Ministry of Forests Lands and Natural Resources Operations

Climate Change Adaptation Workshop:

Fort Saint John October 9, 2013

Ministry of Forests, Lands and Natural Resource Operations

Managing for Resilient Resource Values and Ecosystems

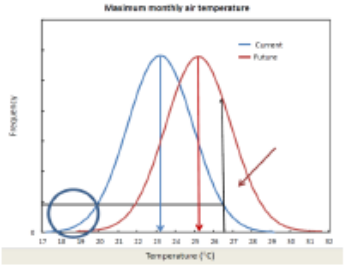
Climate Change Adaptation Workshops

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 resource management practices.

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

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?



- **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: looking at effects on fire, water, and resource values; 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**: Management practices that can be adapted today to maintain resource values and foster resilient forests for a changing climate. What can we do to take action now?

Workshop Location and Date

Fort St. John: Oct. 9 2013

Workshops are open to government, licensees, consultants and professionals.

Attend if you are:

- A Director of Resource Management, District Manager/ Resource Manager, Timber Sales Manager/ Woodlands Manager, Fire Centre Manager/ Deputy for FLNR, Regional silviculture and habitat staff; or,
- An industry or consulting decision maker, prescriber or practitioner.

Or responsible for…

- Resource management, stewardship, ecosystems, tenures, and/or cumulative effects pilots;
- 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); or fish, wildlife and habitat;
- Risk mapping for wildfire management
- Assessment of climate change impacts, risk and vulnerabilities, and in the creation of tools to assist management; or,
- Compliance and enforcement monitoring.

Registration
Send registrations to 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, or Katharine.McCallum@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 Resource Values and Ecosystems

Ministry of Forests, Lands, and Natural Resource Operations

2013

1

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

What is resilience in a Changing Climate?
- Guidance from Vulnerability Assessments
- Resilience through scenario-based risk management
- Local issue presentations and discussion

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:

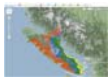
- Dave Peterson, ADM, FLNRO
  - Executive Sponsor
- Karrilyn Vince , North East Region FLNRO
- Casey Macaulay ABCFP

3

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 resilience?
4. What tools are available to you?
5. What can YOU do now to promote resilience!



4

– **Climate Change and the Forest (Natural Resource) Professional**
– Perspectives from the ABCFP

Fostering Resilient Values and Ecosystems workshop series, October 2013
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 (ecosystems.) 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?

Resource professionals have a critical role:

Learning: Knowledge, awareness and innovation

Professional Reliance: Independence, application of knowledge, reflection on decisions

Managing uncertainty and risk: 'Blind corner ahead'

Stewardship mandate: Long term focus

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

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

"*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:
That professionals will be guided in adapting practices in a changing climate..

Work to date:

- 1st Member survey: baseline of awareness (Feb '13)
- 2nd Member survey: barriers to adaptation (Oct '13)
- Collaborating with other professions
- Working with government and the research community to foster awareness
- Practical research summaries

Ongoing projects

- Report on second survey of ABCFP members to determine barriers to adaptation and methods to overcome these barriers (Fall 2013)
- Website materials to engage members in current research in BC, and how it links to changes in practice
- Working with national and provincial organizations; e.g. workshops and training opportunities
- Information sharing and best practices

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
Yes		40%
No		60%
		Total Responses: 1282

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

How can the ABCFP advance and support BC's forest professionals in the fostering of healthy, resilient and productive forest ecosystems in a changing climate?

Training:
Education Standards
Extension
General Training
Information Hub
Magazine
Web-based Training
Workshops

Advocacy:
General Advocacy
Lobby
Public Advocacy
Strengthen Legislation

Decision Support:
Best Practices
Decision Support Tools
Research

Skeptical/Cautious approaches:
Do Nothing
Focus on what we know
Investigate Opportunities
Step off the Band Wagon

Policy/Strategy:
Develop a policy
Strategy Development

Promote Dialogue:
Discussion Forums
Support Local Knowledge

Management approaches:
Conservation
Hedge our bets
Mitigate
Support Specific Practices
Not Sure

Messages that we are working on..

- Resource 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

Work to date – building as we go

Ministry of Forests, Lands and Natural Resource Operations

Tools

This page provides links to tools useful for:

- understanding changes underway in your area and
- adapting forest management so that BC forests remain resilient to climate change, variability and other stressors.

Credit for each of the tools belongs with each developer noted on the linked web pages.

- New link! (June 2013) **Stand Establishment Decision Aids (SEDAs):** These SEDAS show current forest health risk and point to silvicultural tools and practices to deal with environmentally limiting factors within the context of BEC.
- New link! (June 2013) **Forest health change detection risk (hazard/severity) maps** in two formats:
  - **Mapped incidence of pests by TSA and cutblock from the RESULTS database** and,
  - **Regional maps of pest distribution** using the SEDA information.
- February 2013: FORREX Checklist for adapting BC's landscapes to a changing environment. This checklist summarizes the key considerations for buffering your managed forests against the impact of climate change during planning, harvesting, and reforestation. (3 pages).

This website is constantly being updated – note New! links

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

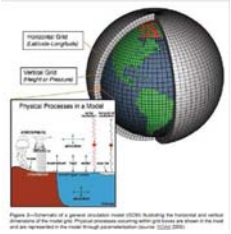
Personal observations

Turn to your Neighbour Discussion

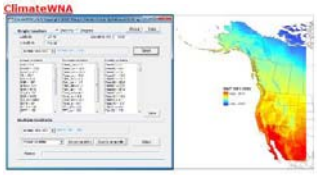
- Discuss what local or regional impacts (differences) you have observed that could be attributed to climate change.
- Debrief as a group

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

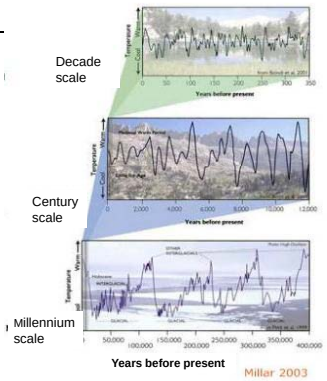
Earth's natural climate system varies over time

Climate changes over time with different patterns and modes.

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

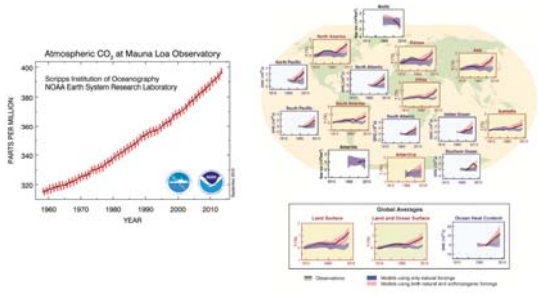
Note: Different mechanisms drive different modes

Source: Millar 2003



Principles of Climate Change Adaptation
Climate Trends

Global observations - IPCC

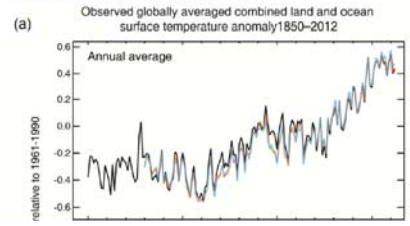


Sources: http://www.esrl.noaa.gov/gmd/ccgg/trends http://www.climatechange2013.org/images/uploads/WGIAR5-SPM_Approved27Sep2013.pdf - Mona Loa - Keeling curve Google image

Principles of Climate Change Adaptation
Climate Trends

Global observations - IPCC

Figure SPM.1 [FIGURE SUBJECT TO FINAL COPYEDIT]



Source: http://www.climatechange2013.org/images/uploads/WGIAR5-SPM_Approved27Sep2013.pdf

Principles of Climate Change Adaptation
Climate Trends

IPCC Representative Concentration Pathways

Table SPM.2 [TABLE SUBJECT TO FINAL COPYEDIT]

Variable	Scenario	2046–2065 mean	2046–2065 *likely* range [c]	2081–2100 mean	2081–2100 *likely* range [c]
Global Mean Surface Temperature Change (°C) [a]	RCP2.6	1.0	0.4 to 1.6	1.0	0.3 to 1.7
	RCP4.5	1.4	0.9 to 2.0	1.8	1.1 to 2.6
	RCP6.0	1.3	0.8 to 1.8	2.2	1.4 to 3.1
	RCP8.5	2.0	1.4 to 2.6	3.7	2.6 to 4.8

These scenarios provide a range of concentrations over time

The RCP2.6 is a mitigation strategy – where CO2 peaks then declines by 2010

RCP4.5 and 6 are stabilization scenarios, while RCP8.5 is a scenario with increasing greenhouse gas emissions.

The RCPs can thus represent a range of 21st century climate policies, as compared with the no-climate-policy of the Special Report on Emissions Scenarios (SRES) used in the Third and Fourth Assessment Report..

Sources: http://www.ipcc.ch/report/ar5/wg1/#.UkXFTzJrbGg

Principles of Climate Change Adaptation
Climate Trends

Global observations and impacts

For each ~1 degree C increase expected impacts include:

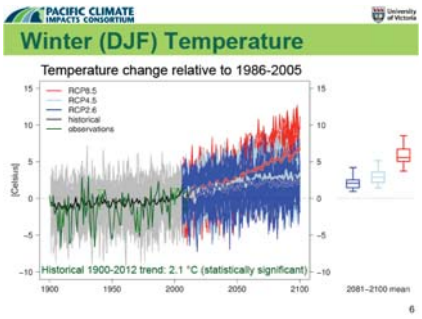
- 5 to 15% reductions in crops as currently grown
- 3 to 10% increases in the amount of rain during heaviest events
- 5 to 10% decreases in some rivers
- 200 to 400% increases in wildfire in parts of Western North America

Sources: http://epa.gov/climatechange/basics/facts.html

28

Principles of Climate Change Adaptation
Climate Trends

Natural Variation

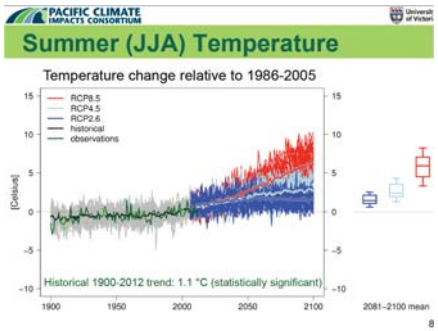


Source: http://www.climatechange2013.org/images/uploads/WGIAR5-SPM_Approved27Sep2013.pdf

29

Principles of Climate Change Adaptation
Climate Trends

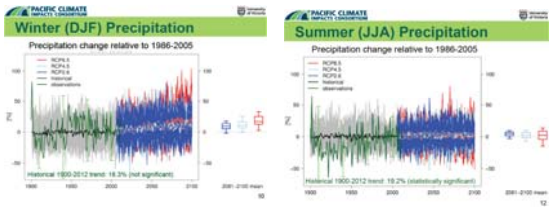
Natural Variation



30

Principles of Climate Change Adaptation
Climate Trends

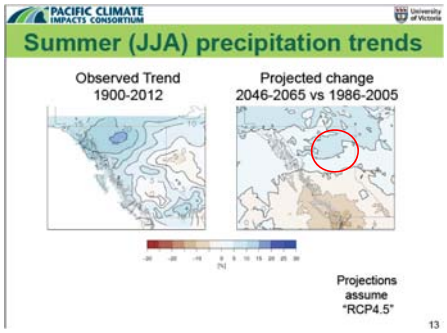
Natural Variation



31

Principles of Climate Change Adaptation
Climate Trends

Natural Variation



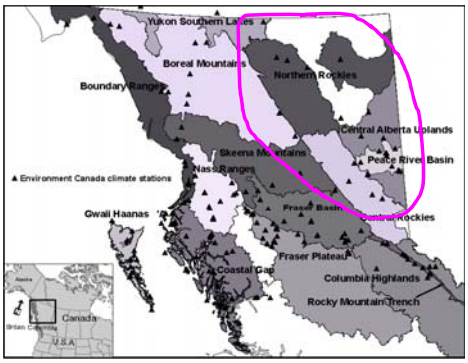
32

Principles of Climate Change Adaptation
Climate Trends

Local trends and data

Local information – Vanessa Foord Climatologist

33



Environment Canada weather stations and regional climate groupings (EcoRegions)
From: Foord et al. Submitted. Atm-Ocean, not for distribution.

Baseline Climate Overview

EcoRegion	Station	Ave Total Precip	Ave Mean Temp	Ave Max Temp	Ave Min Temp
Central Rockies	Hudson Hope BCHPA Dam	554.2	2.2	30.3	-36.0
	Pine Pass Mt. Lemoray	757.7	3.3	31.0	-36.2
	Bullmoose	770.8	2.1	28.9	-34.4
	Tumbler Ridge	471.9	3.4	32.6	-36.8
	Denison Plant Site	546.4	3.5	30.8	-37.0
Peace River Basin	Hudson Hope	407.0	1.4	32.7	-42.0
	Chetwynd BCFS	451.6	2.6	32.2	-36.2
	Chetwynd A	445.7	3.1	31.2	-40.3
	Sweetwater	538.4			
	Pouce Coup	464.8	1.6	32.3	-46.0
	Dawson Creek	465.5	1.1	30.8	-43.2
	Dawson Creek A	470.0	1.7	30.9	-42.6
	Taylor Flats	443.0			
	Fort St. John A	455.5	1.8	30.0	-37.8
	Baldonnel	450.6	1.5	30.5	-39.4
Central AB Uplands	Beatton River A	454.3	-1.2	28.8	-41.9
	Sikanni Chief	567.2	1.0	29.9	-37.7
	Wonowon	538.1	1.2	28.3	-36.1
	Rose Prairie	452.1	-0.4	29.8	-43.9
	Cecil Lake CDA	505.9	0.1	29.2	-38.0
	Charlie Lake	485.5	1.3	29.3	-41.6
Northern Rockies	Fort Nelson A	443.3	-0.9	31.5	-41.8
	Muncho Lake	484.0	0.1	30.1	-41.6
	Toad River	486.2	-0.4	30.3	-42.8
	Tetsa River	648.1	-0.8	28.5	-37.6

Annual Climate Trends

Regions	Period of Record	MAP	MAT	EMXT	EMNT
Central Rockies	1963-2004	-3.2	0.2	-0.1	1.9
Peace River Basin	1916-2008	0.1	**0.7**	-0.5	**3.1**
Central Alberta Uplands	1944-2007	3.7	0.4	-0.1	**2.6**
Northern Rockies	1937-2008	8.9	**1.4**	0.2	**3.2**

Further NE, 1.4ºC mean annual temperature change in 70 years

Extreme minimum temperature change greater than mean

From: Foord et al. Submitted. Atm-Ocean, not for distribution.

Winter Climate Trends

Regions	Period of Record	MAP	MAT	EMXT	EMNT
Central Rockies	1963-2004	-18.4	0.2	0.0	-0.3
Peace River Basin	1916-2008	-10.7	**2.5**	**1.4**	**3.0**
Central Alberta Uplands	1944-2007	-10.5	**2.5**	0.6	**3.4**
Northern Rockies	1937-2008	-27.5	**3.1**	1.2	**3.5**

Winter temperature trends the greatest of all the seasons

Negative precipitation trends

From: Foord et al. Submitted. Atm-Ocean, not for distribution.

Spring Climate Trends

Regions	Period of Record	MAP	MAT	EMXT	EMNT
Central Rockies	1963-2004	5.5	-0.6	-2.2	-3.9
Peace River Basin	1916-2008	1.6	**0.8**	-0.6	**3.1**
Central Alberta Uplands	1944-2007	0.5	0.4	1.2	-0.2
Northern Rockies	1937-2008	11.1	**1.2**	-0.7	2.1

Large increase in spring minimum in Peace River Basin

Increasing spring precipitation

From: Foord et al. Submitted. Atm-Ocean, not for distribution.

Summer Climate Trends

Regions	Period of Record	MAP	MAT	EMXT	EMNT
Central Rockies	1963-2004	**-13.1**	0.3	0.3	**-1.3**
Peace River Basin	1916-2008	5.1	**0.5**	-0.4	**0.9**
Central Alberta Uplands	1944-2007	0.8	0.1	0.2	**0.9**
Northern Rockies	1937-2008	**18.2**	**0.9**	0.4	0.5

Cooler overnight lows associated with less precipitation in Central Rockies

Increasing summer precipitation further north with warmer temperatures

From: Foord et al. Submitted. Atm-Ocean, not for distribution.

Fall Climate Trends

Regions	Period of Record	MAP	MAT	EMXT	EMNT
Central Rockies	1963-2004	-8.0	1.0	0.8	**7.8**
Peace River Basin	1916-2008	4.2	-0.4	-1.1	1.5
Central Alberta Uplands	1944-2007	21.3	0.7	-1.5	0.6
Northern Rockies	1937-2008	-2.2	**-0.6**	3.0	**3.7**

Very large increases in fall overnight lows, Central and Northern Rockies

Negative mean temperature trends Northern Rockies

From: Foord et al. Submitted. Atm-Ocean, not for distribution.

Climate related Disturbances

Climate Trend	Disturbance (s)	Impact (s)
↑MAT	↑Large Rockslides ↑ Large Debris slides, Permafrost melt	Loss of harvestable land, Loss of infrastructure (roads, pipelines), Safety concerns
↓Winter Precipitation	↓ Snow storage	Summer water availability
↑MAT and Warmer summers	↑Stream Temperatures	Suitable fish habitat
↑ Winter Min Temps	↑ Mountain Pine Beetle survival	Loss of harvestable land
↑Spring/Fall Min Temps	↑ MPB, Spruce Beetle	Loss of harvestable land
↑Summer Precipitation	↑ Extreme Storms ↑ Landslides	E.g. Pine River area flooding, rail and highway washouts, slope failures, Jul 2011
↑Summer Mean and Min Temp, ↓ Frost	↑ Forest Pest and Diseases	Loss of harvestable land
↑ Dec diurnal temp range (i.e. temp swings)	↑ Forest Pest and Diseases breaking winter dormancy	Loss of harvestable land

42

Decreasing Slope Stability

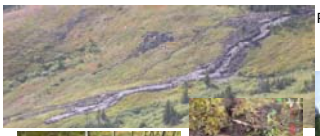
- Increases in MAT associated with **large** landslides
  - Permafrost melt -> Debris slides
  - Mountain ice loss -> Rockslides
- (M. Geertsema and V. Foord)

near Trutch

near Gunnel

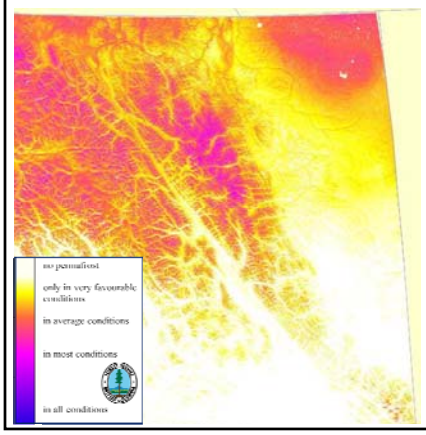
Permafrost and Rock Temperature Monitoring

- 4 weather stations, 20 air & soil temp/snow depth stations, various rock/soil temp probes


Pink Mtn

Tetsa area

near Buckinghorse



BC Permafrost Map

M. Geertsema and A. Hasler,

Model input: mean annual temperature (PRISM), terrain (DEM), and potential incoming solar radiation index

Verified with field data of soil, rock, and air temp, climate data (Foord and Geertsema)

Forest Pests

- Mountain Pine Beetle
  - Decreasing arctic outbreaks mid winter – less extreme temperatures (<35 °C)
  - Increasing spring and fall min temp (<25°C)
  - Warm summers, emergence (>18°C)

Pine Pass, summer 2007

Radiation balance in MPB affected stands

regeneration and snow hydrology (interception, accumulation, timing of melt)

- After >5 years post attack:
  - Canopy openness ↑18-30% in 70% pine; ↑30-50% in 100% pine stands
  - Increasing snow on ground in MPB forest relative to nearby clear-cut

Climate/Natural Disturbance Database – Northern BC

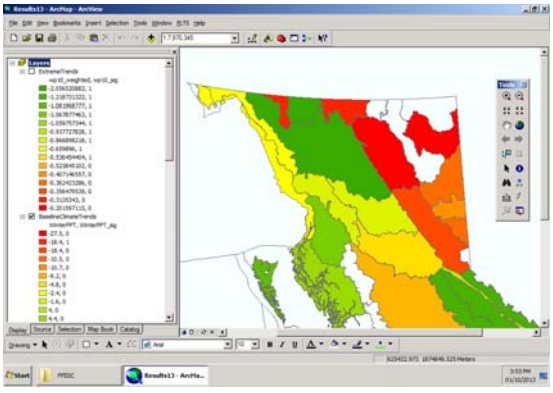
- Known natural disturbance events in northern BC
  - e.g. **Outbreaks**: pests and disease; **Fire**: season length, frequency, area burned; **Natural hazards**: floods, landslides; **Drought**
- Climate variables were assigned to each of the events based on literature, researchers knowledge, or searching disturbance databases
  - e.g. Canadian Large Fire database, Fire Weather Index dataset, BC Natural Disturbance database)
- **Results of the climate analysis and occurrence of the natural disturbances are summarized by ecoregion and available in spreadsheet, figures, and spatial files**

Historical trend analysis

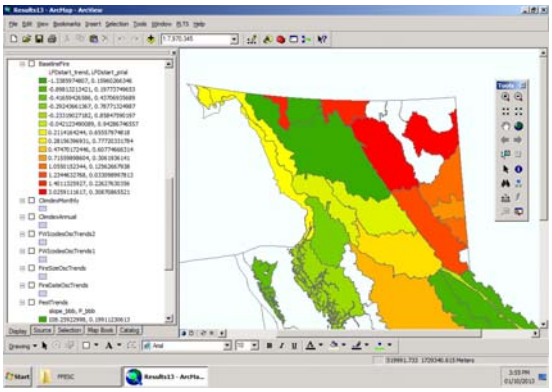
- Mean annual temperature
- Mean annual precipitation
- Extreme maximum temperature
- Extreme minimum temperature
- Seasonal temperature trends
  - Spring cooling
  - Spring warming
  - Winter warming
  - Winter warming extreme min
  - Summer warming
  - Summer warming extreme min
- Seasonal precipitation trends
  - Summer increases
  - Summer decreases
  - Winter decreases
  - Winter increases
- August minimum temperature
- Spring frost
- Summer frost
- Baseline 10/90th percentiles
  - Temperature and precipitation
  - Monthly
  - Seasonal
  - Annual
- Drought
  - Standardized precipitation index (Magyari-Sáska 2007)
  - Climate moisture index (Hogg et al. 1997)
  - No-rain episodes (Groisman and Knight 2007)
- Cold early fall/late spring (-25ºC)

Disturbance analysis

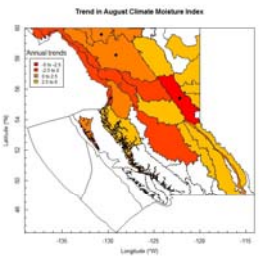
- Geomorphology
  - Large debris slides/rock slides
  - Permafrost melt/Alpine melt
  - Delayed snow-melt and debris slides/rock slides
- Hydrology
  - Flooding
  - Drought
  - Increasing stream temperatures
  - Early freshet
  - Drinking water
- Fire
  - Area burned
  - Season length change
  - Frequency of large fires
  - Relationship to Atmosphere and Ocean oscillations
- Entomology
  - Mountain Pine Beetle
  - Spruce Beetle
  - Spruce Bark Beetle
  - 2-yr cycle budworm
  - Douglas Fir Beetle
  - Spruce weevil
  - Defoliators
  - Increased pest survival
- Pathology
  - Dothistroma
  - Foliar Diseases
  - Pine Stem Rusts
  - Swiss Needle Cast
  - Overwinter survival
  - Breaking dormancy



V. Foord and H. Griesbauer

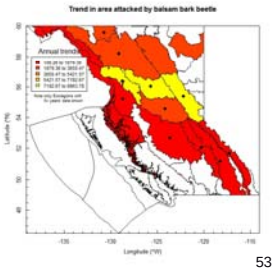


V. Foord and H. Griesbauer



Drought Indicators

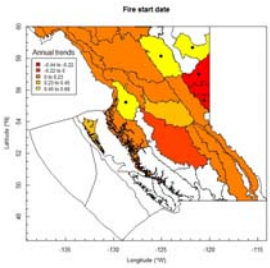
Significant negative trend (red) in CMI, Central Rockies



Pest Area Attack

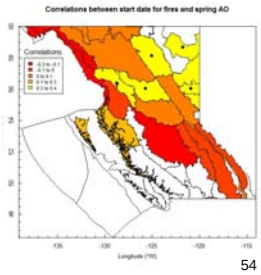
Significant increase (yellow largest area), Central Rockies

53



Fire Indicators

-Earlier fire start date Central AB Uplands
- Later fire start date, Northern Rockies



Fire and Oscillations

-Fires in NE correlated to Atmosphere-Ocean Oscillations
-E.g. Fire start date and positive Arctic Oscillation (Higher jet stream, storms further north in spring, later fire start)

54

Weather Data Resources

- Climate Related Monitoring Program (CRMP)
  - Agreement between MoE (air quality, river forecast centre), MoTI (avalanche weather), FLNRO (wildfire, research), MoA (farmwest), BC Hydro, and Rio Tinto Alcan to make meteorological data available to PCICs

    http://www.env.gov.bc.ca/epd/wamr/crmp.htm
- Pacific Climate and Impacts Consortium (PCICs)
  - Hosting data portal of all available historical and real time BC weather data from agencies in CRMP and Environment Canada

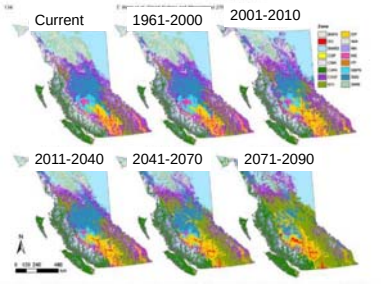
    http://www.pacificclimate.org/tools-and-data/pcds-portal
- Vanessa.Foord@gov.bc.ca or 250-565-4333

55

Principles of Climate Change Adaptation
Climate Trends

Shifts of climate envelopes

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



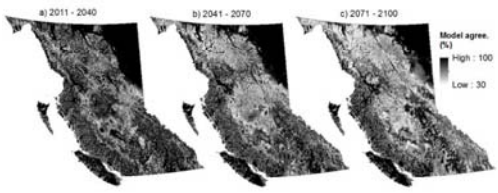
Source: Tongli Wang et al 2012

56

Principles of Climate Change Adaptation
Climate Trends

Shifts of climate envelopes

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



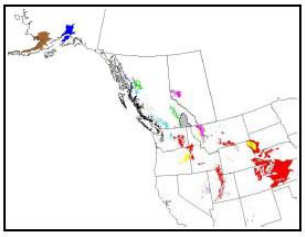
Source: Tongli Wang et al 2012

57

Principles of Climate Change Adaptation
Climate Trends

Shifts of climate envelopes

West Kootenay 2080 output - possible climate from outside BC

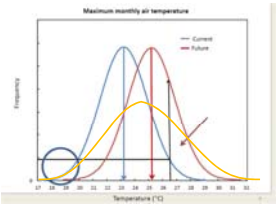


Source: http://www.kootenayresilience.org/Report5_BioclimateShift_Final.pdf

58

Principles of Climate Change Adaptation
Climate Trends

Regional plausible futures



E.g., Shift of the mean and extremes

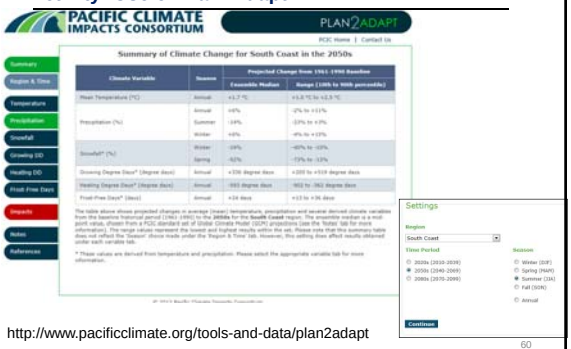
(Spittlehouse 2012)

It is *virtually certain* that there will be more frequent hot and fewer cold temperature extremes over most land areas on daily and seasonal timescales as global mean temperatures increase. It is *very likely* that heat waves will occur with a higher frequency and duration. Occasional cold winter extremes will continue to occur (see Table SPM.1). {12.4} http://www.ipcc.ch/report/ar5/wg1/#.UkXFTzJrbGg

59

Principles of Climate Change Adaptation
Climate Trends

Activity: Use of Plan2Adapt



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

60

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

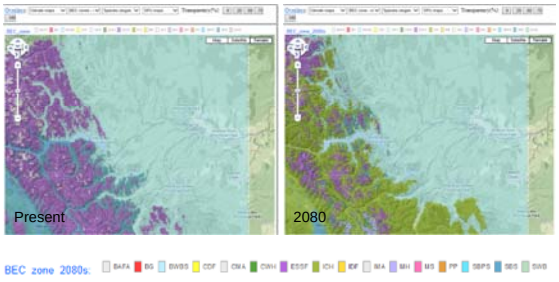
Earlier spring lake ice melt.
- Lake productivity may decline
- Inland fisheries, sport fisheries and related tourism affected
- Salmon smolt migration timing may be affected

Opportunity to for participant input and discussion

61

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

62

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

63

Principles of Climate Change Adaptation
Climate Trends

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

20-45 days shorter

Arrives 29 days earlier

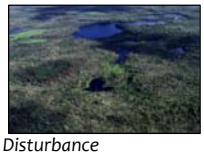
Arrives 9 days earlier

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

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)

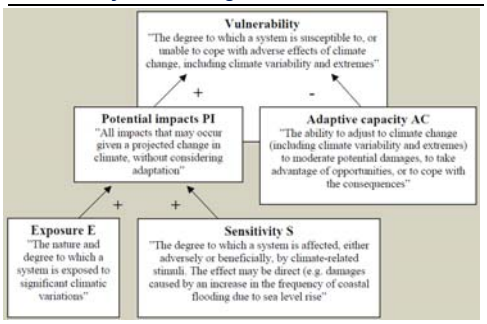
– Exposure (E), (i.e., the magnitude of climate change)
– Sensitivity (S), (sensitivity to change)
– Adaptive capacity (A) (ability to adapt the system to the change)

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

67

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)

68

Principles of Climate Change Adaptation
Climate Change Terminology

Vulnerability–balancing Exposure & Sensitivity with AC

Exposure – depends on which side of the fence you are on.

Sensitivity – your fear of heights, is it windy, wet…)

Adaptive Capacity – staying inside the fence, not going out when wet or windy – keeping your eyes shut?

How does this relate to resource values?

69

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 a local resource value that will become more vulnerable with climate change?
   - Where and why?

70

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

71

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

72

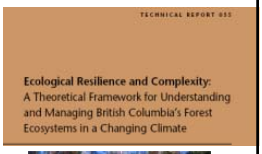
Principles of Climate Change Adaptation
Climate Change Terminology

Ecological Resilience –from BC's FLNRO 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

73

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

74

Principles of Climate Change Adaptation
Approaches to Adaptation

Limits to Resilience

Many boreal conifer forests are prone to fire, however the species are well-adapted to this disturbance and the forest ecosystem rapidly regenerates. Hence, this kind of forest is not resistant to fire but it is highly resilient.

Forest fires in wet tropical forests can overcome the resilience of the ecosystem if they occur too frequently or over very large areas

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

75

Principles of Climate Change Adaptation
Climate Change Terminology

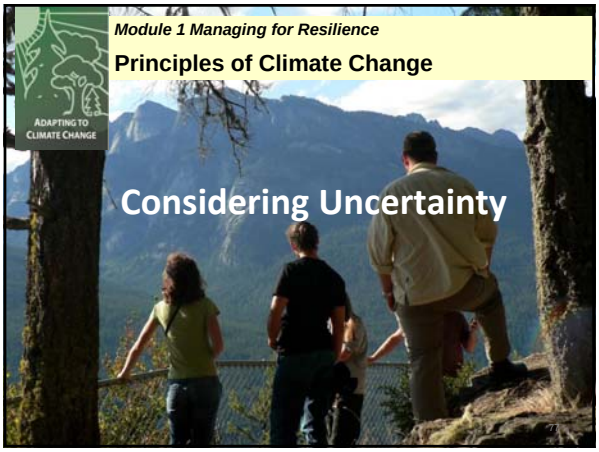
Resilience - Discussion

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)

76



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

78

Principles of Climate Change Adaptation
Considering Uncertainty

Risk, Resilience and Uncertainty

- *Some sources of uncertainty are quantifiable,*
  - *particularly as climate observation networks improve.*
- ***Nonetheless, uncertainty is not the same as incorrect information, nor does it mean we know too little to act".***

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

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

79

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).

An example of taking into account potential impacts of climate change:

Because some climate change impacts are inevitable, planning adaptation strategies now is essential. One example of adaptation is the Confederation Bridge between New Brunswick and Prince Edward Island, which was built a metre higher than currently required to accommodate sea level rise over its one hundred year lifespan.
http://www.elements.nb.ca/theme/climate03/cciarn/adapting.htm

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

80

What can be done now?

Cumulative Impacts

Cumulative Impacts – Status update on the NE Pilot

81

Cumulative Effects Assessment & Management

Steve Wilson, Ph.D., R.P.Bio.
Northeast Operational Trial

82

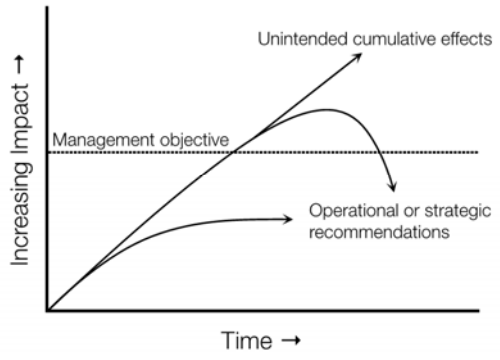
83

84

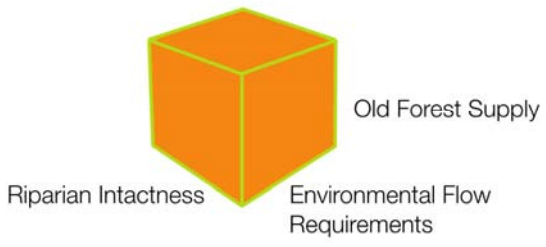
Components of a Cumulative Effects Assessment

- Values
- Management indicators
- Management objectives
- Measures of current conditions
- Near-term trends
- Mitigation actions

85



86



87

Mitigating the Risk of Cumulative Effects

- Understanding the implications of current legislation, regulation and policy
- Promoting consistent approaches/outcomes among sectors
- Providing recommendations for mitigation, new or revised objectives, policy, inventory/ research needs

88

Incorporating Climate Change Adaptation

- Not within the scope of the current operation trial but part of the provincial framework
- Requires scenario modelling
- Need better understanding of interactions
- Adaptation strategies could inform new or revised: values, indicators, management objectives, strategies

89

- Early days of a shift from activity based management to value-based
- Current focus is on developing assessment methods, governance structures, operational tools, engagement with First Nations, stakeholders, communities
- Enables shift from short-term to longer-term assessment of risks, including climate change

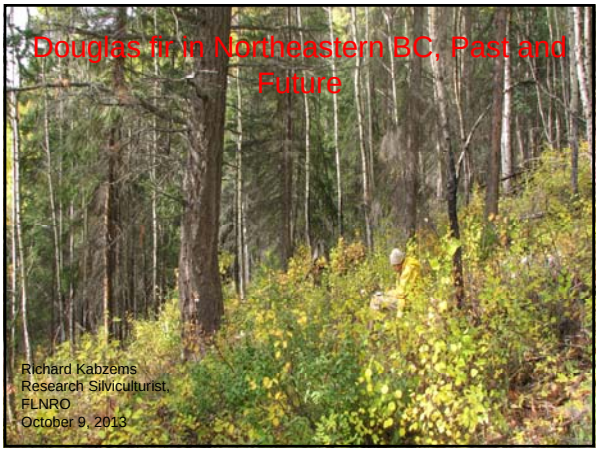
90

What can be done now?

Tree Species Options

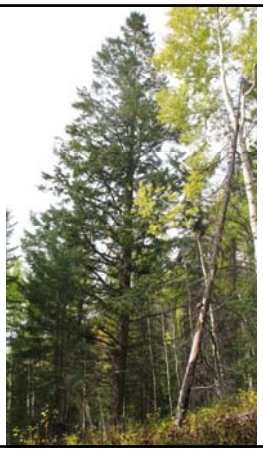
Provenance trials for Douglas-fir - Richard Kabzems

91

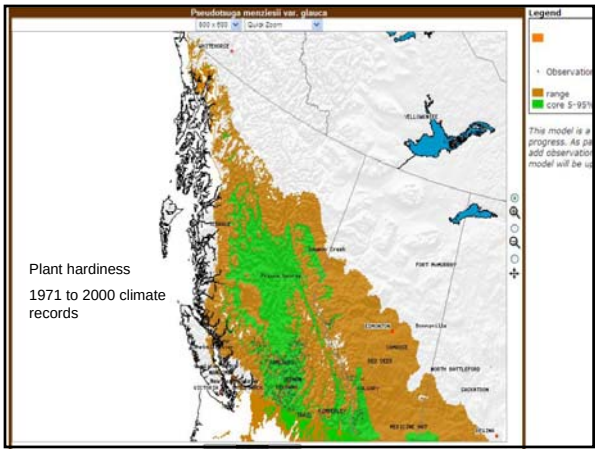


- Analysis of existing migrants & 'exotics'
- Screening evaluations for potential tree species
- Establishment trials

Douglas fir naturals are found in the SBSwk2 subzone southwest of Chetwynd

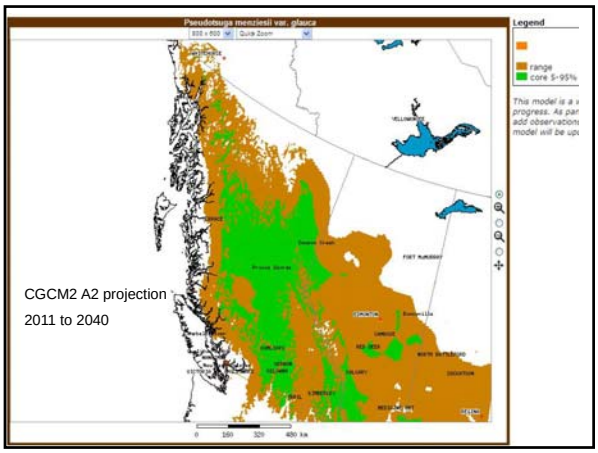


Isolated veterans
South aspect slopes
May reflect previous climatic fluctuations



Plant hardiness

1971 to 2000 climate records



Canfor – Chetwynd mid 1990's plantings of Douglas fir

EP 976 – Barry Jaquish

3 sites established June 2010 - 6,000 seedlings/site
10 open pollinated D fir families, 11 seed zones

Spruce and lodgepole pine at each site
Plus western larch, Ponderosa pine

Mount Robson and Submaritime zones
July 2011 Wildmare site

Fort St John AMAT site Sept 2011

What can be done now?

Tree Species Options

Introduction to Tree Species Shifts and Climate Change – an ecological approach – Bruce Rogers

106

Regional Guidance for Species Use based on Climate Change:

Using The Tools To Developing The Process

Bruce Rogers
FLNRO
Regional BEC Ecologist
Omineca/North East

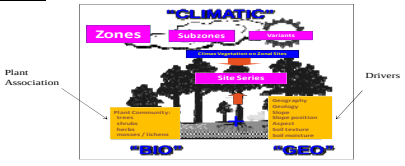
•The Reference Guide for Stocking Standards uses Biogeoclimatic Ecosystem Classification (BEC) site series as the foundation for tree species selection

BEC Classification			Regeneration Guide						Free Growing Guide						
			Species					Stocking		Regen Delay	Competitive Status		Ht Height		
Zone/SZ	Series	Standards ID	Site series (association)	Primary	Preferred (p)	Secondary	Acceptable (a)	Tertiary	Broadleaf (wall-spaced/ha)	Target / MIN ps	MIN p	(Max yrs)	Earliest (yrs)	Latest (yrs)	Species	Ht (m)
BWBSwk1	01		4(5/6)Be - Huckleberry - Step moss	Pl Se	Pl Se				All	1200	700	600	4	9	15	Pl	2.00
															Se	1.00
	b	limited in productivity, reliability and/or feasibility														

•BEC site series are a classification of site level units or ecosystems defined at the plant association level that reflect soil moisture and nutrient regimes and site factors such as slope position, aspect, cold air drainage and pooling

•Macro climate drives the broad zonal level and meso climate the subzone/variant level and within the subzone/variant micro climate and site factors define plant associations

•This strong climate level to site level relationship makes BEC site series an ideal unit of measure for predicting future site conditions and species suitability



•In 2012 Resource Practice's Branch initiated a project entitled Regional Guidance for Species Use based on Climate Change

•The Regional and Provincial BEC Ecologists were asked to participate in Phase 1 of the project by using available tools to develop Reference Guide promotion/demotion rankings for species at the site series level (only the zonal 01 site series was used to start with).

Tools Available For Evaluation:

•Ecologists used a variety of tools to evaluate scenarios and rationalize suggested promotions and demotions form the current Stocking Standards Reference Guide

•Dr. Tongli Wang (UBC Dept of Forest Sciences) used the ClimateWNA (Wang et al. 2010) Model to developed future climate projections for BEC

•For ecosystem/climate niches, 20 climate change scenarios were used to generate a projection consensus map for 2020, 2050 and 2080

•Ecosystem/climate niches were then incorporated into queries in our BEC VPro data base TreeGuideClimateChange.mdb tool and then linked to the tables in the Reference Guide to produce a "% area change for existing BGC units" for 2020, 2050 and 2080 along with the corresponding new suggested species selection

Green = stays the same, Purple=was added, Blue=was promoted, Yellow=was demoted, Red = was removed

Zone	Region	Series	At	Bl	Ep	Fd	Pl	Sb	Se	Sx
SBSmc3	Pr George	01		2			1			1

Current reference guide ranking status

2020	Region	Series	At	Bl	Ep	Fd	Pl	Sb	Se	Sx	Proportion
ESSFmv1	Pr George	01		3			1		3	2	0.00%
SBPSmc	Pr George	01	add	2			0	3		2	6.37%
SBSdk	Pr George	01	add	2	add	2	0			0	57.87%
SBSdw2	Pr George	01	add	2	add	3	0			0	10.71%
SBSdw3	Pr George	01	add	2	add	3	0			0	14.06%
SBSmc2	Pr George	01	add	0			0			0	0.31%
SBSmc3	Pr George	01		0			0			0	10.68%

Direction of ranking status change

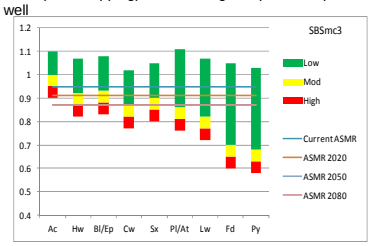
ESSFmv1	Pr George	01		1			2		1	2	
SBPSmc	Pr George	01	4	2			1	3		1	
SBSdk	Pr George	01	4	2	4	2	1			1	
SBSdw2	Pr George	01	4	2	4	1	1			1	
SBSdw3	Pr George	01	4	2	4	1	1			1	
SBSmc2	Pr George	01	4	2			1			1	
SBSmc3	Pr George	01		2			1			1	

New ranking status

•In my Regions I also had available the Drought Species Risk Tool (DeLong et al. 2010) that projects future changes to actual soil moisture regime (ASMR), recently developed as part of Future Forest Ecosystems Scientific Council Project

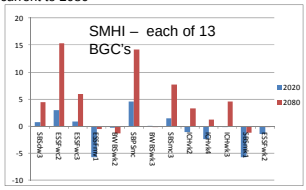
•Changes over time in ASMR for all site series are modeled based on site factor inputs and global climate scenarios using the Tree & Climate Assessment Tool (TACA Mechanistic Model-Nitschke and Innes, 2008)

•Currently cold air (frost mapping) is also being completed as part of the Species Risk Tool as well

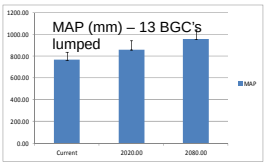


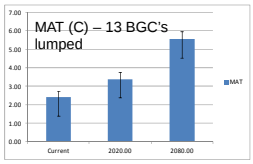
•I also used ClimateWNA to project future climate parameters such as MAT, MAP and SMH Index (a proxy for conductance and available water to plants)

Comparison between change from current SMHI, MAP and MAT to 2020 and then change from current to 2080



BGC 2080	SMH change	Risk Class
BWBSwk2	-1.3	1
SBSmk1	-1.2	1
ESSFmv1	-0.5	1
ESSFwk2	-0.2	1
BWBSwk3	-0.1	1
ICHvk4	1.2	1
ICHvk2	3.3	2
SBSdw3	4.4	2
ICHwk3	4.6	2
ESSFwc3	5.9	2
SBSmc3	7.7	3
SBPSmc	14.2	3
ESSFwc2	15.3	3





My process was to use a variety of tools and then compare them for agreement in a matrix which I then used to shape my rational for promotion or demotion based on risk to individual species. I did the following:

1. Run the VPRo tool and pick the top 4 projected % change BGC's (I did for 10 greatest % changed BGC SV in my Regions)
2. Look at the zonal site series in the Drought Risk Tool projections and see if they agreed
3. Look at the ClimateWNA projected variables and see if they agreed
4. Formulated draft rational for promotion/demotion

DRAFT: Regional Guidance for Species Use based on Climate Change

Species	Present Category	Suggested Category	Preferred/ Acceptable Recommendation	Promotion or Demotion	Rationale/Footnotes

Finally:

•Ecologists all used the VPro % change tool but also each used different tools and processes

•Next step: evaluate the various processes used, select the most favourable and apply the selected process to all site series in all BGC SV throughout the province

•Note: Although we don't know what the extent of ecosystem migration (flying BEC etc.) versus novel ecosystem development will be, the main site and soil drivers associated with each of these existing BEC site series still form a platform on which to project change

•Keep in mind: there are a variety of tools and more becoming available all the time so use everything available to base your decisions on – understand all assumptions, strengths and weaknesses, as they are only tools - "no smoking guns"

•Keep in mind: climate projections used here are based on scenarios. We don't know what scenarios the future will hold. So, once any evaluation processes are determined we should always apply them to a full range of scenarios "If reality deviates from what we think are the most likely scenarios then we also need to be prepared for that"

Module 1 Managing for Resilience

ADAPTING TO CLIMATE CHANGE

RESILIENT FORESTS IN A CHANGING LANDSCAPE

Guidance from Vulnerability Assessments

119

Principles of Climate Change Adaptation
Guidance from Vulnerability Assessments

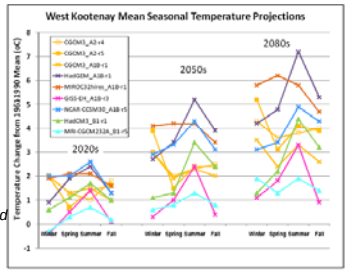
The W. Kootenay FFESC Project

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

Climate Sensitive 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



116

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

117

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/

118

ADAPTING TO CLIMATE CHANGE

Module 1 Managing for Resilience

Resilient Forests in a Changing Landscape

Resilience through Scenario-based Risk Management

119

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

Habitat Supply – links to climate change

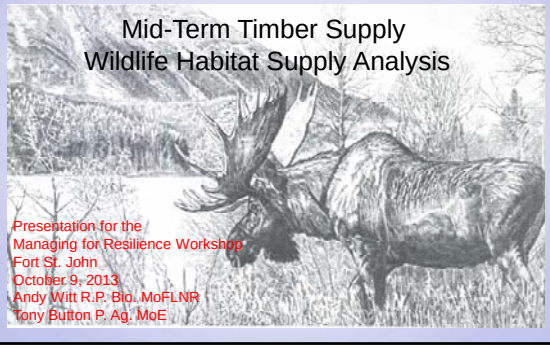
Andy Witt and Tony Button
(FLNRO and MOE)

Applications of habitat supply information:

- Timber Supply Review
- Wildlife Conservation
- Ecosystem Based Management
- Cumulative Effects Analysis
- Climate Change
- Parks and Protected Areas Management
- Monitoring
- Type 4 Silviculture

120

Mid-Term Timber Supply
Wildlife Habitat Supply Analysis



Presentation for the
Managing for Resilience Workshop
Fort St. John
October 9, 2013
Andy Wiitt R.P. Bio. MoFLNR
Tony Button P. Ag. MoE

Overview

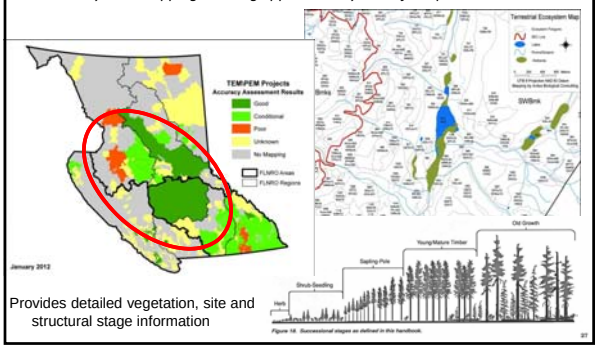
- Introduction
- What is habitat supply?
- How is it done?
- Habitat Supply Applications
- MTTS Product
  - What was the problem?
  - What was the process?
  - What are the products?
  - How were the products reported out for decision makers?
- Extension and ongoing products
- Questions?

Mountain Caribou Winter Habitat – North Thompson

What is habitat supply analysis?

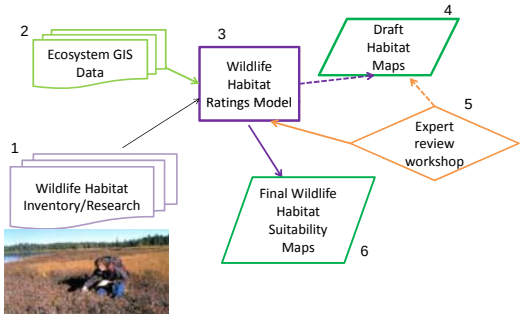
- It is a tool used to evaluate options for sustainable habitat management or to predict potential implications of activities and natural disturbances on habitat supply.
- There are a number of different ways to model habitat supply but all are expert-driven and based on existing, available wildlife habitat information (e.g. VRI, ecosystem mapping, wildlife species data, etc…).

Ecosystem Mapping covering approximately 65% of the province

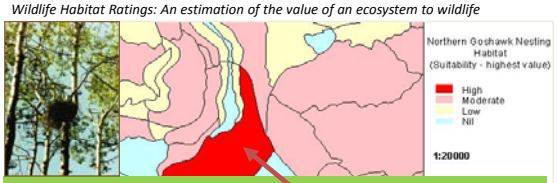


Provides detailed vegetation, site and structural stage information

How are Wildlife Habitat Capability and Suitability Maps developed?

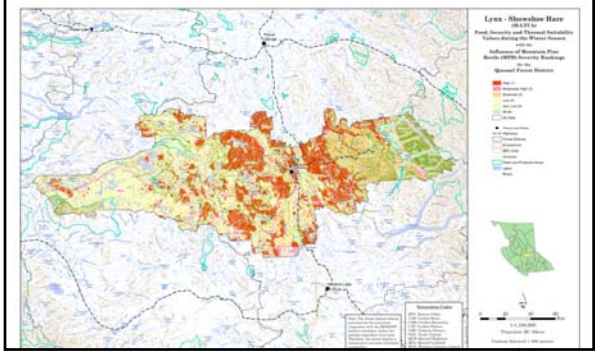


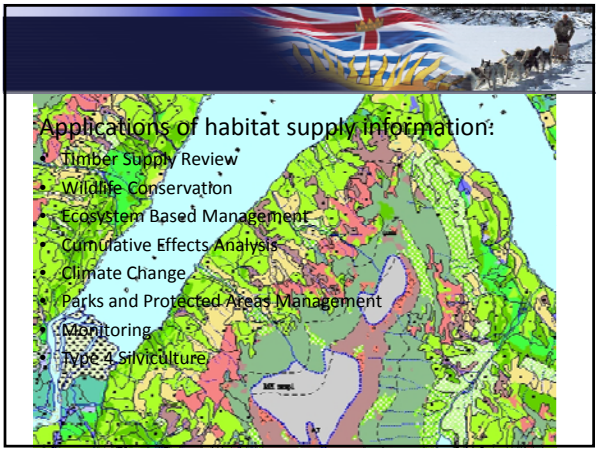
Wildlife Habitat Ratings: An estimation of the value of an ecosystem to wildlife



Ecosystem	*Habitat Rating for Northern Goshawk*		
Spruce-Twinberry-Oak fern	Food	Security	**Nesting**
Shrub/herb	Low	Nil	Nil
Pole/sapling	Moderate	Low	Low
Young forest	Moderate	Moderate	Moderate
Mature forest	High	High	**High**
Old forest	High	High	**High**

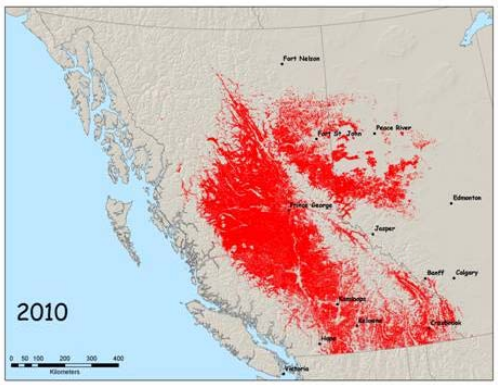
Lynx - Snowshoe Hare Winter Suitability – Quesnel Forest District





The Problem

- Current MPB attack impacts estimated 18.1 million hectares of BC forests
- MPB impacts timber values which leads to increased AAC to salvage harvest of MPB trees while trees had economic value resulting in a "mid-term" reduction in merchantable timber. This has significant potential socio-economic and ecological implications to the areas affected.
- To mitigate the socio-economic impacts, options were considered in how to make more timber available during the Mid Term Timber Supply period. These options include allowing timber harvest to occur in areas with land use objectives that limit the degree of harvest.
- The beetles have impacted not just timber values, but other forest resource values, such as wildlife habitat.
- Deputy Minister Konkin requested a habitat supply analysis to determine the implications to wildlife from the MTTS harvesting scenarios.



The cumulative MPB spread in British Columbia and Alberta (Adapted from the Canadian Forest Service website: cfs.nrcan.gc.ca

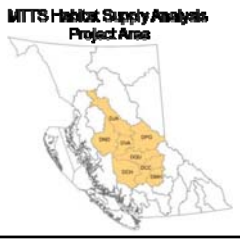
The Questions

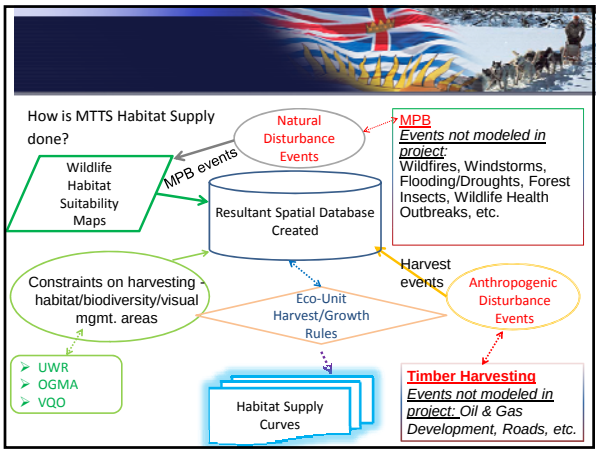
- Has the beetle attack and associated harvest impacted habitat supply
- What is the habitat supply within OGMAs, UWRs, and VQOs
- What is the affect on habitat supply from the proposed harvesting scenarios
- Are there ancillary impacts to species and species habitat supply from the harvesting scenarios

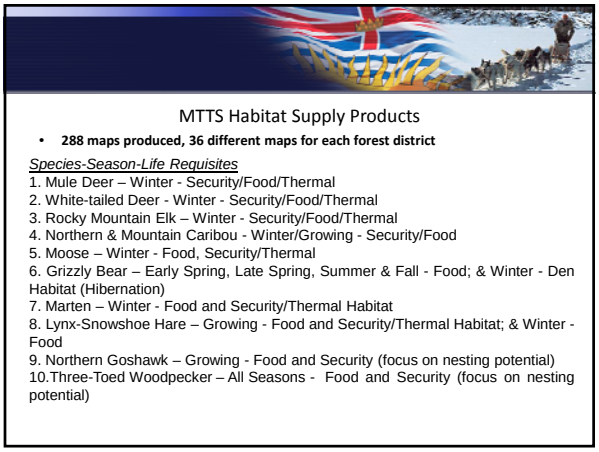
How and why were species selected?

10 species selected on basis of:

- A moderate to high level of existing knowledge;
- TEM/PEM attributes could identify necessary habitat components;
- Species of management concern – Red/Blue listed, harvested species (hunters, trappers, First Nations);
- Designated areas (Ungulate Winter Range) set aside as critical seasonal habitat.
- Mature/old growth dependent species.
- Grizzly Bear, Mountain Caribou, Northern Caribou, Moose, Rocky Mountain Elk, Mule Deer, White-tailed Deer, Marten, Lynx, Northern Goshawk, and Three-toed Woodpecker





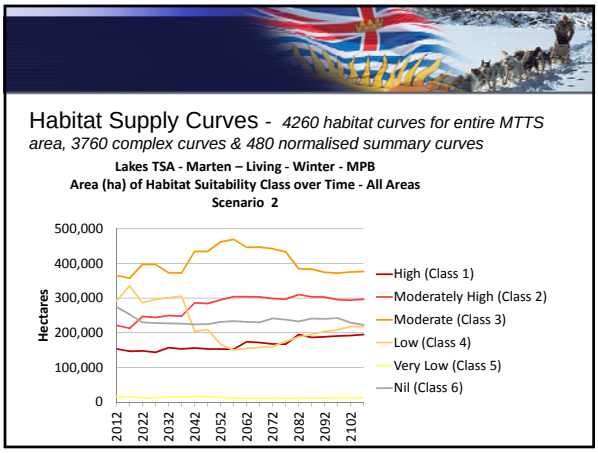


MTTS Habitat Supply Products

- **288 maps produced, 36 different maps for each forest district**

Species-Season-Life Requisites

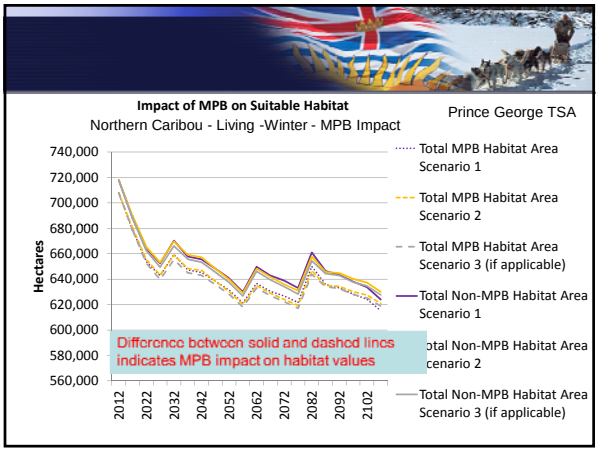
1. Mule Deer – Winter - Security/Food/Thermal
2. White-tailed Deer - Winter - Security/Food/Thermal
3. Rocky Mountain Elk – Winter - Security/Food/Thermal
4. Northern & Mountain Caribou - Winter/Growing - Security/Food
5. Moose – Winter - Food, Security/Thermal
6. Grizzly Bear – Early Spring, Late Spring, Summer & Fall - Food; & Winter - Den Habitat (Hibernation)
7. Marten – Winter - Food and Security/Thermal Habitat
8. Lynx-Snowshoe Hare – Growing - Food and Security/Thermal Habitat; & Winter - Food
9. Northern Goshawk – Growing - Food and Security (focus on nesting potential)
10. Three-Toed Woodpecker – All Seasons - Food and Security (focus on nesting potential)

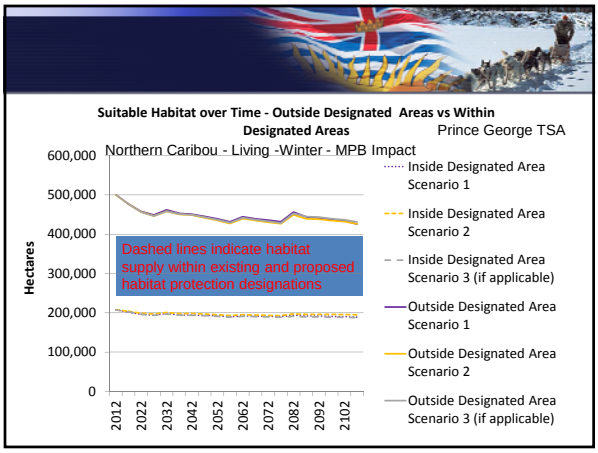


Habitat Supply Curves - *4260 habitat curves for entire MTTS area, 3760 complex curves & 480 normalised summary curves*

Northern Caribou

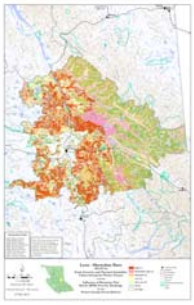
- Habitat supply has been negatively impacted by beetles and associated harvest in all TSAs except in Williams Lake.
- The supply will continue to decline in all TSAs except Lakes where it is predicted to recover and eventually exceed pre beetle levels.
- Logged or burned forest on and adjacent to caribou ranges can indirectly impact caribou population viability by increasing moose populations leading to increased wolf numbers and higher predation on caribou.
- The viability of caribou populations is at risk.





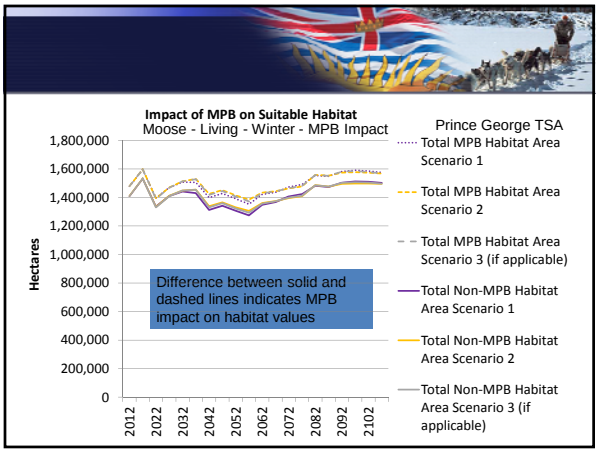
Northern Caribou Winter Suitability Habitat
Prince George TSA

Moose Winter Suitability Habitat
Prince George TSA



Moose

- Beetles and timber harvest Habitat Supply impacts :
  - increased in Lakes, Morice, Prince George and 100 Mile House, with no effect in the other two TSAs.
- The scenarios:
  - supply declines and then eventually recovers in Lakes, Prince George, and Quesnel TSAs.
  - Supply increase in 100 Mile House,
  - no change in Morice TSA.
  - significant fluctuations in supply in Williams Lake leading to an eventual reduction in 100 years.
- Increased roads and access may contribute to increased hunting success, increased illegal harvest, collision losses, increased First Nation sustenance harvest and increased predation risk.

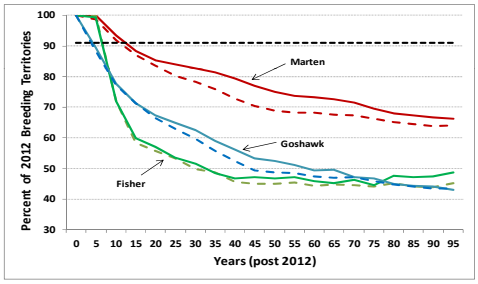


Northern Goshawk

- Beetles and timber harvest Habitat Supply impacts:
  - Declined in all TSAs except Quesnel and Williams Lake TSAs where it has not affected supply.
  - Declines in the Morice, Prince George, and Quesnel TSAs,
  - Increases in the Lakes and 100 Mile TSAs.
  - Declines then recover and then decline again in the Williams Lake TSA.
- The scenarios:
  - negatively affects supply in Morice, Williams Lake, and 100 Mile House TSAs,
  - positively affects supply in the Lakes
  - No influence on supply in Prince George and Quesnel TSAs.

Additional analyses indicate that further increases in disturbance (e.g. timber harvesting or natural agents) above current projected levels will prevent stabilization by the end of the projection period, and may not support viable populations of Fisher and Goshawk

Habitat Trajectories (% of 2012 level) for Marten, Fisher and Goshawk for All TSAs Combined. The dashed lines are for mitigation scenario #2, the horizontal black line is approximate historic average.



Northern Goshawk Habitat based on 2009 MPB data (DCH)

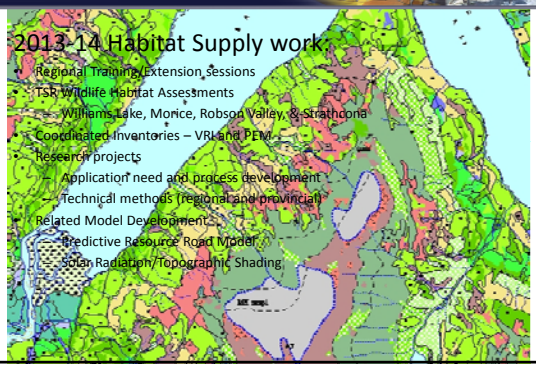
Northern Goshawk Habitat based on 2011 MPB data (DCH)

Conclusions

- Forest resources have been negatively impacted by the catastrophic mountain pine beetle infestation.
- Wildlife habitat supply has been affected both negatively and positively by the beetle infestation and the beetle salvage logging now and into the future.
- The proposed scenarios are predicted to further affect habitat supply and wildlife populations for some species, and may potentially reduce their viability in some TSAs.
- The existing and proposed habitat protection designations are important to mitigating the predicted and existing impact to habitat supply.
- A more detailed analysis of MTTS habitat supply that examines the drivers to change in habitat supply may potentially suggest adjustments or new scenarios that would mitigate habitat supply impacts to wildlife.
- The analysis should be expanded to include the new TSAs recently added to the area of MTTS.

2013-14 Habitat Supply work:

- Regional Training/Extension sessions
- TSR Wildlife Habitat Assessments
  - Williams Lake, Morice, Robson Valley, & Strathcona
- Coordinated Inventories – VRI and PEM
- Research projects
  - Application need and process development
  - Technical methods (regional and provincial)
- Related Model Development
  - Predictive Resource Road Model
  - Solar Radiation/Topographic Shading



Questions about Habitat Supply Information or projects?

Contact Tony at Tony.Button@gov.bc.ca or 250-387-9795

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

What about climate effects on wildfire?

www.environmentdebate.wordpress.com

148

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

Fire and Habitat – what are our options

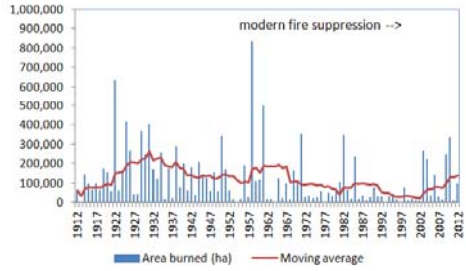
Presentation by Sonja Leverkus

149

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

Anticipating effects from climate change

Fire trends



BC Wildfire Management New Reality

150

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

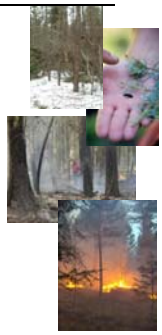
- ***Need to bring this into some thoughtful operational strategic planning***

151

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 resilience with the anticipated effects.
3. Choose the preferred options to manage risk.
4. Empower their use.
5. Monitor and adapt accordingly



152

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

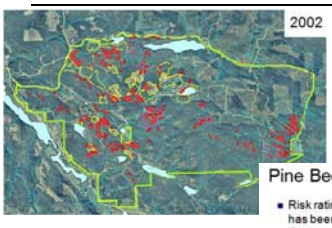
Weather seems unpredictable

- 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

153

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

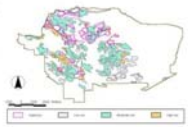
2. Explore Approaches – Scenarios and Risk Assessment



UBC EXAMPLE
E.g., use of MPB sim

Pine Beetle Risk Rating

- Risk rating has been done
- First 1993
- Updated 1997, 2001, 2007



154

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

155

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!

156

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

157

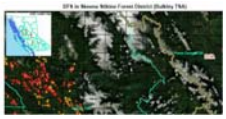
Resilient Forests in a Changing Landscape
Resilience through scenario-based risk management

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*)

158

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.
- 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

159

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.

If this is in place – you will not be paralysed by uncertainty

160

Module 1 Managing for Resilience

ADAPTING TO CLIMATE CHANGE

WHAT CAN BE DONE NOW?

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

162

What can be done now?
Exercise

GROUP EXERCISE – Water

What values are vulnerable to water changes, and what information regarding the changing climate is needed?

Describe local values that are vulnerable to changes in water quantity or quality.

What information is needed to understand the issue?

What will be the impact of climate change – how will we know?

What information would you need to help make an approval decision? – e.g., what tools and or information sources?

E.g. NEWT

http://geoweb.bcogc.ca/apps/newt/newt.html

163

What can be done now?
Exercise

GROUP EXERCISE – Fire and Habitat

What are the implications for habitat and fire with climate change?

Describe local species that are vulnerable to changes in fire frequency and or intensity.

What information is needed to understand the issue?

What will be the impact of climate change – how will we know?

What should we be focusing on?

164

What can be done now?

Provincial initiatives

What is being done provincially:

E.g.,

Forest stewardship action plan on climate change adaptation.

165

What can be done now?
Tools

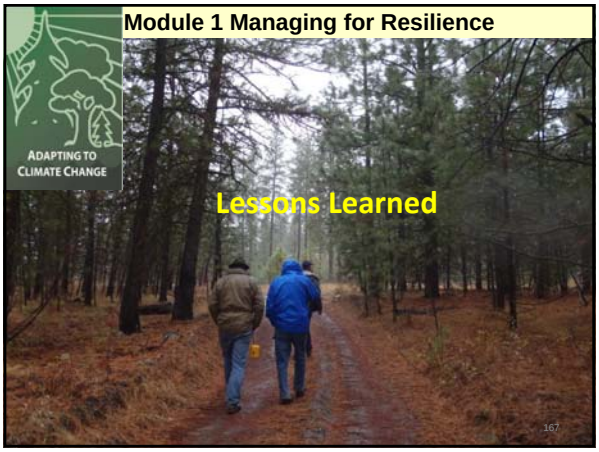
Available tools

An opportunity to discover the range and utility of available tools

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

166

Module 1 Managing for Resilience



167

Lessons Learned

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

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*
- …

Multi day field based workshop

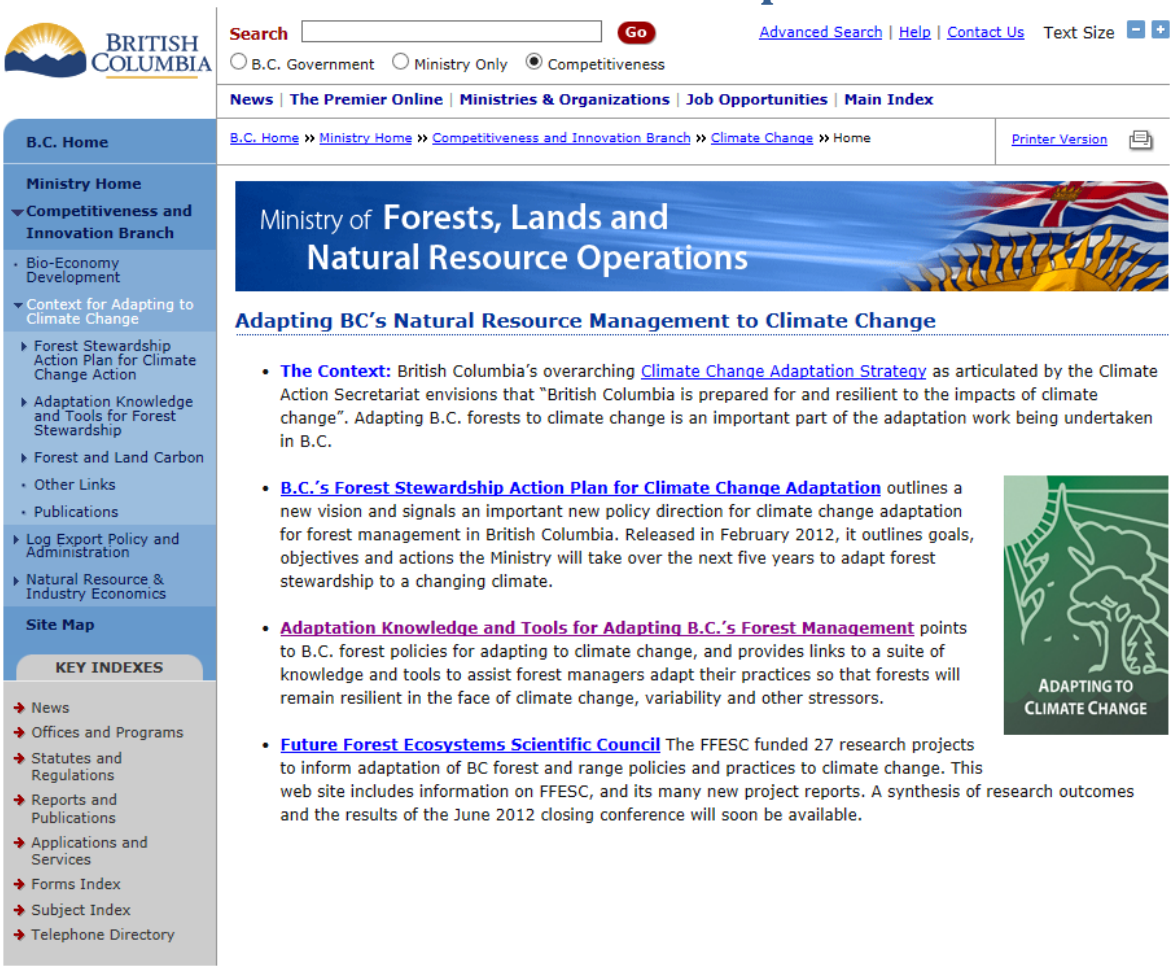
Other modules to follow based on information availability and need – your feedback is welcome

169

Change is here
Learn, Think,
Act, REPEAT…

170

Links to various tools available for practitioners



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 - October 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 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 11
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 16
Forest health hazard ratings in BC: what is potentially an issue? 17
RESULTS data on incidence 17
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
Suggested links on specific subjects – some specific to the North regions: 21
Climate Change Guidelines for Forest Managers 21
Canadian Council of Forest Ministers – suite of four useful resource documents 22
Link to Regional summaries by PCIC 23
Future webinar to solicit feedback 23

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

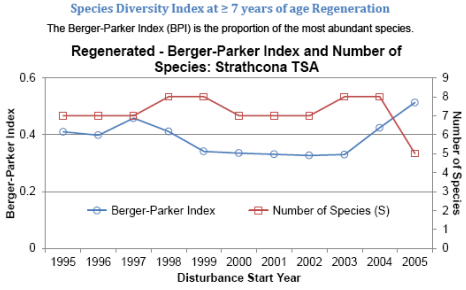
Species monitoring report

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

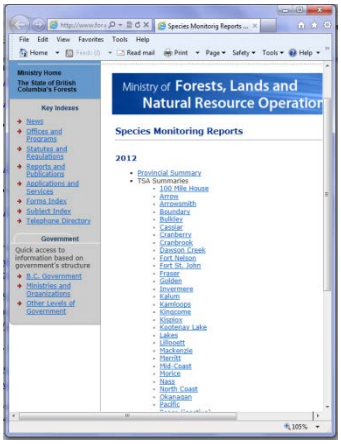
TSA Species summaries

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

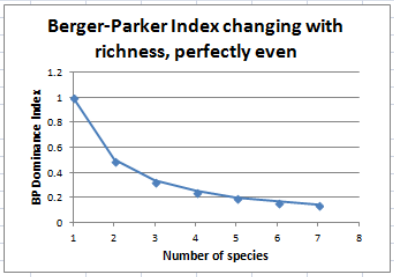
Nmax= Nmax is the volume in the most abundant species

N: Total volume of individuals

Note that the most abundant species is not constant

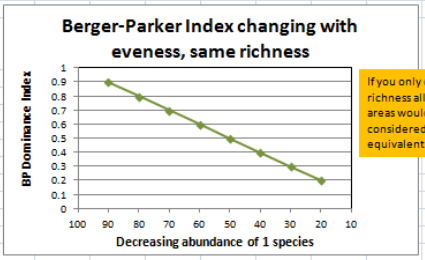
Perfectly even - all species have equal abundance

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.

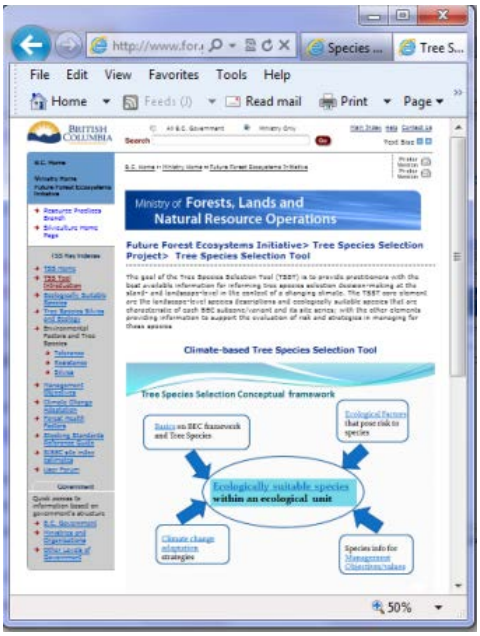
Tree Species selection tool

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

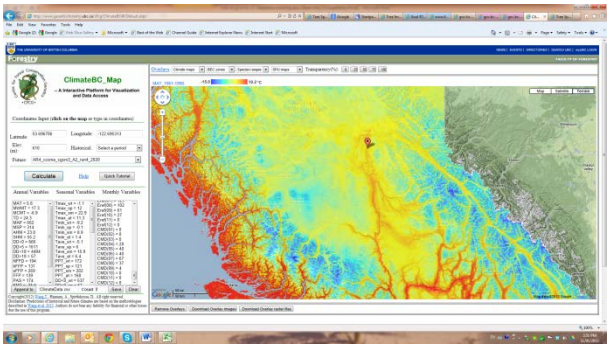
- This link provides a description of the Tree Species Selection Tool. Choose the green box and it takes you to the tool at right.

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

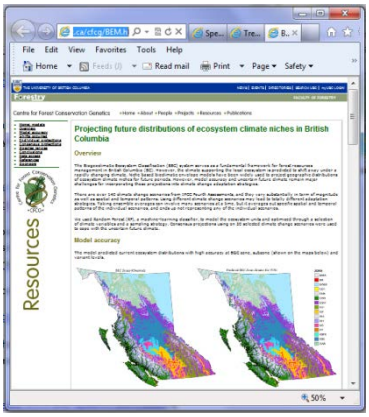


Google map version of Climate BC



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

- Allows for easy exploration of scenarios.

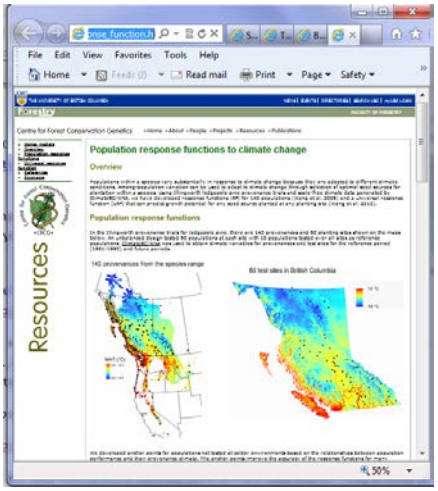


BioClimatic Envelope Modes - shows shifts the zone scale

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

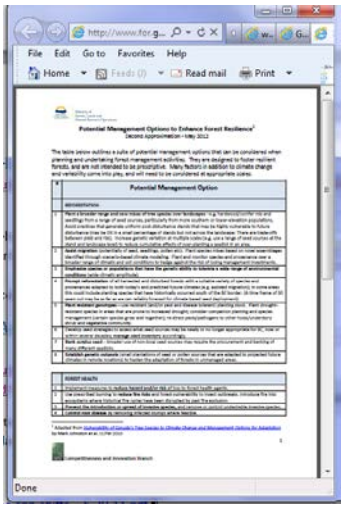
- Stress here the need to track seed source – may already be seed out there that has the propensity for maladaptation.

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.



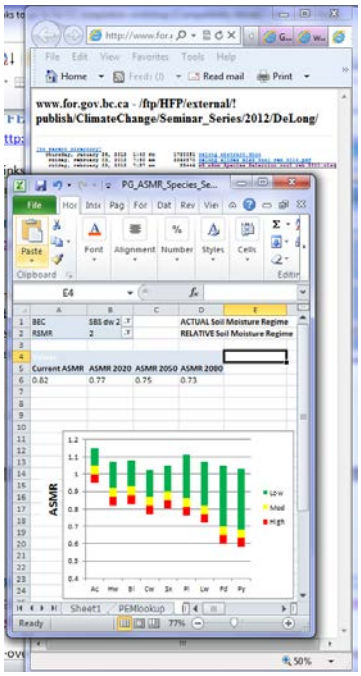
http://www.for.gov.bc.ca/ftp/HFP/external/!publish/ClimateChange/Adaptation/Options/Management_Options_May9_2012.pdf

- 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

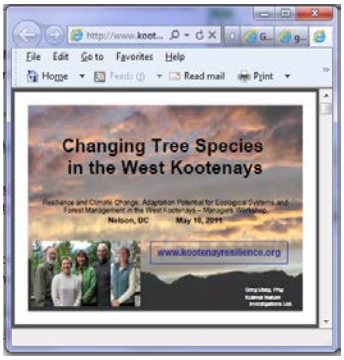


Stand Level Risk and Decision Tool, Link is to a FTP site

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.
- http://www.kootenayresilience.org/ for full list of publications

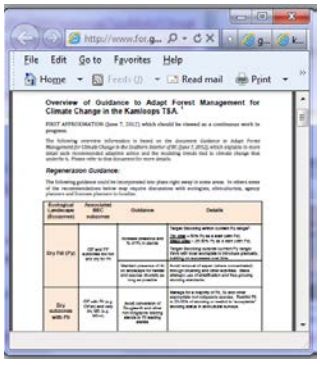
K2 information.

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/

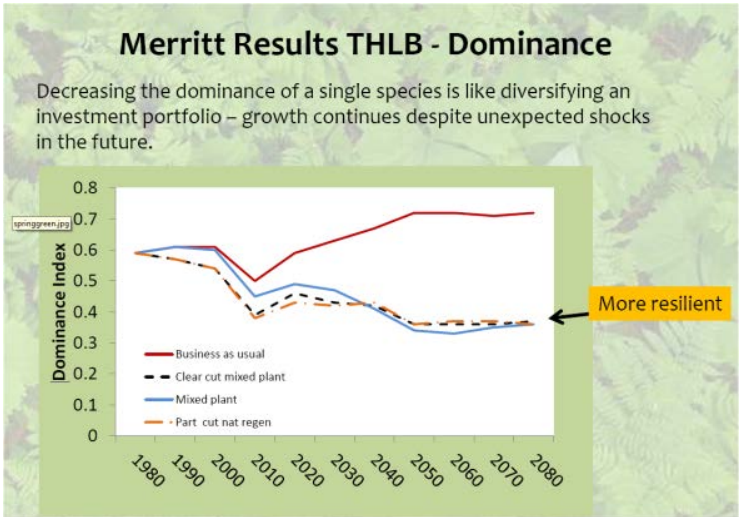
- Nadina Vulnerability Assessment.
- Lots to see here.

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.

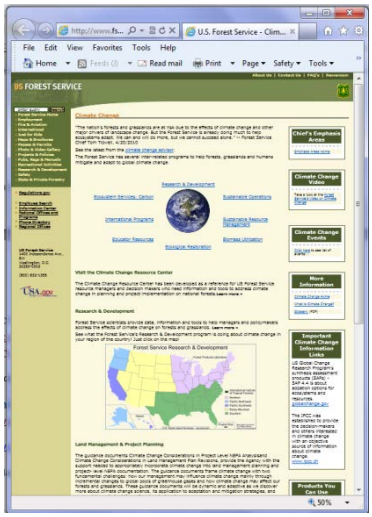
Contact: Caren Dymond Caren.Dymond@gov.bc.ca



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/



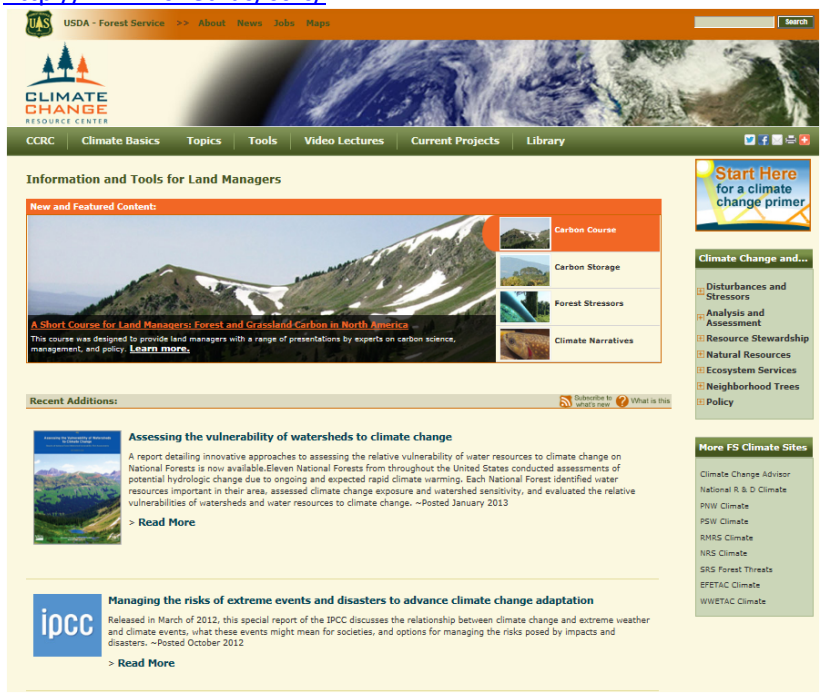
http://www.fs.fed.us/climatechange/advisor/

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

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

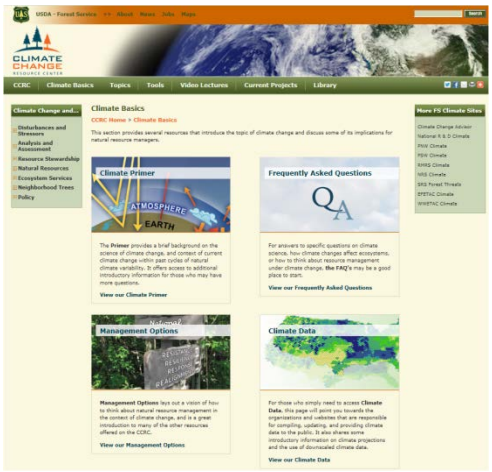
For a thorough overview of adaptation and mitigation see: http://www.fs.fed.us/psw/publications/millar/MillarSwanson_inpress.pdf in Millar, C.I. and C. Swanston. In press. Adaptation and Mitigation. Chapter 4 in National Climate Assessment. US Global Change Research Program.

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



Links to climate background information

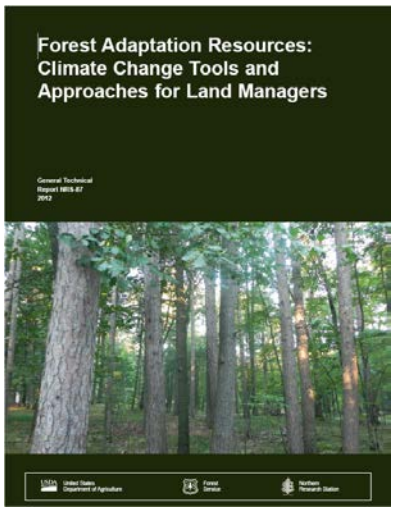
http://www.fs.fed.us/ccrc/climate-basics/

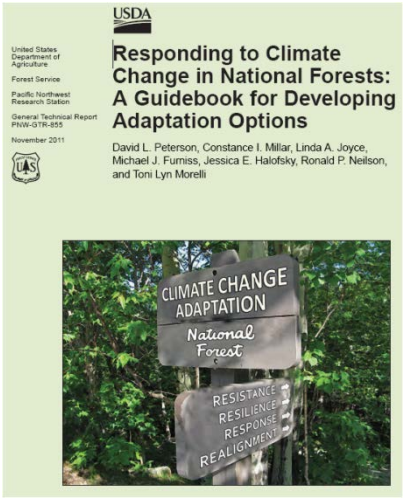


Useful site for understanding climate in an easy to follow approach.

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

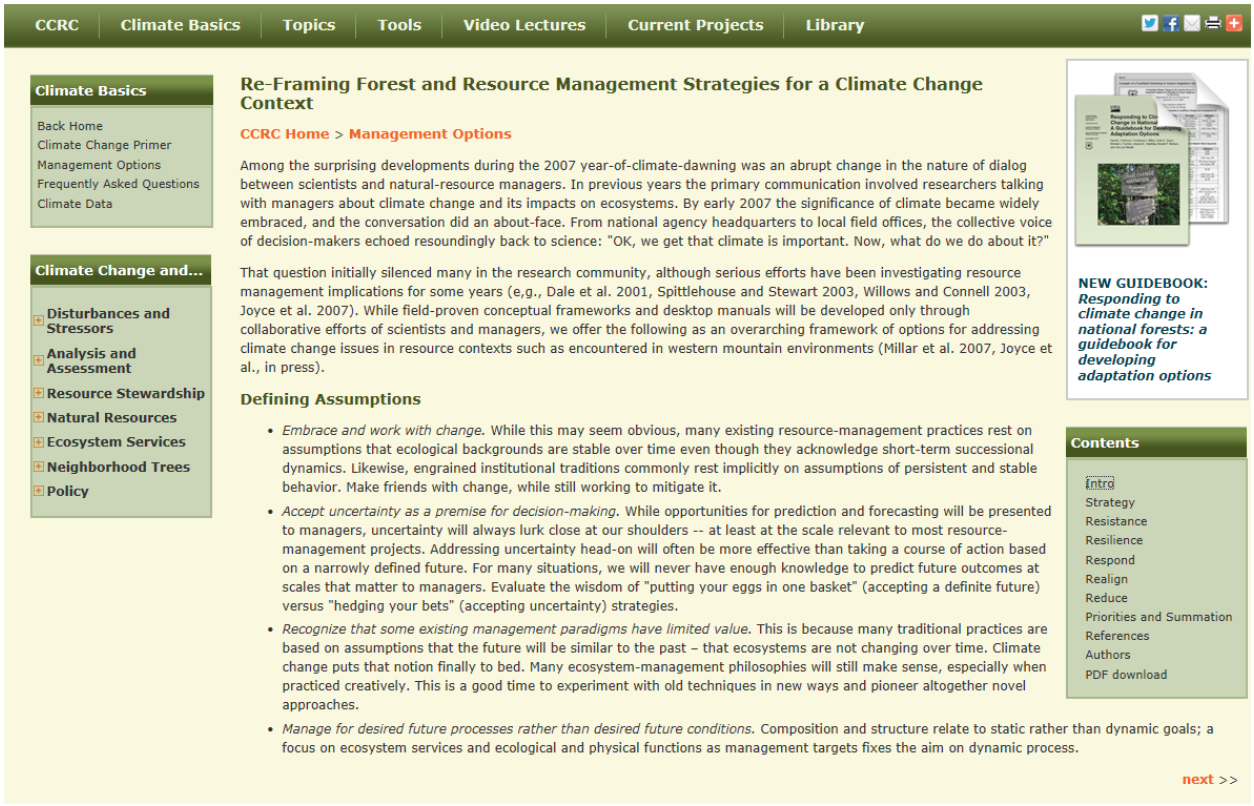
http://www.fs.fed.us/ccrc/hjar/management_strategies.html **Good overview of collaboration:** http://www.fs.fed.us/psw/publications/millar/psw_2011_millar004(littell).pdf **Adaptation resources**: http://www.nrs.fs.fed.us/pubs/gtr/gtr_nrs87.pdf http://www.fs.fed.us/pnw/pubs/pnw_gtr855.pdf





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/



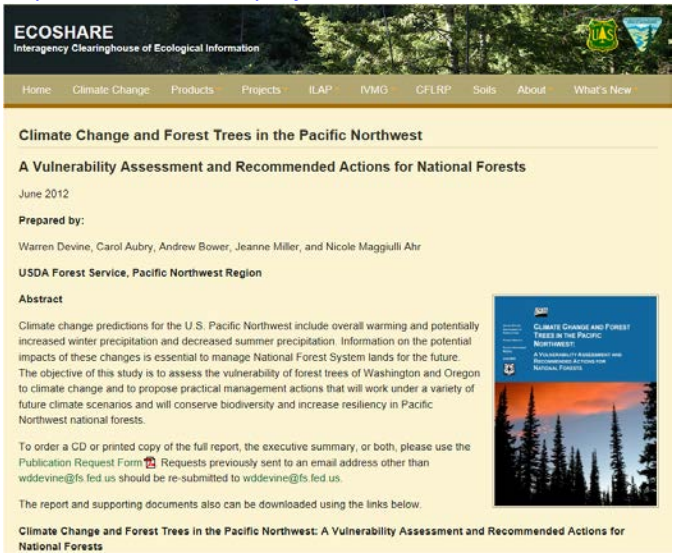
Note the tool bar along the top has links to many useful sites.

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/

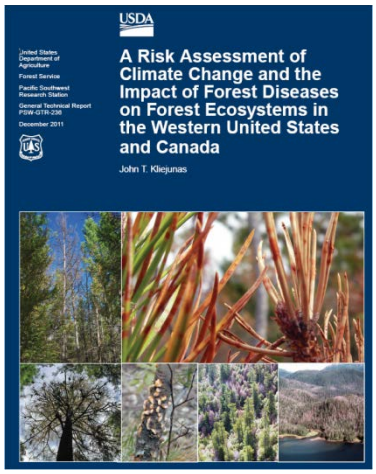


This document provides a list of vulnerabilities based on different characteristics. It clearly provides assumptions and is a useful reference to begin thinking about tree vulnerability.

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

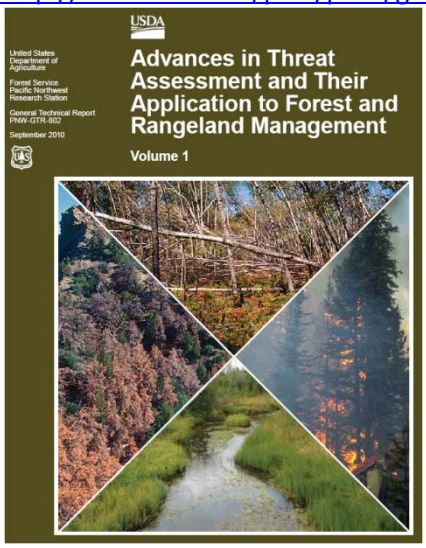
The extensive mortality of yellow-cedar along more than 1000 kilometers of the northern Pacific coast of North America serves as a leading example of climate effects on a forest tree species. In this article, we document our approaches to resolving the causes of tree death, which we explain as a cascade 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

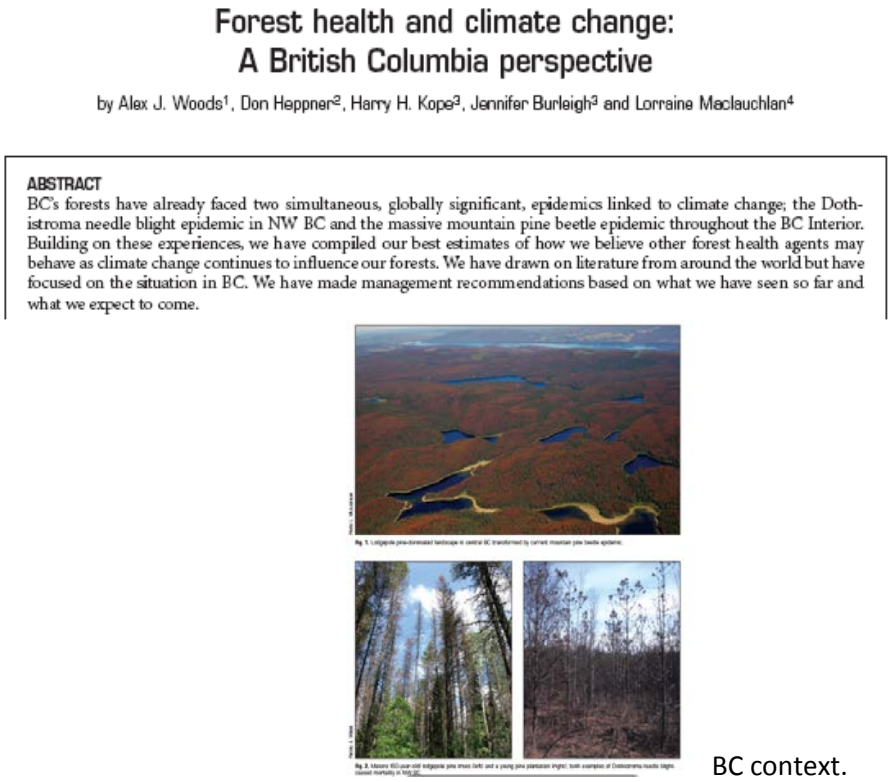
http://www.fs.fed.us/pnw/pubs/gtr802/Vol1/pnw_gtr802vol1.pdf



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

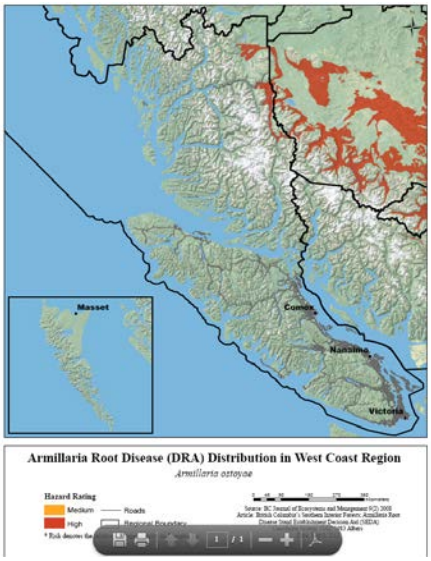
http://journals2.scholarsportal.info/details.xqy?uri=/07060661/v33i0002/117_ithobcciswtp.xml

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

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

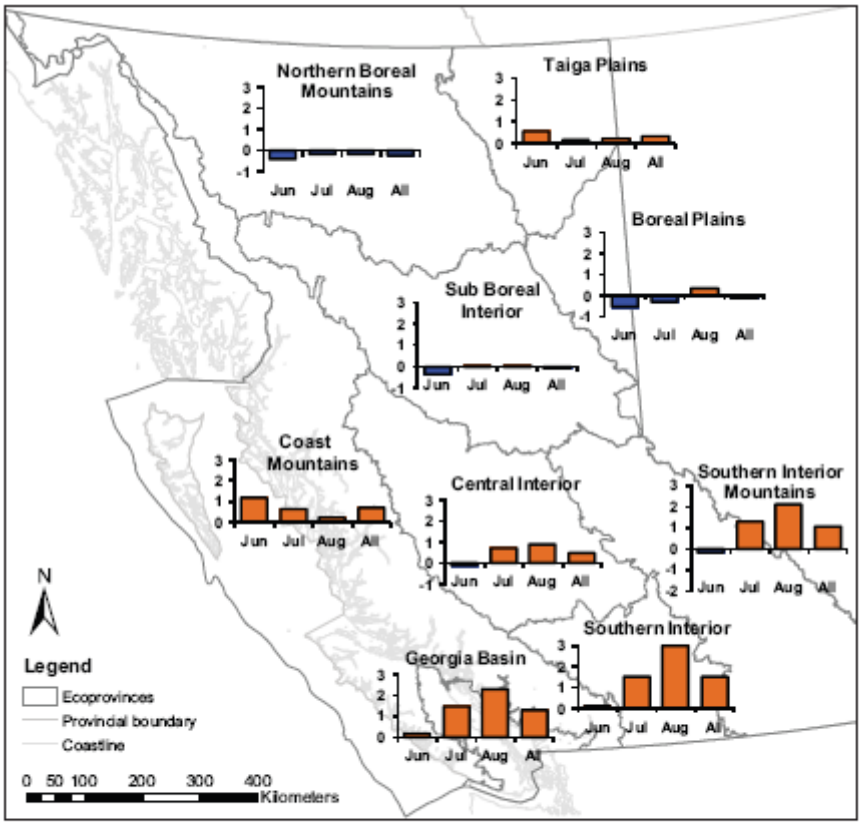


FIGURE 1. Projected changes (approximating the 2080s under the A2 scenario) for British Columbia from current monthly (MSR for June, July, August) and seasonal mean severity ratings (SSR, "all") by ecoprovince. Change is expressed as absolute change in MSR; baseline MSR values range from 0 to 12, with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

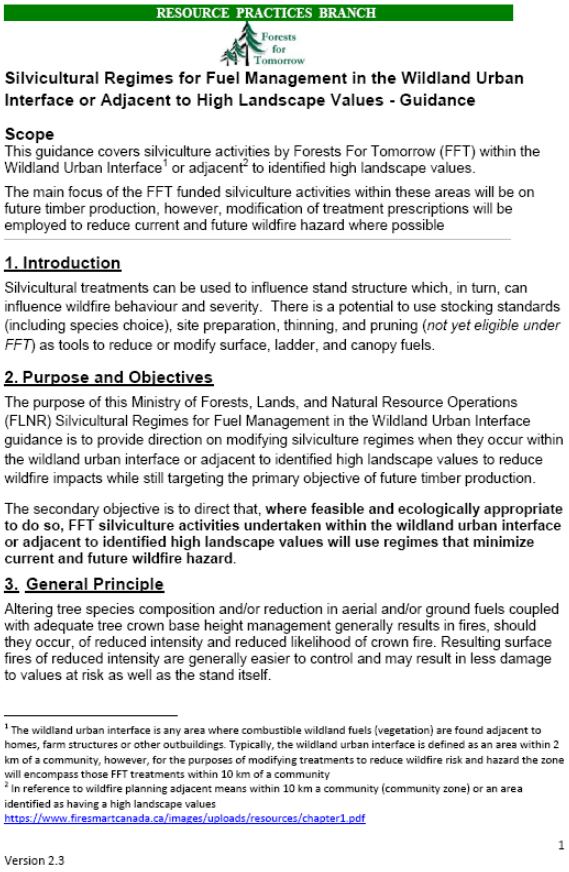
Example information on severity using the Canadian Fire Weather Information System – note regional variation.

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

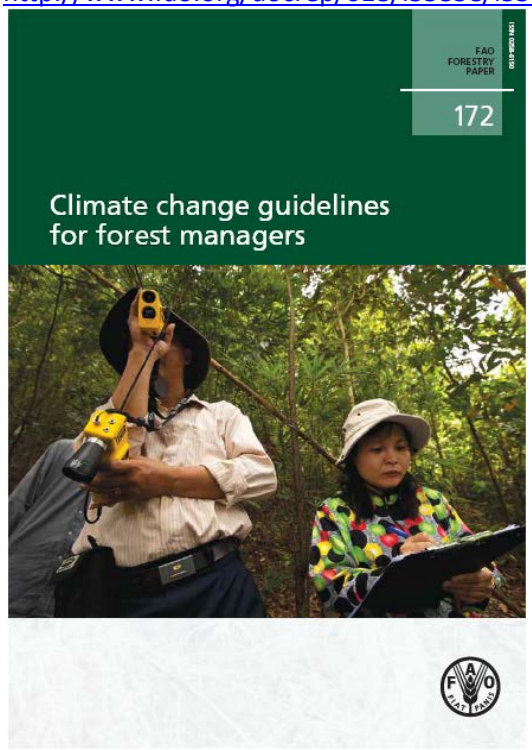
http://www.env.gov.bc.ca/fia/documents/mca_silvbmp.pdf

Suggested links on specific subjects – some specific to the North regions:

Prescribed Fire In BC
http://bcwildfire.ca/prevention/PrescribedFire/docs/BC%20Prescribed%20Fire%20Council%20Brochure.pdf
Ecosystem Restoration in BC http://www.for.gov.bc.ca/hra/Restoration/, http://www.trench-er.com/library/search/search&keywords=wildfire/
Best Management Practices for Invasive Plants in the Oil and Gas Industry:
http://prrd.bc.ca/services/environmental/weed_control/documents/OG-Guide.2013.FINAL.pdf
Seeding Manual for British Columbia http://www.for.gov.bc.ca/hra/Publications/practices/Seeding-Manual/MobileSeedManual/BC%20RL%20Seeding%20Manual_web_single_150dpi.09.04.pdf
Peace Liard Revegetation Manual
http://prrd.bc.ca/services/environmental/weed_control/documents/NEIPC_Reveg_manual_PeaceLiard_April2010_000.pdf

Climate Change Guidelines for Forest Managers

http://www.fao.org/docrep/018/i3383e/i3383e.pdf

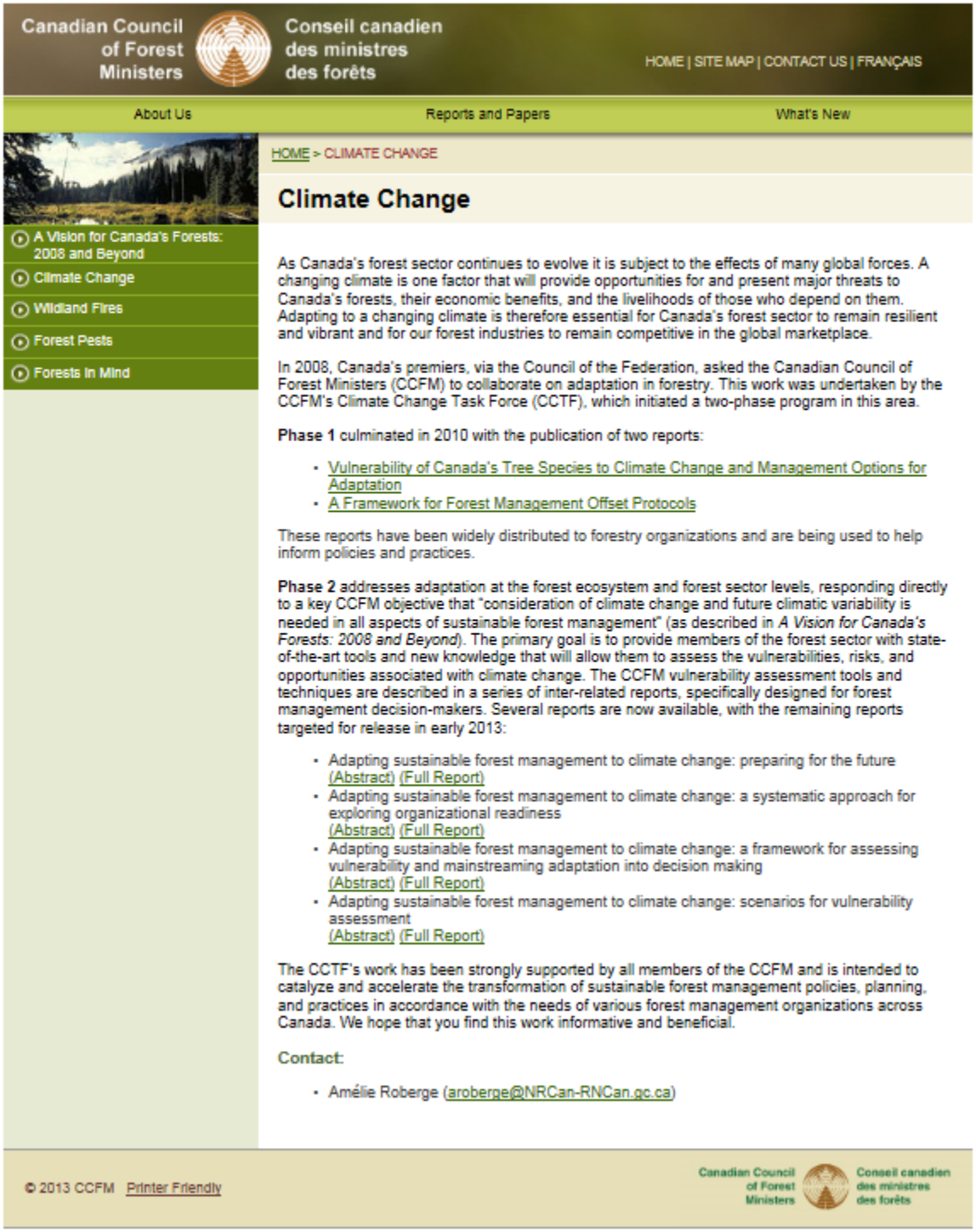


The framework is on page 24:

- Yield & productivity p. 26
- Biodiversity p. 28
- Species p. 29
- Water p. 31
- Fire p. 34
- Pests p. 38
- Extreme events p 41
- Sea level rise p. 44
- Social p. 46
- Economic p. 50
- Institutional p. 54
- Mitigation p. 55

Canadian Council of Forest Ministers – suite of four useful resource documents

http://www.ccfm.org/english/coreproducts-cc.asp



Canadian Council of Forest Ministers | Conseil canadien des ministres des forêts

HOME | SITE MAP | CONTACT US | FRANÇAIS

About Us | Reports and Papers | What's New

HOME > CLIMATE CHANGE

Climate Change

- A Vision for Canada's Forests: 2008 and Beyond
- Climate Change
- Wildland Fires
- Forest Pests
- Forests In Mind

As Canada's forest sector continues to evolve it is subject to the effects of many global forces. A changing climate is one factor that will provide opportunities for and present major threats to Canada's forests, their economic benefits, and the livelihoods of those who depend on them. Adapting to a changing climate is therefore essential for Canada's forest sector to remain resilient and vibrant and for our forest industries to remain competitive in the global marketplace.

In 2008, Canada's premiers, via the Council of the Federation, asked the Canadian Council of Forest Ministers (CCFM) to collaborate on adaptation in forestry. This work was undertaken by the CCFM's Climate Change Task Force (CCTF), which initiated a two-phase program in this area.

Phase 1 culminated in 2010 with the publication of two reports:

- Vulnerability of Canada's Tree Species to Climate Change and Management Options for Adaptation
- A Framework for Forest Management Offset Protocols

These reports have been widely distributed to forestry organizations and are being used to help inform policies and practices.

Phase 2 addresses adaptation at the forest ecosystem and forest sector levels, responding directly to a key CCFM objective that "consideration of climate change and future climatic variability is needed in all aspects of sustainable forest management" (as described in *A Vision for Canada's Forests: 2008 and Beyond*). The primary goal is to provide members of the forest sector with state-of-the-art tools and new knowledge that will allow them to assess the vulnerabilities, risks, and opportunities associated with climate change. The CCFM vulnerability assessment tools and techniques are described in a series of inter-related reports, specifically designed for forest management decision-makers. Several reports are now available, with the remaining reports targeted for release in early 2013:

- Adapting sustainable forest management to climate change: preparing for the future (Abstract) (Full Report)
- Adapting sustainable forest management to climate change: a systematic approach for exploring organizational readiness (Abstract) (Full Report)
- Adapting sustainable forest management to climate change: a framework for assessing vulnerability and mainstreaming adaptation into decision making (Abstract) (Full Report)
- Adapting sustainable forest management to climate change: scenarios for vulnerability assessment (Abstract) (Full Report)

The CCTF's work has been strongly supported by all members of the CCFM and is intended to catalyze and accelerate the transformation of sustainable forest management policies, planning, and practices in accordance with the needs of various forest management organizations across Canada. We hope that you find this work informative and beneficial.

Contact:

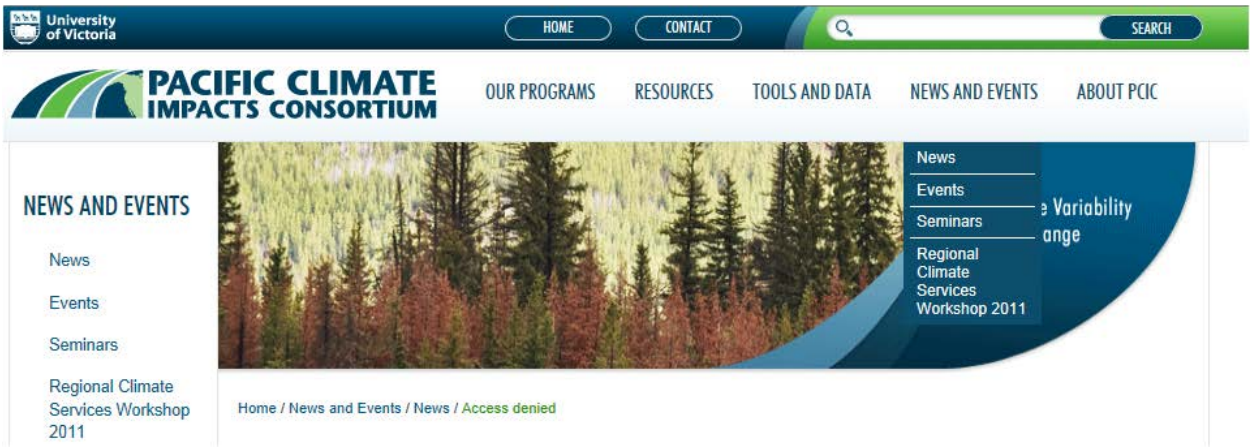
- Amélie Roberge (aroberge@NRCan-RNCan.gc.ca)

© 2013 CCFM Printer Friendly

Canadian Council of Forest Ministers | Conseil canadien des ministres des forêts

Link to Regional summaries by PCIC

http://www.pacificclimate.org/news-and-events/news/2013/bc-regional-climate-summaries-now-online



Future webinar to solicit feedback

The Pacific Climate Impacts Consortium will be running a webinar in the coming months as part of a project to develop National Guidelines on the Use of Climate Scenarios for NRCAN, in collaboration with Ouranos http://www.ouranos.ca/en. As an attendee, you will be invited to attend. The purpose of the webinar is to obtain feedback and questions from people who have attended climate change workshops in regards to what information would be most valuable to include in a guidelines document on the use of climate information.