Planting for a Future Forest

Dr. Iara Lacher

Introduction

Seven Bends
NURSERY

Conservation Futures

Purpose of this Talk

Our Collective Goal

A Healthy Forest

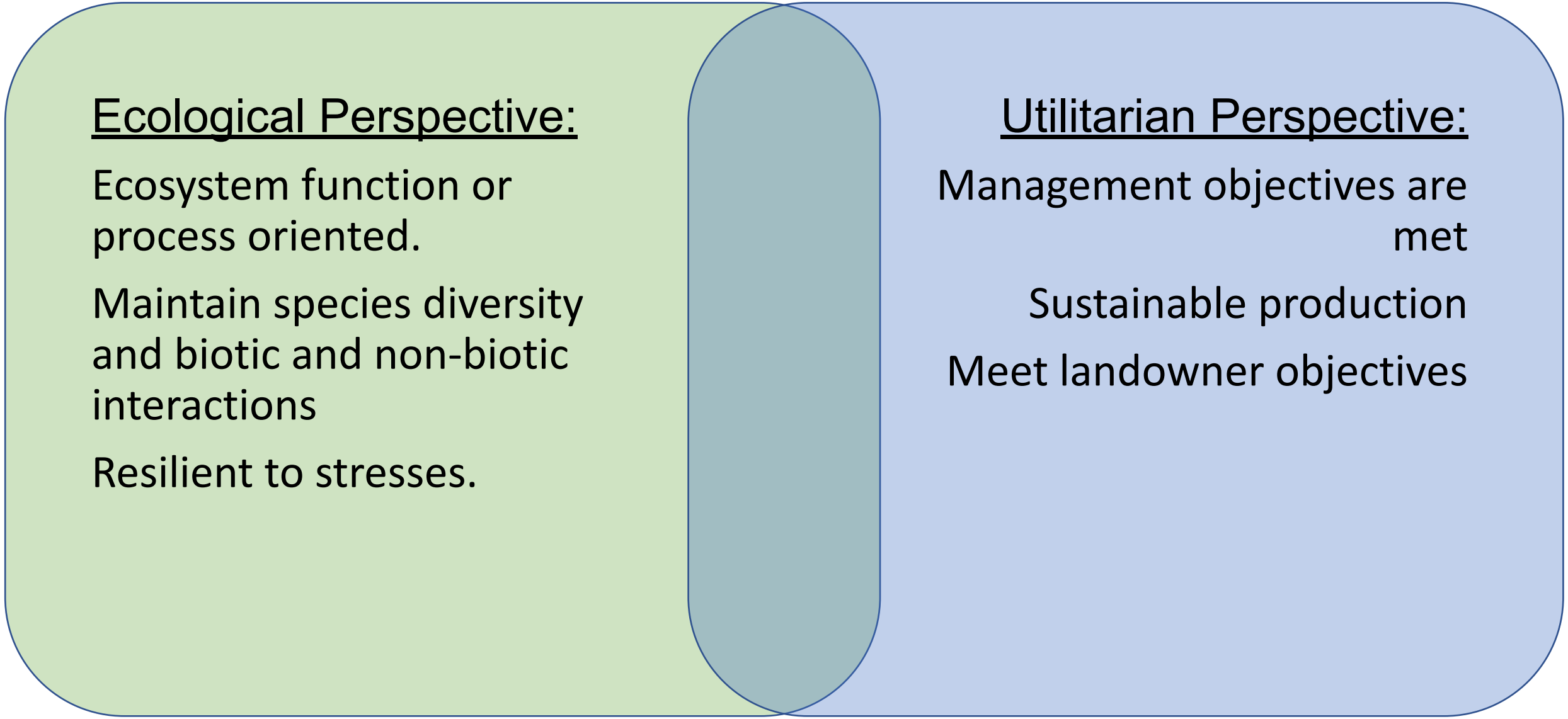
What is a “Healthy Forest”?

What are your opinions on what constitutes a healthy forest, and Why?

What is a “Healthy Forest”?

Forest health has been defined by the production of forest conditions which directly satisfy human needs and by resilience, recurrence, persistence, and biophysical processes which lead to sustainable ecological conditions. Our definitions and understanding of forest health are also dependent on spatial scale.

What is a “Healthy Forest”?



A “Healthy Forest”: The Ecological Perspective

Ecosystem Function

Ecosystem Service

A “Healthy Forest”: The Ecological Perspective

- Focus on multiple forms of diversity:
  - Species Diversity
  - Structural Diversity
  - Functional Diversity
  - Genetic Diversity
- Interactions and Food Webs
  - Above and below-ground
- Indicator species
  - Lichen
  - Mushrooms
  - Highly dependent species
- Absence of invasive species

A “Healthy Forest”: The Utilitarian Perspective

Silviculture

“the art and science of controlling the composition, structure, and dynamics of forests”

- F.E. Putz, in Encyclopedia of Forest Sciences, 2004

Modern silviculturalists respond to diverse and often conflicting demands:

- Sustained yield of timber
- Non-timber forest products (medicinal plants & wildlife)
- Recreation
- Watersheds
- Carbon sinks

… while avoiding loss of multiple measures of diversity.

A “Healthy Forest”: Shifting perspectives

ELSEVIER

Forest Ecology and Management

Volume 421, 1 August 2018, Pages 59-71

Shifting conceptions of complexity in forest management and silviculture ☆

Fahey et al. 2018

- -4 case studies + lit review
- -How var. conceptions of complexity incorporated into design of recent silvicultural experiments in different forest types and regions
- -Identified a shift toward adaptive or resilience notions of complexity

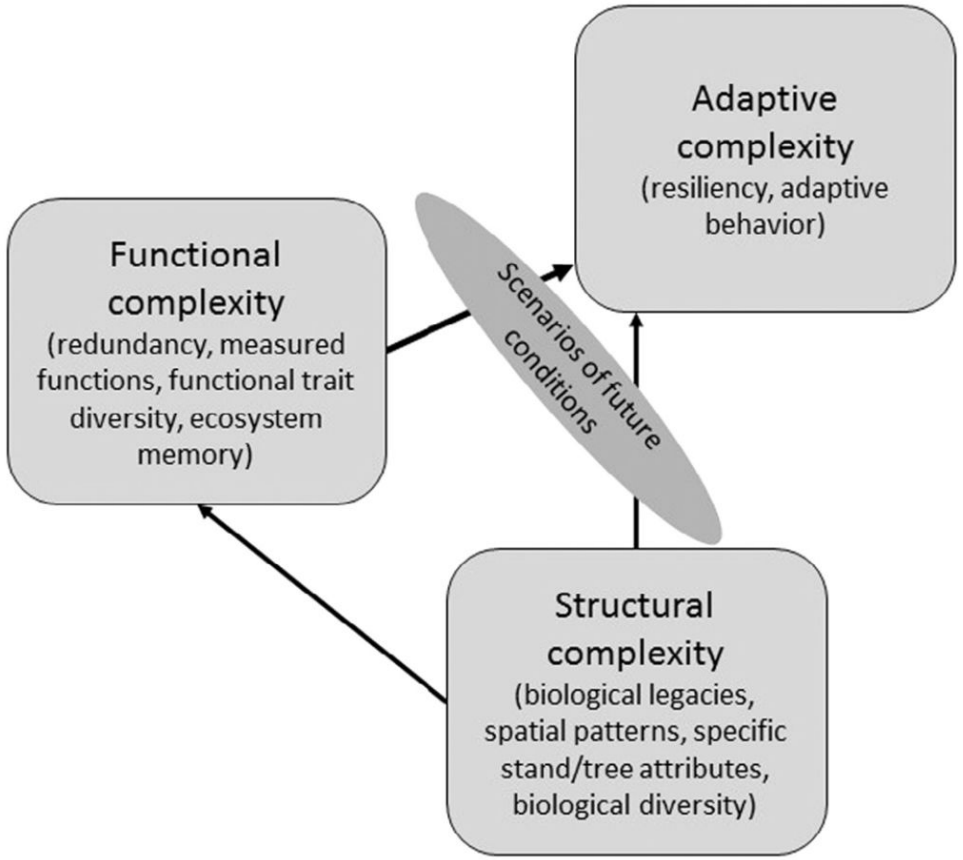


Fig. 1. Conceptual diagram illustrating the relationship between different conceptions of complexity that could be used to analyze or design silviculture treatments.

How do we determine a healthy forest?

- Crown Condition
- Tree Damage
- Tree Mortality and Standing Dead Trees
- Lichen Communities
- Down Woody Materials
- Vegetation Profile
- Soil Quality
- Nonnative Invasive Plants
- Regeneration and Browse Impact
- Fragmentation and Landscape Context

Intersecting goals

- Sustainable resources
  - Ecosystem services
    - Biomass
    - Productivity
    - Economic vitality
    - Soil
    - Carbon sequestration
    - Localized climate regulation
    - Recreation

Intersecting Goals: Diversity and biomass productivity

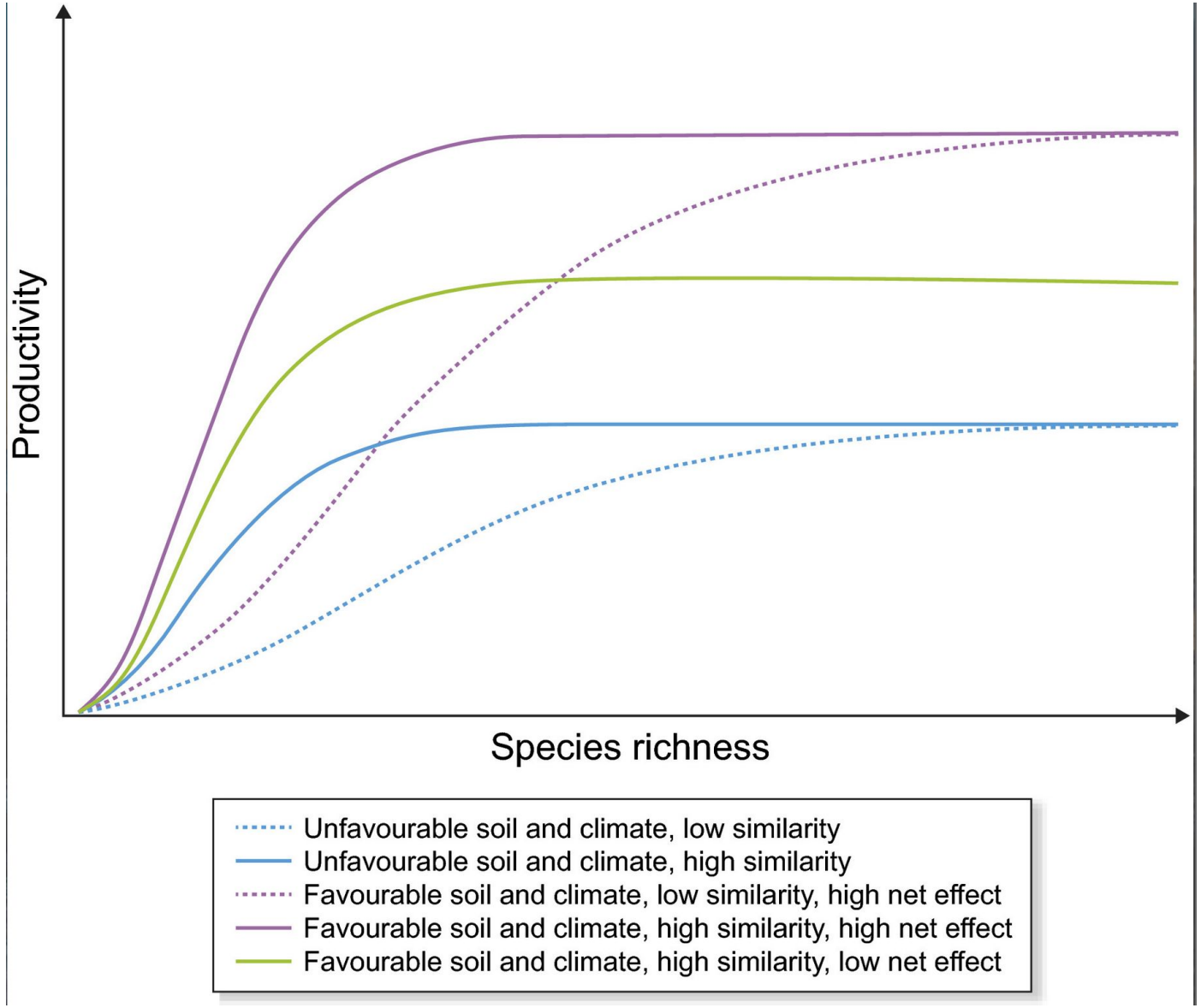
Mixed forests and plantations

- "The insurance hypothesis (Yachi and Loreau 1999) to better prepare forests for the uncertainties derived from global changes"
- Mixed forests are (naturally) more productive
- More able to withstand environmental changes and pest/disease
- All -> Higher ecosystem services provided

Messier et al., Forest Ecosystems. 2019

Intersecting Goals: Diversity and biomass productivity

- shape of the curve relating forest productivity to tree species diversity seems to be similar across biomes.
- both the shape of the *function* and the point at which it becomes asymptotic seem to differ between biomes



Christian Ammer, New Phytologist (2018)

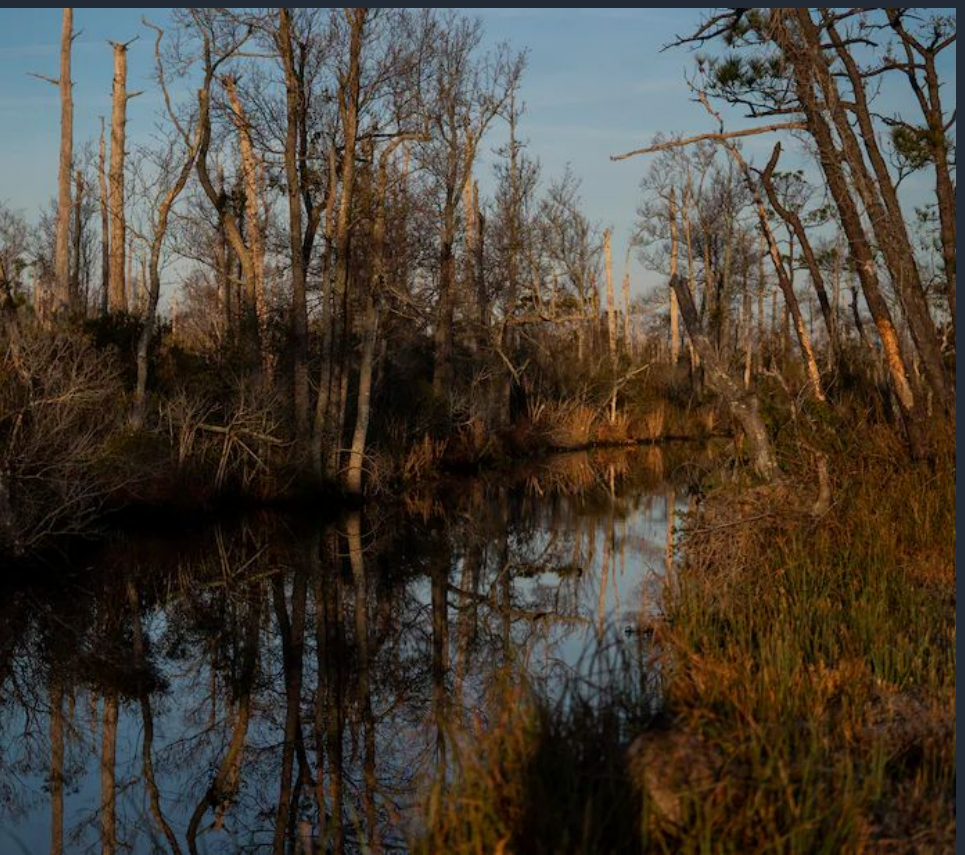
Our forests are changing

The swift march of climate change in North Carolina's 'ghost forests'

ea levels rise and storms become more intense, scientists are racing to study the rapid loss of trees a marshland along the Outer Banks

By Brady Dennis

May 12, 2022 at 10:00 a.m. EDT



- 'Ghost forests'
- Forests killed by sea level rise or increased flooding tied to climate change. Bc of rising water tables, once coastal forests die they're unlikely to be replaced. Ghost forests have been rapidly along parts of the eastern seaboard.

Stands of trees still can be found today in most shadow forest locations, but as forests they bear little resemblance & are much degraded compared to what grew on these sites previously -- or with great patience & careful stewardship, might arise again in the future. 13/

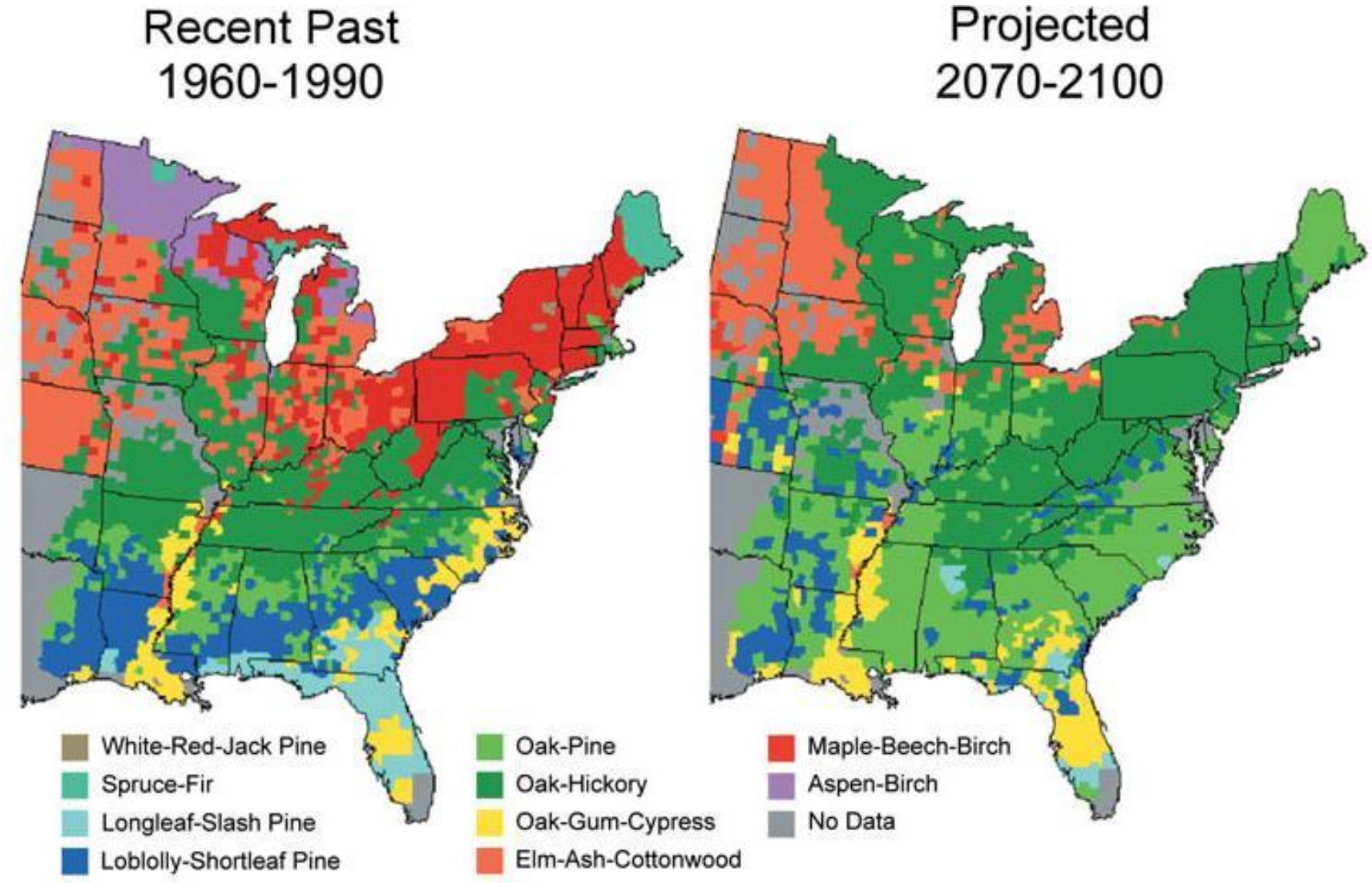
The American Chestnut

Impacts to forest health

- Climate change
- Invasive species
- Disease
- Land use change
- Habitat shifts

Impacts to forest health: Climate change

- Shifts in climatic tolerances
- Increased risk of drought and extreme precipitation events
  - (Seasonal availability of water & Fire)
- Phenological mismatches
- ***Indirect impacts on pests, disease, forest composition***



Projected shifts in forest types. Source: USGCRP (2009)

Impacts to forest health: Invasive species & Disease

- Invasive species and infectious diseases are becoming more prevalent and widespread with increased connectedness and globalization

- Alien species are the second leading cause of extinction in the US and cost approximately $120 billion annually

- Disease vectors and pathogens are spreading across continents due to human transport, land-use change, and climate change

Crowl etal. Frontiers in Ecology and the Environment 2008

Impacts to forest health: Invasive species

- In forest ecosystems alone, invasive species can:
  - Reduce native diversity
  - Alter forest structure
  - Suppress tree regeneration
  - Alter nutrient cycling
  - Modify disturbance regimes
  - AND negatively impact ecosystem services and human health.

- Invasives beget invasives?
  - Chinese privet, amur honeysuckle, and dahurian buckhorn
  - Japanese stilgrass & garlic mustard

- **Relatively "healthy" forests, with older stand ages and more stable function are being invaded.**

Miller et al., Ecological Applications. 2020

Impacts to forest health: Invasive species

Relatively “healthy” forests, with older stand ages and more stable function are being invaded.

Miller et al., Ecological Applications. 2020

Impacts to forest health: Invasive species & Disease

Gypsy moth (Lymantria dispar)

- Regional defoliation
- Especially oak, aspen, or birch
- Short-term impacts include effects on light penetration, nitrogen (N) cycling, and primary production
- Long-term effects of defoliation are unclear, but could involve interactions with other stressors such as pathogens or atmospheric N deposition (Lovett *et al*. 2006).

Crowl etal. Frontiers in Ecology and the Environment 2008

Impacts to forest health: Disease

Chestnut blight


White pine blister rust

Extensive damage to U.S. forests

Unstable and unpredictable climate patterns will make prediction of disease establishment and spread more difficult.

- Trees under stress more susceptible
- Reproduction favored by wetter, warmer climes (warm winters)

Impacts to forest health: Land use change

Human land uses may make it harder for species to move in response to climate change.

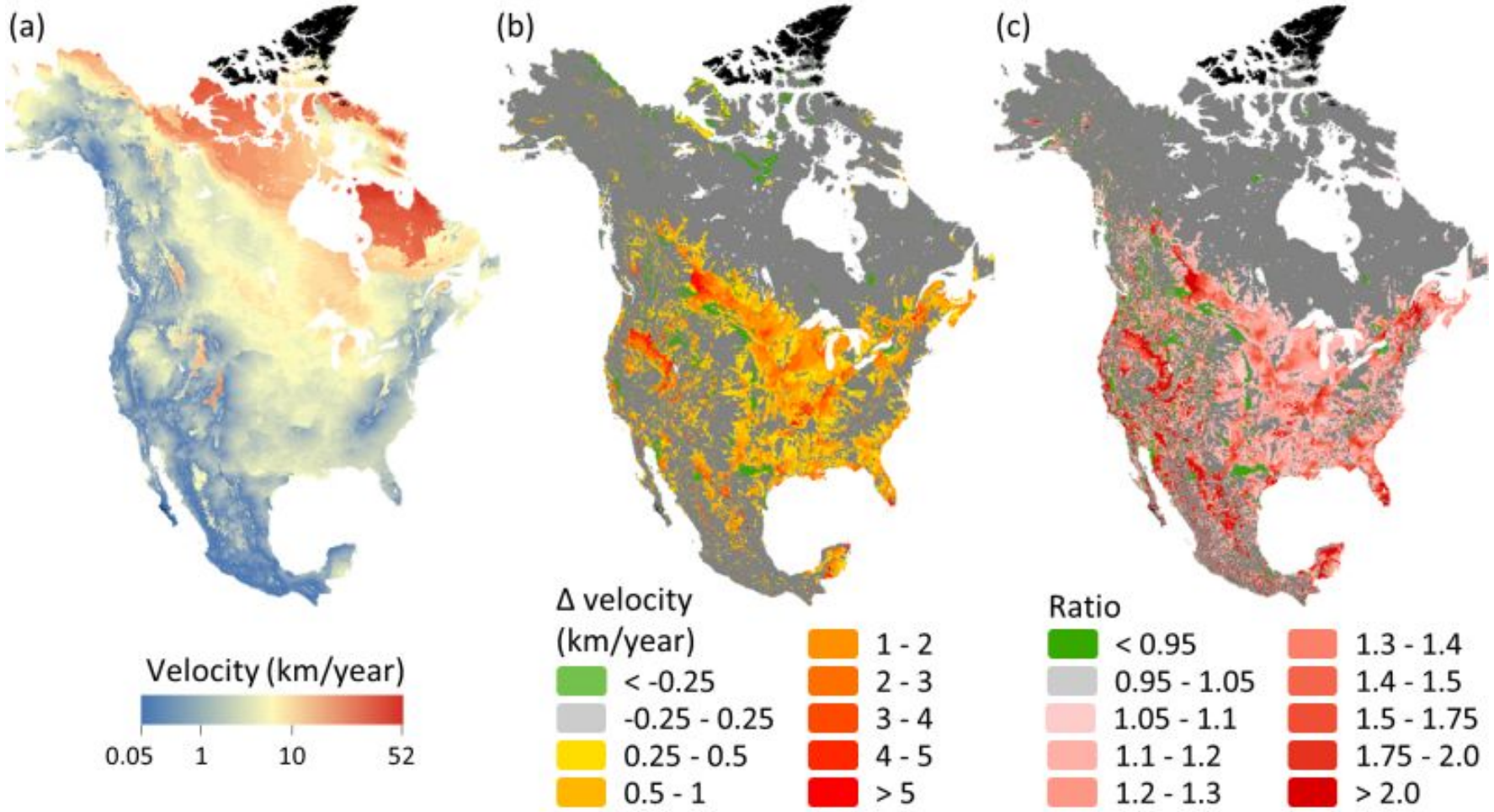


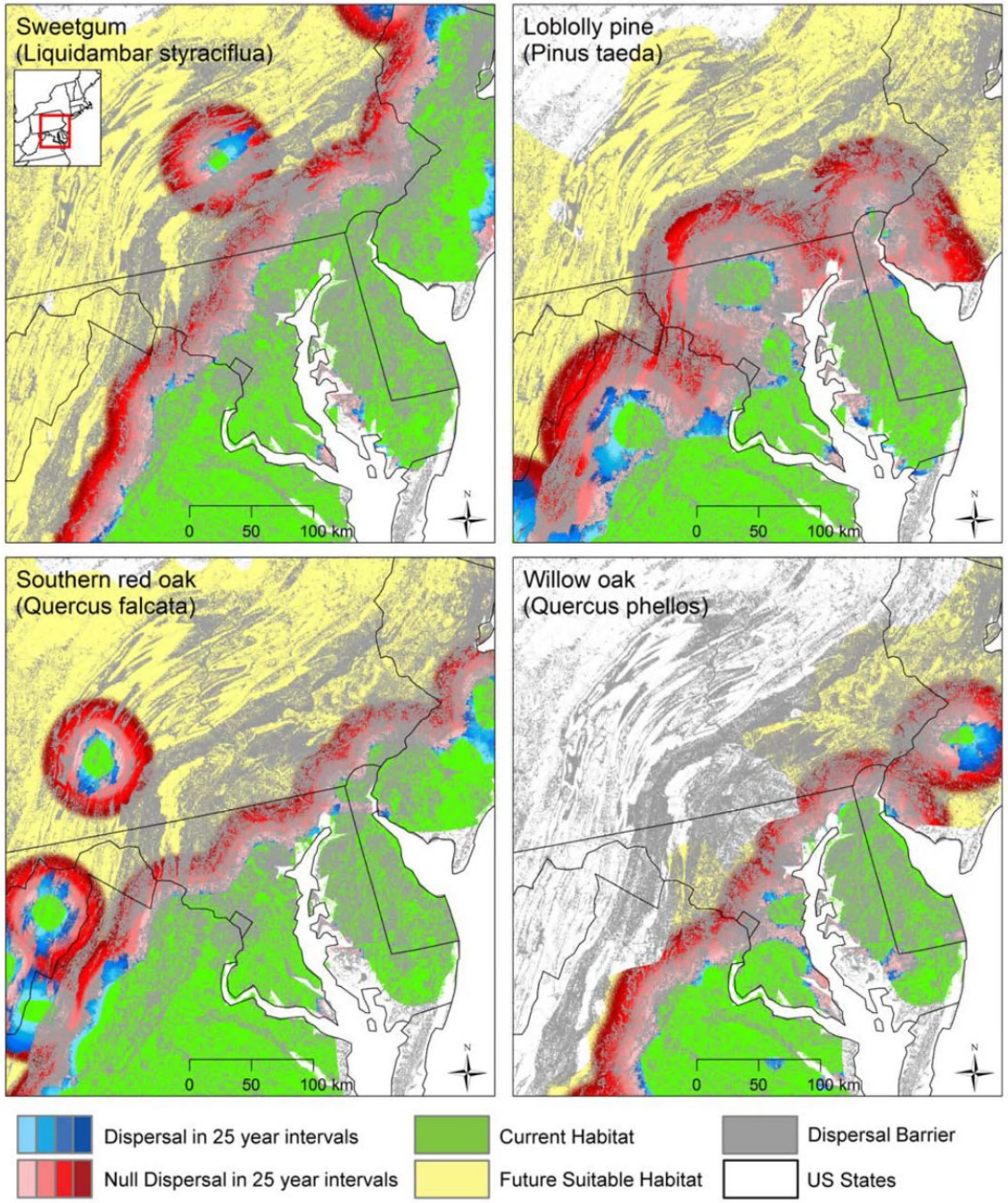
Figure 1: Climate velocity for North America when not incorporating human land uses (a). The difference (km/year) in climate velocity when incorporating human land uses (b). The ratio of climate velocity when incorporating human land uses to that when not (c).

Crowl etal. Frontiers in Ecology and the Environment 2008

Impacts to forest health: Land use change

Simulations suggest that Land use in the human-dominated east-coast corridor slows species dispersal rates by 12–40% and may prevent keeping pace with climate

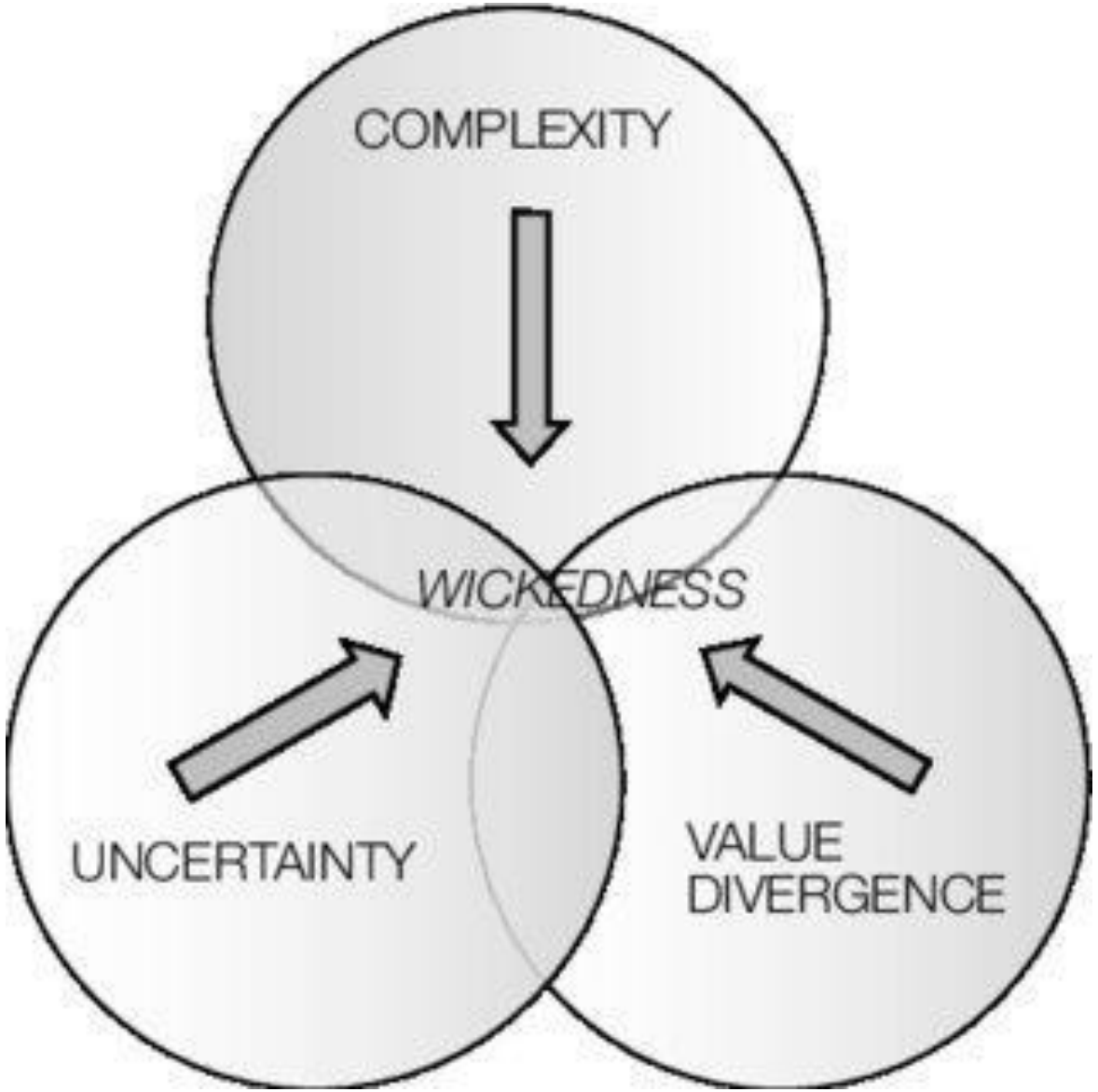
Dispersal mapped
- Barrier (grey)
- Null dispersal results (shades of red)
- Barrier results (shades of blue)



Miller & McGill, Global Ecology and Biogeography. 2017

Managing for forest health – A classic "Wicked Problem"

solutions will need to be creative, considerate, and adaptive



Solutions

Starts with taking a bird’s-eye view

Solutions: Considering the broader context

The United States Forest Service

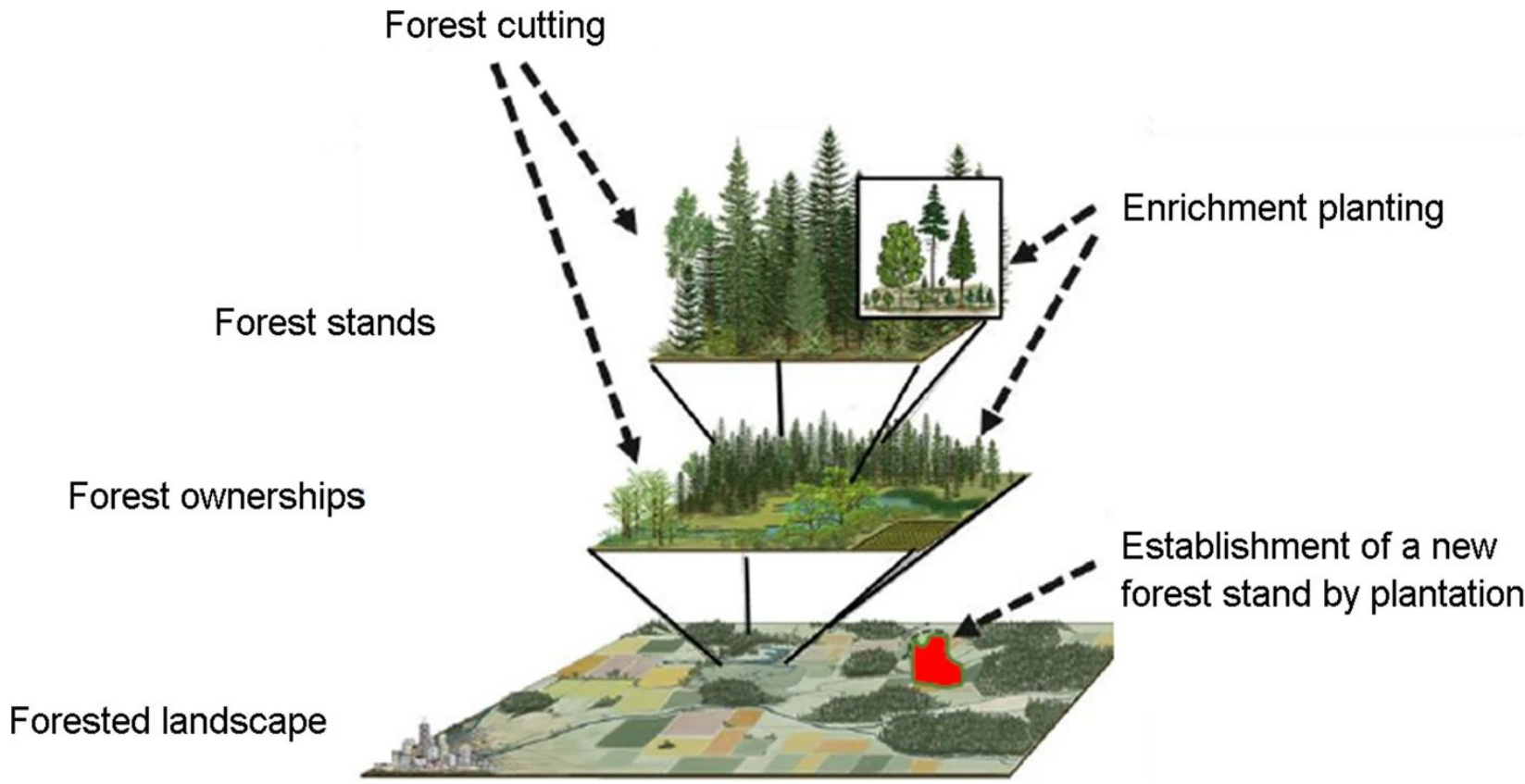
New planning regulations under the National Forest Management Act in 2012 (i.e., the Planning Rule).

“recognized that land management planning for National Forest System lands cannot occur in isolation: the resources, species, and issues for which those lands are managed are often cross-boundary in nature” (USFS).

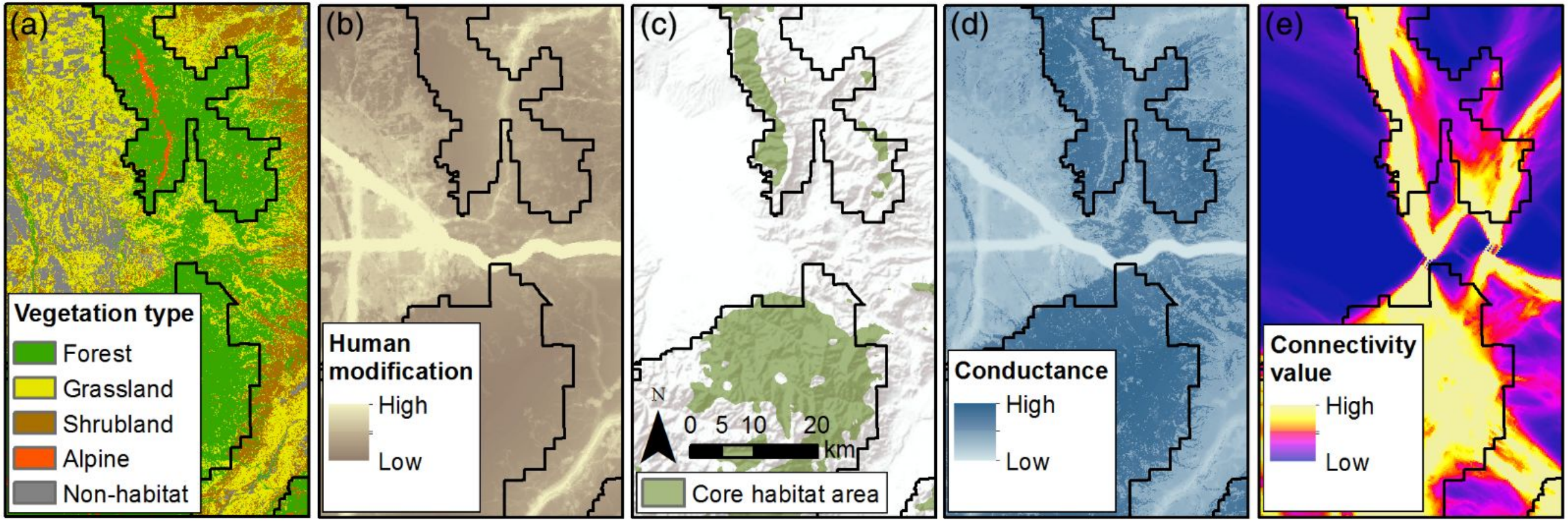
Include the first requirements in U.S. public land management history for National Forests to evaluate, protect, and/or restore ecological connectivity as they revise their land management plans.

Solutions: Thinking at larger geographic scales

Three spatial scales of possible silvicultural intervention: (i) stand, (ii) forest ownership, and (iii) forested landscape.



Solutions: Thinking at larger geographic scales

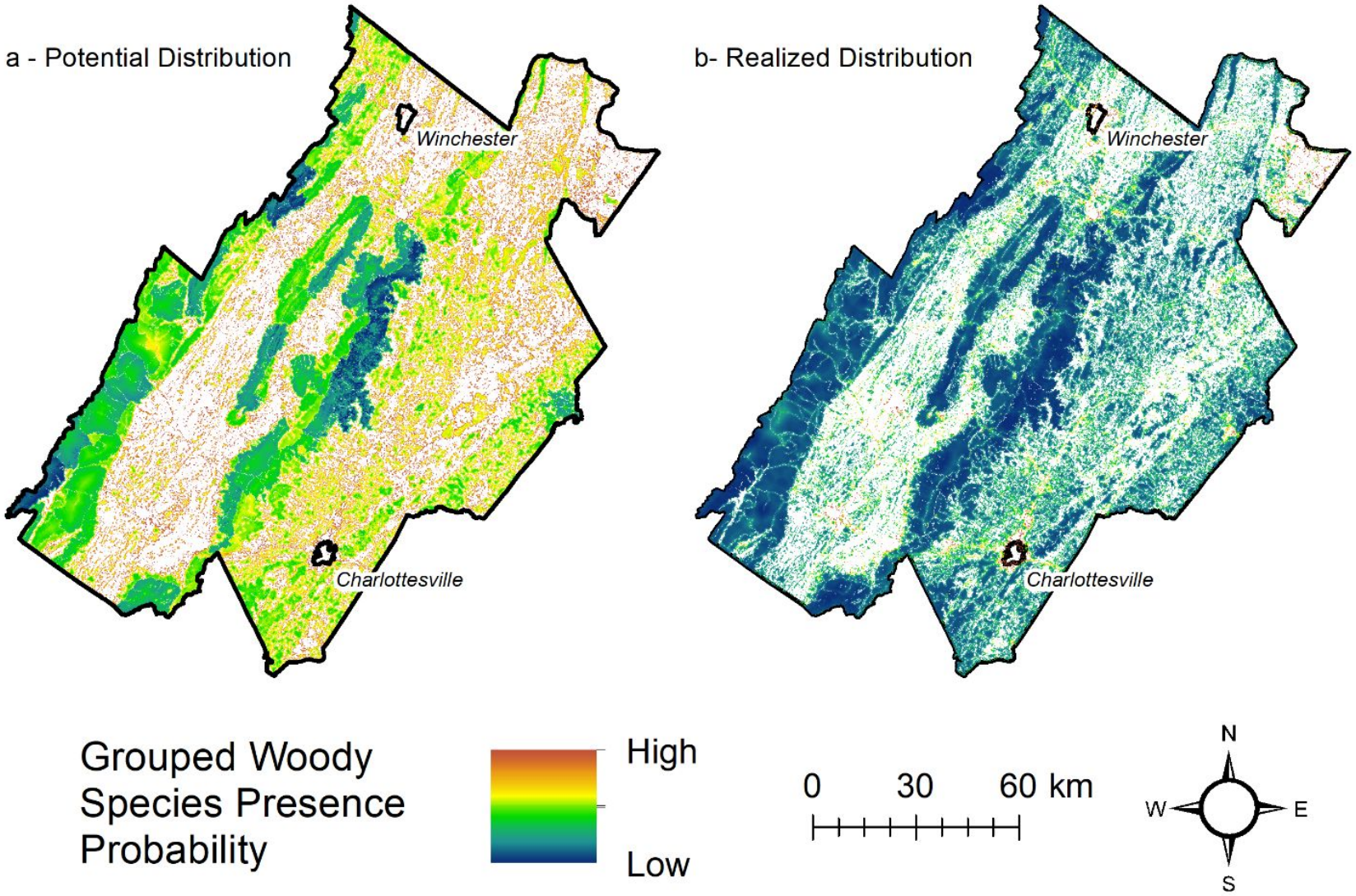


Identify important locations for facilitating movements for a variety of different species across a large landscape containing multiple private, state, and federal jurisdictions.

Williamson, et al. Conservation Science and Practice. 2019

Solutions: Thinking at larger geographic scales

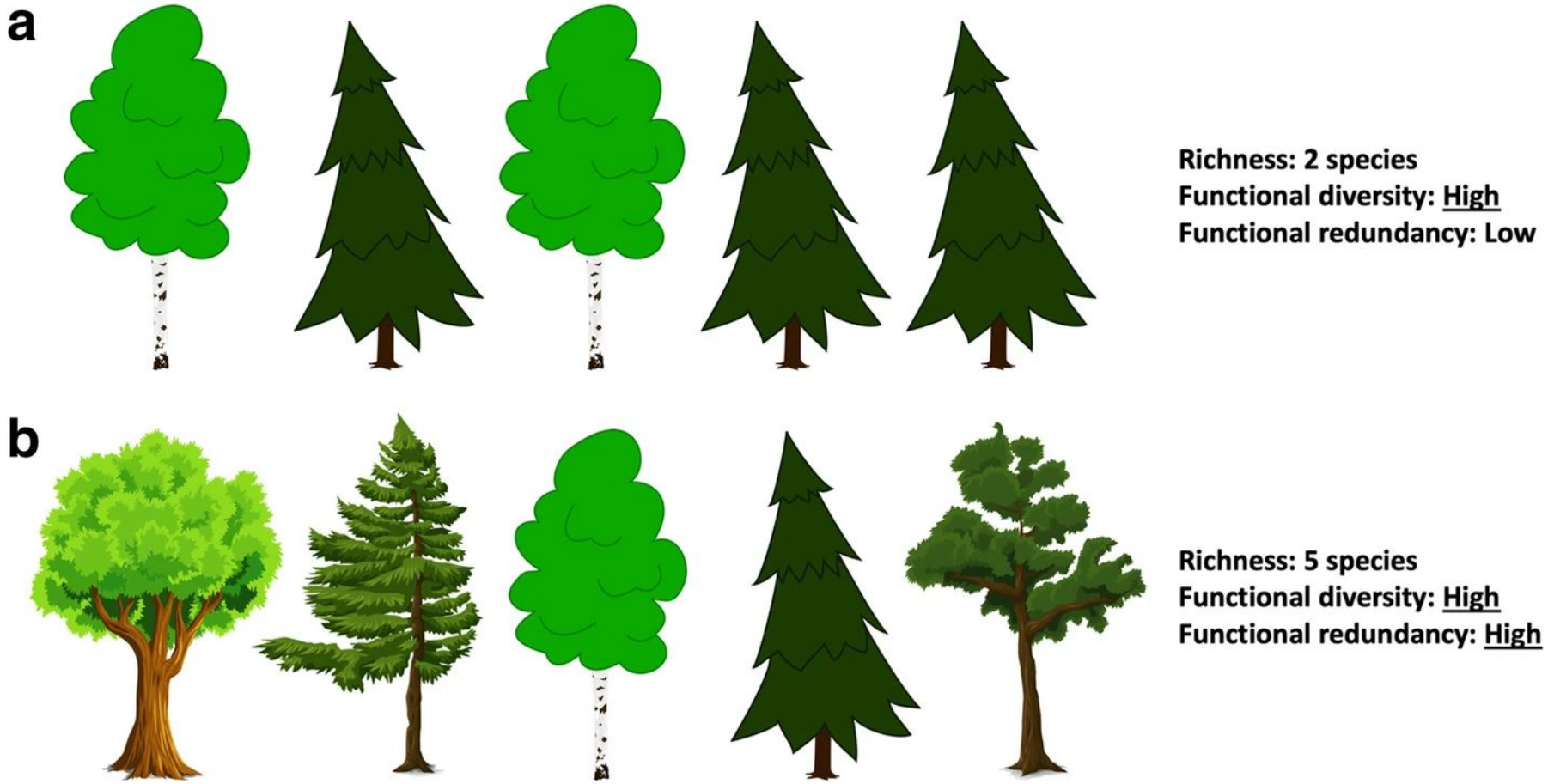
Modeled woody invasive species in response to land use, patch configuration, and dispersal force.



Fergus, Lacher, Hermann, McShea, Akre. Ecological Applications. (in Review)

Solutions: Managing for resilience

If a species disappears, will functional traits will be maintained in the stand?



Messier et al., Forest Ecosystems. 2019

Solutions: Managing for resilience

Remember - It's about the ENTIRE SYSTEM

Actively consider other species within the forest ecosystem

Solutions to forest health: Disease

Planning and mitigation strategies

- Increasing species and age class diversity to promote growth and resilience to mortality,
- Using appropriate silvicultural interventions to increase tree vigor and lower pathogen and insect pest impacts under predicted climate scenarios,
- Carefully and judiciously using facilitated tree species migration, and
- Increasing tolerance and resistance to pathogens as part of breeding programs designed to increase species tolerance to environmental stressors.

Solutions: Intervening to address dispersal and tolerance limitations

<u>Assisted population migration</u>

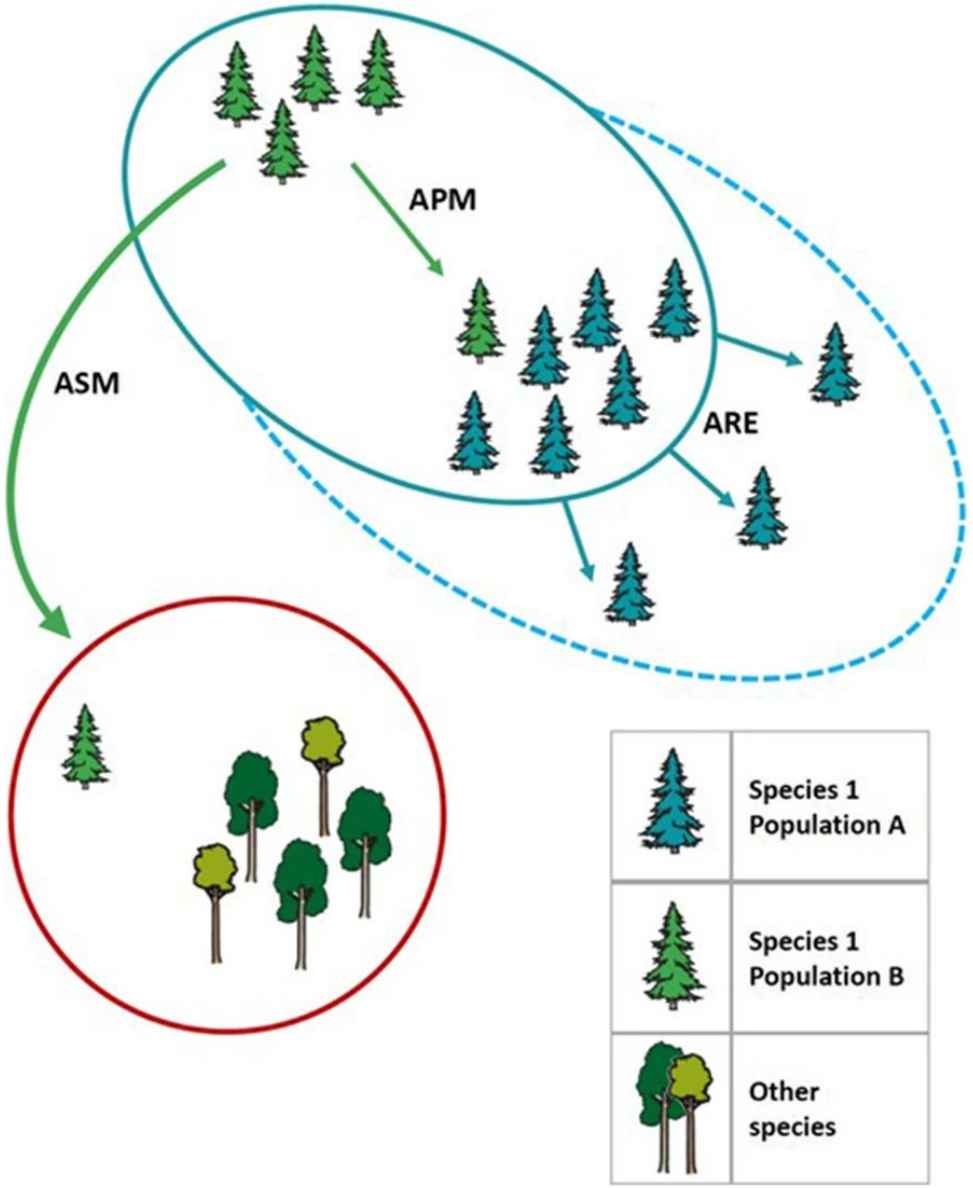
- Movement of populations within current range

<u>Assisted range expansion</u>

- Movement of species *just* outside current range

<u>Assisted species migration</u>

- Movement of species far outside current range



Messier et al., Forest Ecosystems. 2019

Solutions: Intervening to address dispersal and tolerance limitations

<u>Assisted migration: sourcing seedlings from southern seed zones</u>

- Bur Oak and Northern Red Oak
- Measured for 3 years.
- Southern ecotypes expressed traits consistent with climate adaptation hypotheses that species would have higher survival and growth
- Results suggest that state seed sourcing guidelines should be reexamined to permit plantings across seed zones, a form of assisted migration

Minnesota USA

Etterson et al., Ecological Applications. 2020

Solutions: Intervening to address dispersal and tolerance limitations

"I would want to know a lot more about pathogens and insects before I moved things."

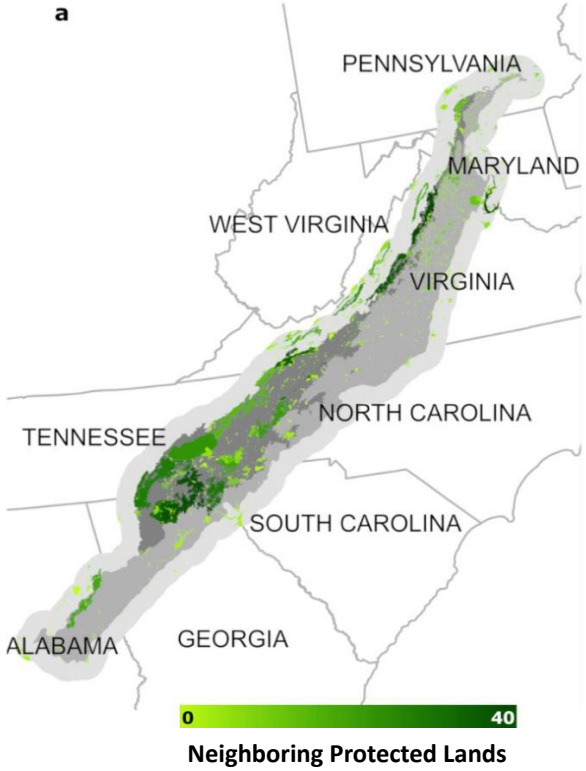
— Daniel Simberloff

Solutions: Monitoring & Forecasting

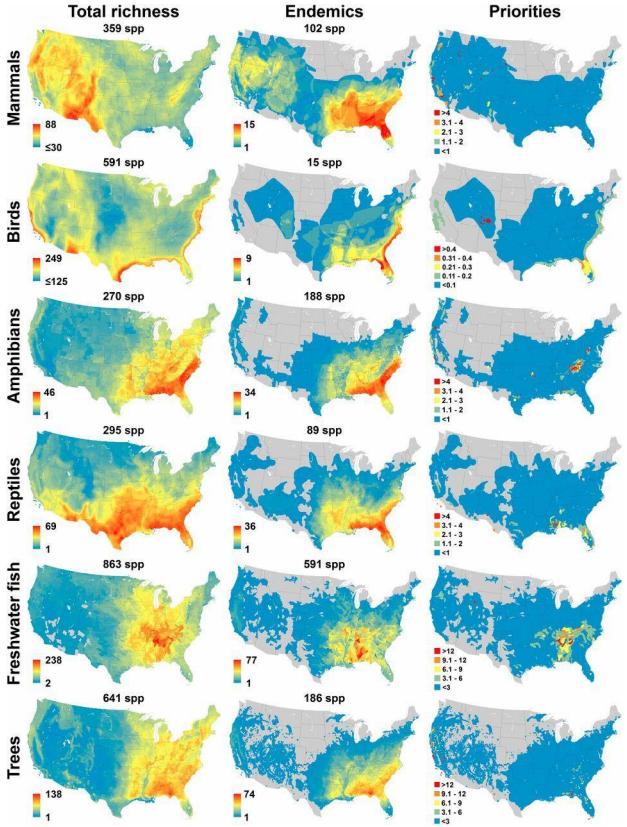
- National programs like the Forest Inventory and Analysis program
- Independent and academic studies that evaluate forest change at all scales

Citizen Scientists Find Rare Orchid In Virginia

Hermann, Lacher, Fergus, McShea, Akre. (TBD)



Lacher et al. Land use and Urban Planning 2019



Jenkins et al. PNAS. 2015

Solutions: Bridge the collaboration & partnership gap

Link between ecological and social components -> "Wicked problem"

Adaptive Silviculture for Climate Change (ASCC) project

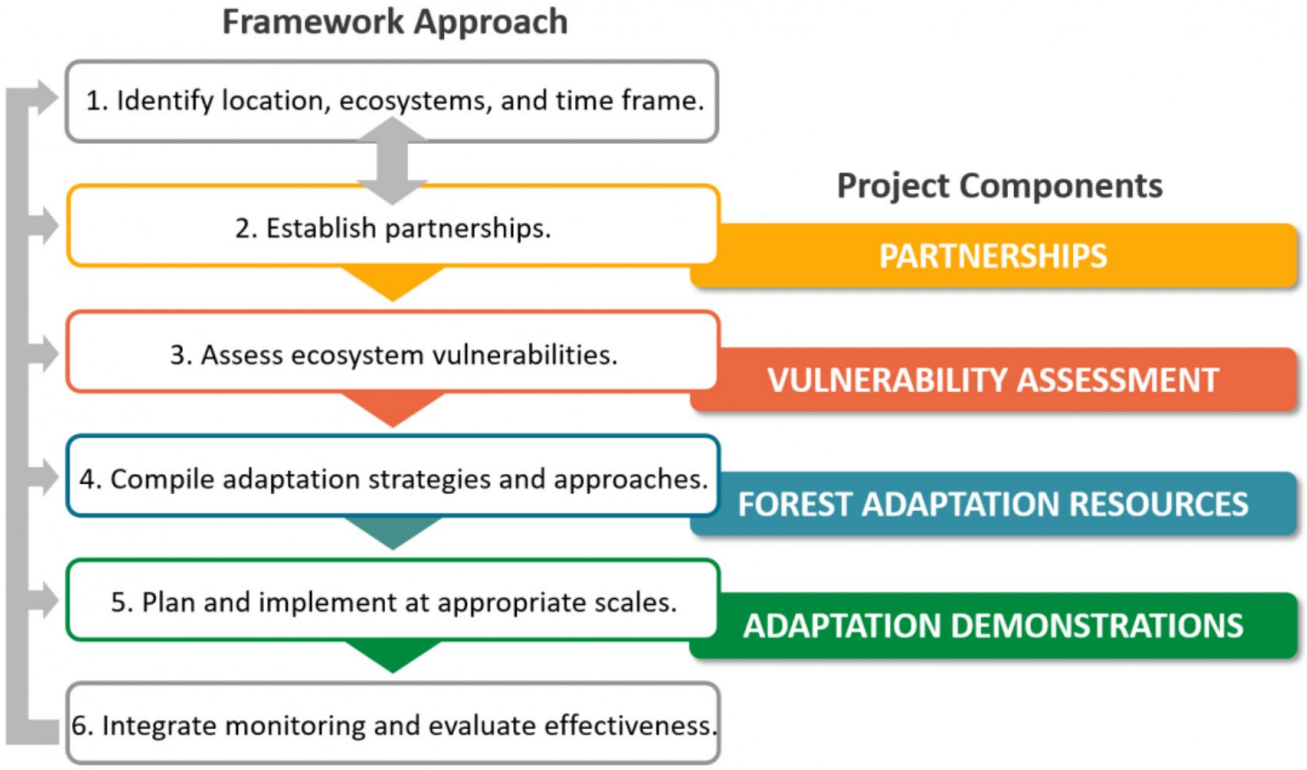
- The Climate Change Response Framework is a collaborative, cross-boundary approach among scientists, managers, and landowners to incorporate climate change considerations into natural resource management.

CLIMATE CHANGE
RESPONSE FRAMEWORK

Nagel et al., Journal of Forestry. (2017)

Solutions: Bridge the collaboration & partnership gap

- Network of long-term silvicultural research sites across multiple regions and a diversity of forest types
- Test a range of adaptation approaches and provide tangible demonstrations
- Training on integrating climate change considerations and identifying locally appropriate adaptation approaches and tactics.



Nagel et al., Journal of Forestry. (2017)

Challenges to the reforestation pipeline

- Species sourcing & availability
  - Ecotypes
  - Sizes / form
  - Cultivars
- Workforce dev
- Pre- and post-planting practices

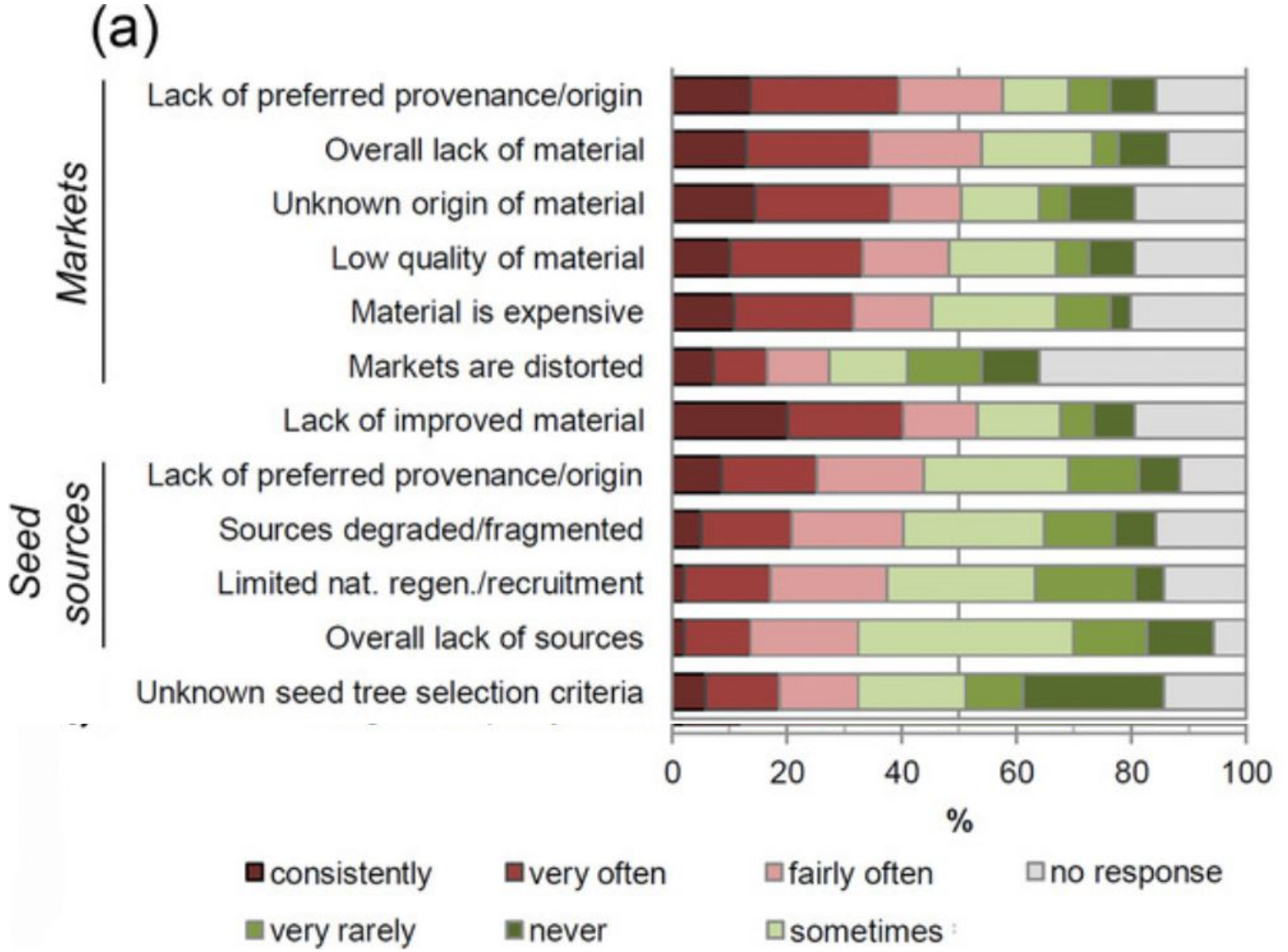
Problems with sourcing plant and seed material

- Successful forest and landscape restoration depends on the genetic diversity and origin of the seed used
  - influence germination, seedling growth and survival, productivity, seed set, resistance to pests and diseases and capacity to adapt to environmental change
- Yet, the few genetic studies in restored forests suggest that restoration practitioners lack awareness of the importance of genetic diversity:
  - projects often use seed that is either not adapted to the planting site or has strongly reduced diversity with collection from very few parent trees
- Need nursery stock to facilitate reforestation and restoration goals
- By current estimates, to meet goals, we need to make significant advances in seed collection, propagation, and planting.

Jalonen et al., Conservation Letters. 2017; Fargione et al.. Frontiers in Forests and Global Change. 2021

Seed shortage for restoration and reforestation

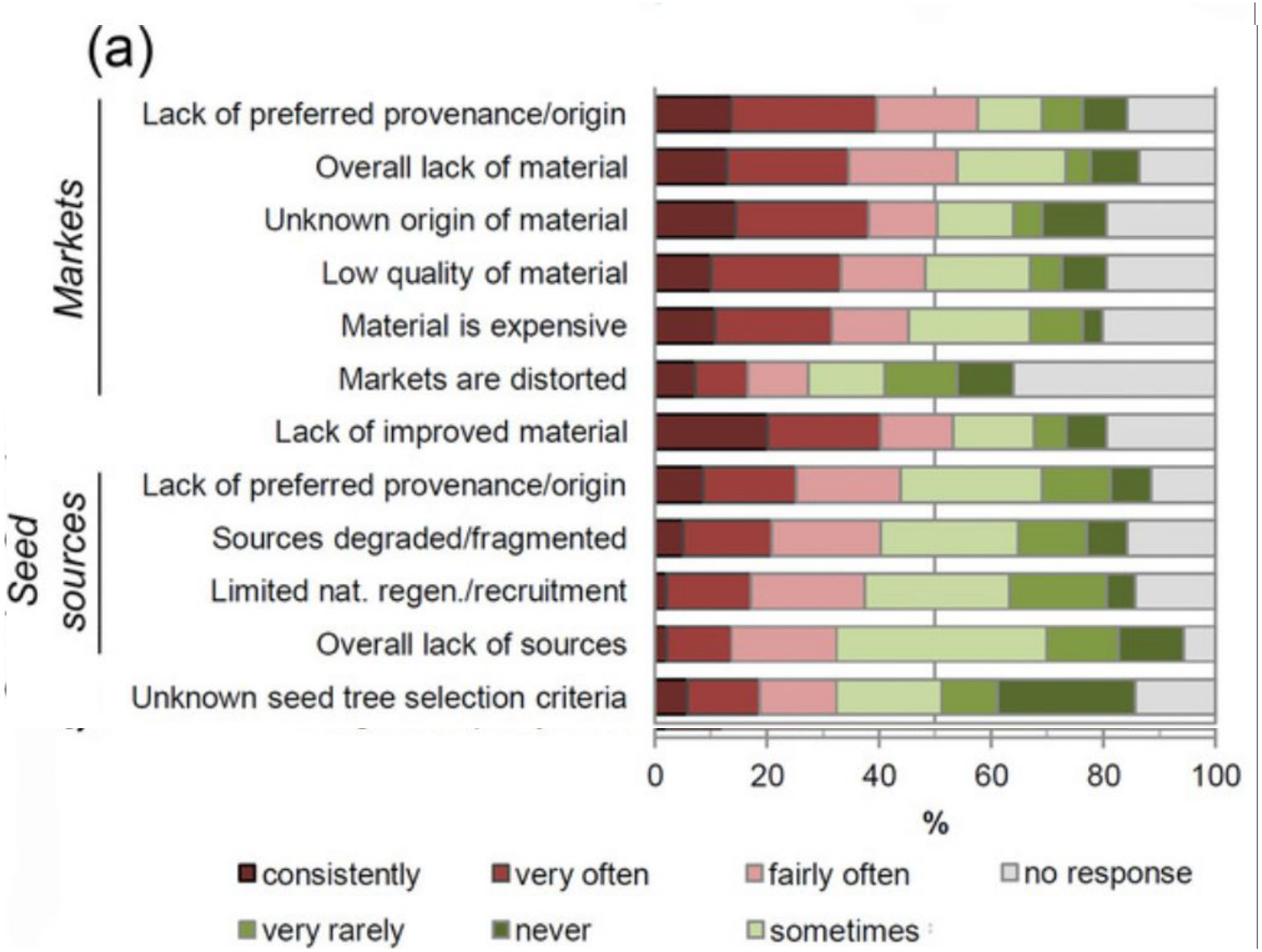
Perceived problems in getting propagation material



Jalonen et al., Conservation Letters. 2017

Seed shortage for restoration and reforestation

Consequences of problems with propagation material



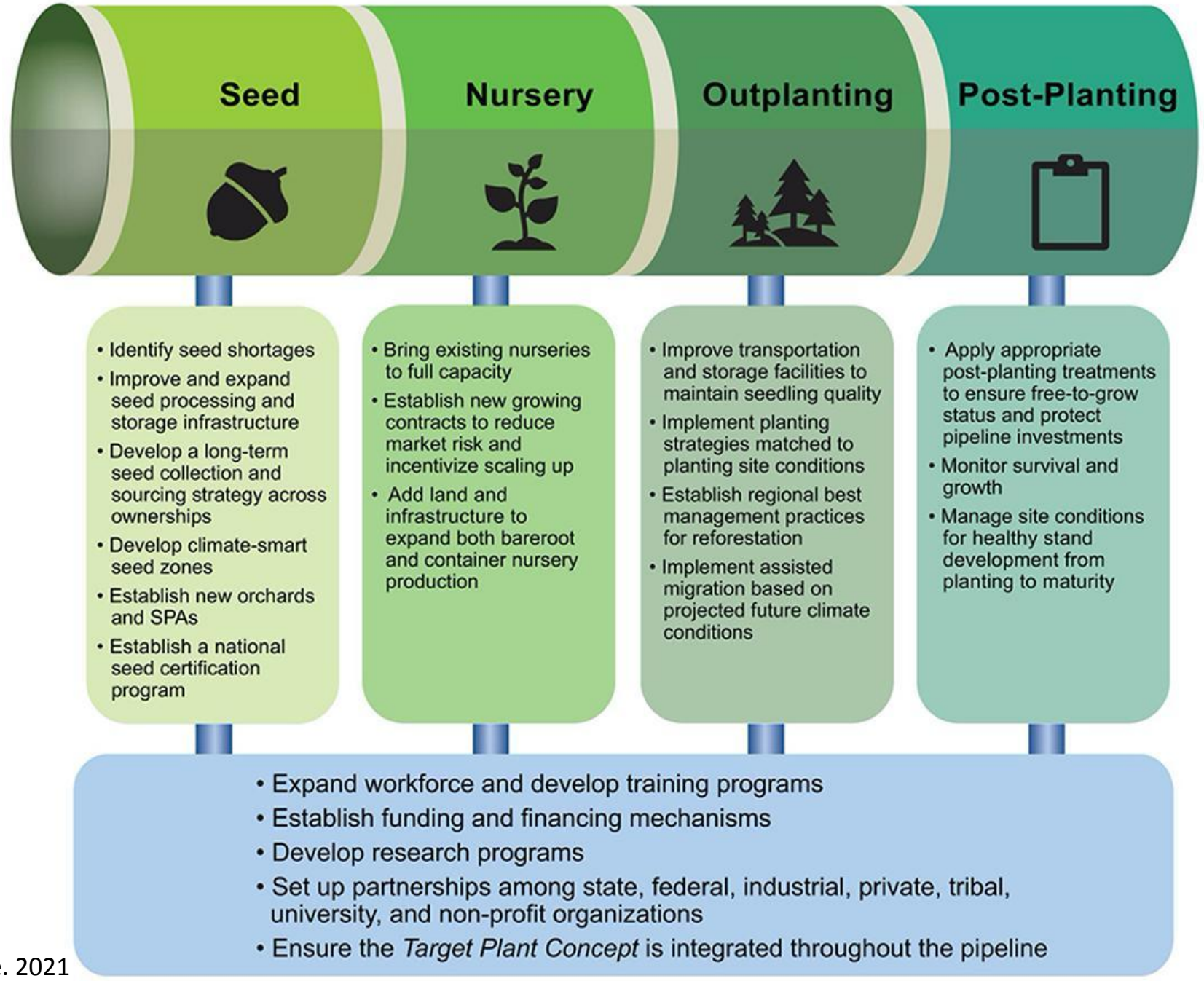
Jalonen et al., Conservation Letters. 2017

Problems with sourcing plant and seed material

What is *more* available for native plants?

- Cultivars
- Seed from non-local ecoregions
- Large variation in quality and size

Actions to address reforestation pipeline limitations



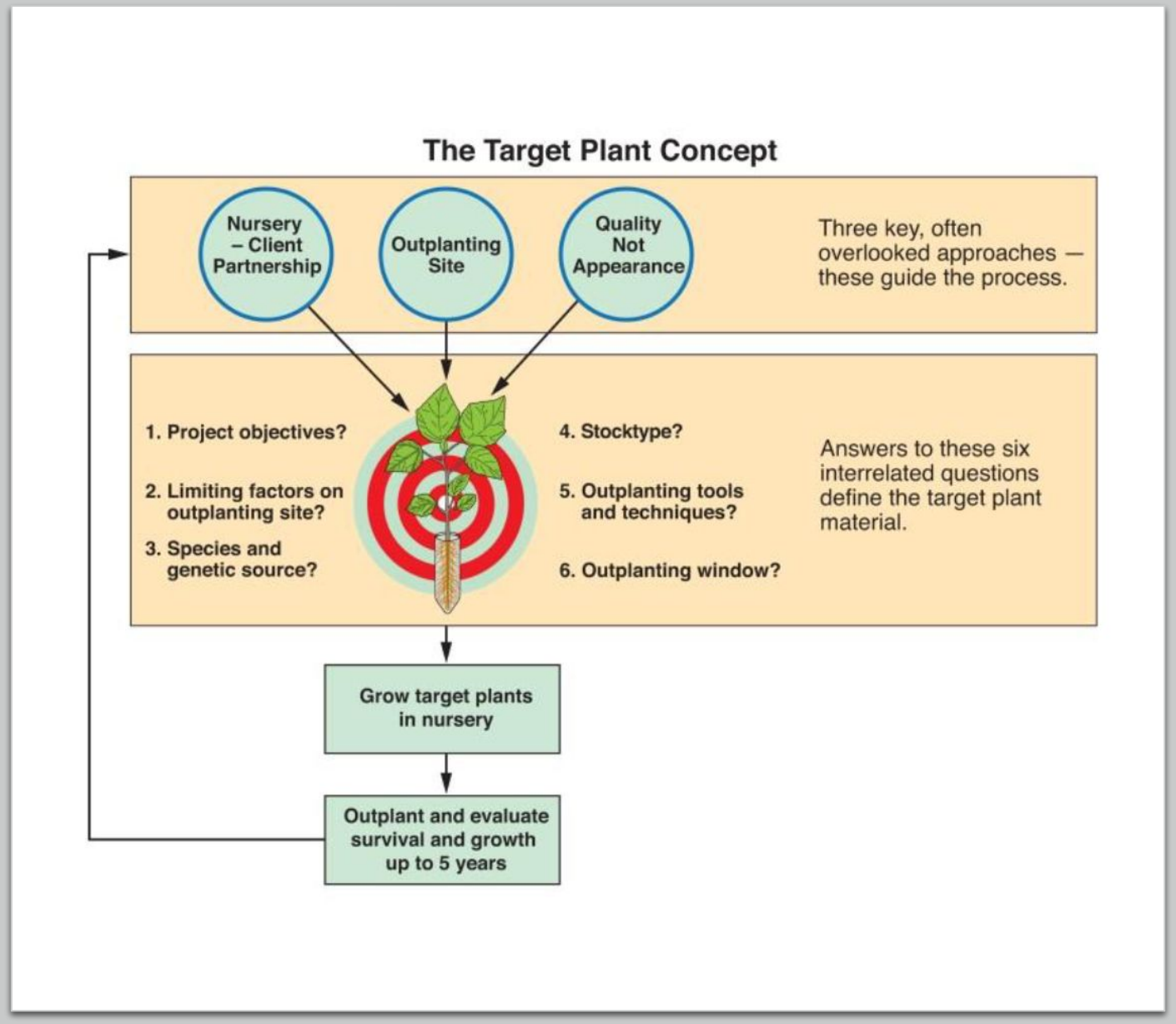
Fargione et al. Frontiers in Forests and Global Change. 2021

Collaboration between partners

The Target Plant Concept

- Starts with a partnership between the client and the nursery manager

- Focuses on putting the best plant materials on specific project sites based on needs to meet project objectives



Davis and Pinto. Forests. 2021

The reforestation pipeline: the numbers

- Reforestable area = 26 million hectares
- Additional trees required per year = national avg of 1,162 stems per hectare or 1.7 billion seedlings
- Seed collection and storage = sourcing 0.3 billion to 2 billion seeds from local ecoregions
- Production capacity; current = only 25% of additional needed 1.7 B seedling
  - Federal nurseries to 151%, State nurseries to 74%, Private nurseries to 21%. Need additional expansion of 47% (bareroot) and 94% (container) to make up remaining deficit.
- Cost = area-weighted national average of $1,262/ ha ($511/acre)
- …And changes in outplanting and post-planting efforts that follow the Target Plant Concept, in which the nursery manager works directly with the client to plan and monitor outplanting activities to optimize seedling performance

Fargione et al. Frontiers in Forests and Global Change. 2021

The future

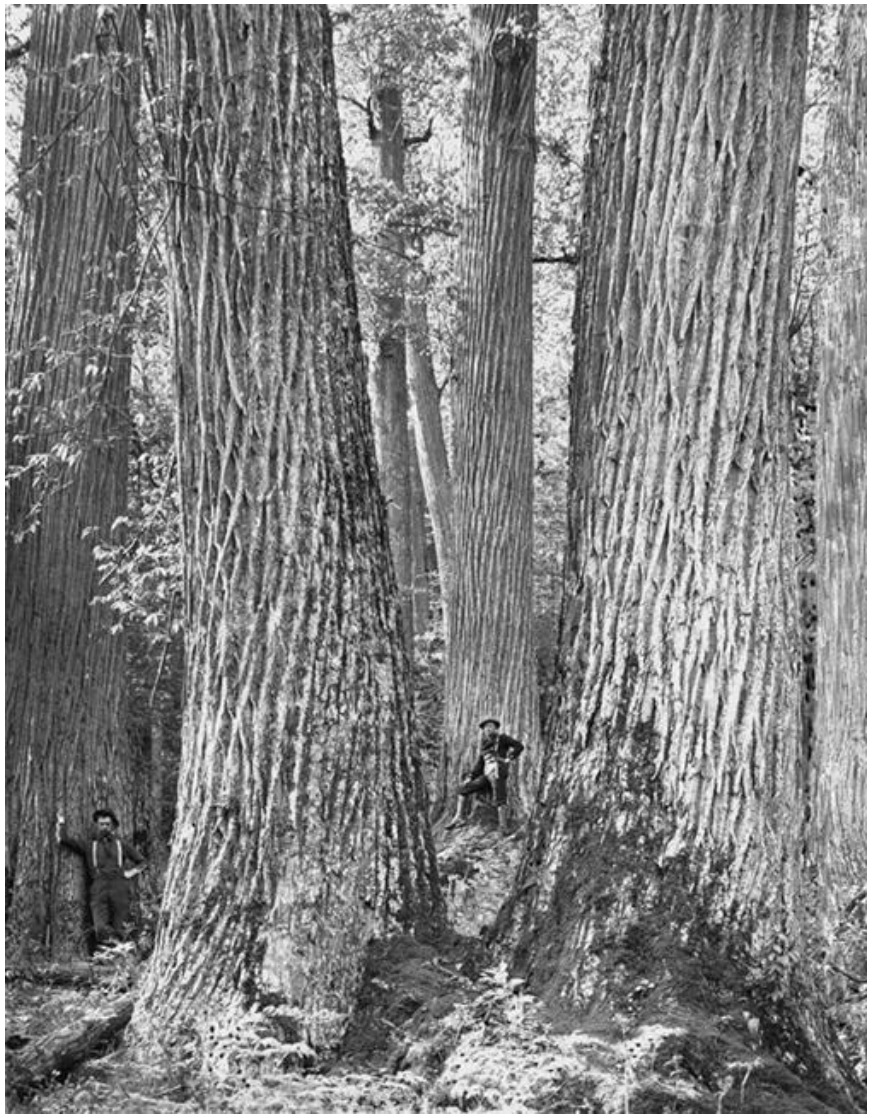
- What is in store for us moving forward?

Scientific advances may help us restore lost systems

The American Chestnut

- “Over the last twenty years, efforts at the nexus of conservation and biotechnology have genetically engineered (GE) the American chestnut to resist the fungus. The goal is to repatriate the forests and restore them to pre-1900s composition, adding back a key species that supported significant biological diversity.”

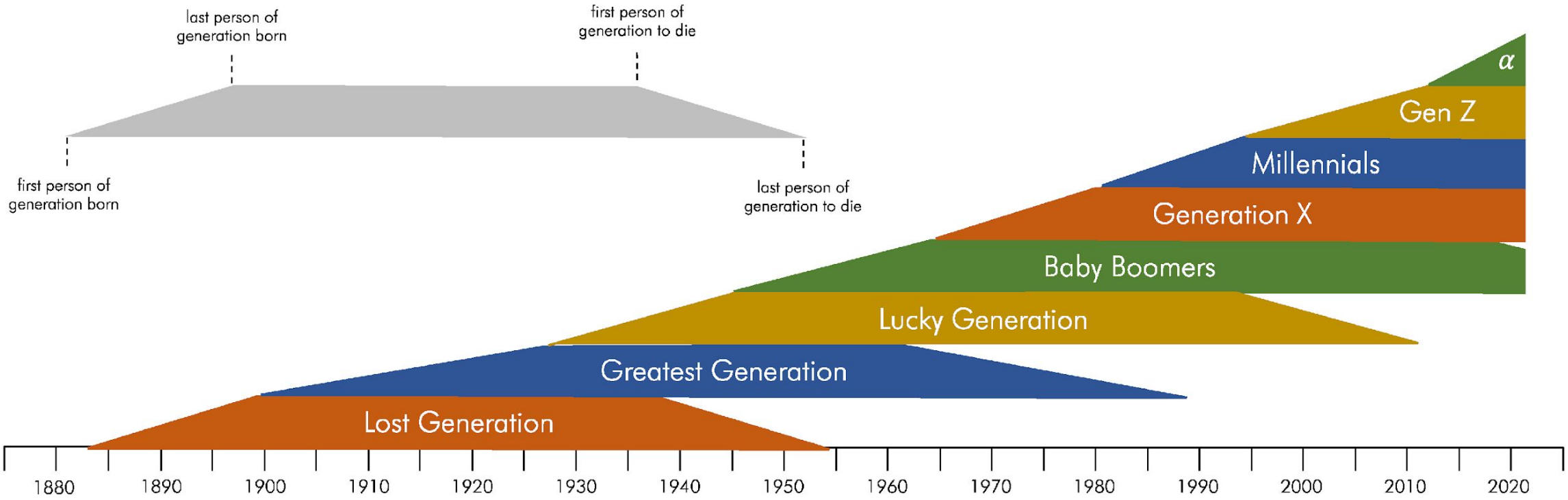
THE AMERICAN CHESTNUT FOUNDATION™



However, we need to consider our new starting point...

The loss of historical reference conditions.

- With rapidly changing environmental and biotic conditions, the suitability of using historical reference conditions to manage our forests is reduced.
- Instead, desired future conditions for forest ecosystems need be derived from the required ecosystem goods and services as well as conservation values.

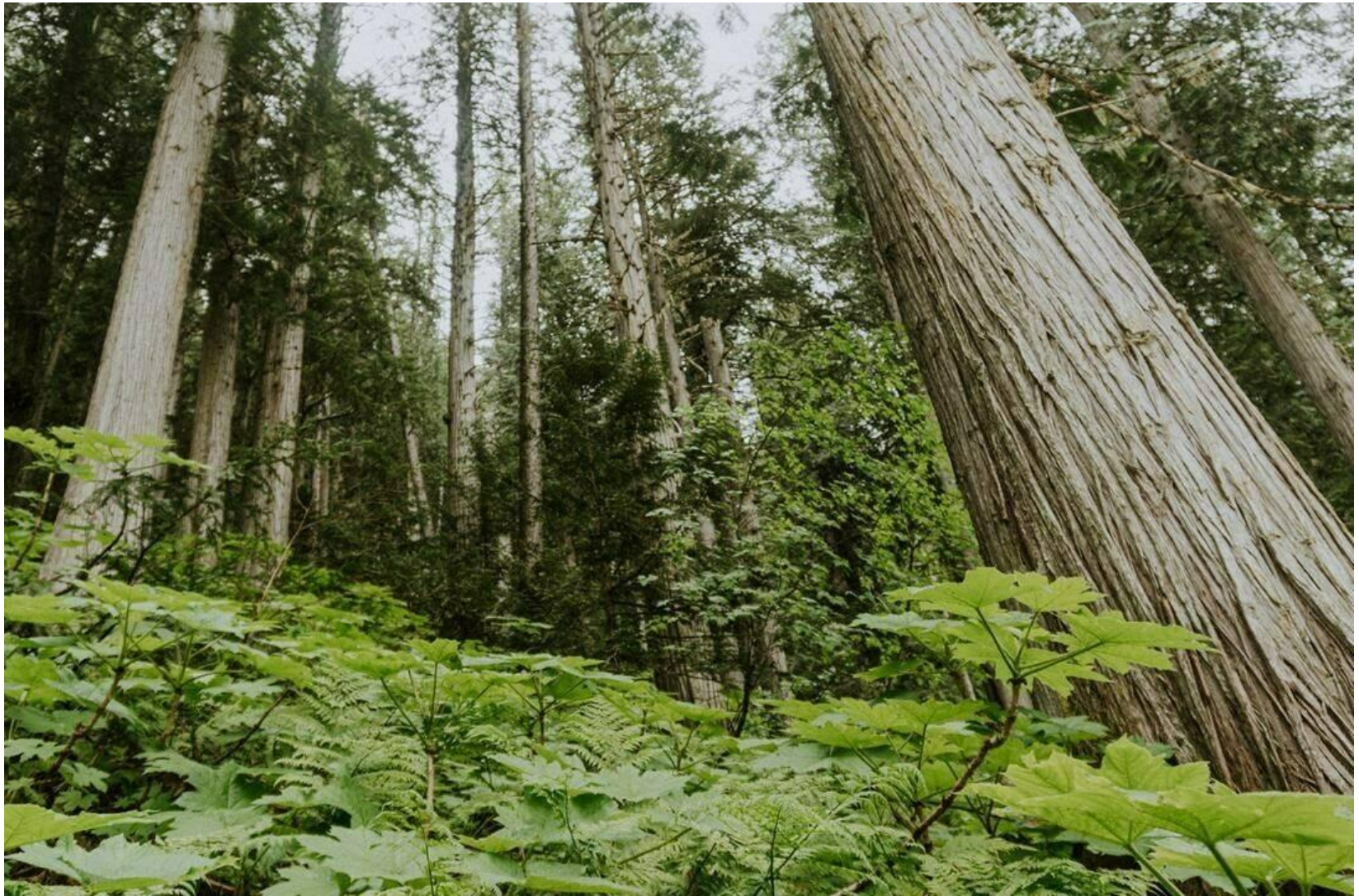


Messier et al., Forest Ecosystems. 2019; Spennemann 2022

We need to preserve and manage at the same time

How can we prepare humanity’s future and learn from errors of our past?

We are all in the same club – we want to do better by our Forests and our Communities



We are all in the same club – we want to do better by our Forests and our Communities

How then, do we use our abilities to make lasting impact?

We are all in the same club – we want to do better by our Forests and our Communities

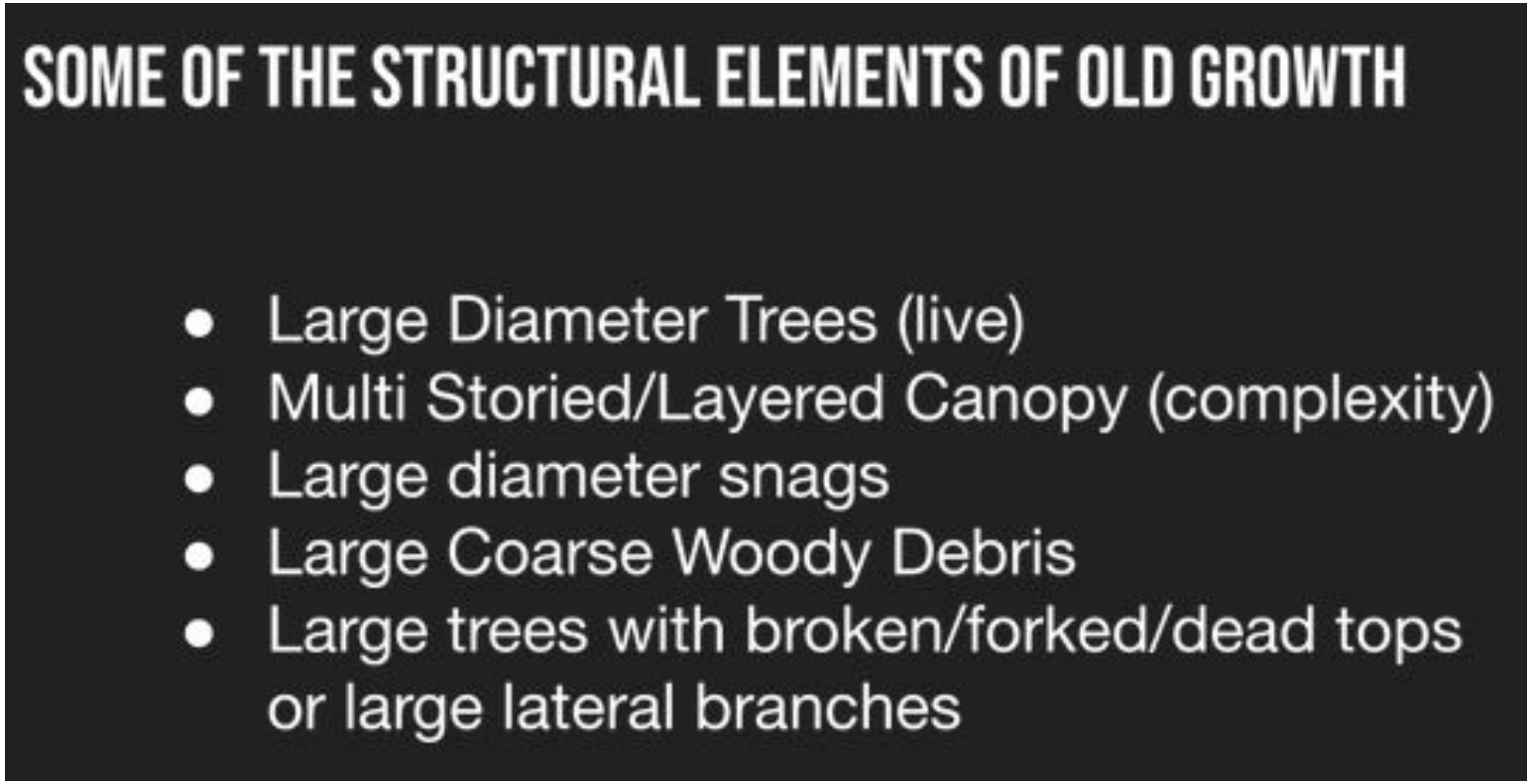
Evan Frost @EFrost_Wildwood · Feb 22

Just in case you get the false impression that shadow forests were mostly created in the distant past --

> **Evan Frost** @EFrost_Wildwood · Feb 22
>
> "According to data from Global Forest Watch, British Columbia lost 86,000 sq km of tree cover from 2001 to 2021. 'We've always logged (old-growth) forest...We've lost a lot of it and it's never coming back.' vancouversun.com/news/local-new...

CONSERVING OLD GROWTH

“Old growth is about complexity. It’s about trees falling over. It’s about snags rotting in place. Trees that have weird leans to them. Gaps in the canopy that allow plants and grasses to thrive.”



Eddie Petryshen, Wildsight

Kentucky Residents Angered by US Forest Service Logging Plan That Targets Mature Trees

Biden pledged to protect old-growth trees, but proposed clear-cutting in national forests collides with climate policy.

By Marianne Lavelle

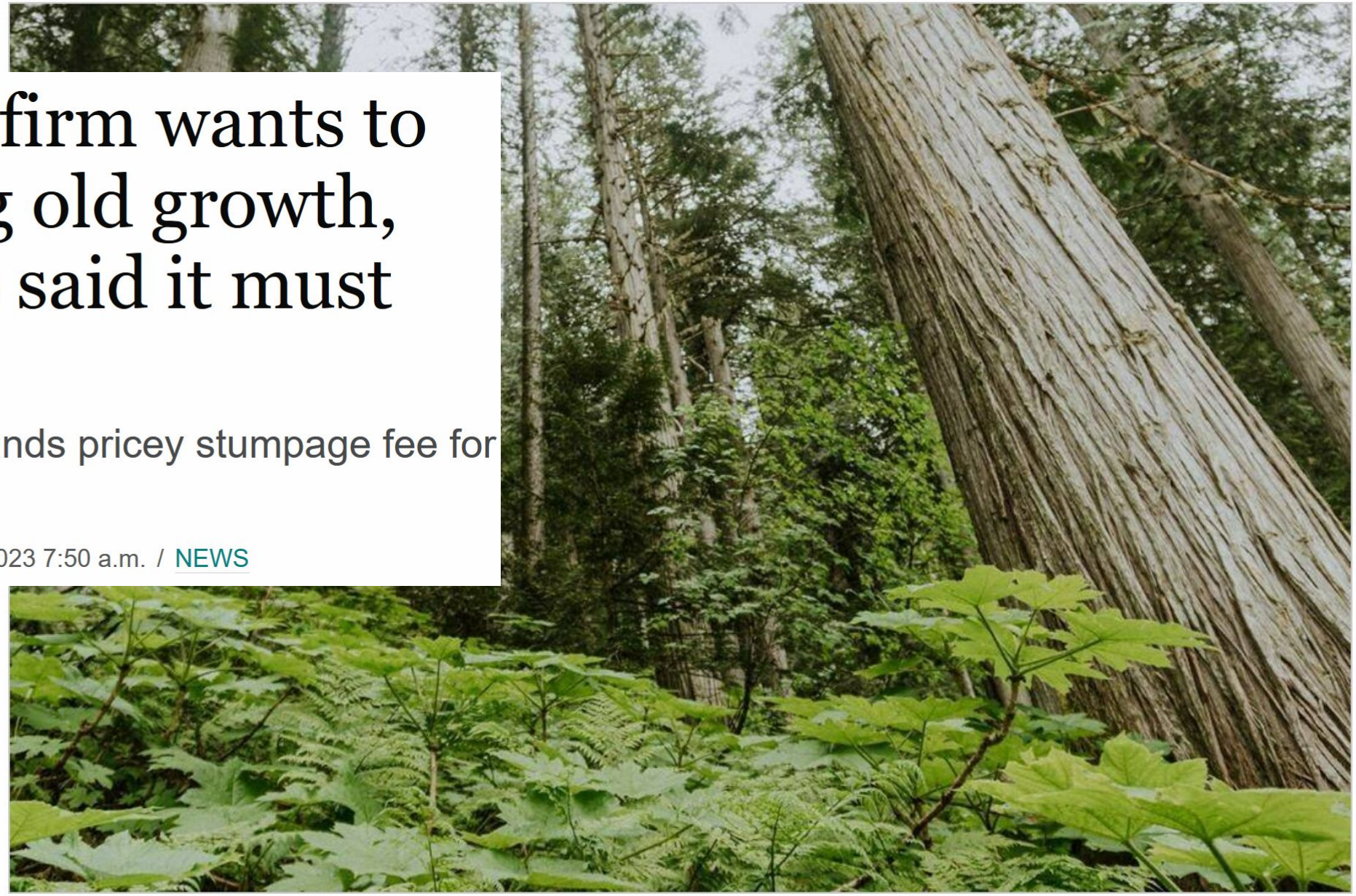
March 5, 2023

Timm Martin points out areas that are part of the Jellico Vegetation Management proposal to clear cut and log on 10.000 acres inside the Daniel Boone National Forest. Credit: Jared Hamilton

B.C. logging firm wants to avoid cutting old growth, but province said it must pay

Forestry Ministry demands pricey stumpage fee for trees left standing

THE CANADIAN PRESS / Mar. 5, 2023 7:50 a.m. / NEWS



Part of an old-growth deferral area is shown in one of Downie Timber's cut blocks north of Revelstoke, B.C. in this undated handout photo. The company wants to avoid logging sections of at-risk old growth but says it was told by the Crown corporation that manages B.C.'s public forests to cut the trees down or pay to leave them standing.THE CANADIAN PRESS/HO, Eddie Petryshen

Okanagan Nation Alliance demands stop of old-growth logging near Revelstoke

Colin Dacre - Aug 24, 2022 / 2:04 pm

West Virginia Groups Rally to Protect Old-Growth Trees

Hundred-year-old trees, such as those found in West Virginia's Monongahela National Forest, continue to soak up carbon over time, according to research published in the journal Nature. (Adobe Stock)

Time is of the essence

"As species disappear from protected areas without commensurate immigration of species suited to the emerging climate (due to climate connectivity failure), many protected areas may be left with a depauperate suite of species under climate change"

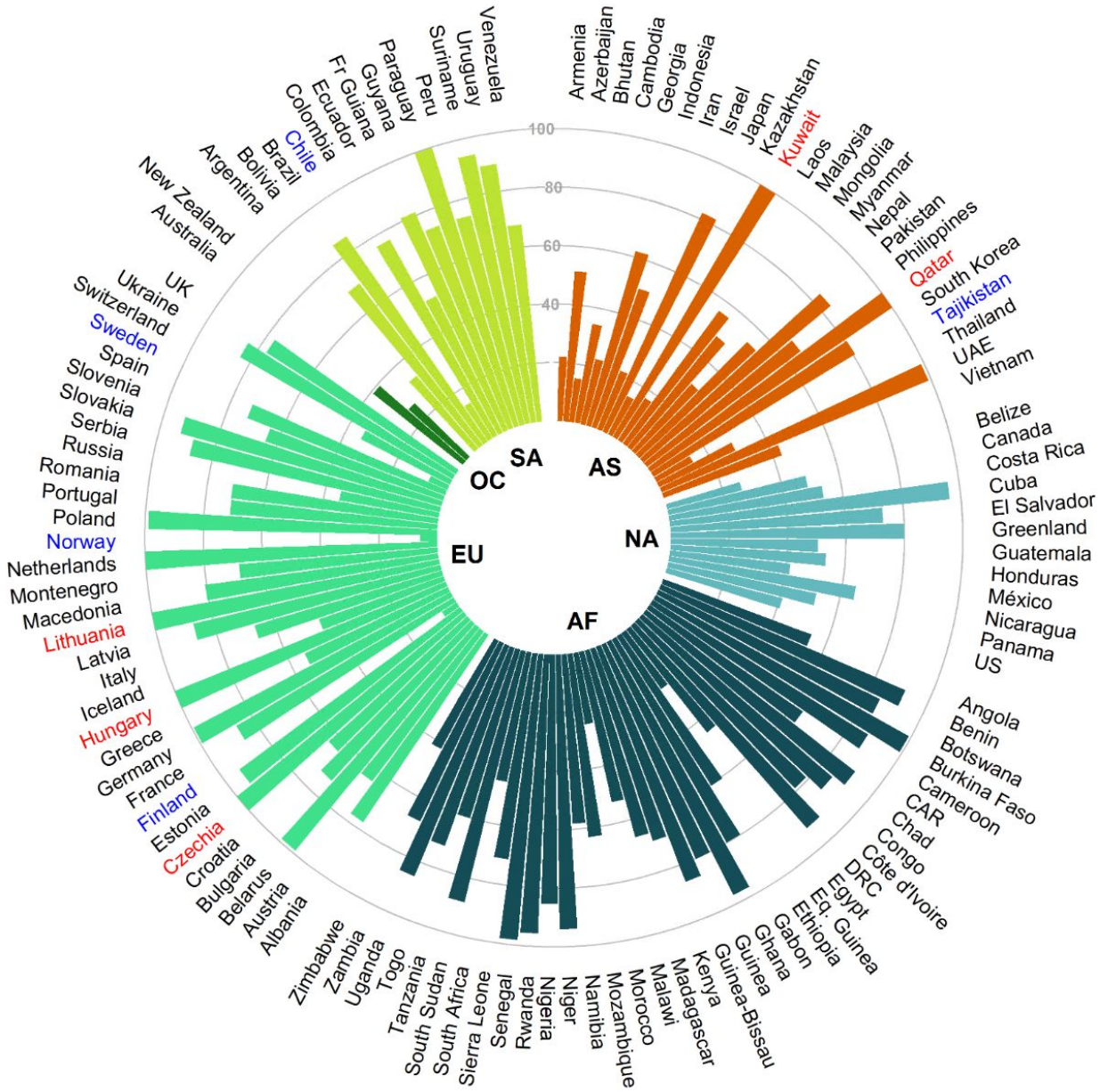


Figure: Percent of protected lands each country exhibiting climate connectivity failure (backward analogs).

Parks et al. Global Change Biology. 2023

Extreme wildfires are turning world's largest forest ecosystem from carbon sink into net-emitter

The boreal forests stretching across the North, including Alaska, hold one-third of the world carbon

The New York Times
@nytimes

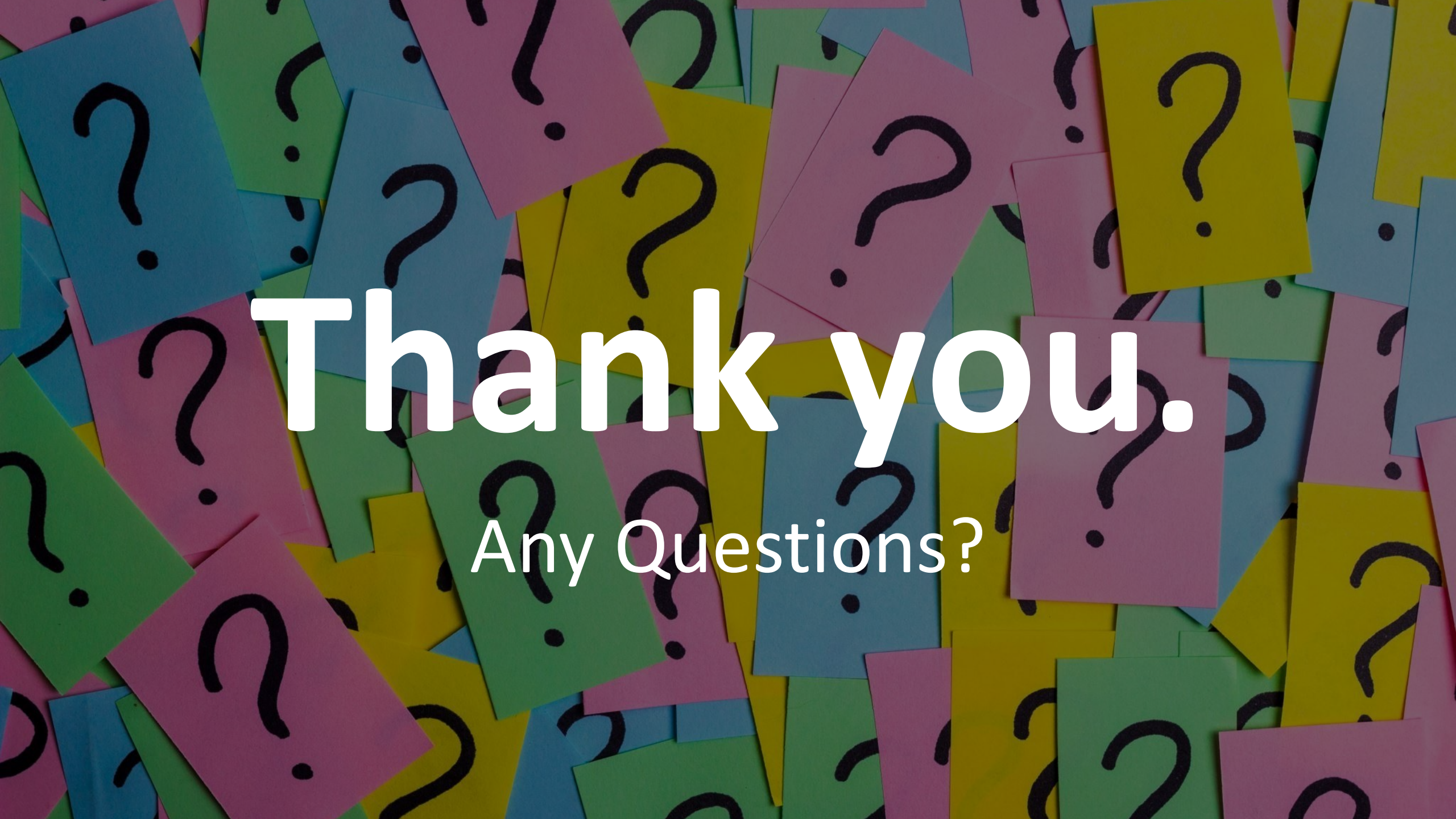
A warming climate has created "zombie forests." A fifth of the conifer forests that blanket California's Sierra Nevada are left stranded in habitats that no longer suit them, according to a new Stanford University study.

Future understanding is needed for:

- Impact of climate-influenced disturbances on productivity
- How diversity in species' functional traits influence productivity
- Understanding of impact and forecasting for future pests and disease
- Landscape-level evaluation and prioritization for management efforts (e.g. invasive species)
- Impacts of "drastic" management decisions such as assisted migration
- Best ways to communicate and integrate research and efforts with other organizations
- Incentives for increased production of ecotypic nursery stock

Thank you!

- I have a complete bibliography from this talk, including studies that I did not highlight.
- I will share with Frank.


Thank you.
Any Questions?