How do deer affect woodlands and oaks in particular?

Plant Ecology Laboratory

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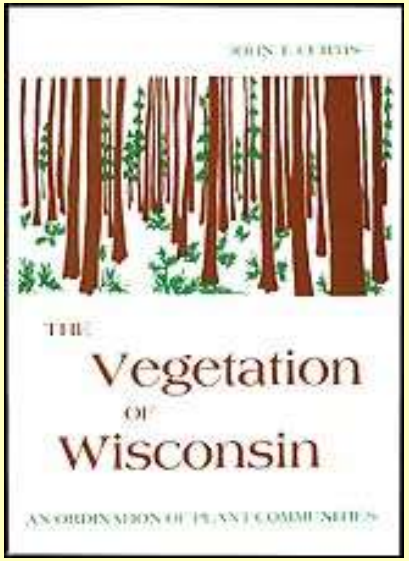
Deer and oak woodlands

- Context: Changes in N & S forests
- How did we get here?
  - Why are deer so abundant?
- What effects are deer having?
- How do deer affect oak regeneration?
- Deer – Jeckyl or Hyde?
- What should we do about deer?

Tracking changes in northern forests

Long-term ecological change

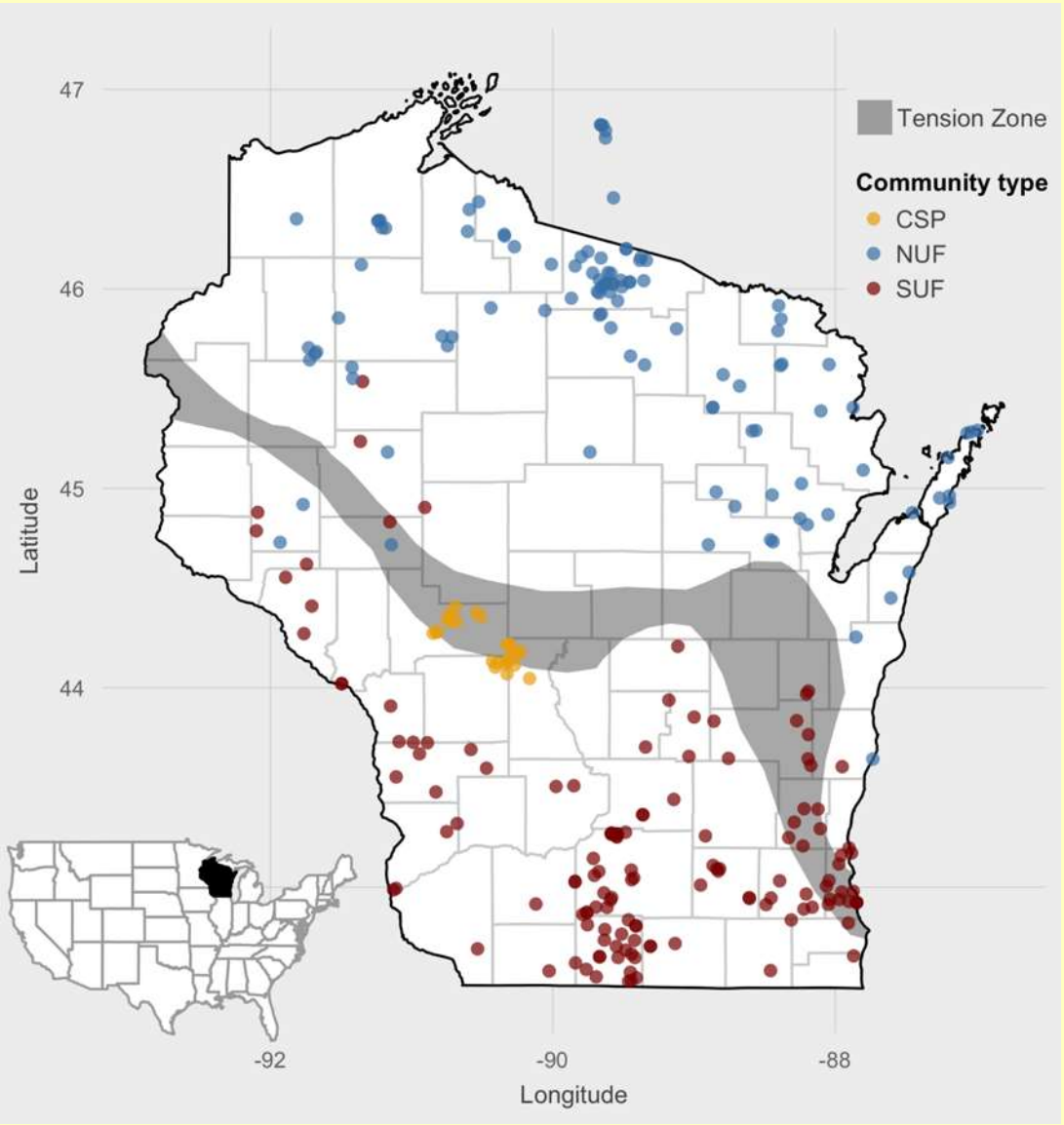


- John T. Curtis & colleagues sampled extensively across Wisconsin from 1942-1956
- Classic work to test how plants respond to local conditions = "**continuum concept**"

- **The Vegetation of Wisconsin** (1959)
- Carefully archived data . . .

Provides ***exceptional baseline***

Wisconsin PEL legacy



50+ year interval:

Original surveys 1946-1956
(no permanent plots, but quantitative)

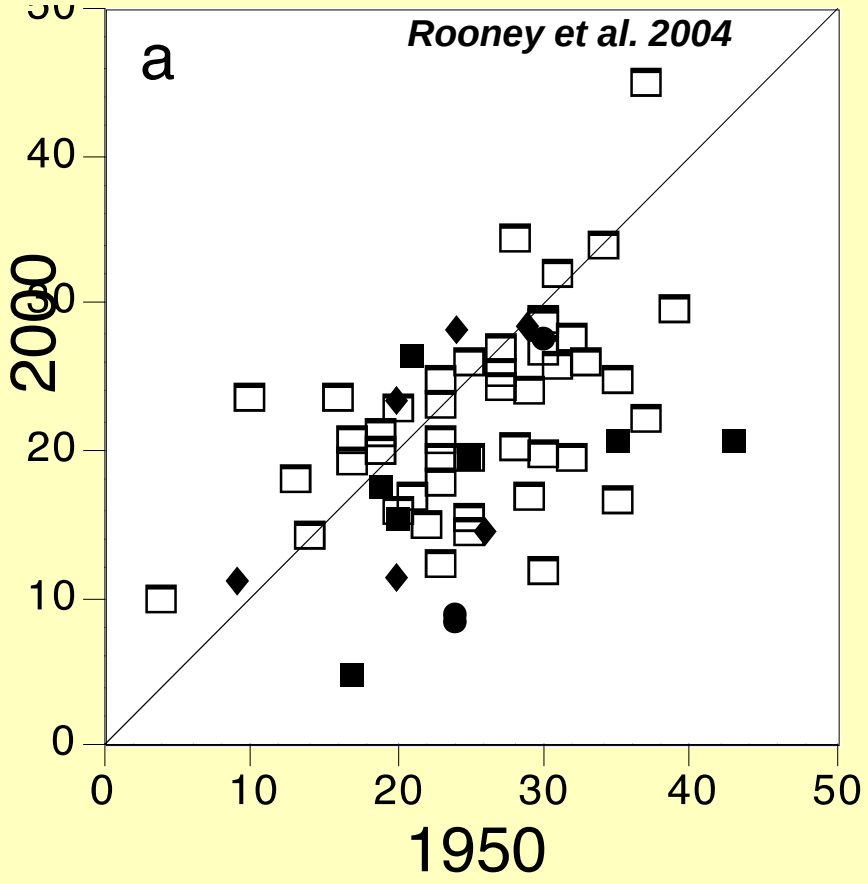
Resurveys:
N Wisconsin: 2000-2001
S Wisconsin: 2003-2008
Pine Barrens: 2011-2012
Prairies: 2013-2015

Generally more intensive

N Wisconsin forests are losing diversity

- **Regional** scale → **No change**
  138 vs. 135.4 species
- **1 m²** scale → **No change**
  4.9 ± 0.3 vs. 5.3 ± 0.3 species
- Yet 65% of sites **lost species**:
  - 20 m² scale: 15% decrease
    (paired t-test; *p*= 0.005)
  - 24.9 vs. 18.9 species

18.5% decrease in native species



Northwoods “Losers”

Orthilia secunda

Linnaea borealis

Mitchella repens

Viola blanda

Clintonia borealis

Mitella diphylla

Uvularia sessilifolia

Cornus canadensis

Fragaria viginiana

“Winners” in the North

Ferns like:

Athyrium filix-femina (400% increase) and *Dryopteris intermedia* (100% increase)

Jack-in-the-Pulpit

Arisaema triphyllum (195% increase)

Grasses & sedges:

Carex (286% increase) - most significant

63- 98% local increase;

now in 20-48% of quads

Oryzopsis asperifolia (54% increase)

Schizachne purpurascens (217%)

Exotic species like:

Hieracium, Epipactis, Galeopsis

Athyrium filix-femina

Schizachne purpurascens

Arisaema triphyllum

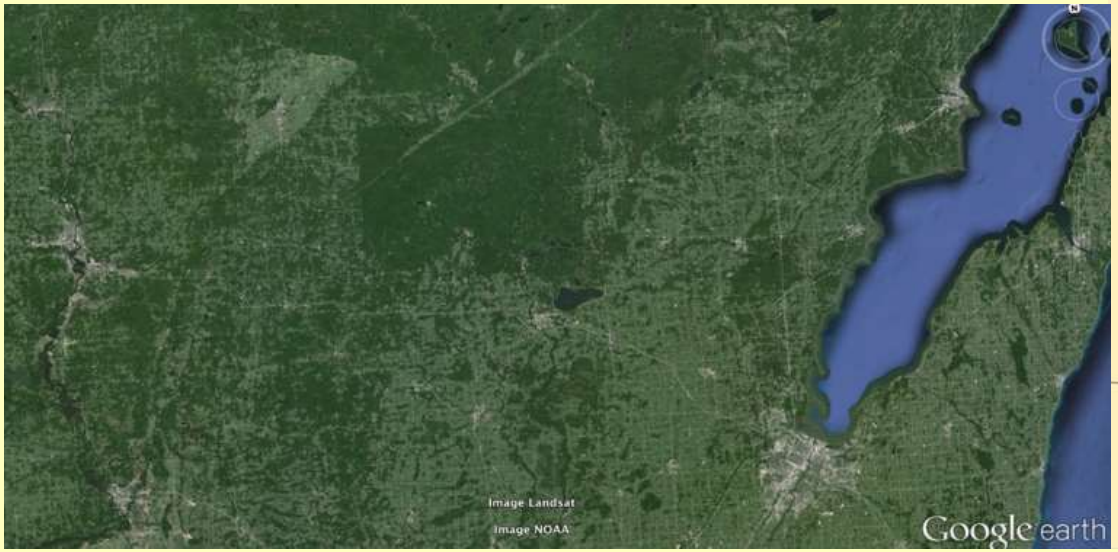
Hieracium

Carex pensylvanica

Where are losses occurring?

- 3 **State Parks** have lost **> 50%** of their plant species
- No net declines in plant diversity on several **islands** or in **Indian reservations**

- **And why?**



What is causing these changes in community composition?

‘**Signature’** points to **white-tailed deer:**

- Conspicuous **showy flowered** species have declined
- Species sensitive to **deer herbivory** have declined
- Resistant species (grasses & sedges) have increased
- Unhunted sites lost 33% of species on average vs. Hunted sites: 9.7%
- Fenced exclosures retain species & support good tree regeneration

What is driving changes in the Northwoods?

Who, me?

Signs of deer impacts:
“Sandwich” trees & “Lolipop” cedars

Cedar browse line

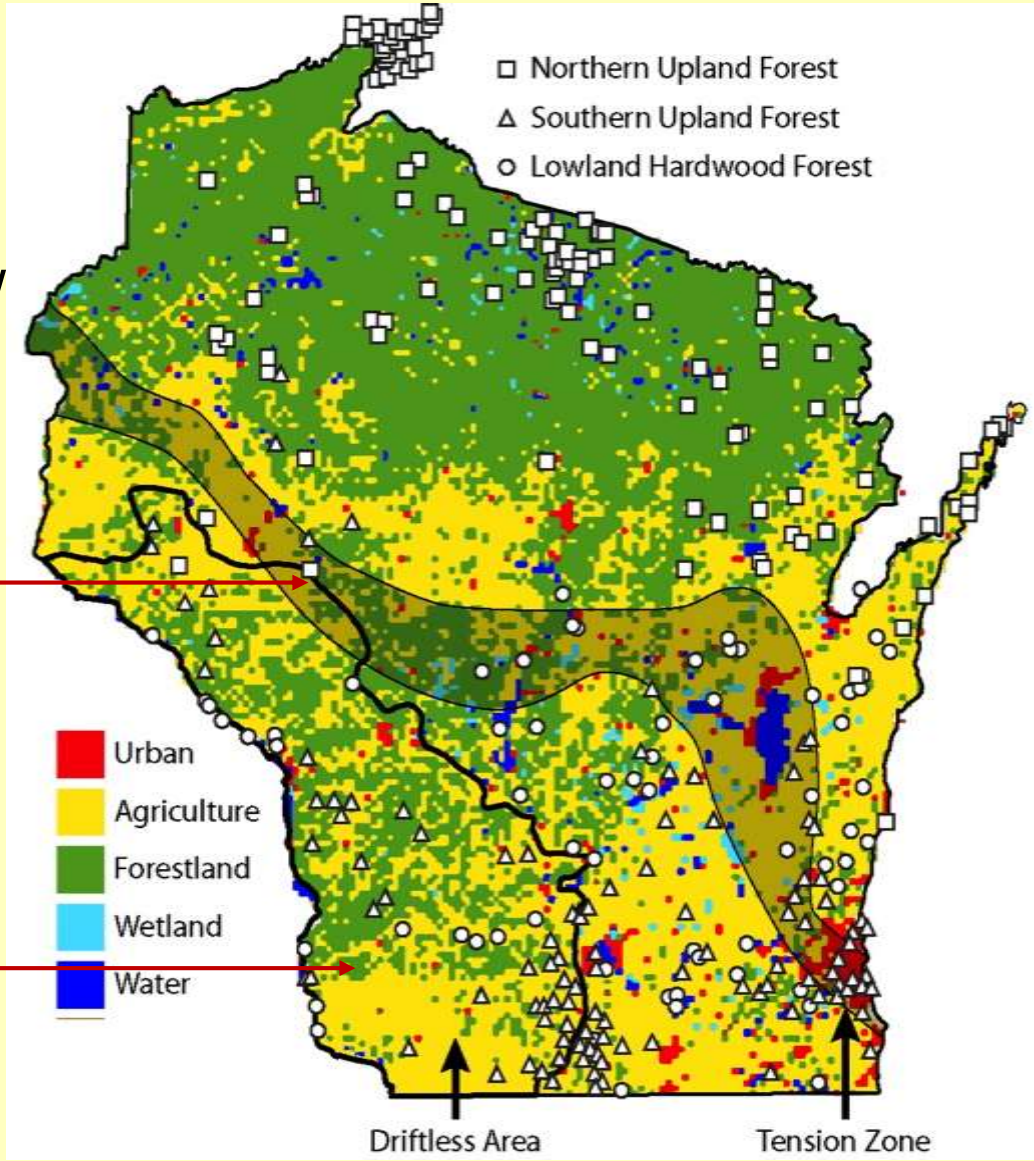
Sylvania Tract, Mich

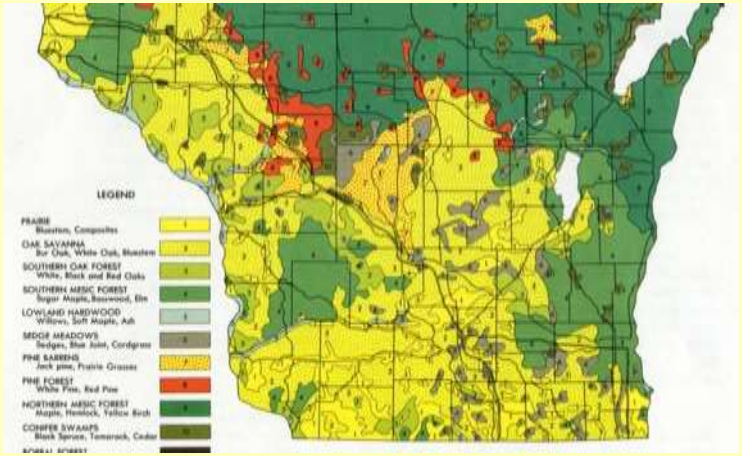
Signs of deer browsing

Rough tears

Tracking changes in Southern forests

- **North** - mostly 2nd growth forests - large patch sizes, low population & road density.
- Separated by a transition = ‘Tension Zone’
- **South** - dominated by agriculture + small and fragmented forests
  - Unglaciated in SW





Southern Forests

BEFORE:

Mosaic of prairie, savanna & oak-hickory forests

Maintained by frequent fires

NOW:

Dominated by agriculture

Forests - small & fragmented

Selective logging, hunting and recreation

Changes in Southern Forests

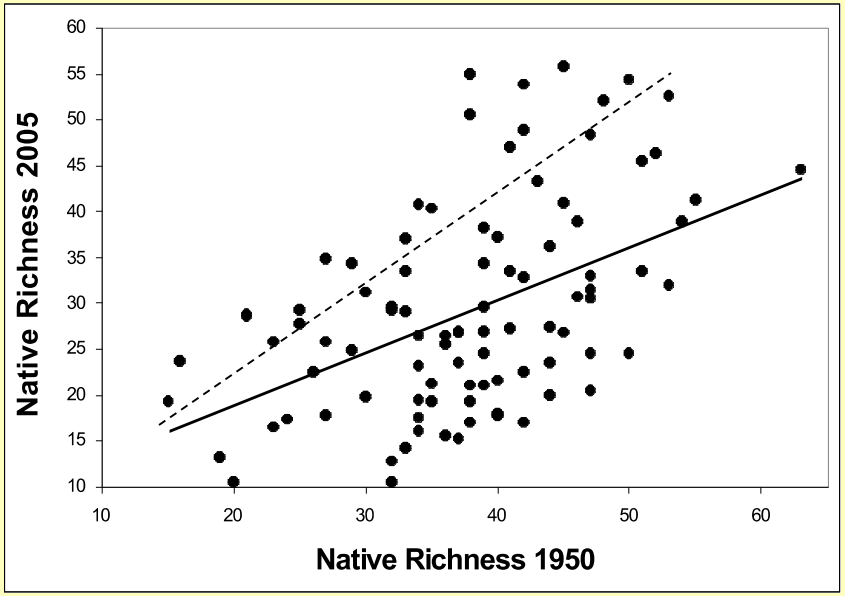
Numbers of tree seedlings have declined by 50+%

Local declines in plant diversity

80% of sites lost diversity

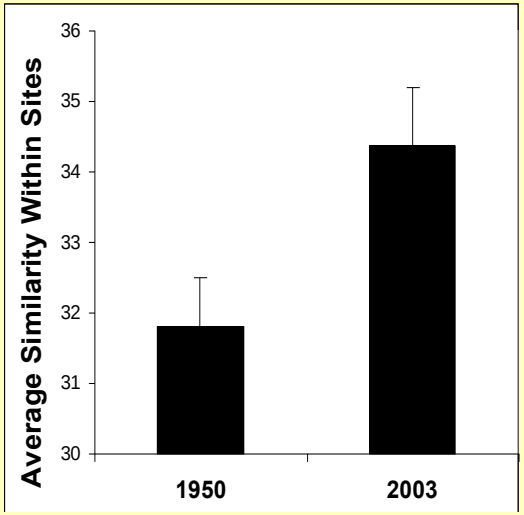
25% per 1 m2

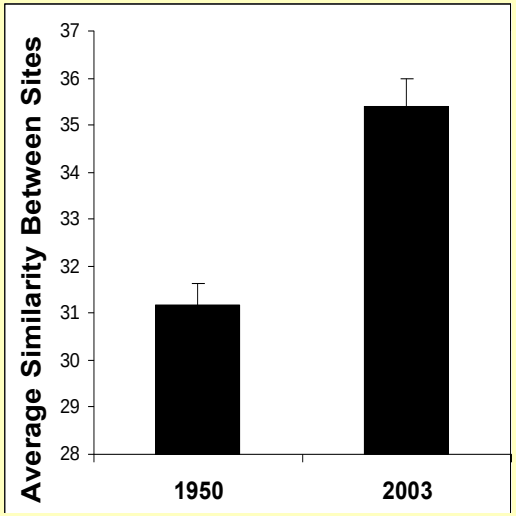
22% over 20 m2



Sites are more

Homogenous:






Bedstraw (4 spp)
Bloodroot
Sweet Cicely
Bellwort
Yellow violet
Lopseed
Wild Yam
Herb Losers
Nodding Trillium
Tick-seed Trefoil

Common native species:

Parthenocissus spp

Geranium maculatum

Winners in S Wisconsin forests:

- Shrubs & woody vines
  - Including exotic *Rhamnus* & *Lonicera*
- Strongly clonal herbs, and
- Exotic herbs
  - e.g., Garlic mustard: *Alliaria*

Exotics:

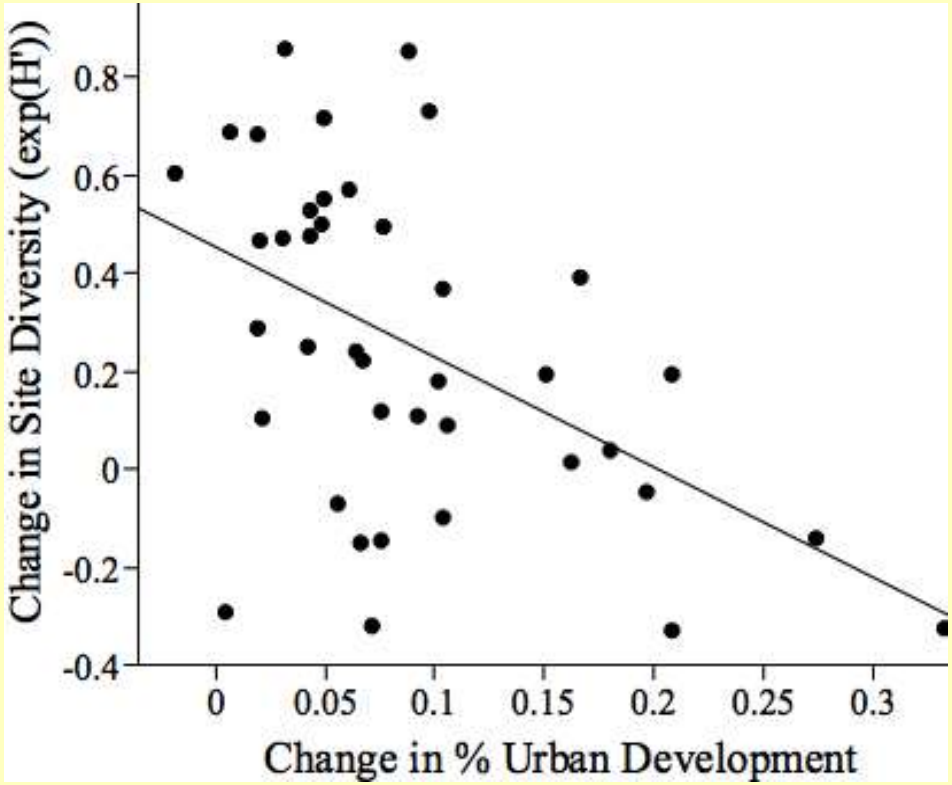
Alliaria petiolata

What drives these declines in diversity?

Urbanization

What does this reflect?

roads?
loss of forest?
weedy invasions?



How have southern forests changed?

Fragmentation & urbanization

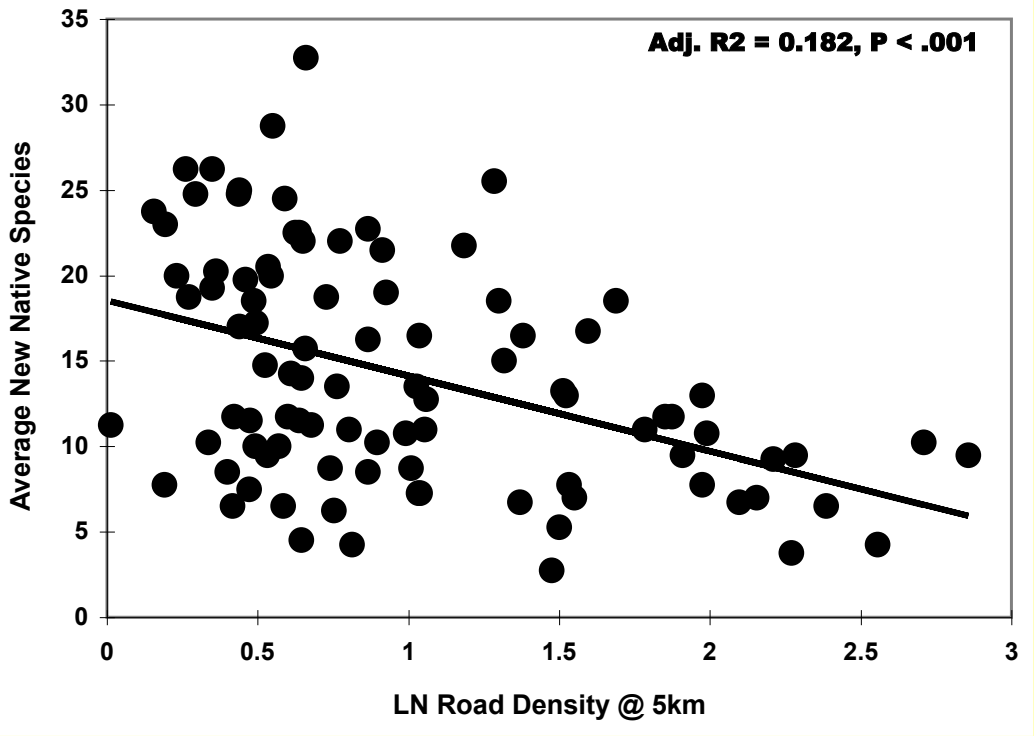
✓ Roads isolate habitats

Roads cut off colonization:

Maintaining diversity is an active process

Roads and urban areas block local colonization

Prevents the ‘rescue effect’

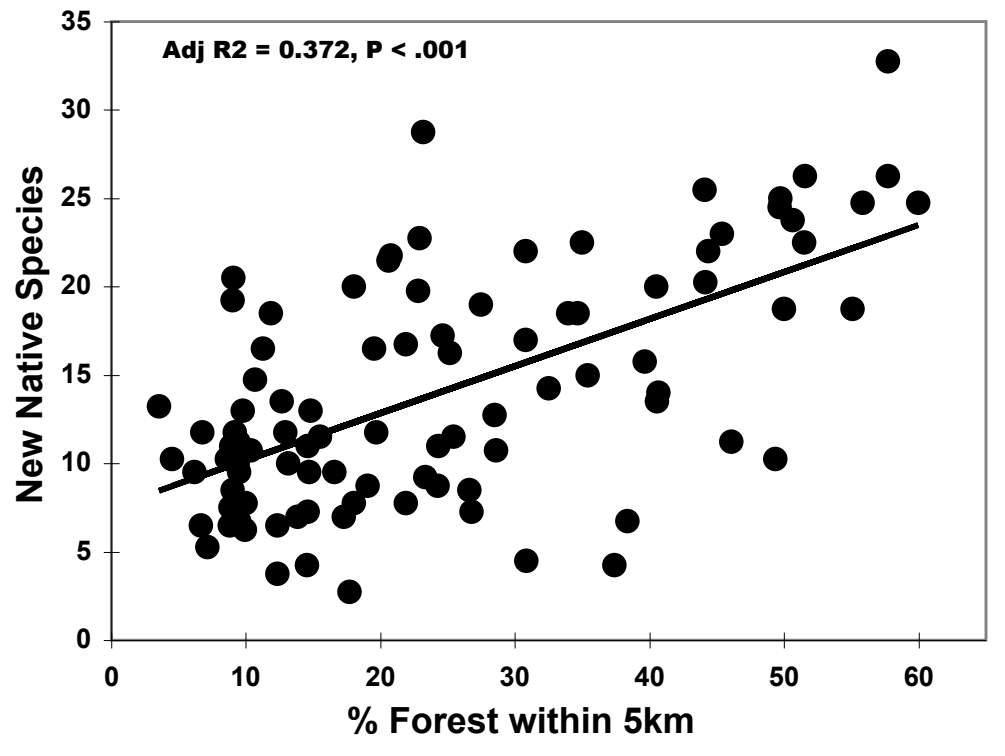


✓ Loss of forest

Native species (re)colonize stands surrounded by **more forest**:

Pay attention to both forest **size** and **proximity** to other stands in these landscapes

Maintaining diversity is an ***active process***



✓ Weedy invasions

26% of stands had exotics in 1950 vs. **82% now**

6x increase in the abundance of exotics

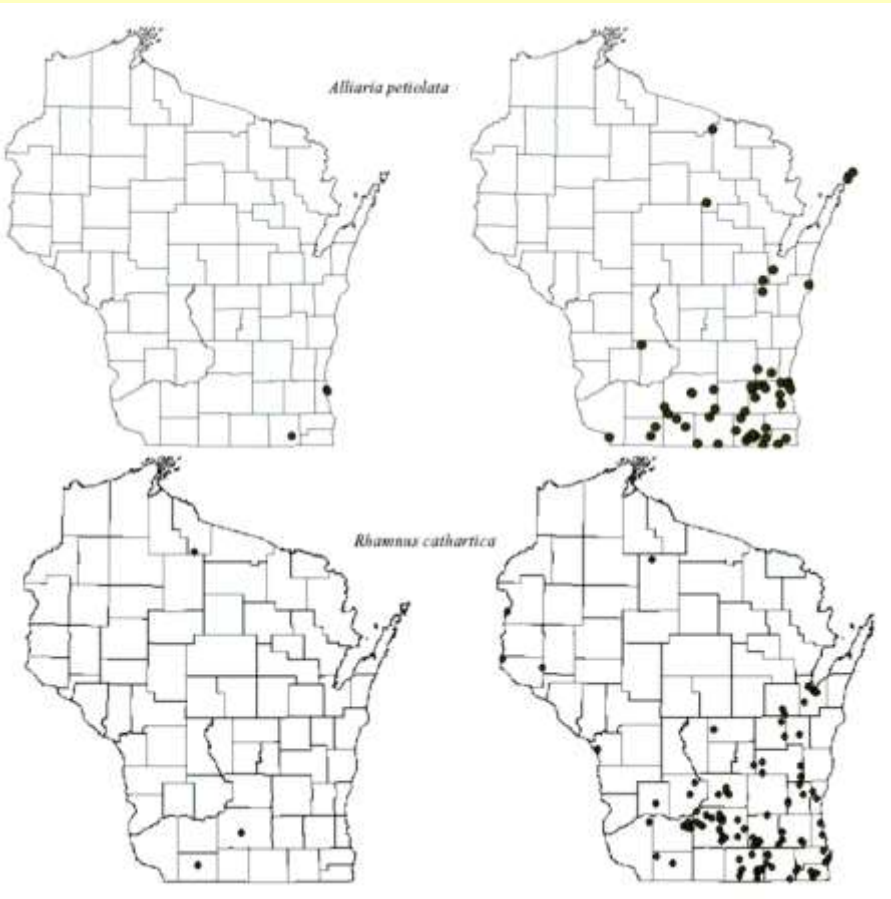
Alliaria

Garlic mustard

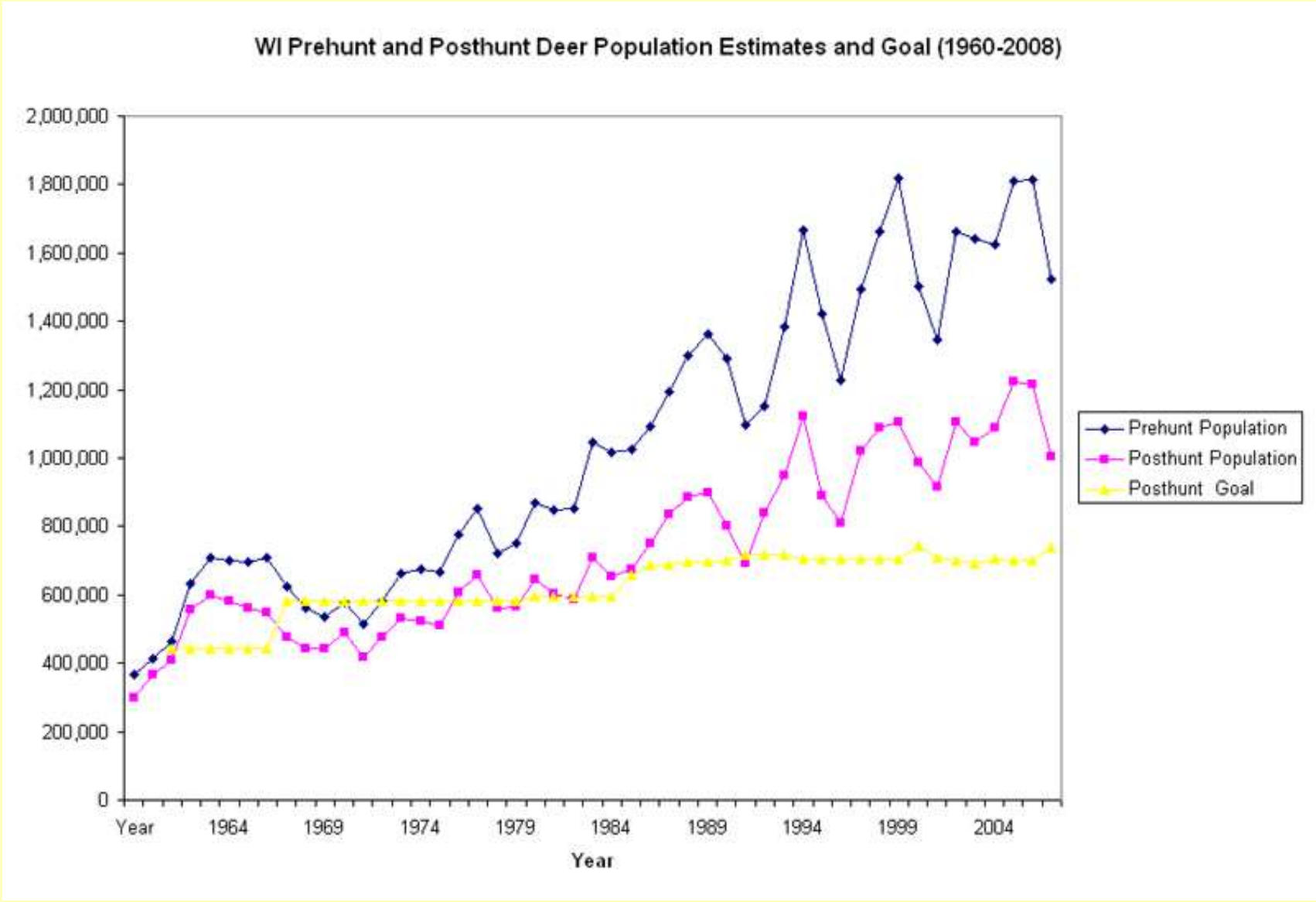
Rhamnus

Buckthorn

Then Now



Why have deer become so abundant?



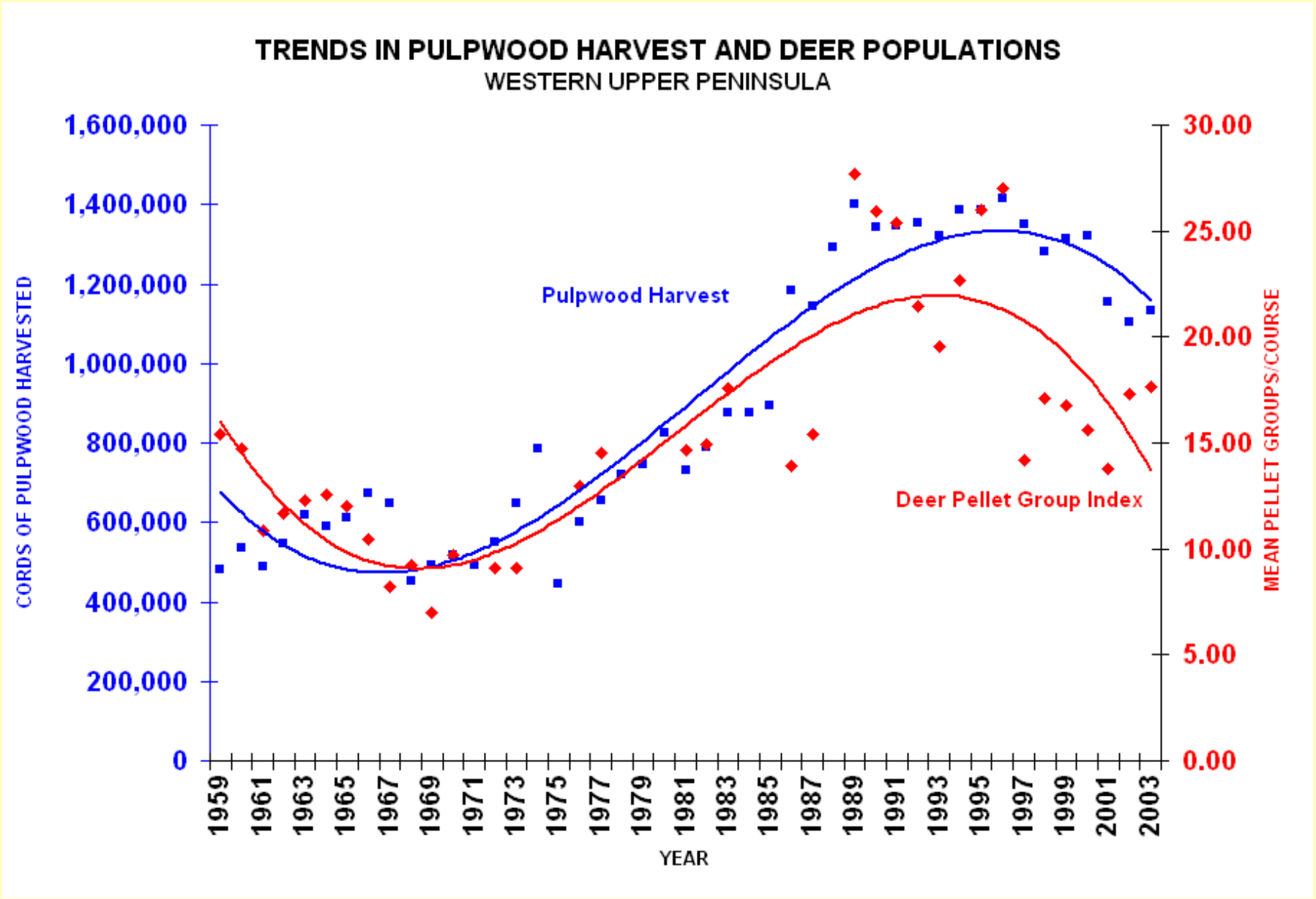
Why are deer so abundant?

- **Bottom-up**: Increased carrying capacity (K)

Deer thrive in the right habitats

Aldo Leopold

- “Game is a phenomenon of edges” “The way to manage game is to manage habitat”
- Early successional trees like **aspen**, ‘wildlife openings & logging tops
- Lots of **Ag fields** in S Wisconsin
- Folks **feed** deer in winter



Bob Doepker, Mich DNR

Foresters know how timber varvests affect deer populations . .

What are the cumulative effects of such management?

Why are deer so abundant?

- ✓ **Bottom-up**: Increased carrying capacity (K)

- Could also be:
  - **Lateral**: No ungulate competitors
  - **Top-down**: Fewer Predators

Shifts in large mammals

Moose

Cougar

Before European settlement:

Predators:

cougar, wolf, wolverine

Ungulates:

Moose, Woodland Caribou
Elk, and White-tailed Deer

Woodland caribou

Elk

Deer

Wolf

Shifts in large mammals

After European settlement:

Predators:

cougar, wolf, wolverine

Ungulates:

Moose, Woodland Caribou
Elk, and White-tailed Deer

Deer ~1.7 Million

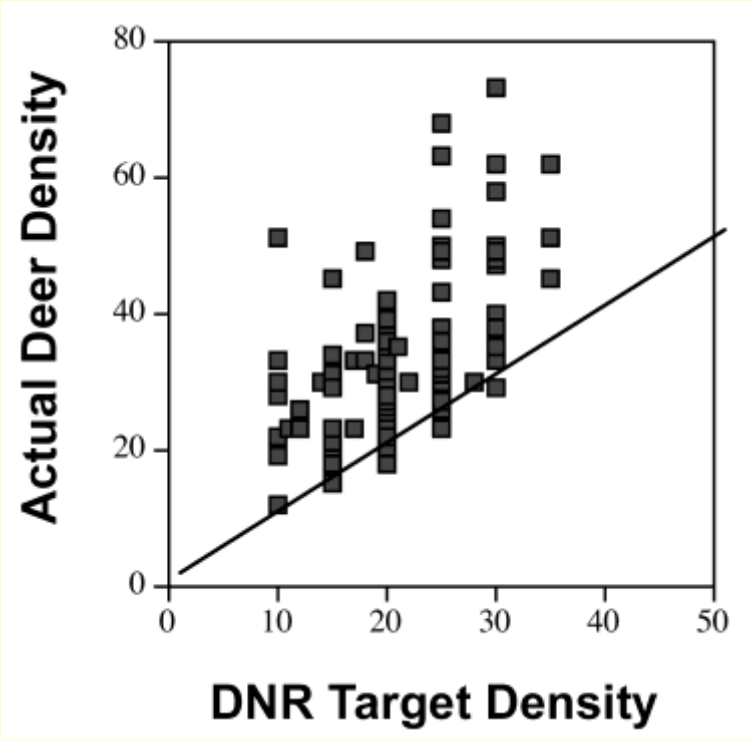
~800 in 2017

Why have deer herds grown?

- Excellent **habitat** conditions
- **Mild winters** - warmest on record

- Few **predators**
- **Restricted hunting** – mostly does & strict limits

- Result? Deer: 10 - 40+ / mi^2 - above targets



2011

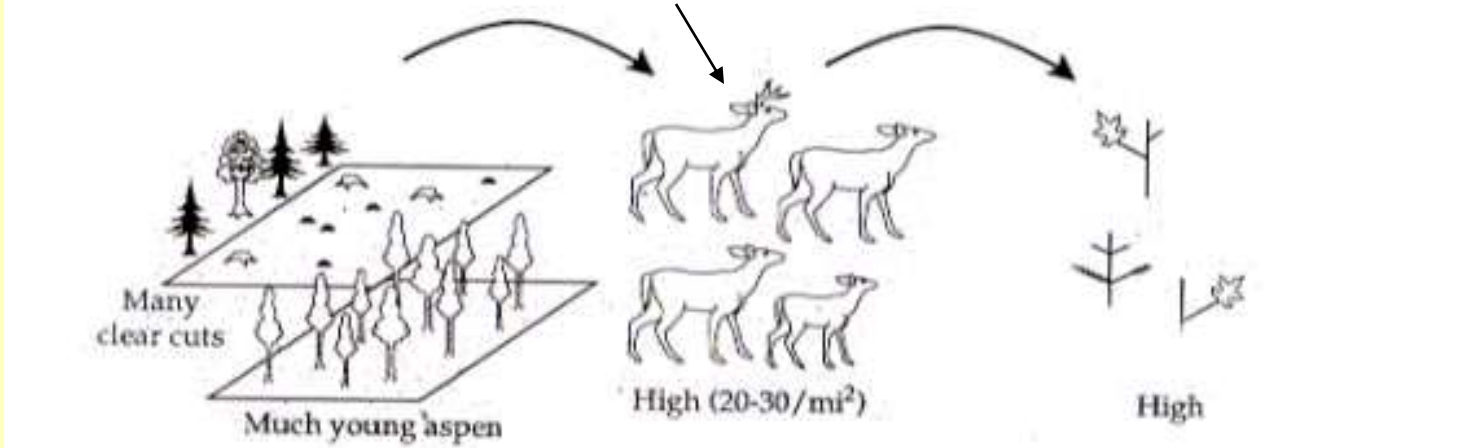
What effects are deer having?

Predators scarce

Before:

Feeding & mild winters

After:



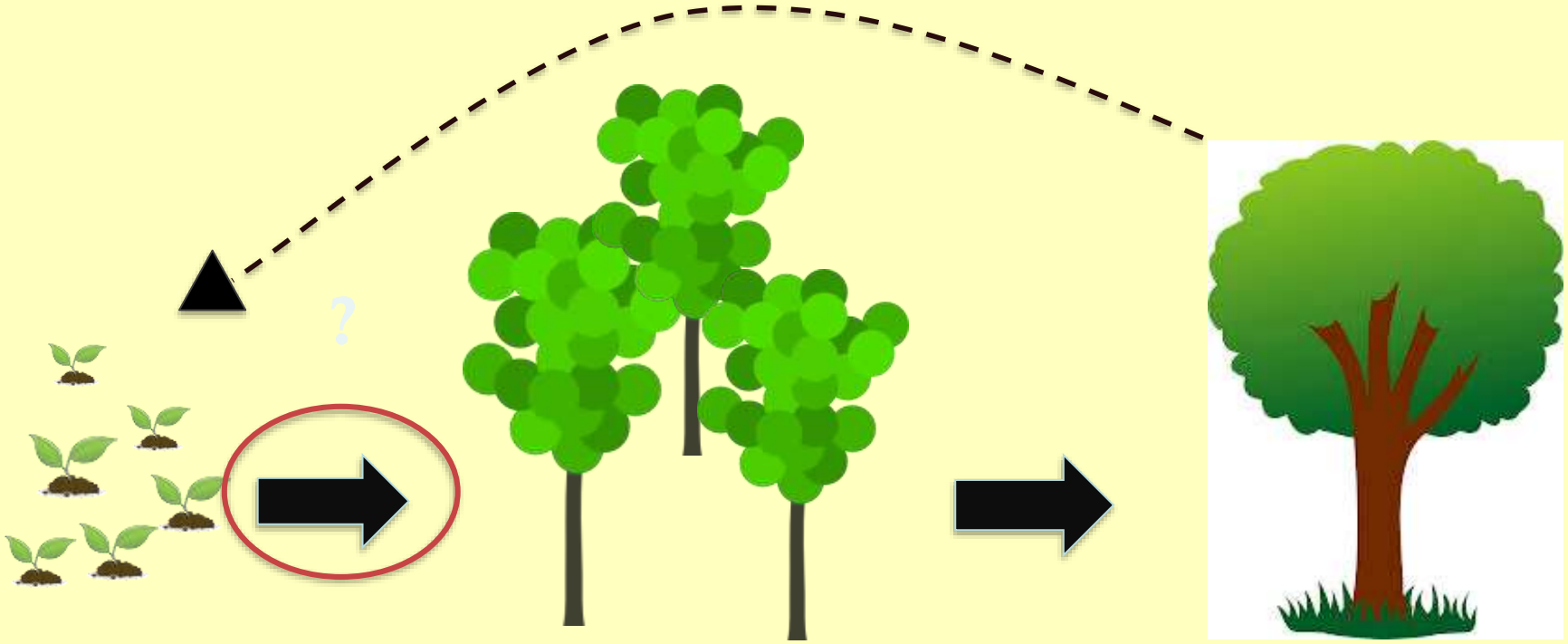
Deer are **browsers** – eat twigs

+ grazers . .

What is recruitment?

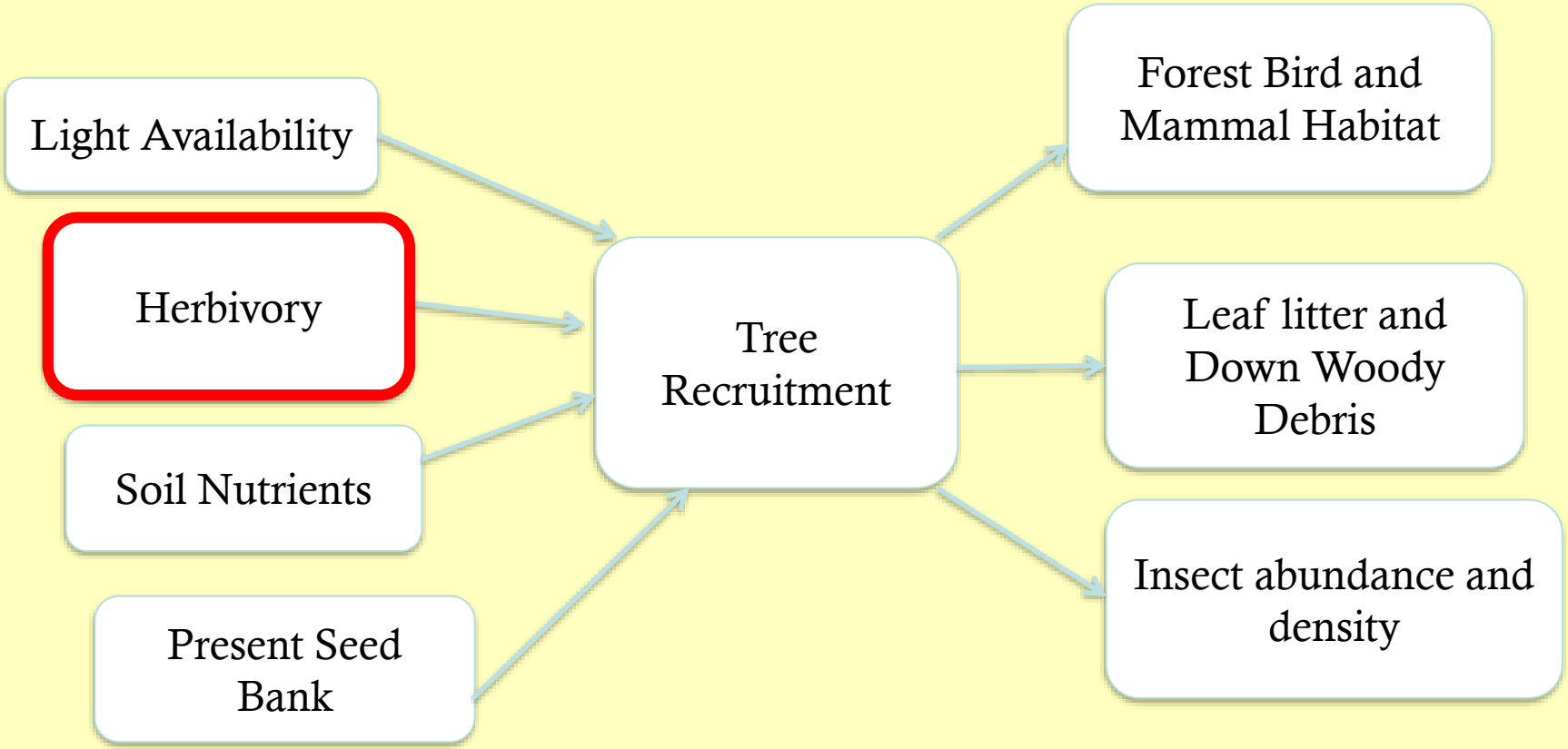
"…the process of adding new organisms to the population…"

Merriam Webster



Components of Successful Recruitment?

Sometimes it's hard to figure out what limits recruitment



Waller & Alverson 1997; Rooney & Waller 2003

Are deer affecting oak regeneration?

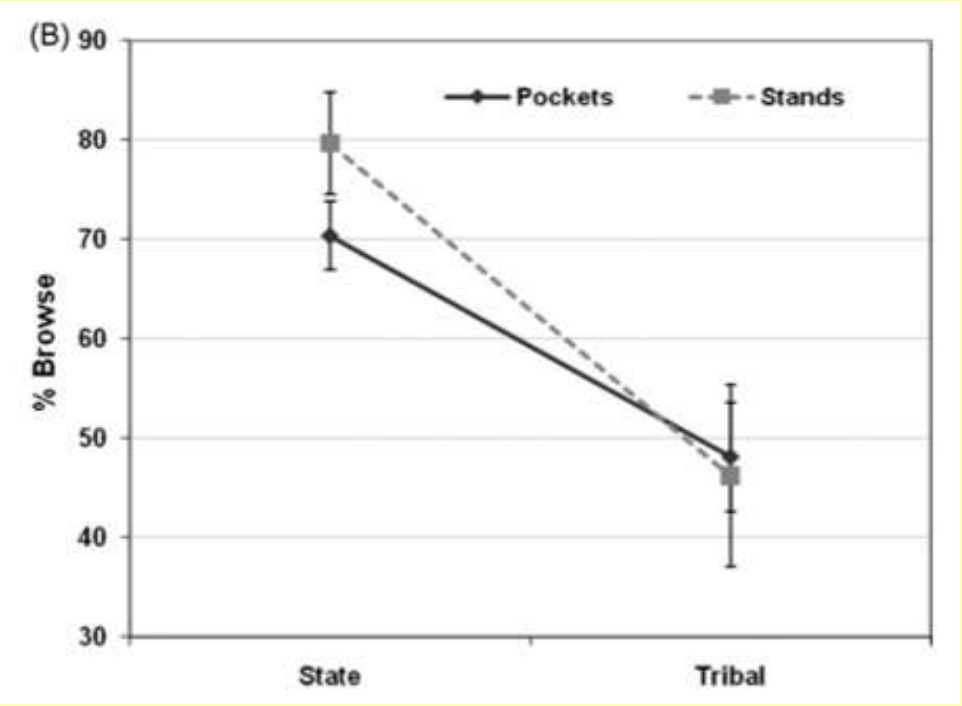
‘Bonsai’ oak ~25 years old
Polk Co., Dave Clausen

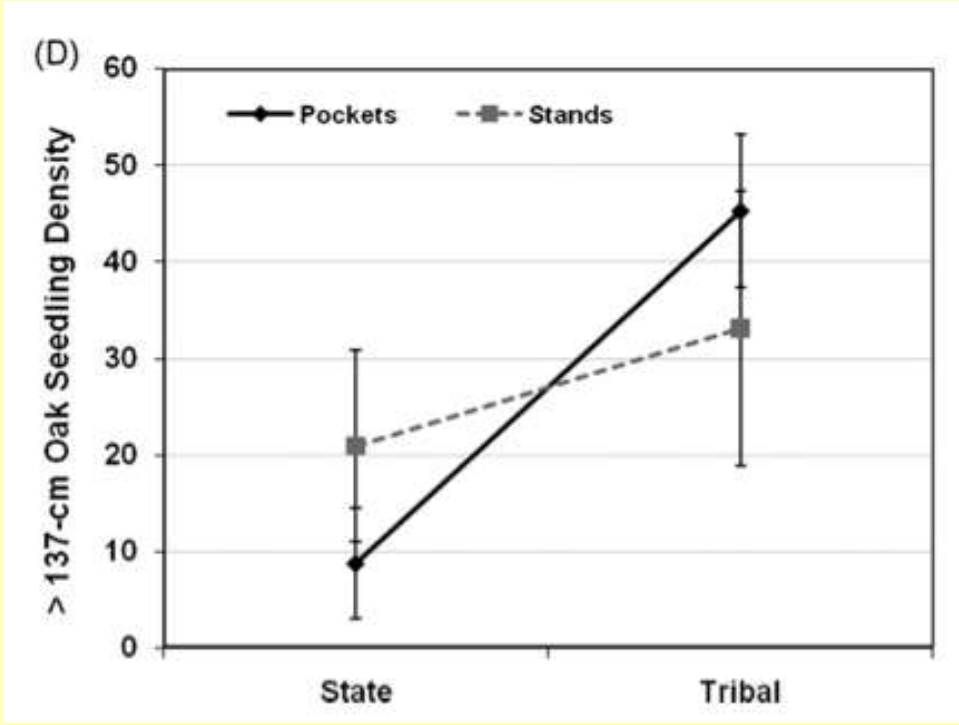
Sometimes it isn’t hard . . .

Nick Reo & Jason Karl 2010

Forest Ecology & Mgmt

particularly in oak pockets. If herbivory levels are too high, even with adequate light, our results suggest that seedlings may not survive in densities sufficient to maintain northern red oak as a co-dominant species in mixed forests. However, when deer densities are kept at 2–4 deer km^{-2}, our results suggest that northern red oak seedlings can survive beyond browseable heights in sufficient numbers for maintaining oak. Tribal lands can provide contemporary examples of longstanding low to intermediate deer densities and sustainable deer–forest relationships.





Reo & Karl 2010

less of management unit size. This result suggests that when deer densities are kept at 2–3 km^{-2}, and given sufficient understory light, resource managers can successfully regenerate northern red oak. This is a noteworthy finding given the widespread hardwood regeneration failures reported elsewhere. For this >137 cm seedling height class, seedling density (number of seedlings/ha) was more highly correlated with percent browse ($r = -0.353$) than canopy openness ($r = -0.073$) (Fig. 5) suggesting further that herbivory played an important role in determining northern red oak seedling survival in this study.

deer–forest relationships. Managers of public lands, such as the Wisconsin DNR, are not able to replicate tribal hunting management programs because their work is situated in significantly different socio-cultural and political contexts. However, to sustain wildlife and forest assets, managers of public lands will need to find their own context-appropriate mechanisms for reducing deer densities.

Fewer deer on Indian reservations → improved hemlock regeneration

Fig. 3. Changes in deer density between 2002 and 2013 on two Ojibwe reservations and surrounding lands. Lower solid lines (circles) show DNR estimated deer densities in the Bad River (a) and Lac du Flambeau (b) reservations. The upper dotted lines (+ symbols) show mean estimated deer densities for the adjacent the Deer Management Units (DMUs). Estimates are based on the sex-age-kill model as implemented by the Wisconsin DNR.

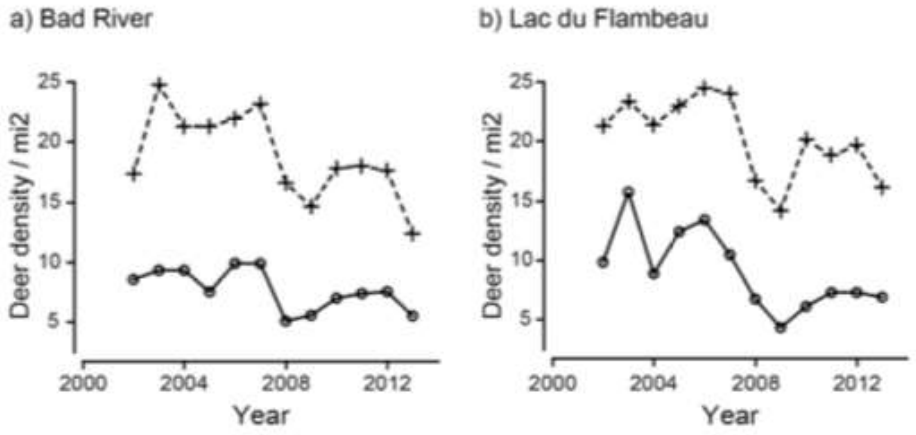
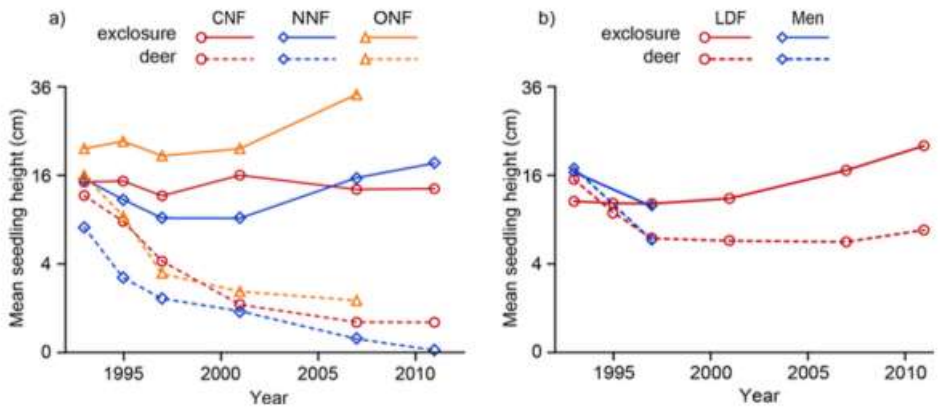
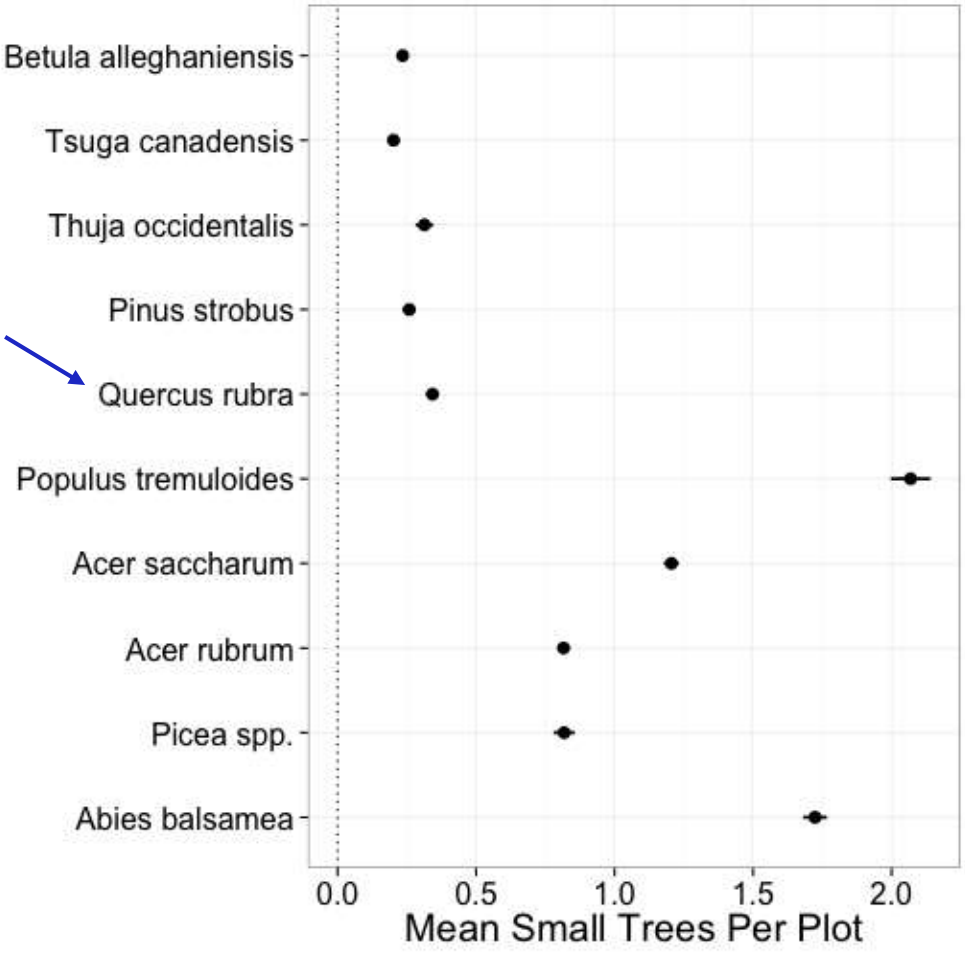


Fig. 4. Trajectories of growth in mean height in eastern hemlock (*Tsuga canadensis*) seedlings growing in and outside fenced exclosures located in three national forests (a) and two tribal reservations (b). Upper solid lines show mean hemlock heights (square root transformed) inside the exclosures. Seedling growth and survival are restricted by deer browsing far more within the national forests than in the tribal lands. Abbreviations: CNF = former Chequamegon National Forest; NNF = former Nicolet NF; ONF = Ottawa NF; LDF and Men = Tribal lands. Note: seedlings on the Men reservation were not tracked after 1997. Source: Alverson, Lea, and Waller, *unpublished data*.



Palatability affects tree recruitment

Highly Preferred by deer



Less Preferred

Yellow birch

Hemlock

N white cedar

White pine

Red oak

Aspen

Sugar maple

Red maple

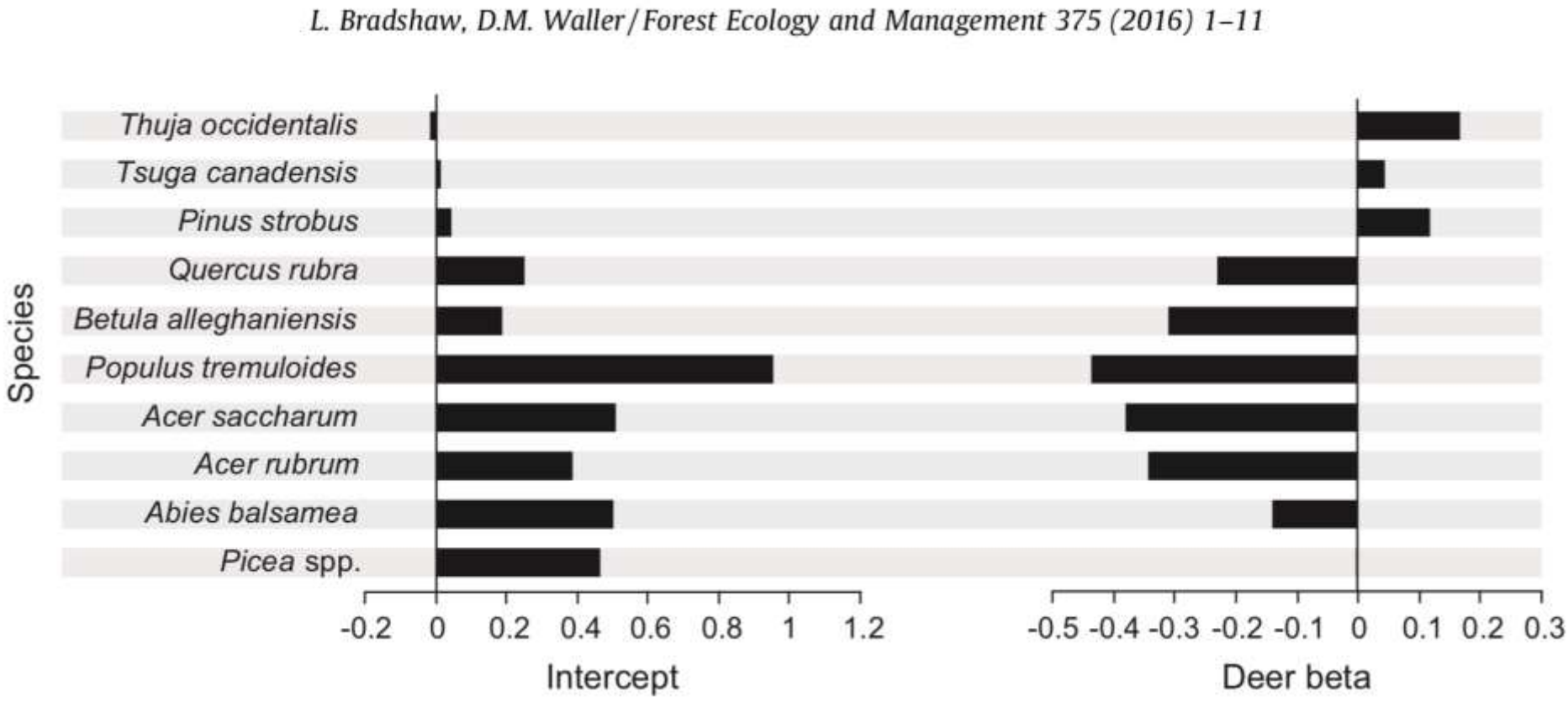
Spruce

Balsam fir

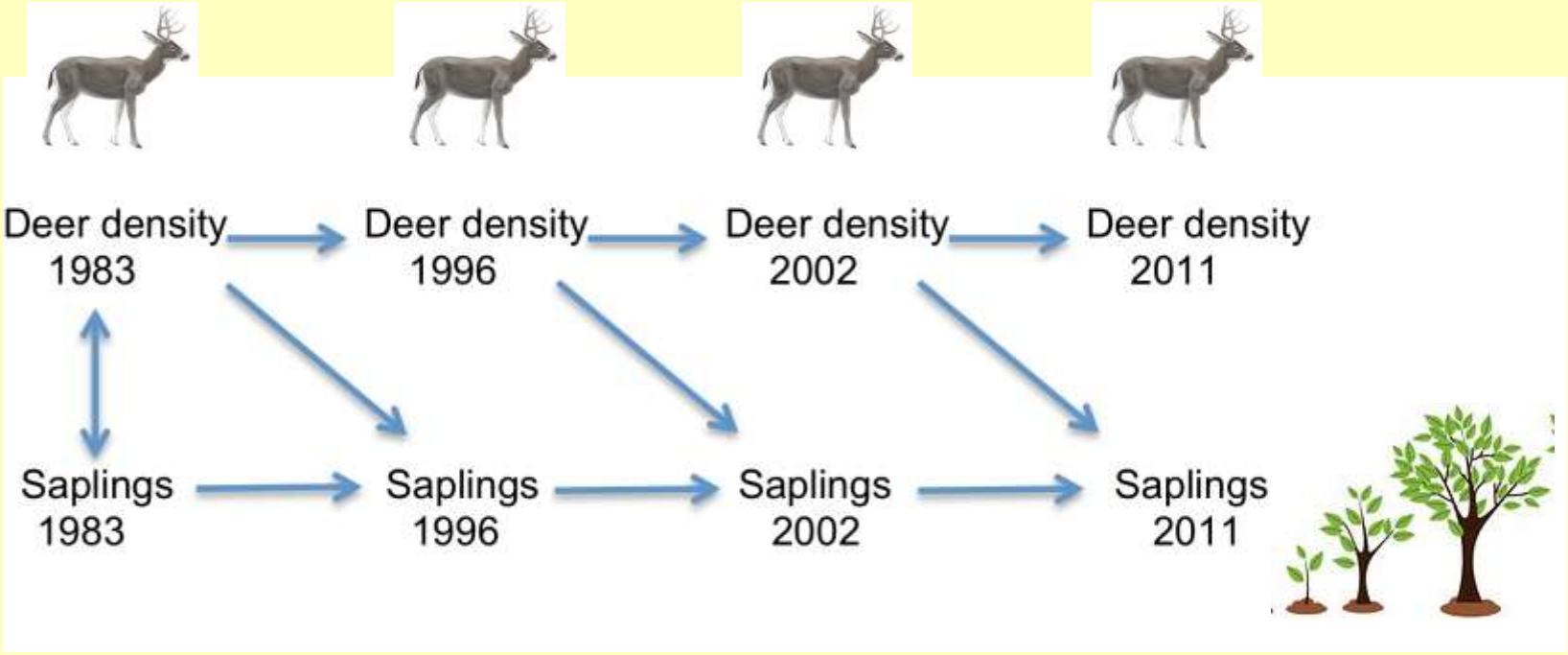
Bradshaw & Waller, 2016.

Bradshaw & Waller 2016

- "Saplings of red oak (*Quercus rubra*) and yellow birch (*B. alleghaniensis*) were low and declined conspicuously in areas/times of higher deer density."



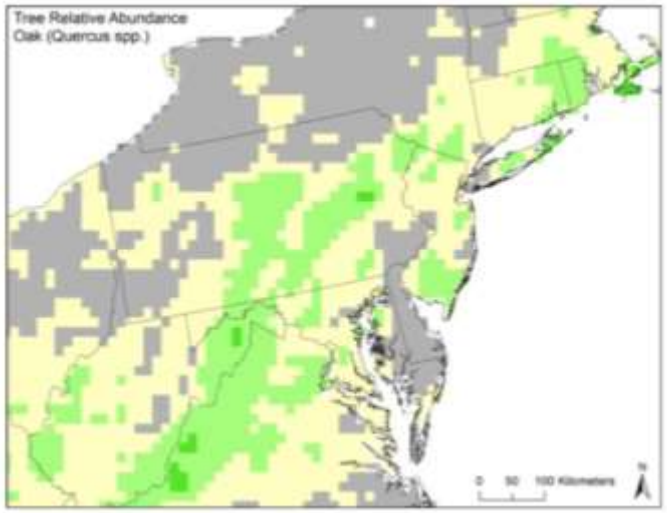
Deer have cumulative impacts on regional forest tree recruitment



Deer are having extensive, pervasive, and long-lasting impacts on which tree species are able to recruit into the canopy.

L. Bradshaw & D.M. Waller 2016. Forest Ecology & Mgmt.

Red oak in eastern U.S. – Miller & McGill

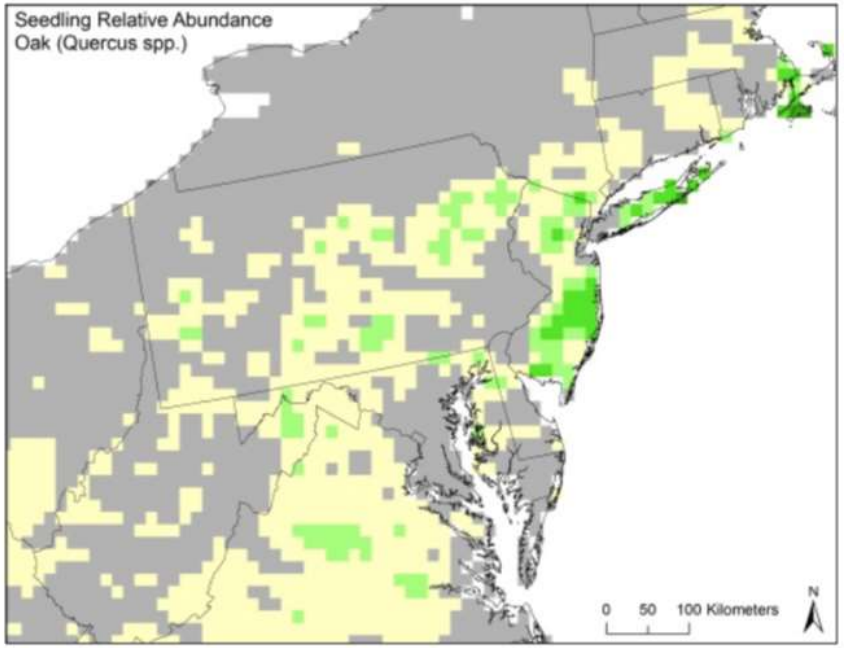


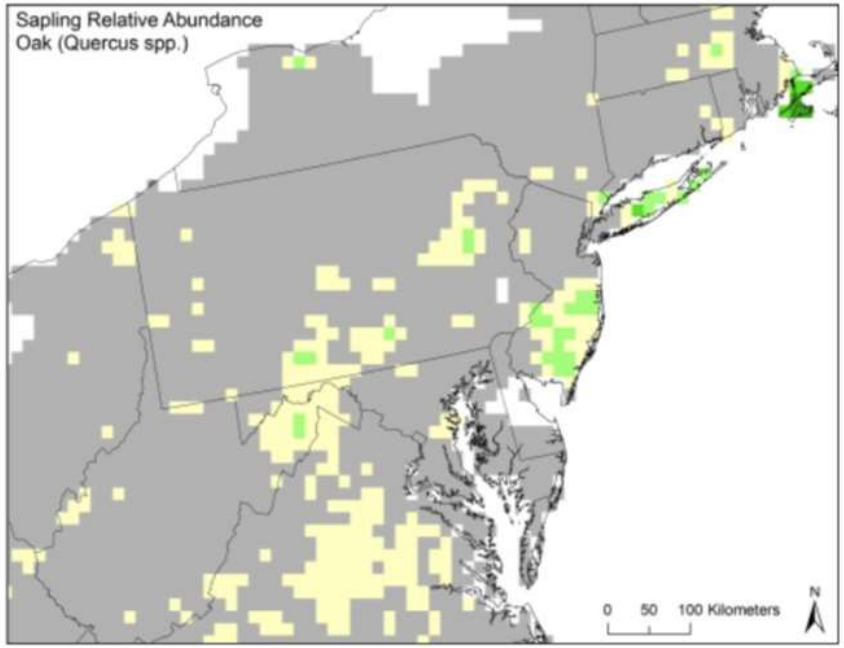
Adult trees

Based on 13 000+
USFS FIA plots

Seedlings

Saplings

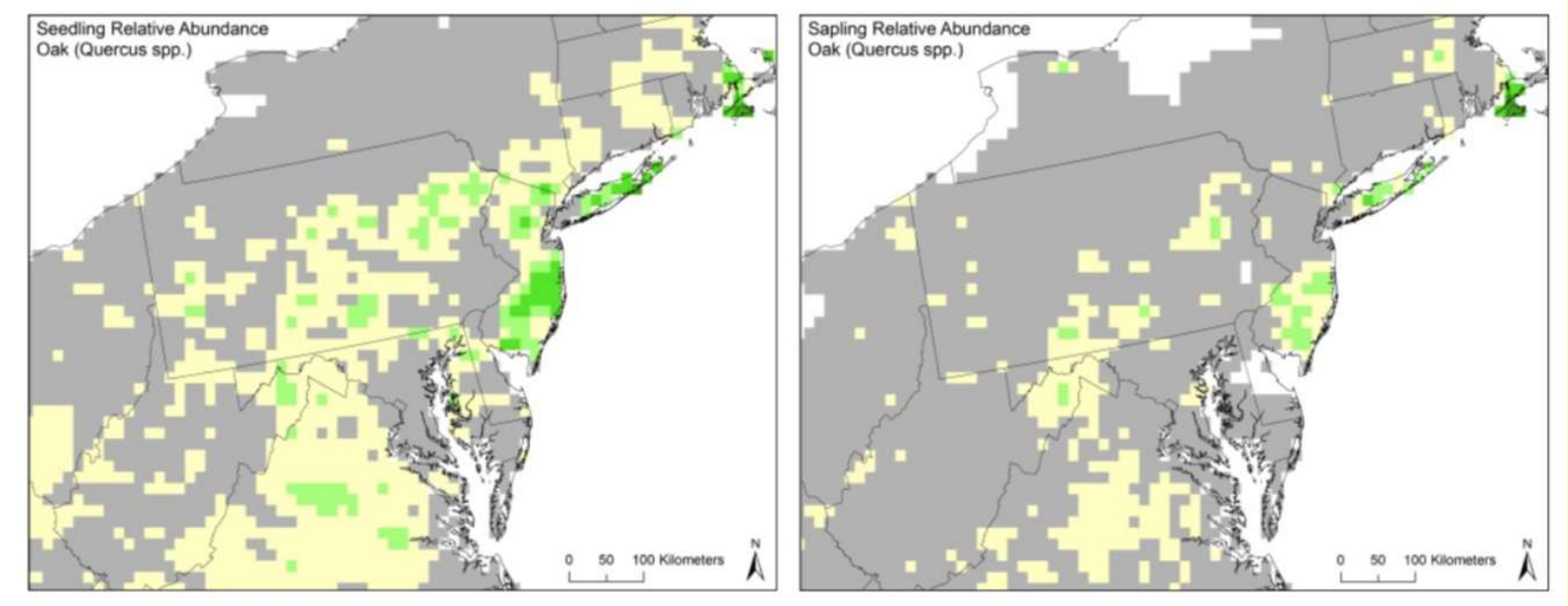




Red oak in eastern U.S. – Miller & McGill

"regeneration was both severely lacking, and where present, was composed of **suboptimal species**, such as disease-prone or low canopy species.

*"Without management, the **regeneration debt** we identified in the mid-Atlantic region could lead to **widespread loss in forest cover** that will have cascading effects on forest-dependent taxa and ecosystem services."*

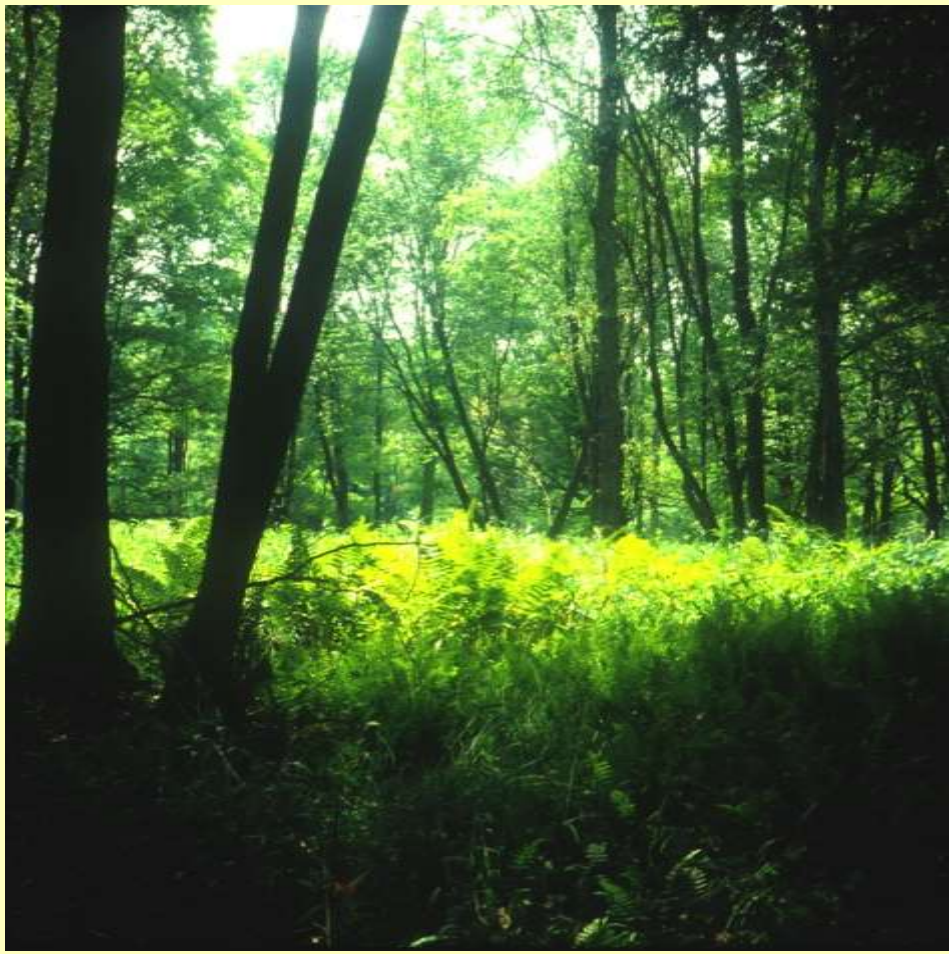


Long-term effects of browsing?

- Lose trees => savanna
- Ferns take over . .
- '**Fern Parks**' develop, as in parts of Pennsylvania

  >20 deer/km^2 for 30+ yrs

Future of Wisconsin forests?



Allegheny plateau, PA

Deer favor invasions

Deer prefer to eat pretty wildflowers and avoid weedy invasive plants . .

Biodiversity, exotic plant species, and herbivory:
The good, the bad, and the ungulate

Marty Vavra *, Catherine G. Parks, Michael J. Wisdom

Pacific Northwest Research Station, USDA, Forest Service, La Grande Forestry and Range Sciences Laboratory, 1401 Gekeler Lane, La Grande, OR 97850, United States

defoliation had no effect. By contrast, Parker et al. (2006) summarized results from 63 manipulative studies of exotic plant invasions as affected by a wide spectrum of ungulate and non-ungulate herbivores. These authors concluded that herbivory by non-native herbivores facilitated exotic plant invasions, while feeding by native herbivores facilitated resistance to such invasions. Parker et al. (2006), however, did not separate results for ungulates from other herbivores, and thus the strength of native versus non-native ungulate effects on this pattern was not clear.

Deer impacts on birds?

ovenbird

A natural experiment on the impact of overabundant deer on songbird populations

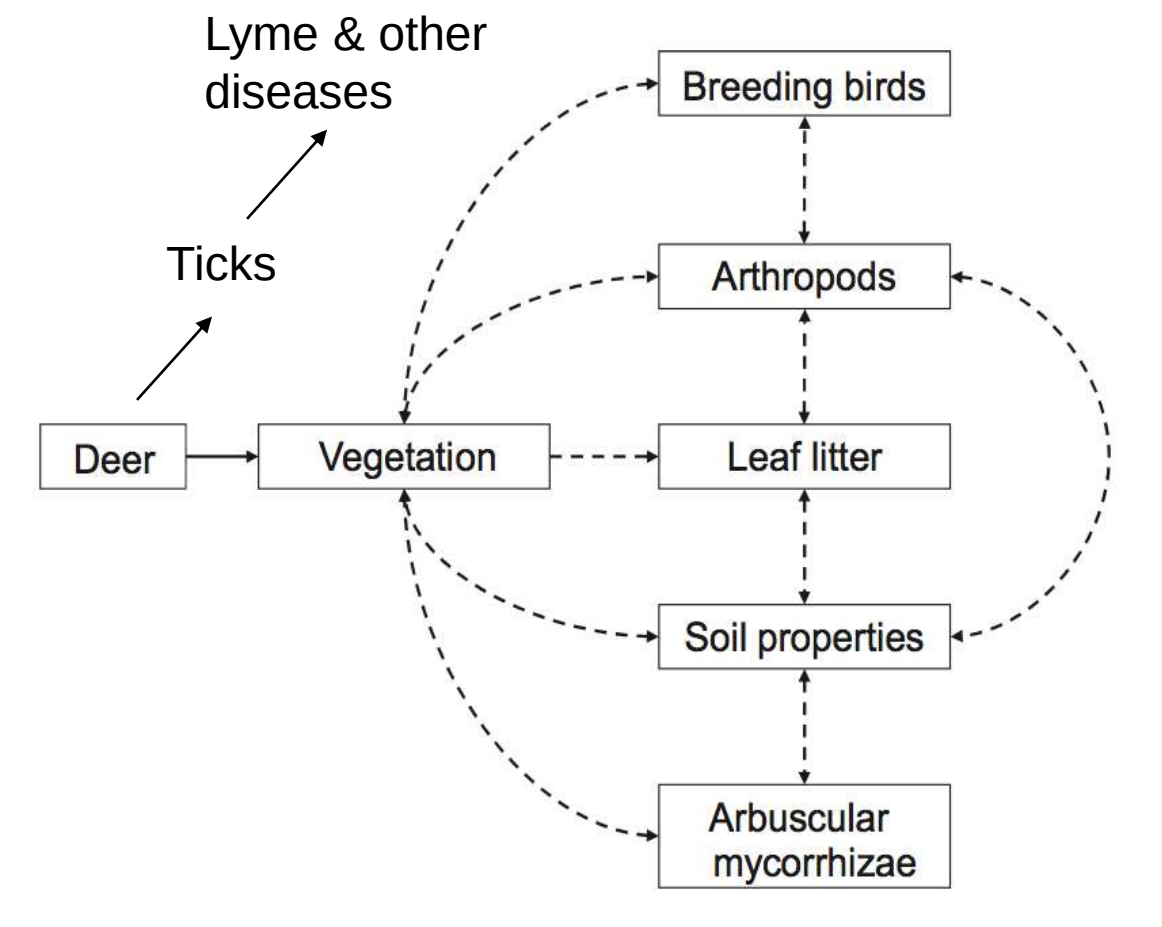
Sylvain Allombert [a], Anthony J. Gaston [b], Jean-Louis Martin [a,*]

and an index of deer impact were available. In the six islands data-set, songbird abundance on islands browsed for more than 50 years was 55–70% lower than on deer-free islands. There was a significant decrease in alpha diversity on islands browsed by deer, but gamma diversity remained unchanged. Bird species with the highest dependence on understorey vegetation were most affected and their abundance decreased by 93%. Bird communities flipped from being 73% dependant on understory vegetation on deer-free islands to 79% not dependant on understory vegetation on islands with deer for more than 50 years. A canonical correspondence

Are songbirds declining because of deer?

Deer = a keystone herbivore

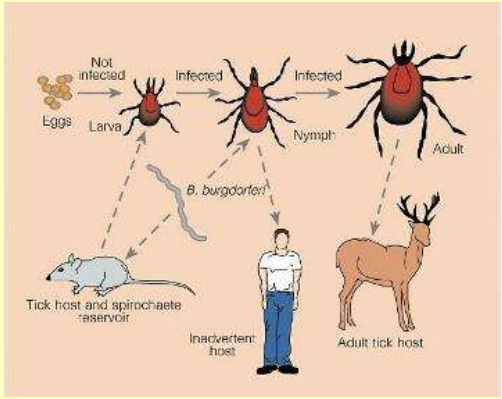
- Deer affect many species via:
  - Browsing
  - Limits tree regeneration
  - Sparse understory
  - Soil compacted
  - Nutrient cycles accelerate
  - Other effects . .



The Deer Dilemma . . .

- A **local** problem?
  - **No** - chronic over much of E. North America
- A **minor** problem?
  - Not just one or a few species -- whole guilds & communities are affected
  - Posing **health** & **safety** risks
- A **temporary** problem?
  - **No** -- Effects persist for **decades**
  - Forest understories recover **slowly**
- *So what should we do?*

40,000 accidents
Lyme disease



What can we do about deer impacts?

- Your ideas?

What should we do about deer impacts? How can we reduce these?

- Re-empower scientific management
- Enhance hunter recruitment
- Enhance hunting effectiveness
- Enlist “Citizen Scientists” as partners
  - for education and to generate data

- Other ideas?

Summary: managing deer

	20th century	Current	Proposed
Focus:	Deer – as game animal	Deer – as game animal	Habitats + ecolog. conditions; trophic interactions
In control:	Professional game biologists	Local deer mgmt groups (hunters & game managers)	Teams of game & forest ecologists + broad public
Goals:	Max sustainable yield (K/2)	Sport hunting opportunities	Sustainability & biodiversity
Monitor:	Deer densities (model & data)	Intermittent & local (mostly deer)	U'story habitats - tree regen., divers.
Manage by:	Sex of deer hunted; expand/restrict take (doe permits, EAB, . .)	Restrict doe hunting to ⇧; ?? to ⇩	Expand/restrict take + predators + habitat mgmt.
Issues:	Complex; led to distrust	Even less science & data	Requires public support & involvement