



Pattern, Process, and Paradigm Shifts: Lessons from Yellowstone and the Rise of Landscape Ecology

**Monica G. Turner
University of Wisconsin-Madison
IALE-NA Annual Meeting
April 28, 2026**

Acknowledgements

Collaborators

- Rupert Seidl
- Werner Rammer
- Bill Romme
- Cory Cleveland
- Kristin Brazian
- Winslow Hansen
- Tyler Hoecker
- Timon Keller
- Nathan Kiel
- Jillian Neece
- Garrett Knowlton
- Brian Harvey
- ...and many more!

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- Vilas Trust, UW-Madison
- NPS Reserve Funds

Special thanks to

- Yellowstone National Park
- Grand Teton National Park
- Bridger-Teton National Forest
- Custer-Gallatin National Forest



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UNIVERSITY OF WISCONSIN-MADISON



**PRINCE ALBERT II
OF MONACO
FOUNDATION**



**DRAPER
NATURAL HISTORY MUSEUM**

The Andrew W. Mellon Foundation



THE ROLE OF
LANDSCAPE HETEROGENEITY
IN THE SPREAD OF
DISTURBANCE

Symposium

University of Georgia
Athens, Georgia
January 15-17, 1986

Sponsors

UGA Institute of Ecology
UGA School of Environmental Design
International Association of Ecology (INTECOL)
State Botanical Garden of Georgia, UGA

Conveners

Monica G. Turner
Frank B. Golley



THE ROLE OF
LANDSCAPE HETEROGENEITY
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DISTURBANCE

Was it really 40 years ago?

January 15-17, 1986

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Path for this morning

1980s



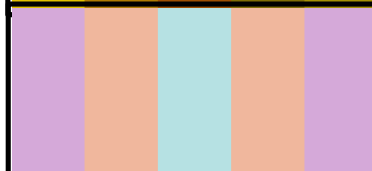
1990s



2000s



2010s



2020s



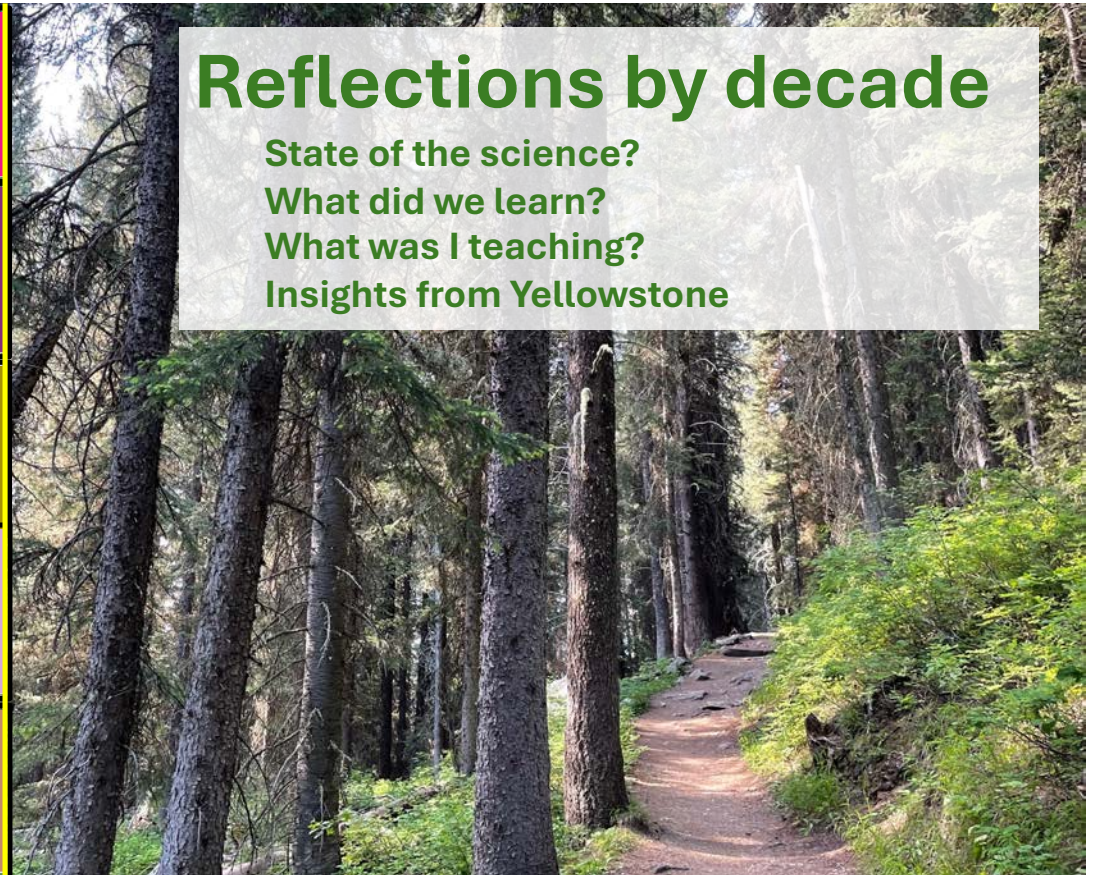
Reflections by decade

State of the science?

What did we learn?

What was I teaching?

Insights from Yellowstone

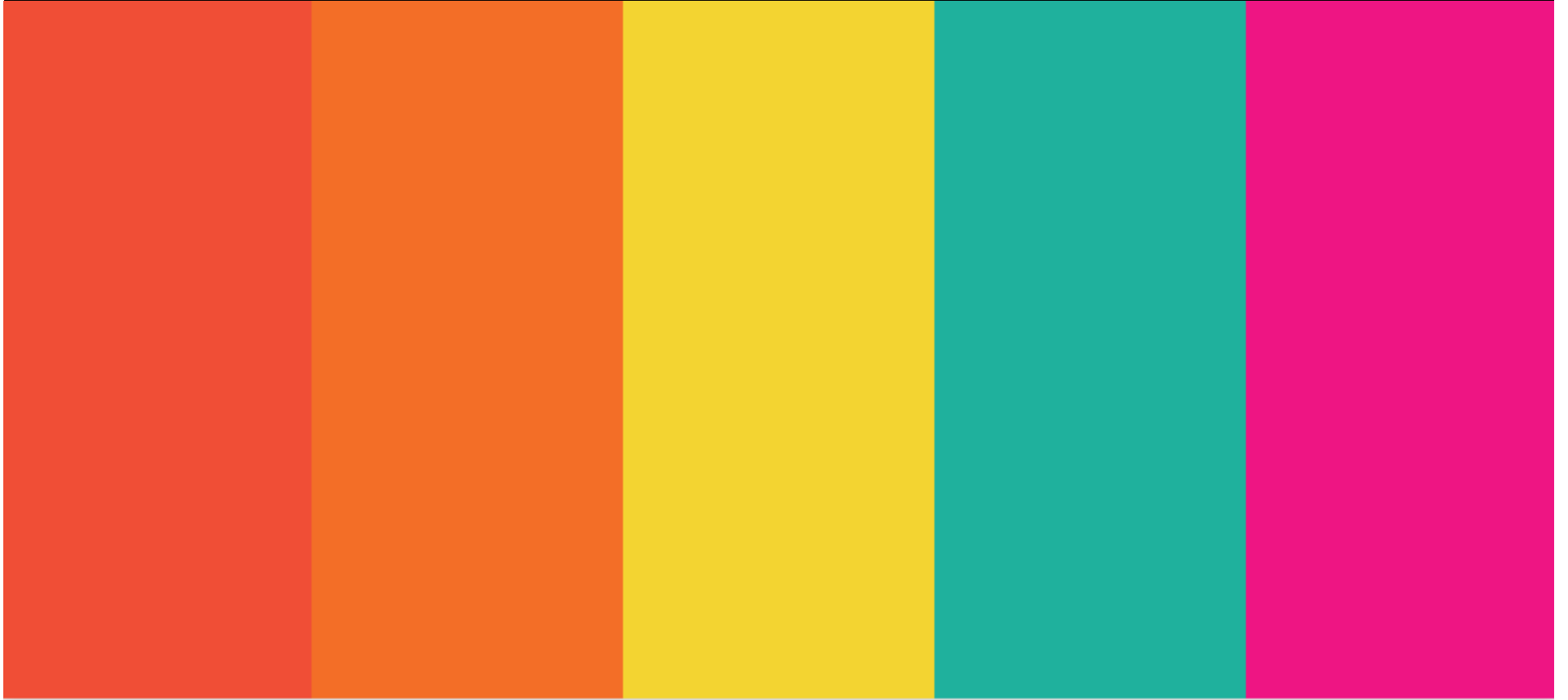


Timeline of landscape ecology

(Illustrative, not comprehensive)



1980s



Ecology in the 1980s

What was it like?

- Limited computational power
 - Macs & PCs were new
- No spatial analysis code
 - We programmed in FORTRAN
- No GIS, no GPS
 - Few spatial data, no “online”
- The literature was at the library!

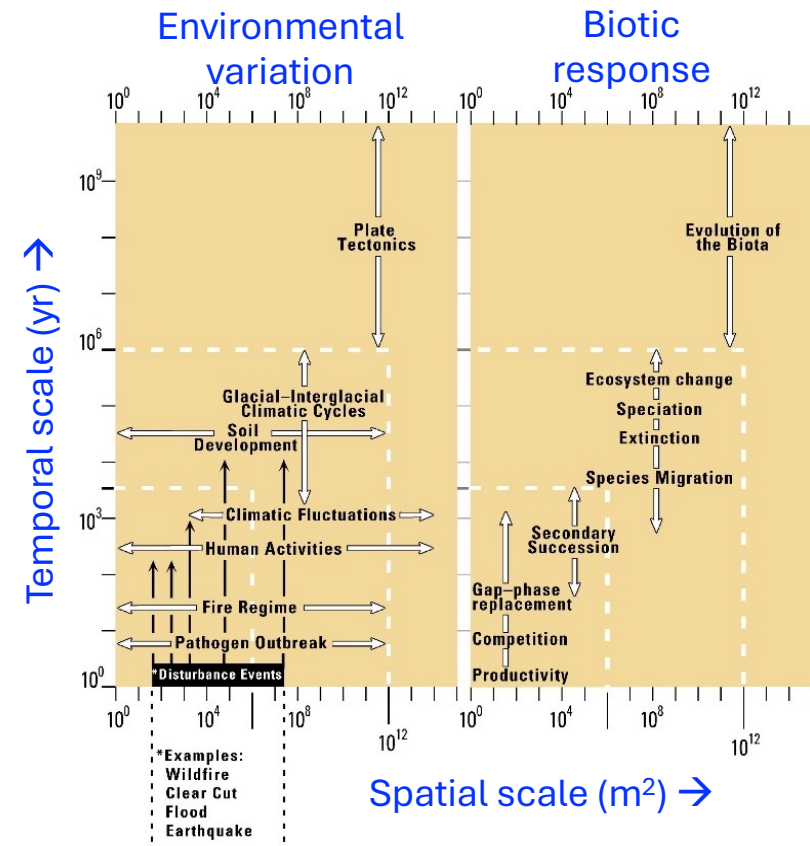


Why landscape ecology?

- Demand for **landscape** science
 - Land-use change
 - Invasive species
 - Non-point pollution
 - Migratory species
 - Habitat loss and fragmentation

Why landscape ecology?

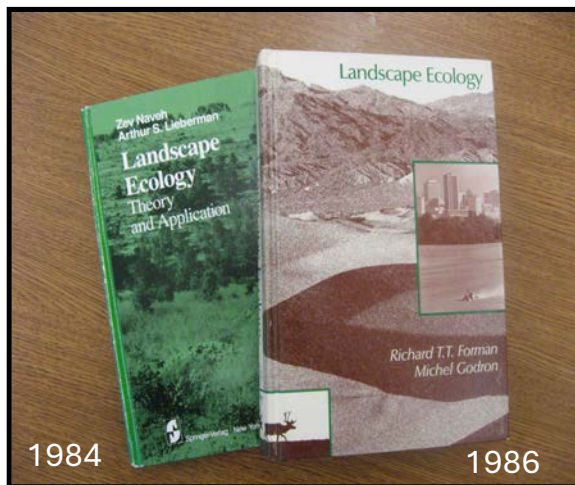
- Demand for landscape science
 - Land-use change
 - Invasive species
 - Non-point pollution
 - Migratory species
 - Habitat loss and fragmentation
- New conceptual frameworks focused on scale



(From classic space-time figure, Delcourt et al. 1983)

Landscape ecology in the 1980s

- Ideas were just emerging in the US
- Lexicon developing, but few publications
- Many ecologists were (very) skeptical
 - Often called a “pseudoscience”



Patches and Structural Components For A Landscape Ecology

Richard T. T. Forman and Michel Godron

November 1981

BioScience Vol. 31 No. 10

Allerton Park Workshop (1983)

LANDSCAPE ECOLOGY Directions and Approaches

Paul G. Risser
Illinois Natural History Survey

James R. Karr
University of Illinois

Richard T. T. Forman
Rutgers University

1984



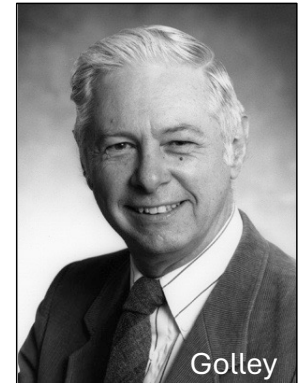
Exciting ideas, lots of discussion



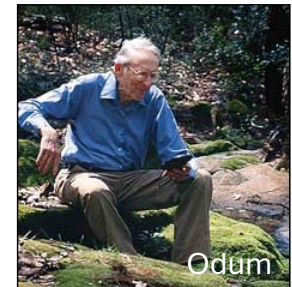


Forward thinkers

- **Frank Golley** (my PhD advisor) sharing ideas from landscape ecology meetings in Europe
 - **Eugene Odum** (my postdoc advisor) continued to “think big”
 - *“Society needs, and must find as quickly as possible, a way to deal with the landscape as a whole...”*
- Odum 1969, The strategy of ecosystem development, SCIENCE*
- **Ron Pulliam** (source-sink dynamics) focused on population dynamics in heterogeneous landscapes



Golley



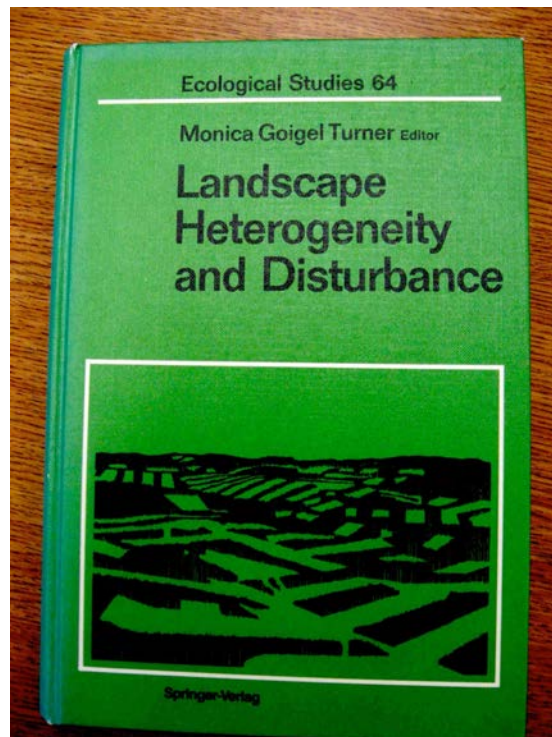
Odum



Pulliam

The 1st US Landscape Ecology Symposium

A key question from the Allerton Park workshop (Risser et al. 1983)



First presented at the meeting:

Landscape Ecology vol. 1 no. 1 pp 5-18 (1987)
SPB Academic Publishing, The Hague

Creating landscape patterns by forest cutting: Ecological consequences and principles

Jerry F. Franklin* and Richard T.T. Forman**

*USDA Forest Service, Pacific Northwest Research Station, 3200 Jefferson Way, Corvallis, OR 97331, USA, and University of Washington, College of Forest Resources, Seattle, WA 98195, USA

**Harvard University, Graduate School of Design, Cambridge, MA 02138, USA

Still recommended reading:

Scale effects in landscape studies

(Meentemeyer and Box 1987, Chapter 2 in the book)

Networking and collaborations

- The most enduring legacy!
 - Sparked many collaborations and friendships
- Formation of



Bob Gardner



Bob O'Neill



Virginia Dale



Bill Romme



Joan Nassauer



Dean Urban

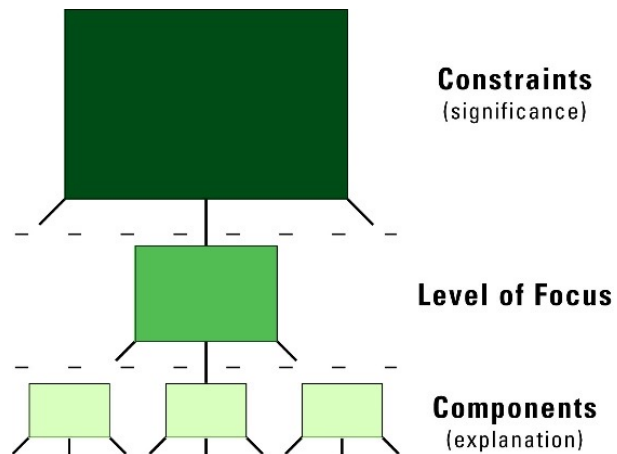


Steve Seagle

Effect of pattern on process

Hierarchical structure

(Urban et al. 1987 BioScience)

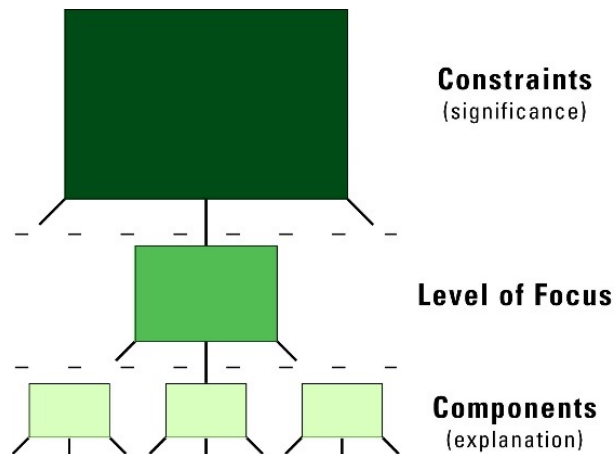


Dean Urban

Effect of pattern on process

Hierarchical structure

(Urban et al. 1987 BioScience)



More questions than answers!

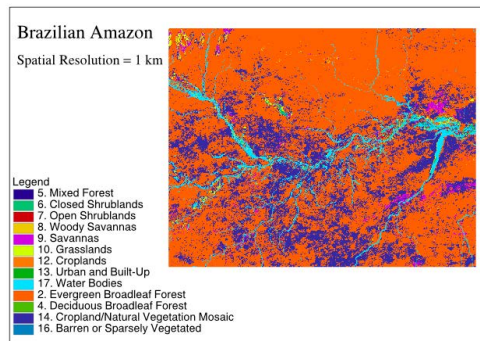
(Turner 1989, ARES)

- Significant change in LS structure?
- What pattern measures relate best to ecological processes?
- Scales of underlying processes?
- Early warning signals for landscape change?

Quantifying spatial pattern (a major focus)

- Landscape metrics

Landscape metrics
(O'Neill et al. 1988)



(* all published in *Landscape Ecology*)

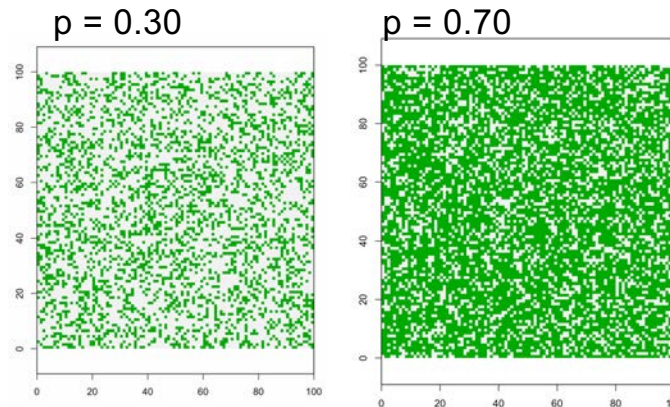
Quantifying spatial pattern (a major focus)

- Landscape metrics
- **Neutral landscape models (NLMs)**

Landscape metrics
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NLMs
(Gardner et al. 1987)



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Quantifying spatial pattern (a major focus)

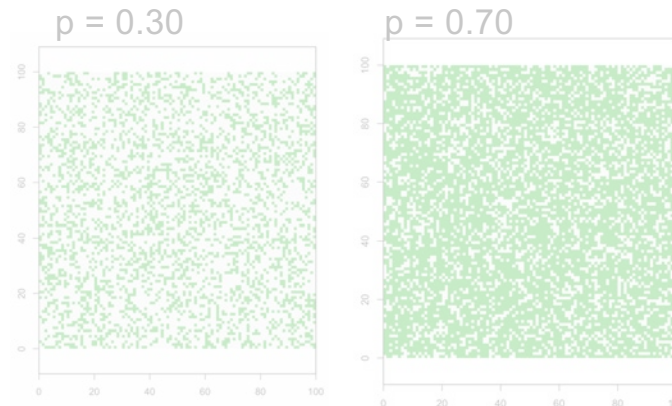
- Landscape metrics
- Neutral landscape models (NLMs)
- **Effects of scale on pattern analysis**

Landscape metrics
(O'Neill et al. 1988)

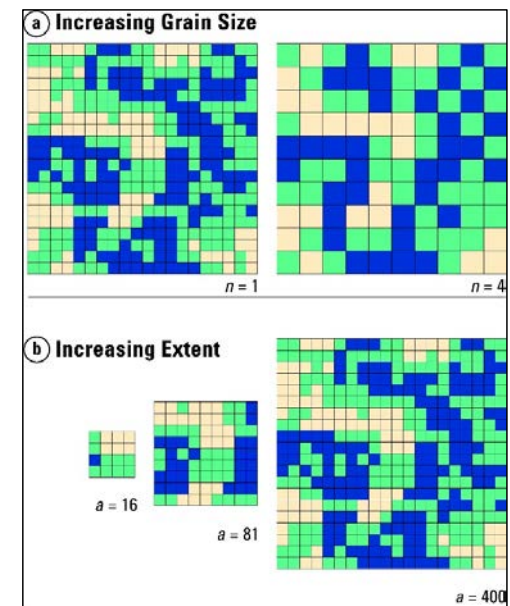


NLMs

(Gardner et al. 1987)



Grain, extent
(Turner et al. 1989)



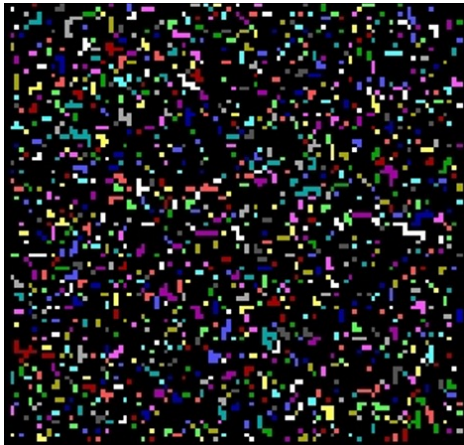
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Connectivity and critical thresholds

Central concept from NLMs *(Gardner et al. 1987)*

- Connectivity changes nonlinearly as habitat proportion, p , rises

$p = 0.20$



$p = 0.40$

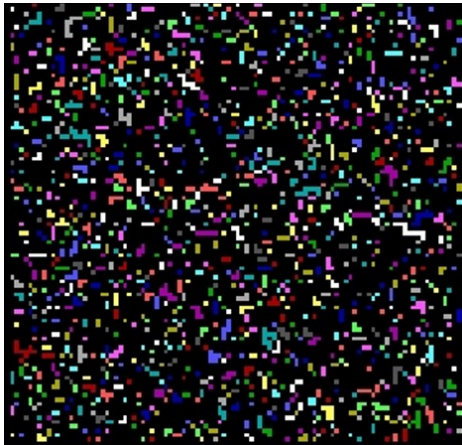


Connectivity and critical thresholds

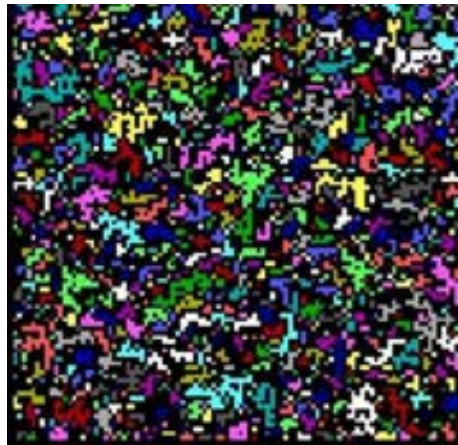
Central concept from NLMs *(Gardner et al. 1987)*

- Connectivity changes nonlinearly as habitat proportion, p , rises
- Above the critical threshold, p_c , a single patch spans the map

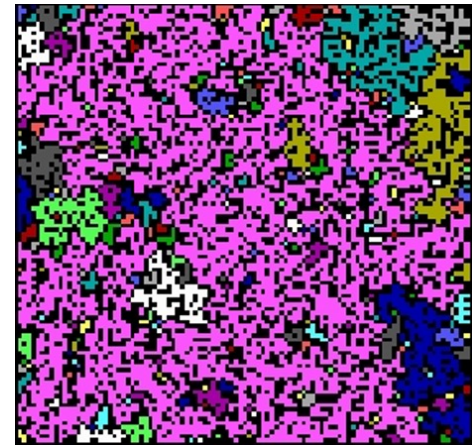
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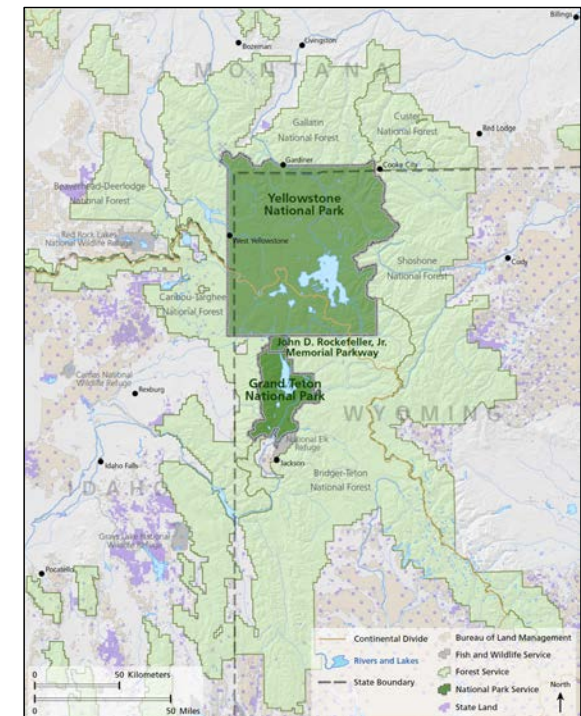
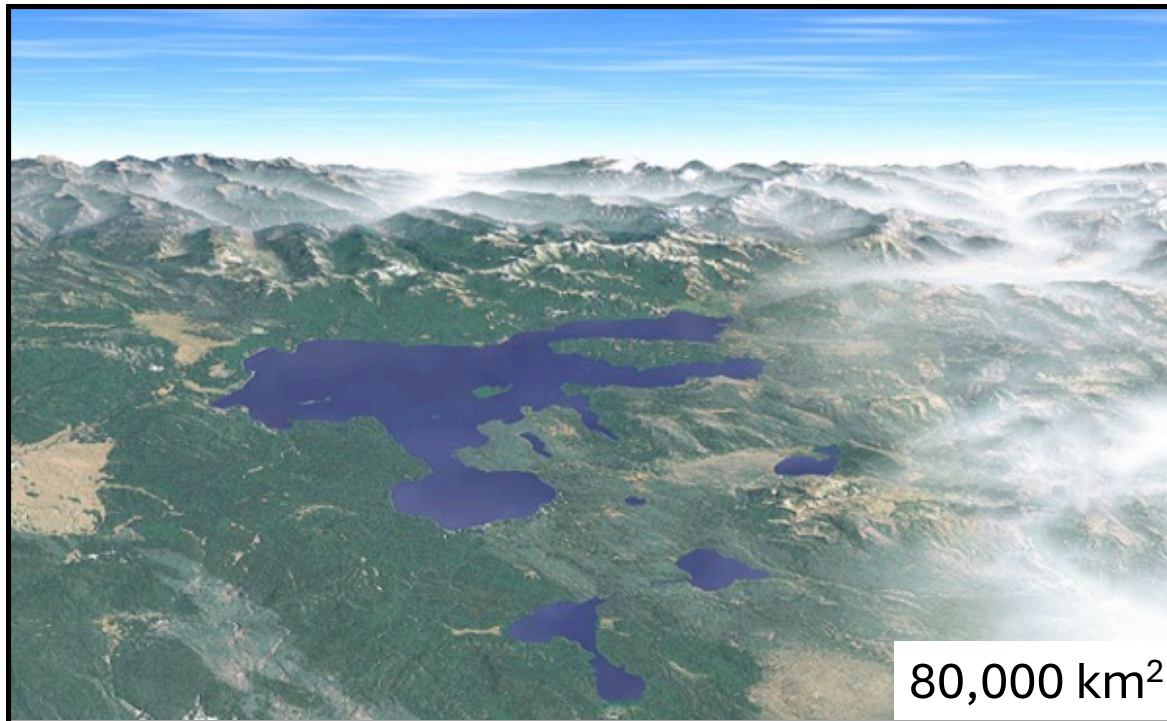
$p = 0.60$





Greater Yellowstone Ecosystem (GYE)

- One of the largest intact temperate landscapes in the world



<https://www.nps.gov/yell/learn/nature/greater-yellowstone-ecosystem.htm>

Forests form the backbone of the landscape







Why Yellowstone?

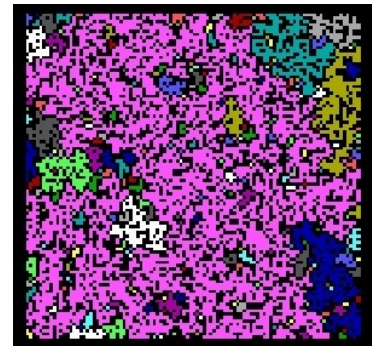
Bulletin of the Torrey Botanical Club 115(3), 1988, pp. 196–202

Multiple disturbances in a *Spartina alterniflora* salt marsh: Are they additive?¹

Monica Goigel Turner²

Environmental Sciences Division, Oak Ridge National Laboratory,
Oak Ridge, TN 37831-6038

- Keen interest in LS heterogeneity & disturbance
 - 1986 symposium theme
 - PhD research (disturbance interactions in salt marsh)
 - How to test NLMs of disturbance spread?



(Turner et al. 1989, *Oikos*)

Why Yellowstone?

Bulletin of the Torrey Botanical Club 115(3), 1988, pp. 196–202

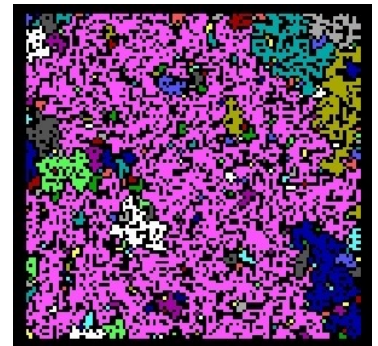
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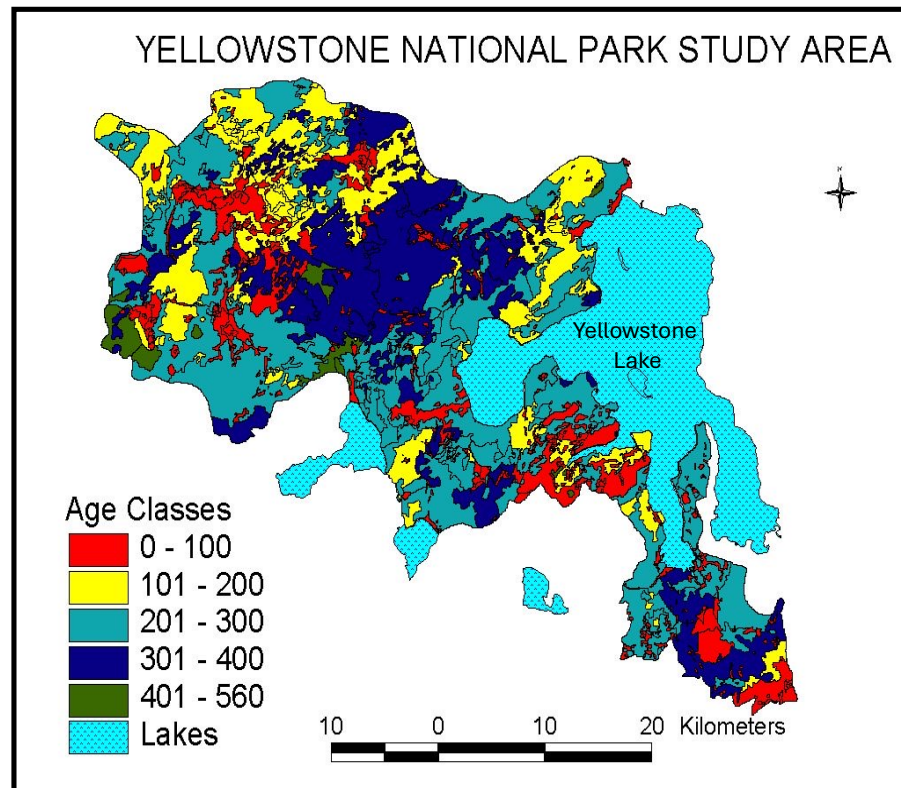
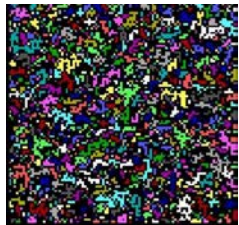
- **Personal connections – people and place**

- Summer as ranger/naturalist at Old Faithful, Yellowstone (age 19)
- Met Bill Romme at 1986 symposium, planned to collaborate



MGT, Old Faithful, age 19

Among first maps of disturbance (fire): opportunity to test theoretical models



Romme 1982 Ecol. Monogr.; Romme and Despain 1989 BioScience

Bill Romme

A surprise in summer 1988

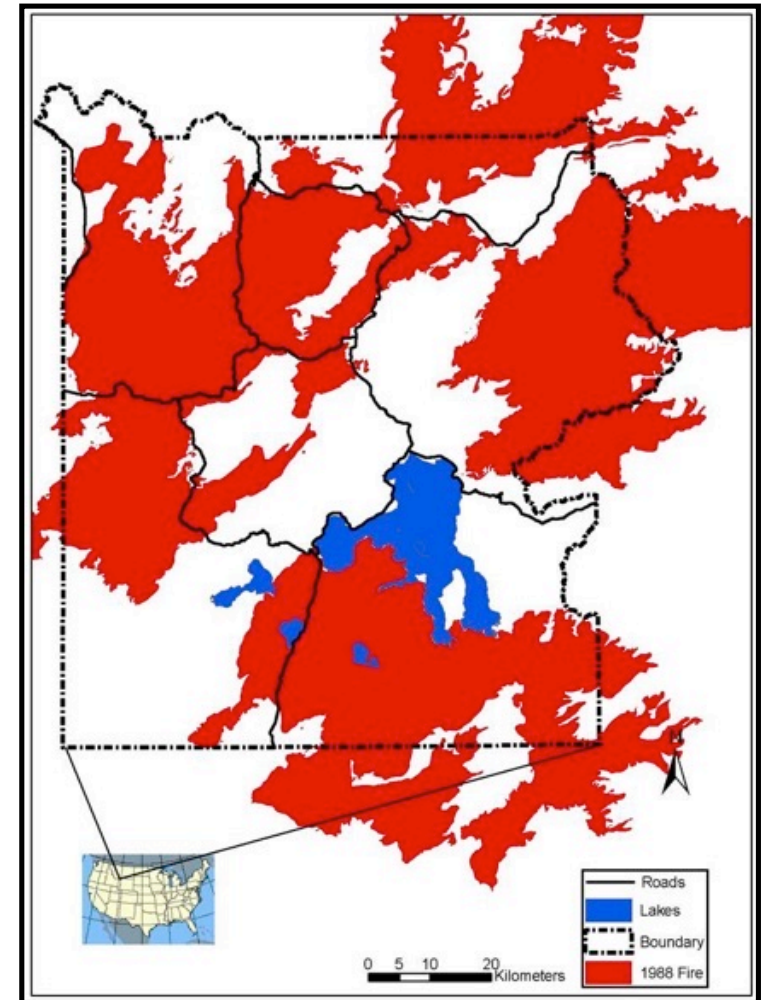


Size & severity were a shock

- Exceptionally dry & windy conditions
 - **NOT** caused by historical fire suppression
- Burned forests of all ages & structures



M. G. Turner, Oct 1988



A landscape shaped by fire

- Infrequent, stand-replacing fires are the norm
 - 100 to 300-yr fire return interval (FRI) over past 10,000 yrs
(Romme and Despain 1989; Whitlock et al. 2003, 2008)
- Driven by climate (not limited by fuels or ignitions)



NPS photo by Jim Peaco



Bozeman Daily Chronicle file photo



The fire pattern looked a lot like NLMs



*NLMs of disturbance
(Turner et al. 1989
Oikos)*



Oct 1988

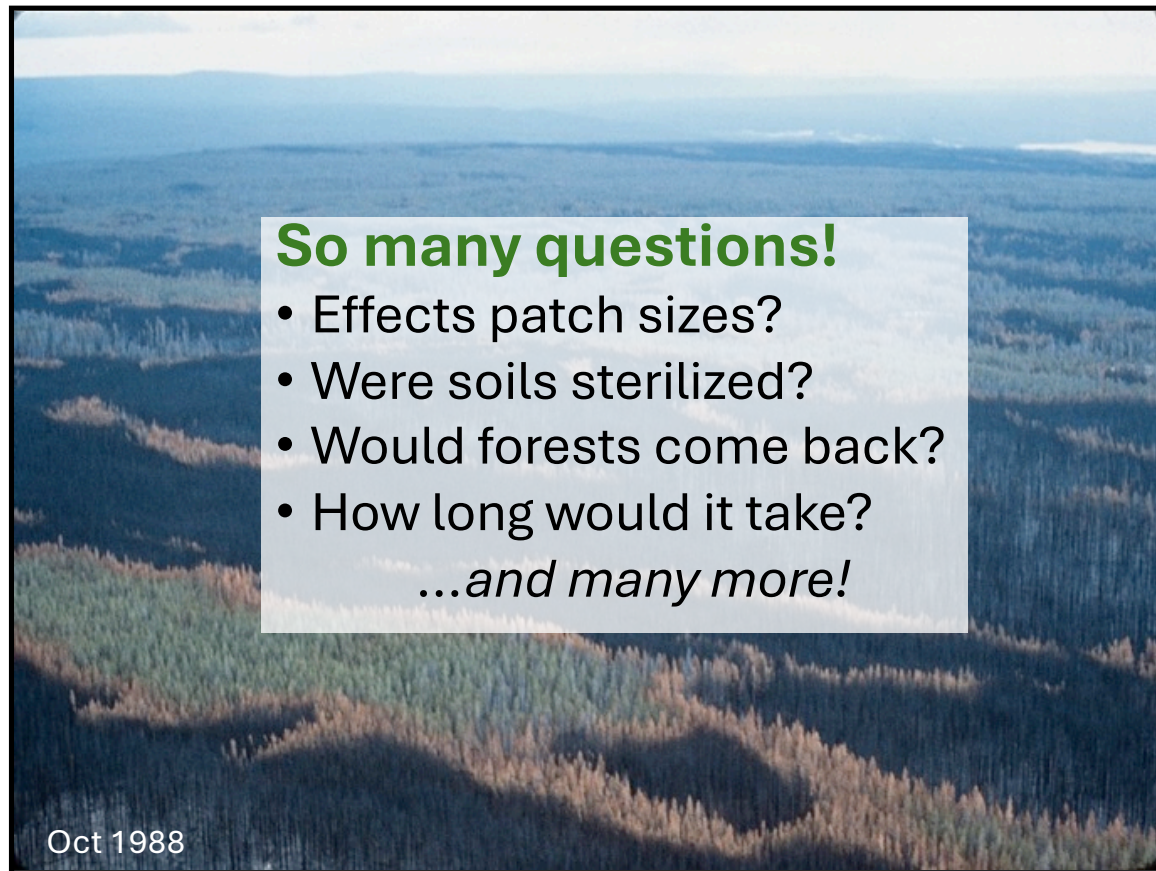
*This was new!
No imagery at our
desktops, no RS
data...we had to fly.*

The 1988 fires increased landscape heterogeneity



(Turner et al. 1994 JVS)

The fires created a *natural experiment*, at scale!

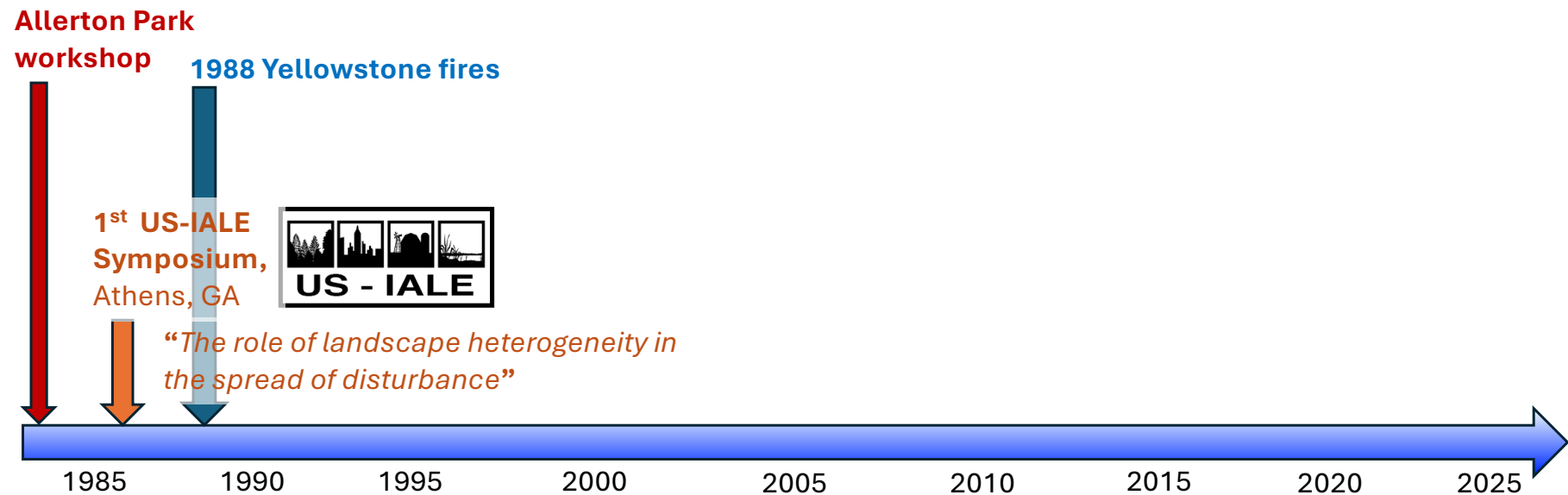


(Turner et al. 1997,
Ecol Monogr)

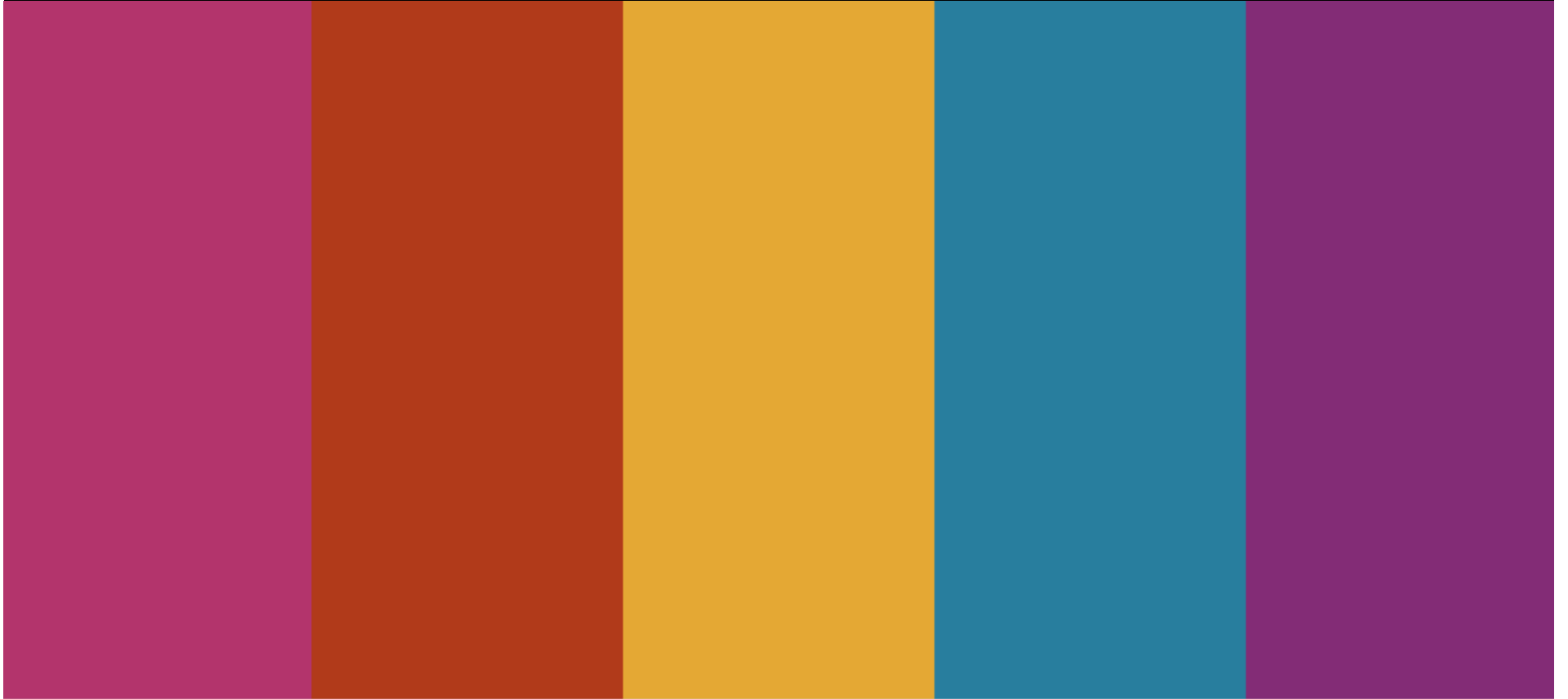


Field studies begin, July 1989

Timeline of landscape ecology



1990s



Ecology in the 1990s

What was it like?

- Slide projectors
- Literature still at the library
 - Web of Science launched ('97)
- Still using compasses & topo maps
- LS studies accelerate with new tech
 - GRASS GIS
 - Laptops (\$\$\$)
 - GPS (scrambled and \$\$\$)
 - **FRAGSTATS** ('95)
 - Still the best documentation for LS metrics



FragStats



Kevin McGarigal



Sam Cushman

Landscape ecology takes off!

- Field studies in real landscapes
 - Organisms
 - Disturbance dynamics
 - Land-water interactions
- Experiments in micro-landscapes
- Ease of spatial analysis

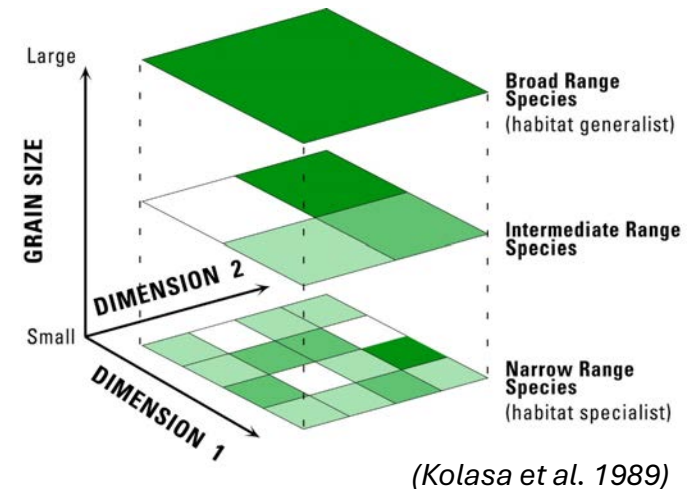


*(Experimental landscapes based on NLMs;
With et al. 1999)*

What did we learn?

Organisms (from a vast literature!)

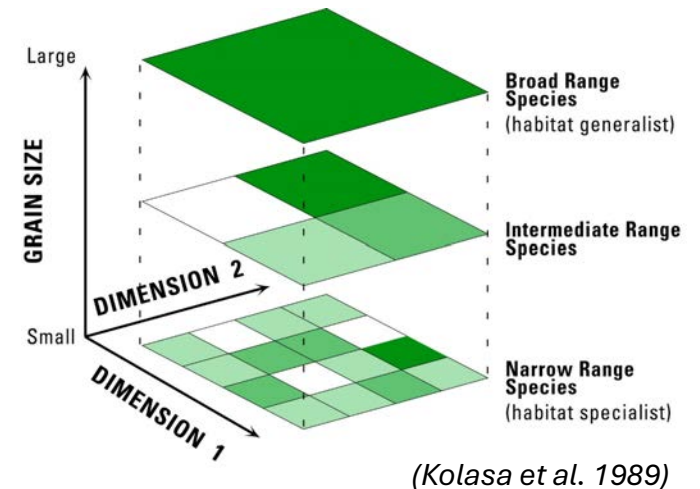
- Species' habitat use is scale-dependent (*Wiens 1989, Kotliar & Wiens 1990*)
- Larger, more heterogeneous patches support more species (*McGarigal and McComb 1995*)



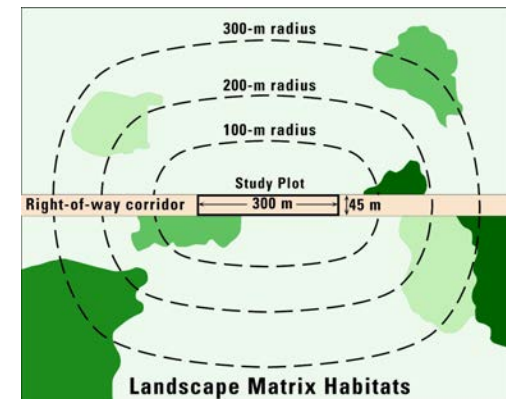
What did we learn?

Organisms (from a vast literature!)

- Species' habitat use is scale-dependent (*Wiens 1989, Kotliar & Wiens 1990*)
- Larger, more heterogeneous patches support more species (*McGarigal and McComb 1995*)
- Landscape context can strongly influence local populations (*Pearson 1993*)



Scott Pearson



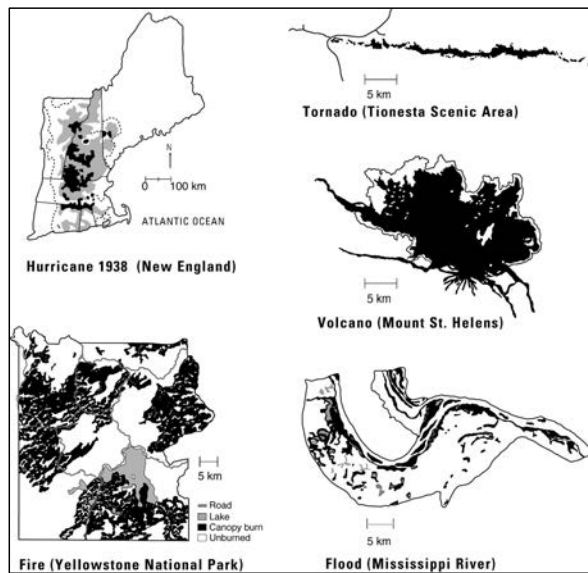
(Pearson 1993)

What did we learn?

Disturbance dynamics

Even very large severe disturbances
create spatial heterogeneity

(Foster et al. 1998 *Ecosystems*)

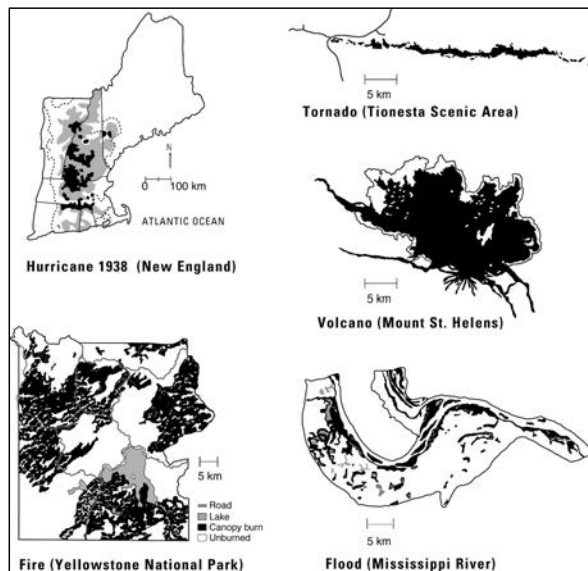


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Disturbance dynamics

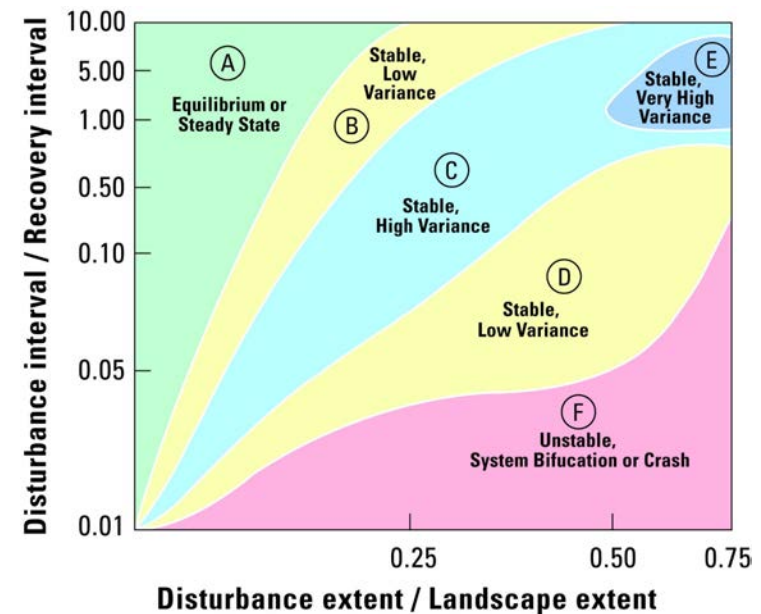
Even very large severe disturbances
create spatial heterogeneity

(Foster et al. 1998 *Ecosystems*)



Many landscape dynamics;
steady-state mosaic is but one

(Turner et al. 1993 *Landscape Ecology*)

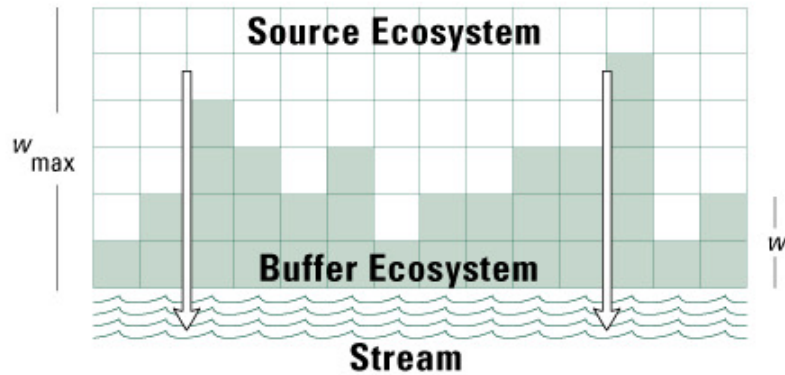


What did we learn?

Land-water interactions

Composition **and** configuration of LULC affect movement of nutrients (N, P) from land to surface waters

(Weller *et al.* 1998)

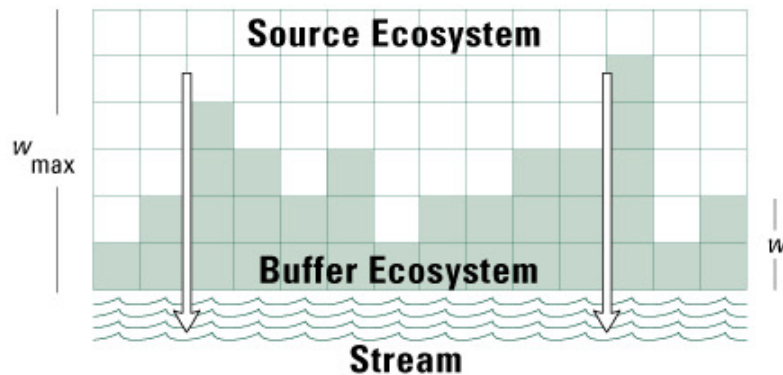


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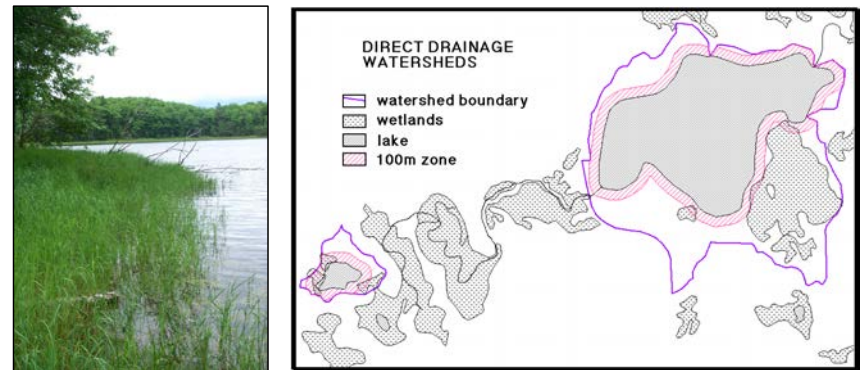
(Weller et al. 1998)



Nutrient movements are scale dependent; context matters

(e.g., DOC from wetlands to lakes/rivers)

(Gergel et al. 1999, *Ecological Applications*)



What did we learn?

Landscape disturbance studies led to a paradigm shift in ecology



Equilibrium	Non-equilibrium
Self-regulating	Regulated by intrinsic and extrinsic factors
Has stable end point or cycle	Lacks stable point or cycle
Lacks disturbance	Incorporates disturbance

(Pickett et al. 1994; Wu and Levin 1994)

Teaching the basics (1990s): What is LE?



Foundations and roots:

- Definitions
- Scale
- Data sources
- Spatial models
- NLMs

Metrics & spatial stats:

- Definitions
- Calculations
- Interpretations

LS heterogeneity and...

- Disturbances
- Organisms
- Ecosystem processes
- Ecosystem management

Many papers now considered classics!

- Forman and Godron (1981)
- Urban et al. (1987)
- Turner (1989)
- Levin (1992)
- Pickett and Cadenasso (1995)
- Franklin and Forman (1987)

- Dunning et al. (1992)
- Peterjohn and Correll (1984)
- Wu and Levin (1994)
- Running et al. (1989)
- With and King (1997)
- Baker (1989)
- Wiens et al. (1993)
- Soranno et al. (1996)
- Holling and Meffe (1993)

****Link to compiled readings (1994-2024) provided at the end***

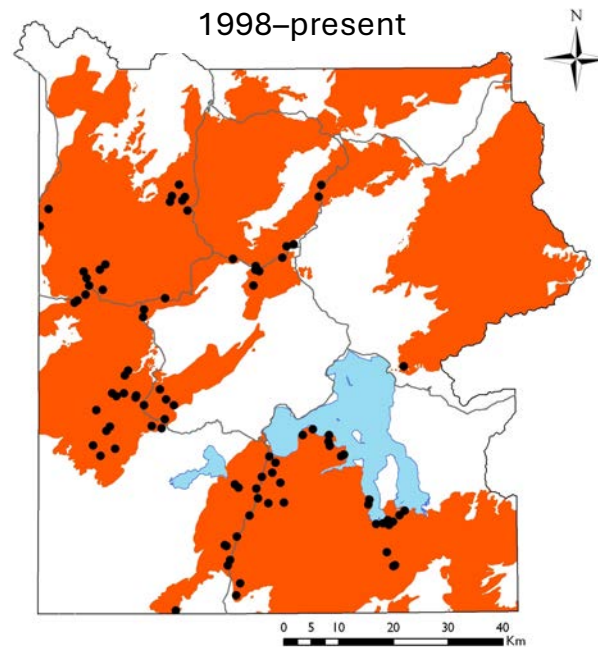
Back in Yellowstone...

- Effects of patch size on forest recovery?



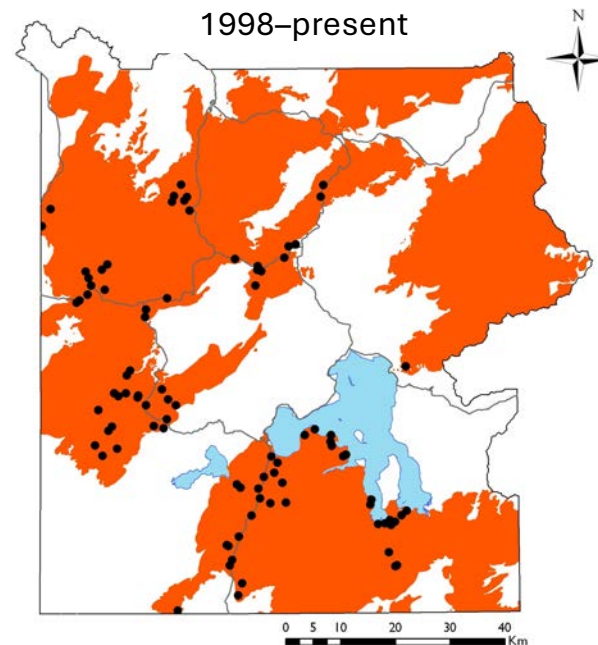
Back in Yellowstone...

- Effects of patch size on forest recovery?
- Recovery patterns across the landscape?

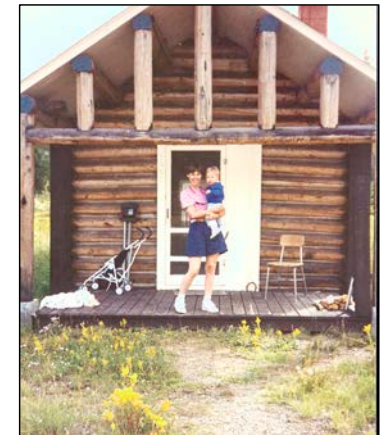


Back in Yellowstone...

- Effects of patch size on forest recovery?
- Recovery patterns across the landscape?



Fieldwork was always
a family affair



What did we learn?

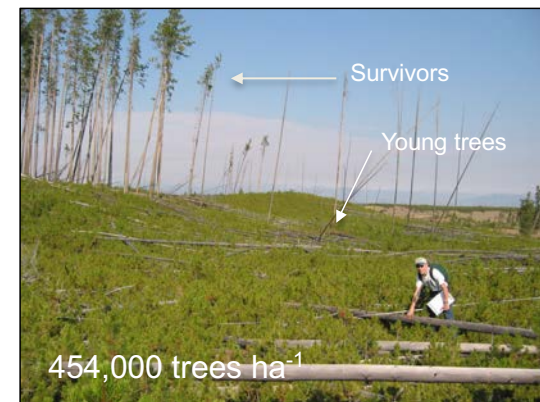
Rapid recovery (even in large patches)



(Turner et al. 1997, 1999, 2003, 2004)

Enormous variation in lodgepole pine regeneration across the landscape

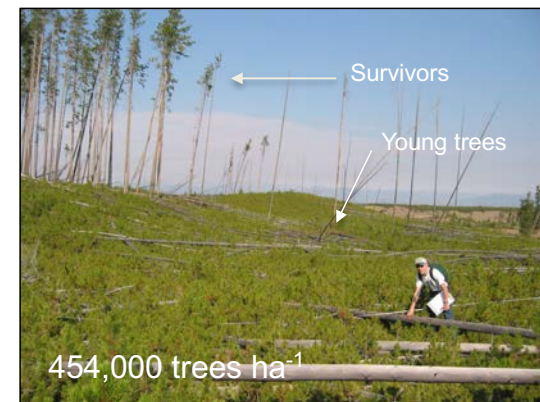
Photos 15 years postfire



*(Turner et al. 1997, Ecol Monogr;
Schoennagel et al. 2003, Ecology;
Turner et al. 2004 Ecosystems)*

Enormous variation in lodgepole pine regeneration across the landscape

Photos 15 years postfire



Why? Interacting spatial drivers (prefire serotiny and burn severity)

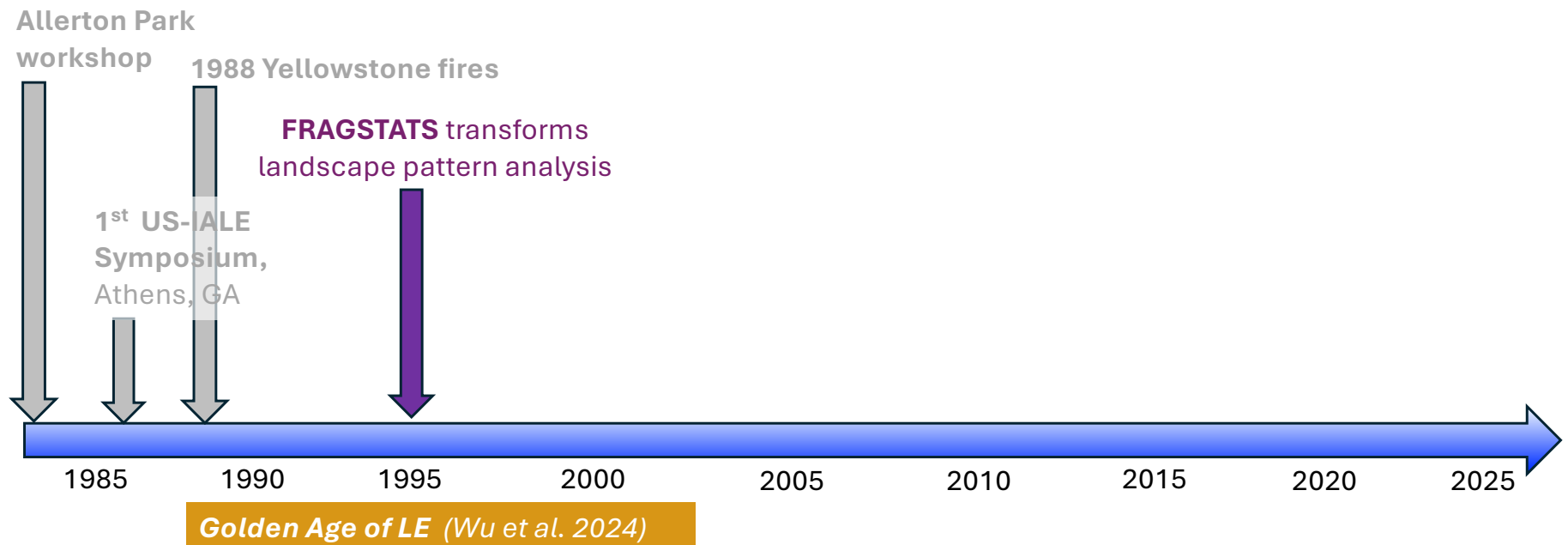


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Schoennagel et al. 2003, Ecology;
Turner et al. 2004)*

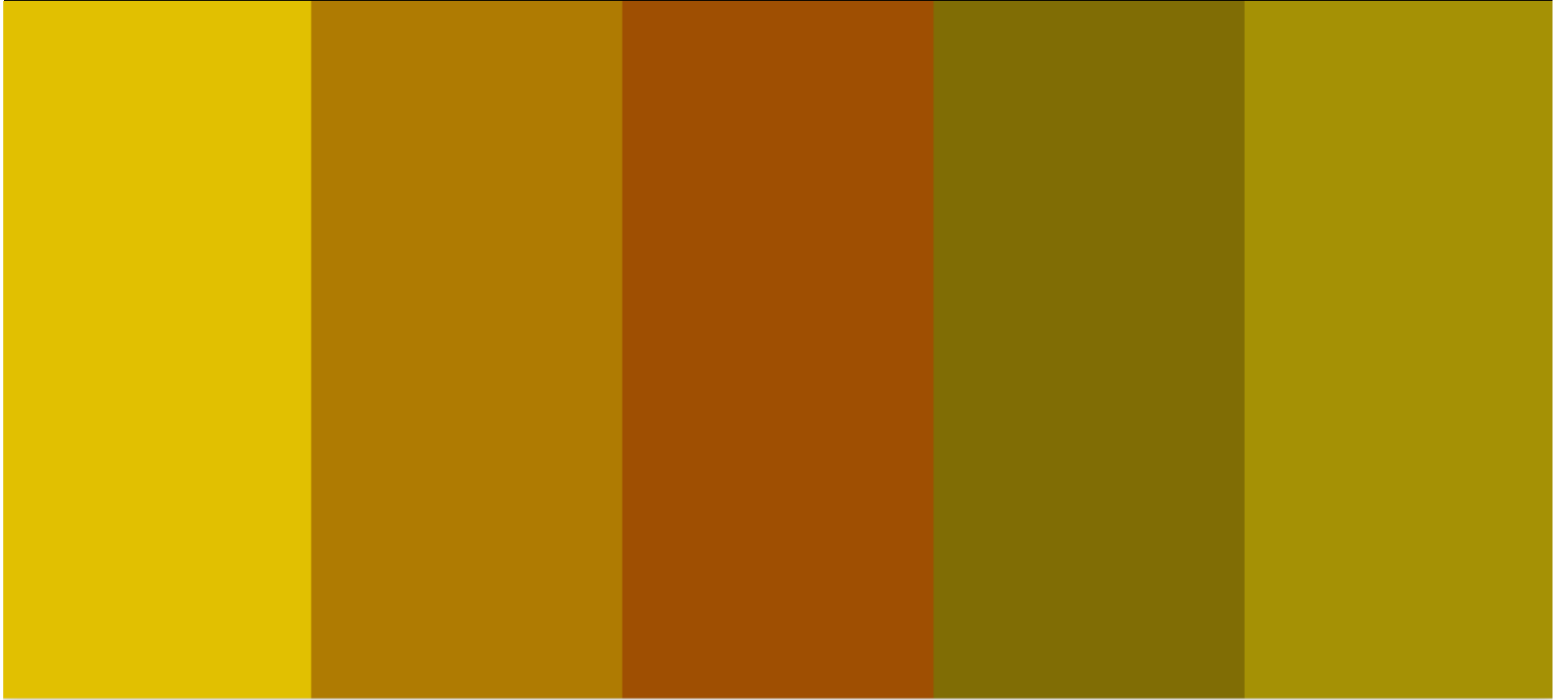
Timeline of landscape ecology

1990s

IALE meetings are THE place
for landscape ecology



2000s



Ecology in the 2000s

What was it like?

- SAS still rules statistical analyses
 - **But...R** version 1.0.0 is released ('00)
- Technology transforms science (and life)
 - Digital cameras (\$\$\$)
 - GPS radio-telemetry collars (\$\$\$)
 - Google Earth released ('05)
 - iPhone debuts ('07)
 - Landsat data available for free ('08)

CD signed by original R Core Team
Univ. Auckland, New Zealand



Landscape ecology in the 2000s

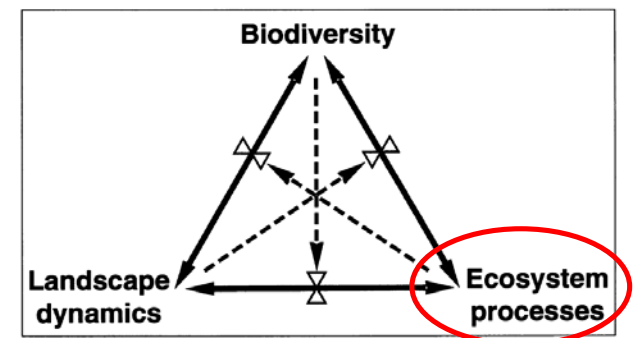
Emerging topics

- Habitat fragmentation
- Ecosystem processes as a frontier

“Spatial heterogeneity within and among ecosystems is critical to the functioning of individual ecosystems and entire regions”

(Chapin et al. 2002)

- Landscape genetics
 - Landscape features → microevolutionary processes, such as gene flow, genetic drift and selection *(Manel et al. 2003)*



(Turner et al. 1995, BioScience)

Central themes begin to coalesce (Wiens 2002)

- Patches differ in quality
- Boundaries affect flows
- LS context matters
- Connectivity is critical
- Scale matters
- View LS from organism perspective

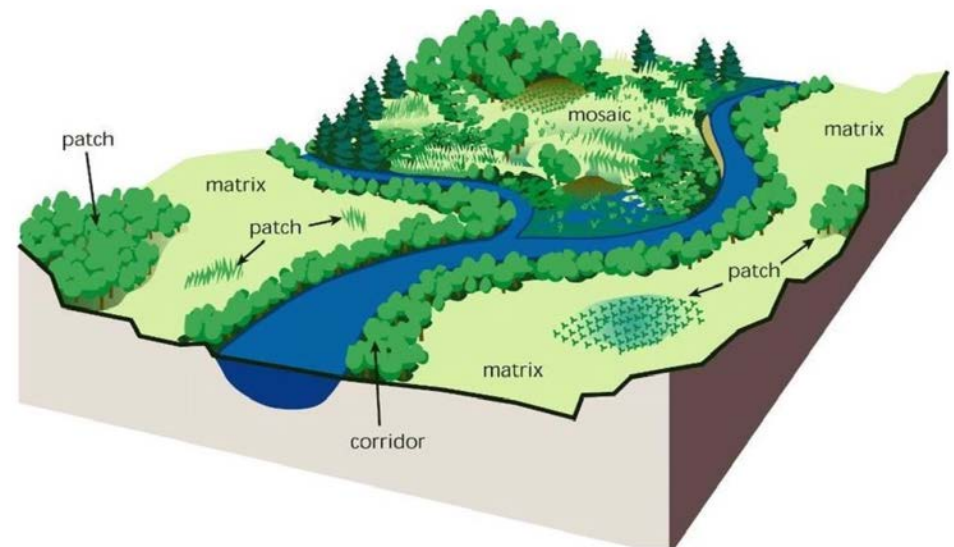
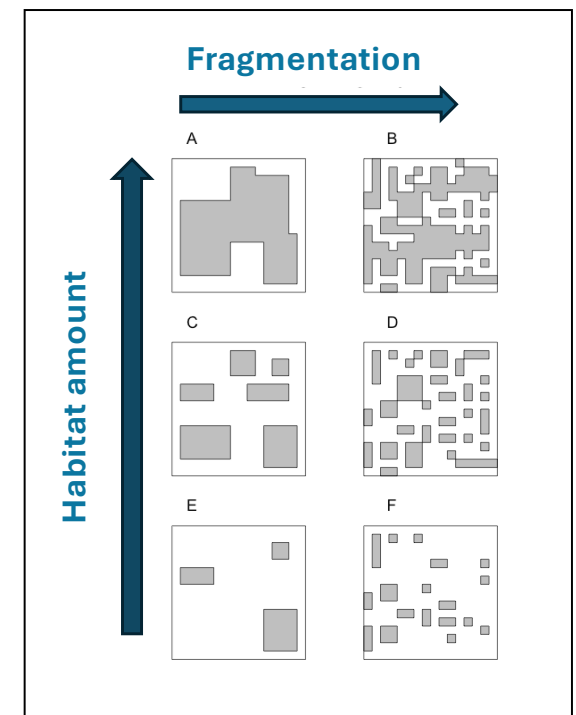


Image: <https://iale.uk/landscape-learning-theory-concepts>

What did we learn?

Habitat fragmentation

- Effects of composition and configuration must be distinguished from each other but considered together

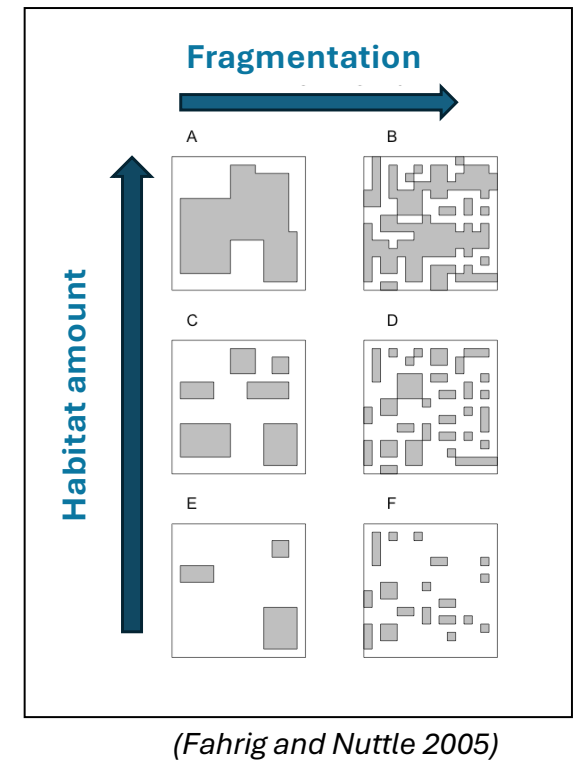
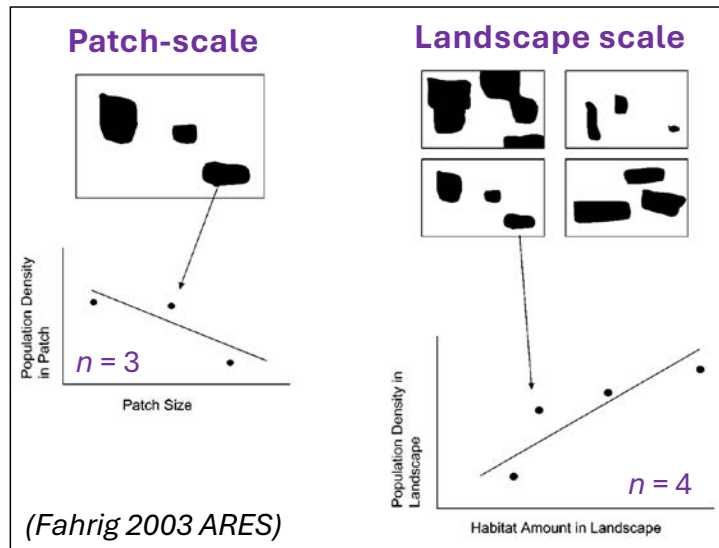


(Fahrig and Nuttle 2005)

What did we learn?

Habitat fragmentation

- Effects of composition and configuration must be distinguished from each other but considered together
- Patch-scale studies $\neq$ landscape-scale studies

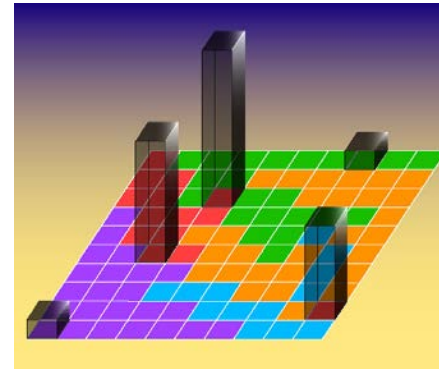


What did we learn?

Ecosystem processes – conceptual framing

Point processes

- Rates measured at a location
 - NPP, C flux, N mineralization



Terry Chapin

(Turner and Chapin 2005 in Lovett et al., eds. Ecosystem function in heterogeneous landscapes.)

What did we learn?

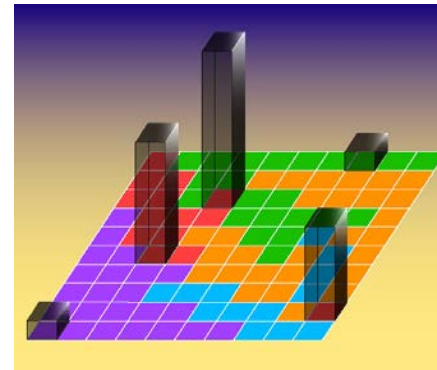
Ecosystem processes – conceptual framing

Point processes

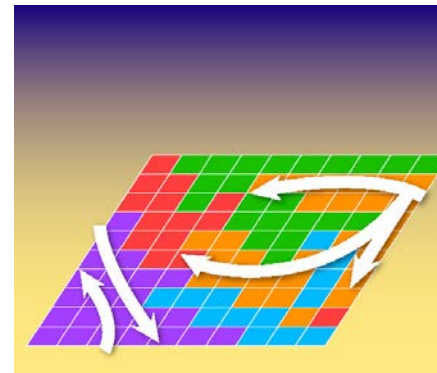
- Rates measured at a location
 - NPP, C flux, N mineralization

Lateral transfers

- Flow of materials from one location to another
 - N or P from land to water
 - Movement of nutrients by herbivores



Terry Chapin



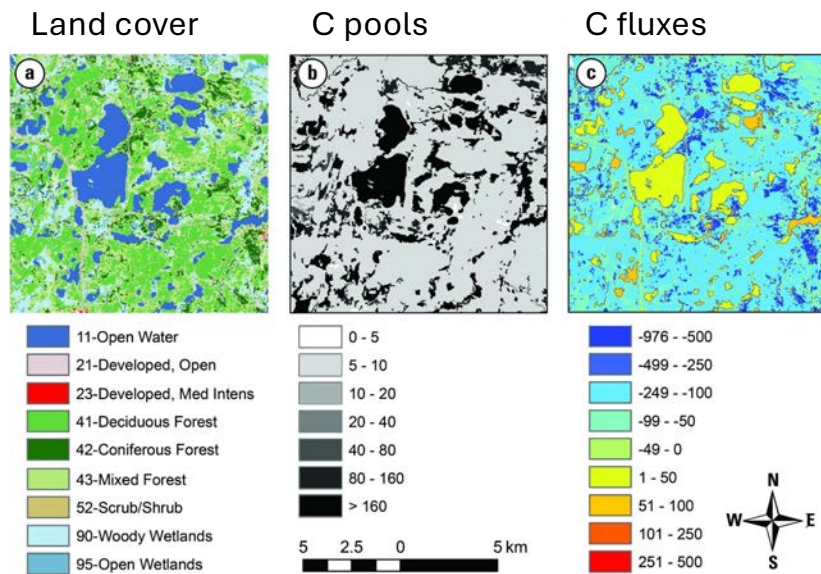
(Turner and Chapin 2005 in Lovett et al., eds. Ecosystem function in heterogeneous landscapes.)

What did we learn?

Ecosystem processes

Landscape-level budgets must
integrate land, water and wetlands

(Buffam et al. 2011)

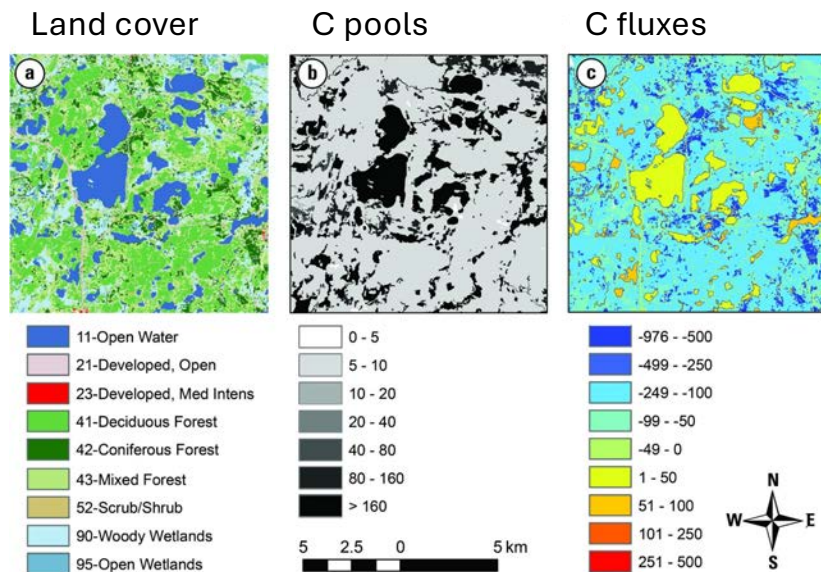


What did we learn?

Ecosystem processes

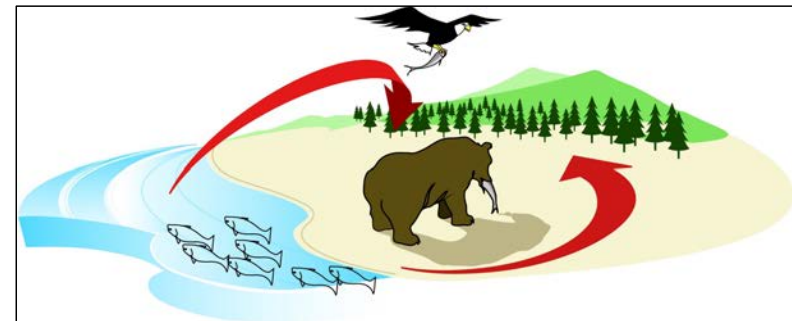
Landscape-level budgets must integrate land, water and wetlands

(Buffam et al. 2011)



Landscape is the template for species-ecosystem interactions

(Wilson et al. 1998, Seagle 2003, Holtgrieve et al. 2009)





Teaching Advanced LE (2000s)

Broadening of LE:

Aquatic landscapes
Cross-scale interactions
Long-term LU legacies

Metrics:

Correlations
Ecological importance vs.
statistical significance

New concepts:

Disturbance interactions, spatial epidemiology
Predation risk, foraging, resource selection (beyond just presence and abundance), ls genetics
Exurban development

Readings focused on state of the science

Full semester of labs

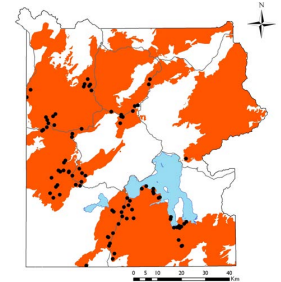
Gustafson (1998)
Wu and Hobbs (2002)
Dupouey et al. (2002)
Rommel and Csillig (2003)
Jenerette and Wu (2004)
Phillips (2007)
Fahrig (2003)
Manel et al. (2003)
Jackson (2006)

New textbooks! ★

Turner et al. (2001) as background
Gergel et al. (2002) for labs
Special feature in Ecology (2005),
'Landscape ecology comes of age'
Foundation papers in LE (2007)

Back in Yellowstone...

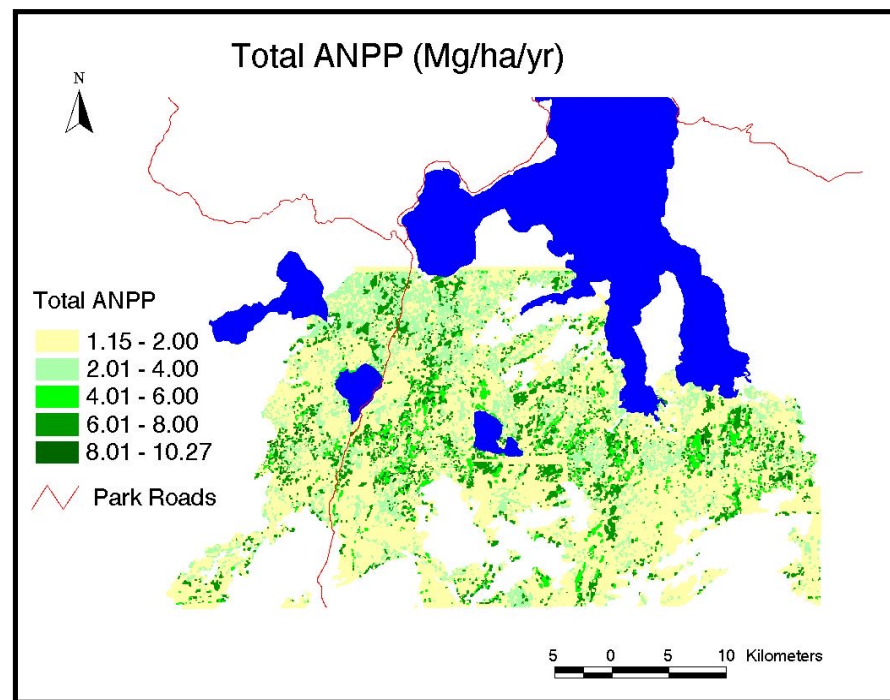
- Does the landscape heterogeneity in postfire tree regeneration affect ecosystem processes?



*Bill Romme, Dan Tinker,
Monica Turner (July 2000)*

What did we learn?

Spatial patterns of tree regeneration generate a landscape mosaic of process rates (C and N)



10 yrs postfire

(Turner et al. 2004, *Ecosystems*)

Legacy of initial spatial patterns of tree regeneration persists for decades to centuries



126-yr stands



Dan Kashian
(July 1999)



Erica Smithwick
(July 2002)

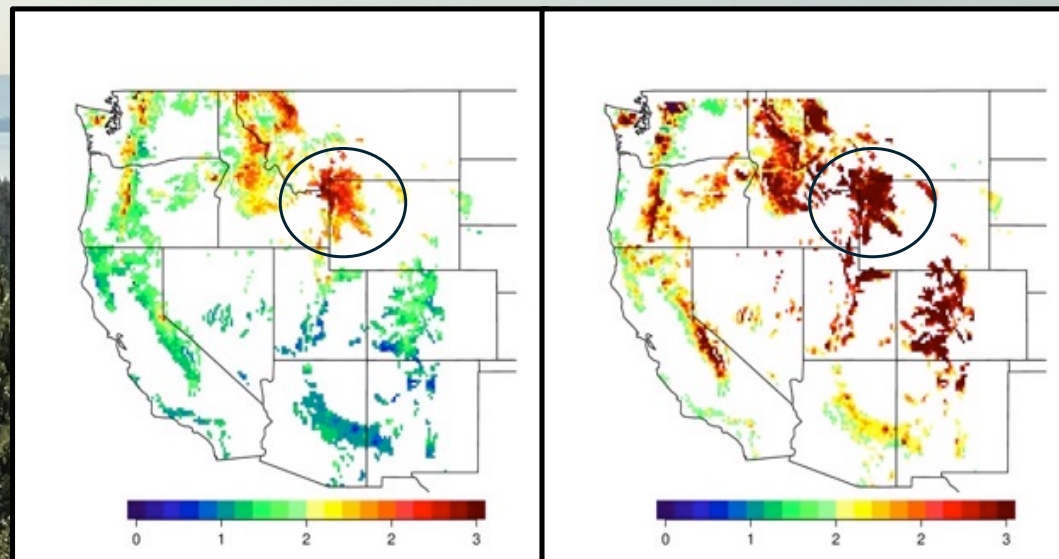
(Kashian et al. 2005a *Ecology*, 2005b *Ecosystems*, 2016 *BioScience*, 2013 *Ecol Monogr*;
Smithwick et al. 2005 *SBB*, 2009 *Ecosystems*; Turner 2010 *Ecology*)

What did we learn after 20 yrs?

Yellowstone forests' structure, composition and function are remarkably resilient



But... will that resilience hold in the future?



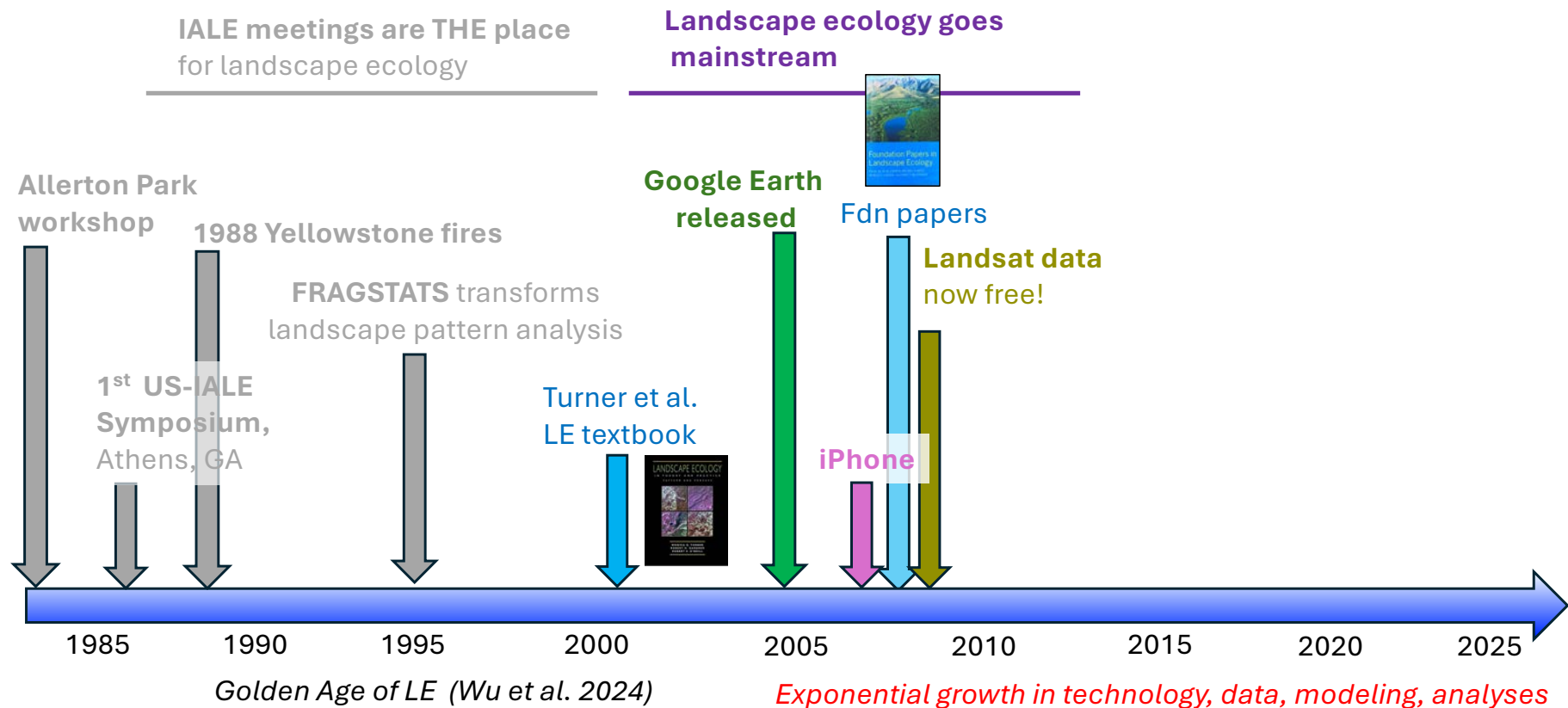
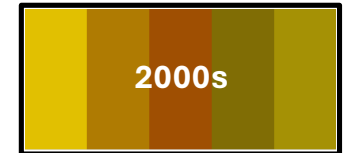
Moisture deficit,
1988

Moisture deficit,
projected 2090

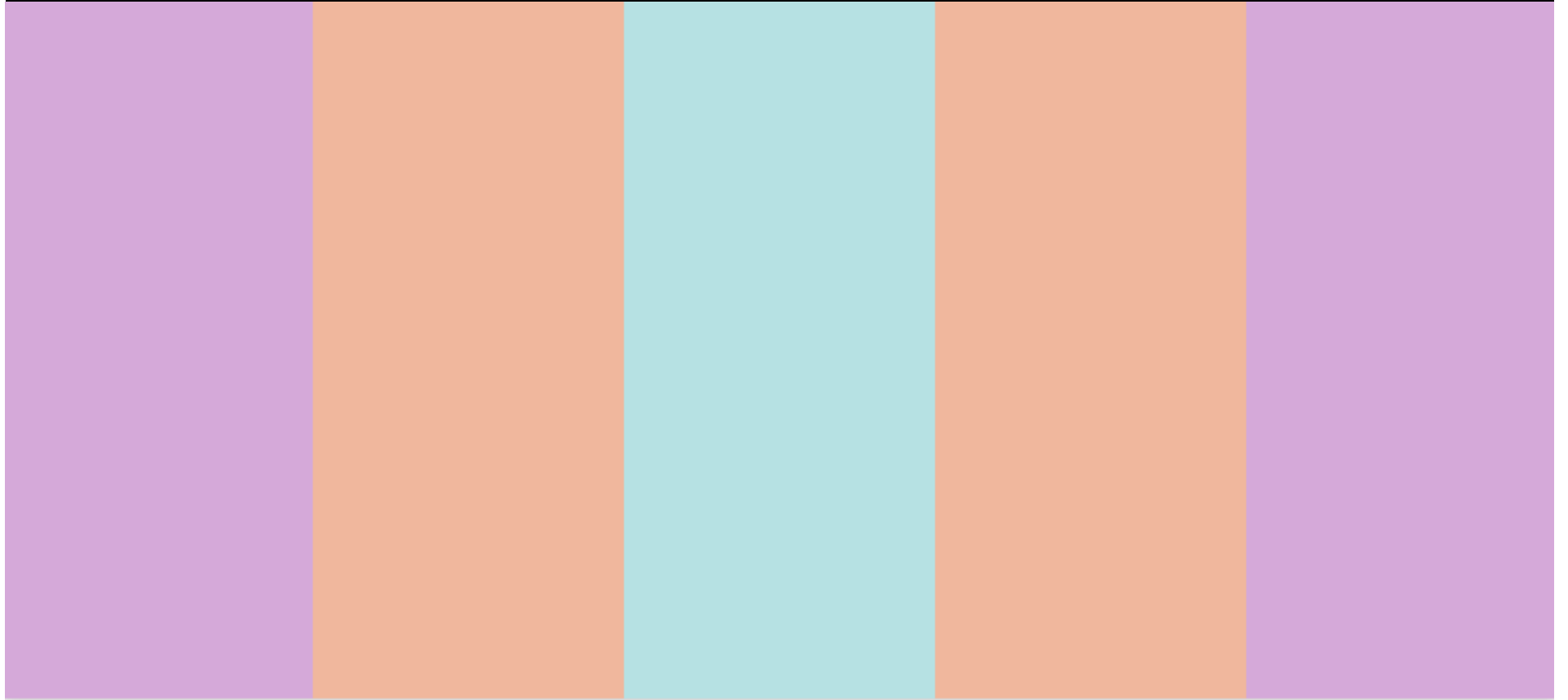
Climate like 1988 as the norm rather than the exception

(Courtesy of LeRoy Westerling, 2008)

Timeline of landscape ecology



2010s



Ecology in the 2010s

What was it like?

- Statistics transition from SAS to 
- Data archiving becomes required
- Technology continues to transform science (and life)
 - New tech, data sources and smartphone apps
 - Drones, wireless sensors, citizen science
 - Increasing availability of digital spatial data
 - Social media changes discourse and #SciComm



Landscape ecology in the 2010s

- Many new R packages!
 - *landscapemetrics.r* and *nlmr.r*
- Research foci expand
 - Climate change
 - Species interactions
 - Disturbance interactions
 - Resilience
 - Landscape sustainability
 - WUI, agricultural, urban landscapes
 - Ecosystem services



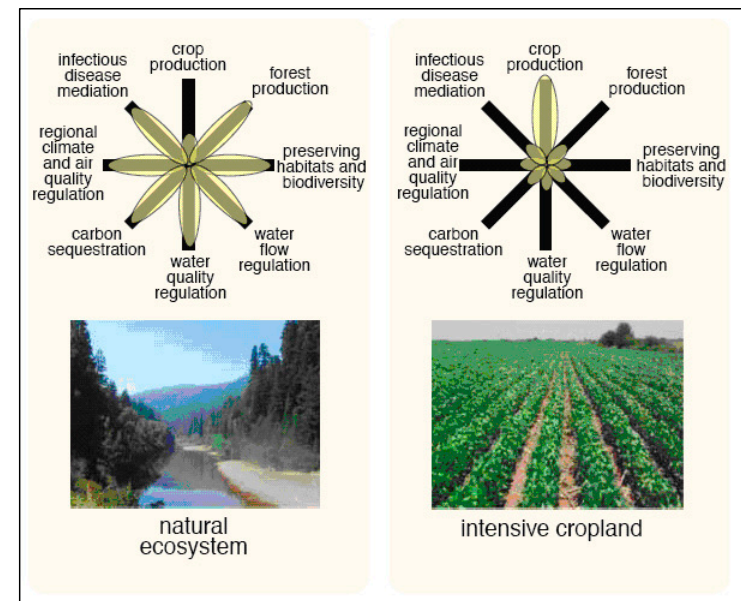
<http://www.csir.co.za/nre/ecosystems/ProEcoServ.html>

Ecosystem services, landscape sustainability

- **Bundles**—ES that always appear together across space or time (*Raudsepp-Hearne et al. 2010*)
- **Synergies**—Multiple services enhanced simultaneously (*Bennett et al. 2009*)
- **Tradeoffs**—Use of one reduces supply of another service (*Rodriguez et al. 2006*)



Elena Bennett



Foley et al. 2005, Science

Advanced LE (2010s): State of the science



Current context:

Land, water, marine
Cross-scale interactions
Climate change
Process-based models
Experimental LE

Metrics:

Parsimony, error propagation
Ecological importance vs.
statistical significance

Emerging concepts:

Changing disturbance regimes, resilience, spatial epidemiology
Corridors, fragmentation, habitat area, communities, behavioral LE, trait-based LE
Urban landscapes, macrosystems
Ecosystem services

Readings focused on state of the science, full semester of labs

Phillips (2007)
Eigenbrod et al. (2012)
Jenerette and Shen (2012)
Kupfer (2012)
Tscharntke et al. (2012)
Gustafson (2013)
Heffernan et al. (2014)
Johnstone et al. (2016)
Fahrig (2017)
McCune and Vellend (2015)



Second edition texts (whew!)

Turner & Gardner (2015) as background
Gergel et al. (2016) for lab

Back in Yellowstone...

- Long-term studies of 1988 fires
 - Can't see the fire for the trees!
- Rising concern about forest resilience
- Outbreaks of bark beetles

Can you “see” the 1988 fire?



What did we learn?

Disturbance interactions...

- Bark beetles kill trees, not forests
 - Fine-grained mosaic
- Outbreaks do not make fires worse
 - (Simard et al. 2011, Harvey et al. 2016, PNAS)



(Brian Harvey, Martin Simard,
Jake Griffin, Monica Turner,
Dan Donato-July 2010)



Simard et al. 2011

What did we learn?

Disturbance interactions...

- Bark beetles kill trees, not forests
 - Fine-grained mosaic
- Outbreaks do not make fires worse
 - (Simard et al. 2011, Harvey et al. 2016, PNAS)
- Bark beetle + fire reduce regeneration
 - If beetle-killed stands lack seed supply (Harvey et al. 2014 Eco Apps)



(Brian Harvey, Martin Simard, Jake Griffin, Monica Turner, Dan Donato-July 2010)

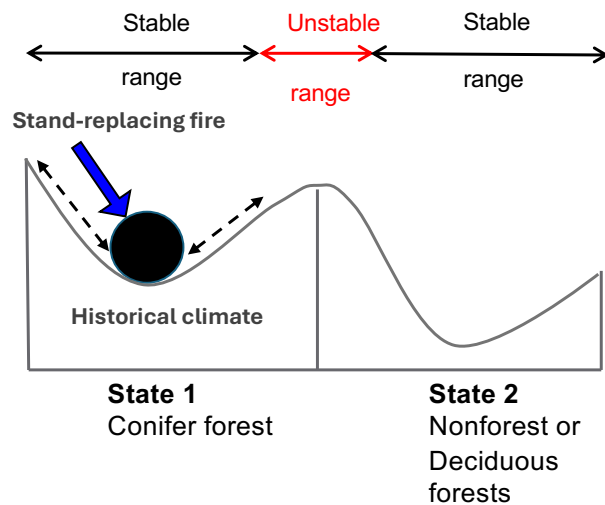


Simard et al. 2011



How and why could forest resilience erode?

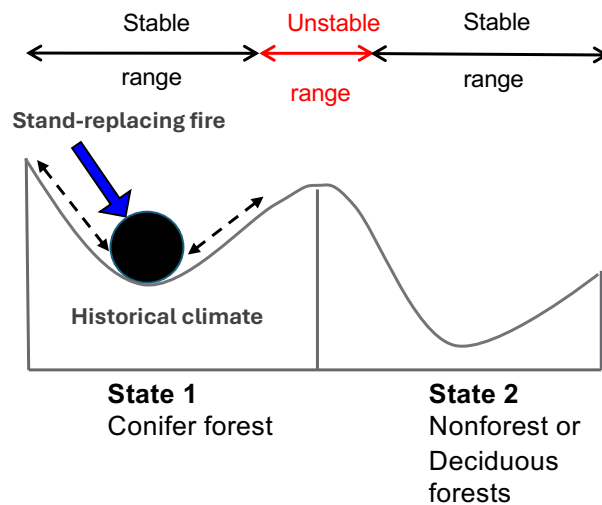
(A) Historical conditions



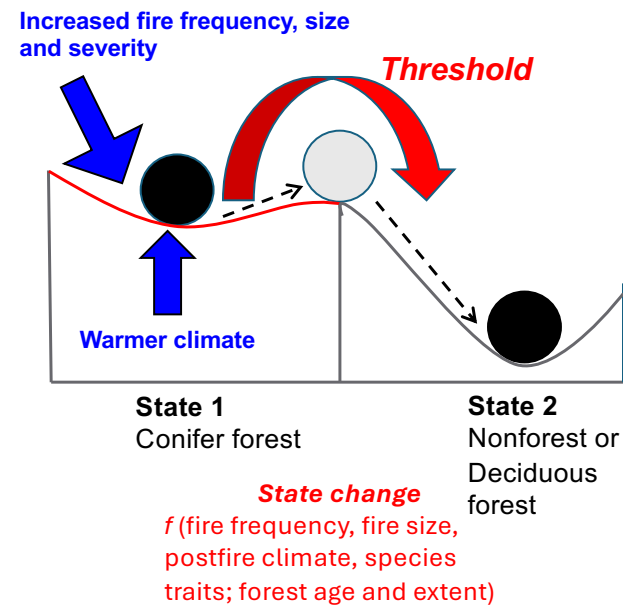
(Johnstone, Turner et al. 2016, *Front Ecol Environ*)

How and why could forest resilience erode?

(A) Historical conditions



(B) Anticipated mid-21st C



(Johnstone, Turner et al. 2016, *Front Ecol Environ*)

2016 Fires

Another natural experiment!

Total area burned = 47,000 ha

Short-interval fire (< 30 yr) = 18,000 ha

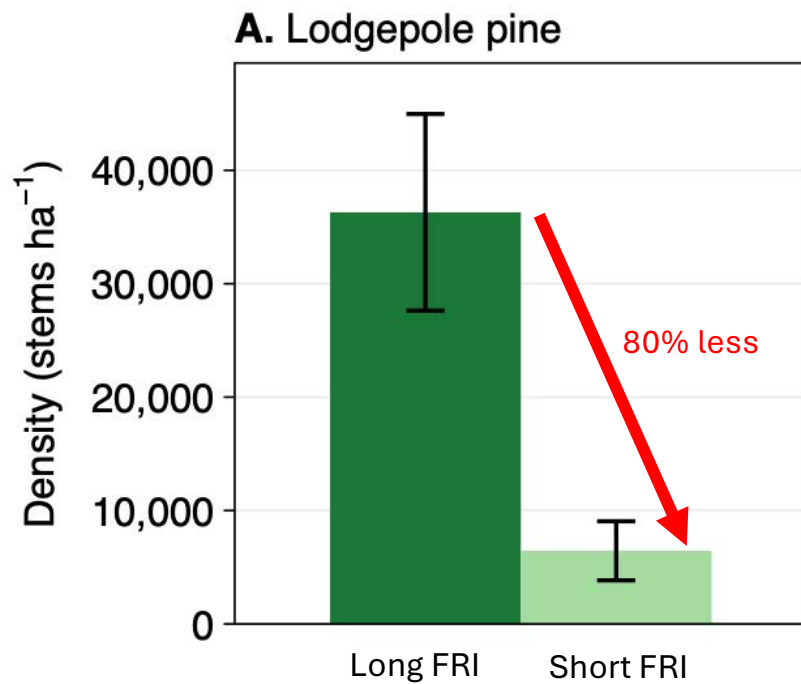


2016 Fires



Berry Fire burned 16- and 28-yr old lodgepole pine (M. G. Turner photo, July 2017)

Sparse regeneration if areas burn again in < 30 yrs



(Turner et al. 2019 PNAS)



Why?

Long fire interval (> 130 yr)

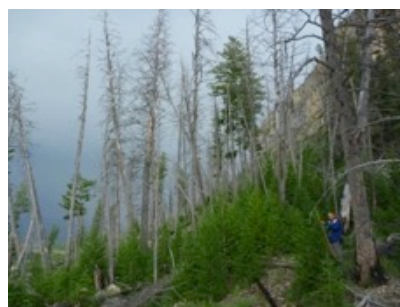


Fewer seeds

More severe fire



Less seed dispersal



vs.

Short fire interval (< 30 yr)



vs.



(Turner et al. 2019 PNAS, Gill et al. 2021 Ecology, Braziunas et al. 2023 Ecology, Kiel et al. 2023 New Phytol, Harvey et al. 2023 GEB)

Double whammy

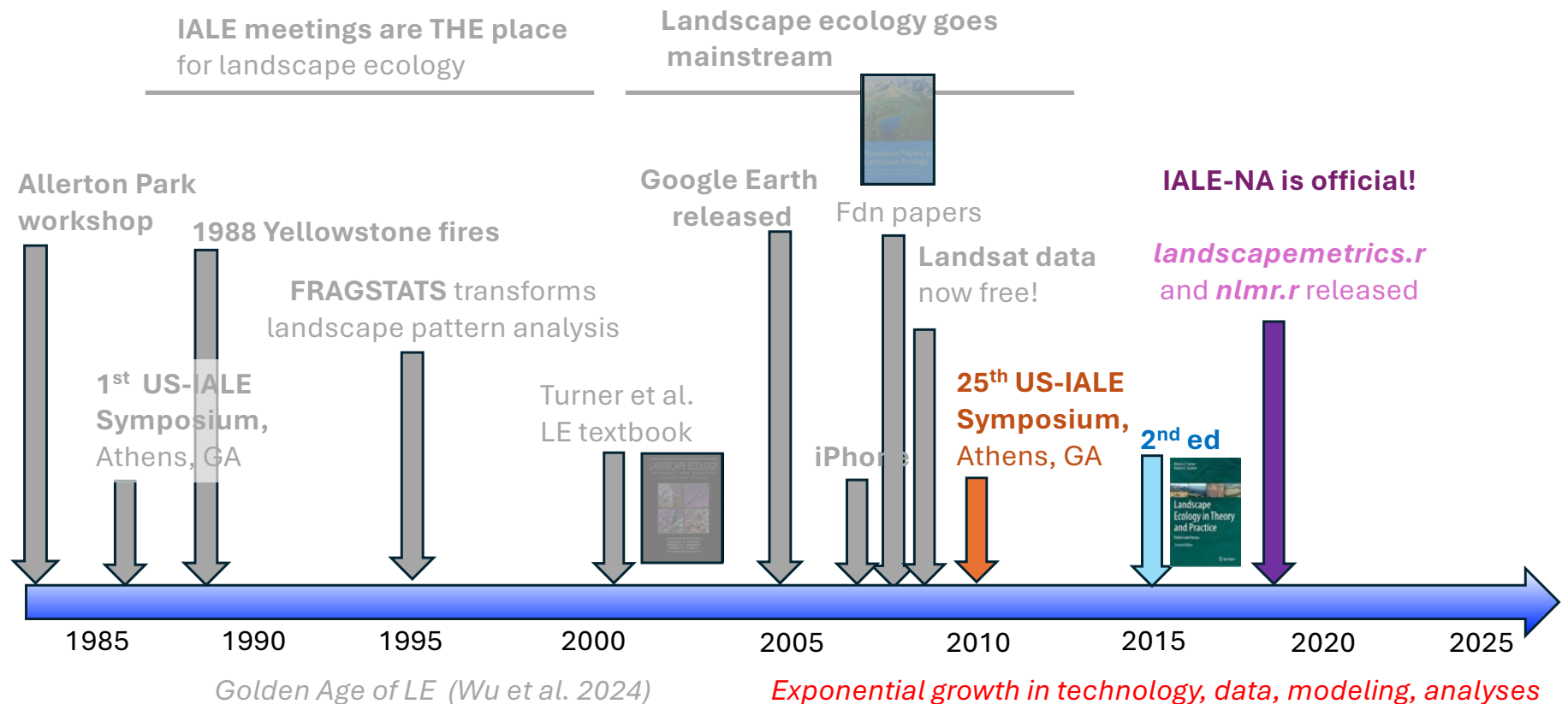
Hotter, drier soils in short-interval fires

Winslow Hansen Tyler Hoecker

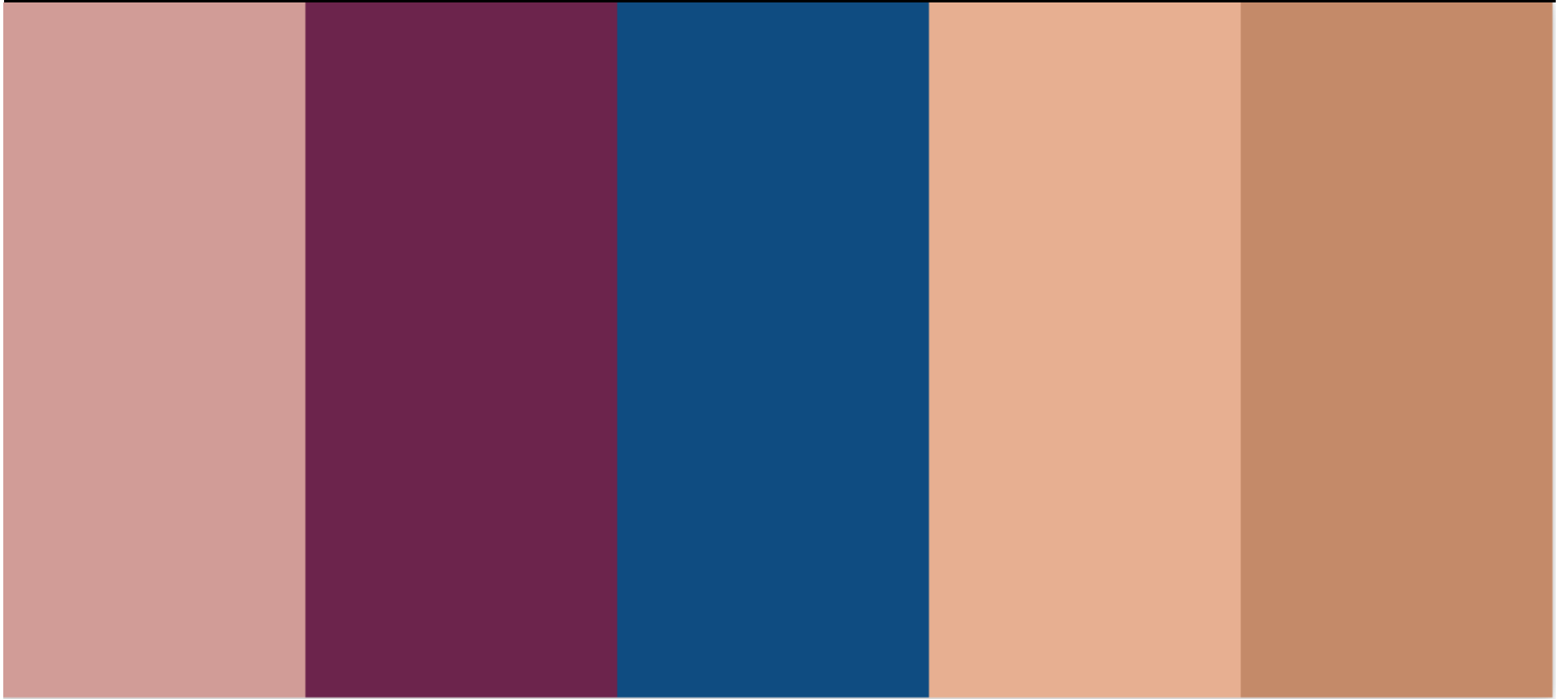


(Hansen et al. 2019 Ecol Monogr; Hoecker et al. 2020 For Ecol Manage)

2010s

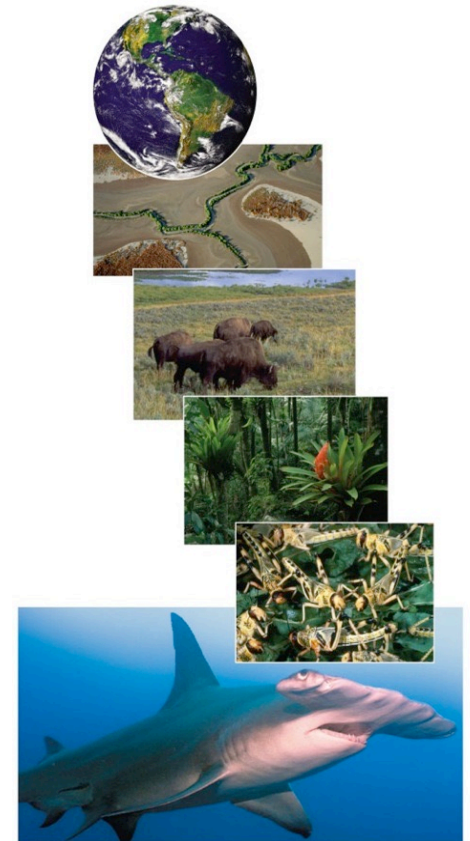


2020s



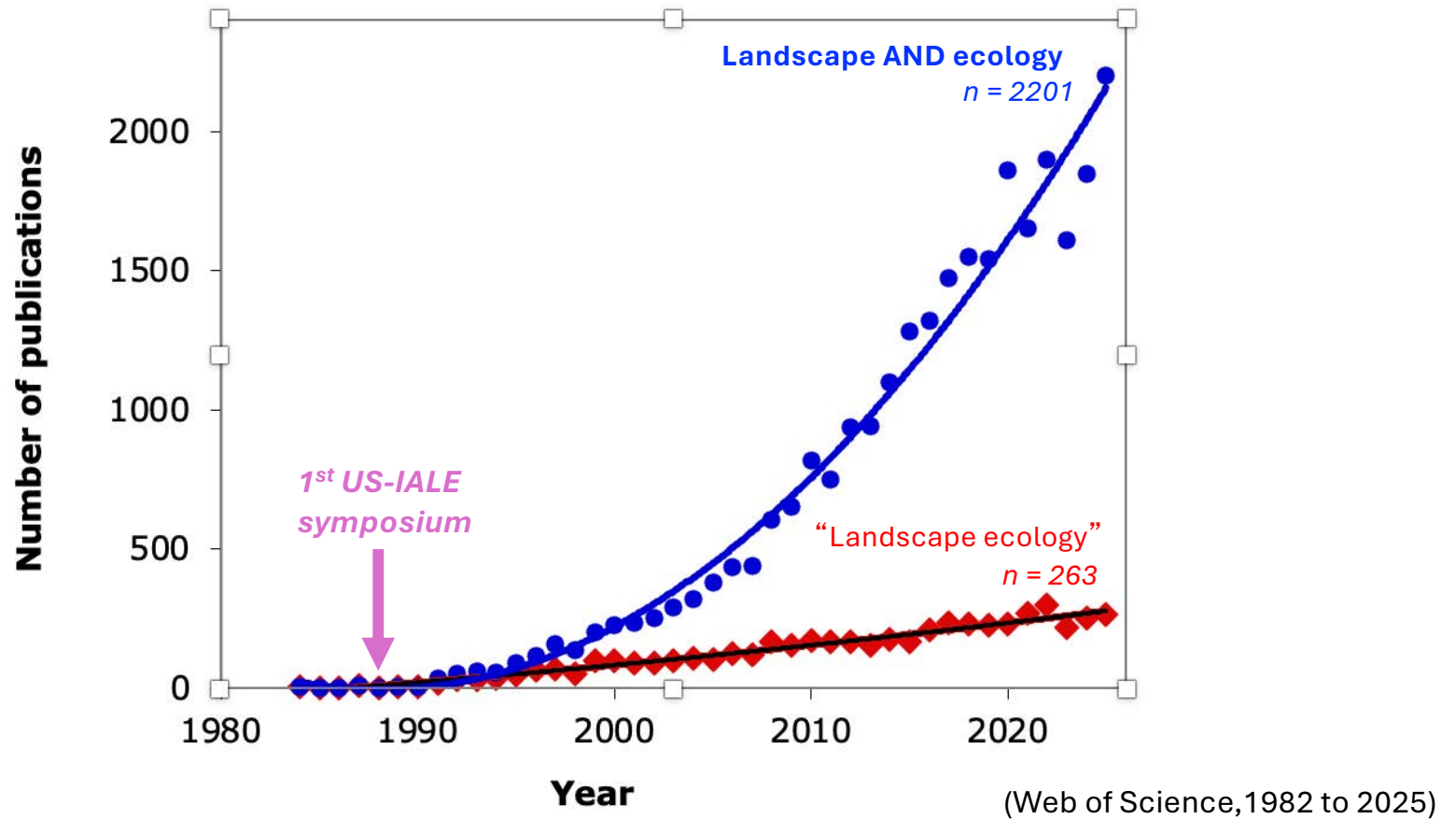
Landscape ecology in the 2020s...

- Spans subdisciplines & scales of ecology
- Benefits from widely available spatial data
- Has solid conceptual frameworks
 - Strong question-driven studies
 - Well-reasoned expectations
 - Many mechanisms understood
 - Exploring future scenarios
- Wealth of empirical and simulation studies
- Is a vibrant science
 - As seen at this meeting!



Publications continue to rise

(can feel overwhelming!)



Advanced LE (2020s): State of the science



Current context:

Process-based models
Optimal landscapes
Future scenarios

Metrics:

Parsimony, error propagation
So many new data sources
LiDAR, acoustics, citizen science, hyperspectral...

Emerging concepts:

HRV to FRV, landscape reorganization and adaptation
Corridors, fragmentation, biodiversity, behavioral LE, trait-based LE
Novel or no-analog landscapes
Multiple drivers

Readings focused on state of the science, full semester of labs

Phillips (2007)

Lepczyk et al. 2021

Eigenbrod et al. (2012)

Williams et al. (2019)

Rose et al. (2016)

Belote et al. (2021)

Littlefield et al. (2019)

Lembrechts and Nijs (2020)

Meyfroidt et al. (2022)

Turner & Gardner (2015) as background
Gergel et al. (2016) for lab

Lab exercises now in R!

Sciani et al. (2018)

Hesselbarth et al. (2019)

Back in Yellowstone...learning goes on

Still learning from the 1988 fires



*Same post-1988 study plot in 2012 and 2022 .
Ten years makes a difference!*



*“Team Nitrogen” finishes
sampling, July 2025*



*Novel recovery pathways
Nathan Kiel, July 2022*

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*Same post-1988 study plot in 2012 and 2022 .
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Interaction of climate change
and novel fire regimes



*Kristin Brazionas,
Monica Turner, July 2021*



*“Team Nitrogen” finishes
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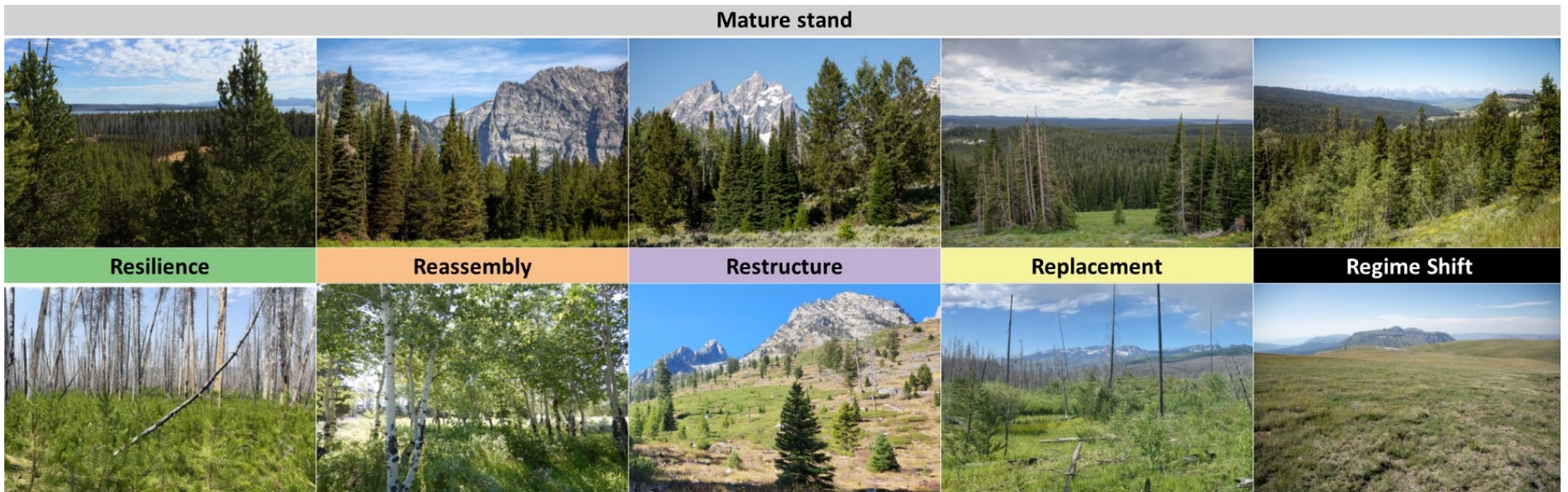
Conveying effects of
climate change in the GYE



Images by Timon Keller

Back in Yellowstone...

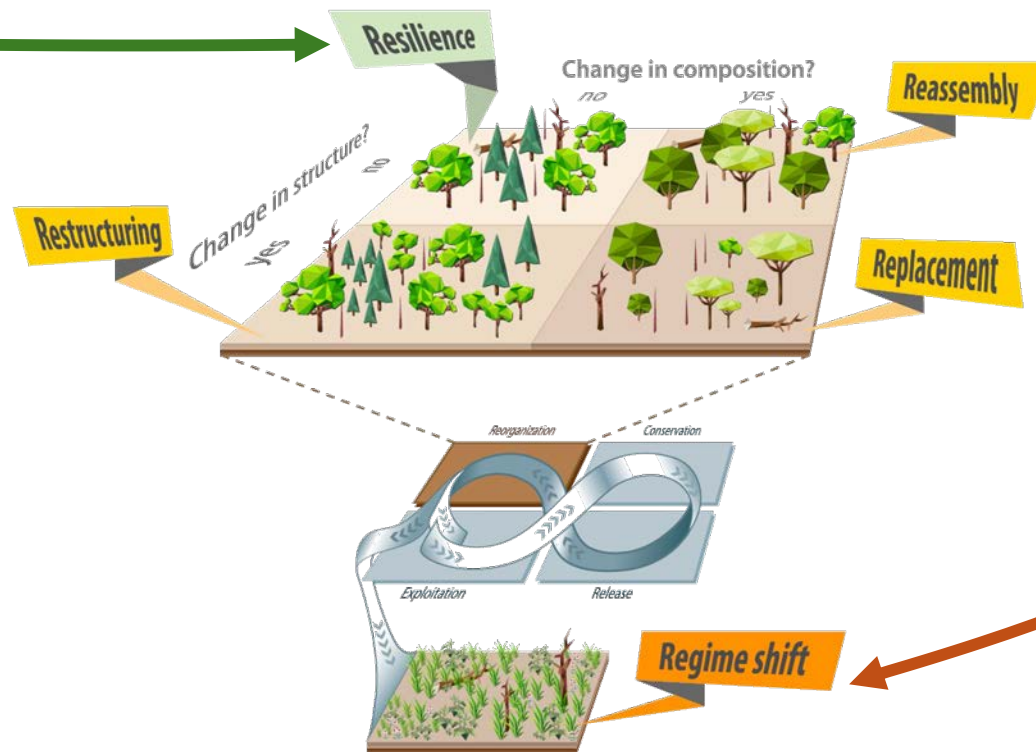
- Evidence of forest reorganization in the field and simulations
- Effects on biodiversity, ecosystem processes, landscape function?



(Knowlton, Keller, Seidl & Turner 2025, Ecosphere)

When, where & why will forests re-organize?

Resilience (recover structure, composition, function) and **regime shift** (state change) are end members



Seidl and Turner (2022, PNAS)



Rupert Seidl

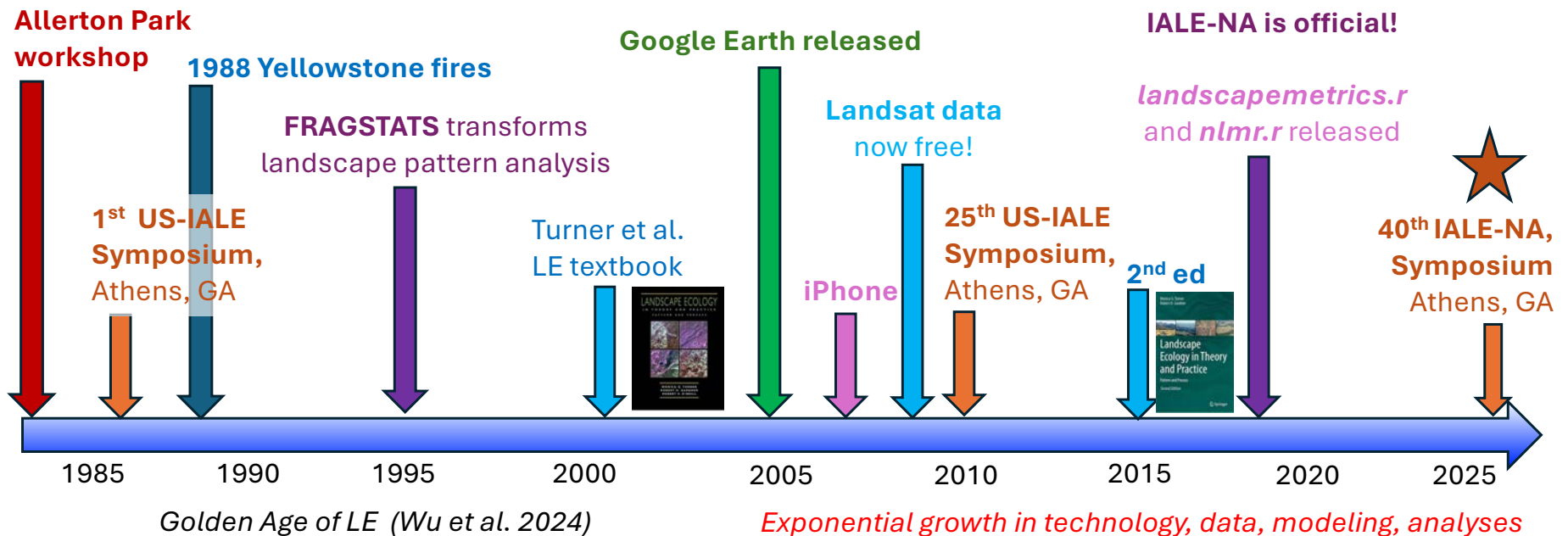
Timeline of landscape ecology

1980s–2020s

IALE meetings are **THE** place
for landscape ecology

Landscape ecology goes
mainstream

Landscape ecology is
everywhere!



Landscape ecology changed our science

1980s



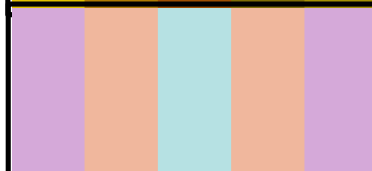
1990s



2000s



2010s



2020s



Landscape ecology for a changing world

- **Past is not prologue.** Landscapes always change, yet future landscapes may differ markedly from those of the past
- **Legacies are ubiquitous and persistent.** Today's disturbances and land-use choices create tomorrow's legacies
- **New tools and big data are not a panacea.** Understanding ecology, mechanisms, interactions is critical...we must learn from our landscapes, not only about our landscapes

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Ecological effects of spatial heterogeneity are pronounced, profound and complex; disregard at your own risk



Today's challenges are daunting

- Attacks on science (and fact)
- Dismantling of agencies and institutions
- Climate change (and denial)
- Viral spread of disinformation
- Proliferation of predatory journals



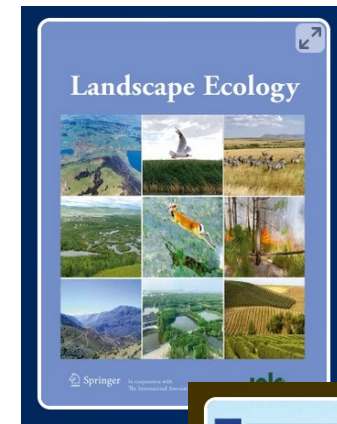
Matt Rourke/AP

We can and must meet these challenges



- Stay focused on our important science
 - LE is **not** a pseudo science!
- Support our societies (IALE-NA) and each other
- Publish and review for **reputable** journals
- Use AI wisely, don't outsource your thinking
- Disturbance can be a source of renewal...

don't lose hope!



Thank you and have a great meeting

Landscape ecology
class reading lists,
1996 to 2024



Video (8:48 min):
*Future Landscapes of
Greater Yellowstone*



Email: turnermg@wisc.edu

Publications:
<https://turnerlab.ibio.wisc.edu/>