

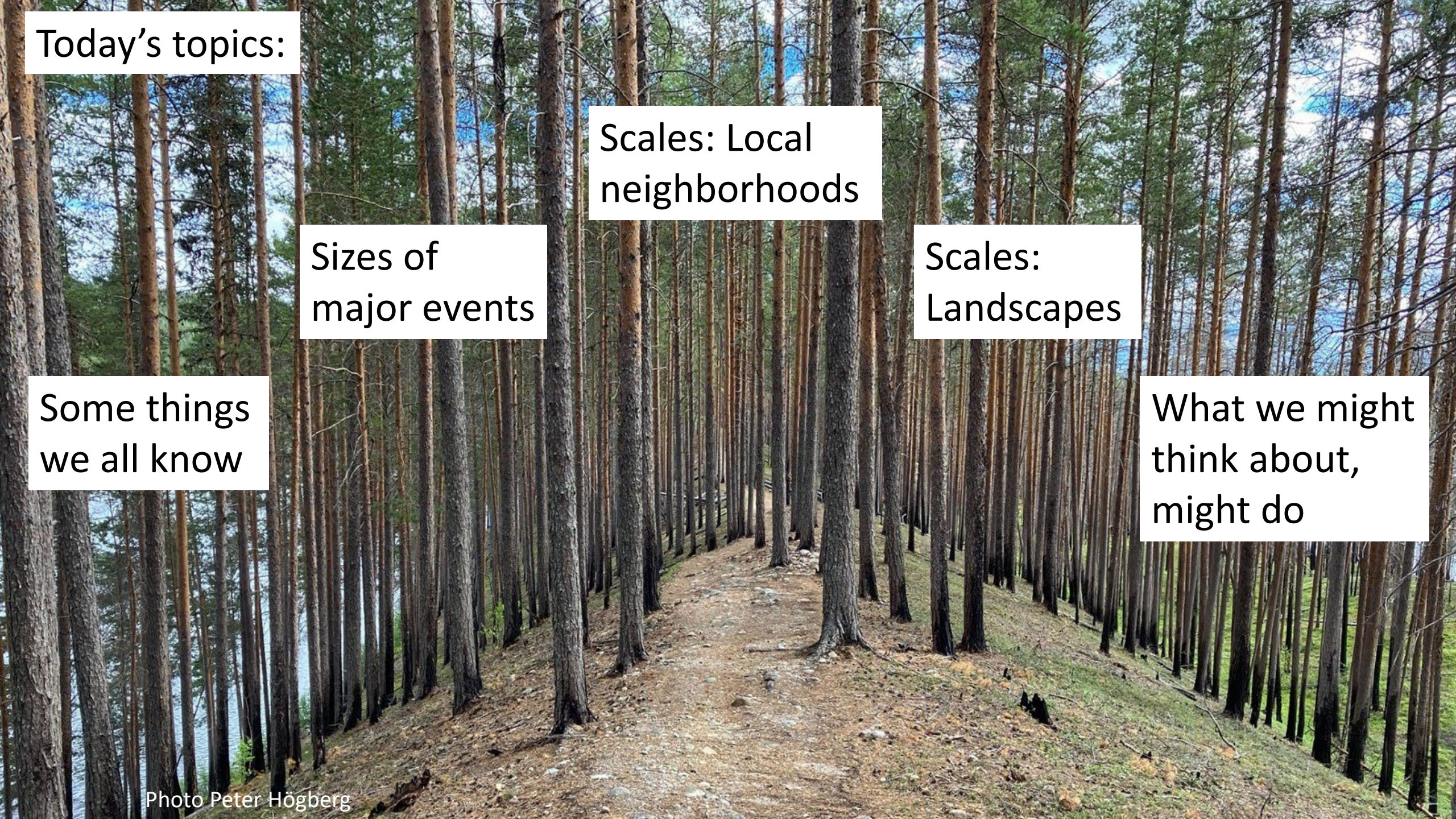
Spatial Ecology of Rotational and Continuous Cover Forestry in Boreal Landscapes

Dan
Binkley



**COLORADO STATE
UNIVERSITY**

Ecosystem Science and Sustainability

A photograph of a dense forest of tall, thin pine trees. The trees are arranged in rows, creating a sense of depth. The ground is covered in brown pine needles and some green moss. The sky is visible through the canopy, showing a blue sky with some clouds. The overall scene is a natural, serene forest landscape.

Today's topics:

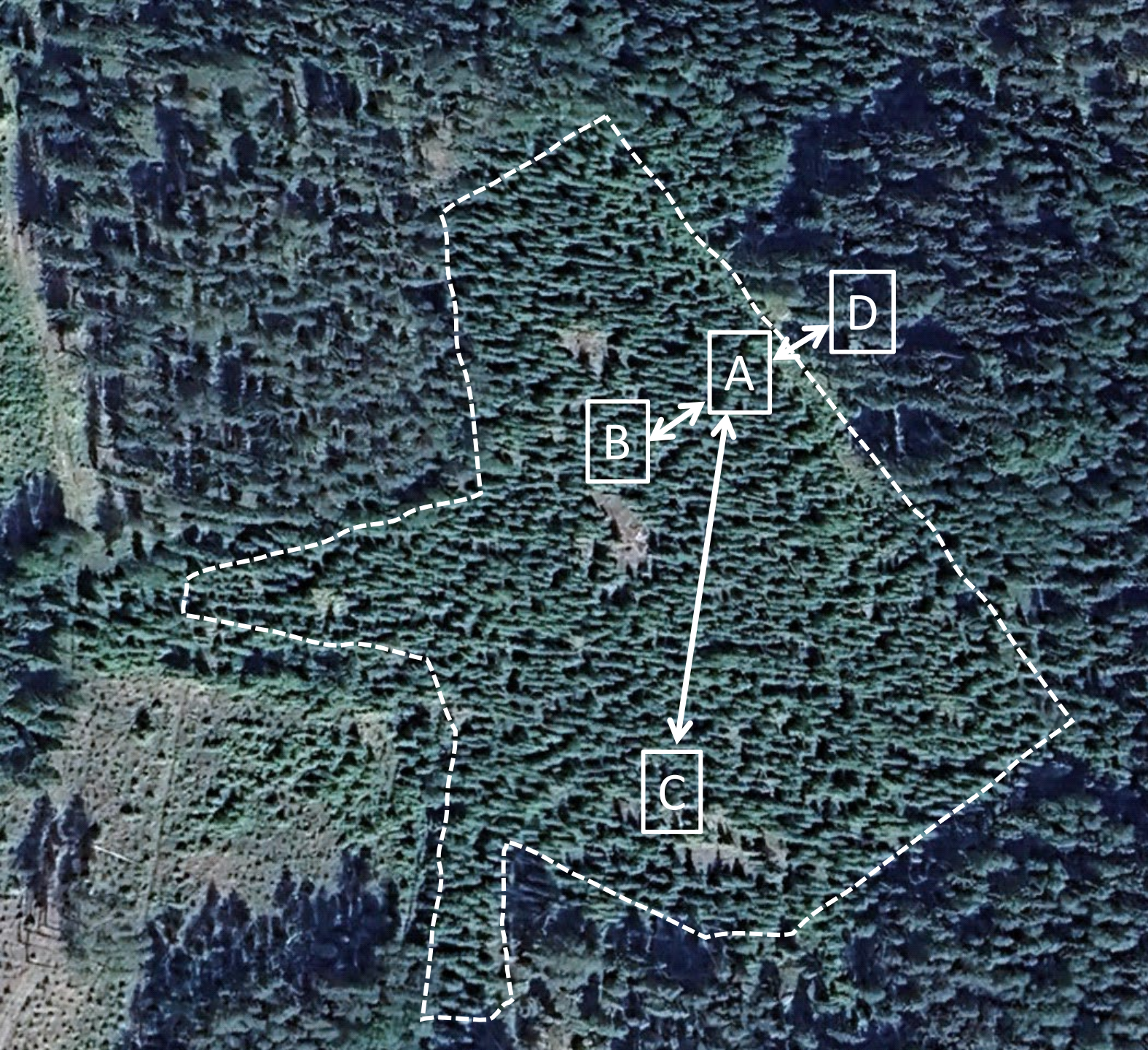
Scales: Local
neighborhoods

Sizes of
major events

Scales:
Landscapes

Some things
we all know

What we might
think about,
might do



We all know

- Forests change over space
- We might define patches, more similar inside than surrounding area
- Forests change over time
 - Patches fade, shift around on landscape

4000 ha fire

In some ways,
this is now
one large
patch

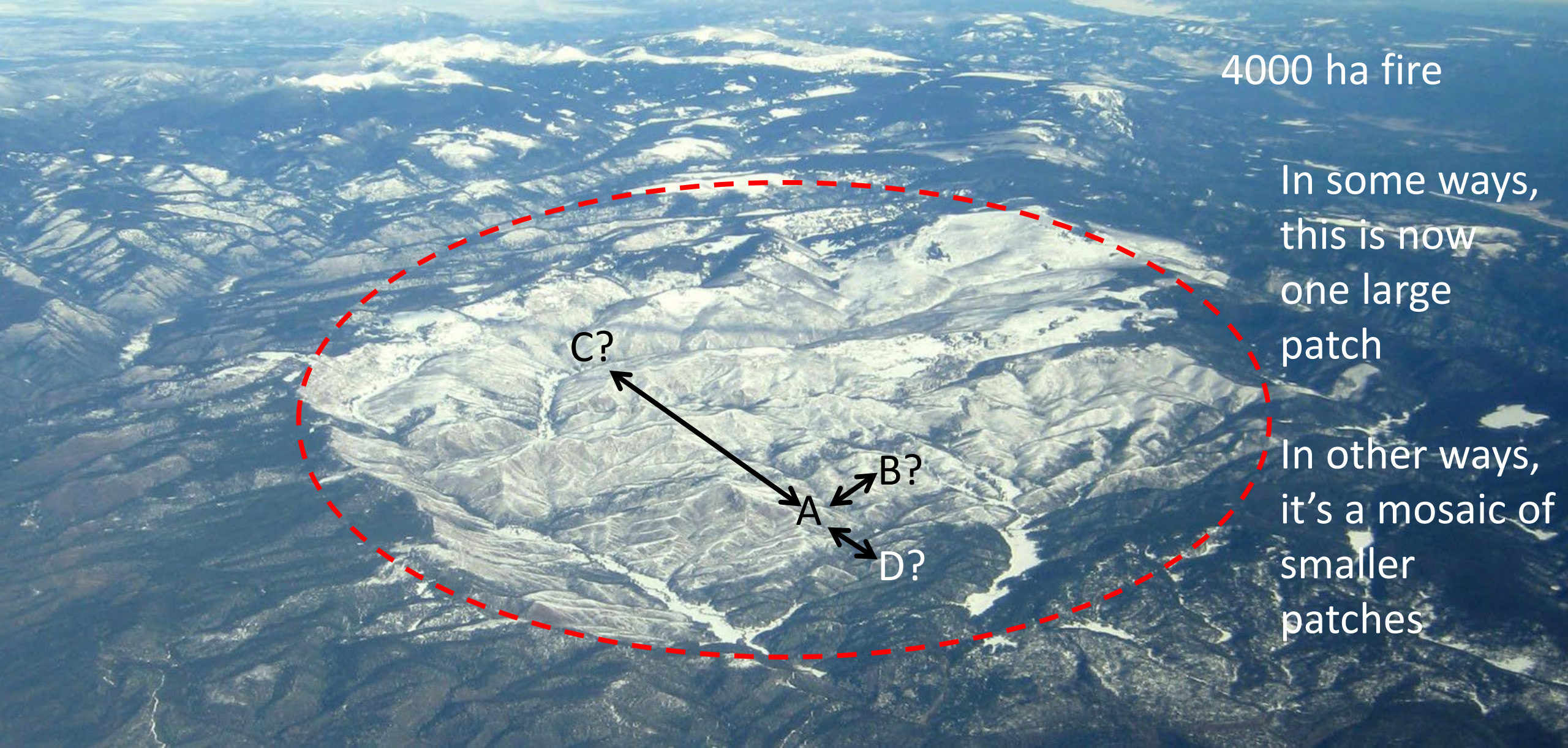
In other ways,
it's a mosaic of
smaller
patches

C?

B?

A

D?





We all know

- Competition for light shapes forests



We all know

- Competition for light shapes forests
- Competition for nutrients and water shapes forests



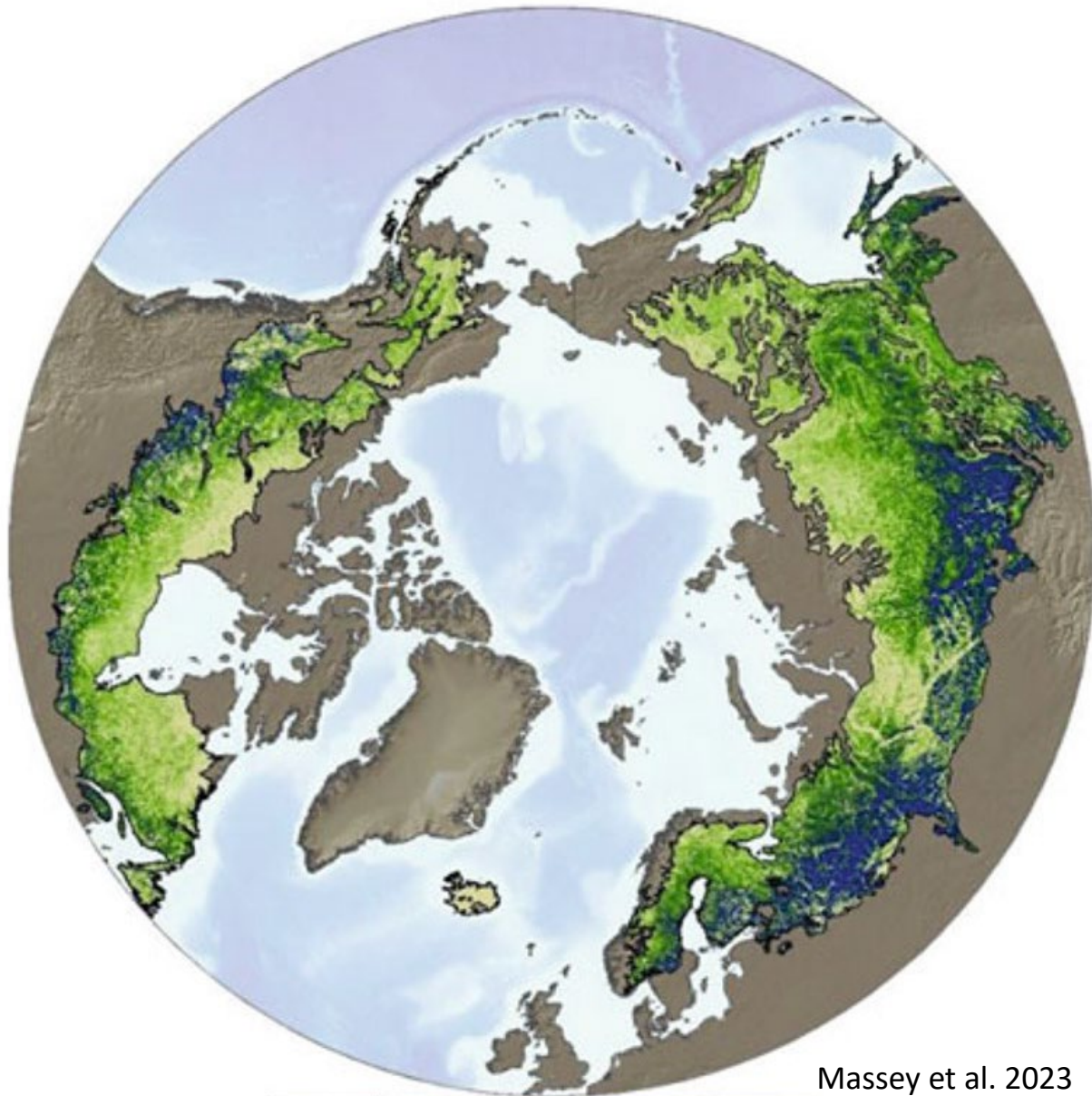
Photo Christian Ammer

We all know

- Competition for light shapes forests
- Competition for nutrients and water shapes forests

Aboveground biomass (Mg ha^{-1})

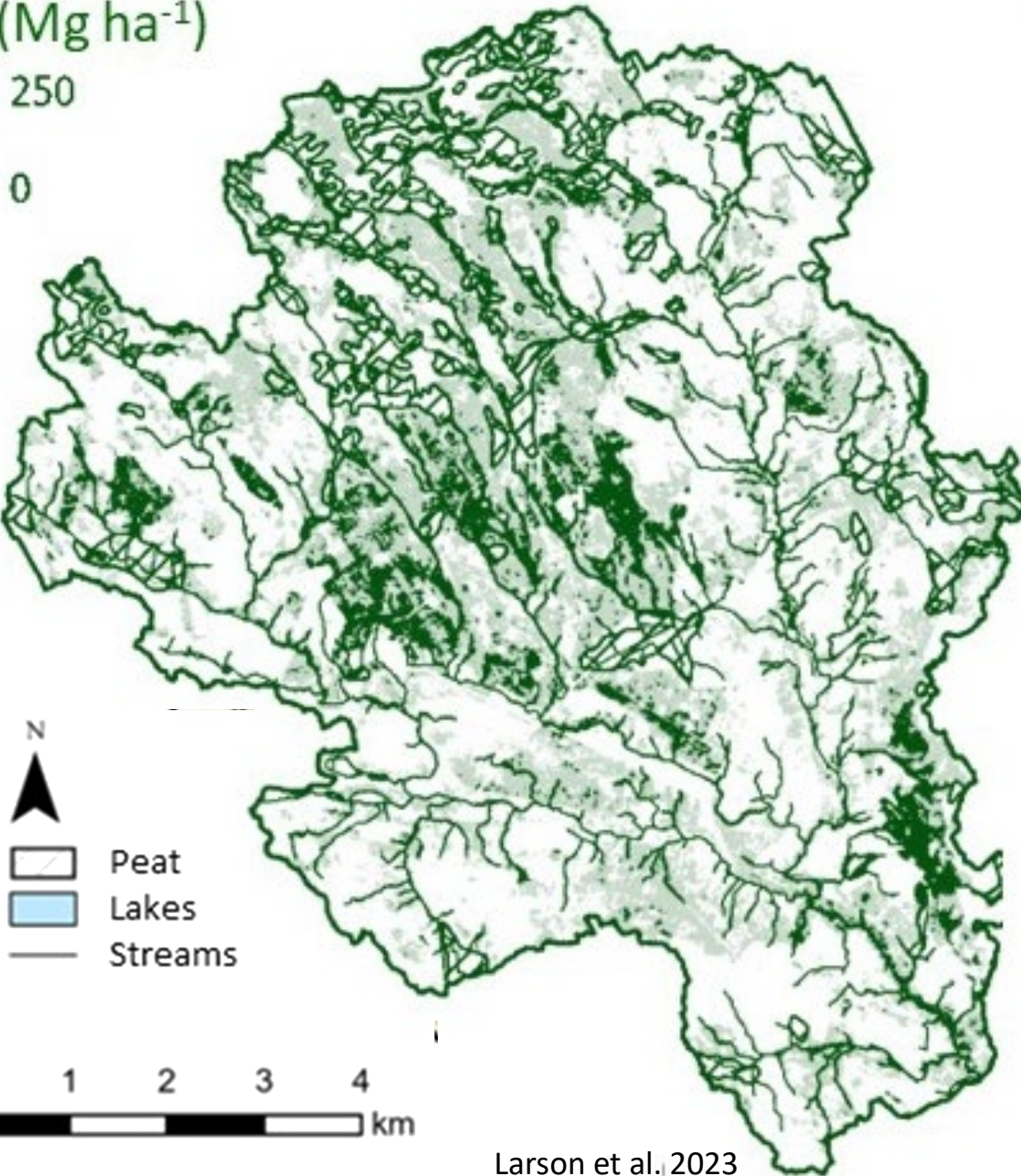
0 20 40 60 80 >100



Massey et al. 2023

We all know boreal forests are the most extensive on Earth, generally with higher biomass in more southern areas

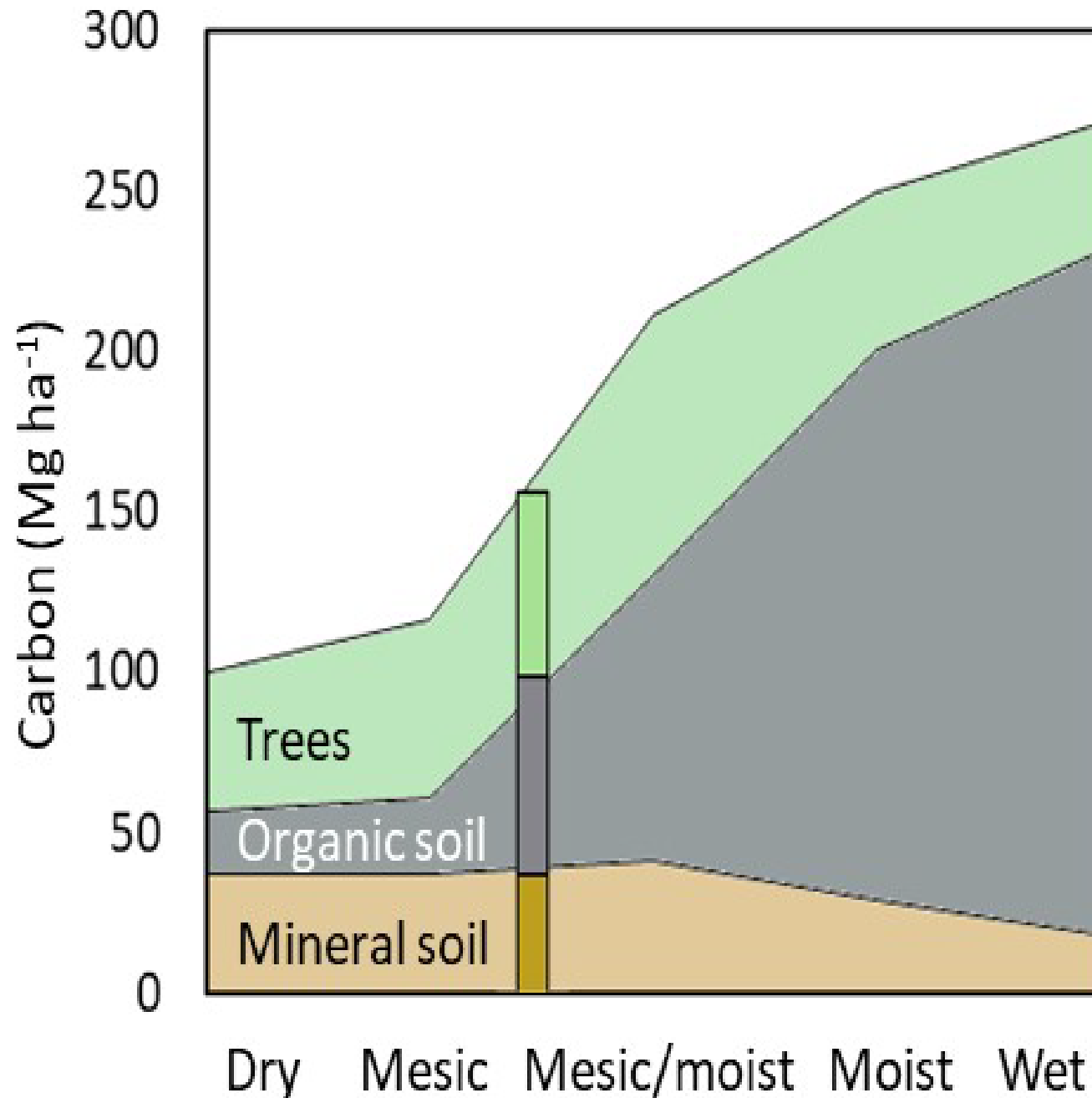
Tree C (Mg ha^{-1})



Larson et al., 2023

We all know forest vary almost as much within regions as across the globe

Krycklan catchment,
Northern Sweden, 68 km²



We all know forest vary as much locally as across the globe

Krycklan Carbon stocks:

¼ of the watershed has >50% more C than lowest ¼

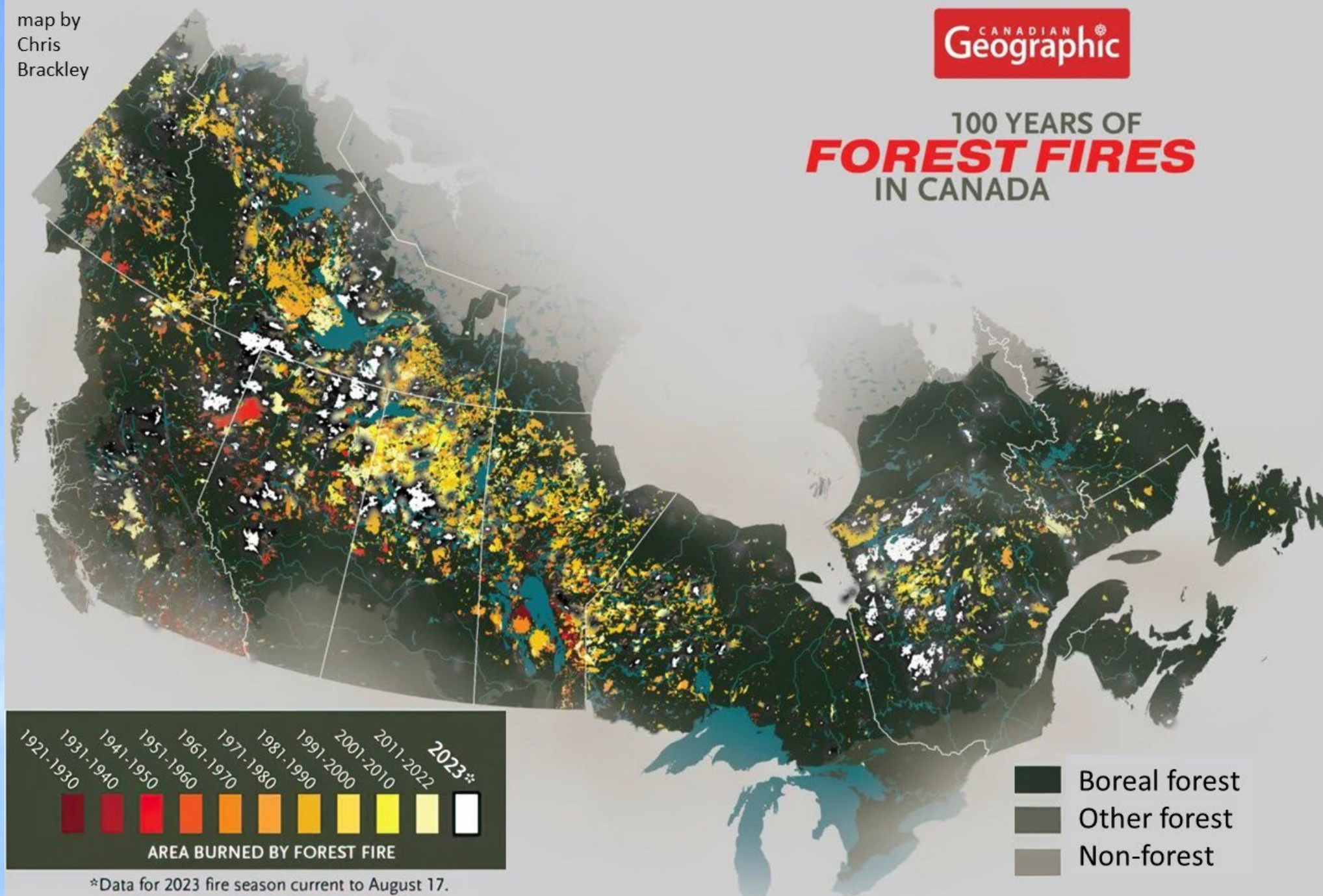
We all know

- This forest is not the same as the one over there
- This forest now is not the same as back then

map by
Chris
Brackley

CANADIAN
Geographic

100 YEARS OF
FOREST FIRES
IN CANADA



We all know
boreal
forests
cannot stay
the same
across
centuries

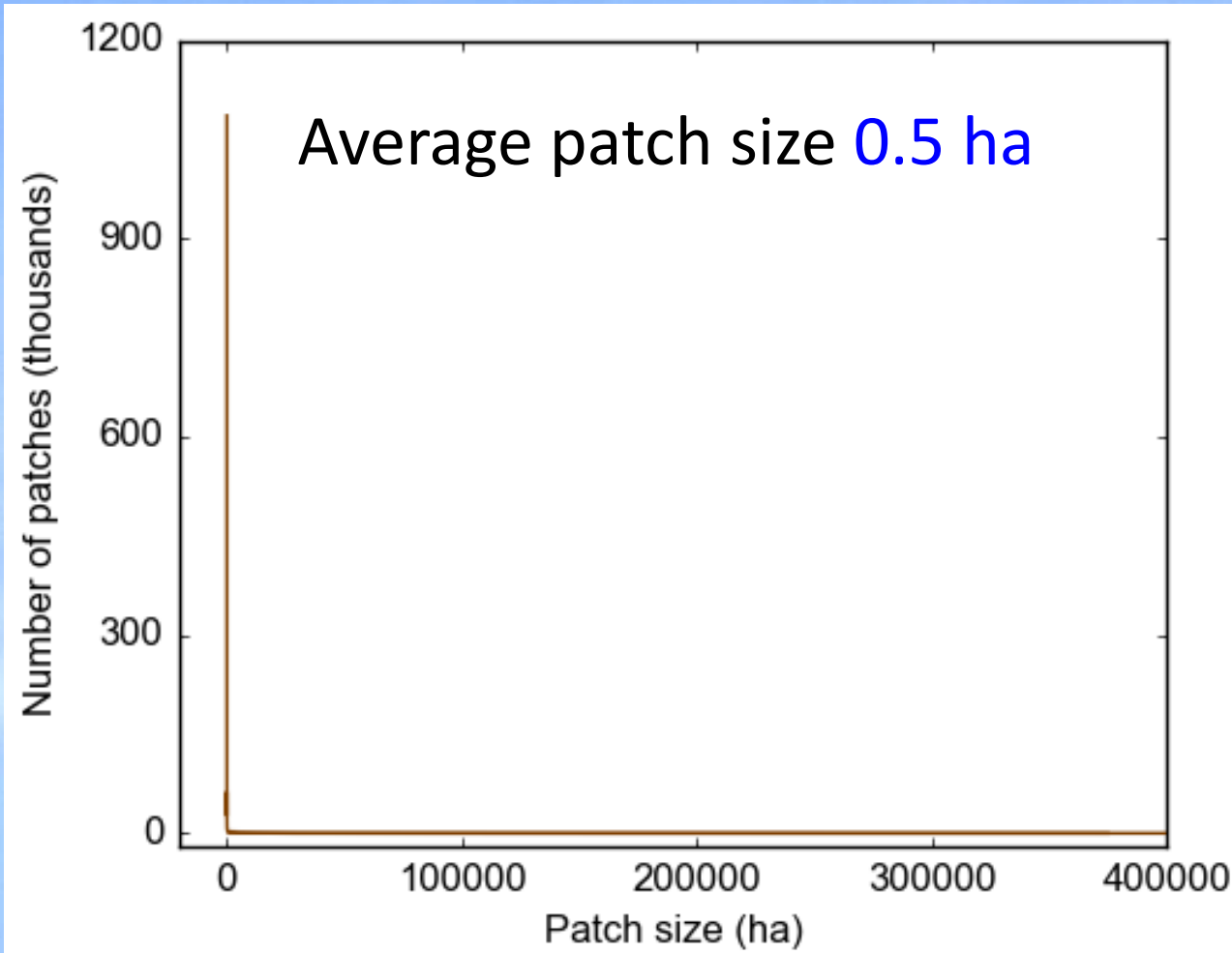
Half of
Canada's
boreal
forests
burned in
the past
century

Sizes of
major events

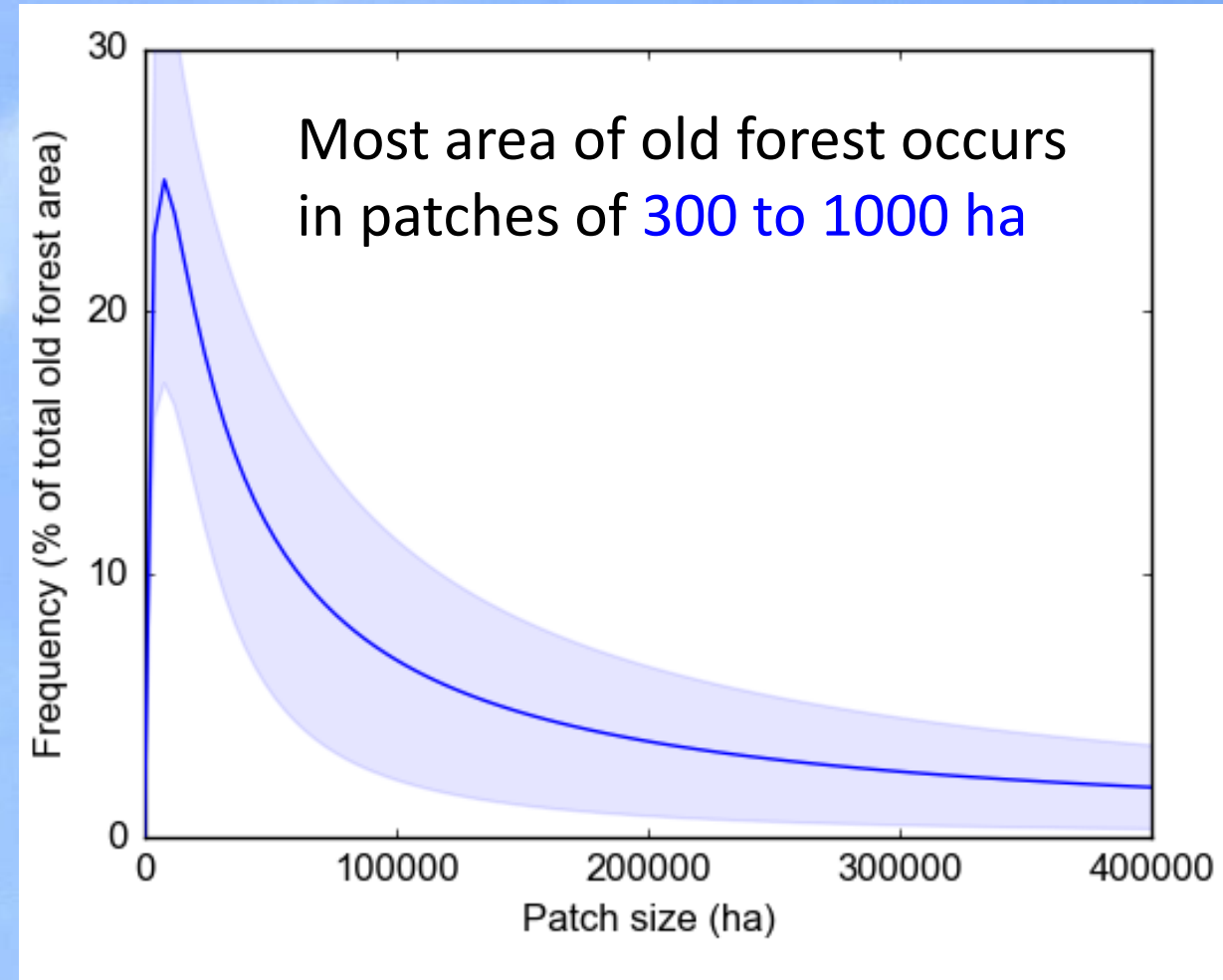
Patch sizes of old forests (>110 years) in Quebec and Ontario, Canada

Landscapes

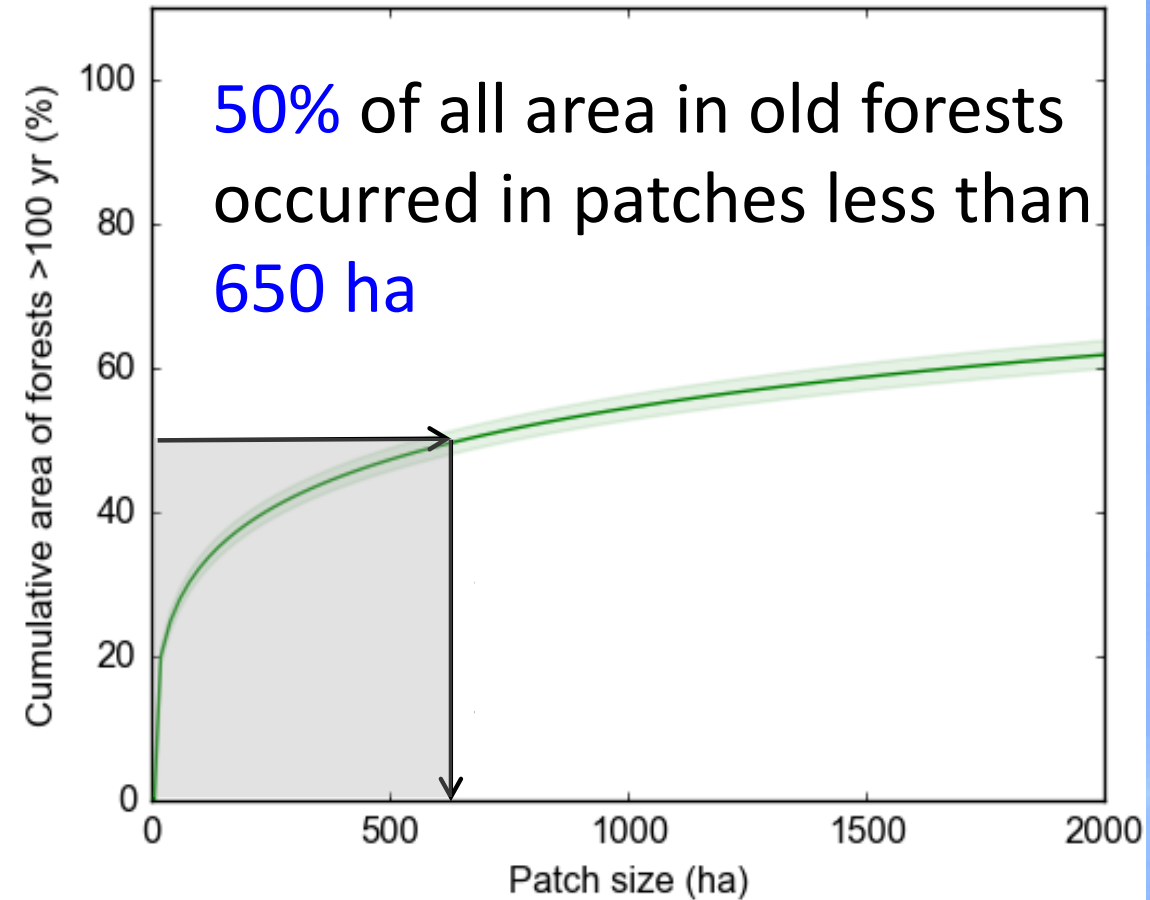
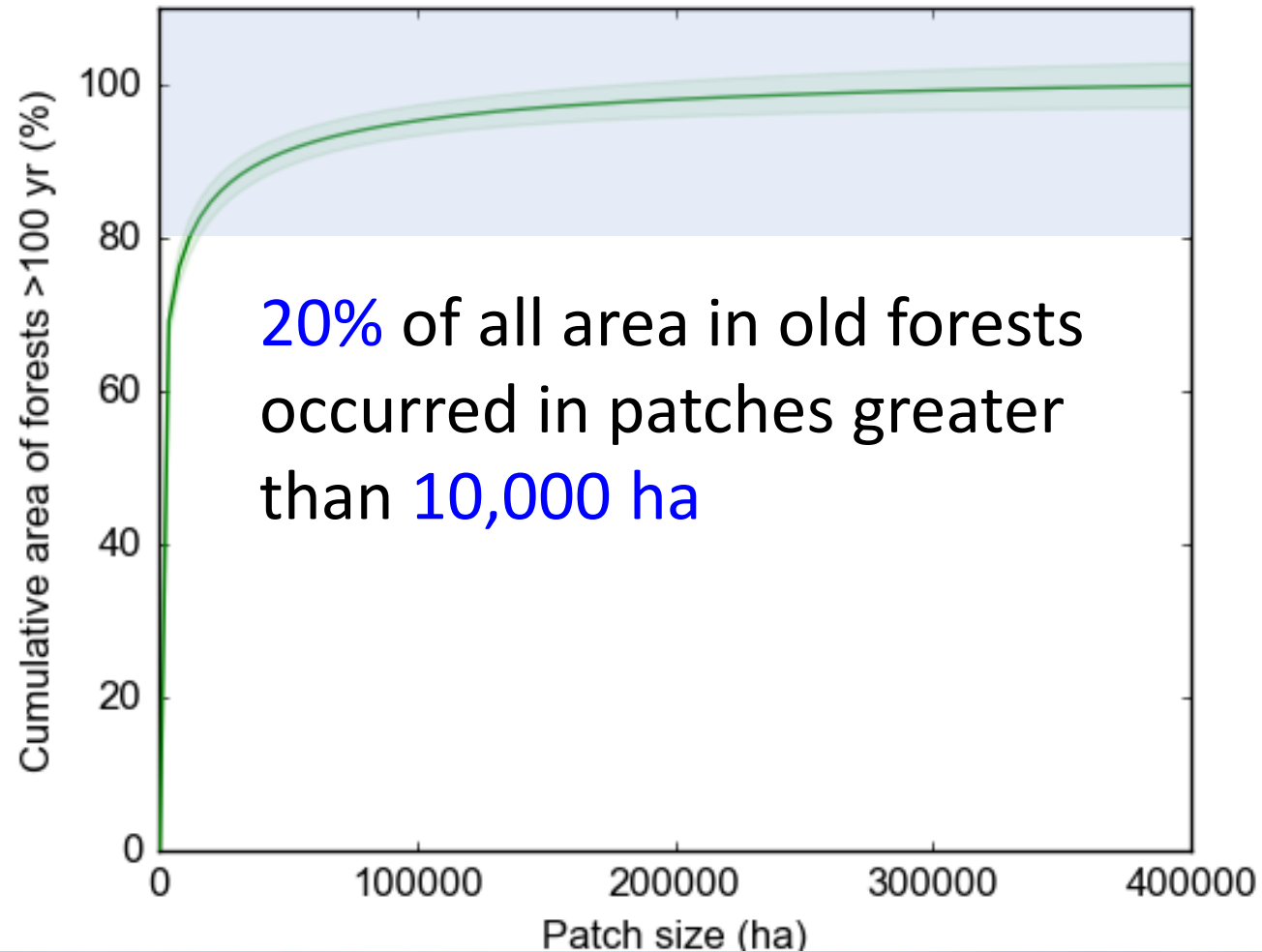
Average patch size, based on
number of patches



*Frequency of area based on
patch size*

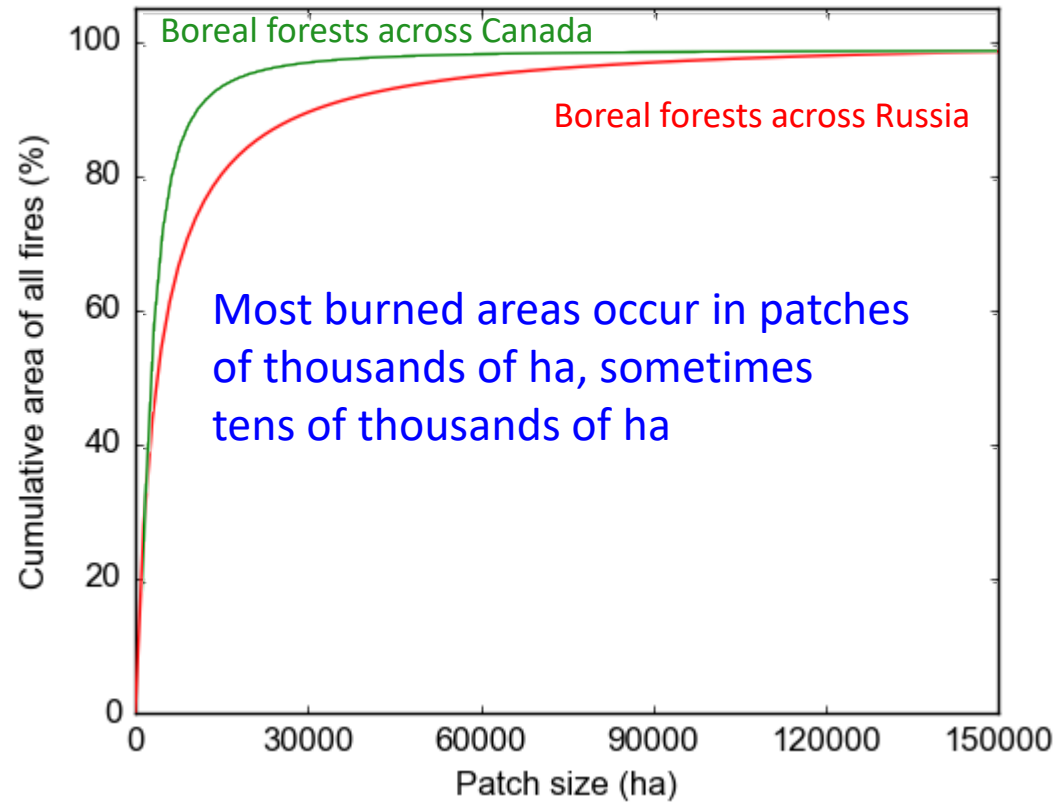


Moving on to cumulative frequency patterns:

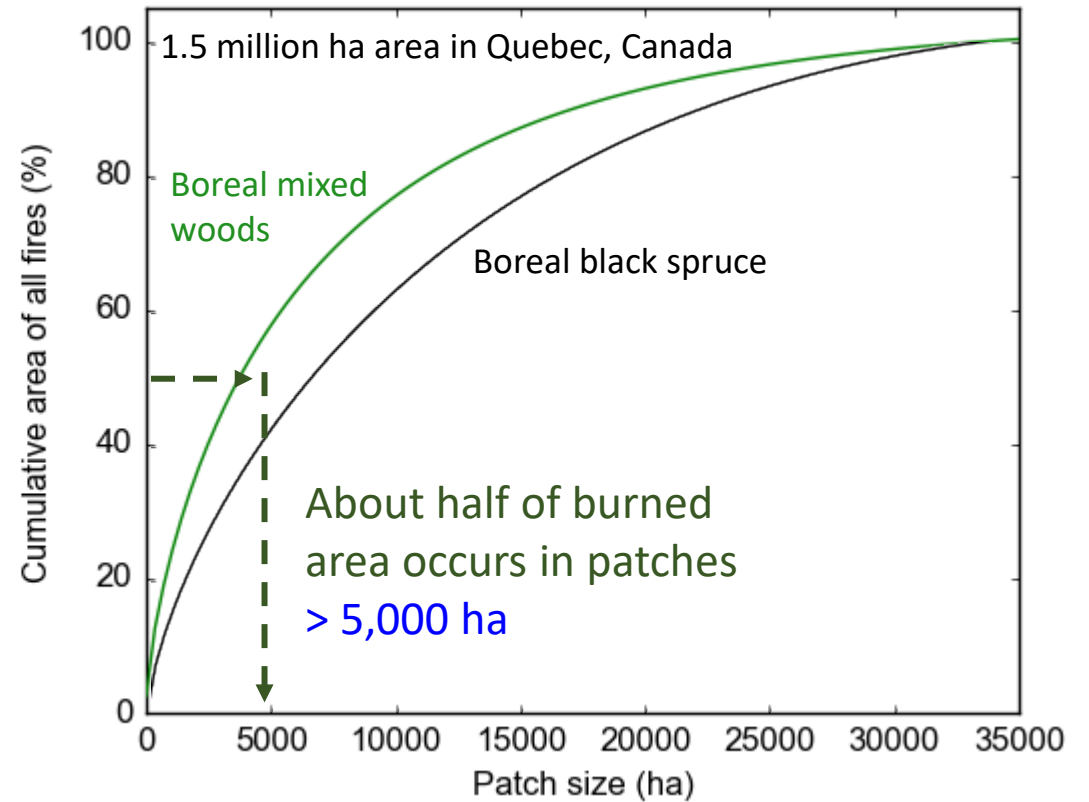


Sizes of major events

Landscapes



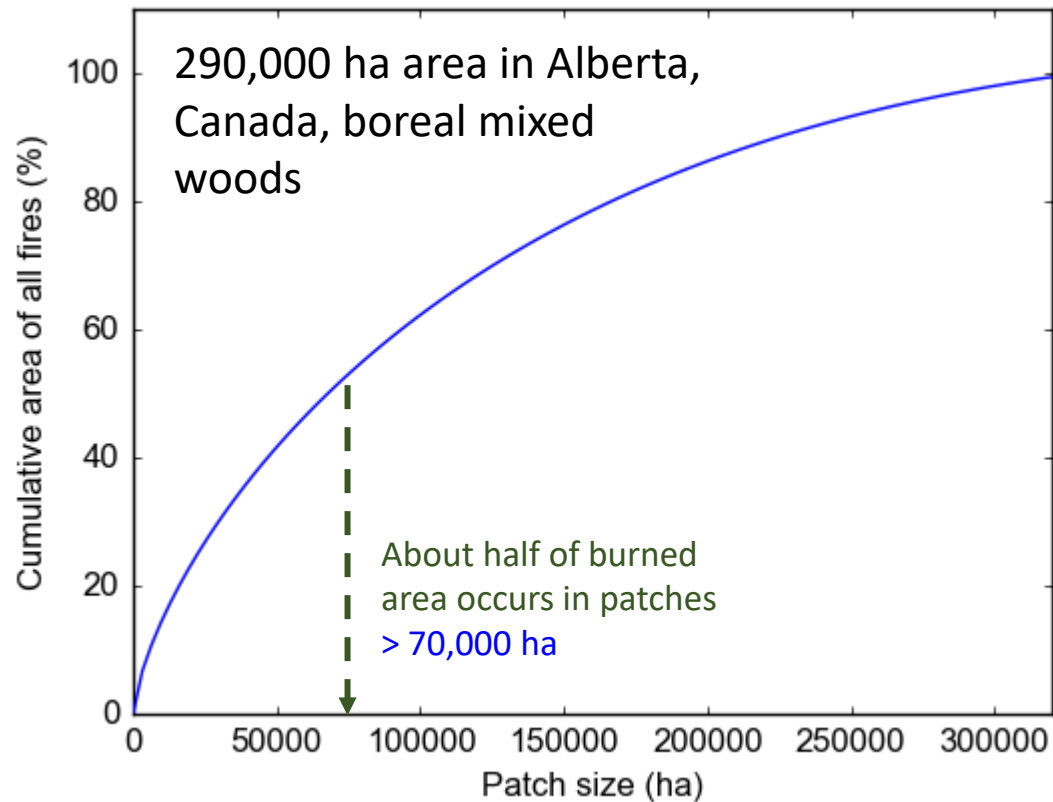
based on de Groot et al. 2013



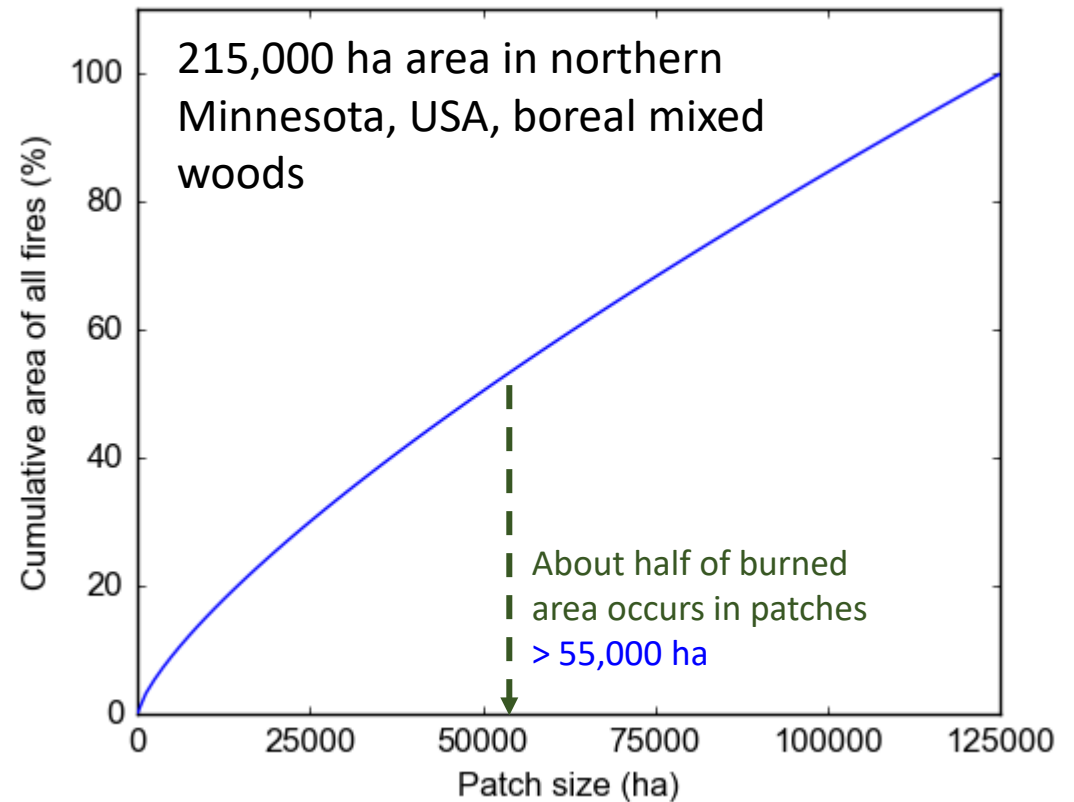
Bergeron et al. 2002

Sizes of major events

Landscapes



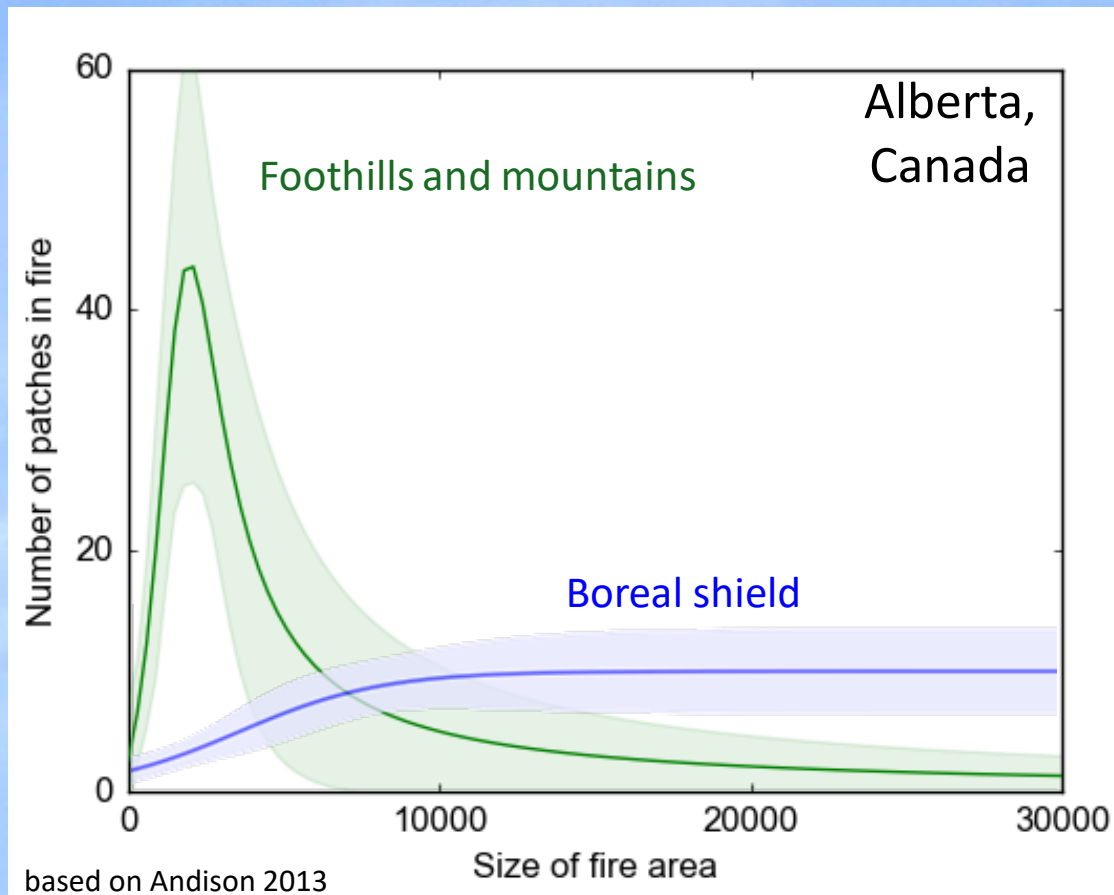
based on Cumming 2011



based on Heinselman 1973

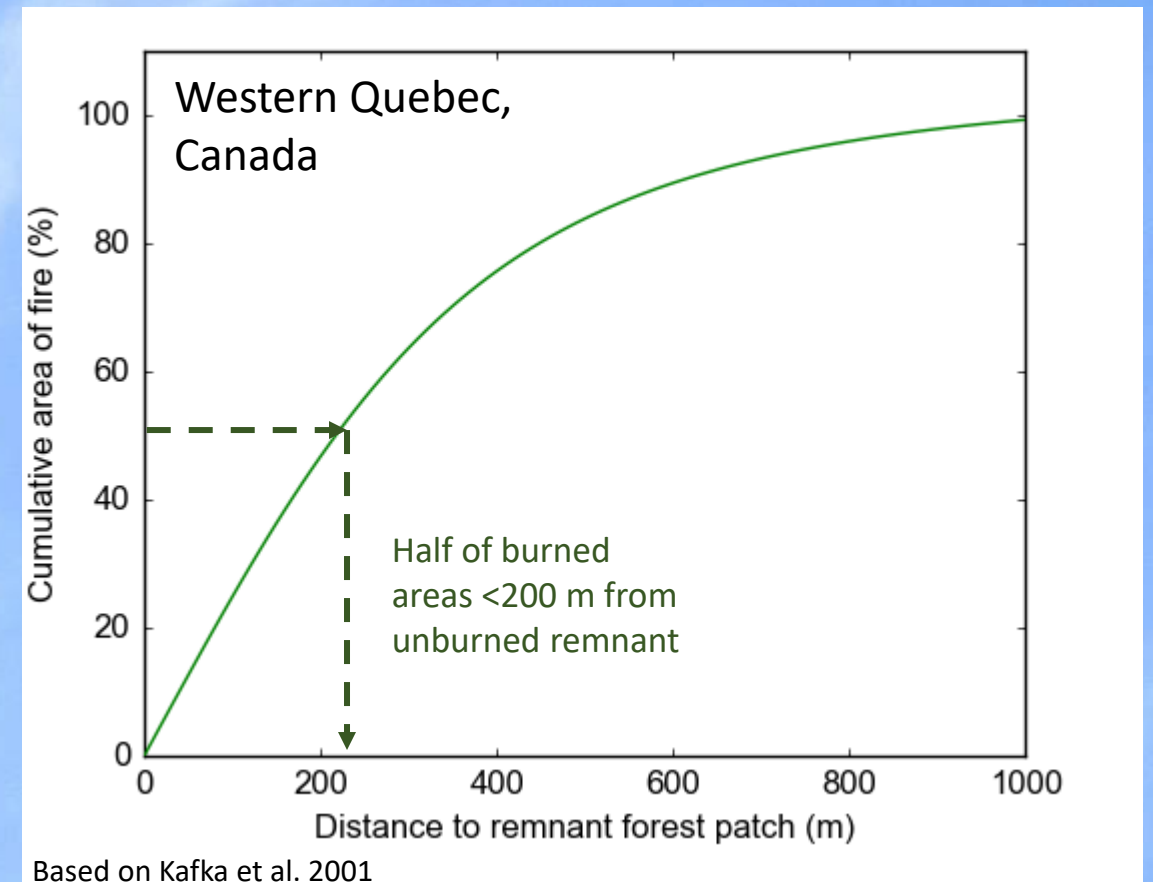
Sizes of major events

The perimeter of a boreal fire often encompasses 5 to 40 patches

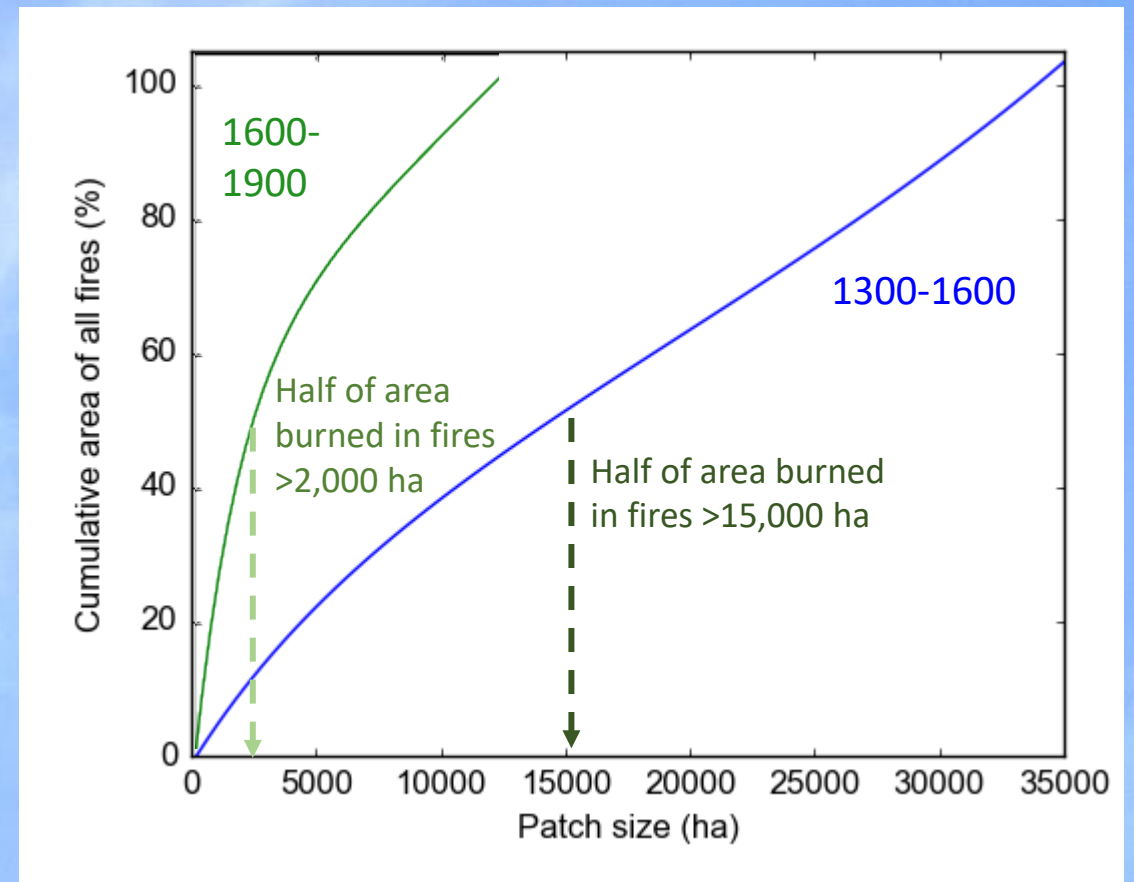
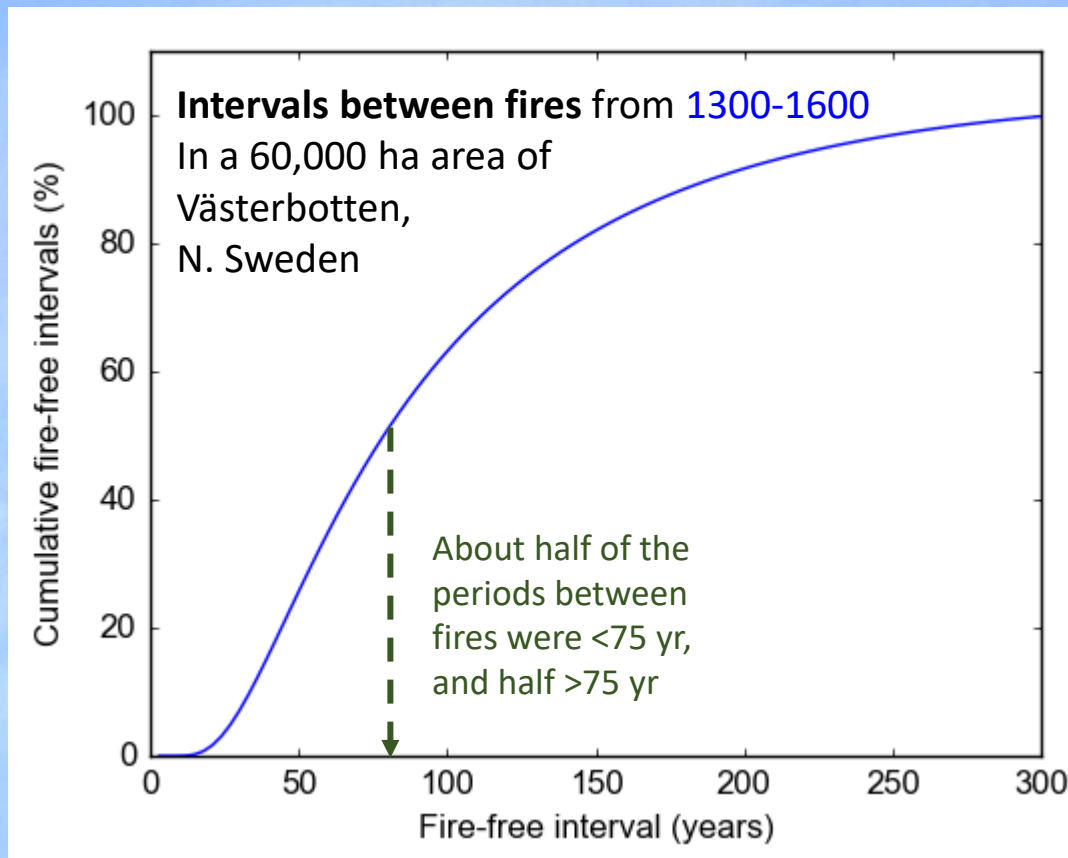


Landscapes

Much of the area within boreal fires are within a few hundred m of remnant patches

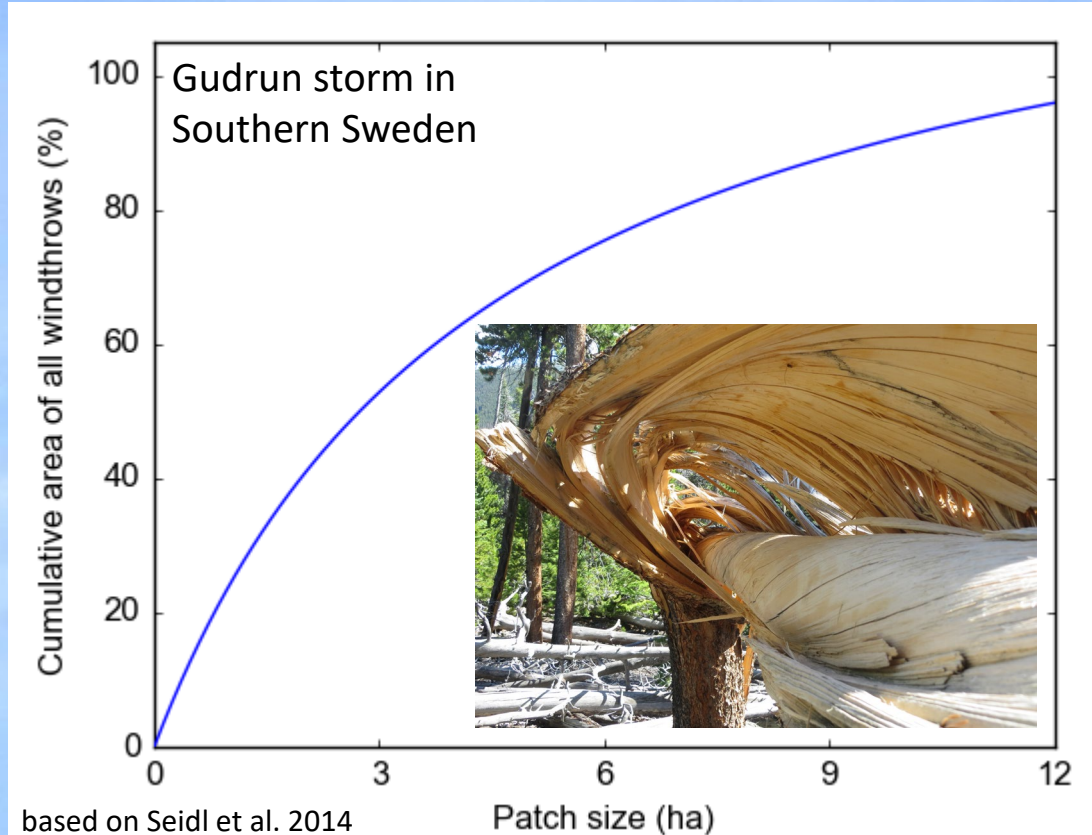


Historical patches of burned areas in Canada, Russia and boreal US tended to be >5000 ha, and often 50,000 ha. Was Fennoscandia similar?



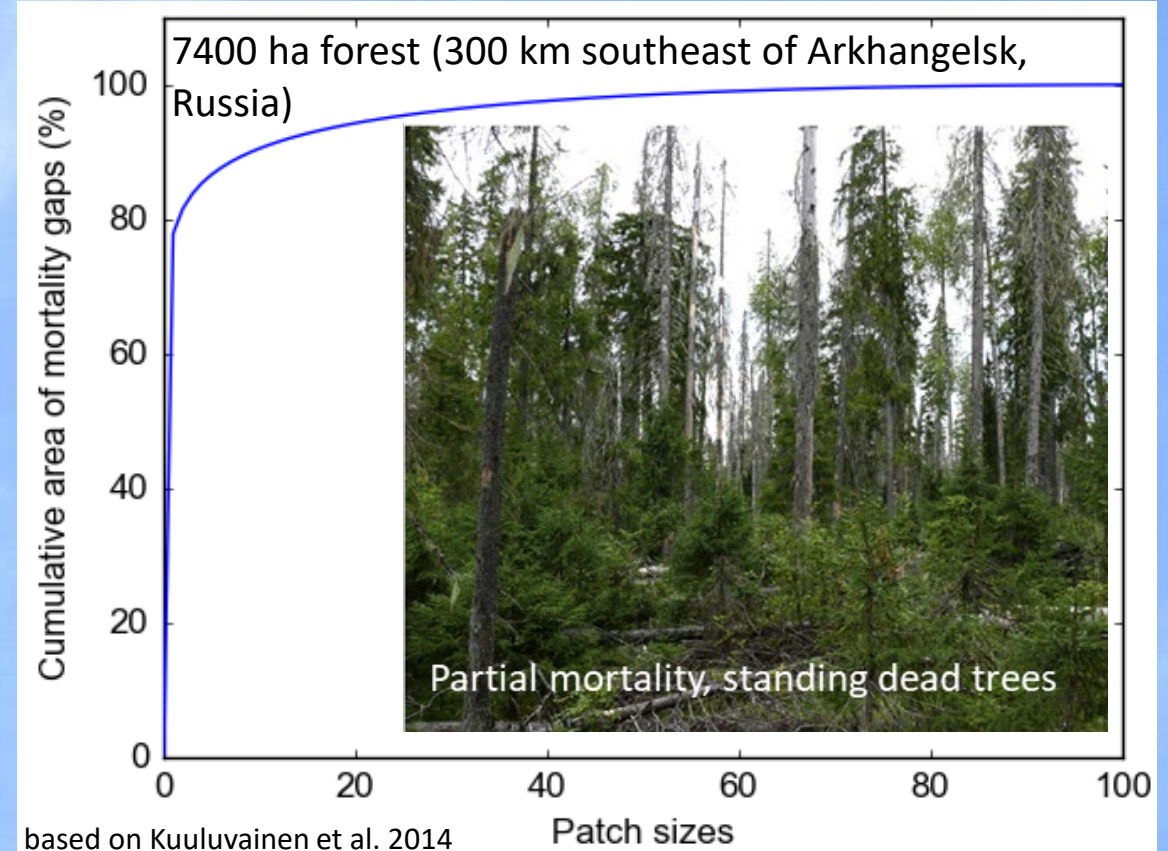
Sizes of major events

In between large fire events, storm events can create patches of several ha



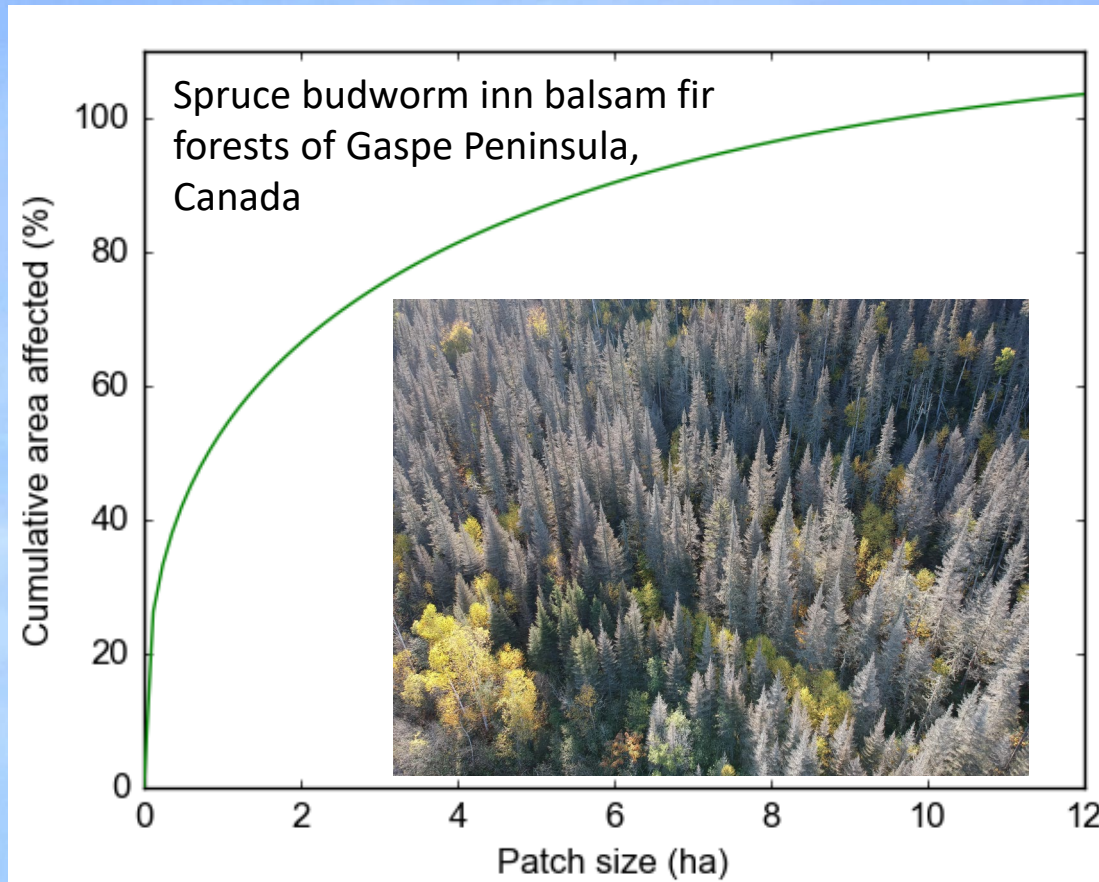
Landscapes

In between events, chronic processes in forests routinely create small “gaps”



Sizes of major events

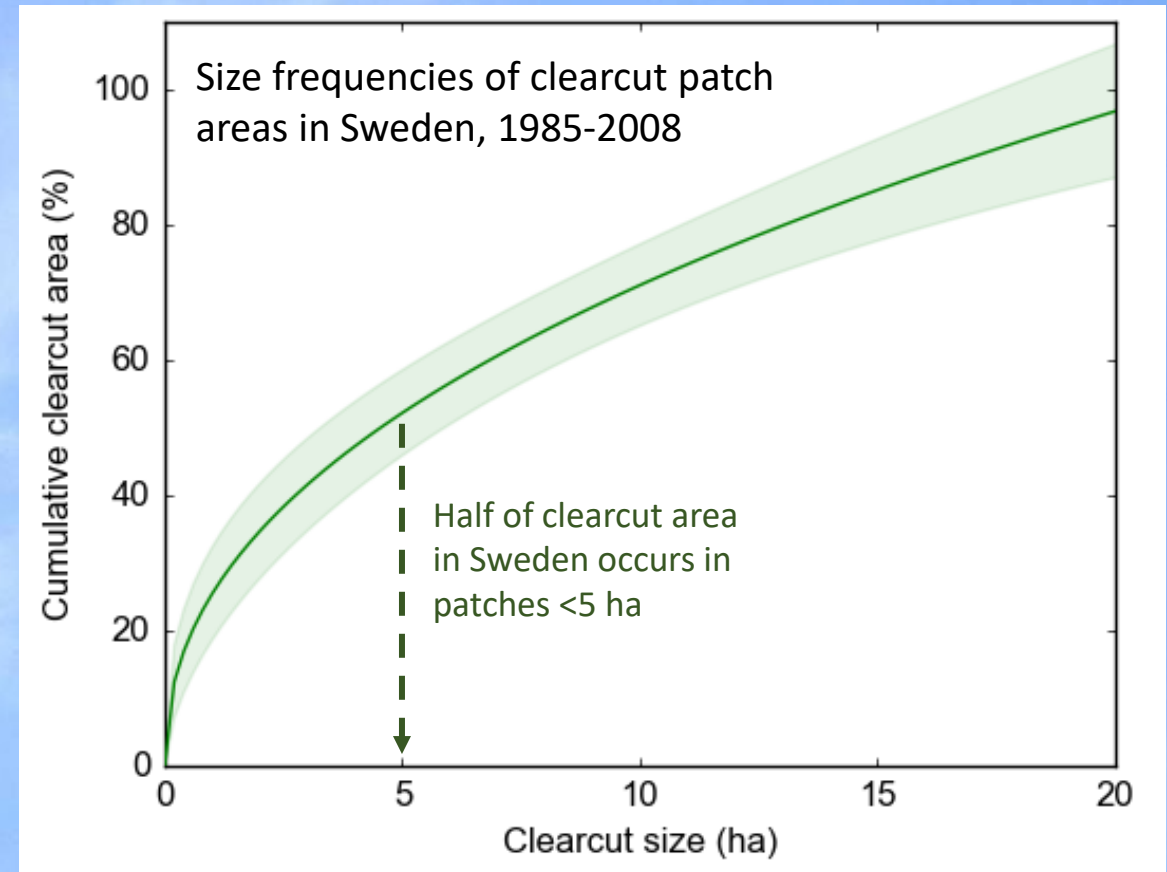
Insect events can also lead to patches of several ha



based on Belle-Isle and Kneeshaw 2007

Landscapes

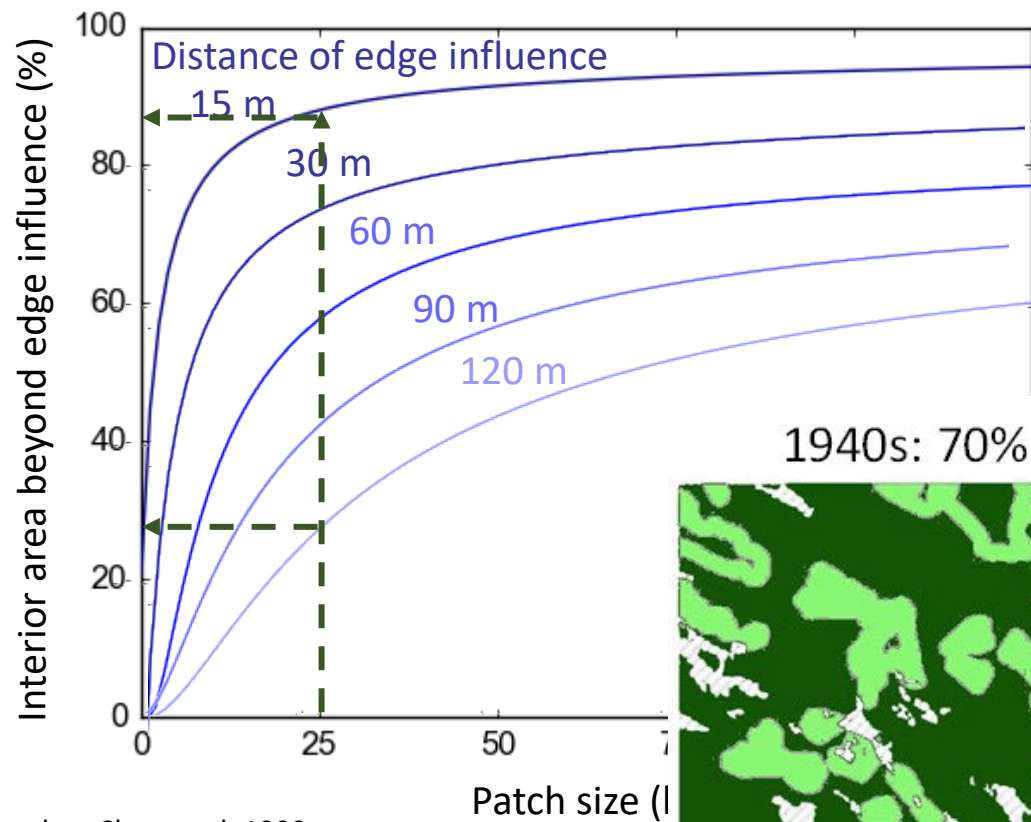
Current rotational forestry systems create patch sizes similar to chronic processes, and small events



based on Skogsdata 2012

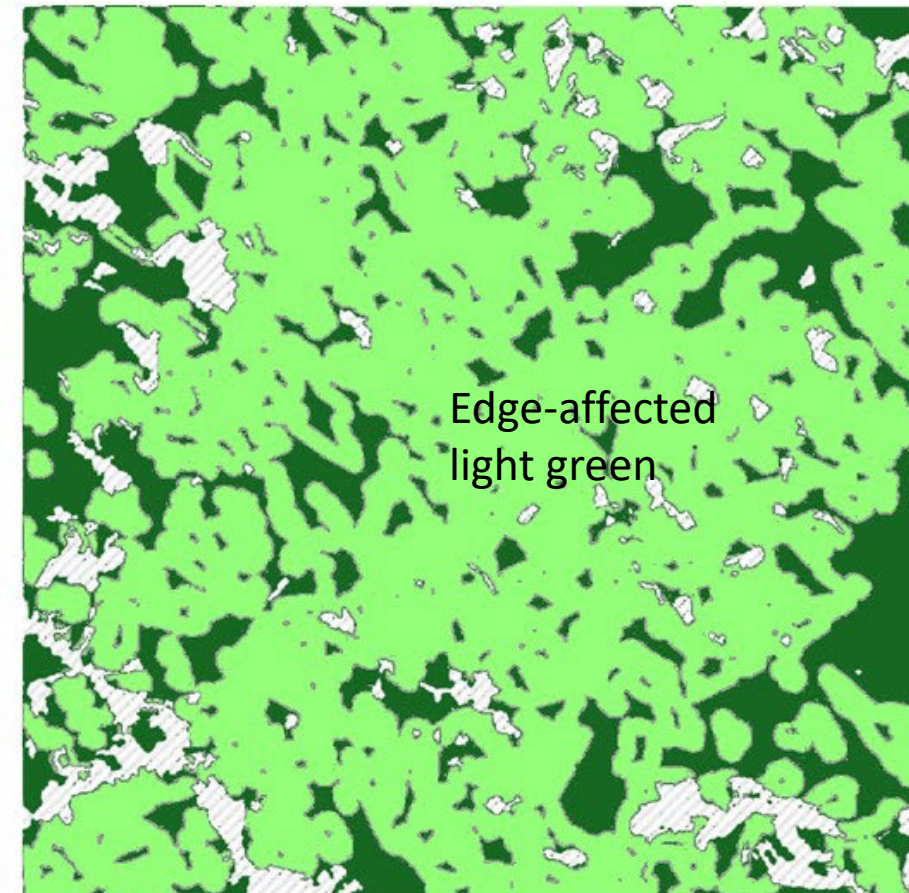
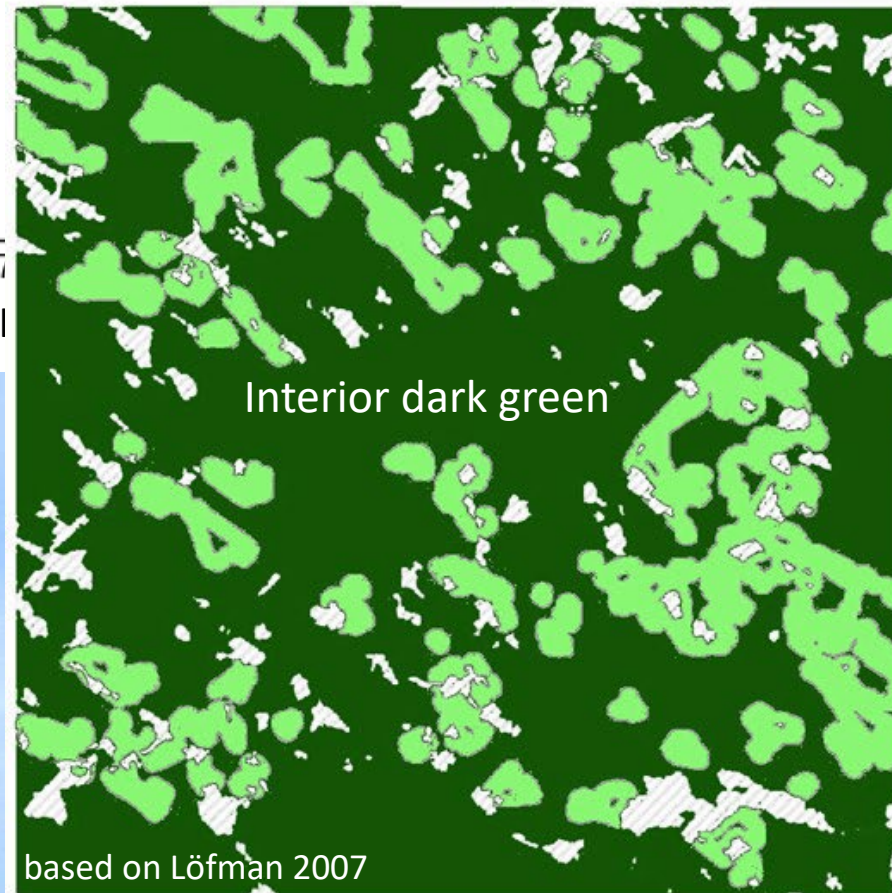
Neighborhoods and landscapes

Adjacent patches may influence each other; the amount of “interior” area depends on depth of edge effect, and patch size



1940s: 70% interior, 30% edge

1990s: 25% interior, 75% edge



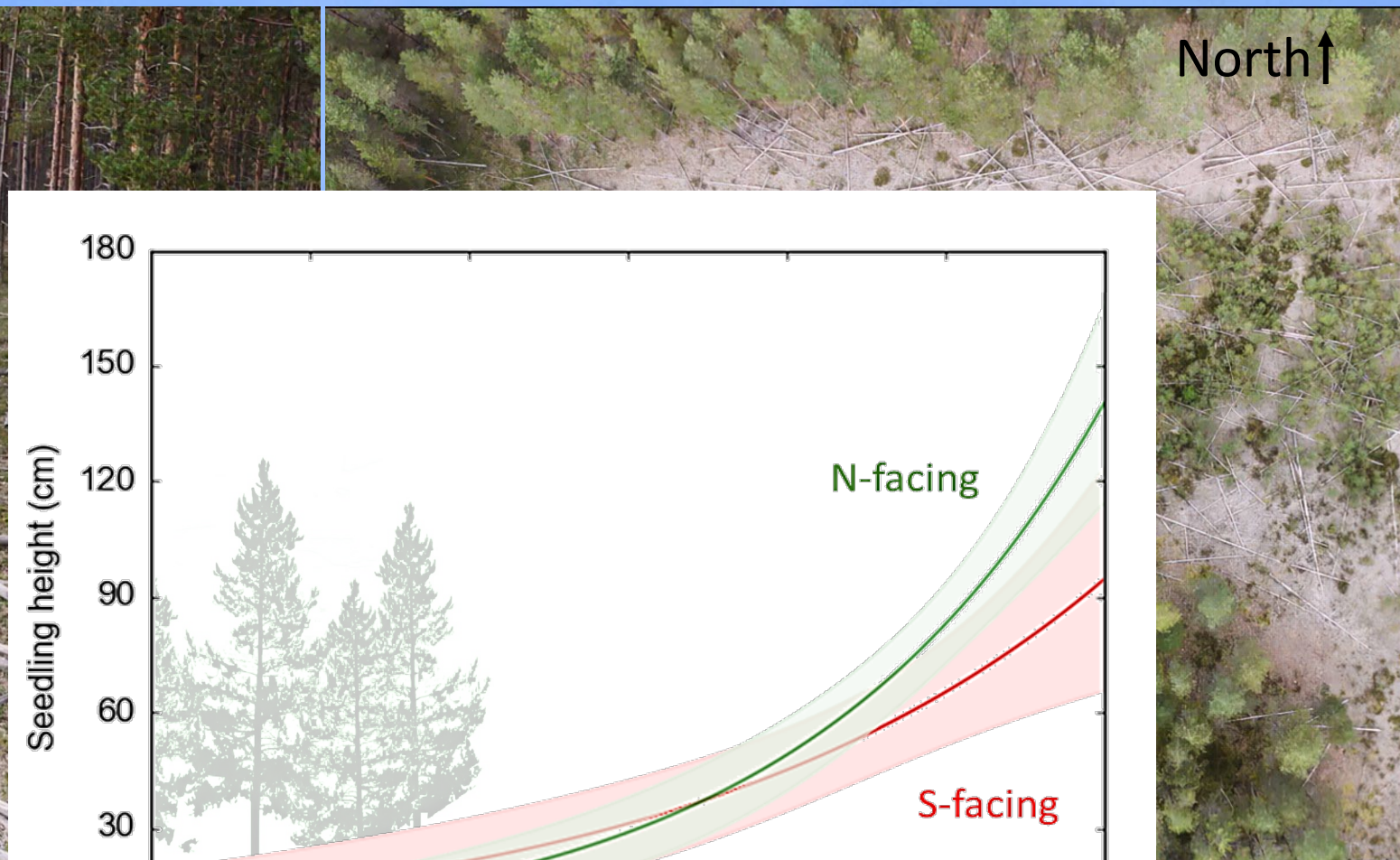
based on Löfman 2007

based on Chen et al. 1992

After 5 decades of management in a 10,000 ha landscape in eastern Finland: (based on 100-m edge effect)

Regeneration is less near large trees at edge of patch,
girdled plot with Scots pine in Sweden

Neighborhoods



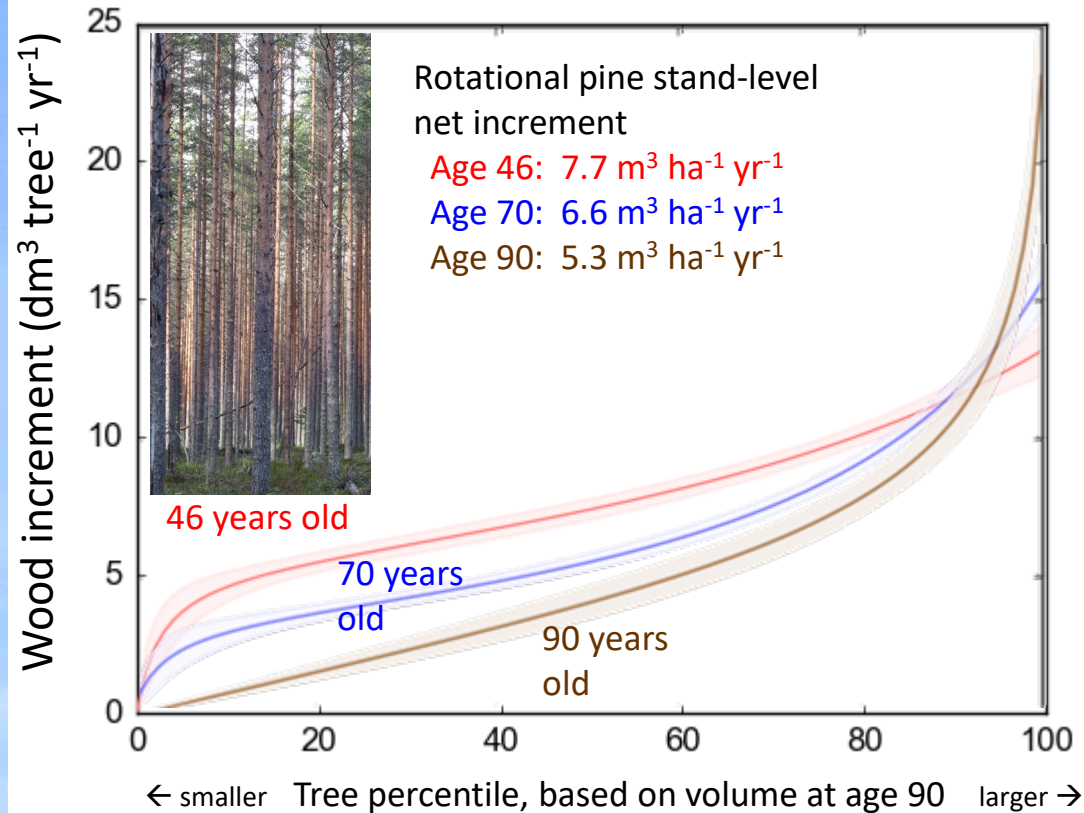
photos courtesy of Andreas Palmén;
see Högberg and Högberg 2022

Same pattern with clearcut
in Västerbotten, Sweden:

based on Axelsson et al. 2014

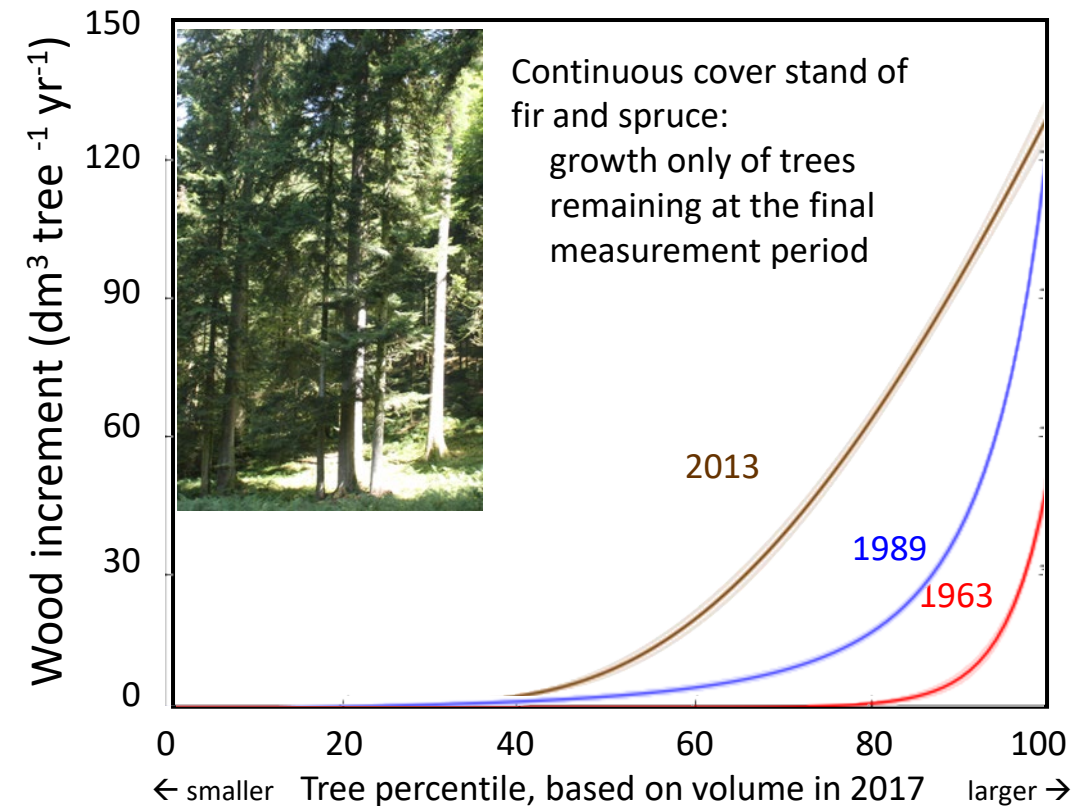
Growth in rotational and continuous cover forests

Rotational Scots pine, Finland



Data from Harri Mäkinen

Continuous cover fir/spruce, Switzerland



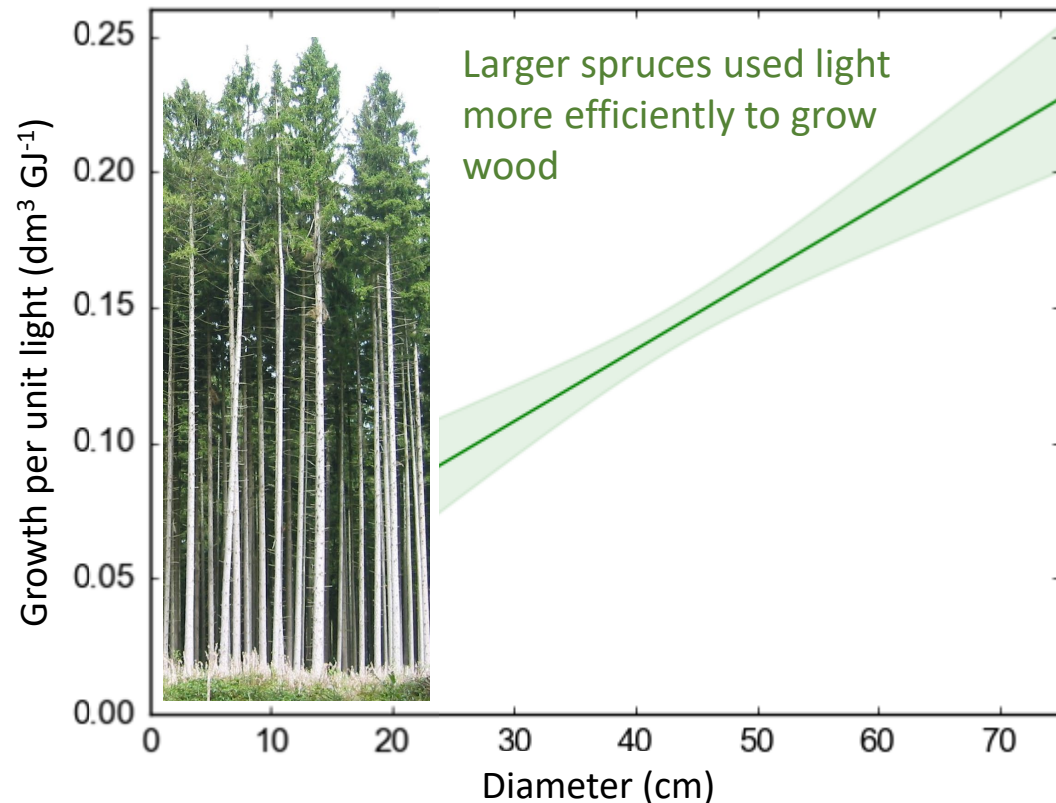
Plot 1015001, EnviDat, Swiss Federal Research Institute for Forest, Snow and Landscape Research

In **rotational forestry**, largest trees usually (not always) use light more efficiently to make wood

In **continuous cover forestry**, maybe the pattern with tree size would be very different?

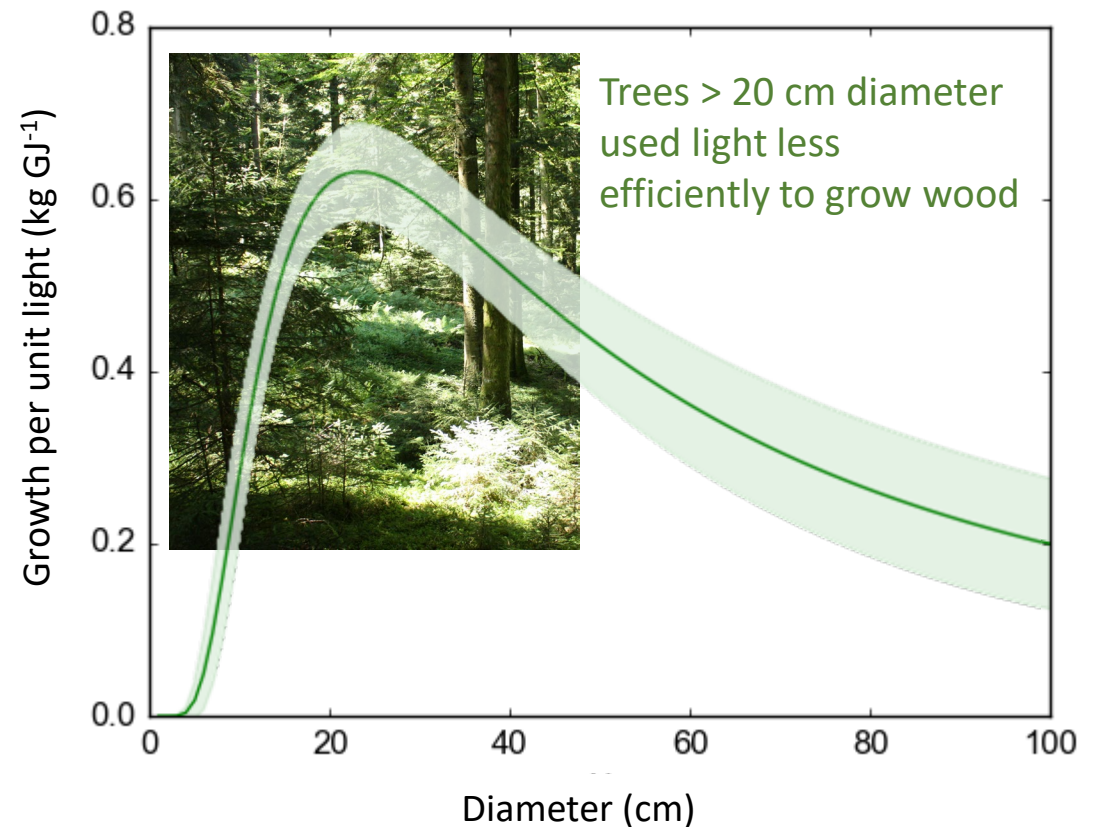
In both systems, what happens to the largest trees is crucial for stand-level growth

Rotational spruce, Austria



based on Gspaltl et al. 2013

Continuous cover fir/spruce



based on Forrester 2019, Forrester et al. 2022



2023

**FOREST
ECOLOGY AND
MANAGEMENT**
SCIENCE TO SUSTAIN THE WORLD'S FORESTS



Long-term yield and biodiversity in stands managed with the selection system and the rotation forestry system: A qualitative review

Adam Ekholm^a, Lars Lundqvist^b, E. Petter Axelsson^a, Gustaf Egnell^b, Joakim Hjältén^a,
Tomas Lundmark^b, Jörgen Sjögren^{a,*}

Neighborhoods

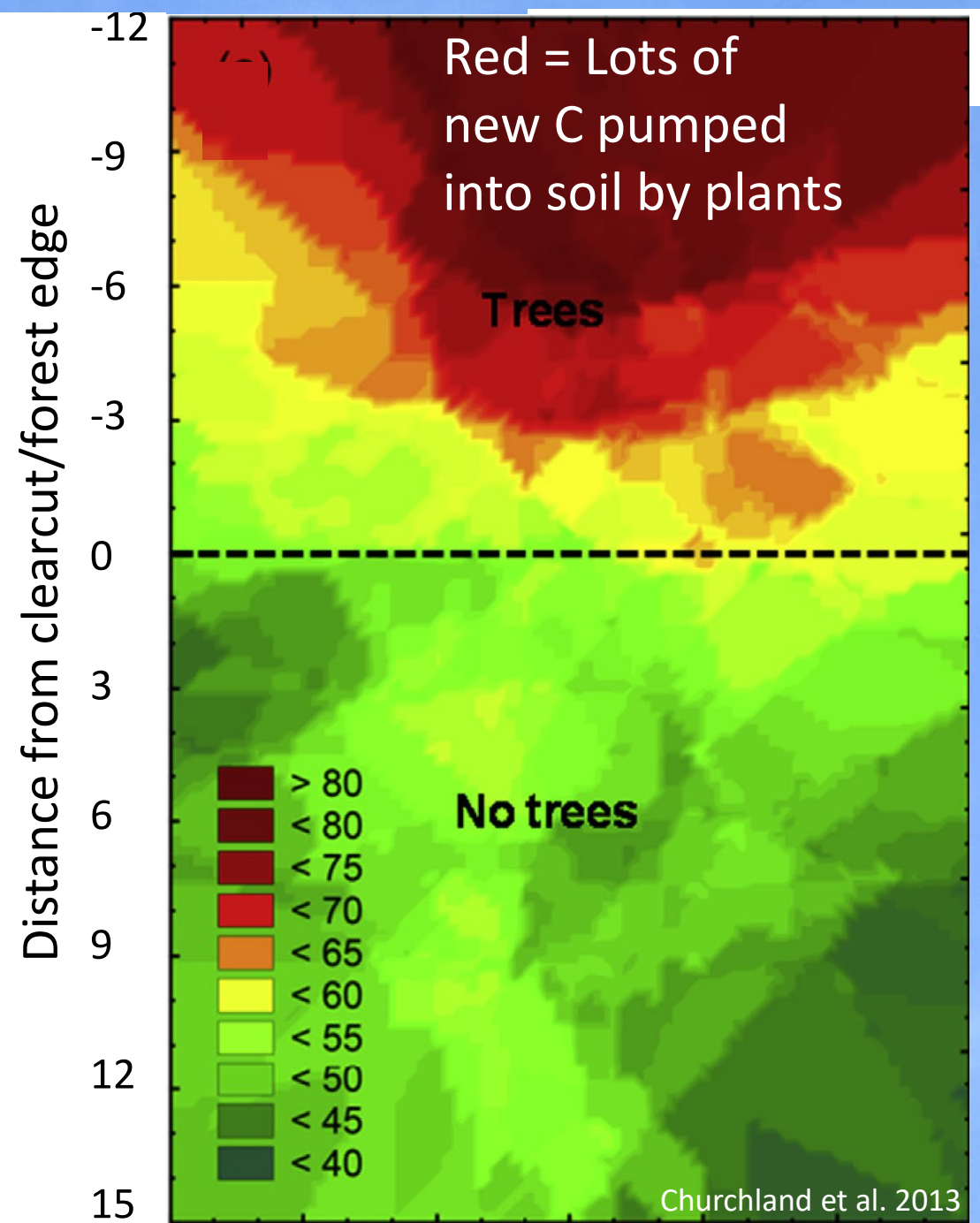
“In conclusion, management with the selection system may come with a loss in long-term stand yield

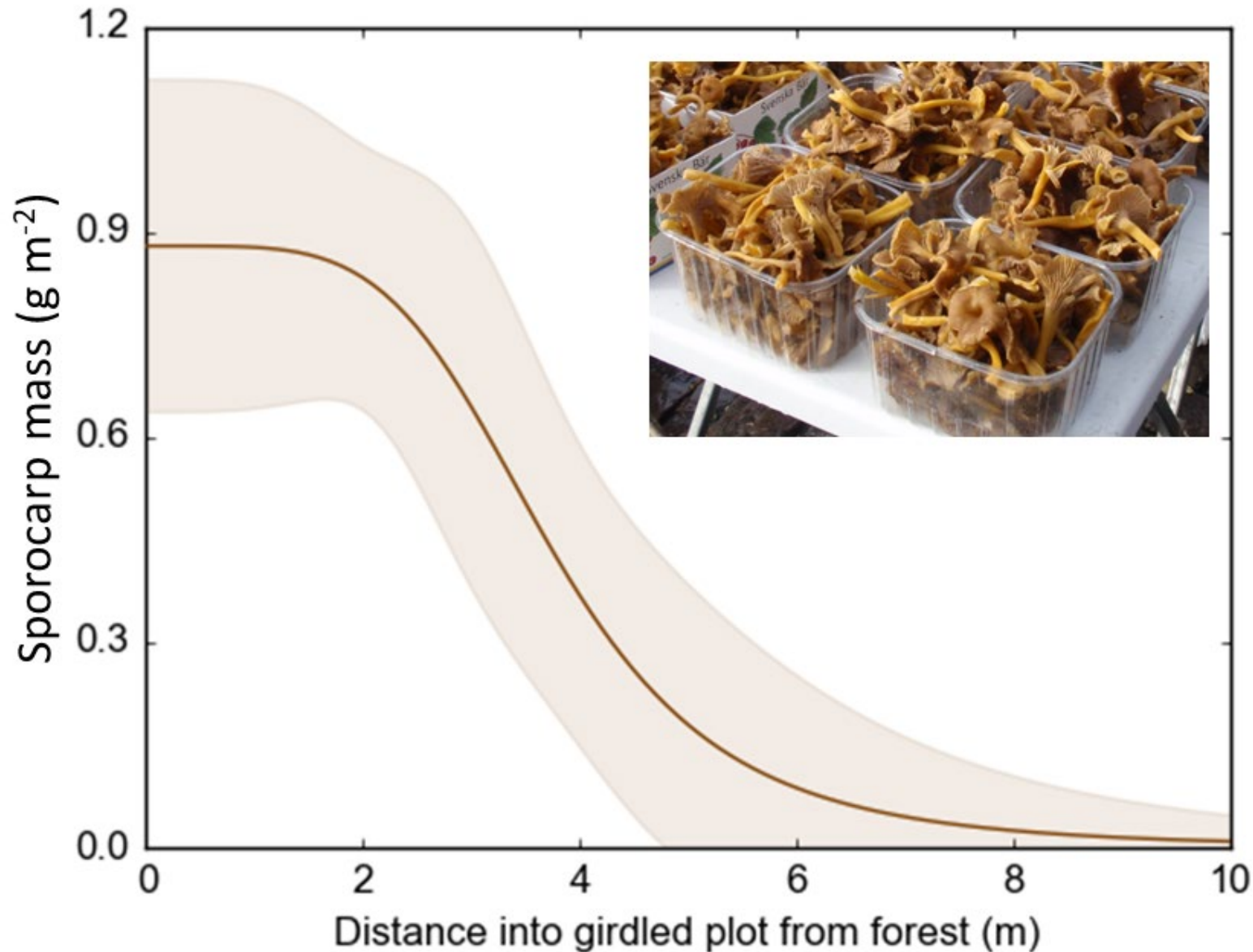
“We recommend future studies to specifically focus on long-term effects on biodiversity – in particular on species of conservation concern

“There is also a need to establish a long-term research infrastructure to further develop the field”

Growth is only one
aspect of space in forests

65-yr-old western
hemlock/Douglas-fir,
Vancouver Island, Canada

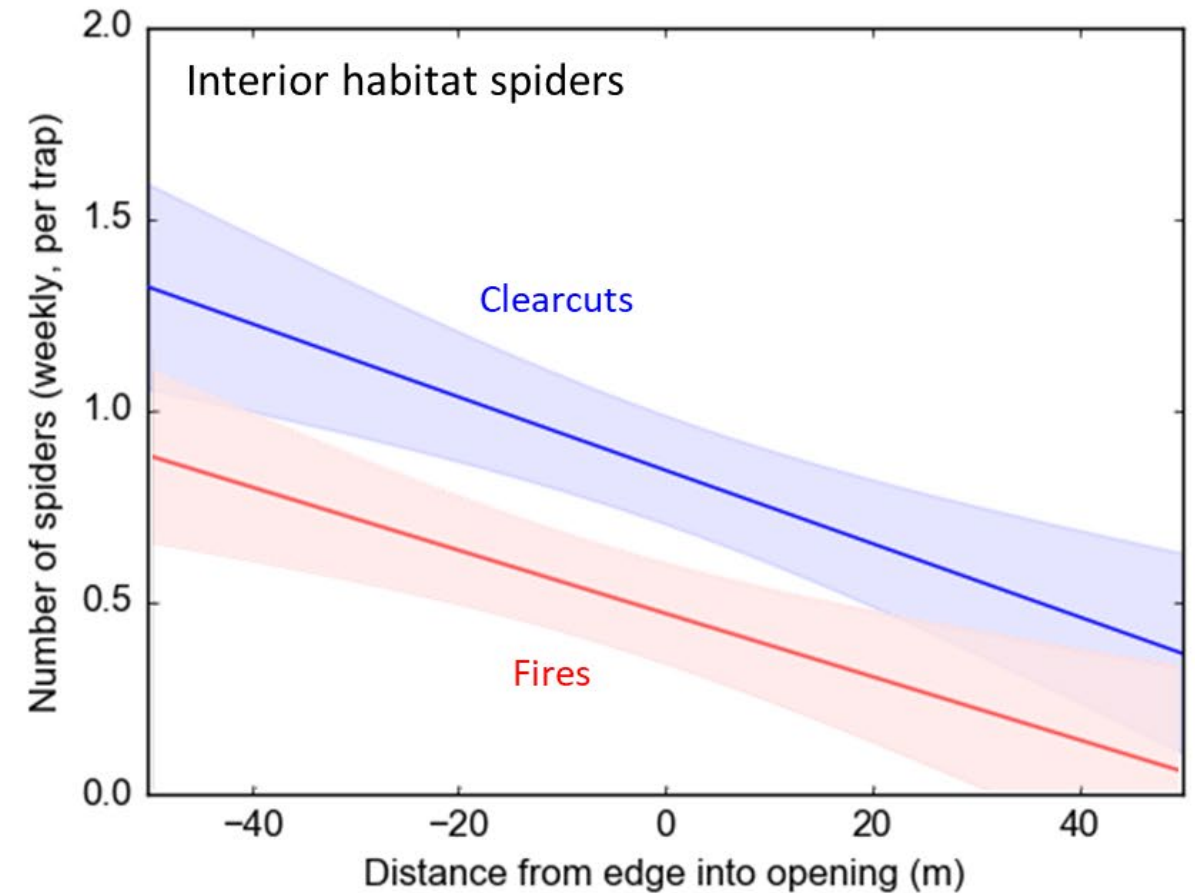
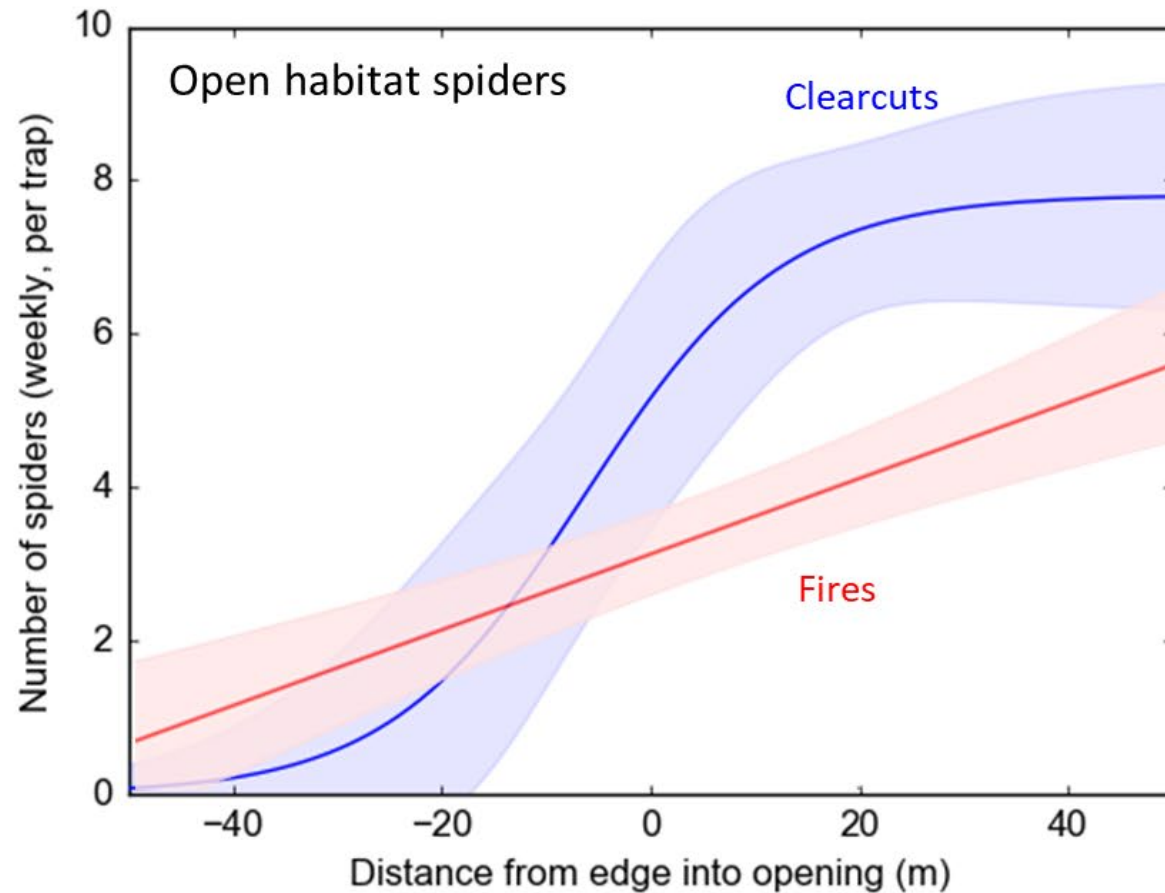




Many mushrooms come from mycorrhizal fungi, and production declines with distance from live trees

- Arthropods differ in responses to distance from forest edges
- Fire events and clearcut events may not lead to the same effects

Neighborhoods

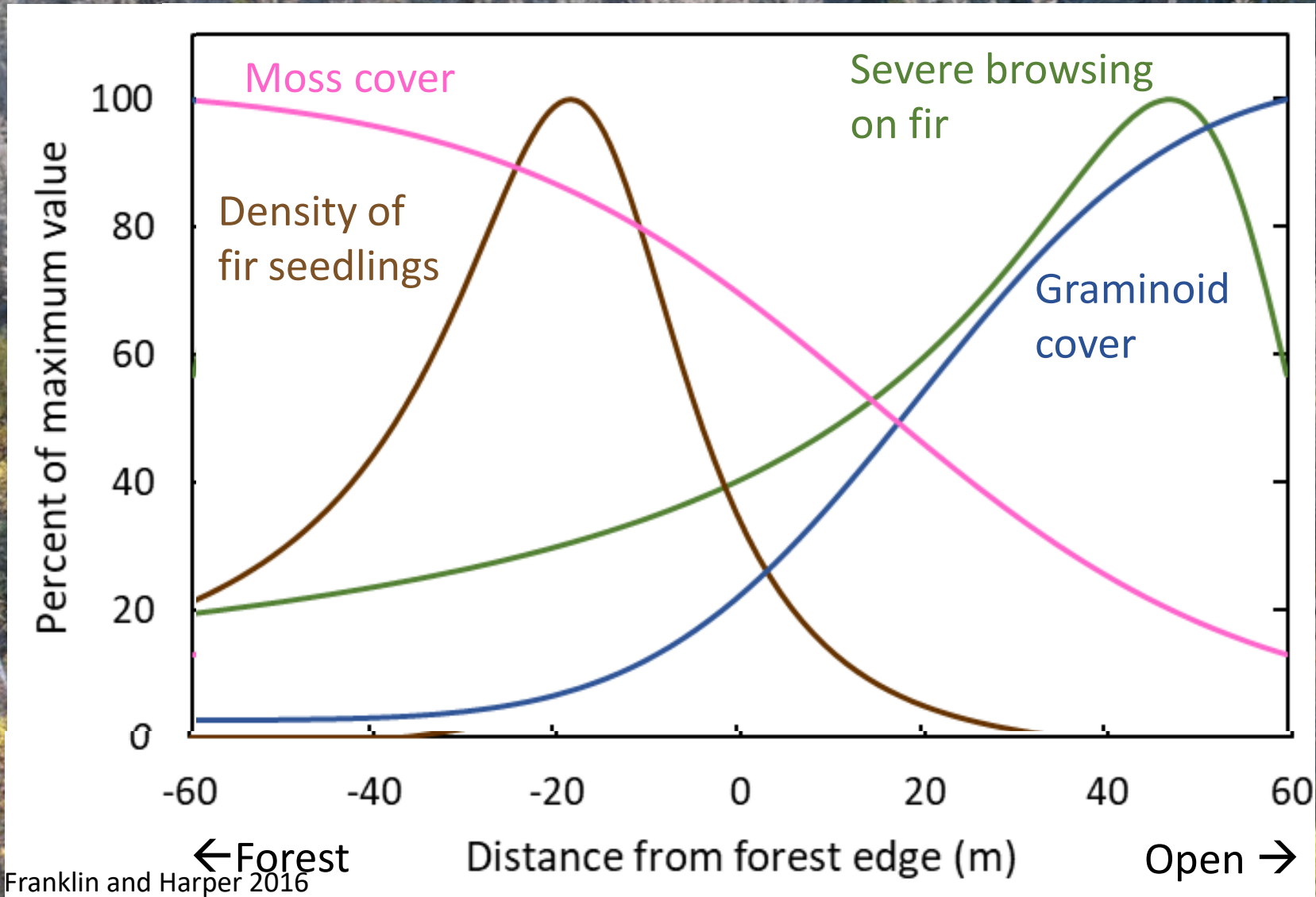


Larri  e et al. 2008

Black spruce forests, eastern Quebec, Canada

Neighborhoods

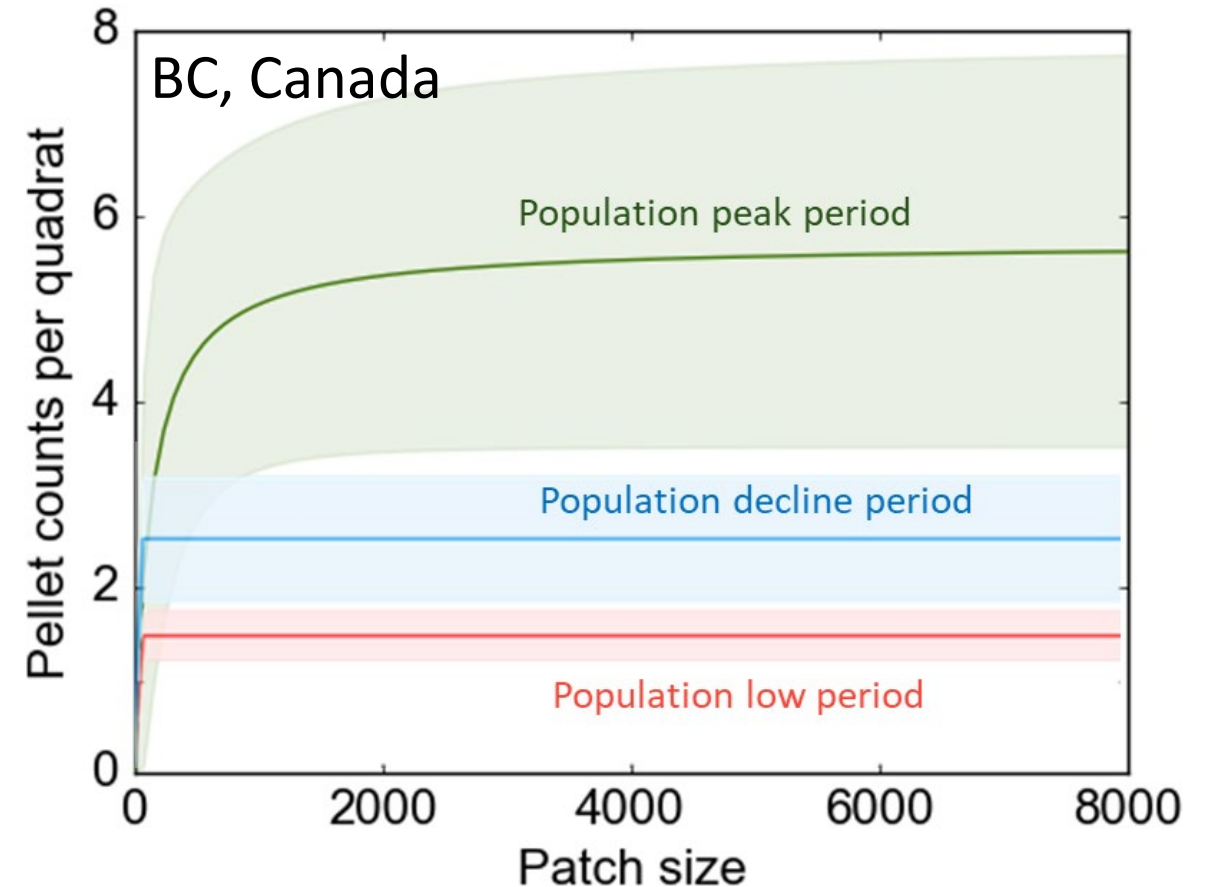
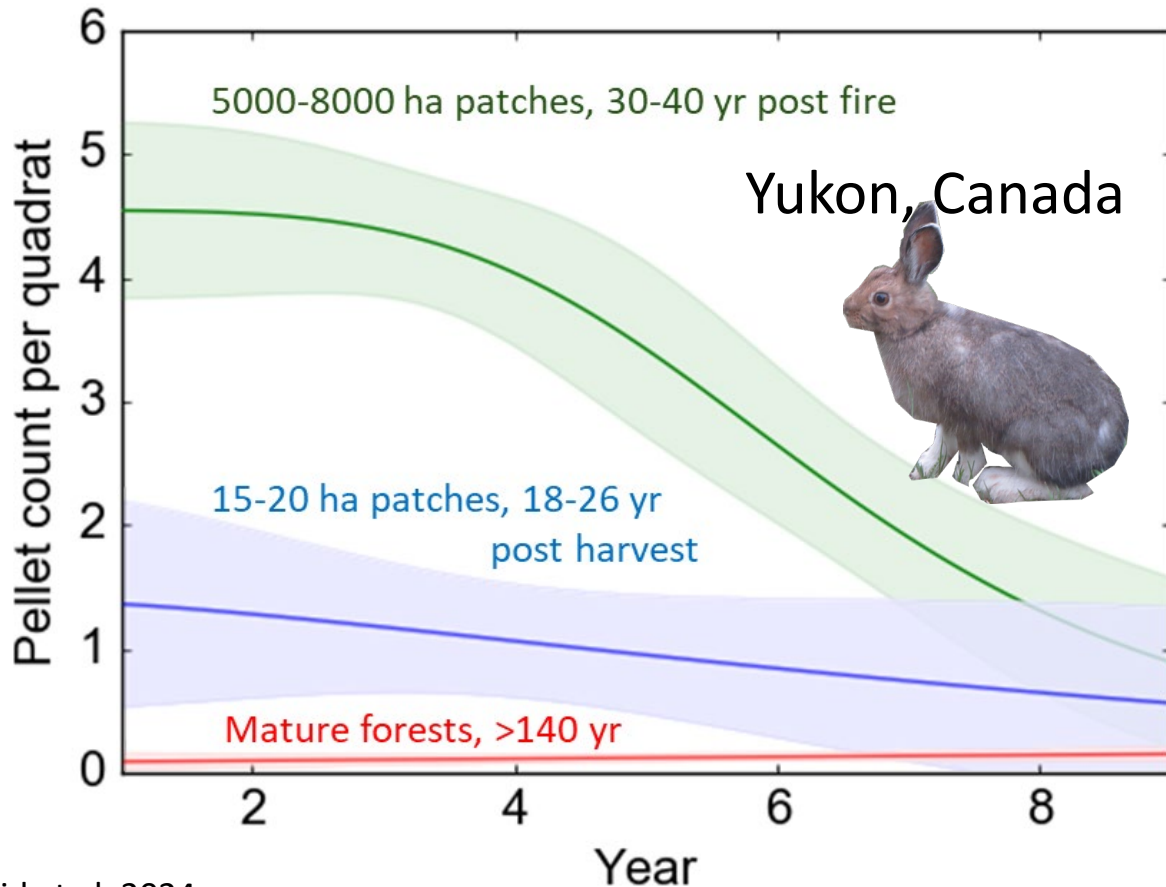
The influences of edges differ among ecological features, with varying distances too



Edge of balsam fir stand in Nova Scotia, Canada (mortality patch from spruce budworm)

Photo provided by Dan Kneeshaw

Snowshoe hares only reach high populations (and cycle) in young forest patches >1000 ha

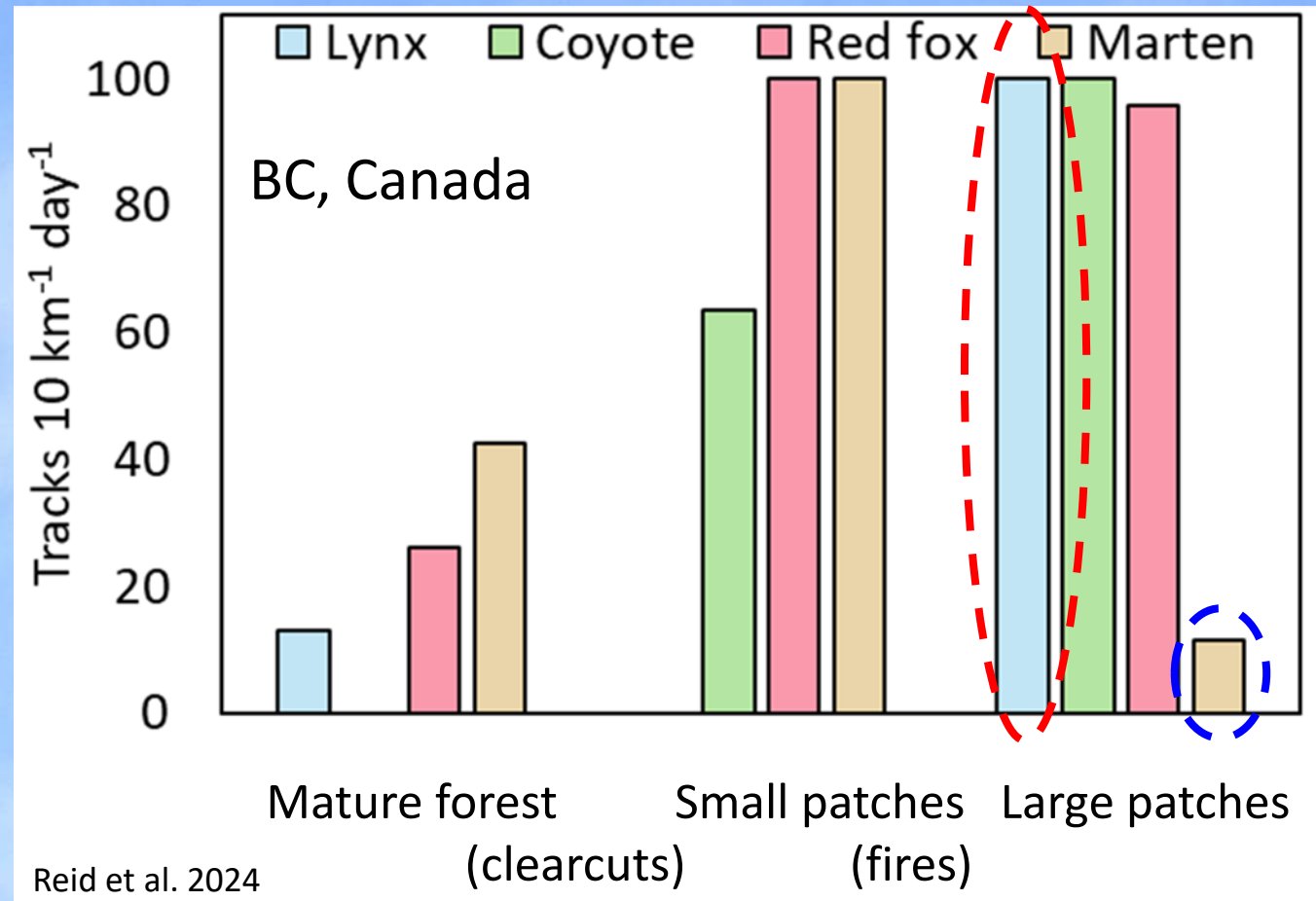


Reid et al. 2024

White spruce/black spruce/lodgepole pine/aspen forests

Predators differed in responses:

Lynx occurred only in large patches, large patches had little use by martens



White spruce/black spruce/lodgepole pine/aspen forests

What can this
Scots pine be
in the future?



What can this
forest be in
the future?



What can this
landscape be
in the future?



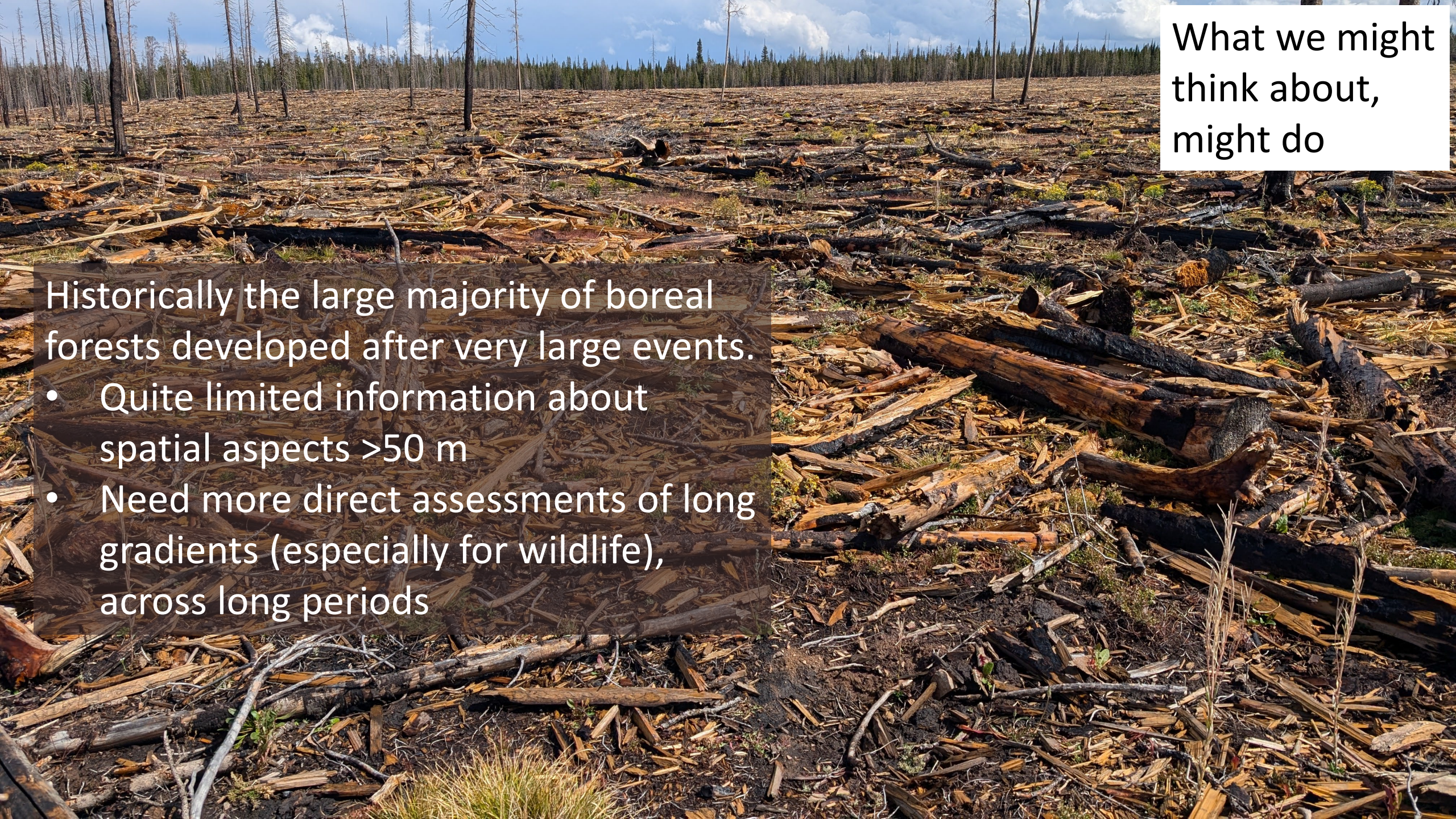
What we might
think about,
might do



What we might
think about,
might do

Aspects of scale have GREAT importance at <50 m:

- Growth – of trees and of stands
- Regeneration creating the next forest
- Root gaps versus Continuous Root Forestry
- Wildlife



What we might
think about,
might do

Historically the large majority of boreal forests developed after very large events.

- Quite limited information about spatial aspects >50 m
- Need more direct assessments of long gradients (especially for wildlife), across long periods



What we might
think about,
might do

The largest trees in
a forest have the
biggest effects in
both RF and CCF –
but maybe not the
same effects?

A clear focus on
largest trees might
teach us a lot.

Some thoughts to develop

Forests do not have just
one way to be

Forests do not tell one
story across landscapes

Forests do not
repeat the same
stories across
decades and
centuries

What we might
think about,
might do

If forests have so many
viable ways to develop,
how do we make wise
decisions about stands
and landscapes?



- If forests don't have single stories, "command and control" policies and prescriptions may not be the best
 - If a single desired future forest isn't the focus, consider "undesired" futures to avoid
 - "Pocket Science" approaches every management unit as a learning opportunity

What we might think about, might do

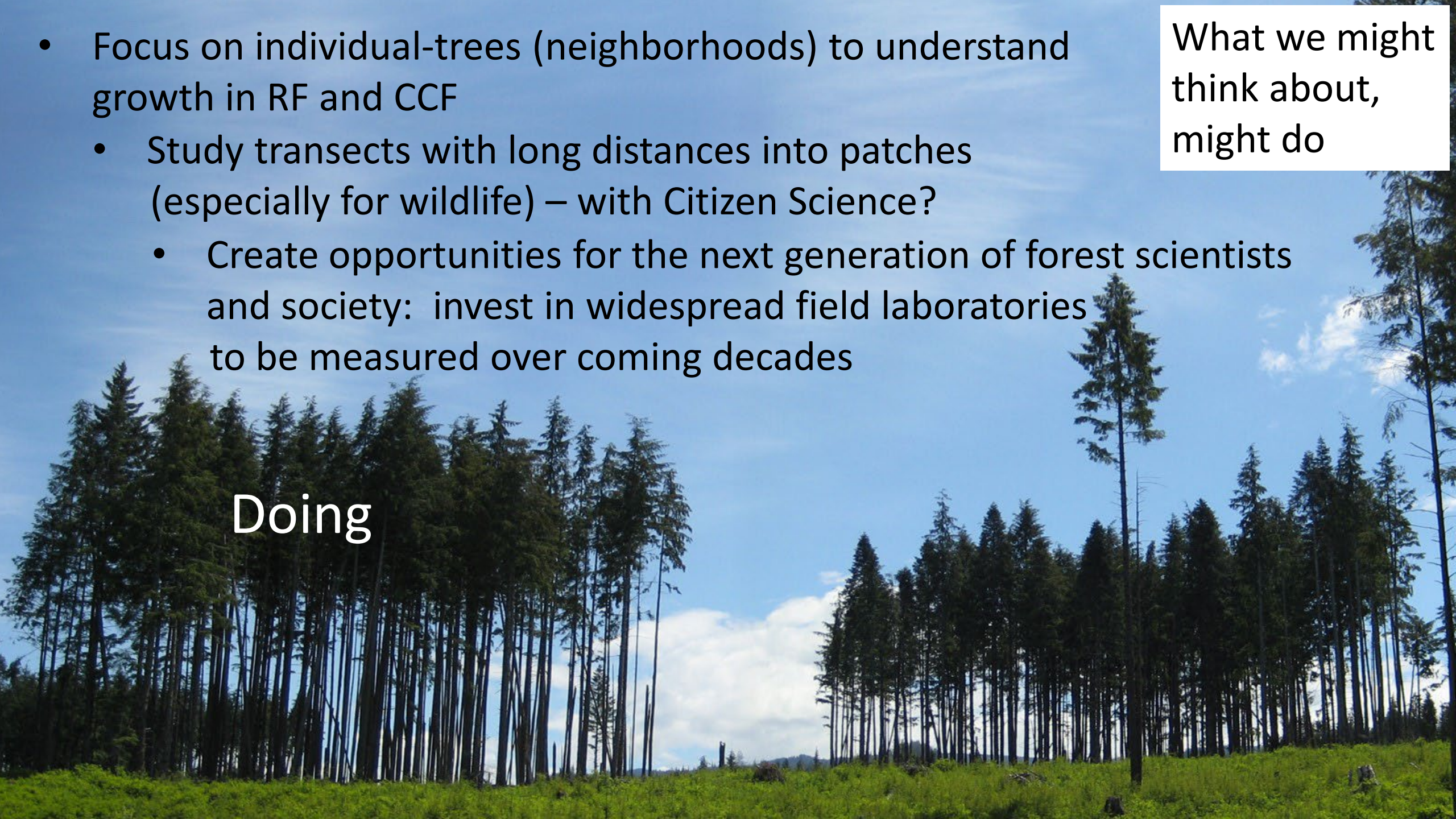
Thinking



- Focus on individual-trees (neighborhoods) to understand growth in RF and CCF
 - Study transects with long distances into patches (especially for wildlife) – with Citizen Science?
 - Create opportunities for the next generation of forest scientists and society: invest in widespread field laboratories to be measured over coming decades

What we might think about, might do

Doing



Tack!



Spatial implications of 100 year “rotations”

