Vulnerability relates to VALUES

Vulnerability V = ƒ (E, S, A)

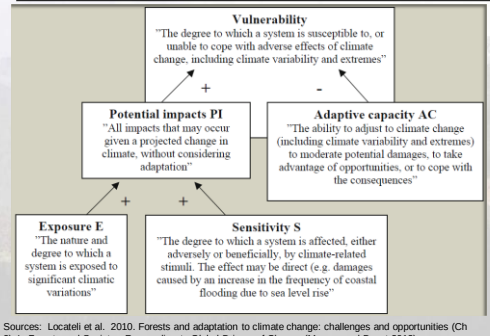
- Exposure (E), (i.e., the magnitude of climate change)
- Sensitivity (S), (sensitivity to change)
- Adaptive capacity (A) (ability to adapt the system to the change)

Sources: From Morgan - Turner et al. 2003, Smit and Pilifosova 2003, Ford and Smit 2004, IPCC 2007

40

Principles of Climate Change Adaptation
Climate Change Terminology

Vulnerability – balancing E & S with A

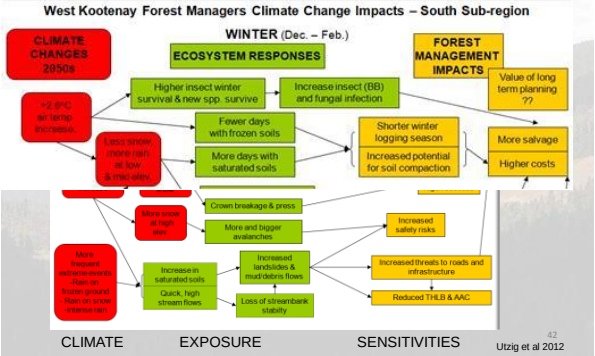


Sources: Locateli et al. 2010. Forests and adaptation to climate change: challenges and opportunities (Ch 2). In Forests and Society—Responding to Global Drivers of Change (Morgan and Daust 2012)

41

Principles of Climate Change Adaptation
Climate Change Terminology

Assessing Vulnerability - showing linkages



42

Utzig et al 2012

Principles of Climate Change Adaptation
Climate Change Terminology

Assessing Vulnerability - EXERCISE

Vulnerability V = f (E, S, A)

TURN TO YOUR NEIGHBOUR (TIME = 15 minutes)

1. Provide one tree species that will become vulnerable in your area?
   - Where and why?

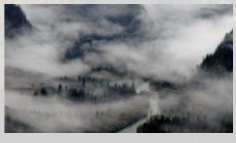
2. What is a vulnerable ecosystem?
   - Provide one

43

Principles of Climate Change Adaptation
Climate Change Terminology

Adaptation and Mitigation

- **ADAPTATION – WHAT WE CAN DO…**
  - Actions to moderate the vulnerability of forests and ecosystems
  - Manage forests to become more healthy, resistant, & resilient
  - Facilitate ecosystem responses to climate change when appropriate
- **MITIGATION AS IT RELATED TO FOREST MANAGEMENT**
  - Use of forests to sequester carbon, provide renewable energy from biomass, & avoid carbon emissions from fossil fuels, fire, mortality, and conversion in a thoughtful manner



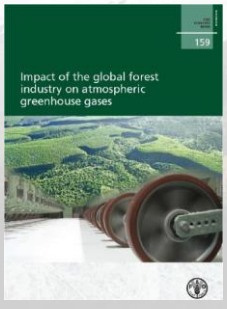
44

Principles of Climate Change Adaptation
Climate Change Terminology

Adaptation and Mitigation

The role of forest management:

"In the long term, a sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks, while producing an annual sustained yield of timber, fibre or energy from the forest, will generate the largest sustained mitigation benefit."



http://www.fao.org/docrep/012/i1580e/i1580e00.pdf

45

Principles of Climate Change Adaptation
Climate Change Terminology

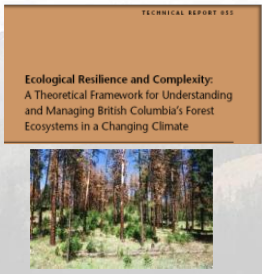
Ecological Resilience – Thoughts from BC Ecologists:

The Long-term goal of managing for ecological resilience is:

Use forest management practices that minimize the risk of:

- *the risk of rapid, unexpected ecosystem changes*
- *that could in turn generate negative socio-economic pressures*".

E.g., MPB – impact on timber, visuals, water, wildlife habitat, carbon sequestration...



From: Campbell, E.M., S.C. Saunders, K.D. Coates, D.V. Meidinger, A. MacKinnon, G.A. O'Neill, D.J. MacKillop, S.C. DeLong, and D.G. Morgan. 2009. Ecological resilience and complexity: a theoretical framework for understanding and managing British Columbia's forest ecosystems in a changing climate. B.C. Min. For. Range, For. Sci. Prog., Victoria, B.C Tech. Rep. 055. www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr055.htm

46

Principles of Climate Change Adaptation
Climate Change Terminology

Resilience – it is about values

"***Resilience is*** *- the long-term capacity of a system to deal with change and continue to develop."*

For a forest ecosystem...it is the capacity to deal with:

- *storms, fires and pollution,*

For a society ... it is the capacity to deal with:

- *political uncertainty or natural disasters.*
- *in a way that is sustainable in the long-term.*

From http://www.stockholmresilience.org/21/research/what-is-resilience.html

47

Principles of Climate Change Adaptation
Approaches to Adaptation

Limits to Resilience

From: Forest Resilience, Biodiversity, and Climate Change A Synthesis of the Biodiversity/Resilience/Stability Relationship in Forest Ecosystems 2009

48

Principles of Climate Change Adaptation
Climate Change Terminology

Resilience - Discussion

Characteristics of Resilient Ecosystems – What do these terms mean to you?

1. Complex
2. Diverse
3. Rich biological legacies
4. Seed & pollen dispersal
5. Vigorous vegetation with ample growing space
6. Multiple representation of values
7. Connectivity
8. Reduced exposure and sensitivity to large scale disturbance!

E. Campbell et al (2009) (as summarized by Don Morgan, MFLNRO)

49

50

Principles of Climate Change Adaptation
Approaches to Adaptation

The 5 R's - Adaptation Approaches

Resistance
Resilience
Response
Realignment
Reduce

Management Opportunities

Millar et al 2007, 2008 as used by Nagel et al 2012

51

Principles of Climate Change Adaptation
Approaches to Adaptation

The 5 R's - Adaptation Approaches

Resistance
Resilience
Response
Realignment
Reduce

RESISTANCE – improve the defenses of the forest against effects of change

- Short-term
- High-value

Isolate, protect, and prepare resources for direct & indirect effects of climate:
Mgmt Examples:
Thinning; Mixed Spp plantations; Fire Breaks; Manage age classes at the landscape

Millar et al 2007, 2008 as used by Nagel et al 2012

52

Principles of Climate Change Adaptation
Approaches to Adaptation

The 5 R's - Adaptation Approaches

Resistance
Resilience
Response
Realignment
Reduce

RESILIENCE – accommodate gradual change, usually returning to a prior condition after disturbance

Reduce and minimize stress within habitats

Mgmt Examples

-Thin Stands
-Increase Buffers
-Stock Seed Banks
-Intensive Reforestation

Use redundancy, spread risks

Millar et al 2007, 2008 as used by Nagel et al 2012

53

Principles of Climate Change Adaptation
Approaches to Adaptation

The 5 R's - Adaptation Approaches

Resistance
Resilience
Response
Realignment
Reduce

RESPONSE – intentionally accommodate change, enabling ecosystems to adaptively respond

- Assist transitions and range shifts
- Increase connectivity for migration corridors

Respond – e.g., assisted migration, Promote Porous Landscapes-Larger mgmt units -Lower fragmentation-Higher mgmt decision flexibility -Continuous riparian zones

Millar et al 2007, 2008 as used by Nagel et al 2012

54

Principles of Climate Change Adaptation
Approaches to Adaptation

The 5 R's - Adaptation Approaches

Resistance
Resilience
Response
Realignment
Reduce

- **REALIGNMENT** – move heavily disturbed systems into alignment with current and future conditions rather than restoring to a historical baseline.

- Create more resilient conditions
- Look forward not just back.

Millar et al 2007, 2008 as used by Nagel et al 2012

55

Principles of Climate Change Adaptation
Approaches to Adaptation

The 5 R's - Adaptation Approaches

Resistance
Resilience
Response
Realignment
Reduce

- **REDUCE – mitigation** of greenhouse gases through carbon sequestration and renewable energy use.

Millar et al 2007, 2008 as used by Nagel et al 2012

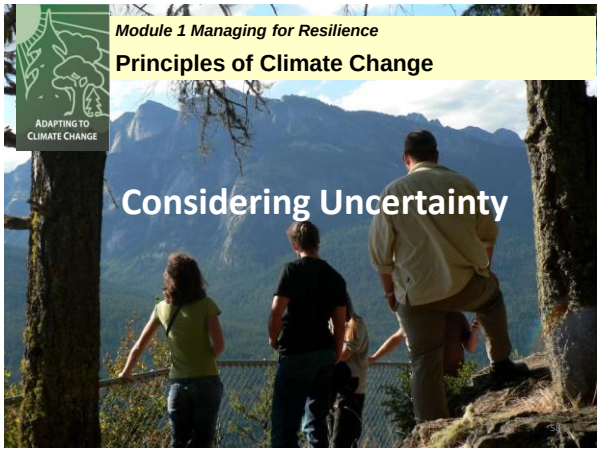
56

Principles of Climate Change Adaptation
Approaches to Adaptation

The 6th step – not an R

From Connie Millar Presentation: Climate Change at Multiple Scales Rethinking Management Paradigms to Address Uncertainty

57



Principles of Climate Change Adaptation
Considering Uncertainty

Risk and Uncertainty

- ***Risk*** *is the likelihood that an undesirable outcome will occur, considering the consequences associated with that outcome.*
- *E.g., Higher consequence = higher risk with the same likelihood.*
- ***Uncertainty*** *describes the* ***quality of our knowledge*** *concerning risk.*
- *Uncertainty is not the same as unknown, for example, we know the climate in the future will be different – we just are not certain what that will look like.*

http://www.ukcip.org.uk/wordpress/wp-content/PDFs/Risk.pdf
Climate adaptation: Risk, uncertainty and decision-making UKCIP Technical Report May 2003

59

Principles of Climate Change Adaptation
Considering Uncertainty

Risk, Resilience and Uncertainty

- *Some sources of uncertainty are quantifiable,*
  - *particularly as climate observation networks improve.*
- *Others are not – consider the cumulative global GHG emissions from human activity in 2050 or 2100.*
- ***Nonetheless, uncertainty is not the same as incorrect information, nor does it mean we know too little to act".***

http://www.digitalengagement.info/2012/03/09/my2050-carbon-emissions-reduction-simulator/

http://www.ukcip.org.uk/wordpress/wp-content/PDFs/Risk.pdf
Climate adaptation: Risk, uncertainty and decision-making UKCIP Technical Report May 2003

60

Principles of Climate Change Adaptation
Considering Uncertainty

Decisions made in the face of uncertainty

- *"Decisions are routinely made in the context of military operations, monetary policy or financial investments—to name a few examples—where levels of uncertainty often exceed those of climate projections"* (Mabey and others 2011).

http://www.quantrisk.com/optimization.php

http://www.ukcip.org.uk/wordpress/wp-content/PDFs/Risk.pdf
Climate adaptation: Risk, uncertainty and decision-making UKCIP Technical Report May 2003

61

Principles of Climate Change Adaptation
Considering Uncertainty

Risk in the context of likelihood and consequences

Adding in Likelihood and Consequence – What is the Risk?

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Severe
Almost certain	M	H	H	E	E
Likely	M	M	H	H	E
Possible	L	M	M	H	E
Unlikely	L	M	M	M	H
Rare	L	L	M	M	H

http://andrewmedia.dyndns.org/Dartnell/images/risk_matrix.gif

62

What can be done now?
Exercise

GROUP EXERCISE – Tree Species Options

To explore species options for a changing climate on some high risk local sites – incorporation into FSPs

Local situation where species changes are warranted – provided or agreed upon by participants.

How do you determine where there may be a desire for different species – either due to risk or opportunity? What information is available?

Describe who you think should be involved in the process for making the case for the changes?

What information would you suggest you would use to help make the decision? – e.g., what tools and or information sources?

Exercise to take 30 minutes for discussion and group summaries an additional 30 minutes to debrief

63

Module 1 Managing for Resilience

ADAPTING TO CLIMATE CHANGE

RESILIENT FORESTS IN A CHANGING LANDSCAPE
Guidance from Vulnerability Assessments

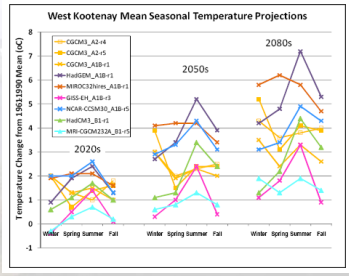
64

Principles of Climate Change Adaptation
Guidance from Vulnerability Assessments

The W. Kootenay FFESC Project

Looked at multiple scenarios, while all different - trends are observable.

Utzig et al. 2012
www.kootenayresilience.org



65

Principles of Climate Change Adaptation
Guidance from Vulnerability Assessments

Where to start?

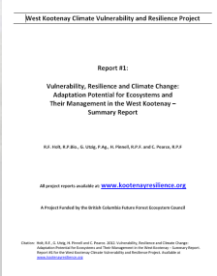
- *What constitutes Low vs High Risk from Climate Change?*
- *Where to start? – Local Vulnerability Assessments*

Kootenay's FFESC project
Even with uncertainty direction can be provided: e.g.,

Climate Sensitive Silviculture Prescriptions:

"In the West Kootenay's, initially these should focus on the highly vulnerable valley-bottom/ mid-elevation landscapes where forests could be significantly altered in the near term."

Utzig et al. 2012
www.kootenayresilience.org


West Kootenay Climate Vulnerability and Resilience Project

Report #1:

Vulnerability, Resilience and Climate Change:
Adaptation Potential for Ecosystems and
Their Management in the West Kootenay –
Summary Report

Principles of Climate Change Adaptation
Guidance from Vulnerability Assessments

Where to start?

- *Local Vulnerability Assessments - Example output:*

Kamloops FFESC Project

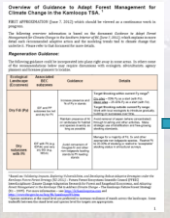
Eco. Sensitivity #2	Natural disturbance as a "stand-replacing impact" on the landbase over the next 100 years could double relative to the previous century.
Mgmt. Risks	This represents a significant threat to property and safety in the urban interface, recreational areas and agricultural lands. As well, by 2100, age class distributions are projected to become highly skewed to younger ages - with most stands younger than 60 years of age. Associated threats: • Significant reduction in timber harvesting flows in the twenty-second century. • Threats to species that rely on old growth habitat with a dramatic decline in all old growth patches (30-50%) and an 80% reduction in large (> 1000 ha) patches.

Kamloops FFESC project
Nelson et al 2012 http://www.for.gov.bc.ca/hfp/future_forests/council/
Zielke et al 2009 http://www.for.gov.bc.ca/hcp/ffs/kamloopsFFS.htm

67

Principles of Climate Change Adaptation
Guidance from Vulnerability Assessments

Where to start?



Ecological Landscape (Ecozones)	Associated BEC subzones	Guidance	Details
Dry Fdi (Py)	IDF and PP subzones too hot and dry for Pli	Increase presence and % of Py in stands	**Target Stocking within current Py range[2]:** *Dry sites* – 50% Py as a start (with Fd). *Mesic sites* – 25-30% Py as a start (with Fd). **Target Stocking outside current Py range:** Work with local ecologists to introduce gradually, building on successes over time.
		Maintain presence of Ai on landscape for habitat and species diversity as long as possible	Avoid removal of aspen (where concentrated) through brushing and other activities. Make strategic use of stratification and free-growing stocking standards.
Dry subzones with Pli	IDF with Pli (e.g. IDFdk) and very dry MS (e.g. MSxk)	Avoid conversion of Douglas-fir and other non-lodgepole leading stands to Pli leading stands	Manage for a majority of Fd, Sx and other appropriate non-lodgepole species. Restrict Pli to 20-30% of stocking or restrict to "acceptable" stocking status in silvicultural surveys.

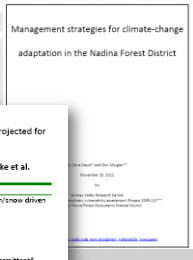
Kamloops FFESC project
http://www.for.gov.bc.ca/ftp/HFP/external/!publish/Web/FFESC/reports/NelsonrevisedK2adaptationguidanceoverview120607.pdf

68

Principles of Climate Change Adaptation
Guidance from Vulnerability Assessments

Where to start?

Nadina FFESC project



Management strategies for climate-change adaptation in the Nadina Forest District

Effects on hydrology in the Nadina

In general, the Nadina follows the climatic trends and related hydrological impacts projected for BC (Table 5).

Table 5. Projected changes in winter weather, storm impacts and streamflow in BC (from Pike et al. 2008a, b).

Winter	Summer	Storms and their impacts	Streamflow
Temp ↑	Temp ↑	Frequency & magnitude ↑	Snowmelt → hybrid rain/snow driven
Precipitation ↑	Precipitation ↓ ↑	Landslides ↑	Rain on snow events ↑
Rainfall ↑	Evaporative demand ↑	Avalanche ↑	Earlier freshet
Snowfall ↓	Plant transpiration ↑	Erosion ↑	Peak flow ↑ ↓
Snowpack ↓	Moisture deficits ↑	Sedimentation ↑	Summer low flow ↓
Snowline up & north	Stream/lake temp ↑	Big log jams ↑	Low flow period ↑
Extreme weather ↑	Risk to salmon ↑	Channel stability ↓	Perennial stream → intermittent*
		Log supply (long term) ↓	

*where snowmelt not stored in ground water

http://bvcentre.ca/research/project/a_multi-scale_trans-disciplinary_vulnerability_assessment/

69

Principles of Climate Change Adaptation
Guidance from Vulnerability Assessments

Nadina FFESC project – Example Adaptation Strategies

Trees and Timber
Increased tree growth potential on sites with sufficient moisture
• Plant climatically-suited species and genetic stock
• Fertilize appropriate sites
• Partially-cut stands on dry sites
Increased tree disease virulence (mainly younger stands)
• Plant climatically-suited species and genetic stock
• Increase stand-scale species diversity
• Remove stumps with root disease
Increased bark beetle virulence (mainly older stands)
• Plant climatically-suited species and genetic stock
• Increase stand-scale species diversity
• Shorten rotations of susceptible stands
• Monitor and control beetle populations

http://bvcentre.ca/files/research_reports/ManagementStrategies-ClimateChangeNadina-Nov15.pdf

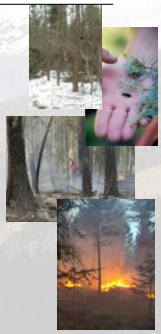
For all reports: http://bvcentre.ca/research/project/a_multi-scale_trans-disciplinary_vulnerability_assessment/

70

Resilient Forests in a Changing Landscape
Resilience through scenario-based risk management

STEPS

1. Anticipate the effects of climate change.
2. Explore approaches to promote more resilient forests with the anticipated effects.
3. Choose the preferred options to manage risk.
4. Empower their use.
5. Monitor and adapt accordingly



72

Resilient Forests in a Changing Landscape
Resilience through scenario-based risk management

1. Anticipating Effects of Climate Change

A REAL LIFE EXAMPLE of PROMOTING RESILIENCE by ADDRESSING RISK

Alex Fraser Research Forest - observations

Weather seems unpredictable

- Drought (2010)
- Record snowpack (2011)
- Winter rainfall (2003)
- Warmer winter minimum temperatures
- Hotter summer maximum temperatures
- More humidity
- Return periods for extremes appear closer and more varied

73

Resilient Forests in a Changing Landscape
Resilience through scenario-based risk management

2. Explore Approaches – Scenarios and Risk Assessment

What path to follow?

No adaptation: future climate change impacts are not planned for and are not acknowledged as likely to occur.

Reactive adaptation: climate change impacts are not planned for and adaptation takes place after the impacts of climate change have been observed.

Anticipatory adaptation: Responsive: future climate change impacts are acknowledged as likely to occur and responses to those changes are planned for when changes are observed.

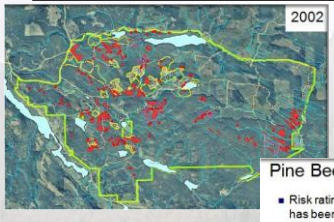
Proactive: climate change impacts are acknowledged as likely to occur and adaptation responses are planned for before the changes are observed.

Adapted from : Preliminary Review of Adaptation Options for Climate-Sensitive Ecosystems and Resources 2008 http://www.climatescience.gov/Library/sap/sap4-4/final-report/sap4-4-final-report-all.pdf

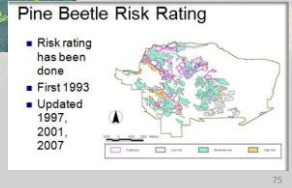
74

Resilient Forests in a Changing Landscape
Resilience through scenario-based risk management

2. Explore Approaches – Scenarios and Risk Assessment



UBC EXAMPLE
E.g., use of MPB sim



75

Resilient Forests in a Changing Landscape
Resilience through scenario-based risk management

3. Manage Risk with Preferred Options – UBC example

Example: Set Sensible Harvest Priorities

a) Consider the risk of loss stand by stand

- Establish a harvest queue
- Harvest most likely to be lost first
- Revisit the priorities periodically

b) Management Plan #3 (2007)

Harvest Priority

1. Imminent loss
2. Dead and dying
3. Regeneration cuts in partial-cut systems
4. At risk of infestation
5. Declining vigour
6. Affected by disease
7. Healthy vigorous timber

76

Resilient Forests in a Changing Landscape
Resilience through scenario-based risk management

4. Empower the Use of Preferred Options

KEY LESSON - Mountain pine beetle has confirmed: many of the lessons of the old textbooks remain sound

Empowering Preferred Management Options:

- Manage for vigorous stands
- Cut stands with greatest risk of loss
- Be aggressive when markets are favorable
- Be careful with investments
- Incorporate risk in operational decision-making – use climate change adaptation tools.

Remain vigilant, MONITOR, watch for new risks, ensure plans are forward looking!

77

Resilient Forests in a Changing Landscape
Resilience through scenario-based risk management

5. Monitor to ID issues as they emerge

What is being done?

FH monitoring initiatives include:

100% survey of FG blocks,

Stand Development Monitoring, Provincial aerial overview survey

Provincial FH report, annually updated TSA Forest Health strategies.

Remember Your best source of info is your Regional Forest Health specialist!

These data sources should show what the current status of FH in your area.
What other sources of information are there? - E.g., Link to RESULTS output

78

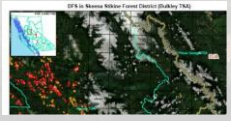
Resilient Forests in a Changing Landscape
Resilience through scenario-based risk management

5. Monitor to ID issues as they emerge

In your area will this situation worsen with CC, remain the same or decrease?

How will you know?

What could we do better?



E.g., DFS
Dothistroma Needle Blight (*Dothistroma septosporum*)

79

Resilient Forests in a Changing Landscape
Resilience through scenario-based risk management

Dealing with Risk and Uncertainty

Be an adaptive thinker...

- Instead of fighting change work with it.
- Accept uncertainty, and use the best available information - revise as we learn more.
- The past is not the future – new ways of thinking may be needed.
- Focus on how forests grow and change instead of what they look like.
- Recognize we live with risk, and need to manage our behaviour and risk tolerance.

[1]Adapted from Natural Inquirer, Climate Change Edition Number 14
http://www.naturalinquier.org

80

Resilient Forests in a Changing Landscape
Resilience through scenario-based risk management

Dealing with Uncertainty

Need a Planning Framework to...

- Monitor and collect more data to help clarify key uncertainties
- Collaborate with researchers
  - Explore uncertainties
  - Test assumptions
- Revisit mgmt options with the latest science and data.

<u>If this is in place</u> – you will not be paralysed by uncertainty

81

Resilient Forests in a Changing Landscape
Resilience through scenario-based risk management

What about climate effects on wildfire?

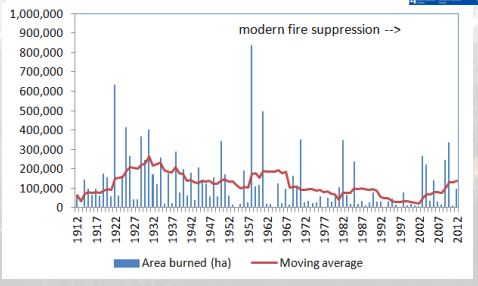
www.environmentdebate.wordpress.com

82

Resilient Forests in a Changing Landscape
Resilience through scenario-based risk management

Anticipating effects from climate change

Fire trends



BC Wildfire Management New Reality

83

Resilient Forests in a Changing Landscape
Resilience through scenario-based risk management

Anticipating effects from climate change

TRENDS

Area burned (wildfires) projected to DOUBLE

Spatial simulation – at 2060-2070

- 10 year area burned by stand replacing fires.

BC Wildfire Management Future Reality

84

Resilient Forests in a Changing Landscape
Resilience through scenario-based risk management

Managing Risk and Exploring Options

LOTS OF THOUGHT ON THIS ONE

The BC Wildland Fire Management Strategy 2010

Framework for achieving fire resilient landscapes.

Forest Sector Strategy for BC 2012

...Province will implement landscape fire management planning...

The BC Forest Stewardship Action Plan for Climate Change

...Manage risks and capture opportunities for fire resilience

- ***Need to bring this into some thoughtful operational strategic planning***

85

What can be done now?
Tools

Available tools

An opportunity to discover the range and utility of available tools

Note tools include, memos, summaries, and model outputs.

87

What can be done now?
Exercise

GROUP EXERCISE – Fire Risk Options

Explore Fire risk and management options with climate change – in some high risk local ecosystems

1. Materials to be provided.
   - BurnP3 maps for a pertinent area
   - Any other relevant map information – e.g., values
   - Climate change projections
   - List of potential treatment options
2. Form to summarize thoughts and suggestions.

Exercise to take 30 minutes for discussion and group summaries an additional 30 minutes to debrief

88

Module 1 Managing for Resilience

89

Lessons Learned

GROUP DISCUSSION – What are you going to do differently based on what you learned today?

Lessons Learned

What is on the horizon to help?

Some FLNRO Initiatives to help moving forward:

1. Action Plans for climate change adaptation (introduce the 'Forest Stewardship' Action Plan, and need for regional or district level action plans)
2. Keeping score on climate change adaptation (introduce the 'Resilient Forests' Scorecard)
3. Reporting out annual accomplishments for climate change adaptation (linkages to FS/Resilient Forests actions)

91

Module 1 Managing for Resilience

Climate Change Adaptation Workshops Overview

Long range view for Adaptation Workshops

Modules to be created by subject area, e.g.,

Forest Health

Hydrology

Habitat

…

Possible multi day field based workshop

Other modules to follow based on information availability and need – your feedback is welcome

92

Change is here
Think, Learn,
Act, Think again

93

Links to various tools available for practitioners

Adaptation Knowledge and Tools for Forest Stewardship

This site provides links to B.C.'s forest policy, tools and knowledge for adapting to climate change. Forest managers can use this information to adjust their plans and practices so that forests remain resilient in a changing and variable climate.

- The **Forest Policy** elements form part of B.C.'s forest management framework. They are under the auspices of the B.C. Ministry of Forests, Lands and Natural Resource Operations.
- **Tools** are ready to be used by forest managers for adapting to climate change.
- **Knowledge** provides more in-depth information on incorporating adaptation into forest management.
    - New! **Climate Change Adaptation Workshops Fostering Resilient Forests and Ecosystems** BC's climate is changing: What does this mean for BC forests, and what can we do about it? Workshops will be held in six locations in **February and March 2013**. For more information or to register, see: http://www.for.gov.bc.ca/ftp/HFP/external/!publish/ClimateChange/Workshops/
- Resilient Forests Newsletter No 2: November 2012. This issue focuses on tools for fostering resilient forests. These tools include, e.g. climate change projections, adaptation workshops, Type 4 Silviculture Strategies, and the tree species selection tool.
- Resilient Forests Newsletter No. 1: February 2012 B.C.'s Forest Stewardship Action Plan for Climate Change Adaptation

A companion document to Fostering Resilient Forests and Ecosystems – Climate Change Adaptation Workshops – winter 2013

The following links are meant to help integrate Climate Change into your day to day practice. They cover a range of topics, some provide computer adapted tools, and others provide guidance as text or examples. There is much to see, take your time, drill-in and enjoy.

The Climate Change Adaptation Team - February 2013

Contents

Links to various tools available for practitioners 1

Climate Change Policy link 3
Climate-Based Seed Transfer policy and guidance link 3
Knowledge link – a useful gateway http://www.for.gov.bc.ca/het/climate/knowledge/knowledge.htm 3
Species monitoring report 3
TSA Species summaries 3
Tree Species selection tool 4
Google map version of Climate BC 5
BioClimatic Envelope Modes - shows shifts the zone scale 5
Population response functions to climate change 5
Plan2Adapt 5
Potential Management Options for Adaptation, Link to pdf on FTP. 5
FFESC Output 6
Stand Level Risk and Decision Tool, Link is to a FTP site 6
Changing tree species in the West Kootenays 6
K2 information. 6
Bulkley Valley project link 7
Quantifying risks and opportunities from climate change interim results from the Merritt TSA 7
USFS links 8
Links to short presentations –worth checking out, an example link below to a presentation by Connie Millar on adaptation: 9

Forest Health links 12

Review of Literature on Climate Change and Forest Diseases of Western North America 13
Predicting Forest Insect Disturbance under Climate Change (Allan Carroll) 14
Climate change and forest diseases – Sturrock et al 2011 15
Yellow-cedar decline and climate change 15
Advances in threat assessment and their application to Forest and Rangeland Management 16
Forest Health and Climate Change: A British Columbia perspective. 16
Is the health of British Columbia's forest being influenced by climate change? If so, was this predictable? By Alex Woods, 2011 17
Forest health hazard ratings in BC: what is potentially an issue? 17
RESULTS data on incidence 18
Expected Effects of Climate Change on Forest Disturbance Regimes in British Columbia 18
Direction on fuel management in the Wildland Urban Interface 20
Useful link for managing habitat – Just add a climate change lens 20

Climate Change Policy link

http://www.for.gov.bc.ca/het/climate/knowledge/index.htm

Climate-Based Seed Transfer policy and guidance link

http://www.for.gov.bc.ca/hti/climate_based_seed_transfer/index.htm

http://www.for.gov.bc.ca/hti/climate_based_seed_transfer/2cbst_project.htm

- Ongoing project; see CBST project charter, 2012 to 2017

http://www.for.gov.bc.ca/hti/climate_based_seed_transfer/3cbst_project.htm

- Provides links to upward elevation transfer limit changes (Nov. 2008)
- Provides links to the recent range expansion for Lw (June, 2010)

For further information on statutory seed use requirements, see the Chief Forester's Standards for Seed Use at: http://www.for.gov.bc.ca/code/cfstandards/

Knowledge link – a useful gateway

http://www.for.gov.bc.ca/het/climate/knowledge/knowledge.htm

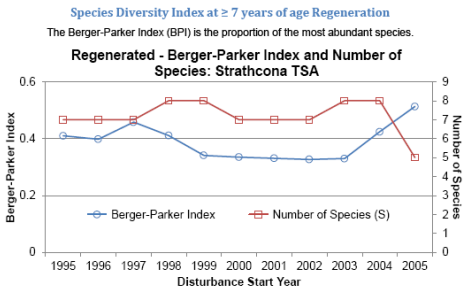
Species monitoring report

http://www.for.gov.bc.ca/hfp/sof/species/Spp%20Monitoring%20Report%20-%20Province%20(May%2010,%202012).pdf

TSA Species summaries

http://www.for.gov.bc.ca/hfp/sof/species%20monitoring%20reports.htm

- Provides local context.



The index addresses the proportion of species present not simply presence or absence as richness describes.

Understanding the Berger-Parker Dominance Index

d=Nmax/N

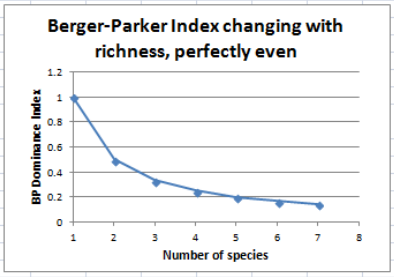
Nmax= Nmax is the volume in the most abundant species

N: Total volume of individuals

Note that the most abundant species is not constant

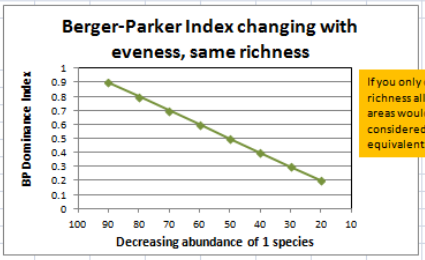
Perfectly even - all species have equal abundance

Number of species (richness)	Pine	Spruce	Fir	Hardwoo	Larch	True fir	Cedar	Total	B-P Index
1	1000							1,000	1
2	500	500						1,000	0.5
3	333	333	333					1,000	0.33333
4	250	250	250	250				1,000	0.25
5	200	200	200	200	200			1,000	0.2
6	167	167	167	167	167	167		1,000	0.16667
7	143	143	143	143	143	143	143	1,000	0.14286



Constant richness - 5 species in all cases

Decreasing abundance of primary species (increasing eveness)	Pine Abundance	Spruce	Fir	Larch	True fir	Total	B-P Index
90	900	25	25	25	25	1,000	0.9
80	800	50	50	50	50	1,000	0.8
70	700	75	75	75	75	1,000	0.7
60	600	100	100	100	100	1,000	0.6
50	500	125	125	125	125	1,000	0.5
40	400	150	150	150	150	1,000	0.4
30	300	175	175	175	175	1,000	0.3
20	200	200	200	200	200	1,000	0.2

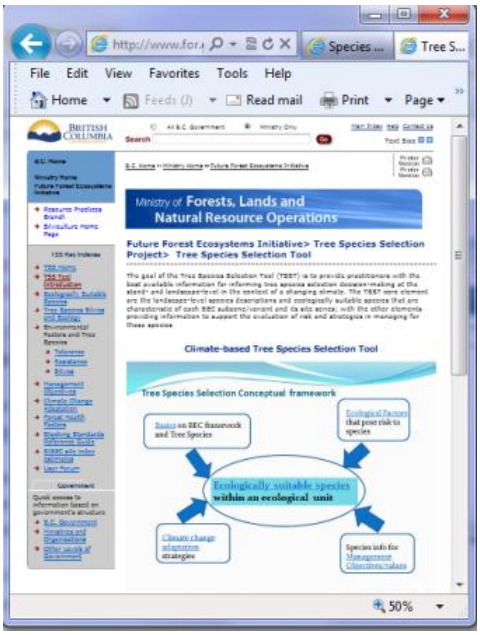


If you only considered richness all of these areas would be considered equivalent.

Tree Species selection tool

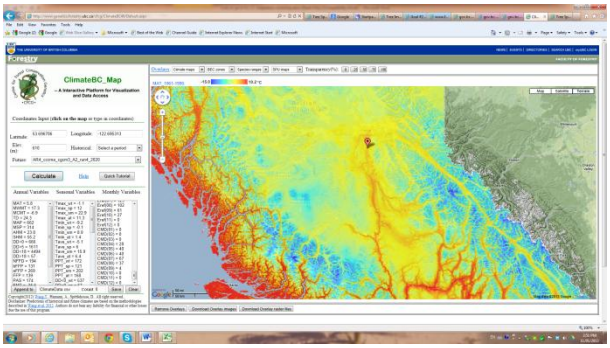
http://www.for.gov.bc.ca/hfp/silviculture/TSS/tss.htm

- This link provides a description of the Tree Species Selection Tool. Choose the green box and it takes you to the tool at right.



The following Link provides an example, using Lw on where information is found within the site to help make a decision on use.

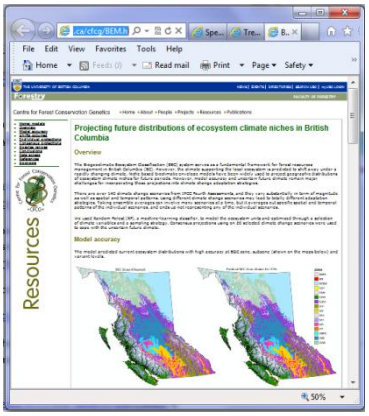
http://www.for.gov.bc.ca/hfp/silviculture/TSS/example1.pdf



Google map version of Climate BC

http://www.genetics.forestry.ubc.ca/cfcg/ClimateBC40/Default.aspx

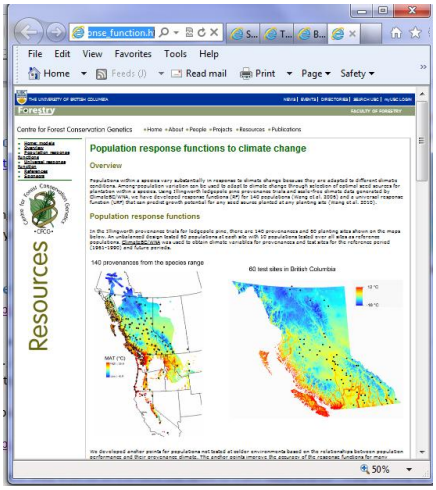
- Allows for easy exploration of scenarios.



BioClimatic Envelope Modes - shows shifts the zone scale

http://www.genetics.forestry.ubc.ca/cfcg/BEM.html

- Note: 20% shifted already from historic climate data. Consensus maps show greater consensus in 2020 diminishing with time as uncertainty increases. Presently this information has been summarized and is linked with species by BEC site series data for easy observation in shifts over time.



Population response functions to climate change

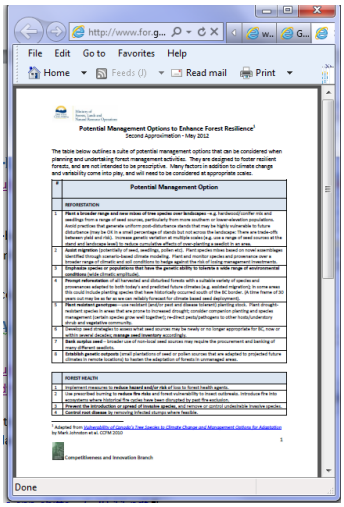
http://www.genetics.forestry.ubc.ca/cfcg/response_function.html

- Stress here the need to track seed source – may already be seed out there that has the propensity for maladaptation.

Plan2Adapt

http://pacificclimate.org/news/2012/pcic-updates-plan2adapt

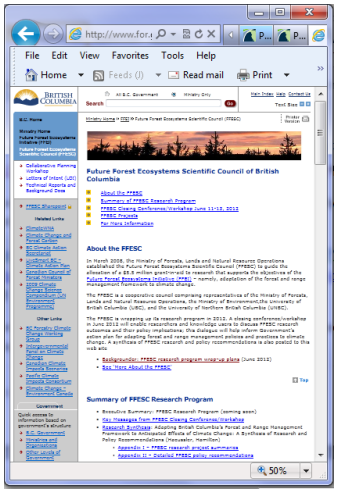
- This tool has been explored earlier.



Potential Management Options for Adaptation, Link to pdf on FTP.

http://www.for.gov.bc.ca/ftp/HFP/external/!publish/ClimateChange/Adaptation/Options/Management_Options_May9_2012.pdf

- This provides an overall list of general strategies. Where and how they are used will need local involvement, planning, implementation and monitoring. Worthwhile perusing the list.

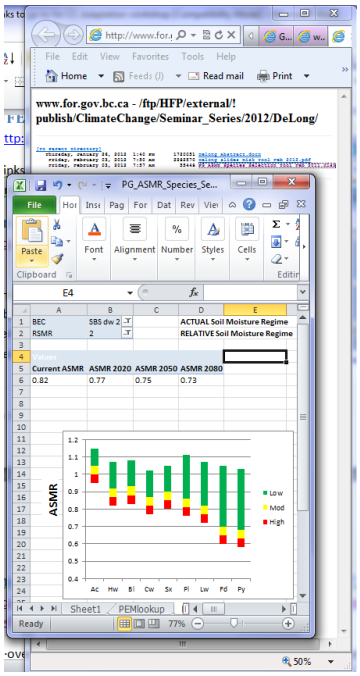


FFESC Output

http://www.for.gov.bc.ca/het/climate/knowledge/knowledge.htm

http://www.for.gov.bc.ca/hfp/future_forests/council/

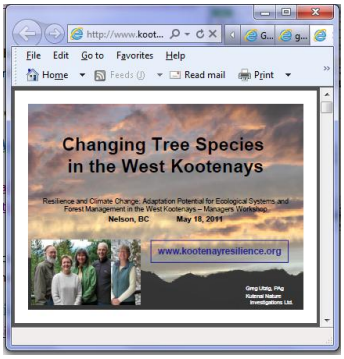
- Links to program description and research project websites and reports.
- Not presently on the Tools webpage – should be linked



Stand Level Risk and Decision Tool, Link is to a FTP site

http://www.for.gov.bc.ca/ftp/HFP/external/!publish/ClimateChange/Seminar_Series/2012/DeLong/

- We will go to the tool link and describe what is being provided. Note it is not presently available for the Coast. This information may be used in some area specific guidance.
- Need to obtain the newer version with wider scope.

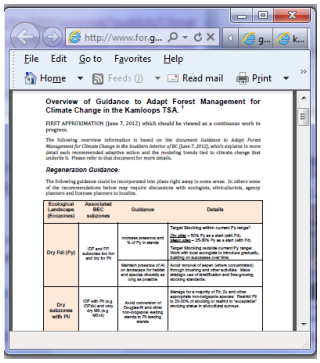


Changing tree species in the West Kootenays

http://www.kootenayresilience.org/WK-CC-Tree-spp-shifts__6-30-11.pdf

- Presentation that shows different plausible futures and possible impacts for species choice.

K2 information.



http://www.for.gov.bc.ca/ftp/HFP/external/!publish/Web/FFESC/reports/NelsonrevisedK2adaptationguidanceoverview120607.pdf

- This is the guidance overview

http://www.for.gov.bc.ca/ftp/HFP/external/!publish/Web/FFESC/reports/NelsonrevisedK2adaptationguidance120607.pdf

- A more detailed guidance piece with discussion of similarities and differences from K1.

Bulkley Valley project link

http://bvcentre.ca/research/project/a_multi-scale_trans-disciplinary_vulnerability_assessment/

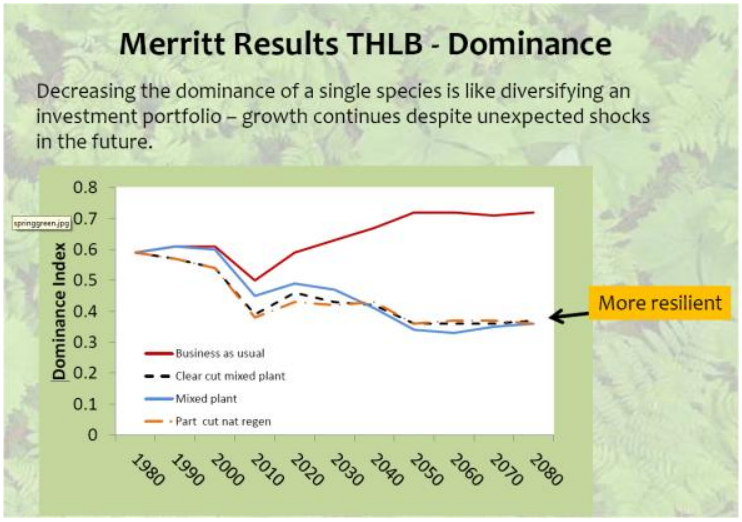
- Nadina Vulnerability Assessment.
- Lots to see here.

Quantifying risks and opportunities from climate change interim results from the Merritt TSA

- ftp://ftp.for.gov.bc.ca/HFP/external/!publish/ClimateChange/Seminar_Series/2012/Dymond/Dymond_slides_Socio-econ%20risk%20and%20opps-Merritt%20v3.pdf
- Not presently on the FLNRO site but can be found through FLNRO FTP site.

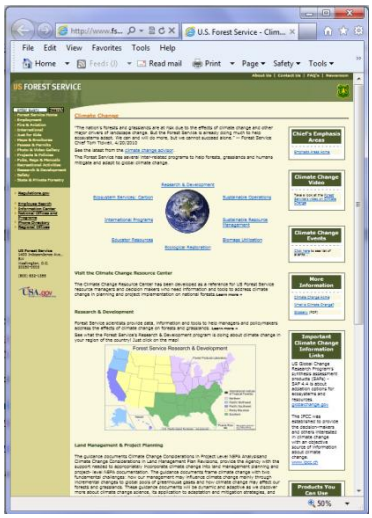
The socio economic portion is not yet complete but preliminary information shows that species mixes can provide for greater long term net revenue than business as usual.

Contact: Caren Dymond Caren.Dymond@gov.bc.ca



USFS links

The USFS has embraced climate change as reality and has created a range of resources that are useful for understanding the impacts, provide tools to screen projects for applicability and assess options. The following provide an entry point into their system.



http://www.fs.fed.us/climatechange/

http://www.fs.fed.us/climatechange/advisor/

http://www.fs.fed.us/ccrc/

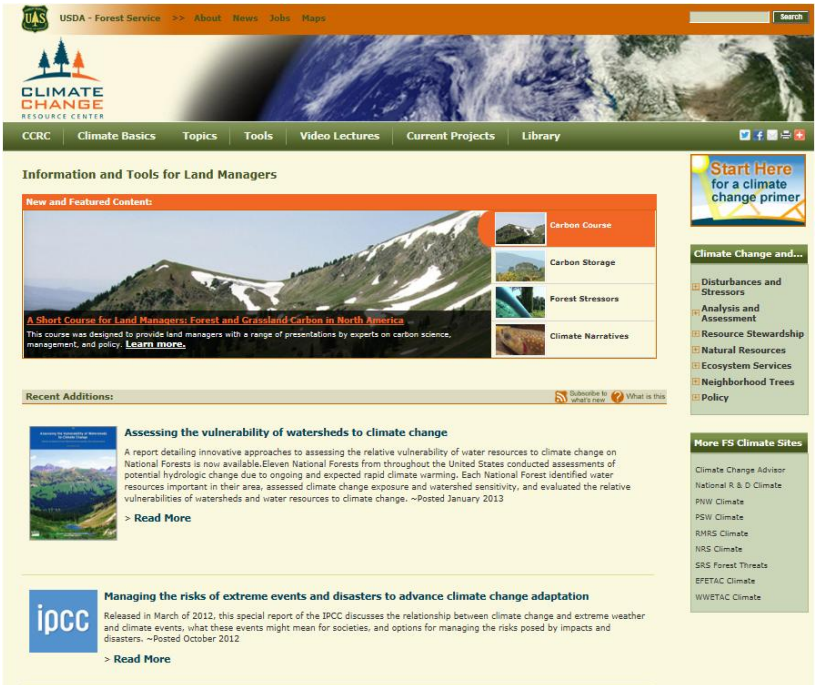
- This provides a portal to some of the work being done south of the border.

For a thorough overview of adaptation and mitigation see:

http://www.fs.fed.us/psw/publications/millar/MillarSwanson_inpress.pdf in

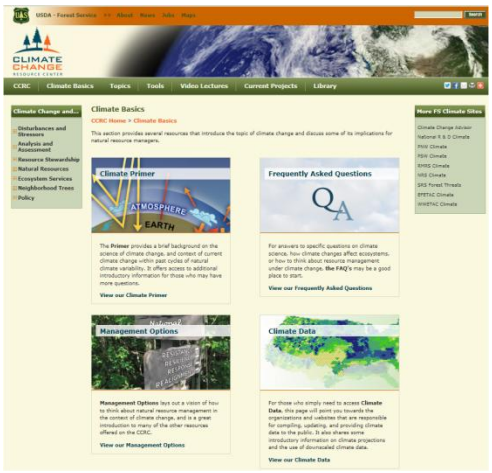
Millar, C.I. and C. Swanston. In press. Adaptation and Mitigation. Chapter 4 in National Climate Assessment. US Global Change Research Program.

http://www.fs.fed.us/ccrc/



Links to climate background information

http://www.fs.fed.us/ccrc/climate-basics/

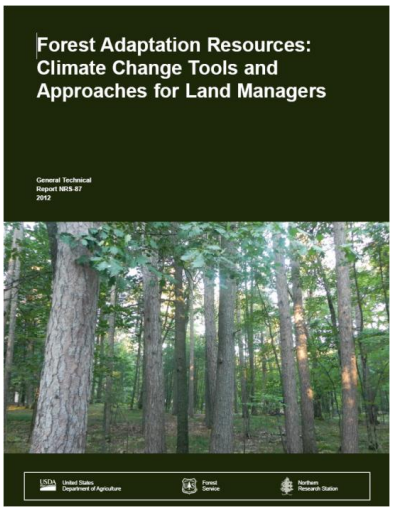


Useful site for understanding climate in an easy to follow approach.

Links to short presentations –worth checking out, an example link below to a presentation by Connie Millar on adaptation:

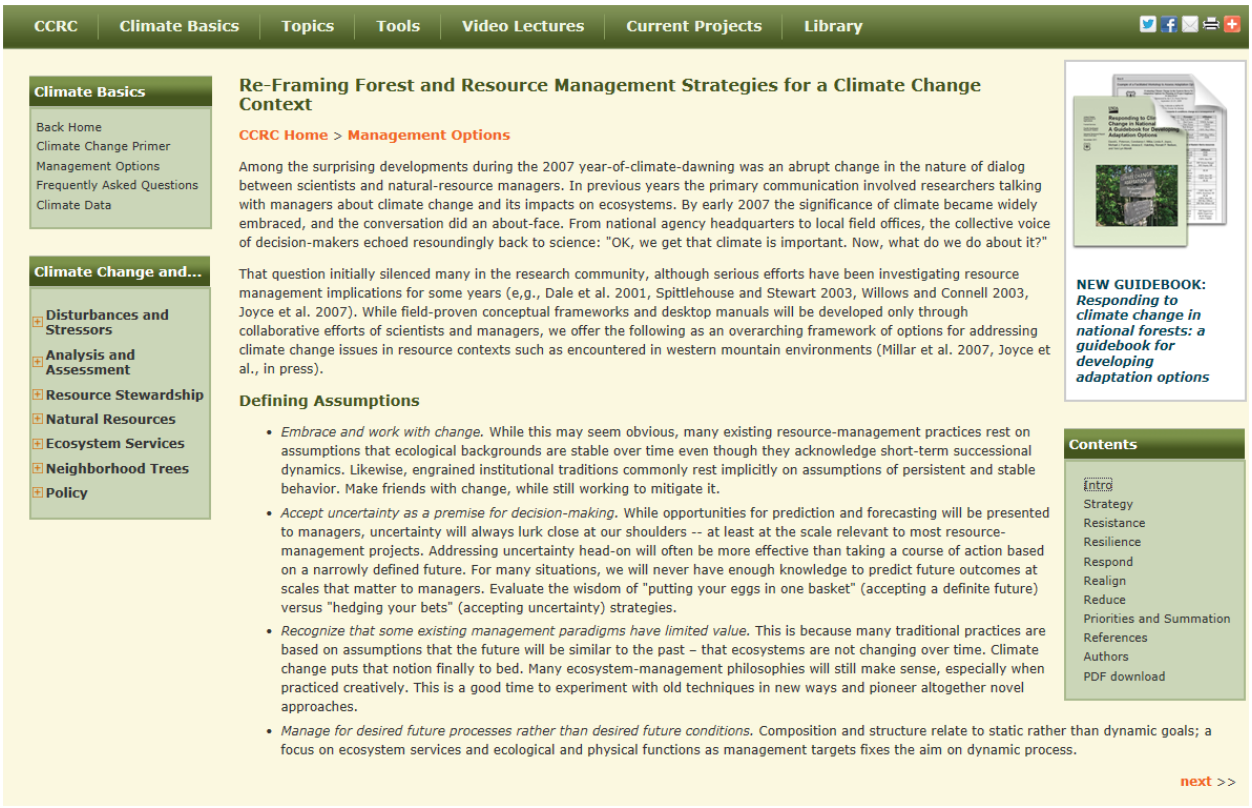
http://www.fs.fed.us/ccrc/hjar/management_strategies.html

Adaptation resources: http://www.nrs.fs.fed.us/pubs/gtr/gtr_nrs87.pdf



This publication provides a clearly laid out approach to address climate change, with examples. The appendix provides a series of worksheets that aid in identifying vulnerable conditions, options and steps to address the issue.

Link to climate change options: http://www.fs.fed.us/ccrc/mgmt_options/



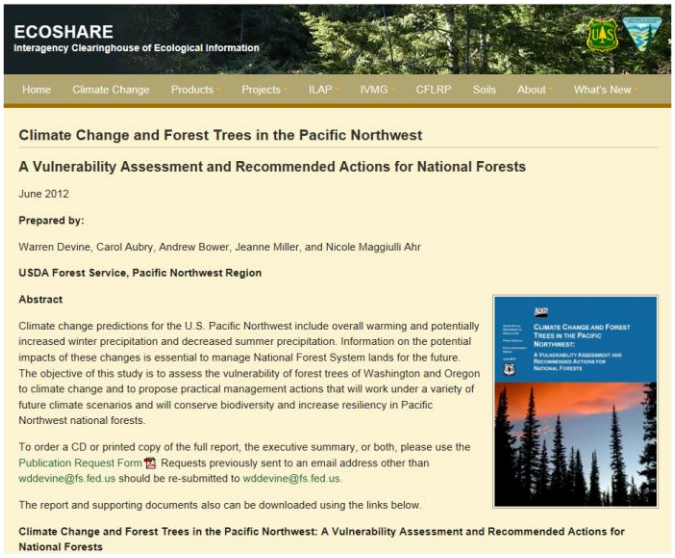
Note the tool bar along the top has links to many useful sites.

Taccimo (Template for Assessing Climate Change Impacts and Management Options) – science at your fingertips – web tool: http://www.sgcp.ncsu.edu:8090/

Taccimo is worth a look through, it is created to help USFS planners but has information useful to all planning with a Climate Change filter.

Climate change and forest trees in the Pacific Northwest: A vulnerability assessment and recommended actions for National Forests:

http://ecoshare.info/projects/ccft/

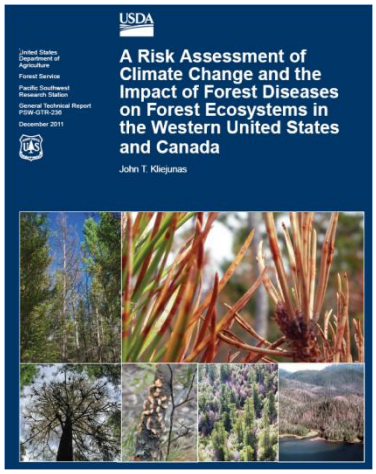


This document provides a list of vulnerabilities based on different characteristics. It clearly provides assumptions and is a useful reference to begin thinking about tree vulnerability.

Forest Health links

A Risk Assessment of Climate Change and the Impact of Forest Diseases on Forest Ecosystems in the Western United States and Canada

http://www.fs.fed.us/psw/publications/documents/psw_gtr236/psw_gtr236.pdf



Information is provided on Dothistroma, Swiss Needle Cast, Sudden Oak Death, Ramorum Blight, White Pine Blister Rust, Cytospora Canker of Alder, Dwarf Mistletoes, Armillaria Root Disease, Yellow Cedar Decline.

Armillaria example (page 2-4)

Likelihood and the consequences were each assigned a certainty category as described in Orr and others (1993). The certainty categories are a function of the information that is available and the confidence of the assessor in it. Certainty categories used in the risk assessment process are:

- *Very certain*
- *Reasonably certain*
- *Moderately certain*
- *Reasonably uncertain*
- *Very uncertain*

Likelihood of increased disease damage

Warmer, drier—High (very certain) (Applicable criteria: a, b, d, e).
Warmer, wetter—Moderate (moderately certain) (Applicable criteria: a, d, e).
The incidence of Armillaria root disease is likely to increase as temperatures increase and precipitation decreases (Shaw and Kile 1991, U.S. Office of Technology Assessment 1993), especially when hosts are stressed by moisture deficiency.

Five criteria were used to estimate likelihood (risk) of increased disease damage:

a. Suitability of conditions for pathogen survival, reproduction, spread, or host infection will increase as climate changes.

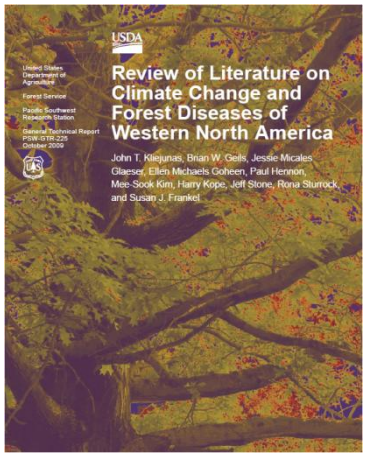
b. Changes in climate will stress the host and increase its susceptibility to the pathogen.
c. Pathogen is capable of substantial increases in population size (has a high reproductive potential).
d. Pathogen has a broad host range.
e. Control techniques are unknown, not feasible, or ineffective.

Consequences of increased disease damage *(pages 40-41)*
High (reasonably certain) (Applicable criteria: a, b, c). As precipitation decreases, increased growth reduction and mortality losses in British Columbia could increase. Increased growth loss and mortality would likely increase as sites become drier elsewhere as well.

Risk potential *–*
Warmer, drier—Very high (9) (Likelihood of increased disease damage = high; consequences of increased disease damage = high). Warmer, wetter—High (6) (Likelihood of increased disease damage = moderate; consequences of increased disease damage = high). A warmer climate will generally increase Armillaria incidence and impact as host stress increases. A drier climate would, in general, stress hosts more than a wetter climate, and thus increase host susceptibility.

Review of Literature on Climate Change and Forest Diseases of Western North America

http://www.fs.fed.us/psw/publications/documents/psw_gtr225/psw_gtr225.pdf



Provides good general guidance: e.g.: below

Key points:
"Although rusts can adapt to a wide range of environmental conditions, their tolerances are unknown. Under a changing climate, the incidence of rusts will be determined chiefly by host distribution. Rusts are likely to remain the cause of damaging and lethal diseases. Typically, rusts increase in intensity and distribution in "wave years" during which the weather is especially favorable for sporulation, dispersal, and infection. As climate changes, the frequency of such wave years is expected to change." P 19

Predicting Forest Insect Disturbance under Climate Change (Allan Carroll)

http://www.for.gov.bc.ca/ftp/HFP/external/!publish/Web/FFESC/reports/Carrollfinalreport.pdfion

"*ABSTRACT*

This paper comprises a review of literature regarding climate change impacts to forest insect disturbances. Its primary objectives were three-fold. First, commonalities were sought among systems regarding the effects associated with altered temperature and/or precipitation patterns on forest insect herbivores, the proximate and ultimate form of the response by the insects, and the outcome in terms of forest disturbance. Second, a general framework within which to assess future disturbances to temperate and boreal forests by insect herbivores was constructed. Finally, uncertainty regarding predictions of the extent/severity of forest insect disturbances under climate change into the future was discussed.

Conclusions

The preceding analysis suggests that disturbance by bark beetles is more likely to be exacerbated by climate change than defoliators, mainly because of the former's positive response to host tree stress and lack of a requirement for strict phenological synchrony. Given that there is little doubt of climate change-aggravated disturbance by bark beetle populations occurring already, priority should be given to development of realistic predictive tools that will facilitate proactive strategies intended to minimize impacts. Vigilance toward native innocuous, native invasive and alien invasive species should also be stressed due to their potential to erupt unpredictably in space and time. For example, lesser known bark beetle species occurring in the southern regions of North America have the potential to move northward as temperatures increase (Gan 2004, Bentz et al. 2010). Although the response by defoliators may be less predictable compared to bark beetles, their potential to cause disturbances over vast areas of forest cannot be ignored. The predictive framework suggested in this study provides a suite of potential outcomes for an eruptive forest defoliator under climate change; however, research efforts should focus on the development of predictive models of defoliator dynamics in a warming environment."

Climate change and forest diseases – Sturrock et al 2011

http://onlinelibrary.wiley.com/doi/10.1111/j.1365-3059.2010.02406.x/abstract

Table 1 Predicted change in impact on forests of several examples of forest diseases as they respond to warmer and drier or warmer and wetter future climates (adapted from Dukes *et al.*, 2009)

		Climate change			
		Warmer/Drier		Warmer/Wetter	
Group	Forest disease (pathogen)	Predicted change in impact[a]	Level of uncertainty[b]	Predicted change in impact[a]	Level of uncertainty[b]
Diseases caused by group-1 pathogens (temperature and moisture directly affect pathogen reproduction, spread, infection and survival)	Phytophthora root rot (*Phytophthora cinnamomi*)	–/0	L	+	L
	Sudden oak death/ramorum blight (*Phytophthora ramorum*)	–	M	+	L
	Dothistroma needle blight (*Dothistroma septosporum*, *Dothistroma pini*)	0/–	M	+	L
	Swiss needle cast (*Phaeocryptopus gaeumannii*)	–	M	+	L
	White pine blister rust (*Cronartium ribicola*)	–	L	0	M
Diseases caused by group-2 pathogens (temperature and moisture more directly affect host susceptibility to pathogen)	Armillaria root disease (*Armillaria* spp.)	+	L	0	M
	Sphaeropsis shoot blight (*Sphaeropsis sapinea*)	+	L	0	M
	Charcoal canker (*Biscogniauxia mediterranea*)	+	L	0	M
	Botryosphaeria canker (*Botryosphaeria* spp.)	+	L	0	M
	Pitch canker (*Fusarium circinatum*)	+	M	+	H
	Septoria canker (*Septoria musiva*)	+	M	0	M
Decline and abiotic diseases	Yellow-cedar decline	+	L	+	M
	Sudden aspen decline	+	L	0/+	M
	Oak decline	+	M	0	M

[a]+, increase in impact; –, decrease in impact; 0, no change in impact.
[b]The effects of climate change on pathogen/host interactions are complex and uncertain. Dukes *et al.* (2009) lists four types of uncertainties: those associated with (i) internal ecosystem processes, (ii) climate projections (general agreement that mean annual surface temperatures will increase but amount of warming and nature of precipitation change is less certain), (iii) future human actions, and (iv) a lack of data on the pathogens themselves. These four types of uncertainty were considered when estimating predicted changes in impact by the case study diseases; associated uncertainty levels were estimated to be low (L), moderate (M) or high (H).

Plant Pathology (2011) 60, 133–149

Yellow-cedar decline and climate change

http://www.nrs.fs.fed.us/pubs/jrnl/2012/nrs_2012_hennon_001.pdf

Shifting Climate, Altered Niche, and a Dynamic Conservation Strategy for Yellow-Cedar in the North Pacific Coastal Rainforest

PAUL E. HENNON, DAVID V. D'AMORE, PAUL G. SCHABERG, DUSTIN T. WITTWER, AND COLIN S. SHANLEY

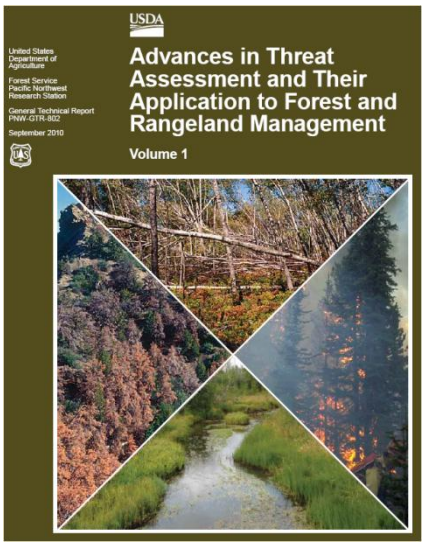
The extensive mortality of yellow-cedar along more than 1000 kilometers of the northern Pacific coast of North America serves as a leading example of climate effects on a forest tree species. In this article, we document our approaches to resolving the causes of tree death, which we explain as a cascade of interacting topographic, forest-structure, and microclimate factors that act on a unique vulnerability of yellow-cedar to fine-root freezing. The complex causes of tree mortality are reduced to two risk factors—snow depth and soil drainage—which are then used to model present and future cedar habitat suitability. We propose a dynamic, comprehensive conservation strategy for this valuable species on the basis of zones created by shifting climate, cedar's ecological niche, and observed risk factors. Research on yellow-cedar decline is offered as a template for understanding and adapting to climate change for other climate–forest issues.

Keywords: climate adaptation, forest decline, root cold tolerance, Callitropsis nootkatensis, Chamaecyparis nootkatensis

Provides compelling evidence of snow level impacts on yellow cedar – shows that the impacts of climate change may not be simple to identify.

Advances in threat assessment and their application to Forest and Rangeland Management

http://www.fs.fed.us/pnw/pubs/gtr802/Vol1/pnw_gtr802vol1.pdf



Interesting reference, may be of limited use in BC.

Forest Health and Climate Change: A British Columbia perspective.

http://bcwildfire.ca/ftp/HFP/external/!publish/ClimateChange/FRPA/Workshop/Forest_Health_CC.pdf

Forest health and climate change:
A British Columbia perspective

by Alex J. Woods[1], Don Heppner[2], Harry H. Kope[3], Jennifer Burleigh[3] and Lorraine Maclauchlan[4]

ABSTRACT

BC's forests have already faced two simultaneous, globally significant, epidemics linked to climate change; the Dothistroma needle blight epidemic in NW BC and the massive mountain pine beetle epidemic throughout the BC Interior. Building on these experiences, we have compiled our best estimates of how we believe other forest health agents may behave as climate change continues to influence our forests. We have drawn on literature from around the world but have focused on the situation in BC. We have made management recommendations based on what we have seen so far and what we expect to come.

BC context.

Is the health of British Columbia's forest being influenced by climate change? If so, was this predictable? By Alex Woods, 2011

http://journals2.scholarsportal.info/details.xqy?uri=/07060661/v33i0002/117_ithobcciswtp.xml

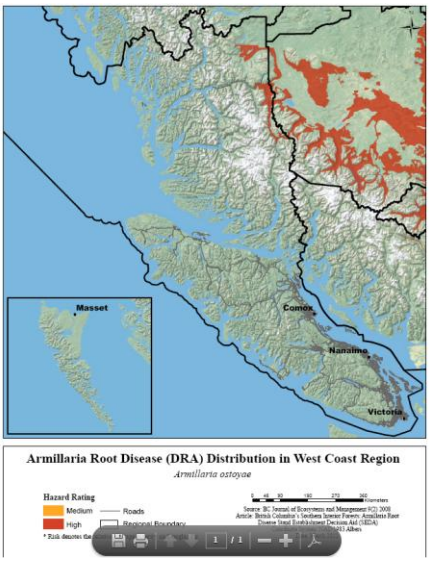
An excerpt from the conclusion: *"The current MPB epidemic in BC was arguably predictable given the strong link between the insect's vulnerability to very cold winter temperatures and the recent marked increase in winter minimum temperatures. Increasing winter temperatures are one of the most confidently predicted trends in climate change projections. Forest pathogens are similarly following a pattern of increased incidence and impact but the greater role that precipitation plays in their collective life histories presents a far less predictable scenario. The DNB epidemic in northwest BC has been linked to an increase in summer precipitation but increasing precipitation should have been beneficial for the trees. Increasing precipitation and warmer temperatures should also have benefited lodgepole pine plantations in the central interior but instead hard pine rusts may be increasing due to these new environmental conditions. A shortage of winter precipitation combined with increasing temperatures is causing more severe drought in portions of the southern interior which may already be exacerbating root disease severity."*

Forest health hazard ratings in BC: what is potentially an issue?

http://www.for.gov.bc.ca/ftp/HFP/external/!publish/Forest_Health/SEDA_maps/Individual%20Regional%20PDFs/

Example for Armillaria Root disease from the SEDA maps showing hazard rating – good starting point when looking forward in time. Note the high hazard area is for the entire BEC unit and may have areas within that have characteristics that are either greater or less than the identified hazard rating.

SEDA link from FORREX http://www.forrex.org/stand-establishment-decision-aids-sedas



RESULTS data on incidence

http://www.for.gov.bc.ca/ftp/HFP/external/!publish/Forest_Health/RESULTS%20incidence%20maps /

This site houses incidence maps based on survey information found in RESULTS. This provides a description of severity in a local area from actual data and is not extrapolated.

Expected Effects of Climate Change on Forest Disturbance Regimes in British Columbia

http://jem.forrex.org/index.php/jem/article/view/152

HOME | ABOUT | LOG IN | REGISTER | SEARCH | CURRENT | ARCHIVES | ANNOUNCEMENTS | SURVEY | PUBLICATIONS | FORREX

Home > Vol 13, No 1 (2012) > Haughian

Expected Effects of Climate Change on Forest Disturbance Regimes in British Columbia

Sean R. Haughian, Philip J. Burton, Steve W. Taylor, Charles Curry

Abstract

Projections for forest disturbance and damage under a changing climate in British Columbia are summarized, with the objective of collating regionally specific expectations so that land managers can take pro-active steps to avoid or adapt to the changes expected. While some projections are based on extrapolations of recent multi-decadal trends, most are based on global climate models (GCMs) that must make assumptions about the range of CO_2 emissions and the status of atmospheric greenhouse gas emissions over the next century. Regardless of emission scenarios, it is universally expected that British Columbia will experience warmer air temperatures, coupled with more precipitation in some regions and less in others. Forest fires are expected to be more frequent and more intense in the southern half of the province and in the Taiga Plains, but less important in other portions of the province. Forest insects and fungal pathogens are expected to more fully occupy the current range of their host tree species and expand ranges northward and to higher elevations along with their hosts. More frequent and detrimental pest outbreaks are expected in some regions when several years of favourable weather align. Wind damage, floods, and landslides can be expected to increase on terrain where they are already a risk factor. For many agents of tree mortality, expected changes in disturbance regime amount to an expansion or shifting of the seasonal window of activity, sometimes with different trends projected for different seasons and different regions of the province. The prediction of future forest disturbance regimes is in its infancy, requiring a much more concerted effort in compiling both empirical and simulated data, but managers may wish to adjust plans accordingly where there is largely a consensus among current and projected trends.

Keywords

disturbance ecology, ecoprovinces, forest pathogens, insect outbreaks, tree mortality, wildfire, wind damage

Full Text: PDF

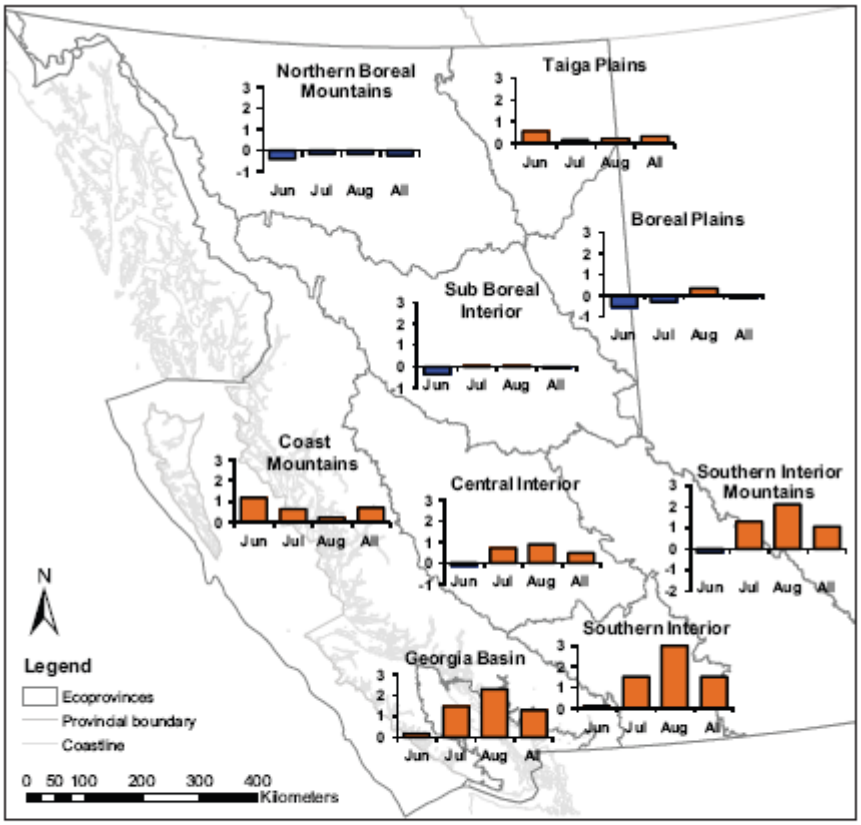


FIGURE 1. Projected changes (approximating the 2080s under the A2 scenario) for British Columbia from current monthly (MSR for June, July, August) and seasonal mean severity ratings (SSR, "all") by ecoprovince. Change is expressed as absolute change in MSR; baseline MSR values range from 0 to 12, with higher values in the south and lower values in northern and coastal areas. Data are summarized and extended from Taylor et al. (2010).

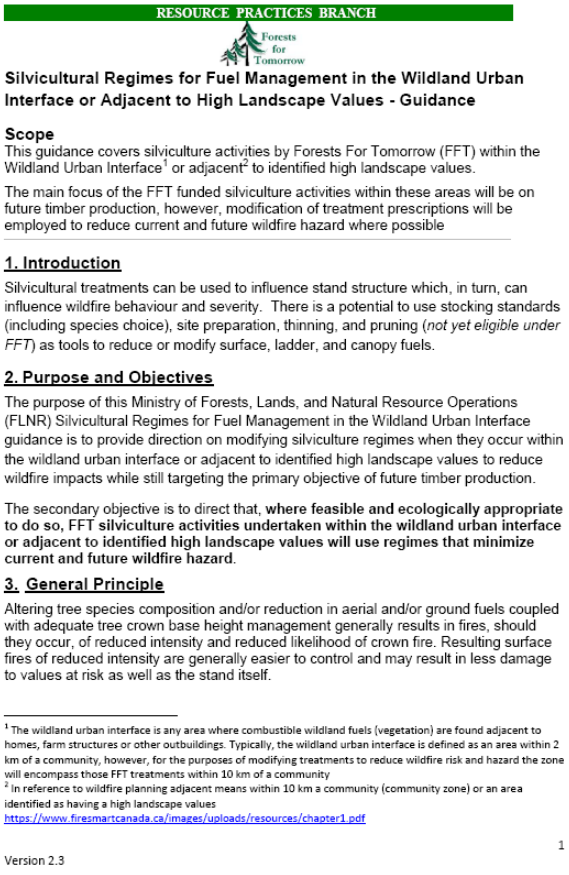
Example information on severity using the Canadian Fire Weather Information System – note regional variation.

Direction on fuel management in the Wildland Urban Interface

The attached link provides some guidance on integrating fuel management regimes into silvicultural treatments and high lights a prime opportunity for collaboration with fuel and fire management specialists throughout the province so that when planning and undertaking FFT treatments we can realize multiple benefits.

Thanks to all those who contributed comments in the development of this document and especially thanks to Ed Korpela and Bev Atkins for their very detailed contributions. (Al Powelson contact)

http://www.for.gov.bc.ca/ftp/HFP/external/!publish/LBIS_web/Guidance/FFT%20guidance%20-Silvicultural%20Regimes%20for%20Fuel%20Management%20in%20the%20WildLand%20Urban%20Interface_V2.3.pdf



RESOURCE PRACTICES BRANCH

Forests for Tomorrow

Silvicultural Regimes for Fuel Management in the Wildland Urban Interface or Adjacent to High Landscape Values - Guidance

Scope

This guidance covers silviculture activities by Forests For Tomorrow (FFT) within the Wildland Urban Interface[1] or adjacent[2] to identified high landscape values.

The main focus of the FFT funded silviculture activities within these areas will be on future timber production, however, modification of treatment prescriptions will be employed to reduce current and future wildfire hazard where possible

1. Introduction

Silvicultural treatments can be used to influence stand structure which, in turn, can influence wildfire behaviour and severity. There is a potential to use stocking standards (including species choice), site preparation, thinning, and pruning (*not yet eligible under FFT*) as tools to reduce or modify surface, ladder, and canopy fuels.

2. Purpose and Objectives

The purpose of this Ministry of Forests, Lands, and Natural Resource Operations (FLNR) Silvicultural Regimes for Fuel Management in the Wildland Urban Interface guidance is to provide direction on modifying silviculture regimes when they occur within the wildland urban interface or adjacent to identified high landscape values to reduce wildfire impacts while still targeting the primary objective of future timber production.

The secondary objective is to direct that, **where feasible and ecologically appropriate to do so, FFT silviculture activities undertaken within the wildland urban interface or adjacent to identified high landscape values will use regimes that minimize current and future wildfire hazard**.

3. General Principle

Altering tree species composition and/or reduction in aerial and/or ground fuels coupled with adequate tree crown base height management generally results in fires, should they occur, of reduced intensity and reduced likelihood of crown fire. Resulting surface fires of reduced intensity are generally easier to control and may result in less damage to values at risk as well as the stand itself.

[1] The wildland urban interface is any area where combustible wildland fuels (vegetation) are found adjacent to homes, farm structures or other outbuildings. Typically, the wildland urban interface is defined as an area within 2 km of a community, however, for the purposes of modifying treatments to reduce wildfire risk and hazard the zone will encompass those FFT treatments within 10 km of a community

[2] In reference to wildfire planning adjacent means within 10 km a community (community zone) or an area identified as having a high landscape values

https://www.firesmartcanada.ca/images/uploads/resources/chapter1.pdf

1

Version 2.3

Useful link for managing habitat – Just add a climate change lens

http://www.env.gov.bc.ca/fia/documents/mca_silvbmp.pdf