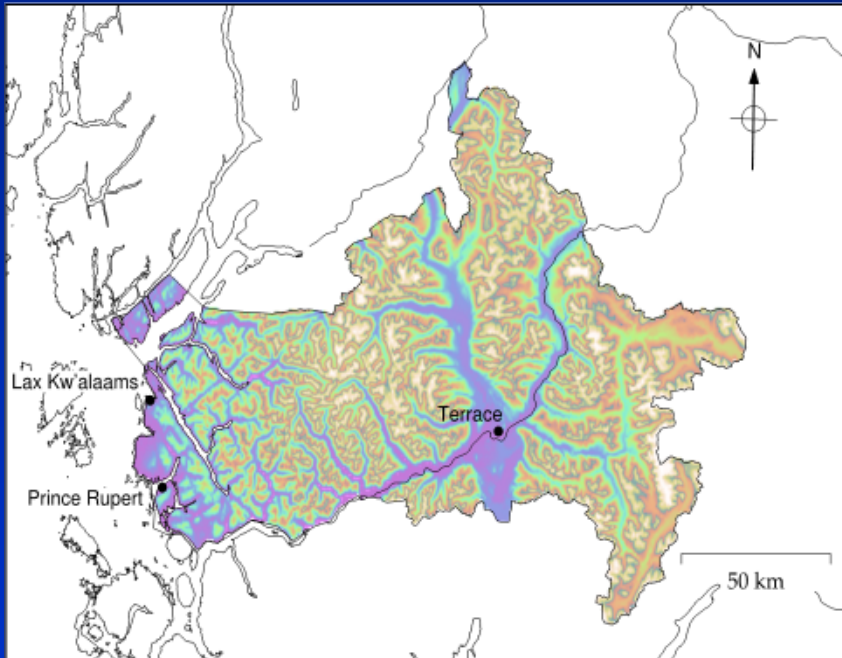# Climate Change Adaptation Planning for Northwest Skeena Communities
Projected Vegetation Changes
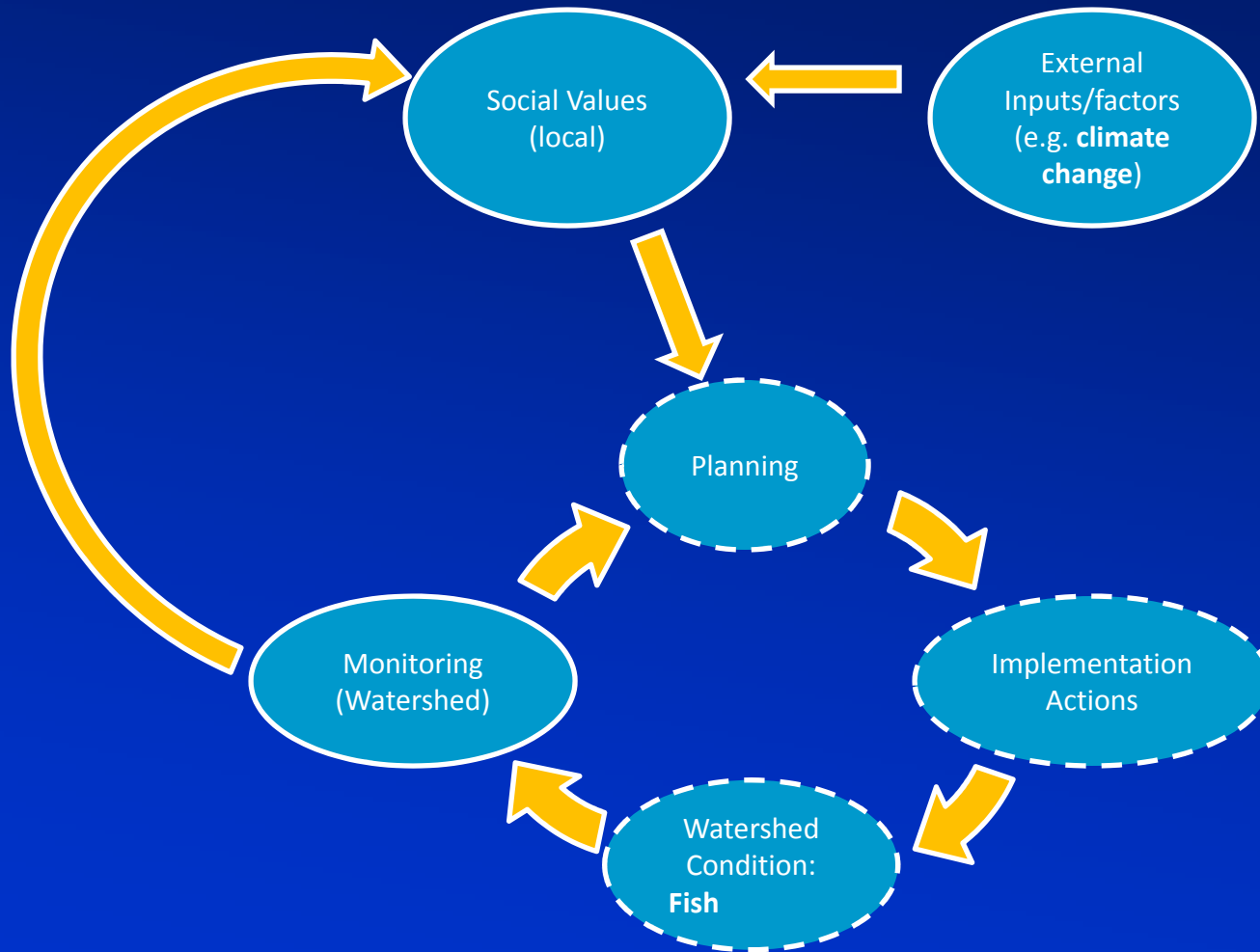
Joe Melton[1], Don Robinson[2], Jed Kaplan[1] & Dave Marmorek[2]

[1] ARVE Group, École Polytechnique Fédérale de Lausanne, Switzerland
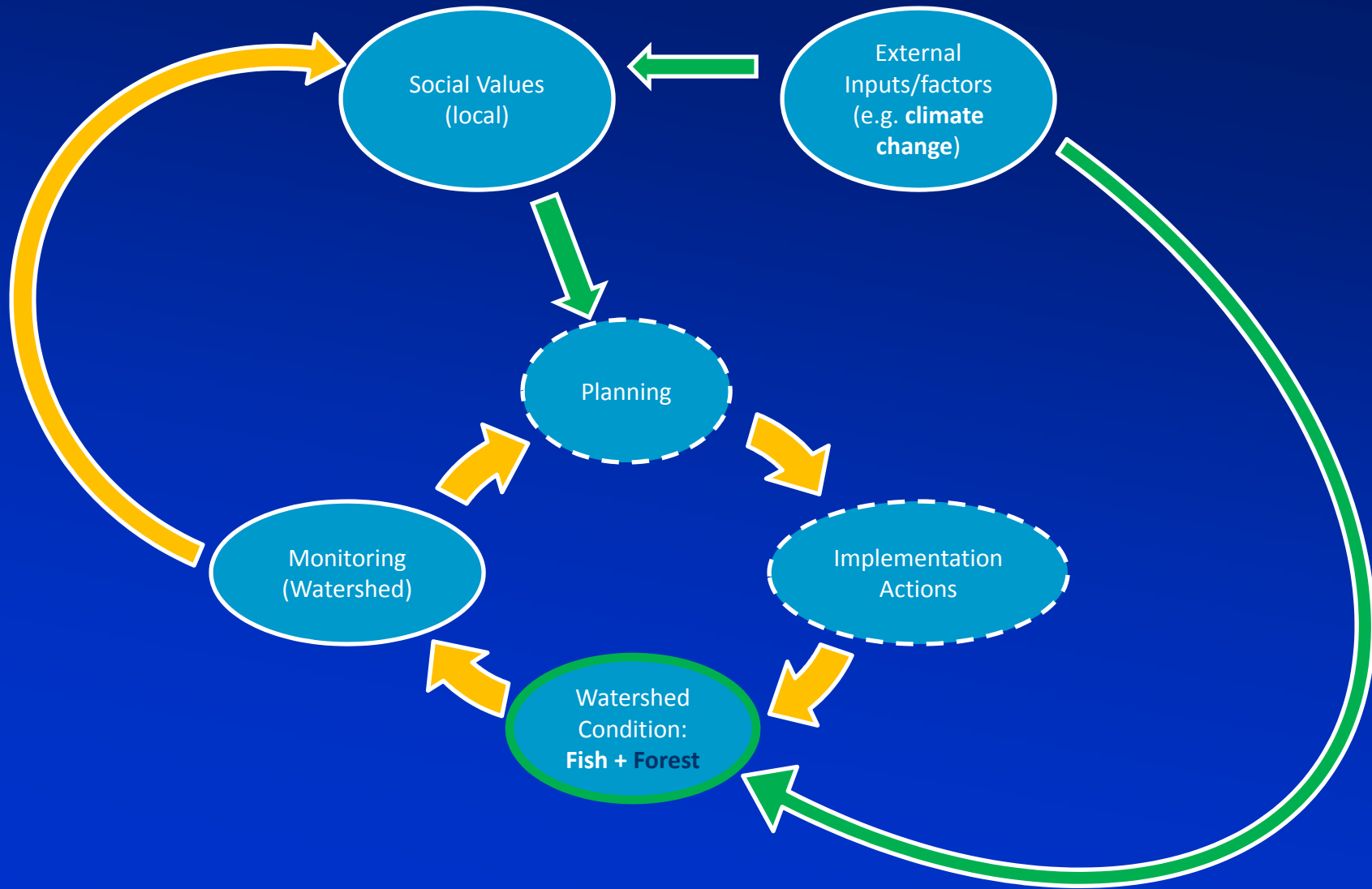[2] ESSA Technologies, Vancouver

Planning… Where Does "Vegetation Change" Fit?

Planning… Where Does "Vegetation Change" Fit?

Why Use a Simulation Model?

Simulation models can help to…
- organize the thinking of many people in a consistent way
- combine, test and refine scientific knowledge
- provide possible answers to "what if" questions
    about the future *when past experience may not be enough*

Can use current information and knowledge, to cautiously extrapolate to conditions that may not have been seen before

Every time you read a tide-table, check the weather forecast or look at a stand growth curve, you're checking with a simulation model. You might not trust it totally, but you check it anyway and then make up your own mind.

Introducing… Global Climate Models

simulate the process of heating, cooling &
  air movement over entire globe: *GHGs*
multiple air layers & ocean layers
can include sea ice, clouds, vegetation
about 300 km resolution

numerous GCMs: different governments,
  laboratories and universities involved

United Nations (IPCC) a major contributor: scenarios of future
  human development, analysis & communication

*No one knows which GCM is the best, or which human
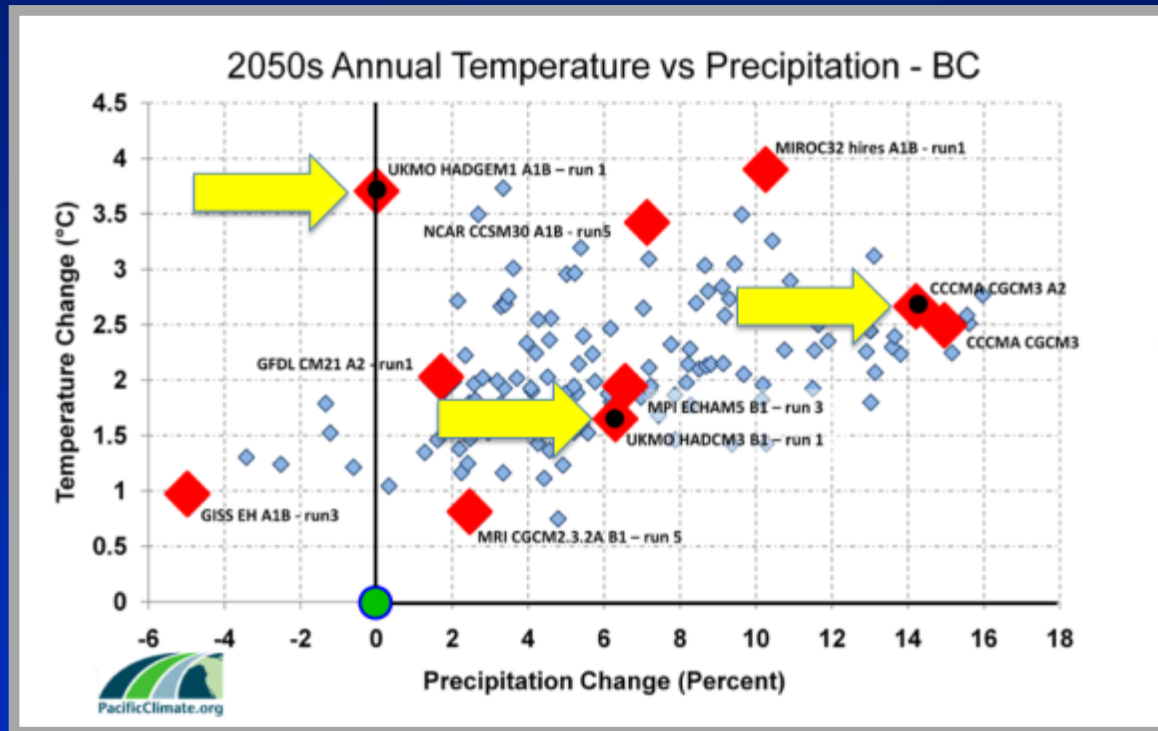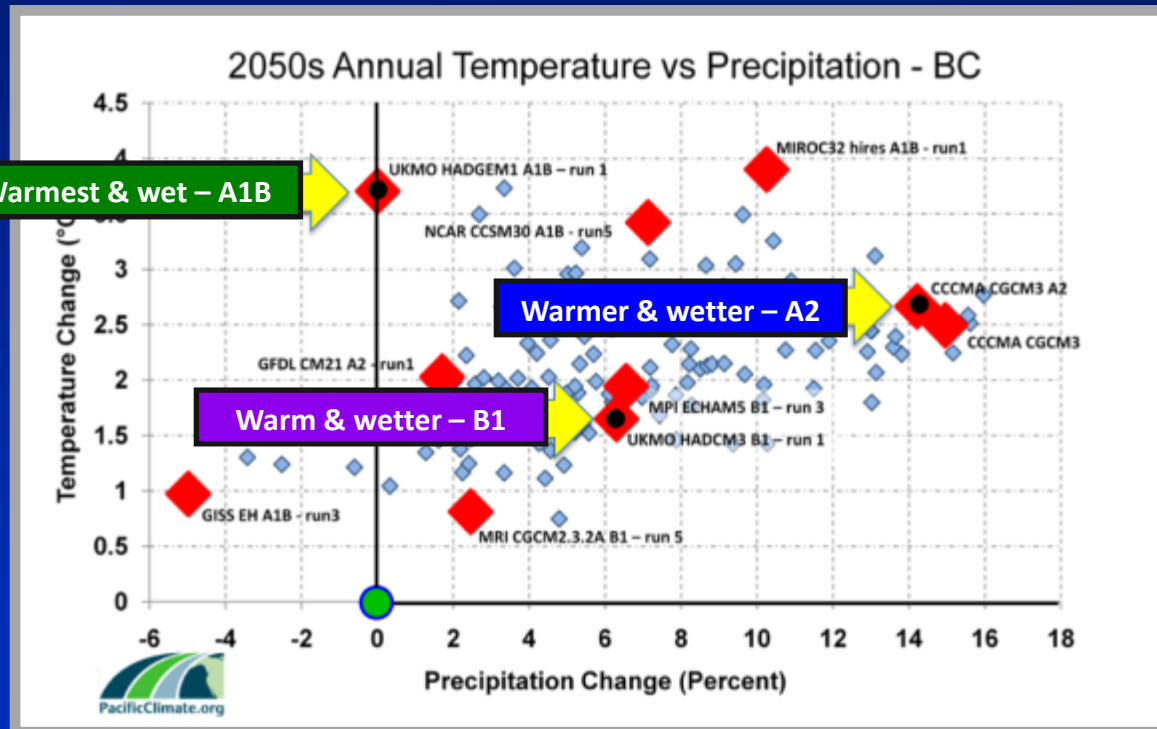development-industrialization scenario will actually happen*

Introducing... Global Climate Models
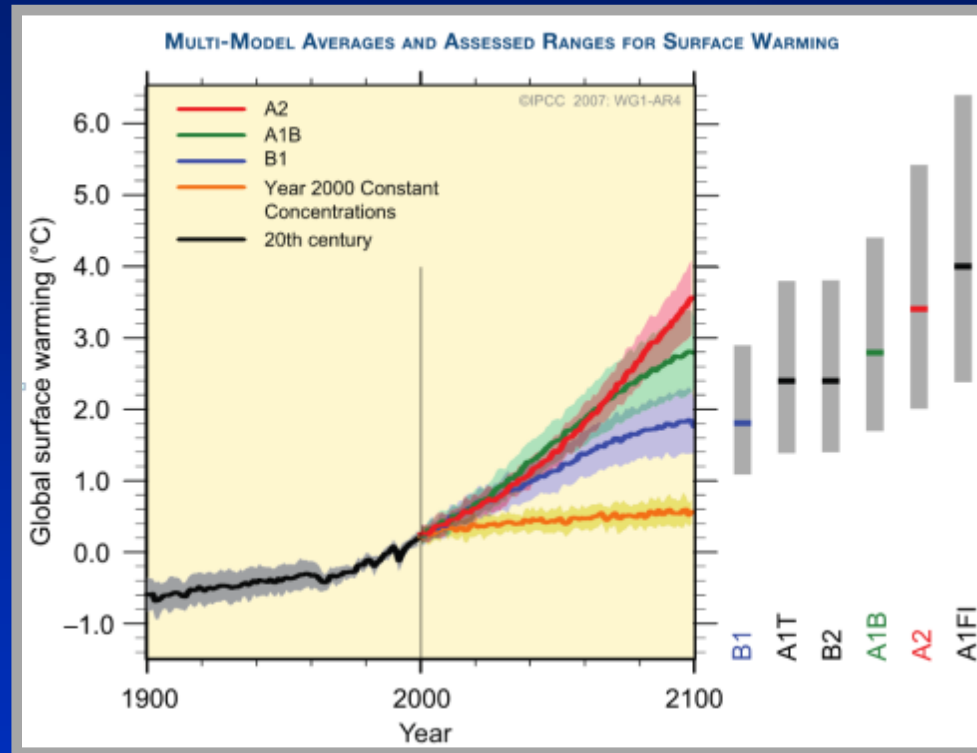
No one knows which GCM is the best, or which human development-industrialization scenario will actually happen

Solution 1: use an **average** from multiple GCMs and look for adaptation and mitigation options that do some good under many development scenarios

Introducing... Global Climate Models

2050s Annual Temperature vs Precipitation - BC

No one knows which GCM is the best, or which human development-industrialization scenario will actually happen

Solution 2: use predictions from a **range of models & scenarios** and look for adaptation and mitigation options that do some good under many development scenarios

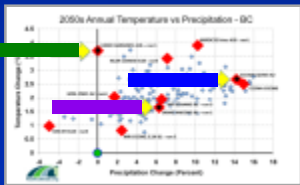# *Introducing...* Global Climate Models

*No one knows which GCM is the best, or which human development-industrialization scenario will actually happen*

Solution 2: use a range of model predictions and look for adaptation and mitigation options that do some good under many development scenarios

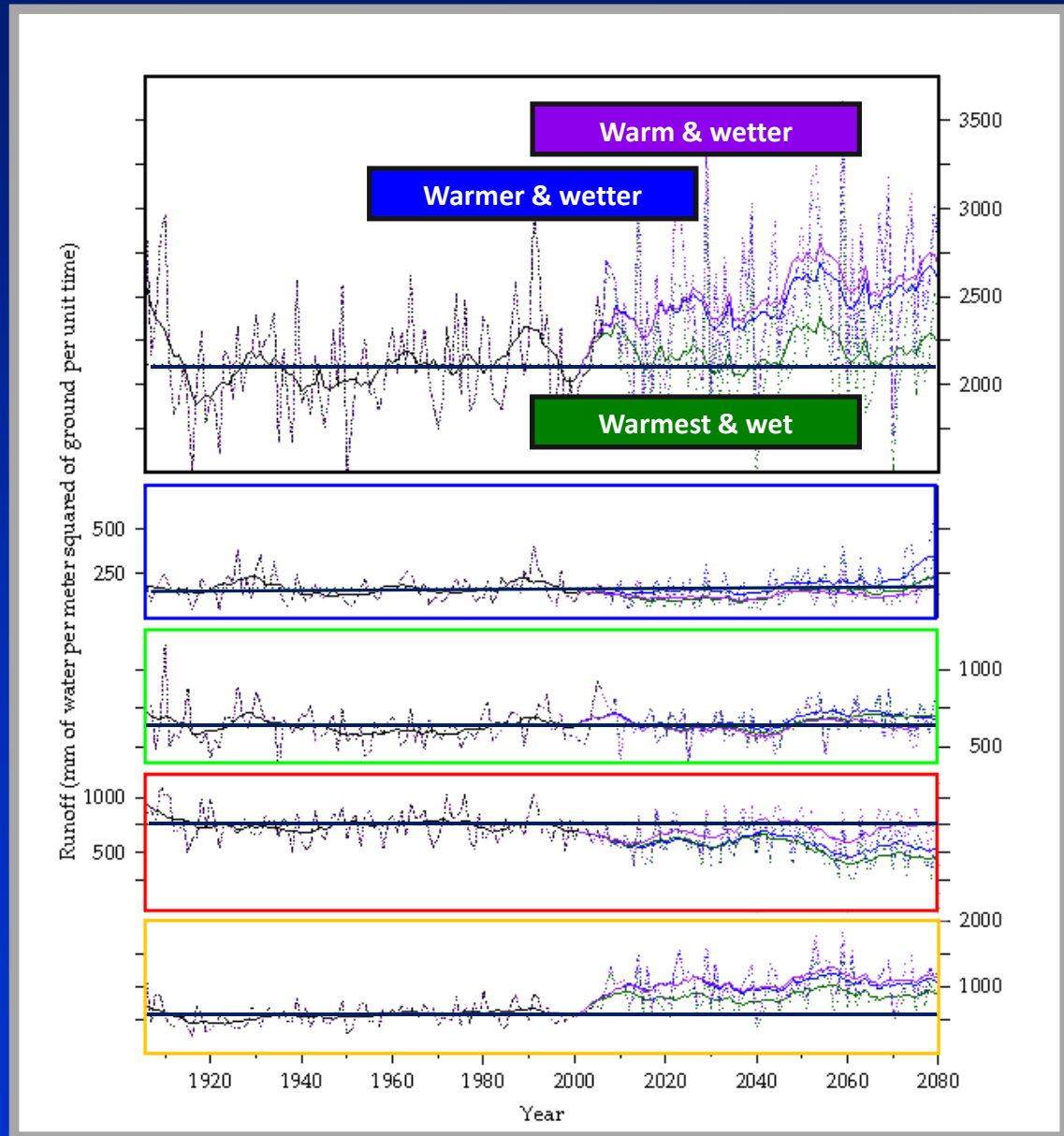# *Introducing...* Global Climate Models
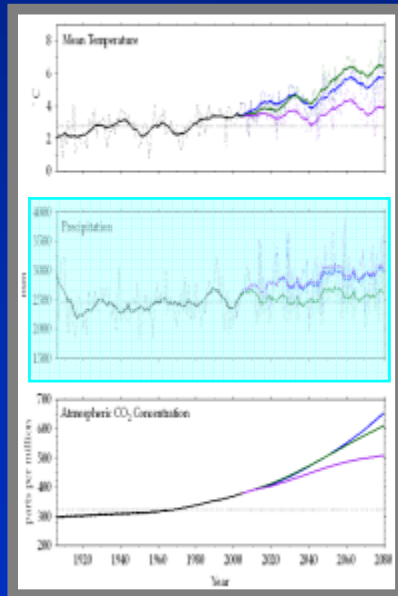
average
values
over entire
region

temperature,
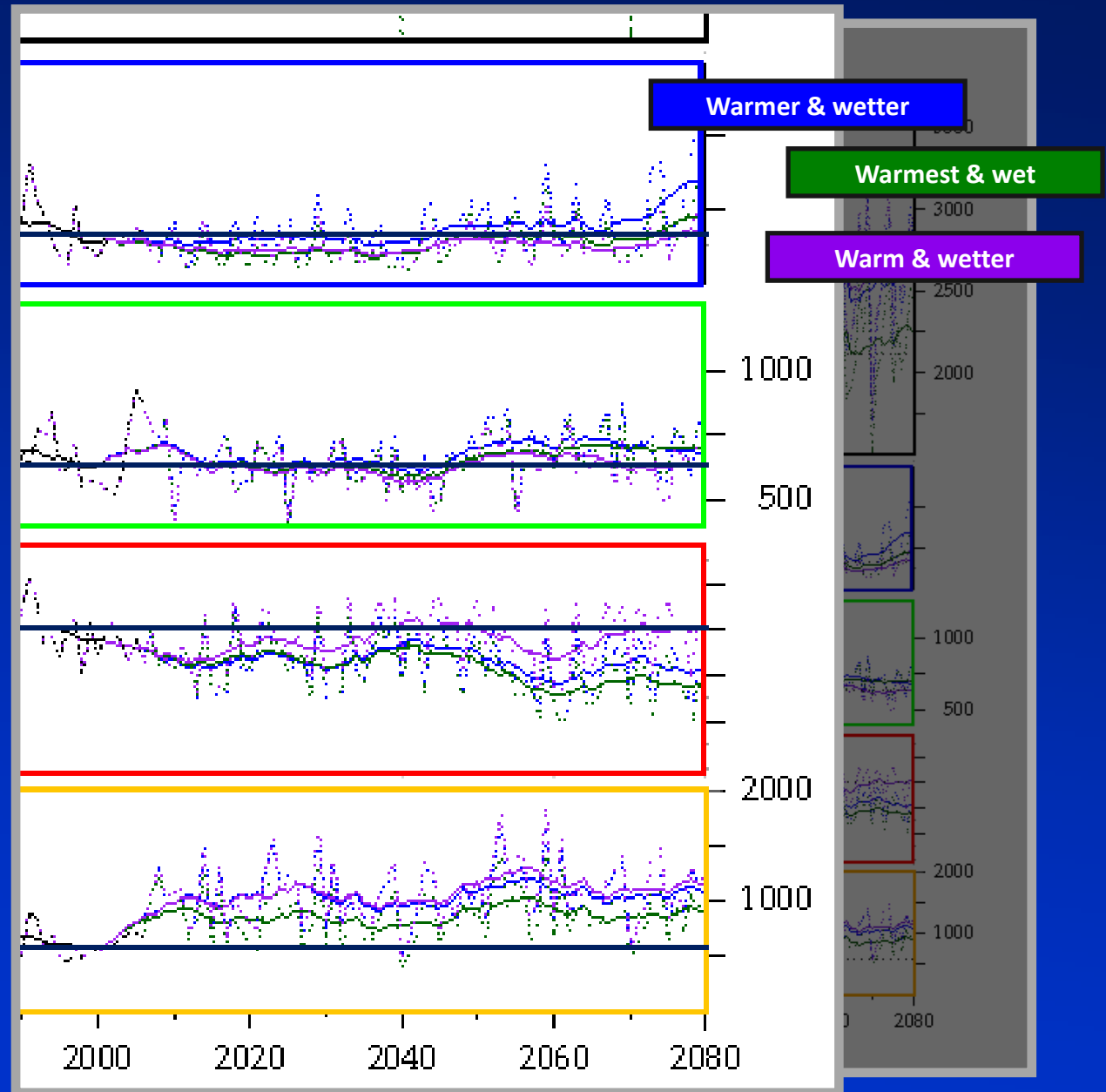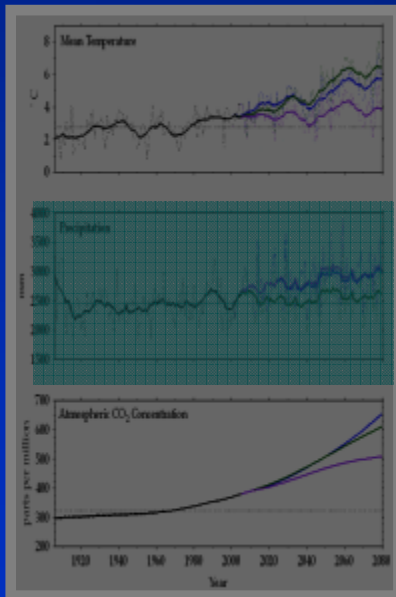precipitation,
& CO_2
are all fed
into the
vegetation
model

Warmest & wet

Warmer & wetter

Warm & wetter
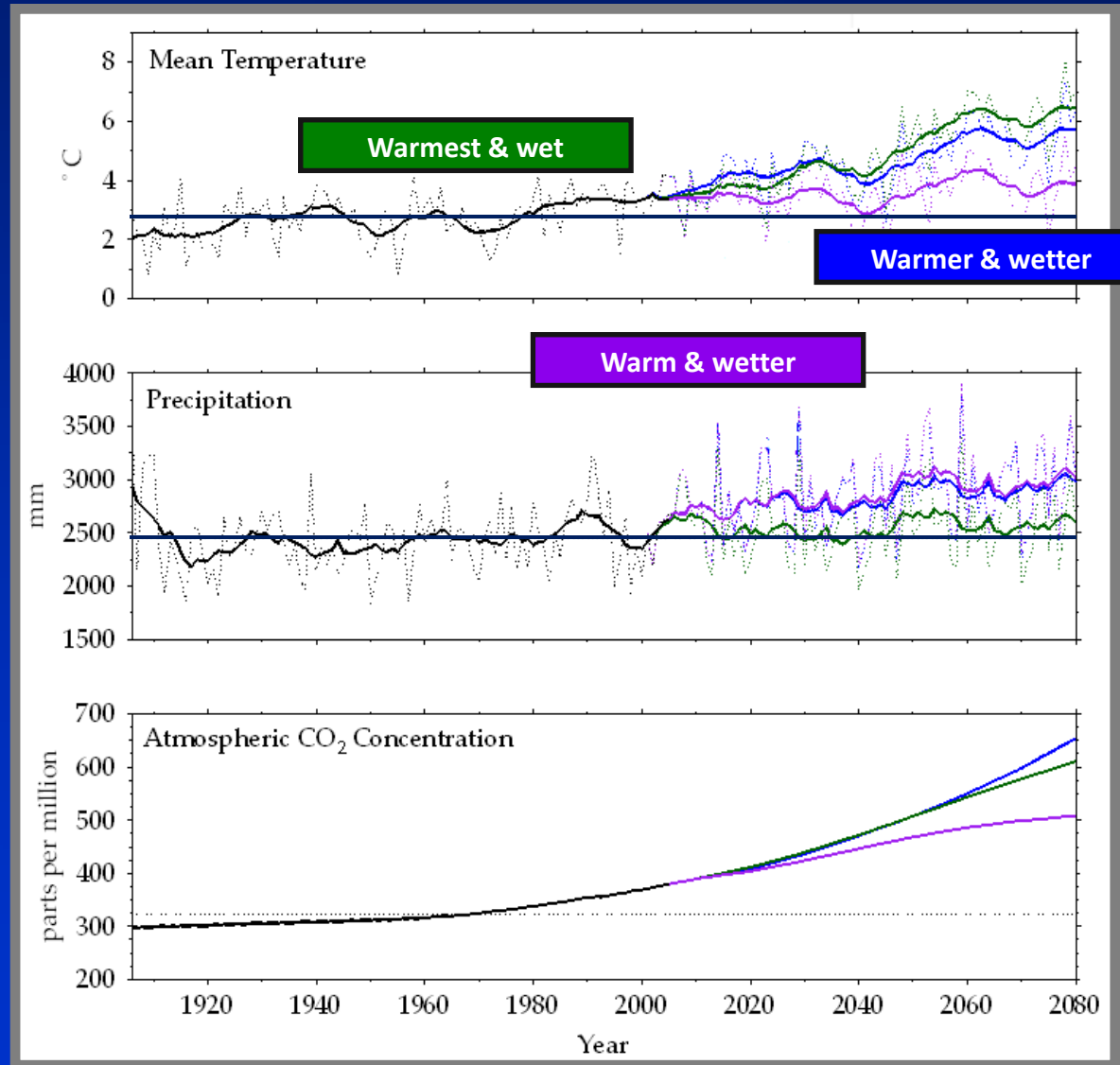
Introducing… Global Climate Models

changes in runoff timing

Introducing… Global Climate Models

changes in runoff timing

Warmer & wetter
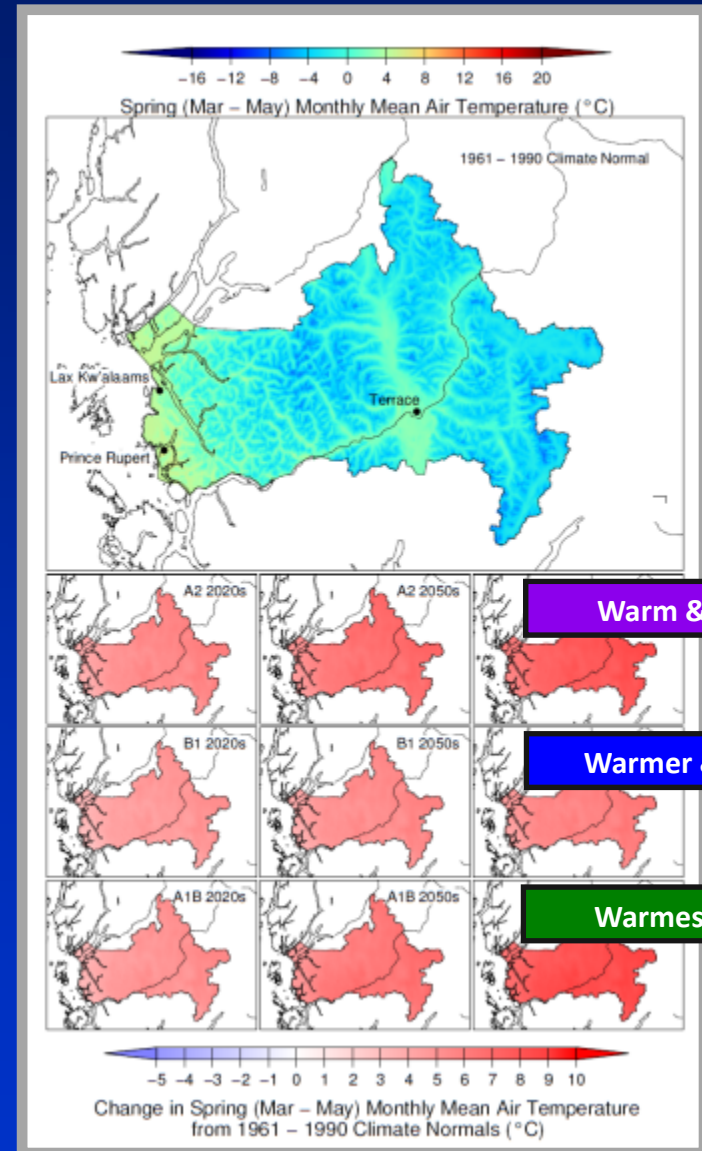
Warmest & wet

Warm & wetter

Introducing... Global Climate Models

local conditions "downscaled" from large-scale simulation models

daily pattern based on *monthly* averages

may not capture the full range of future conditions

may not capture changes in localized intense weather events like storms, heavy rain or snow, ocean conditions

Spring (Mar – May) Monthly Mean Air Temperature (°C)
1961 – 1990 Climate Normal

Warm & wetter

Warmer & wetter

Warmest & wet

Change in Spring (Mar – May) Monthly Mean Air Temperature from 1961 – 1990 Climate Normals (°C)

Introducing… The LPJ-Guess vegetation model

responsive to light, heat, moisture & CO_2
calibrated for about 20 northwest tree species
grows cohorts of trees, plus grass
tree growth sensitive to surrounding stand conditions
allows clearcut and stand-replacing fire with limited
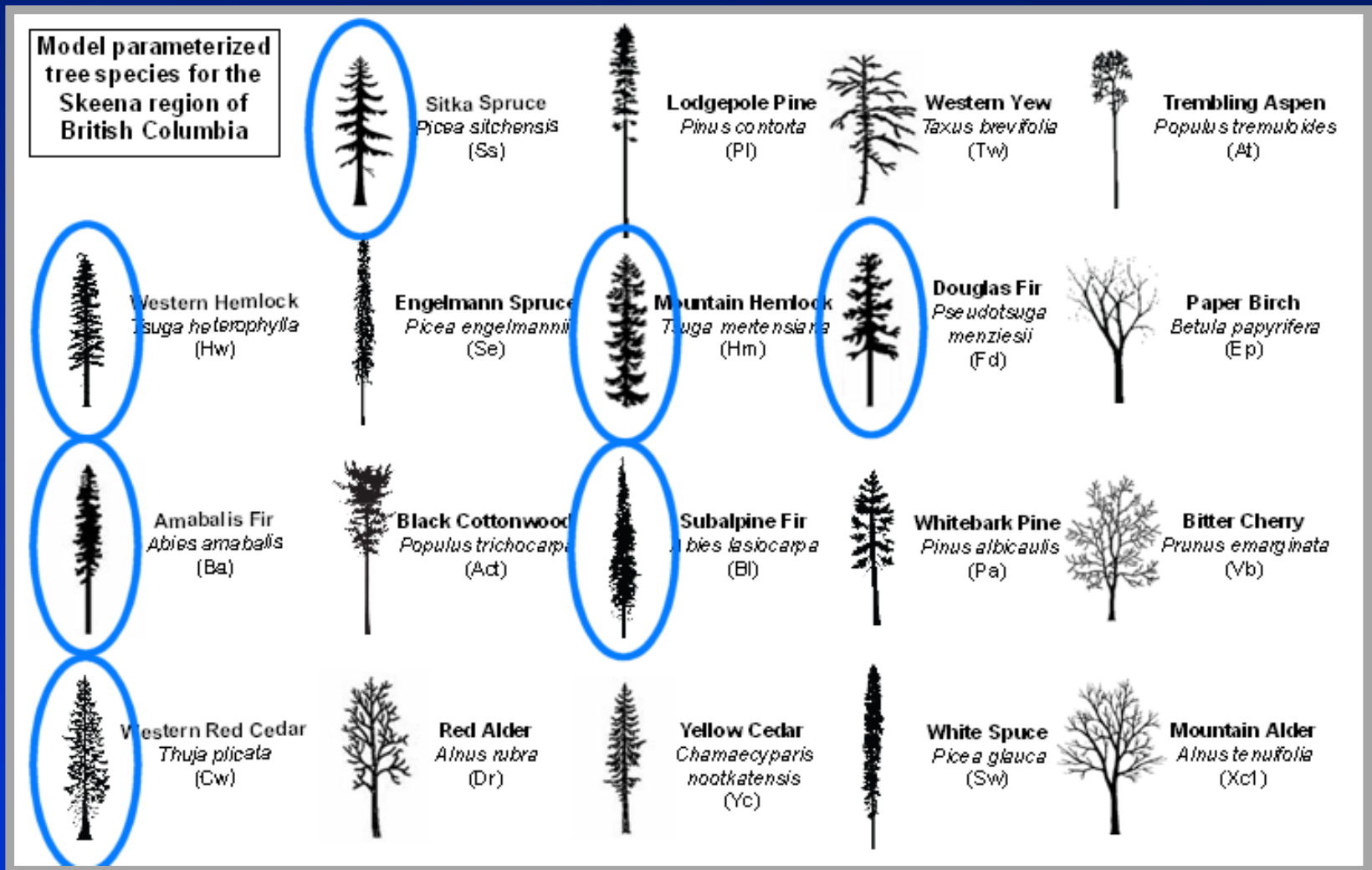   spatial detail

works on a 1 km^2 patch of land
uses simulated daily weather data
local weather is downscaled from
    large-scale models
daily time is based on monthly
    averages

each year…
    predicts amount of each species in each patch
    calculates amounts ("pools") of biomass as Carbon
    calculates changes ("fluxes") among the pools
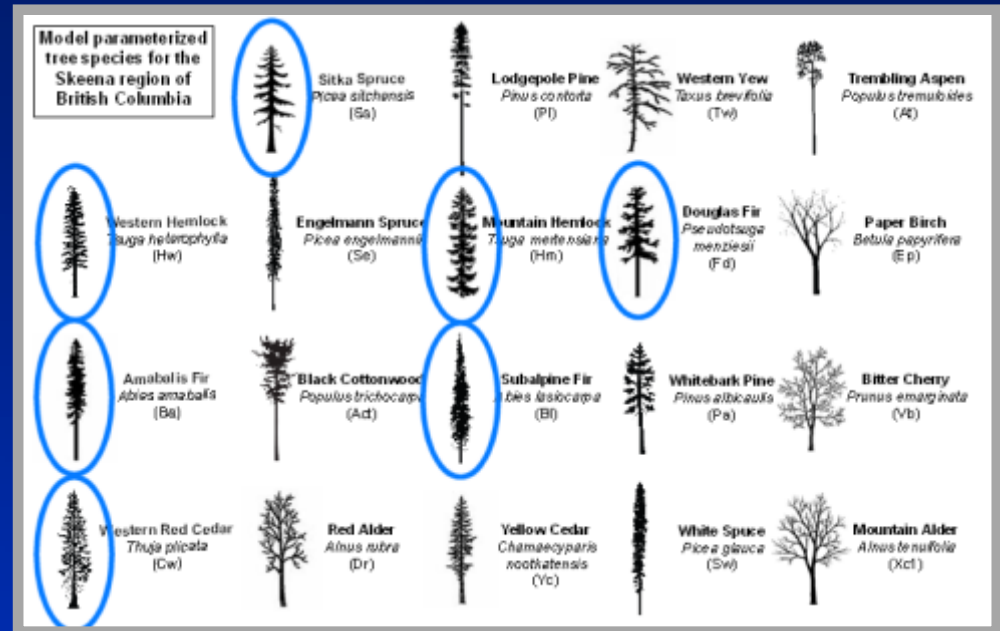
LPJ-Guess and Trees

Model parameterized tree species for the Skeena region of British Columbia

Sitka Spruce
Picea sitchensis
(Ss)

Lodgepole Pine
Pinus contorta
(Pl)

Western Yew
Taxus brevifolia
(Tw)

Trembling Aspen
Populus tremuloides
(At)

Western Hemlock
Tsuga heterophylla
(Hw)

Engelmann Spruce
Picea engelmannii
(Se)

Mountain Hemlock
Tsuga mertensiana
(Hm)

Douglas Fir
Pseudotsuga menziesii
(Fd)

Paper Birch
Betula papyrifera
(Ep)

Amabalis Fir
Abies amabalis
(Ba)

Black Cottonwood
Populus trichocarpa
(Act)

Subalpine Fir
Abies lasiocarpa
(Bl)

Whitebark Pine
Pinus albicaulis
(Pa)

Bitter Cherry
Prunus emarginata
(Vb)

Western Red Cedar
Thuja plicata
(Cw)

Red Alder
Alnus rubra
(Dr)

Yellow Cedar
Chamaecyparis nootkatensis
(Yc)

White Spuce
Picea glauca
(Sw)

Mountain Alder
Alnus tenuifolia
(Xc1)

LPJ-Guess and Trees

responsive to light, heat, moisture & CO_2

calibrated for main BC northwest tree species *plus grass*

tree growth sensitive to surrounding stand conditions

allows clearcut and stand-replacing fire with limited spatial detail

Model parameterized tree species for the Skeena region of British Columbia

Main species...
western & mountain hemlock
Douglas-fir
western red-cedar
Sitka spruce
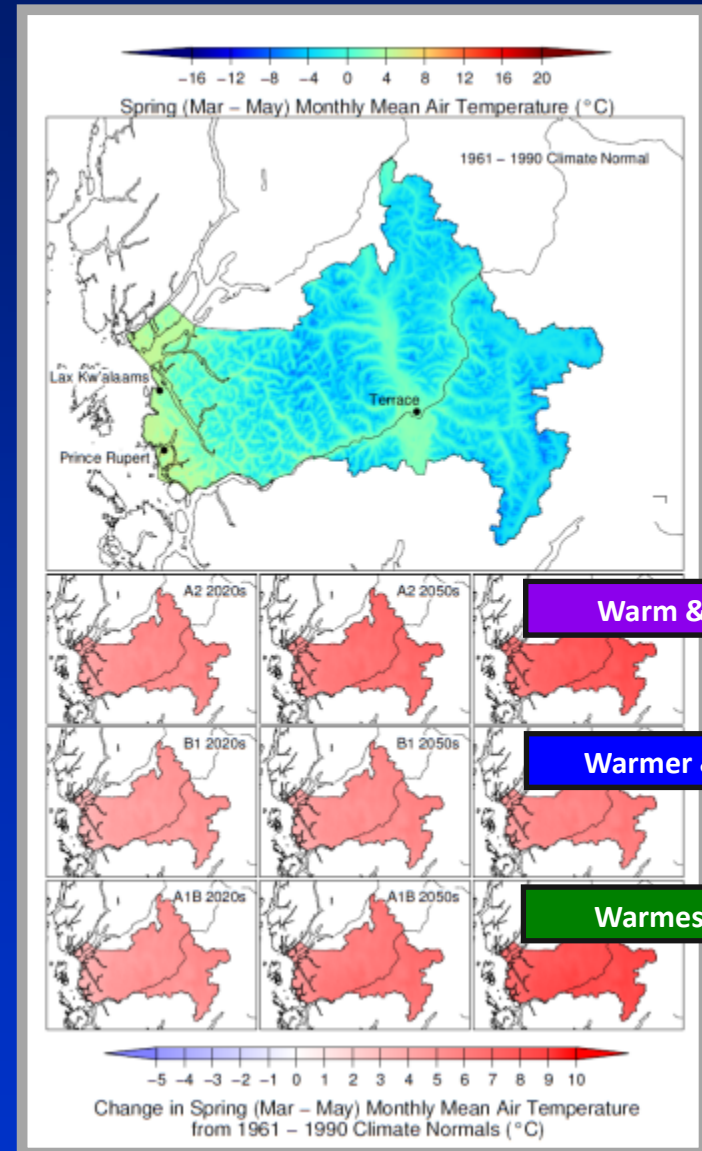subalpine & silver fir

LPJ-Guess and Climate

daily pattern based on **monthly** averages

may not capture the full range of future conditions

works on a 1 km² patch of land

uses **simulated** daily weather data

local weather is downscaled from large-scale models

daily time is based on monthly averages

LPJ-Guess and Shifts in Tree Species

The following 4 animated cartoons show shifts in suitability for 3 common species, and grasses

   subalpine fir – spreads west and up slopes
   mountain hemlock – is displaced by balsam fir
   grass – alpine grass displaced by trees
   western redcedar – eastward migration possible

Note that orange-yellow colours signal a very small proportion of occupancy: "just arrived" or "just leaving"

LPJ-Guess and movies don't actually simulate *migration* or what is on the ground: they show changes in potential or suitability…
   - "subalpine fir would grow well here"
   - "trees would do well here and could replace meadows"
   - "should we replant after harvest with something different?"

LPJ-Guess and subalpine fir

Year 2006
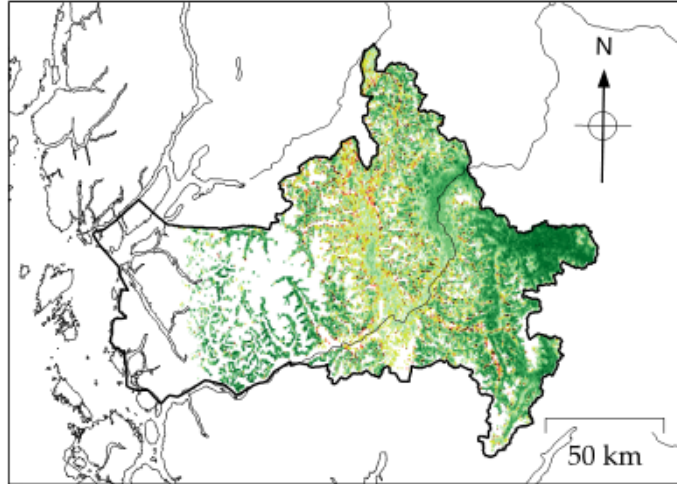
Subalpine Fir

- reduced in valley bottoms
- moves upslope

Year 2080

Warmer & wetter   **Warm & wetter**   **Warmest & wet**

0 1 5 10 15 20 30 45 60 80 100
Percent of living carbon mass
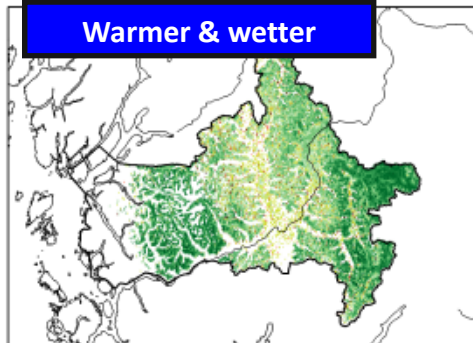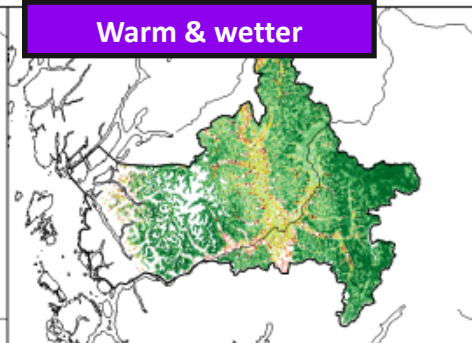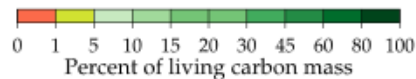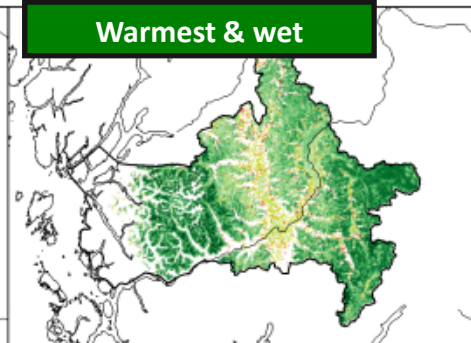
Abies lasiocarpa

LPJ-Guess and mountain hemlock

Year 2006

Mountain Hemlock

50 km

N
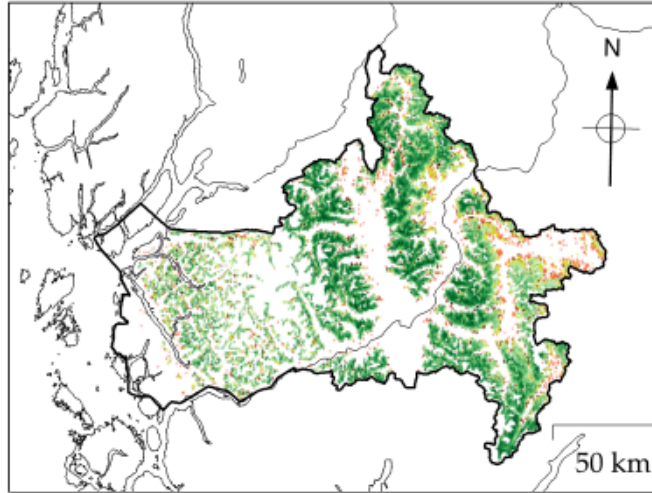
- reduced at middle and high elevations
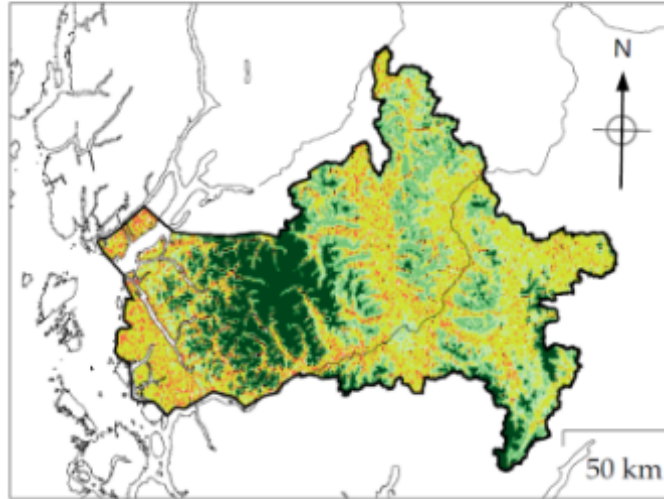
Year 2080

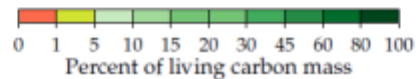Warmer & wetter

Warm & wetter

Warmest & wet

0 1 5 10 15 20 30 45 60 80 100
Percent of living carbon mass
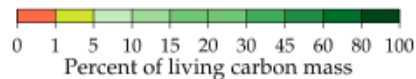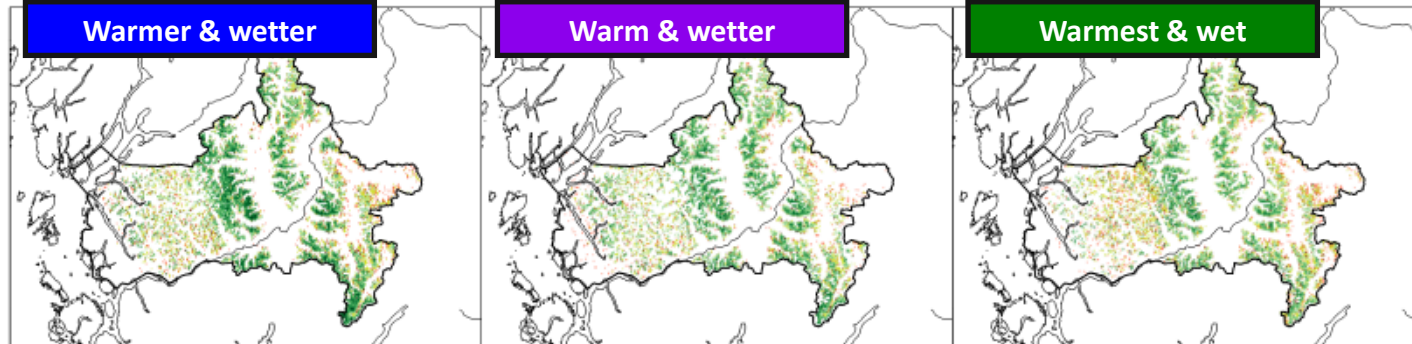
Tsuga mertensiana

LPJ-Guess and grasses

Year 2006

- losses at high elevation to shifting trees
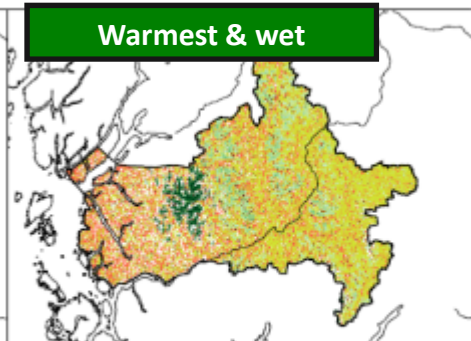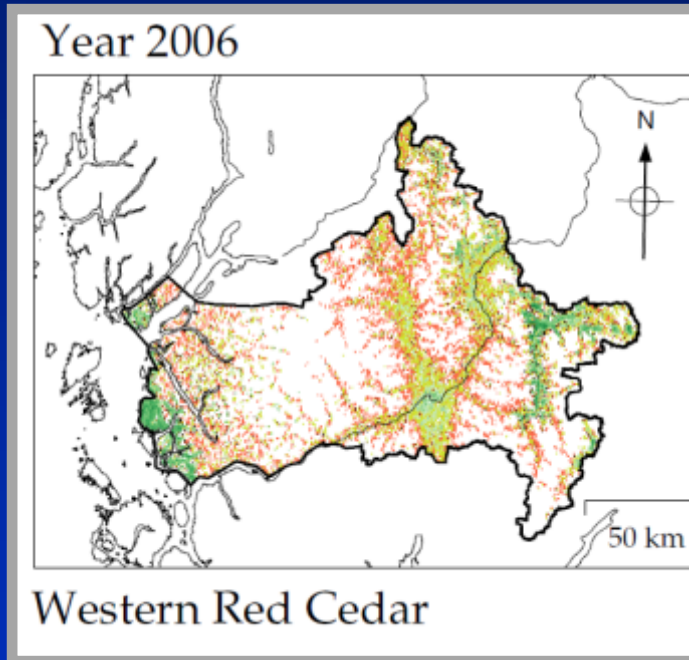- small losses at low elevation to increased trees
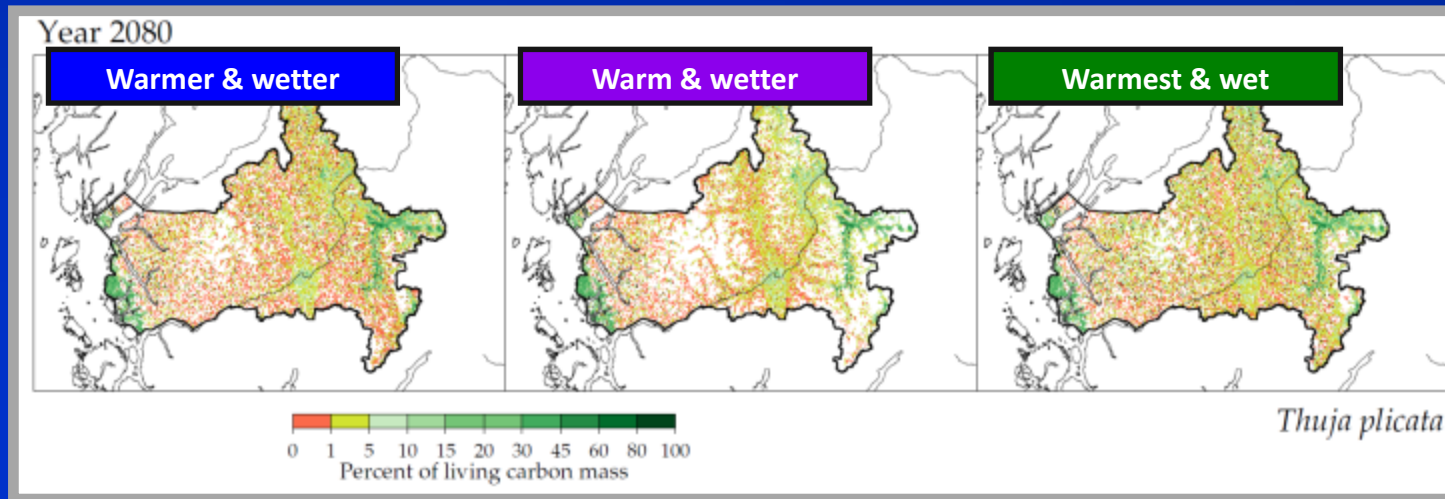

Year 2080

Warmer & wetter | Warm & wetter | Warmest & wet

0 1 5 10 15 20 30 45 60 80 100
Percent of living carbon mass
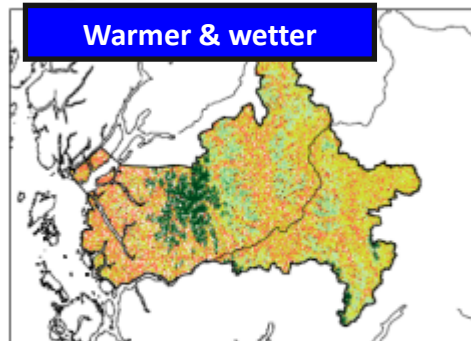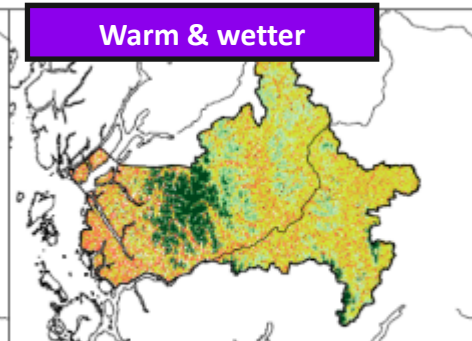
LPJ-Guess and western redcedar

Year 2006

Western Red Cedar

50 km

N

- slight expansion over time
- remains prevalent on coast

Year 2080

Warmer & wetter

Warm & wetter

Warmest & wet

0 1 5 10 15 20 30 45 60 80 100
Percent of living carbon mass

Thuja plicata

LPJ-Guess and Species Shifts across Study Area
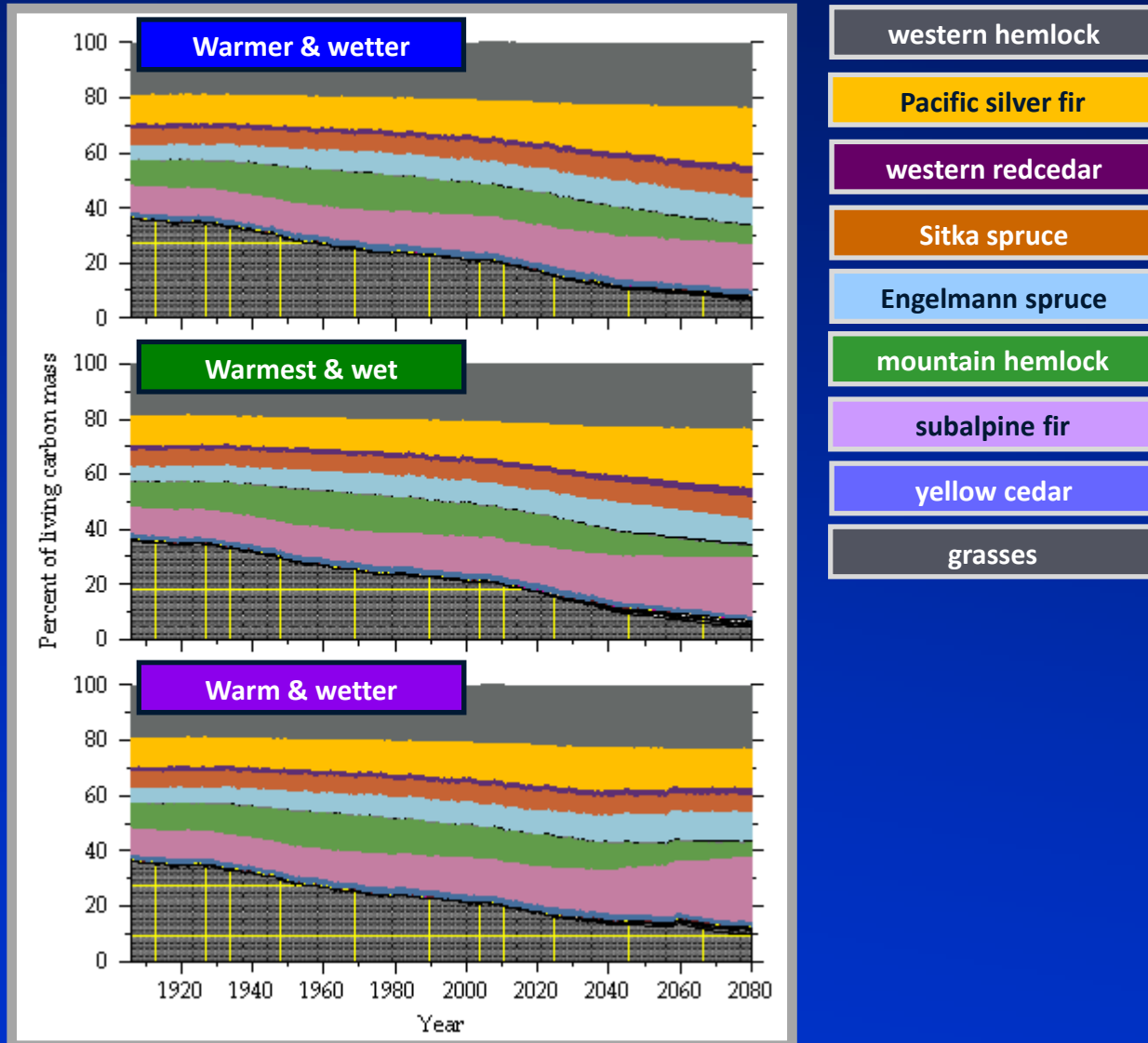
LPJ-Guess and Shifts around Communities
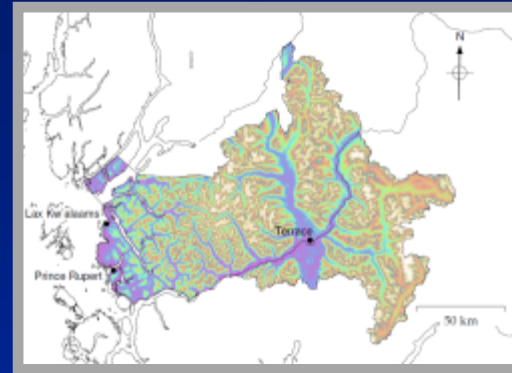
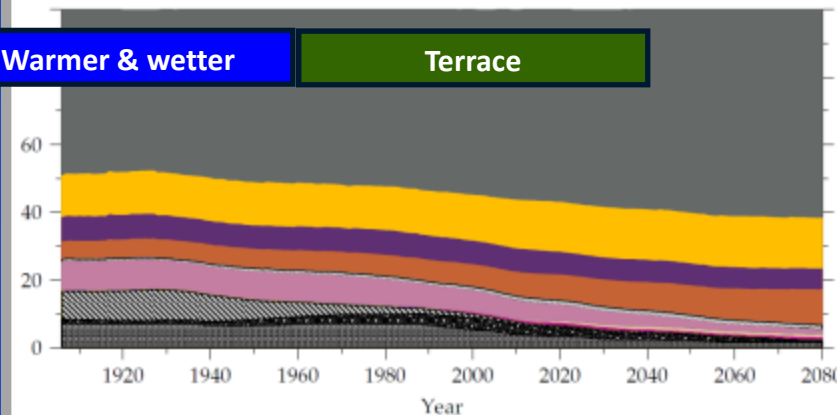**Warmer & wetter** | **Prince Rupert**
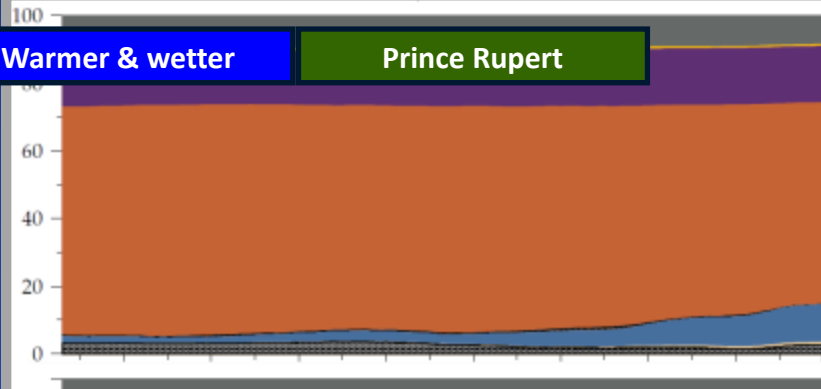
Warmer & wetter | **Lax Kw'alaams**
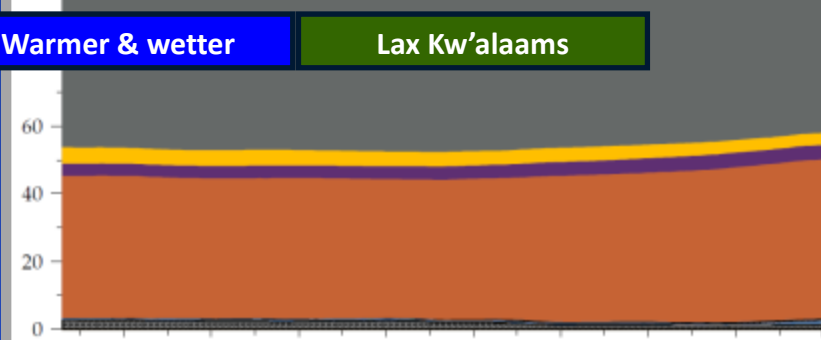
Warmer & wetter | **Terrace**

Legend:
- western hemlock
- Pacific silver fir
- western redcedar
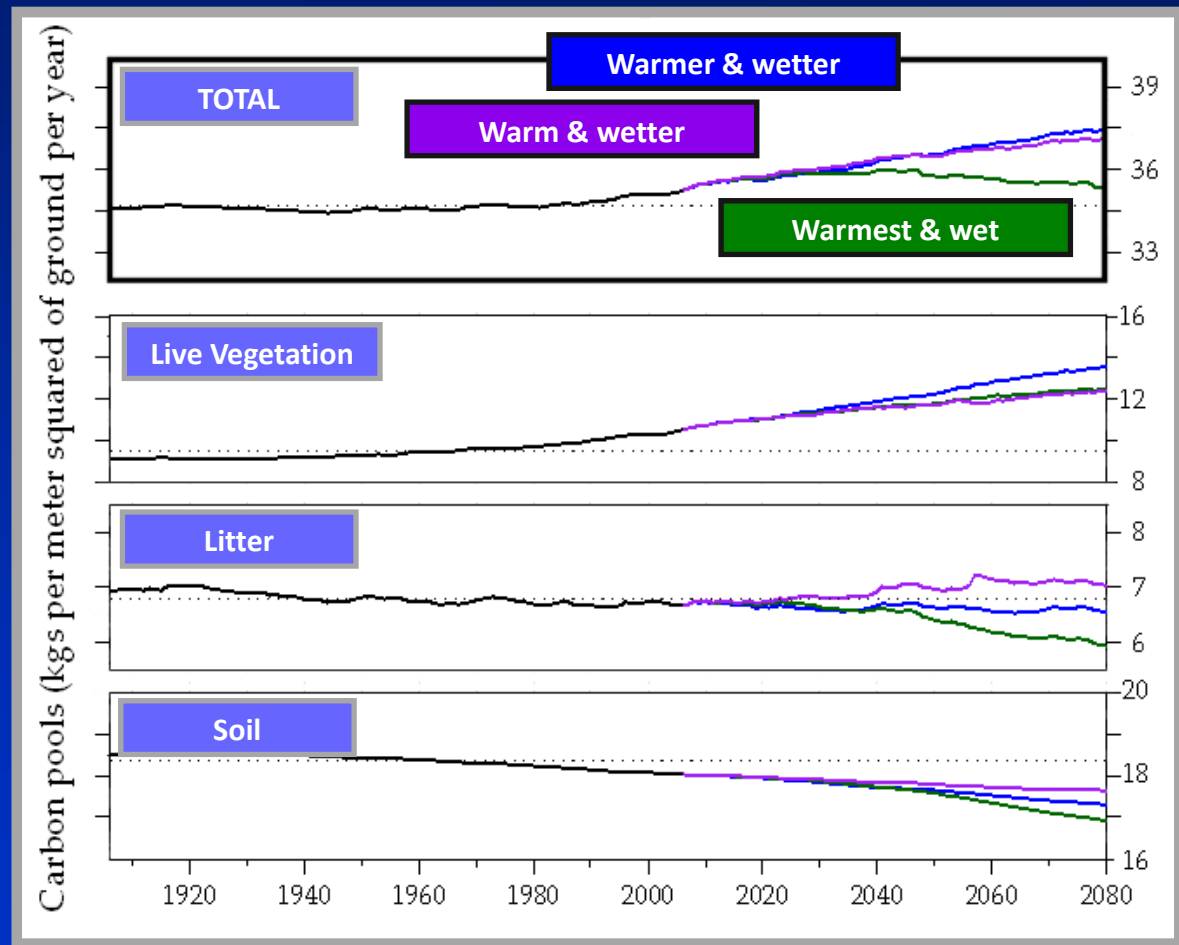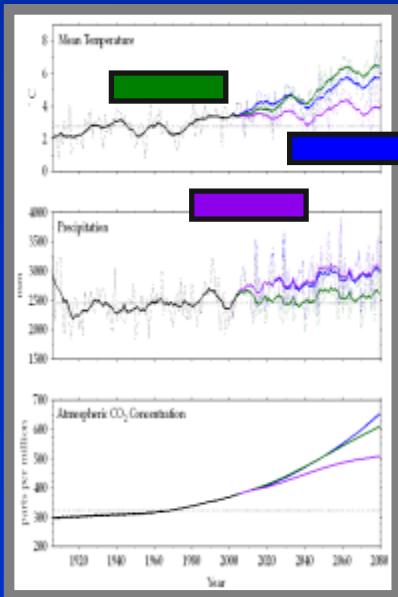- Sitka spruce
- subalpine fir
- yellow cedar
- black cottonwood
- bitter cherry
- grasses

LPJ-Guess and Carbon

smoothed
average
values
over entire
region;
no harvest

LPJ-Guess and Carbon

- future increase in live C stocks from
    CO_2 fertilization and warmer growing
    season

- Carbon sequestration could become a
    management option

- faster decomposition rates reduce
    soil and litter pools

- interplay between faster growth/litter
    and faster decomposition

- total C increases until about 2040,
   Possibly declining after that in "warmest wet" scenario
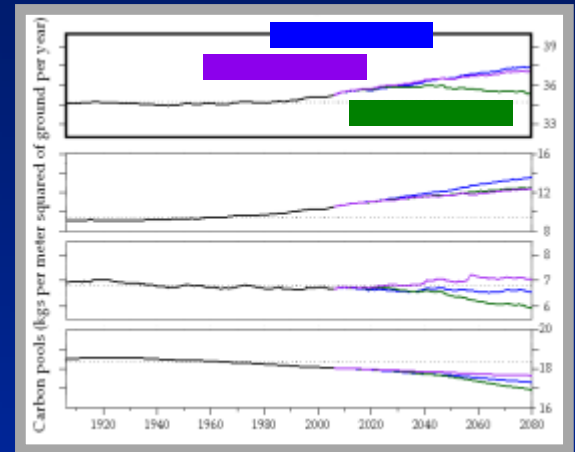
What about Fire?

- fire is infrequent in much of the study area, and remains that way under all 3 climate scenarios

- most fires caused by people

- regionally, future fire conditions will be similar to (unsuppressed) early 1900s levels

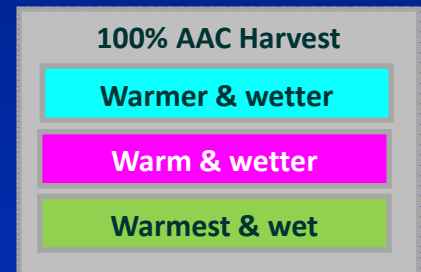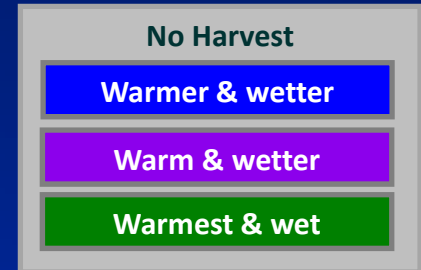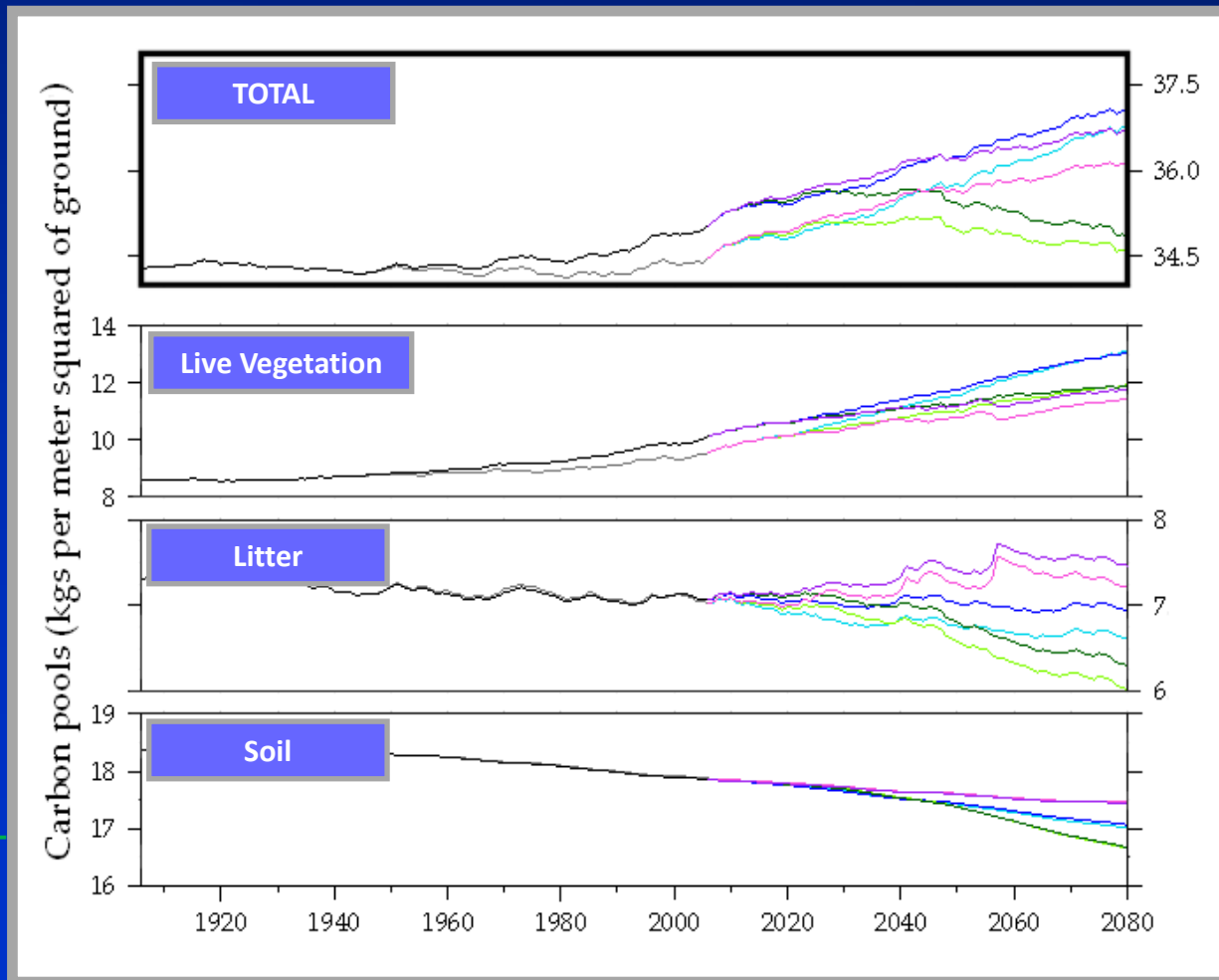- increased fire risk for ~750 km^2 eastern side of study area
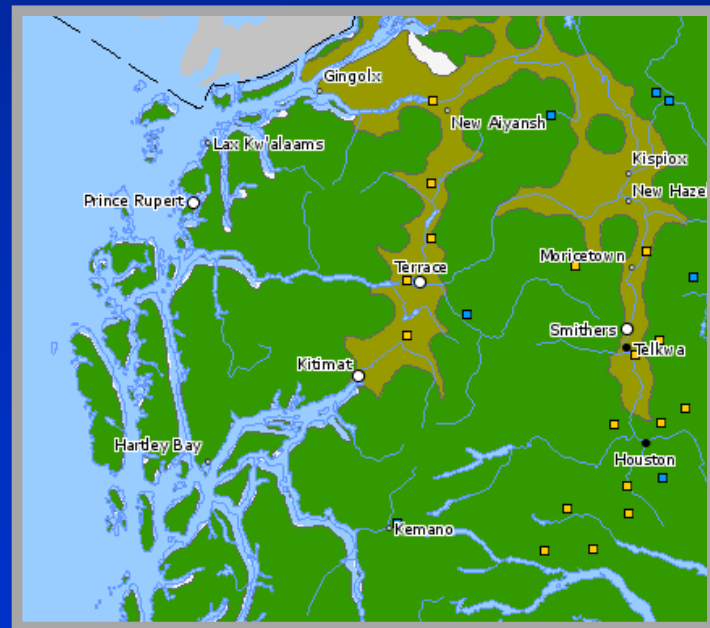
What about Harvesting?

- some simulations include historic and estimated historic harvest in TFL1

- 3 scenarios… **50%, 100%, 150%** of 2010 AAC, converted to hectares
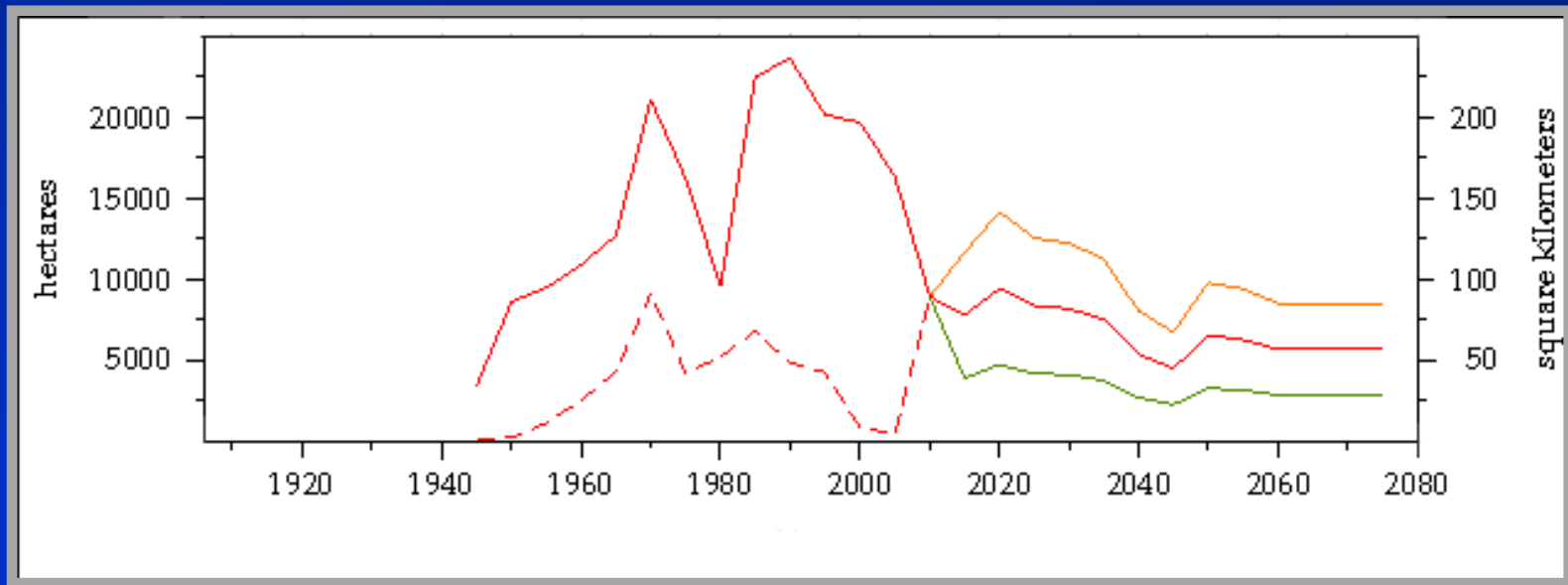
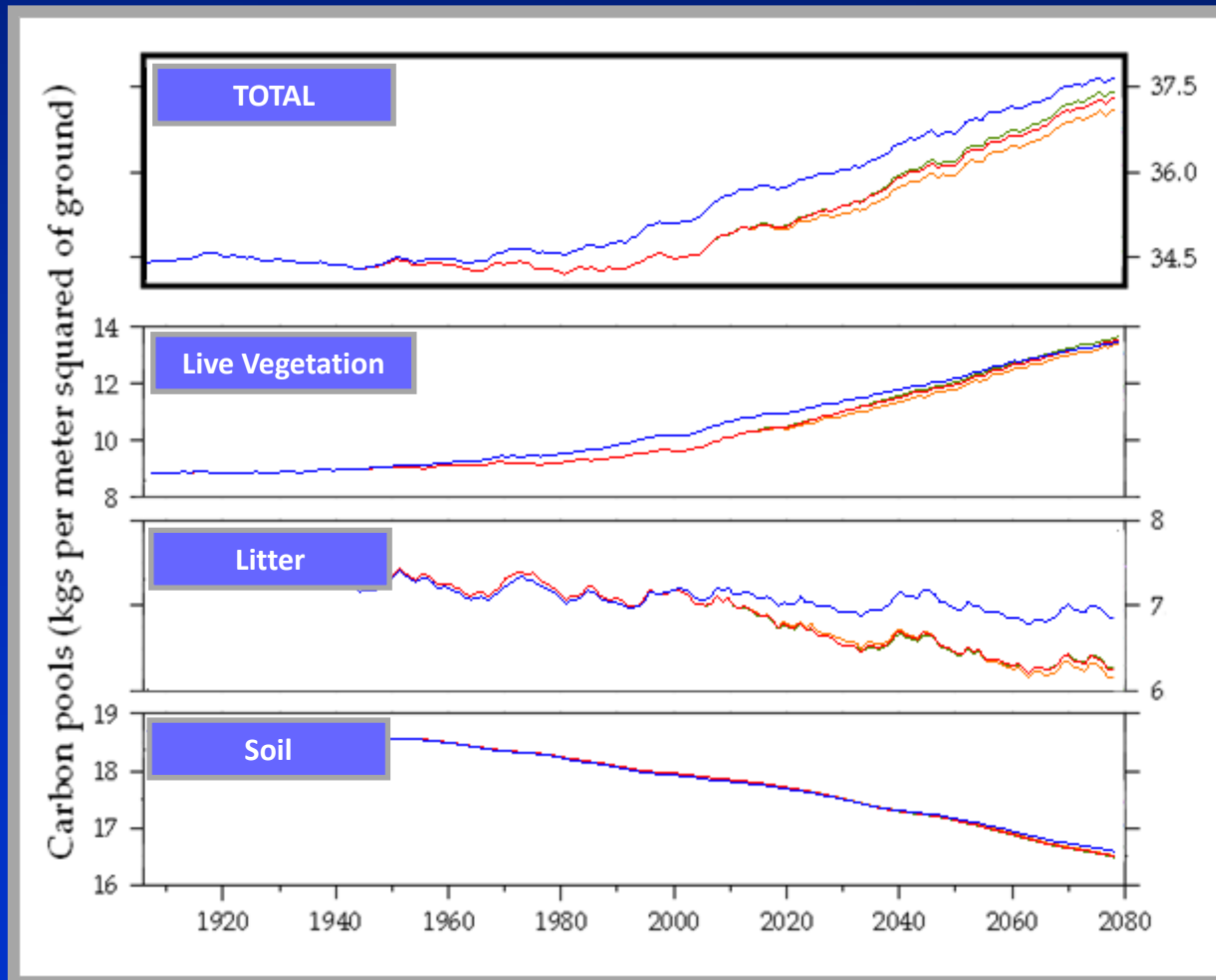- Annual harvest in figure is reported every 5 years

What about Harvesting?

Comparison 1: Across Climate Scenarios

What about Harvesting?
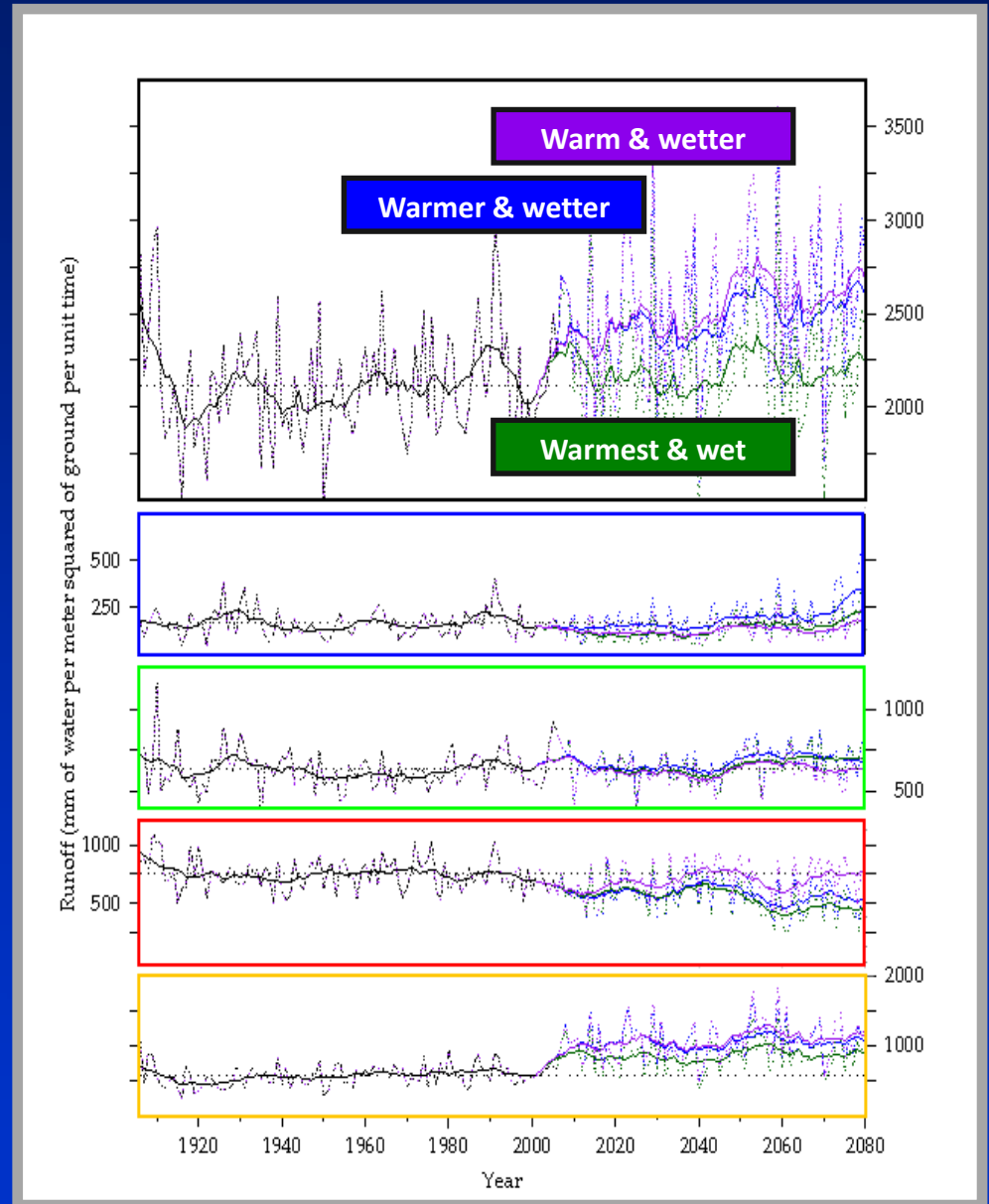
Comparison 2: Across AAC Scenarios

What about Harvest & Runoff?

Harvest is <1% annually over 32,000 km² study area

At this scale, harvesting has a very small effect on runoff

Why Use a Simulation Model?

Simulation models can help to…
- organize the thinking of many people in a consistent way
- combine, test and refine scientific knowledge
- provide possible answers to "what if" questions
  about the future *when past experience may not
  be enough*

Can use current information and knowledge, to cautiously extrapolate to conditions that may not have been seen before

Every time you read a tide-table, check the weather forecast or look at a stand growth curve, you're checking with a simulation model. **You might not trust it totally, but you check it anyway and then make up your own mind.**

What Can We Take Away?

1. Change in runoff timing: 70 years from now…
   -20% summer, +100% autumn
2. Lots of weather variation year-to-year, but consistent warming trend; usually wetter

3. Landscape is greener: grass replaced by trees
4. Alpine tree species replaced by mid-slope species
5. Climate change scenarios have much bigger impact on vegetation or carbon than harvesting or fire

6. Regional results (runoff) don't scale down to the site level in simplified LPJ-Guess hydrology
7. Uncertainty about reliability of scaling: **monthly** and **regional** temperature and runoff don't automatically predict **daily** and **local** temperature and rainfall patterns