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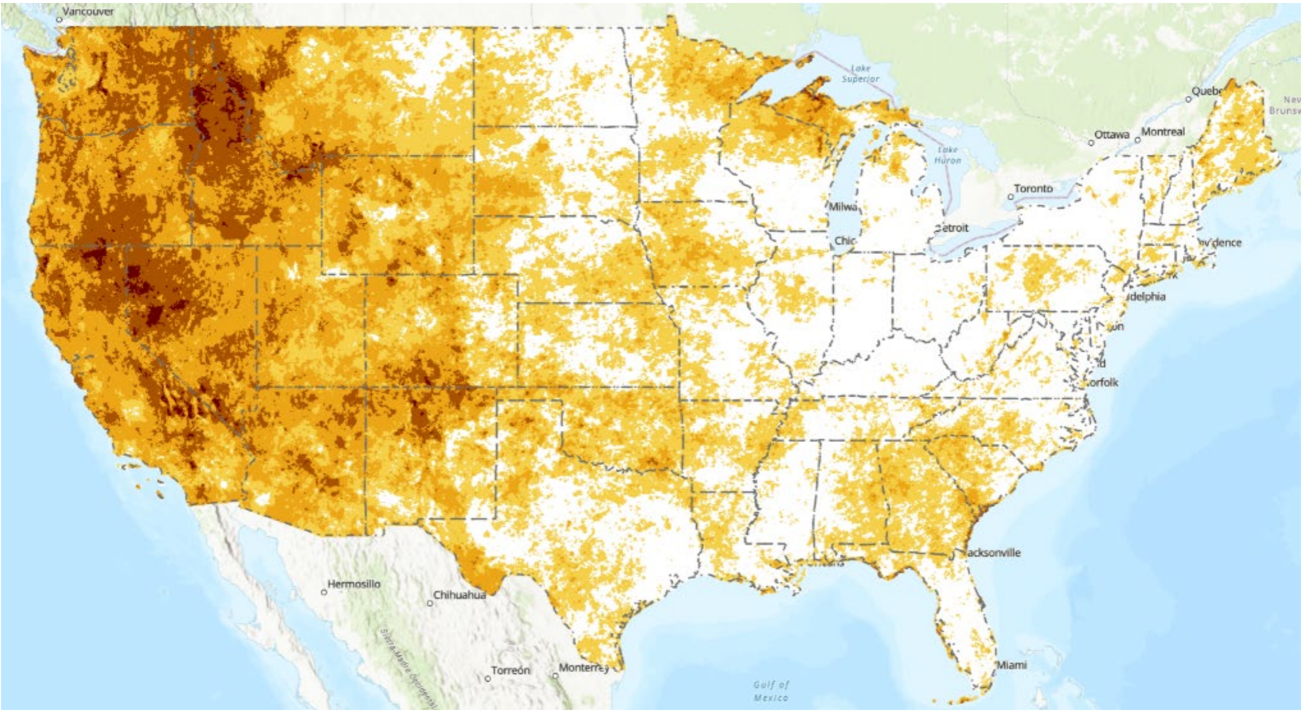
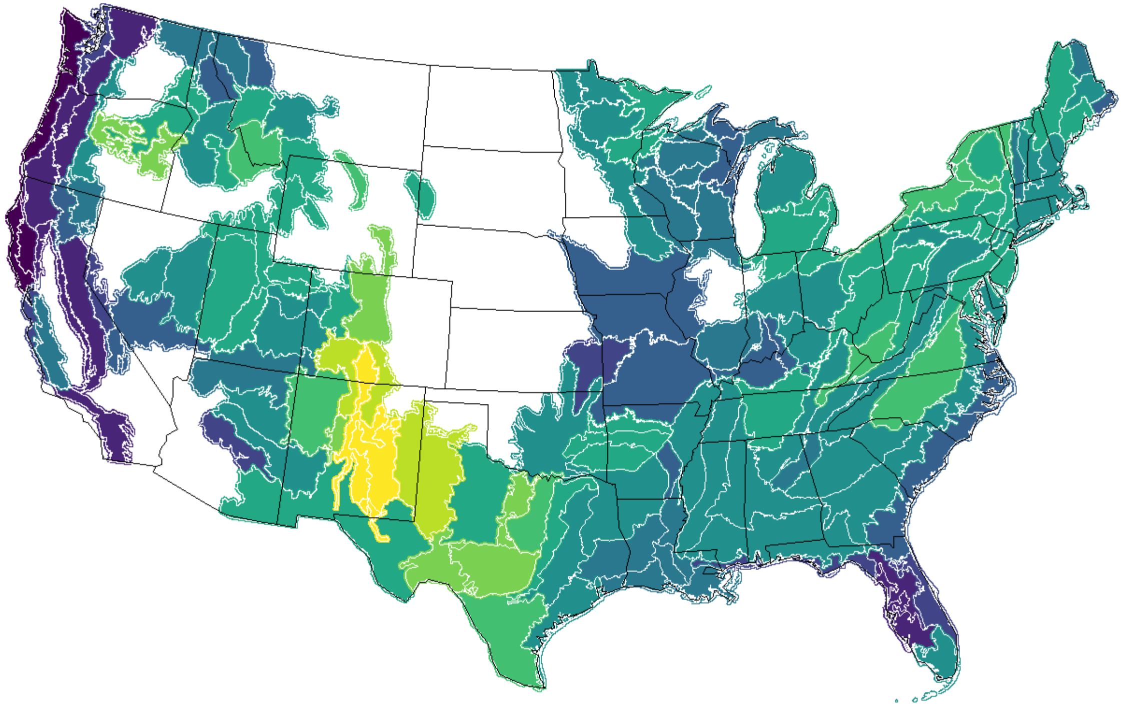




National Trends in Forest Disturbance

Jen Costanza, jennifer.costanza@usda.gov
USDA Forest Service, Southern Research Station
31 October, 2023

Special thanks to these Forest Service colleagues

- Shelley Crausbay, Office of Sustainability and Climate
- John Coulston, Southern Research Station
- Frank Koch, Southern Research Station
- Miranda Mockrin, Northern Research Station
- Kevin Potter, Southern Research Station
- Kurt Riitters, Southern Research Station
- David Walker, ORISE Fellow

Topics today

Why should we care about forest disturbances?

Recent trends and future projections: results from the 2020 Resources Planning Act (RPA) Assessment

Wrap up: management implications and future work

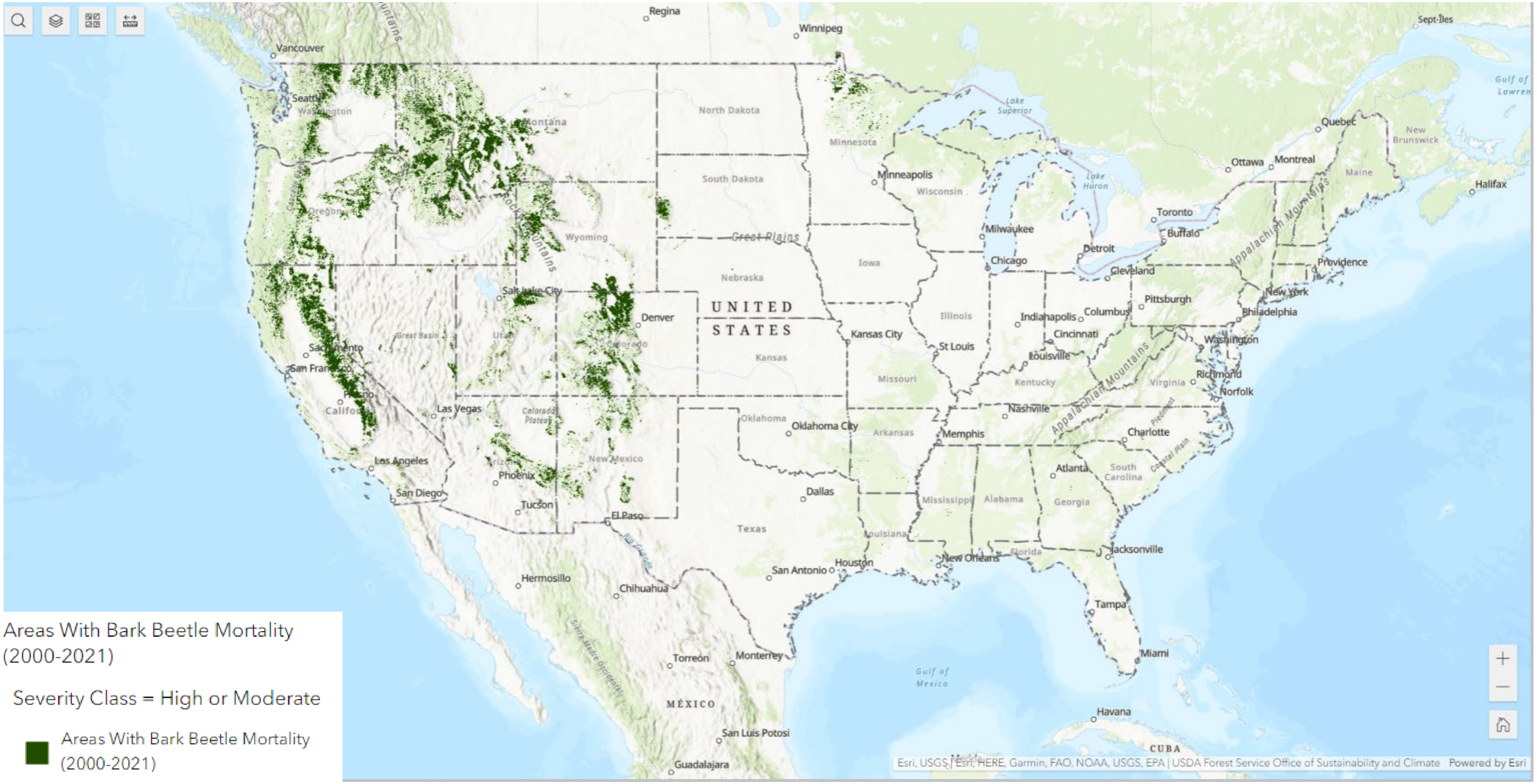
Topics today

Why should we care about forest disturbances?

Disturbances are part of the natural dynamics of forests

Source: USDA / Flickr

Bark beetle mortality



Source: USDA Forest Service Climate Risk Viewer

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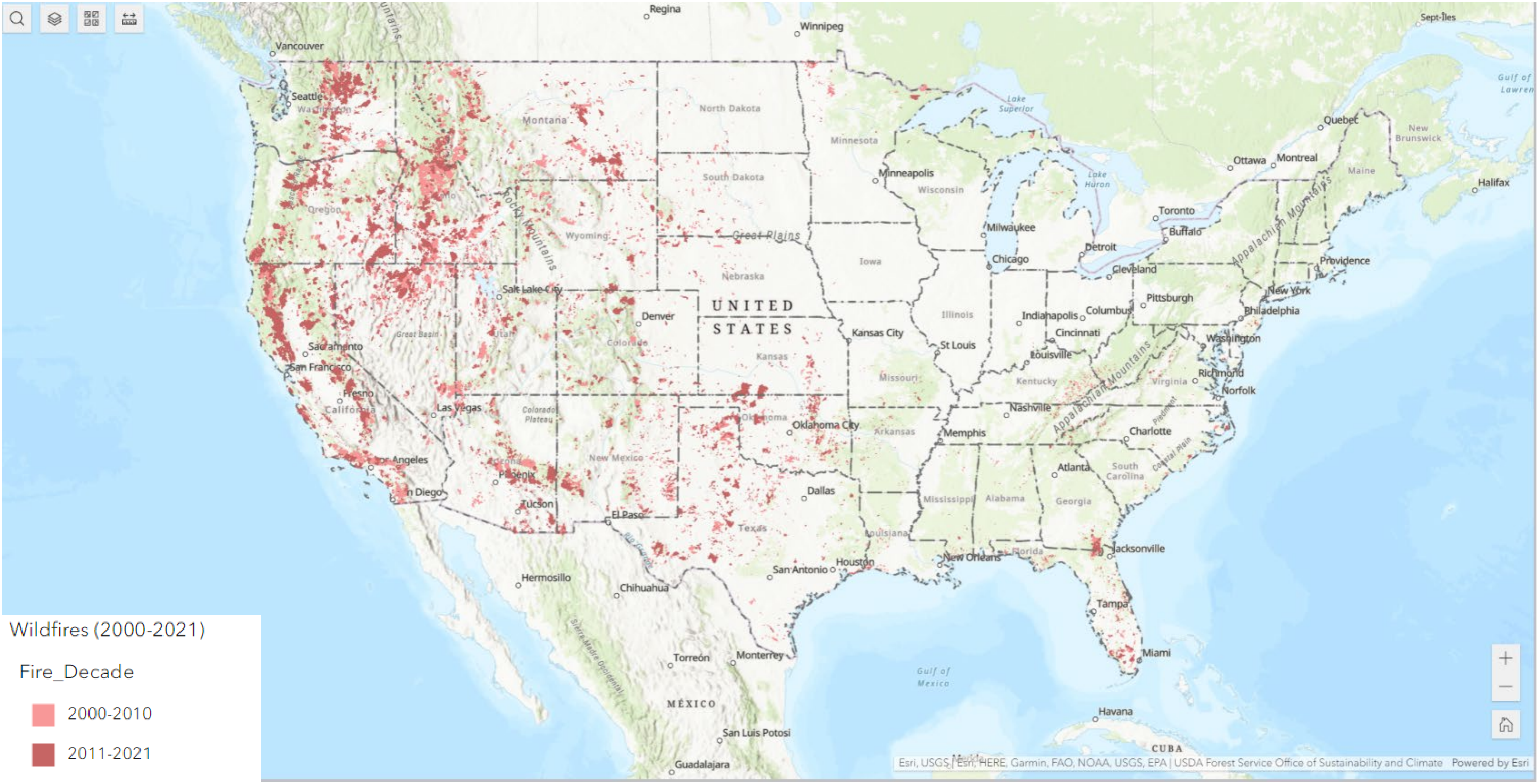
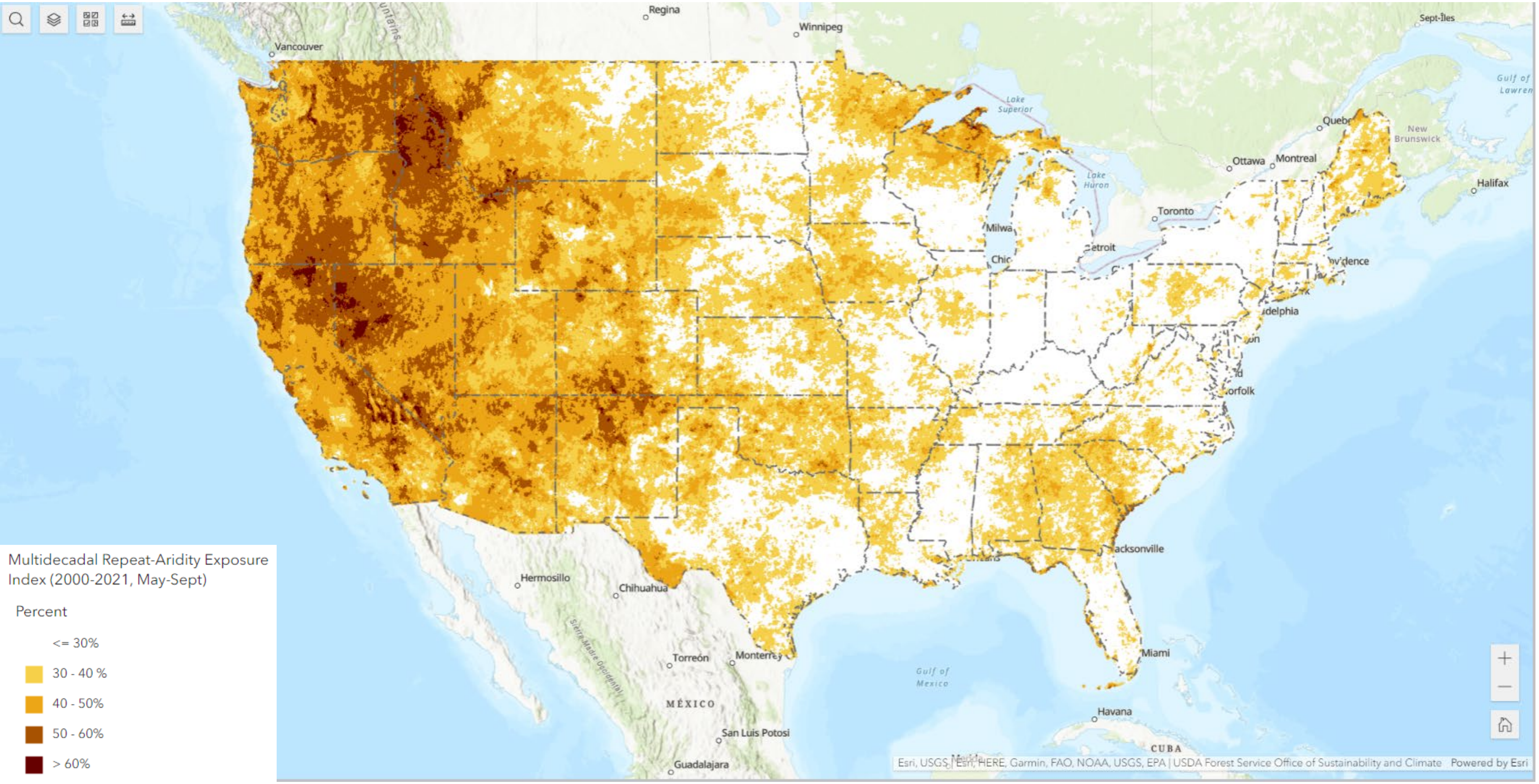
Wildfire



Source: USDA Forest Service Climate Risk Viewer

Repeat drought exposure



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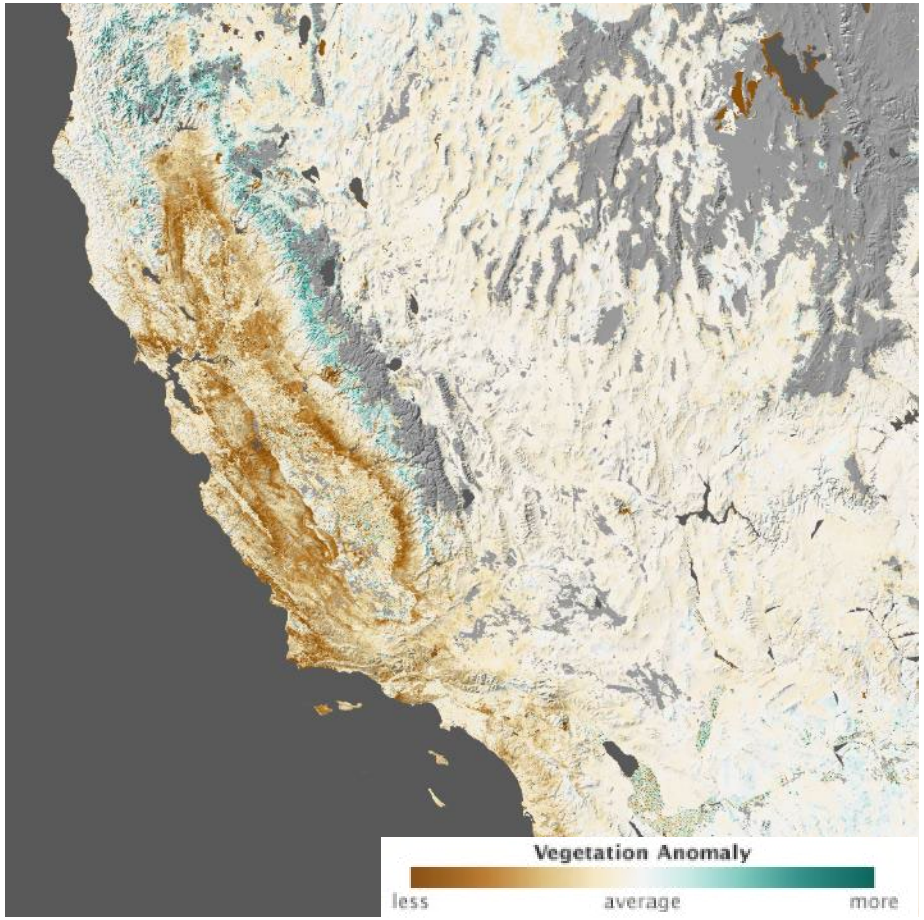
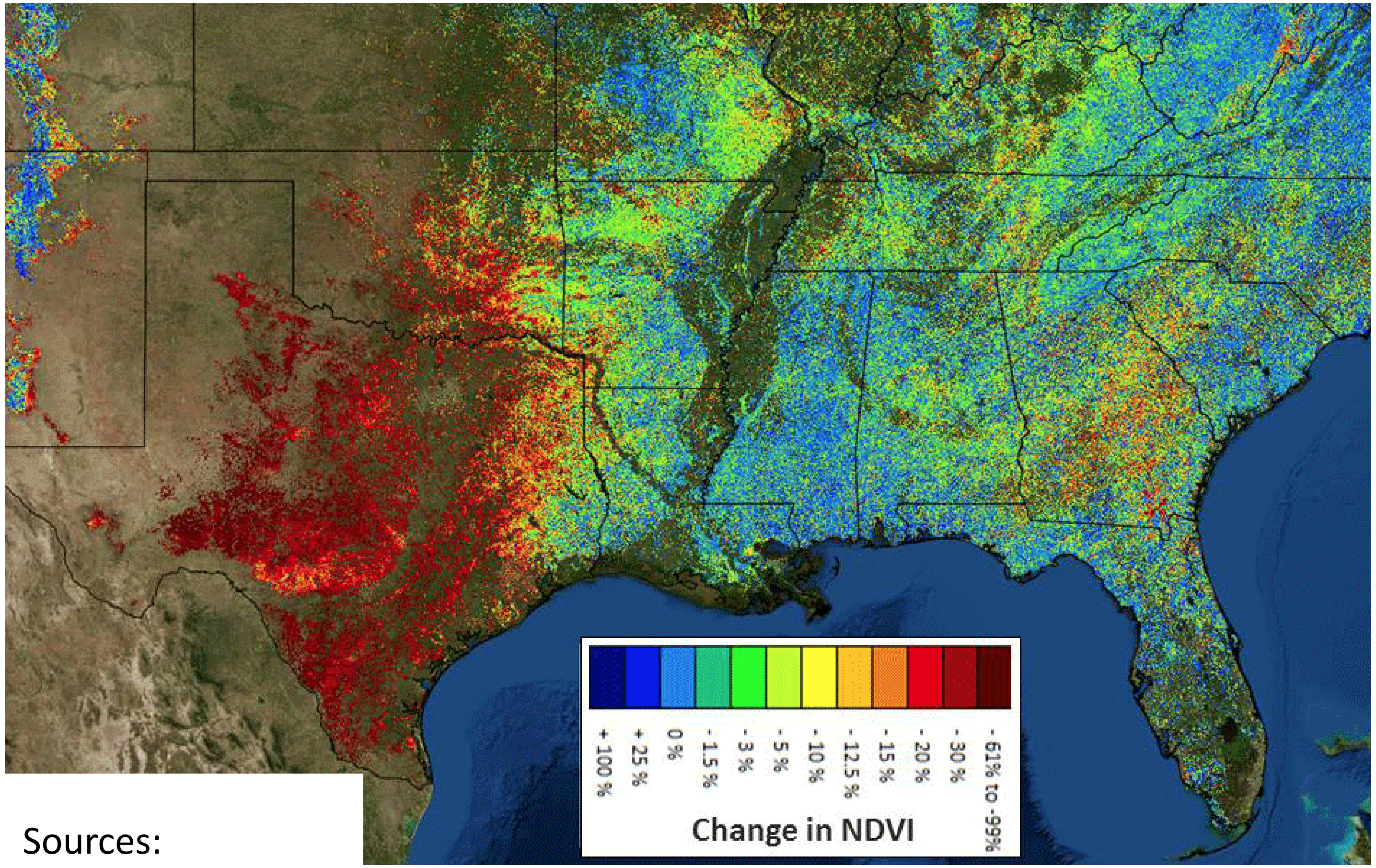
Source: USDA Forest Service Climate Risk Viewer

Drought effects at broad extents

California, c. 2014

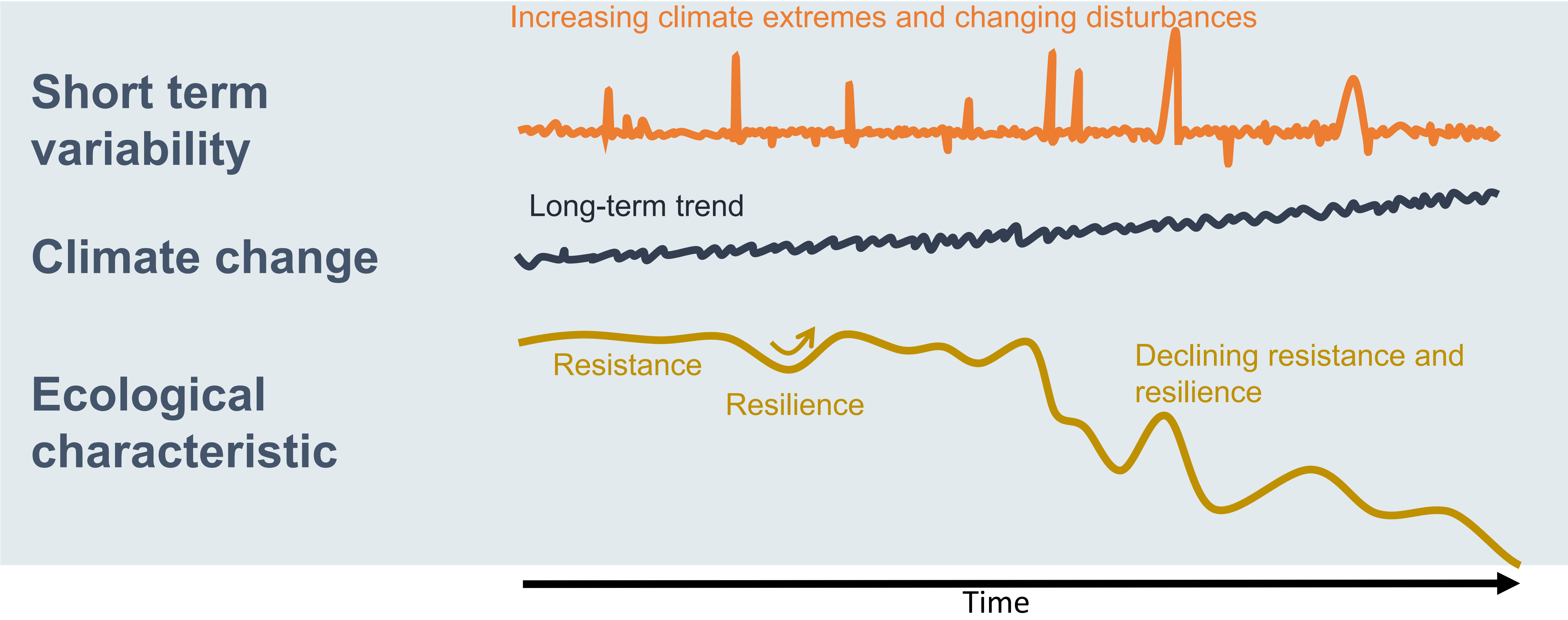


Texas, c. 2011



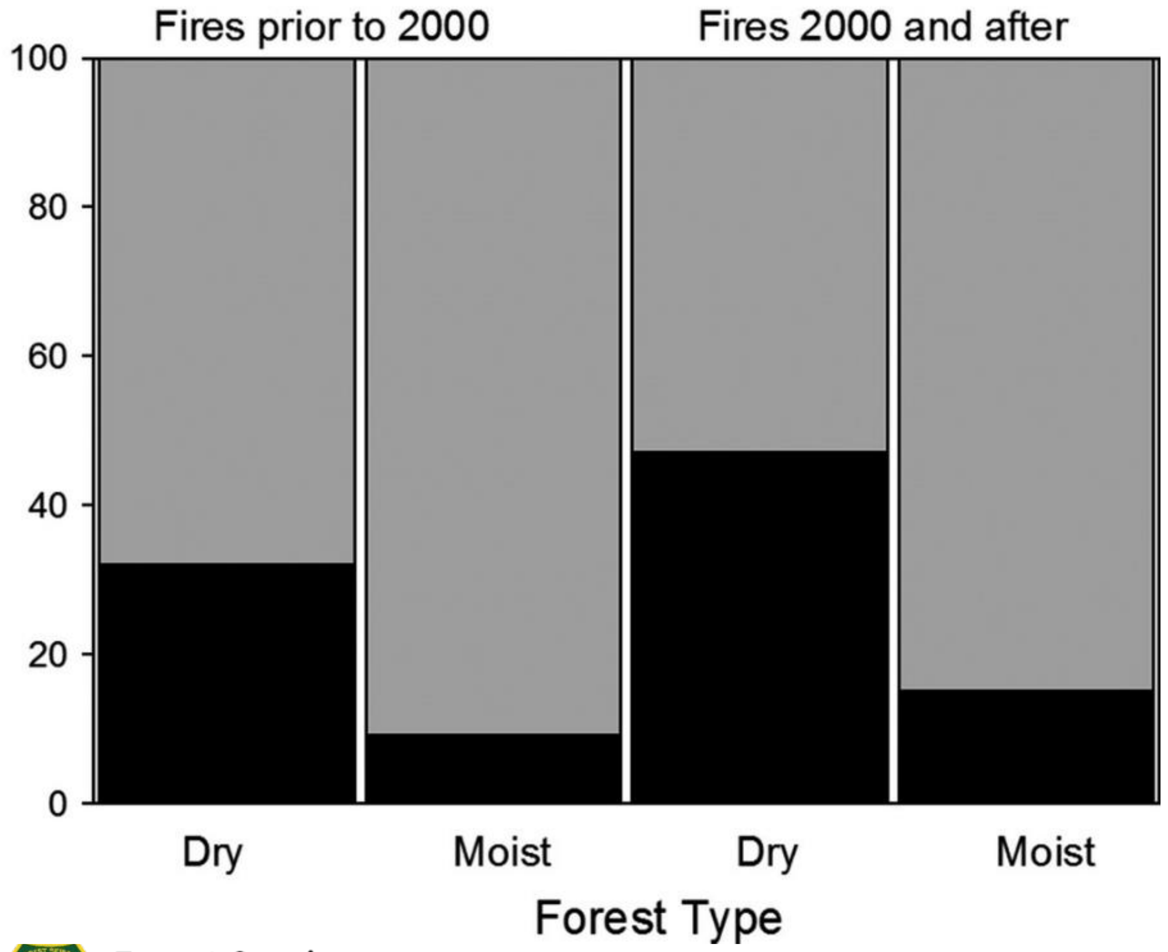
Sources:
https://earthobservatory.nasa.gov/images/83124/drought-stressing-californias-plantscape
https://forwarn.forestthreats.org/highlights/99

Changing disturbance can transform ecosystems

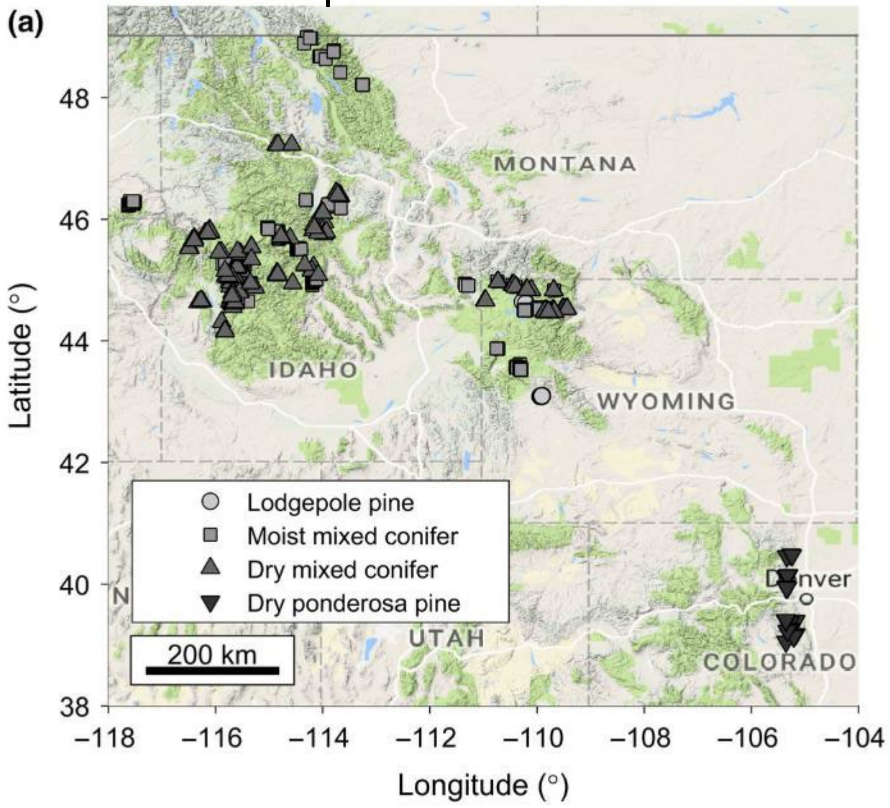


Slide: Shelley Crausbay, USDA Forest Service
Adapted from Harris et al. 2018 Nature Climate Change

Post-fire regeneration failure



Study sites with fires 1988-2011, temperate conifer forests

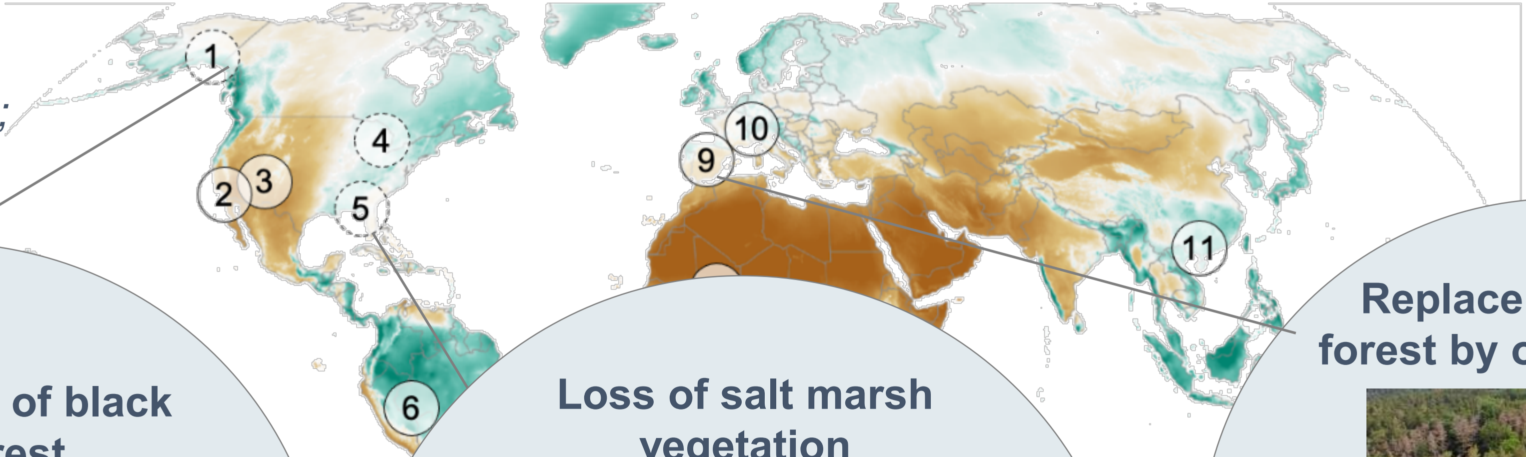


Conifer seedlings present

No conifer seedlings present

Stevens-Runman et al. 2018

Drought-triggered transformations



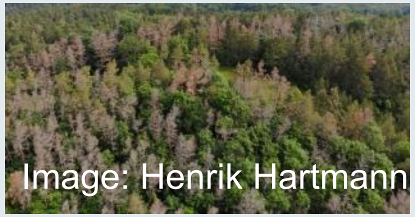
Baltzer et al 2021 *PNAS;* Johnstone et al 2020 *Ecosphere*

Transformation of black spruce forest

Loss of salt marsh vegetation

Alber et al 2008 *Estuar Coast Mar Sci;* McKee et al 2004 *Global Ecol Biogeogr*

Replacement of pine forest by oak woodlands



Vila-Cabrera et al 2013 *Ecosystems*
Gazol et al 2018 *Front Plant Sci*

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Slide: Shelley Crausbay, USDA Forest Service

Why should we care about forest disturbances?

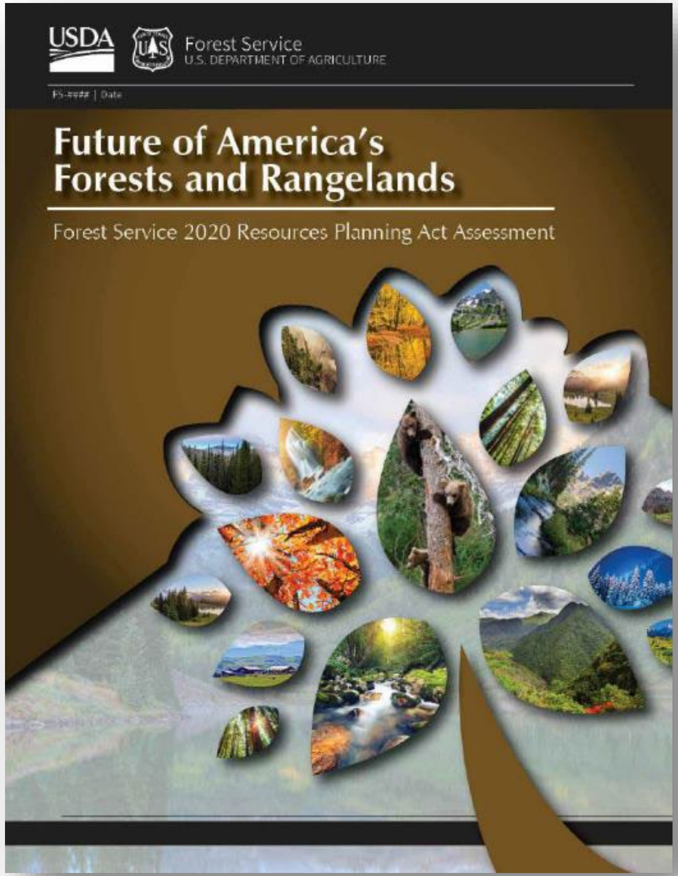
- Changes in tree growth or productivity, “stress”
- Tree mortality and temporary loss of forest cover
- Regeneration failure
- Transformation to new forest ecosystems or non-forest

- Disturbance regimes are changing
- Combine with climate change to alter ecosystems

Topics today

Recent trends and future projections: results from the 2020 Resources Planning Act (RPA) Assessment

The 2020 Resources Planning Act (RPA) Assessment



- Broad (regional and national) trends in forest resources
- Recent past; future to 2070
- Climate and socioeconomic scenarios
- Supporting data, publications, land management planning data guides, and more: https://www.fs.usda.gov/research/inventory/rpaa

Resources Evaluated in the 2020 RPA Assessment

Forest Resources

Forest Products

Rangelands

Land Resources

Disturbance

Water Resources

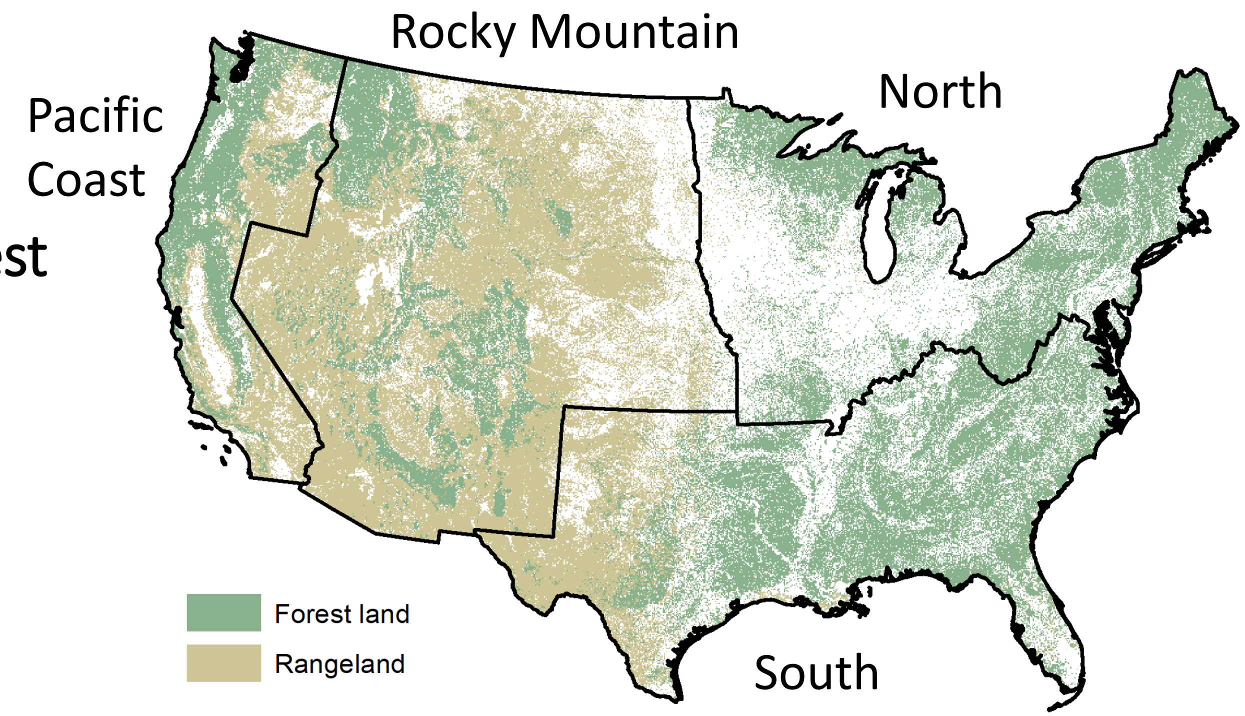
Outdoor Recreation

Wildlife & Biodiversity

Disturbance in RPA

- **Fire and drought**: recent trends and future projections
- **Invasive plants, insects and disease, forest removals (harvest)**: Recent trends
- Conterminous U.S., by region, by ecosystem
- Case studies on drought impacts, prescribed fire, sea-level rise
- Primarily analyze *exposure*
- In this talk, focus on **fire, drought, disease**

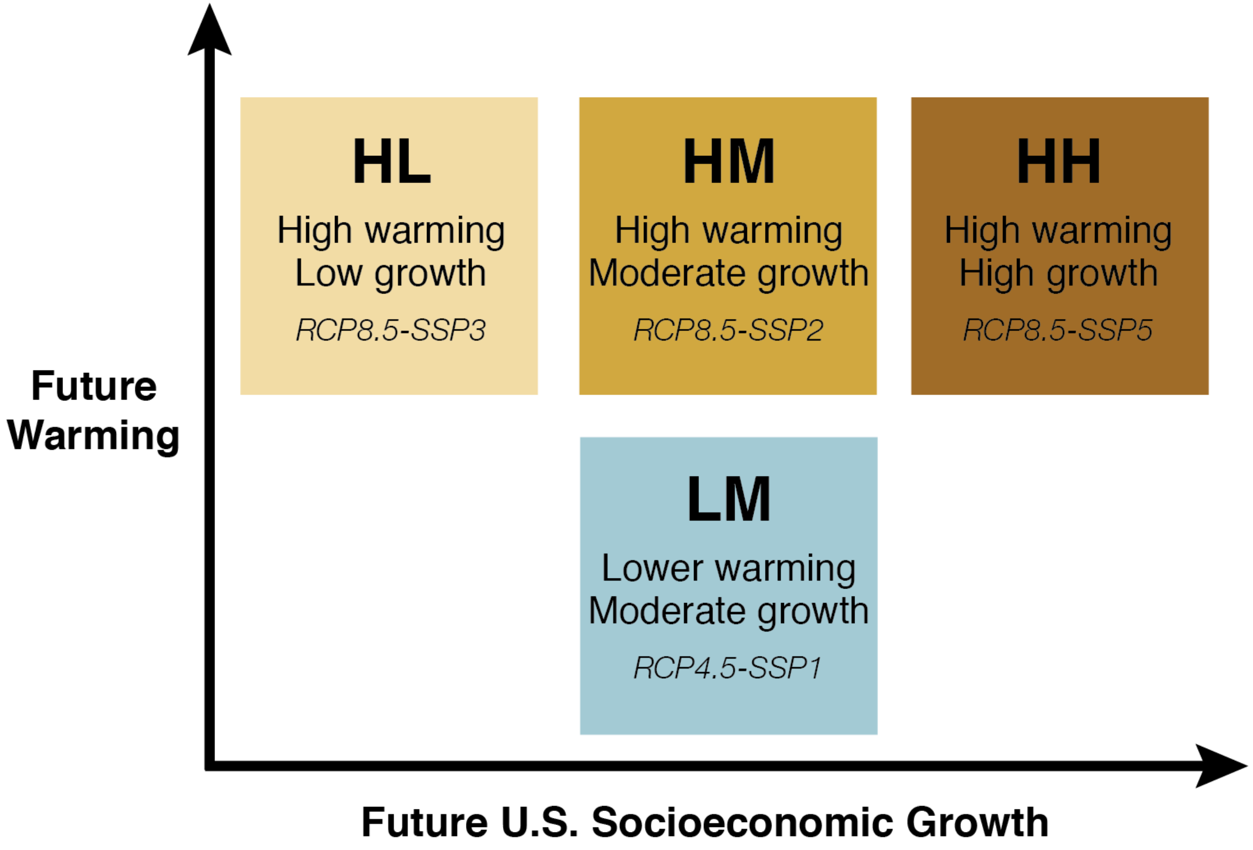
(new projections for the North and South)



Disturbance data sources

- Recent fire: **Monitoring Trends in Burn Severity (MTBS)**
- Recent drought exposure: **meteorological index based on PRISM data**
- Future drought exposure: **meteorological index based on downscaled climate projections**
- Future fire (future disease): **RPA Forest Dynamics Model**
  - Status and trends defined by FIA data
  - Projection model focused on moving the FIA inventory forward in time
  - Creates future realizations of the FIA inventory as driven by land use change, regeneration, forest succession and maturing, climate, global demand for wood and wood products
  - Future disturbance projections are generally in terms of volume killed

2020 RPA Assessment scenarios vary in terms of future atmospheric warming and U.S. socioeconomic growth



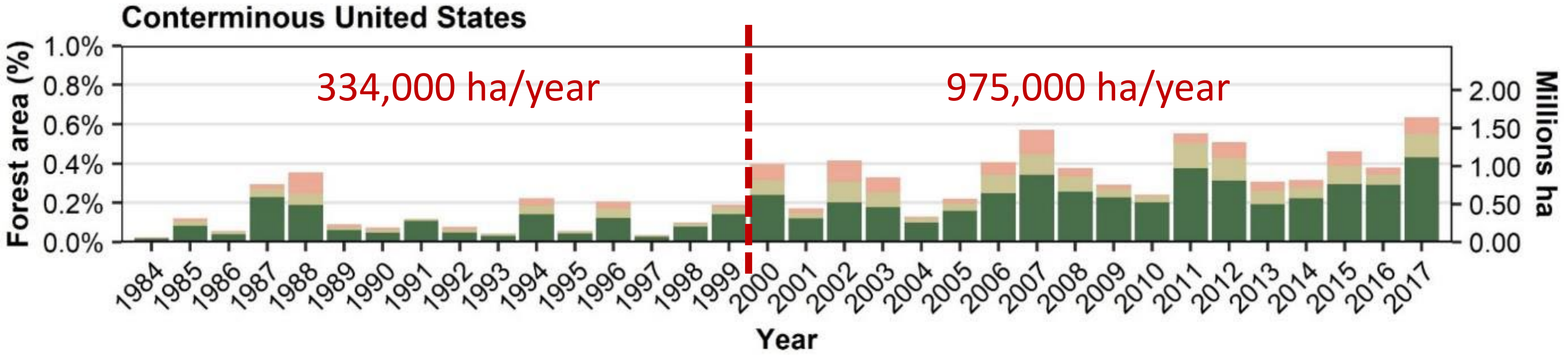
For each scenario, 5 climate models:

Least Warm – MRI-CGCM3
Hot – HadGEM2-ES
Dry – IPSL-CM5A-MR
Wet – CNRM-CM3
Middle – NorESM1-M

Drought: alternative warming levels only = *10 futures*

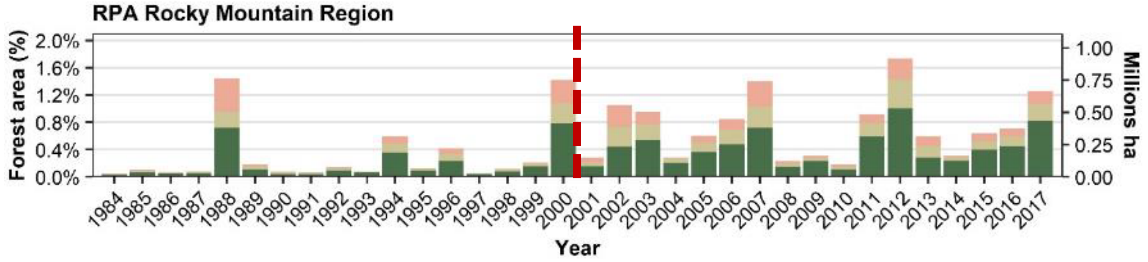
Forest area burned by fire has been increasing

189% increase

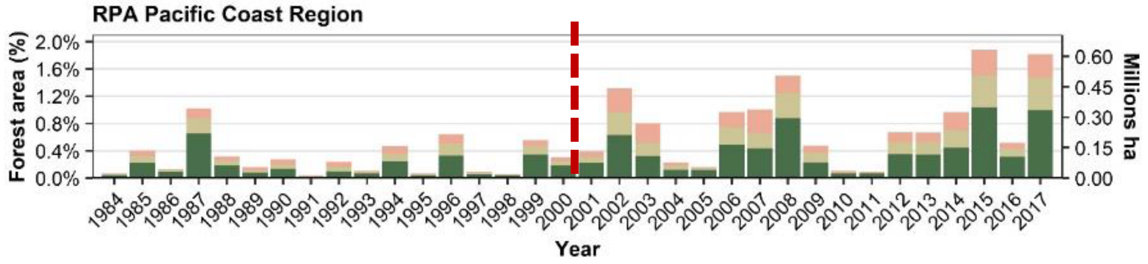


Burn severity:
High
Moderate
Low/other

Average annual area burned from 2000 to 2017 was more than double the pre-2000 average.



219% increase



165% increase

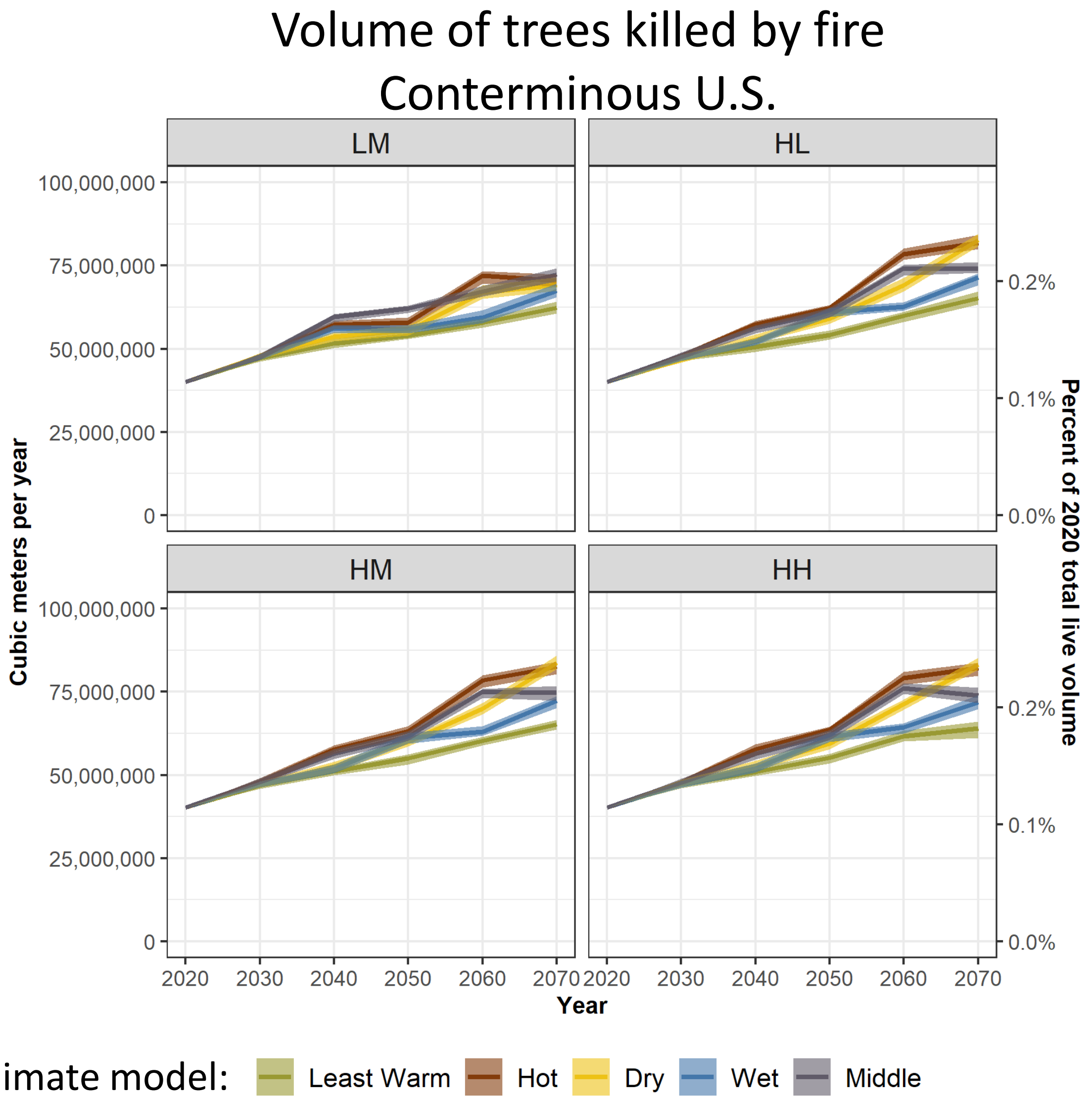
F. Koch *in* Costanza et al. 2023 *RPA Chapter: Disturbance*

Future tree mortality from fire

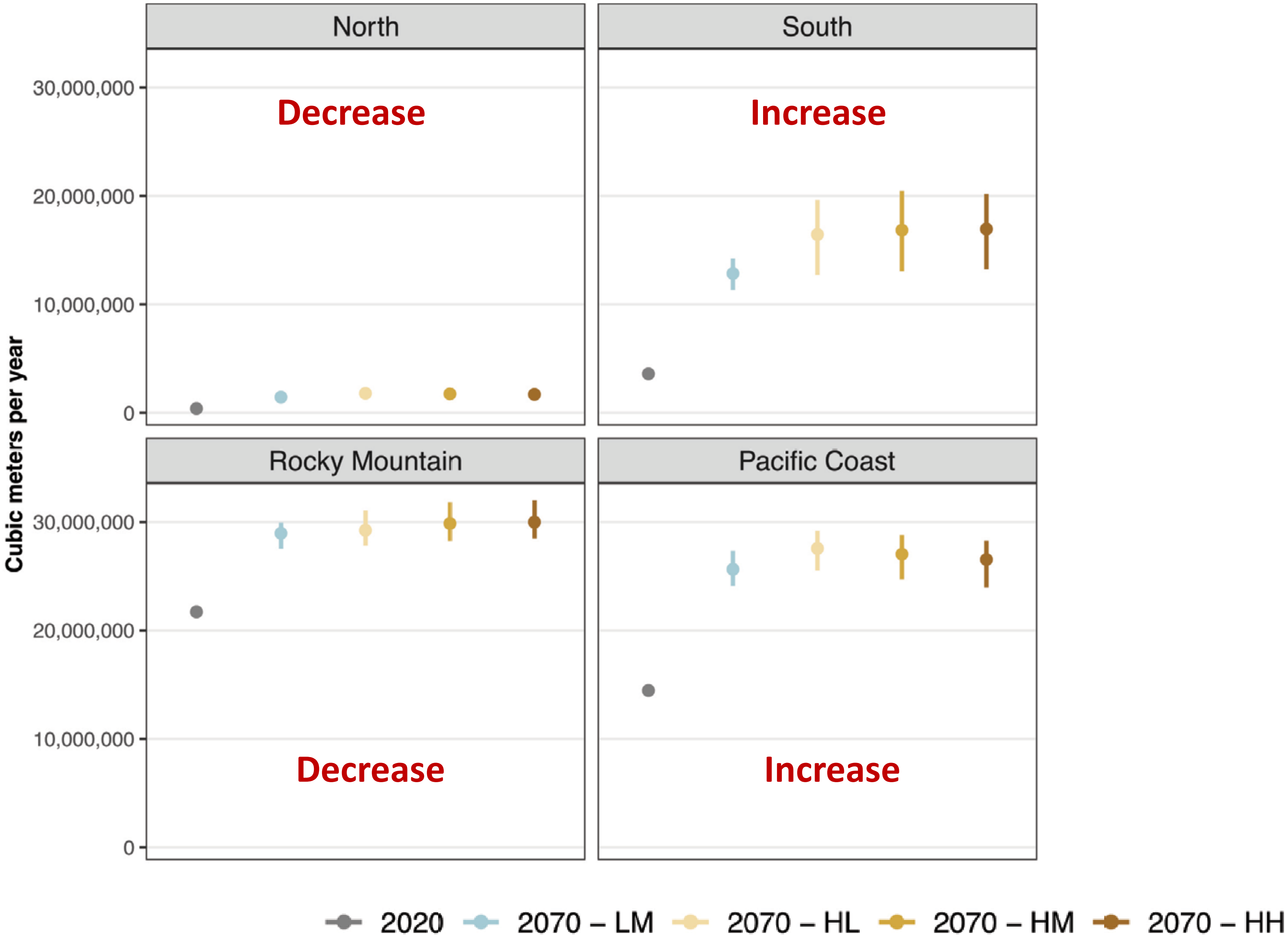
From Forest Dynamics Model projections

Result for the CONUS:

- Between 55-108% increase in tree mortality (volume) by 2070
- Largest increases in the hot and dry climate models in the high warming scenarios.



Proportion of overall volume



Costanza et al. 2023 *RPA Chapter: Disturbance*

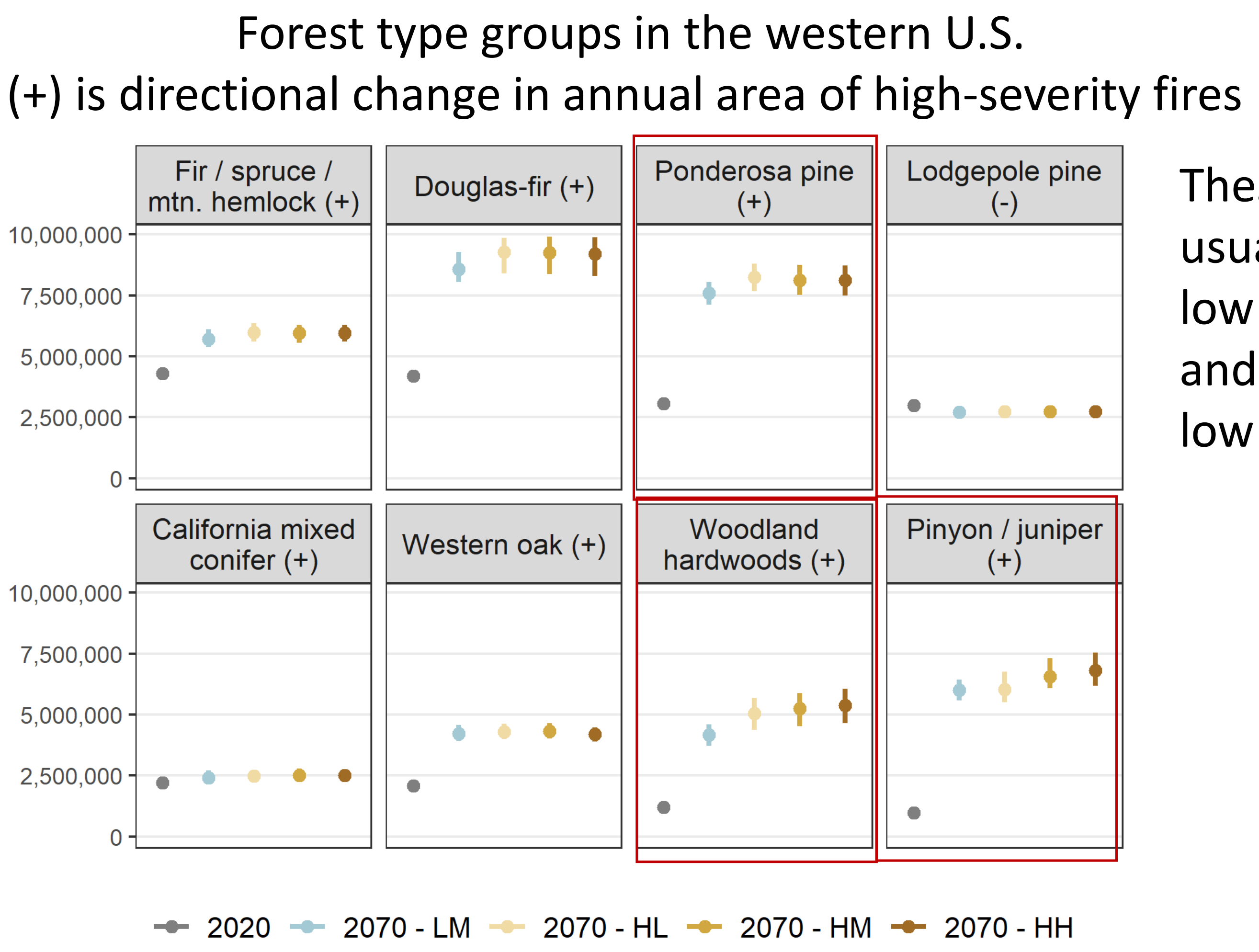
Areas of moderate and high severity fires

	Change 2020-2070 Change in area of moderate-severity fires		Change 2020-2070 Change in area of high-severity fires	
	ha	percent	ha	percent
North	6,000-11,000	483-884 +	-1,300-4,800	-16-62 -
South	12,000-54,000	72-330 +	19,000-70,000	70-256 +
Rocky Mountain	46,000-76,000	108-179 +	-3,300-34,000	-2-24 - / +
Pacific Coast	40,000-53,000	141-185 +	36,000-49,000	69-95 +

Moderate severity: 25-70% of live volume killed
High severity: > 70% of live volume killed

Costanza et al. 2023 *RPA Chapter: Disturbance*

Future tree mortality from fire

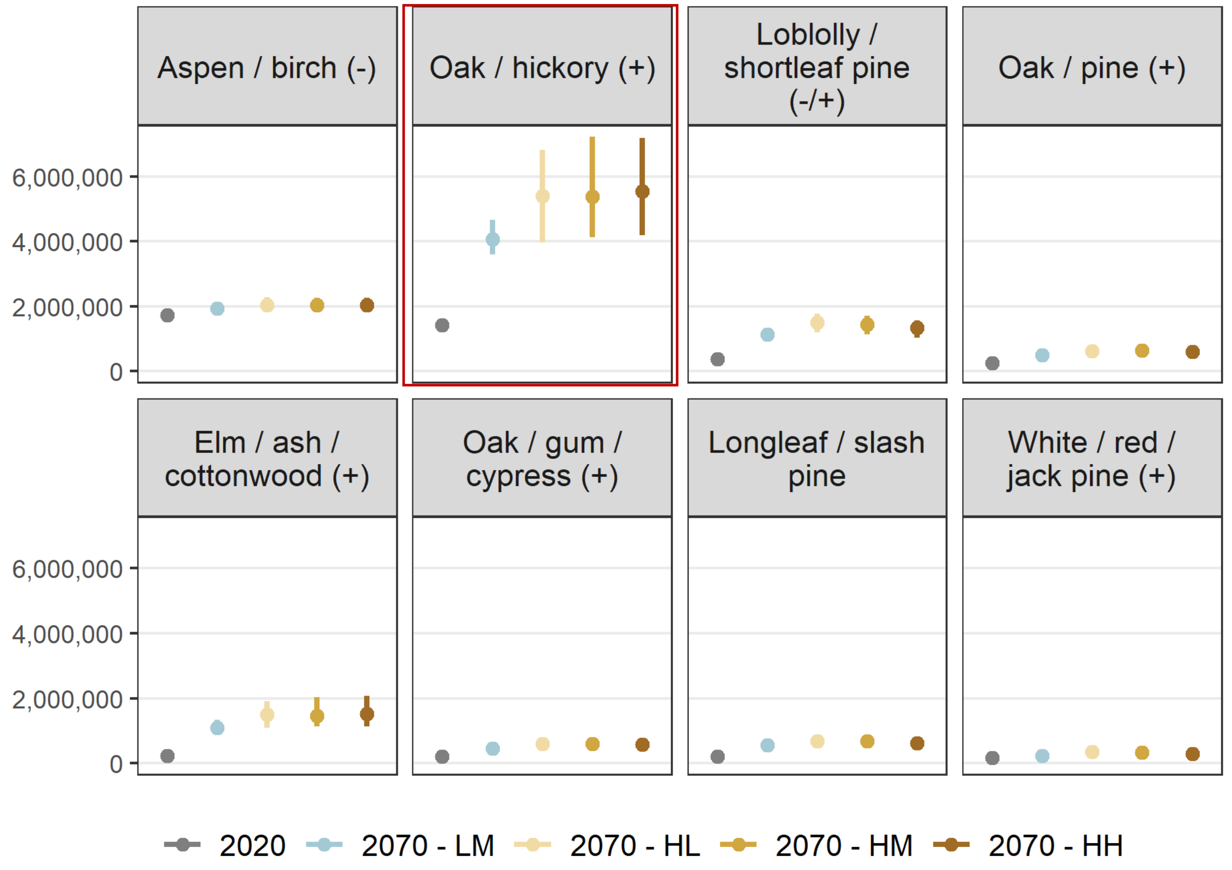


These type groups usually have relatively low total live volumes and experience frequent, low severity fires

Costanza et al. 2023 *RPA Chapter: Disturbance*

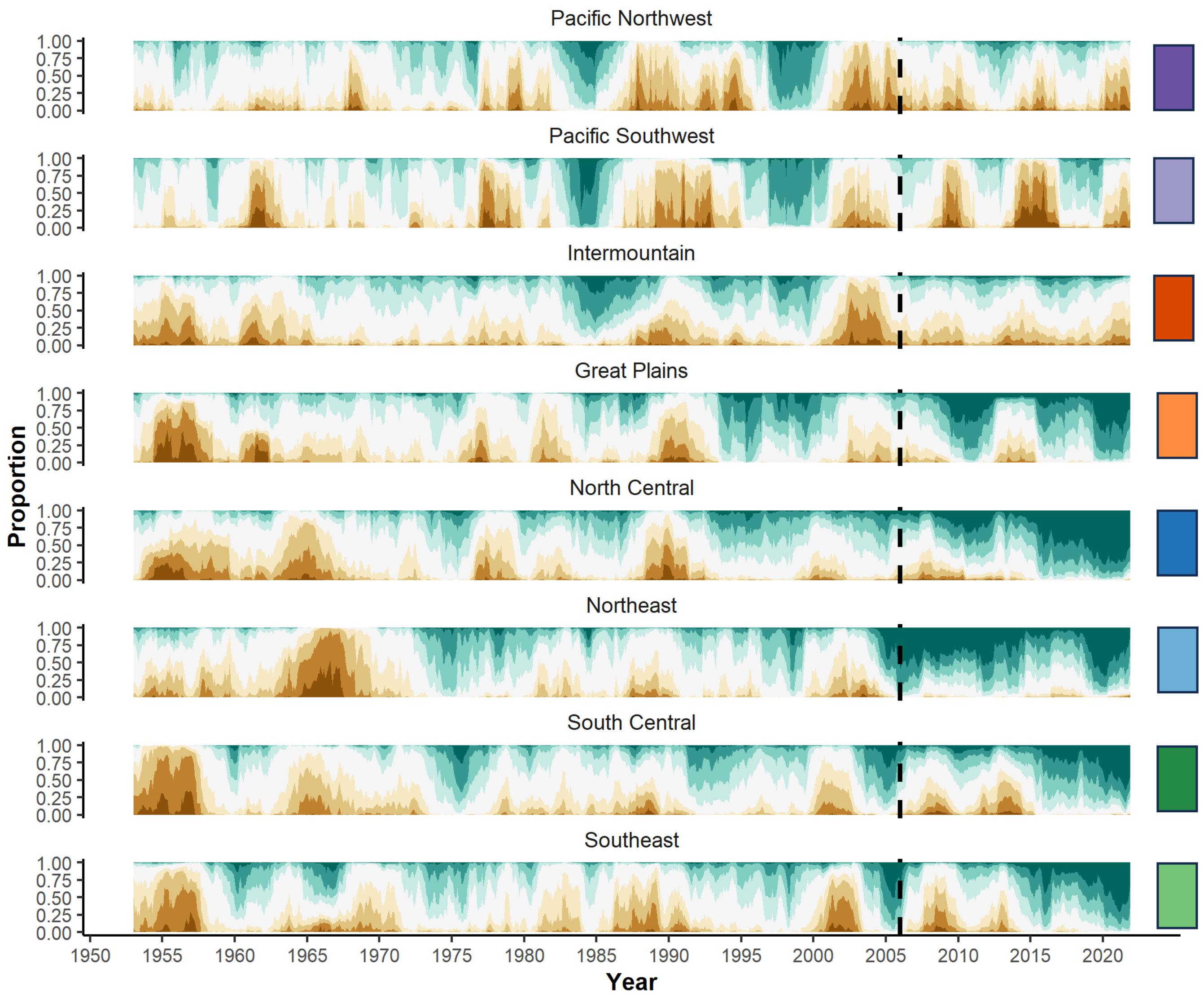
Future tree mortality from fire

Forest type groups in the eastern U.S.
(+) is directional change in annual area of high-severity fires



Costanza et al. 2023 *RPA Chapter: Disturbance*

Recent forest exposure to drought

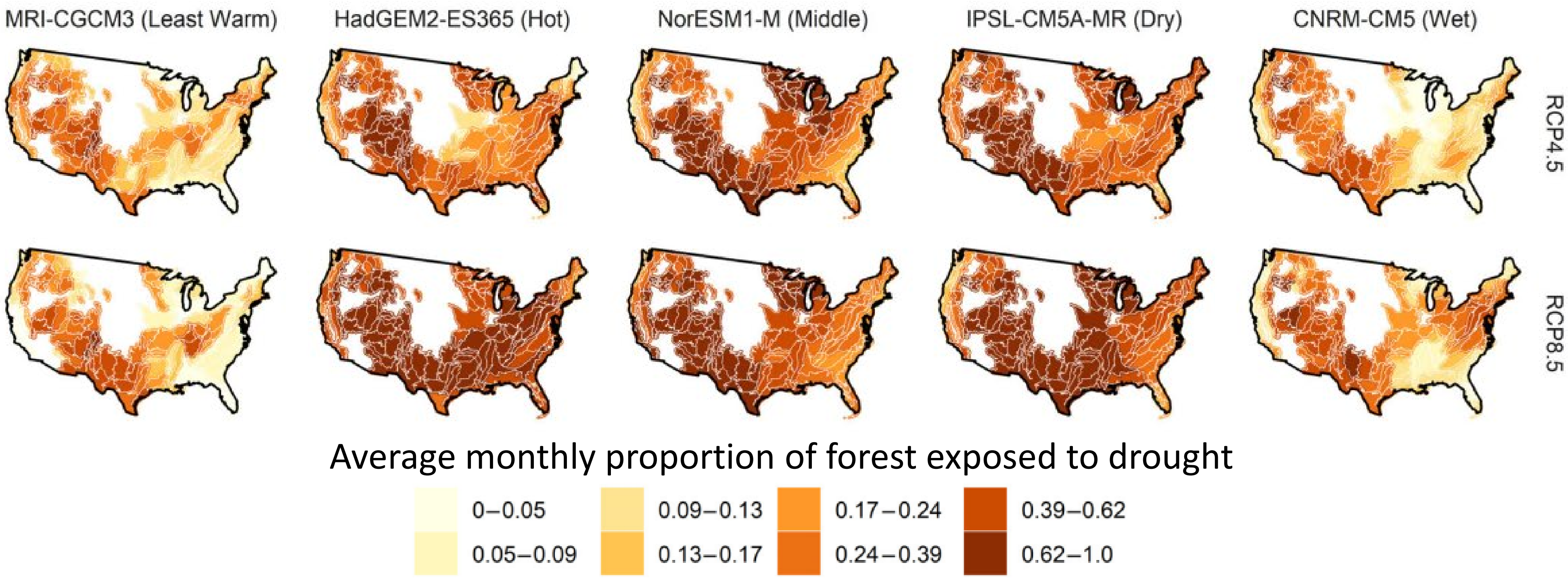


Meteorological drought: ***36-month*** Standardized Precipitation-Evapotranspiration Index (SPEI)

- SPEI > 2, Extremely wet
- 1.5 < SPEI < 2, Severely wet
- 1 < SPEI < 1.5, Moderately wet
- 0.5 < SPEI < 1, Slightly wet
- -0.5 < SPEI < 0.5, Near normal
- -1 < SPEI < -0.5, Slightly dry
- -1.5 < SPEI < -1, Moderate drought
- -2 < SPEI < -1.5, Severe drought
- SPEI < -2, Extreme drought

Costanza et al. 2023 *RPA Chapter: Disturbance*

Future drought exposure in forests



Recent
1991-2020
11% average

Mid-century
2041-2070
38% average

More than a tripling of monthly proportion of forest exposed to drought by mid-century

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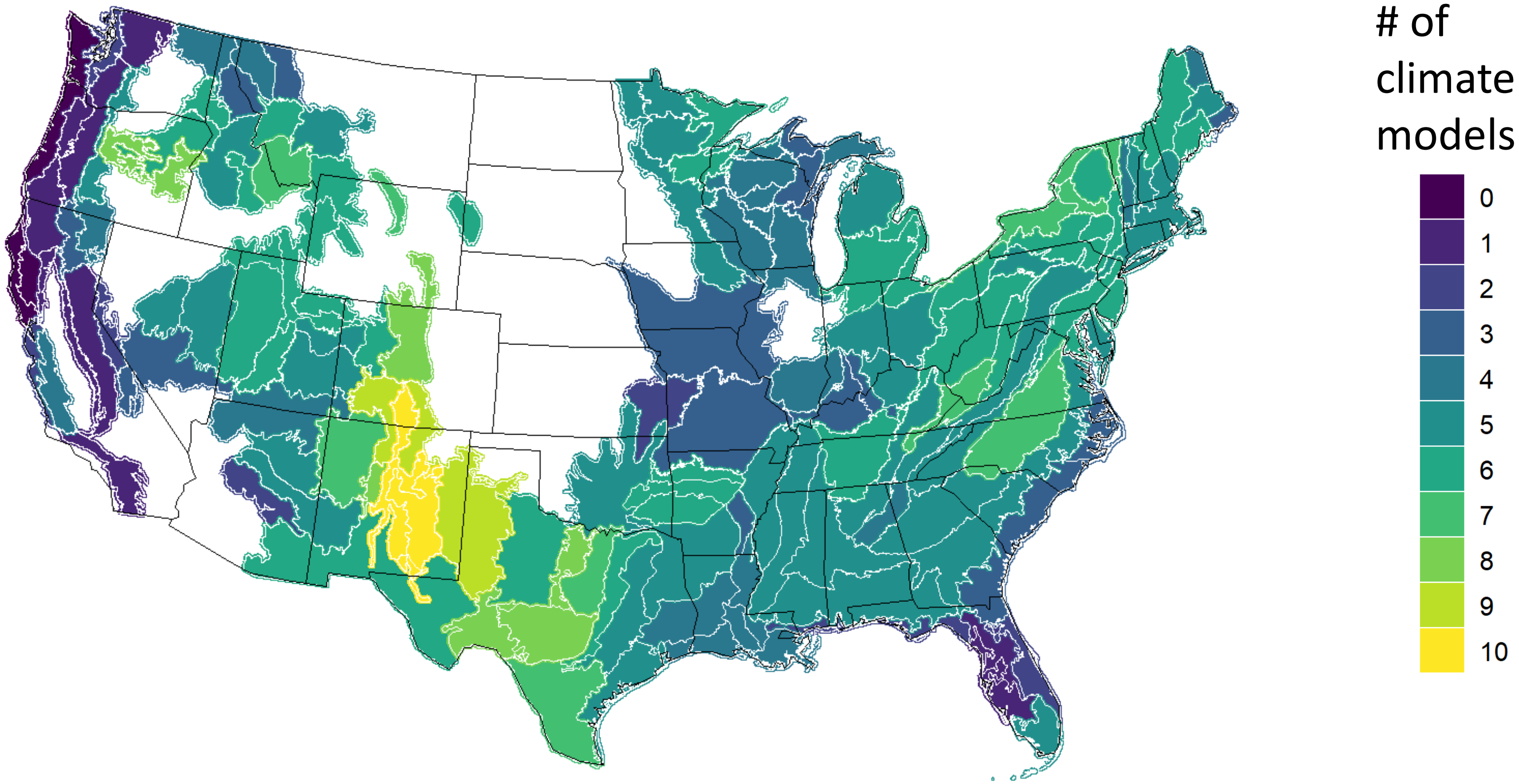
Costanza et al. 2023 *RPA Chapter: Disturbance*
Costanza et al. 2023 *Ecosphere*

Model agreement: forest exposure by mid-century

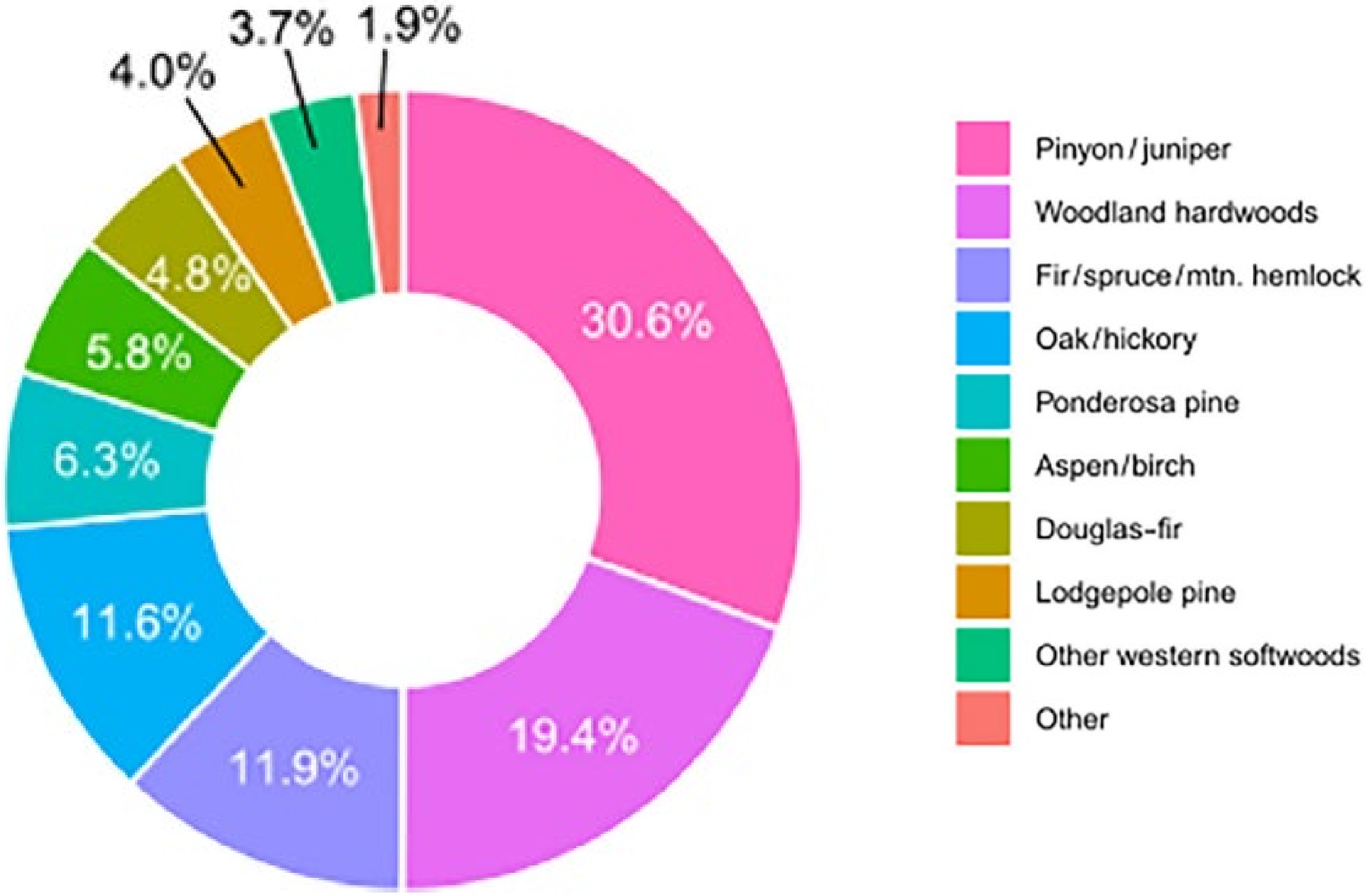
Where is more than a tripling of monthly forest exposure projected to occur?



Costanza et al. 2023 *Ecosphere*

Forest types found in areas of greatest drought exposure

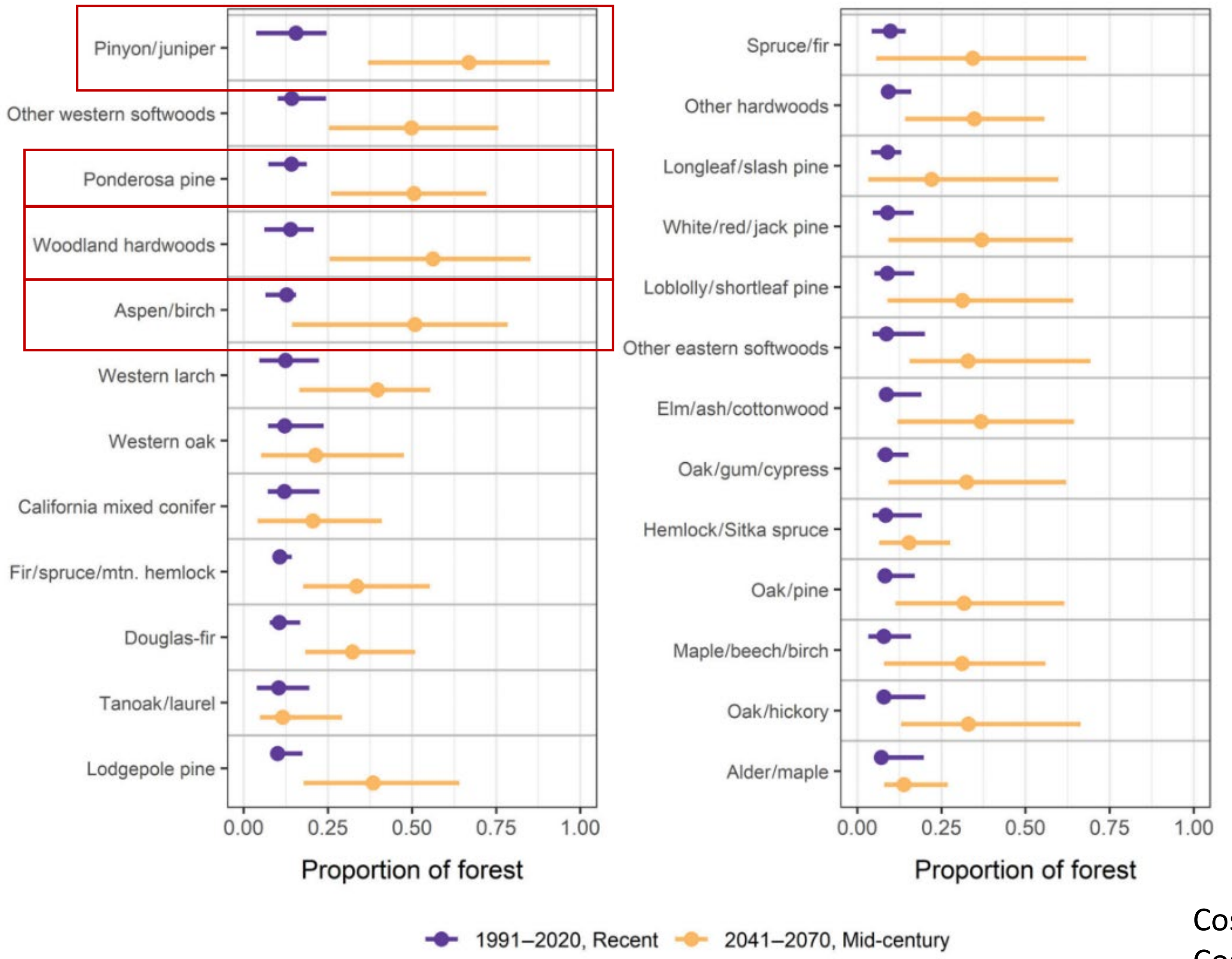
Where models agree on change in exposure



Costanza et al. 2023 *Ecosphere*

Projected drought exposure of forest types

Monthly proportion of forest exposed to drought in the 10 climates



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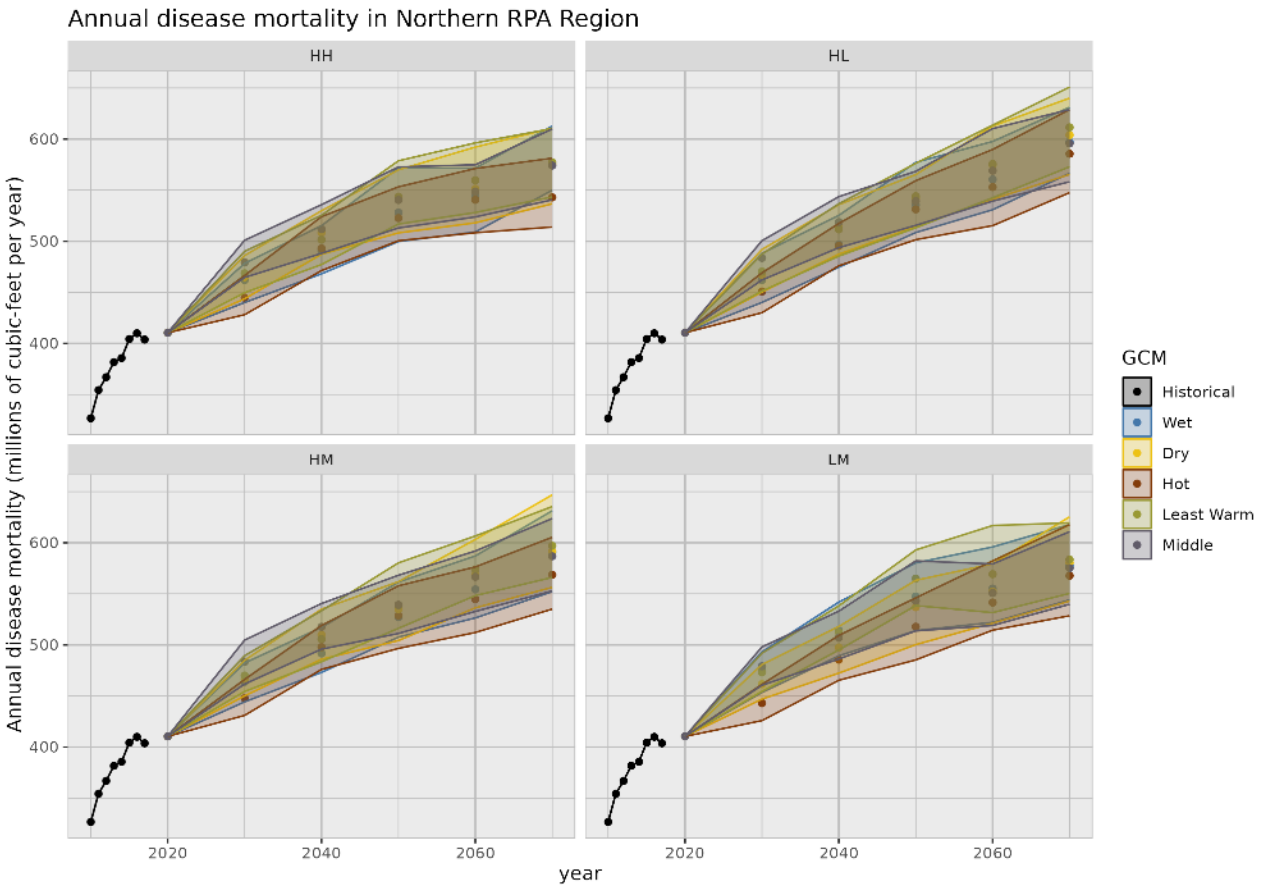
Costanza et al. 2023 *RPA Chapter: Disturbance*
Costanza et al. 2023 *Ecosphere*

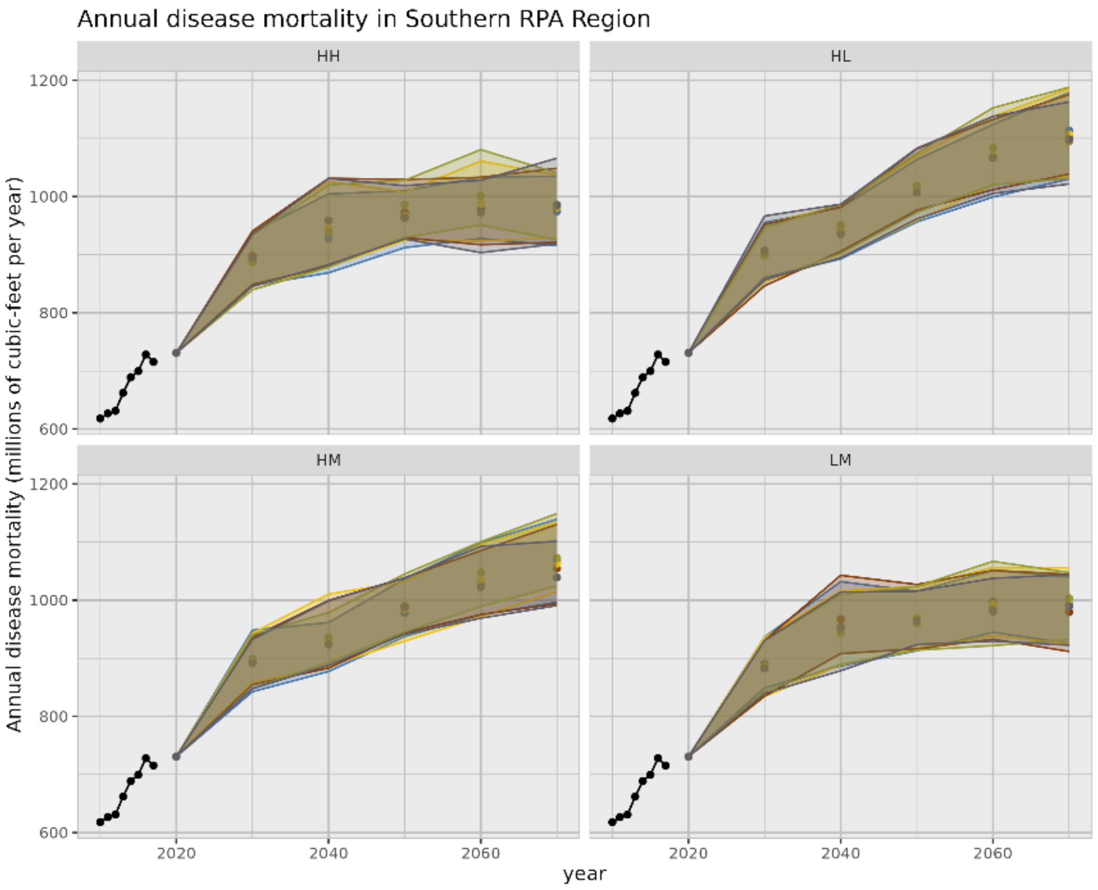
Disease mortality: projections for North and South

From Forest Dynamics Model projections

North region



South region



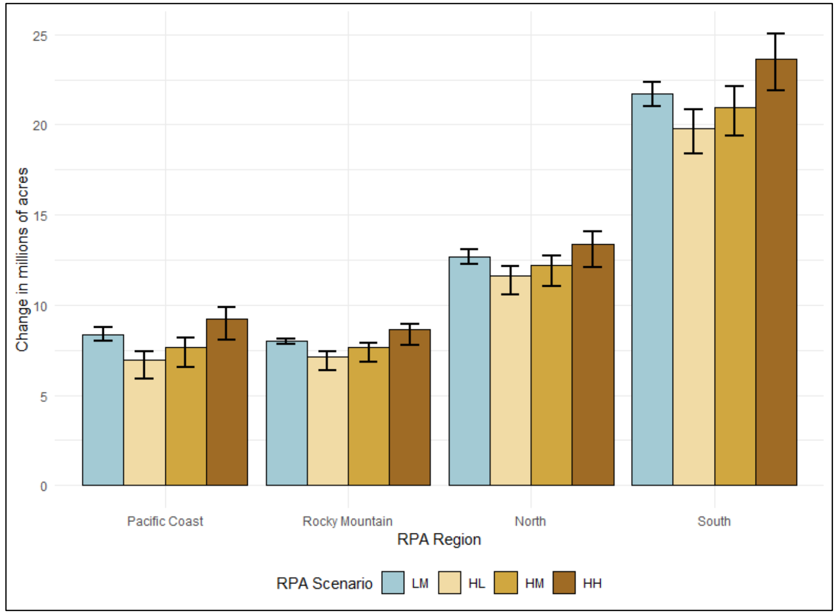
Courtesy D. Walker, USDA Forest Service

Results from other 2020 RPA Chapters

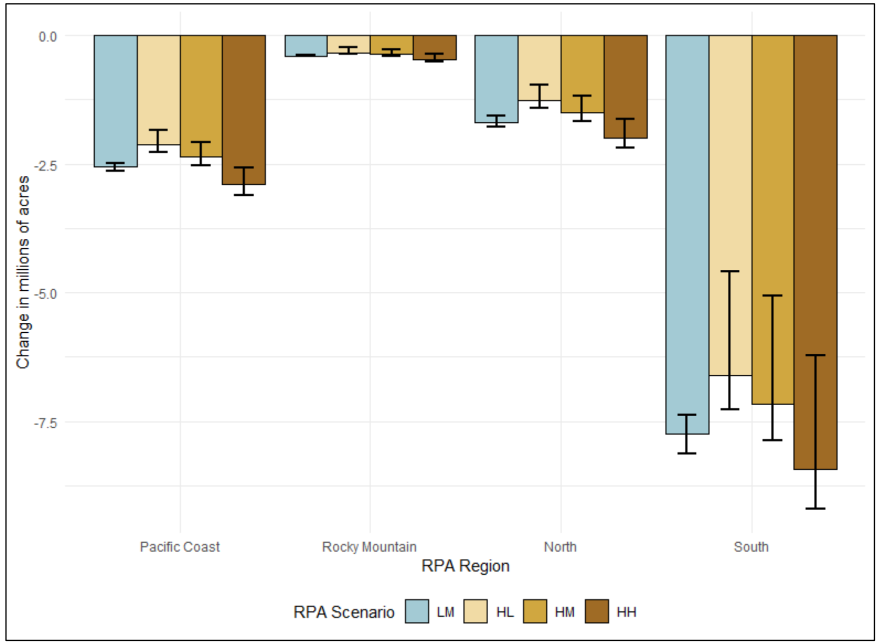
Area of forest land is expected to decrease

Developed lands are projected to continue to expand in all scenarios by 2070

Developed land use
Change 2020-2070

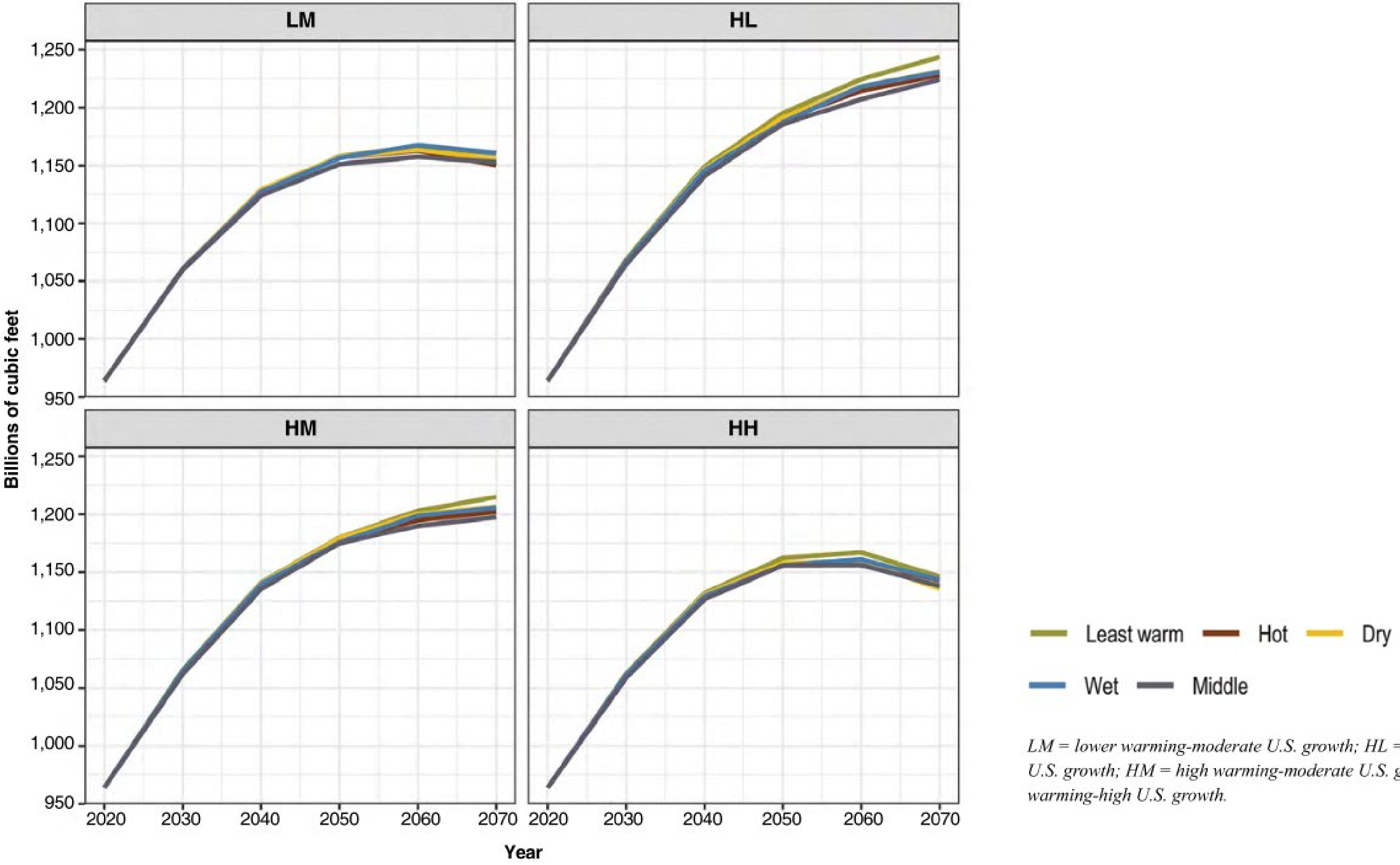


Forested land use
Change 2020-2070



Mihiar and Lewis 2023 *J. Agric and Appl Econ Assoc.*
Riitters et al. 2023 *RPA Chapter: Land Resources*

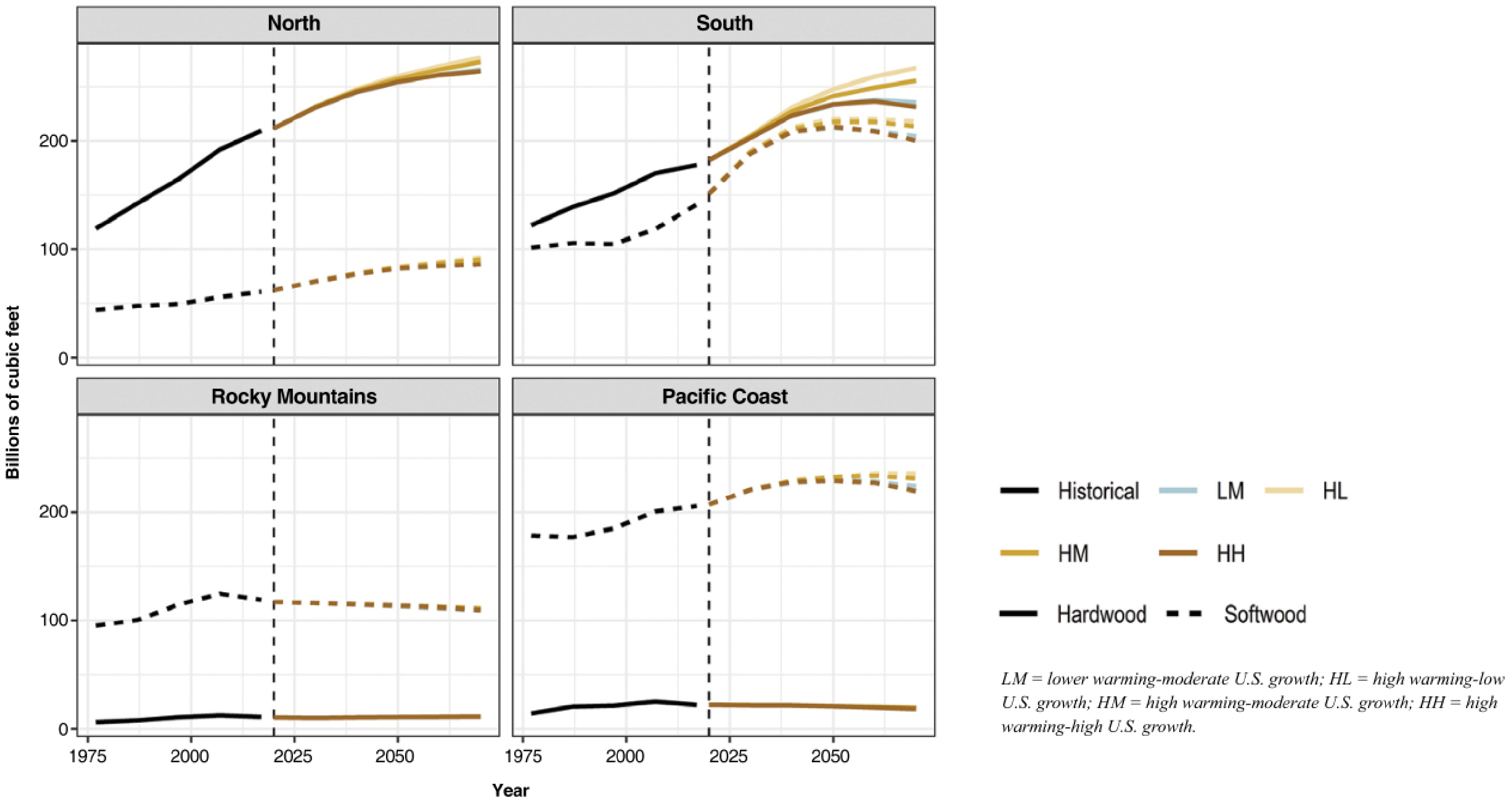
Live volume is projected to increase across the U.S.



LM = lower warming-moderate U.S. growth; HL = high warming-low U.S. growth; HM = high warming-moderate U.S. growth; HH = high warming-high U.S. growth.

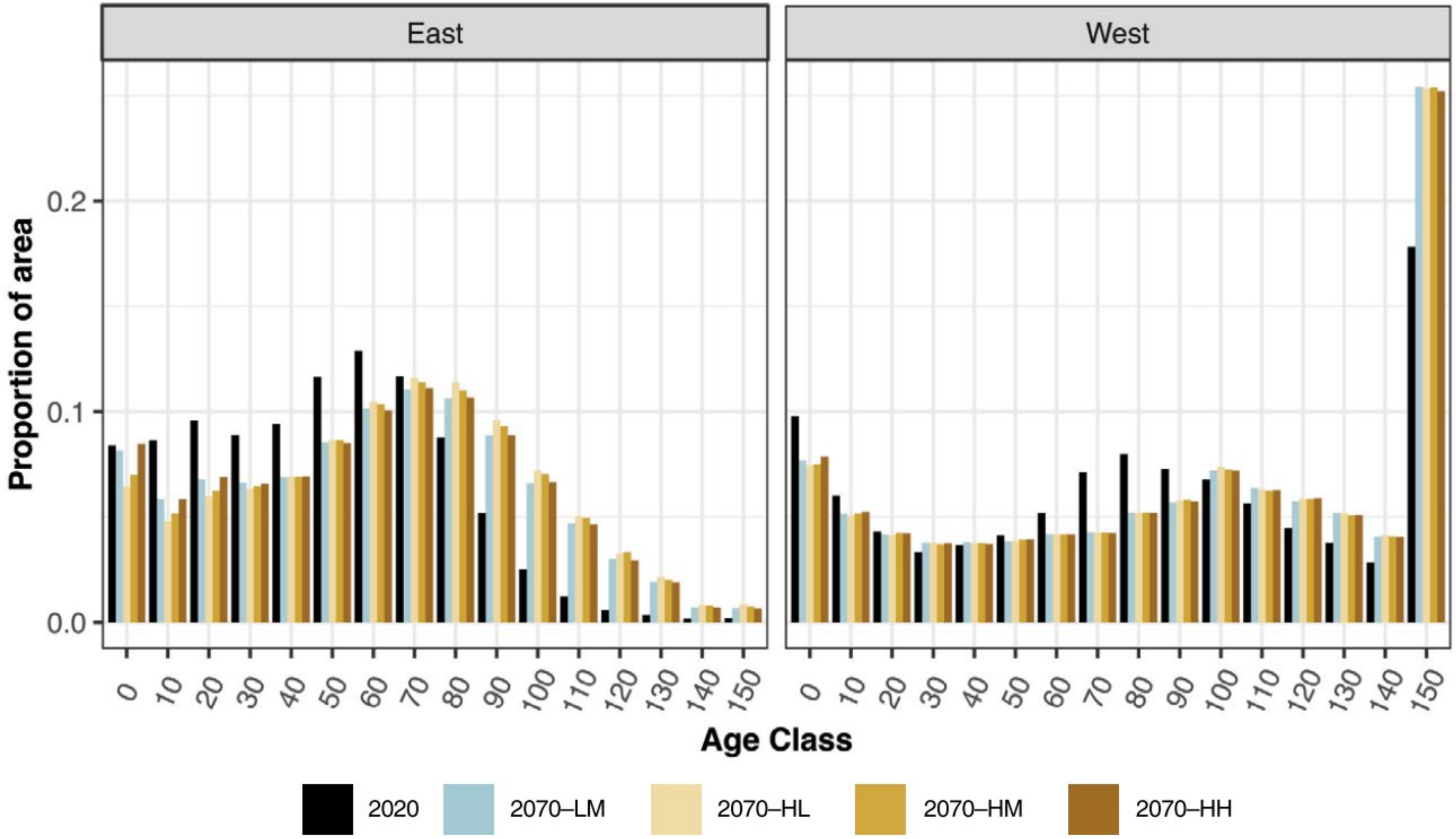
Coulston et al. 2023 *RPA Chapter: Forest Resources*

Live volumes increase in North and South, less so in Rockies and Pacific



Coulston et al. 2023 *RPA Chapter: Forest Resources*

Results from other 2020 RPA chapters: forest ages



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Coulston et al. 2023 *RPA Chapter: Forest Resources*

Recent trends and future projections across the U.S.

- Forest disturbances are projected to increase by 2070
  - \+ Tree volumes burned by wildfire
  - \+ Areas of moderate and high severity fires
  - \+ Forest exposure to drought
  - \+ Forest mortality from diseases
- Disturbances are still projected to affect a relatively small portion of forest area or volume
- Ecological integrity, functioning, and ecosystem services are likely to be affected by increasing disturbance, and those effects may be more local
- Projections of forest dynamics indicate that succession and aging are the dominant signal nationally through 2070
  - Do see some signal in volume trends for Rocky Mountain and Pacific regions
  - Extreme events are relatively rare and their effects are uncertain

Topics today

Wrap up: management implications and future work

Management actions can play a key role in ameliorating effects of disturbance

- Forest thinning alone or in combination with prescribed fire can reduce the effects of disturbances
  - Dry forests in California
  - Pacific Northwest
  - Ponderosa pine forests
- Proactive actions may be critical
- Consistent, broad-scale studies are needed for an actionable framework at regional and national scales

Tree mortality, Sequoia National Forest, 2017

Fettig et. al. 2019 *Forest Ecology and Management*

New disturbances present novel challenges

a

b

c

d

Sea-level rise in North America

Geographic distribution of sea-level driven land conversion in North America. a) Red spruce ghost forest and buried stumps, New Brunswick, Canada, **b)** Atlantic white cedar ghost forest in New Jersey (indicated by dashed line), **c)** Salt damaged agricultural field in Virginia, where white and grey areas indicate bare ground, and yellow-red colors represent stressed crops, **d)** Palm tree ghost forest in Florida.

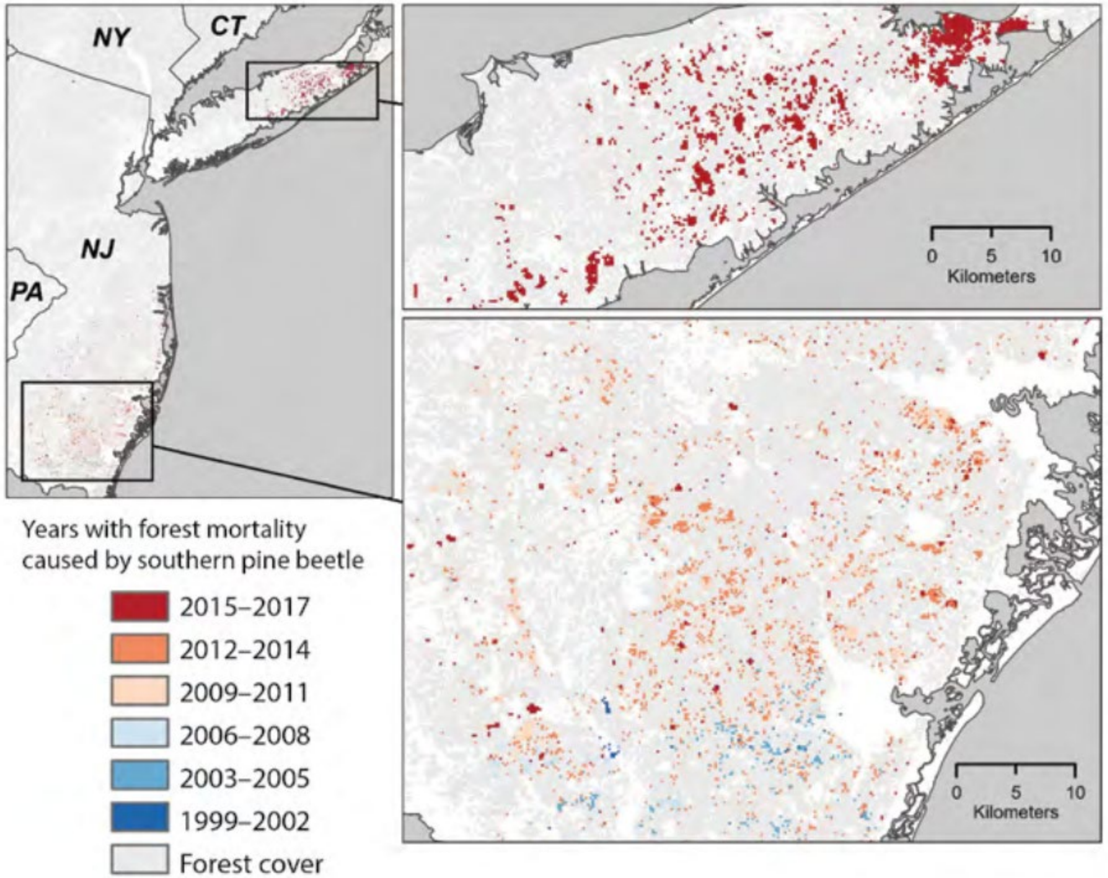
Photo: David Johnson (**a**), Kenneth W. Able (**b**), USDA Farm Service Agency (**c**), and Amy Langston, Virginia Institute of Marine Science (**d**).

Source: Kirwan, M.L., K.B. Gedan. 2019. Sea-level driven land conversion and the formation of ghost forests. Nature Climate Change 9:450–457.

Disturbances in new places present novel challenges

Southern pine beetle: documented migration northward

Figure 5-27. Forest mortality caused by southern pine beetle in New York and New Jersey from 1999 to 2017.

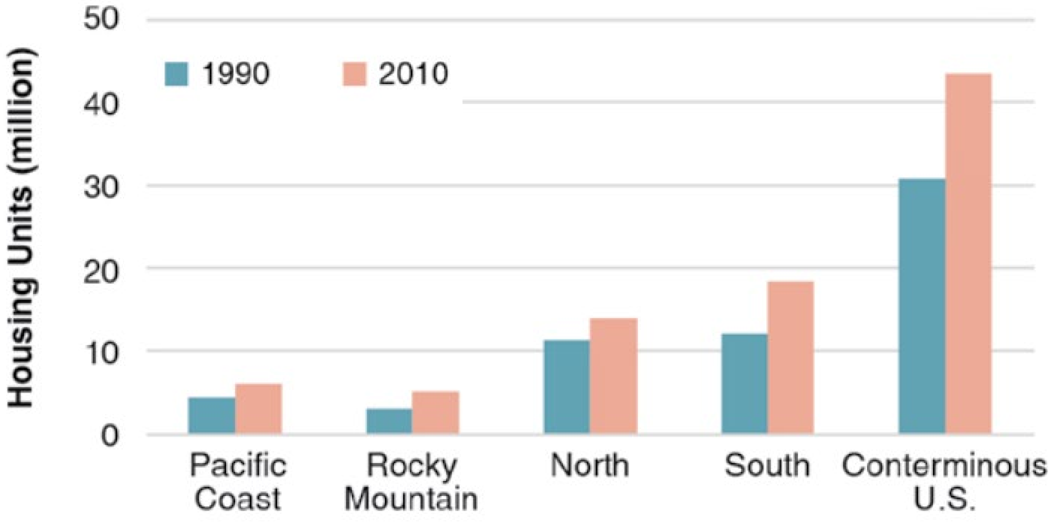


Source: Insect and Disease Survey data (FHP 2019).

F. Koch, *in* Costanza et al. 2023 *RPA Chapter: Disturbance*

People living in or near wildlands present challenges

Housing units in the wildland-urban interface



M. Mockrin, in: Riitters et al. 2023 *RPA Chapter: Land Resources*

- Risks to human life and property
- Challenges, constraints, complexities for management

Final thoughts

- Disturbances are part of the natural dynamics of forests
- Results in the 2020 RPA indicate they have been increasing and further increases are projected by 2070
- Effects of increasing disturbance on ecological integrity and functioning of forests will be critical to understand
- Changing dynamics of disturbances in a context of climate and land-use change mean new challenges for management and conservation
- Future work in the RPA will focus on quantifying important aspects of forest impacts from disturbance at broad scales

Thank you!

Contact me:

jennifer.costanza@usda.gov

2020 RPA Assessment
Supporting data, publications, land management planning data guides, more
https://www.fs.usda.gov/research/inventory/rpaa