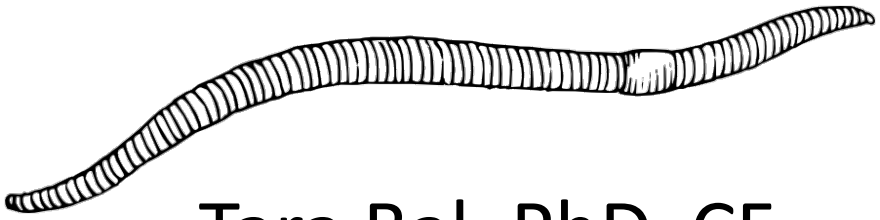
Forest Regeneration Issues – Invasive Earthworms

Sustainable Forestry Conference
Florence, Wisconsin 2018



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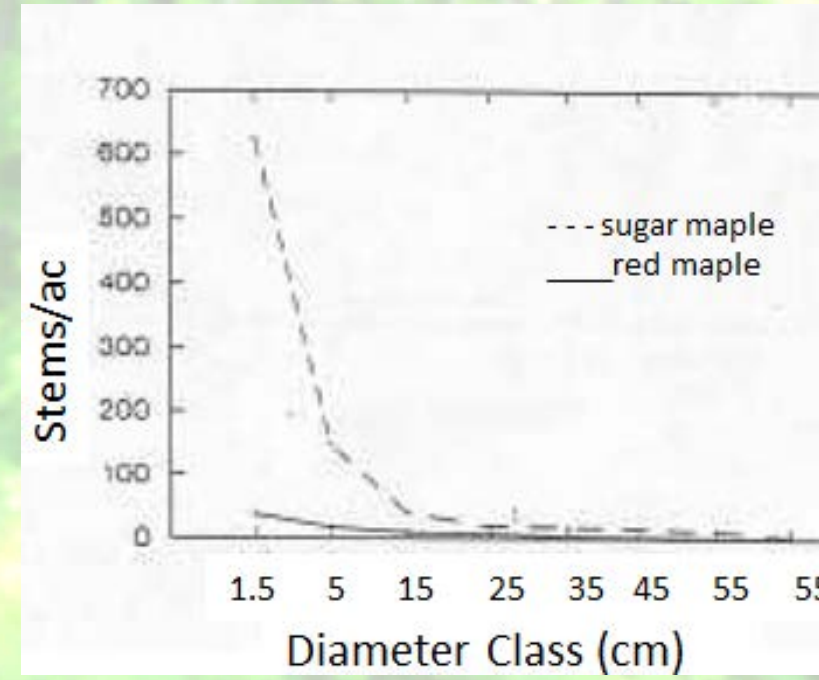
Outline

Forest Regeneration and Earthworms

- Background
  - Regen Ecology
  - Known Factors for Failure
- Maple Health Monitoring
  - Dieback/Decline
  - Regeneration Correlates
- Interactions of Factors
- Worm Info
- Management Strategies

Regen Ecology- Maple

- Classic shade tolerant
- Large #'s seeds every 2-3 years
- # of seeds correlated with size/density, not age
- Common, 50% seedling mortality 1 year
  - 85% after 5 yrs only 2 leaves (Gardescu, 2003)
- Can survive >30 yrs at <1m height
- Common, 150,000/acre seedlings



Demographic curves, Dukes Research Forest, Marquette, MI (Kerry Woods). In Jenkins et al., 1997

Sugar Maple Regen Failure

Recruitment failures (no saplings in understory)

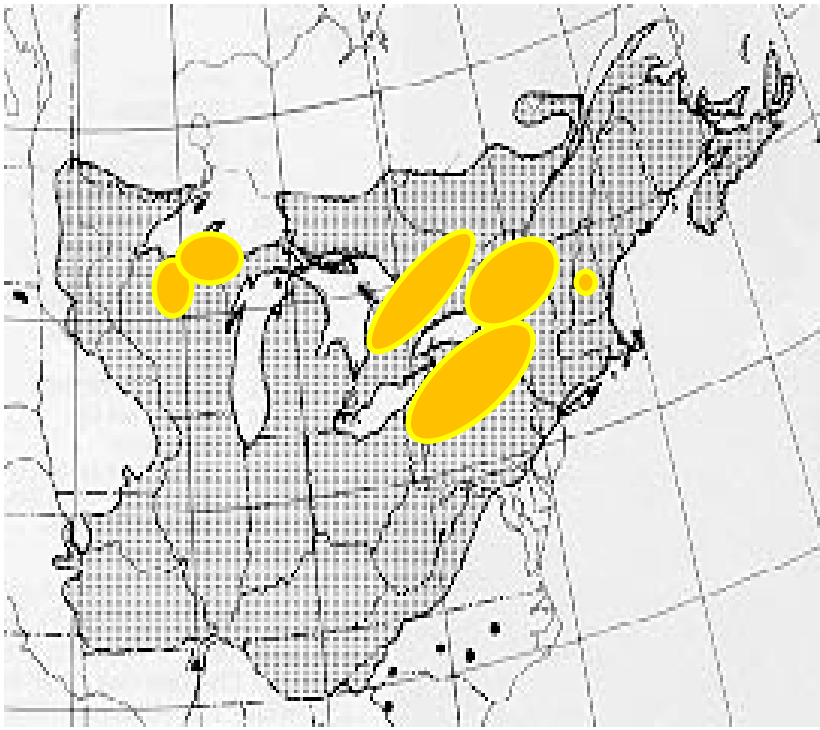
Regeneration failures (Seedlings either do not emerge or exhibit excessive, early mortality)

- Previously reported on private/public lands, even old-growth forests
- Reports of sugar maple regen failure relatively recent, particularly in midwest unless deer…

Sugar Maple Regeneration Failure

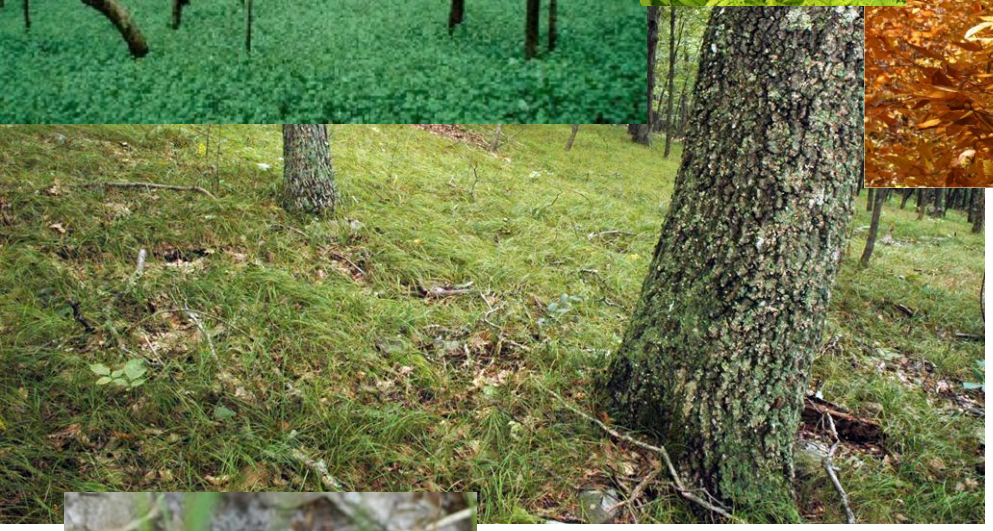
Where has this been studied? (examples)

- **RESEF network, Quebec, Canada**
  - Duchesne et al, 2005
- **Adirondacks, NY**
  - Gardescu 2003, Jenkins 1999
- **Hubbard Brook Exp. Forest, NH**
  - Juice et al, 2006
- **Alleghany National Forest, PA**
  - McWilliams et al, 1996
- **Chequamegon-Nicolet NF, WI**
  - Powers, Nagel 2009
- **Upper Peninsula, MI**
  - Matonis et al, 2011, Donovan 2005, Bal et al 2017



- TAKE AWAY: May be northern hardwoods but *many different* conditions, abiotic and biotic – local!

Factors Associated with Maple Regeneration Failures



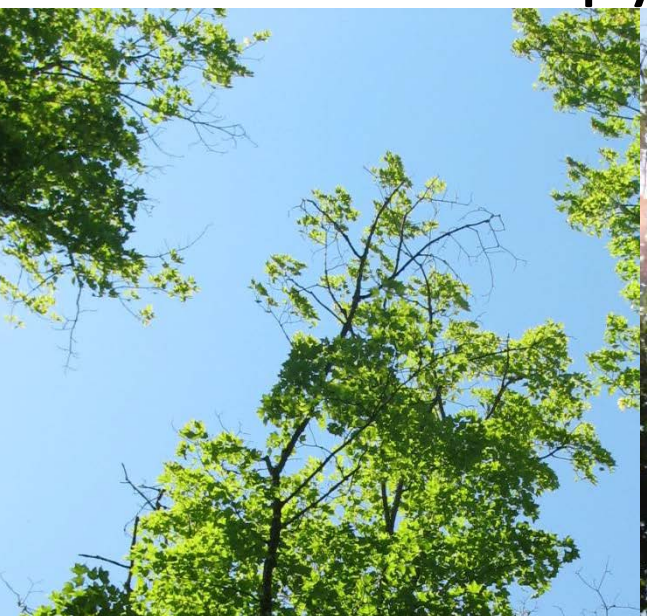
Reported SM Dieback Etiologies

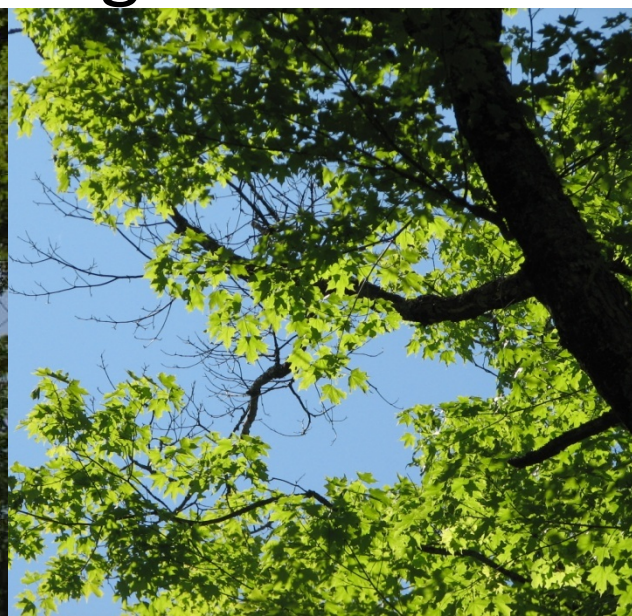
- soil nutrition and moisture
- extreme weather events
- atmospheric deposition
- highway salt
- defoliating insects- i.e. pear thrips
- management activities
- sugar maple borer
- *Armillaria* spp. and decay

Horsley et al., 2002; Houston 1992; Whitney 1999: Bailey et al., 200

Why is Maple Decline on the Radar?

- Severe dieback noted in UP MI by area foresters, beginning ~2005
  - MI, WI DNR Forest Health Highlights, ~2012-15
- High Value of Sugar Maple
- Concern about management induced dieback?
- Loss of canopy = potential loss of regen?

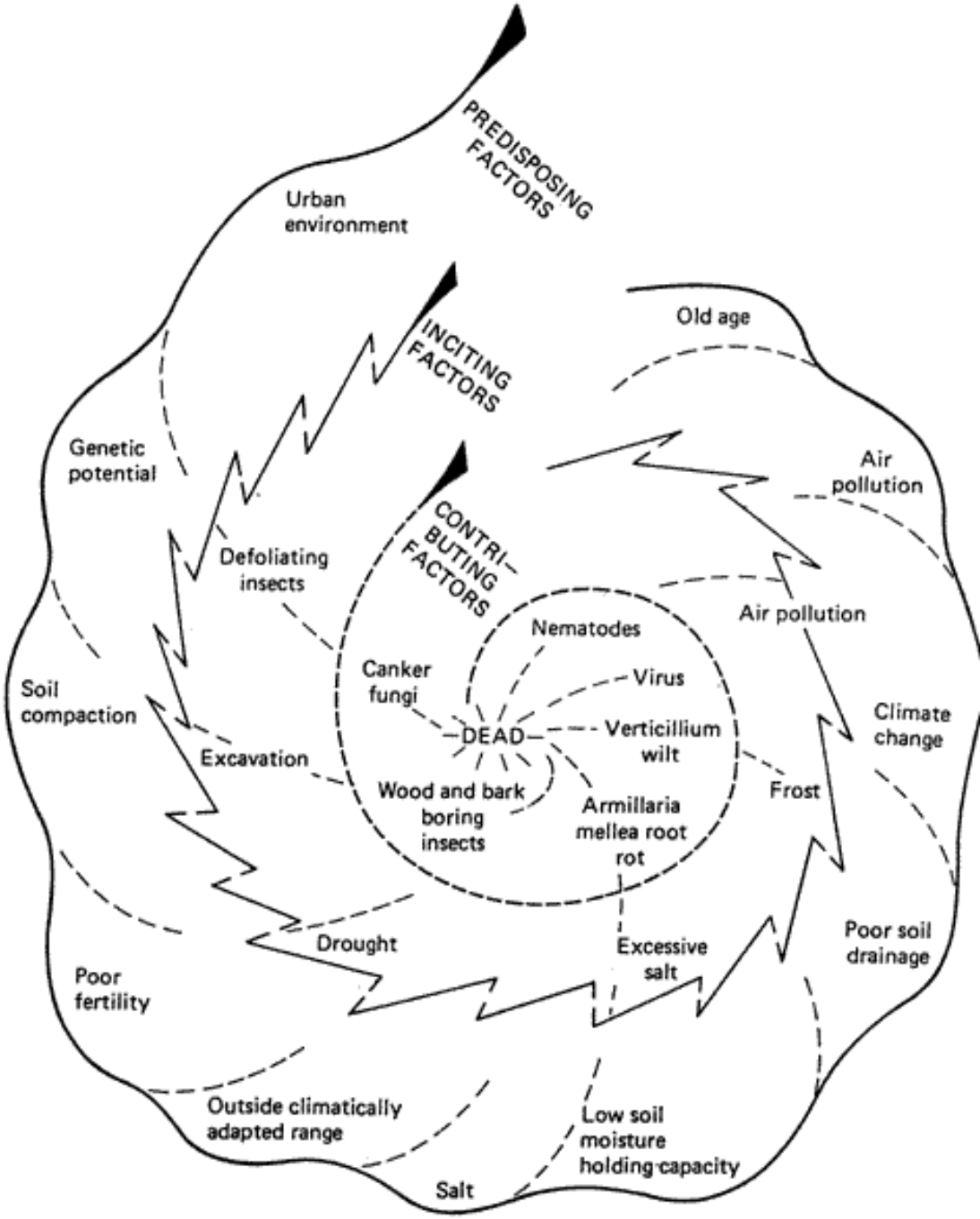




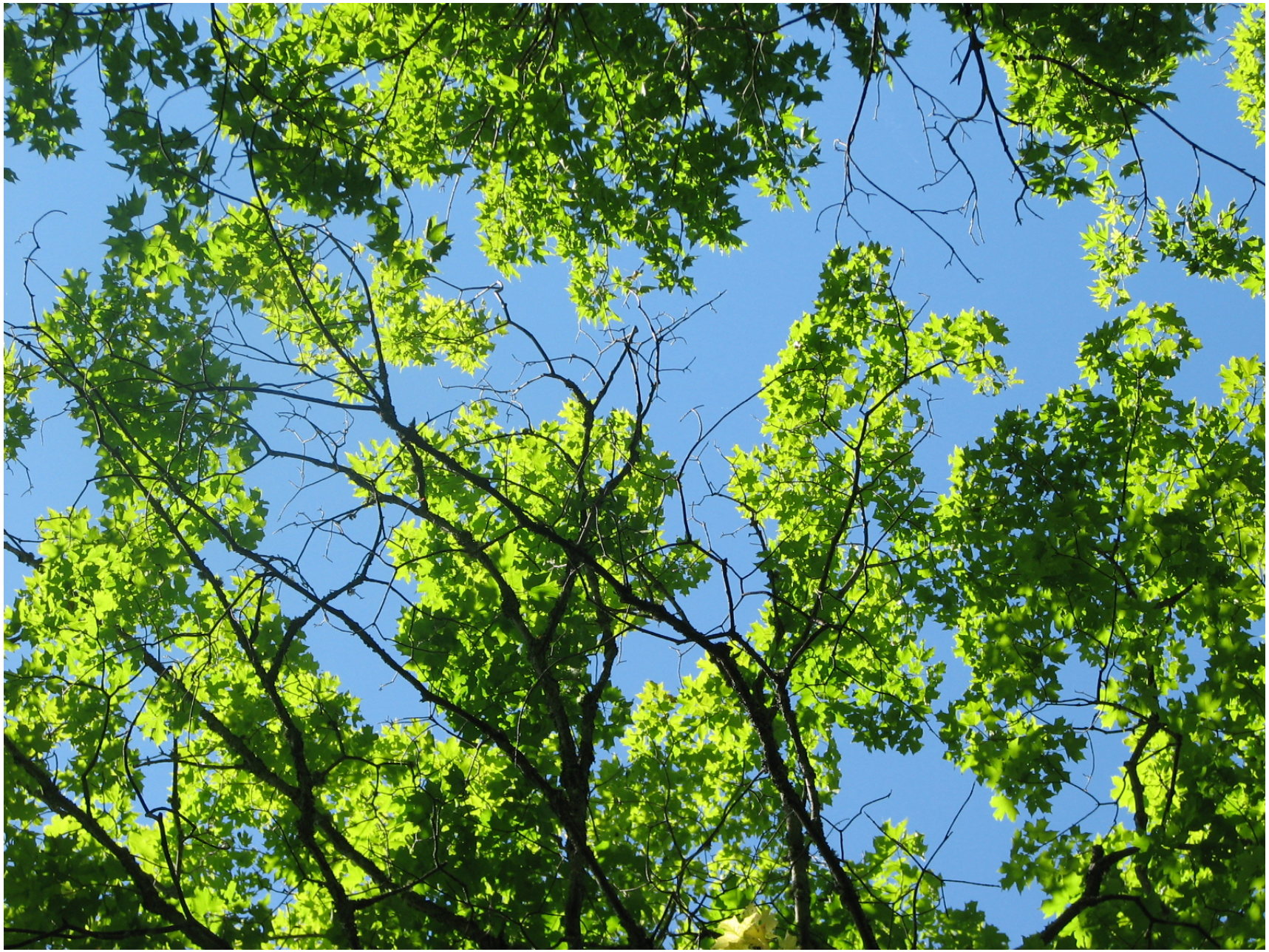
Dieback Defined

Dieback: loss of portions of a crown due to a single factor

Decline: loss of vigor and growth and eventual mortality due to a combination of predisposing, inciting, and/or contributing factors



(Manion 1991; Houston 1992)



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Hazel Swamp Rd, Houghton County, MI, 2010

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Lizzardro Rd, Keweenaw County, MI, 2009

Sugar Maple Dieback Monitoring 2009-2012

Crown & Bole

Growth and Climate

Forest Floor Condition

Sapstreak Investigation

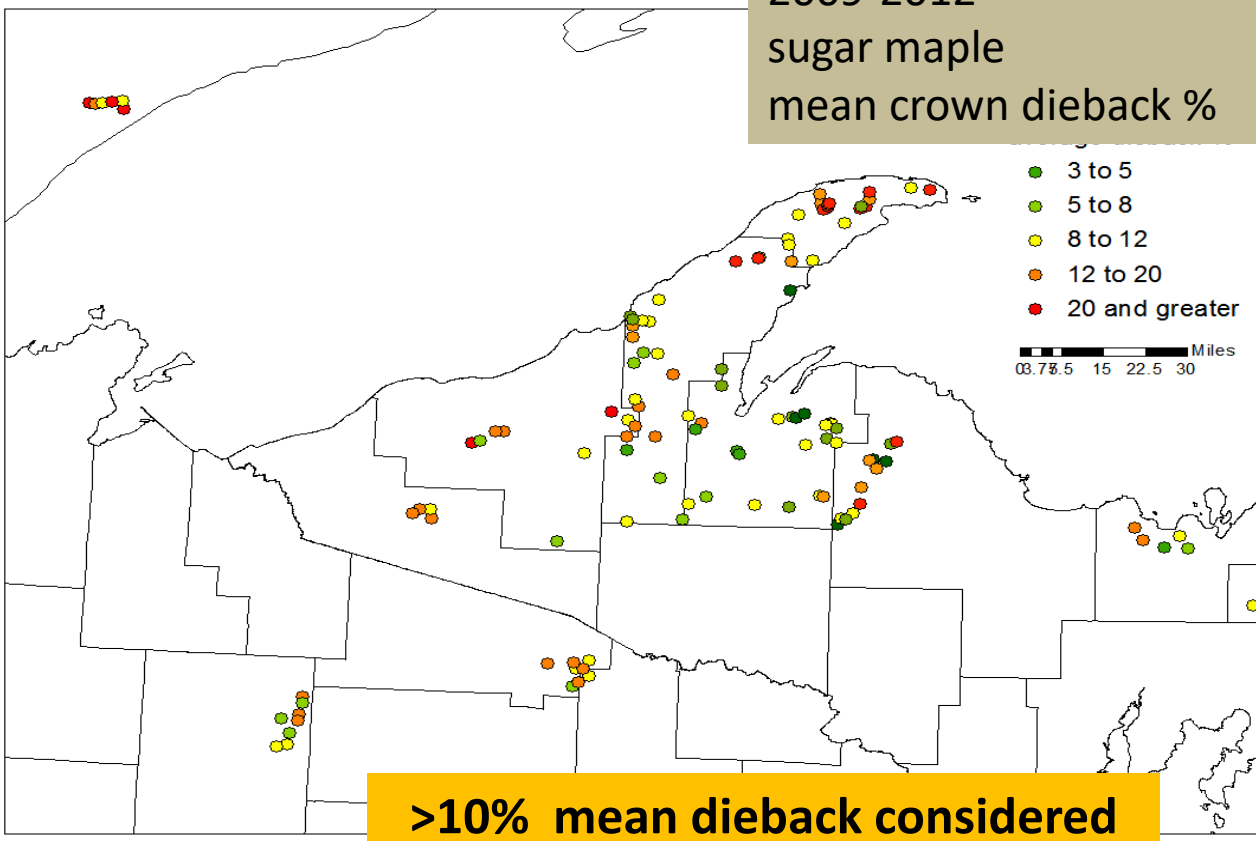
Soil Nutrients

Foliage Nutrients

Regeneration Counts

Herbaceous Comp.

Ownership, Mgmt



>10% mean dieback considered unhealthy in literature!

Sugar Maple Dieback Monitoring

Mean SM regeneration counts (2009-2012)

Modeled plot level variables (n=25):

Significant Variables	p value	Trend Direction
Herbaceous Diversity	0.008	-
Mean SM DBH	<0.001	+

Sugar Maple Dieback Monitoring

Mean SM regeneration counts (2009-2012)

Modeled plot and edaphic variables (n=65):

Significant Variables	p value	Trend Direction
Mean SM Tree Height	<0.001	+
Seedling Mortality Rating	0.001	+
Soil Calcium	0.002	+
Soil Potassium	0.004	-
Soil Ca/Al ratio	0.039	-

*No significant beech component in these plots.

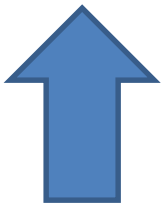
**Did not include deer density.

Modeled Relationships with Dieback

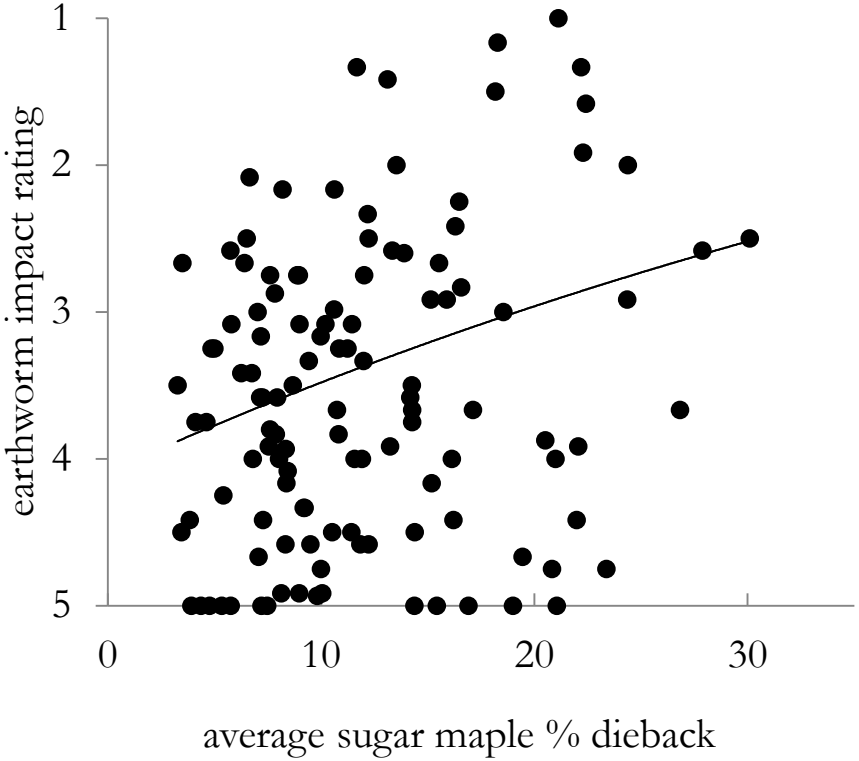
Plot variables with mean crown dieback (2009-2012):

forest floor rating (earthworm impacts), (p=0.014)

1 = heavy impact



5 = no impact



Sugar Maple Dieback Monitoring

mean crown dieback (2009-2012)

Modeled plot and edaphic variables (n=65):

Significant Variables	p value	Trend direction
Forest floor rating (worms)	0.009	+
Soil Carbon	<0.001	+
Soil Manganese	<0.001	-
Herbaceous Cover	<0.001	-

Earthworm Impact Rating

- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5

0 3.5 7 14 21 28 Miles

N

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How are worms measured?

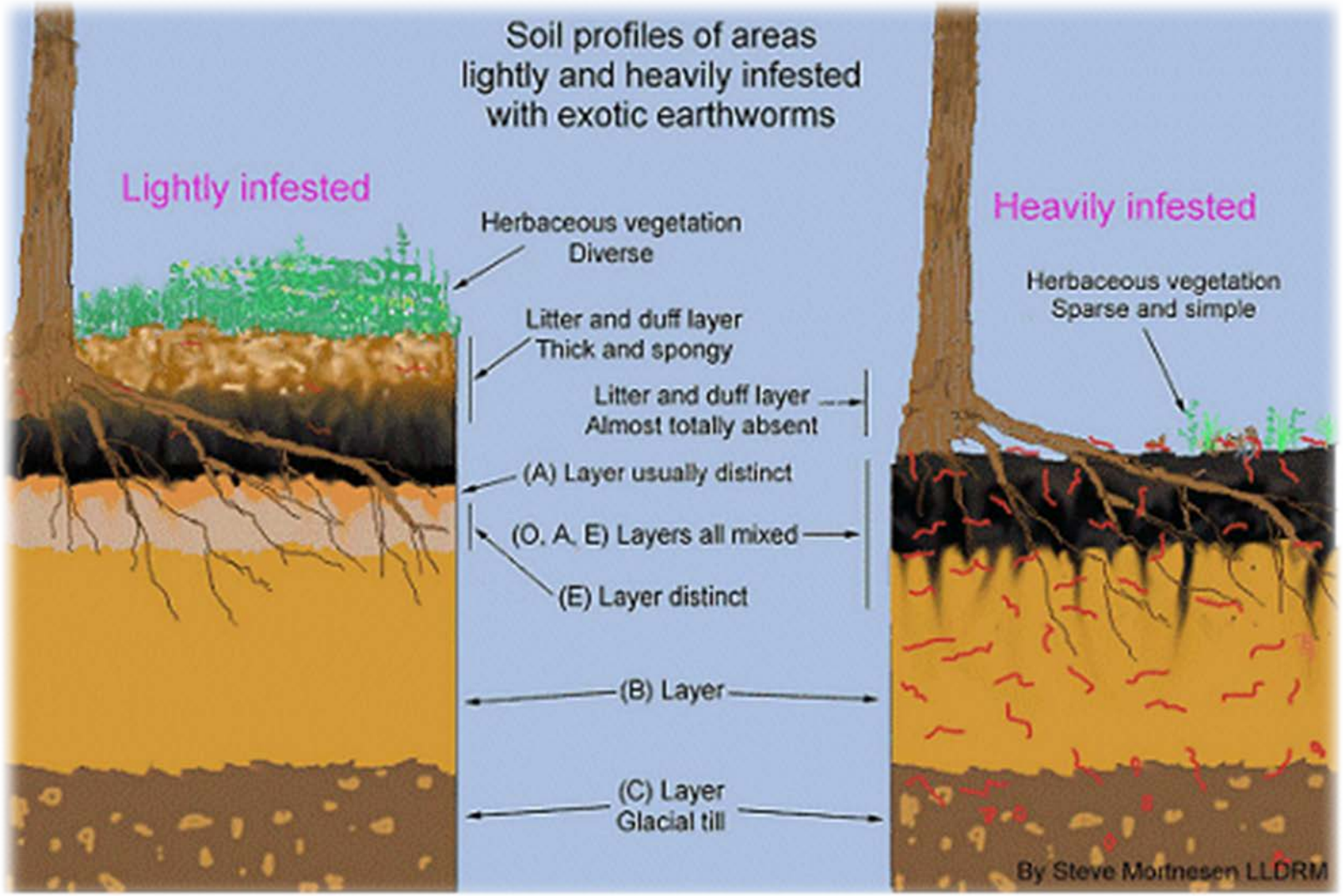
Forest Floor Condition, Earthworm Impact Rating Scale (Lilleskov, USFS)

Rating	Description of class characteristics
1	No forest floor. Previous year's litter over mineral soil. Worm sign abundant.
2	No humus, large old leaves under litter. Worm sign present or absent. Roots absent.
3	No humus. Small leaf fragments, larger old leaves present. Sparse roots. Some worm sign , but rare large casting piles.
4	Humus patchy, may be mixed in soil. Some roots, but not thick. Small worms may be found in the forest floor, but no large castings or middens.
5	Humus fully intact. Roots present in humus and leaf fragments. Forest floor coherent when picked up with intact recognizable layers. No worms or worm sign present.

Worm sign?

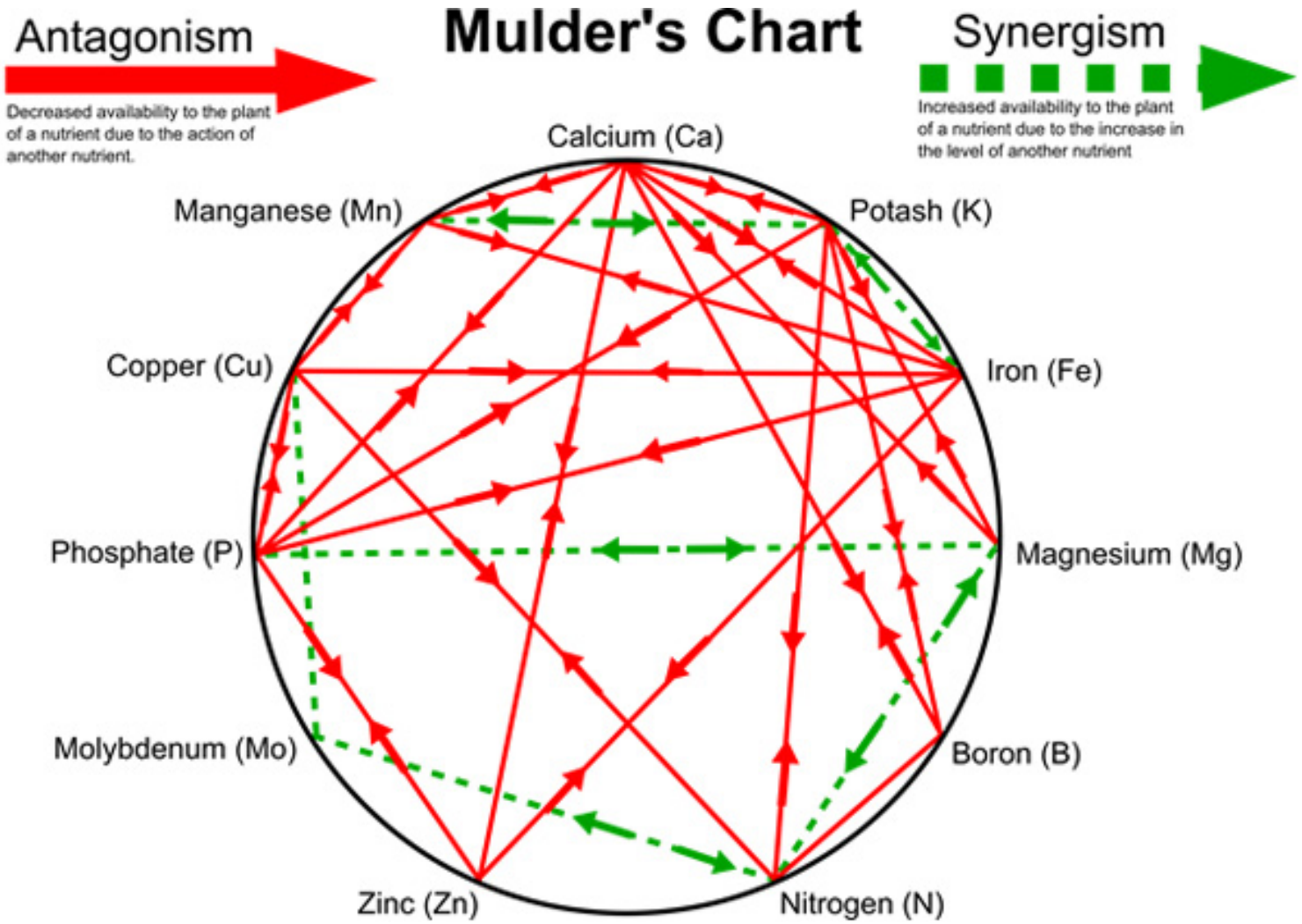
Worm sign

What do earthworms do?



http://www.nrri.umn.edu/worms/forest/soil_layers.html

What about soil nutrients?



http://nutriag.com/article/mulderschart

Ecological Groups

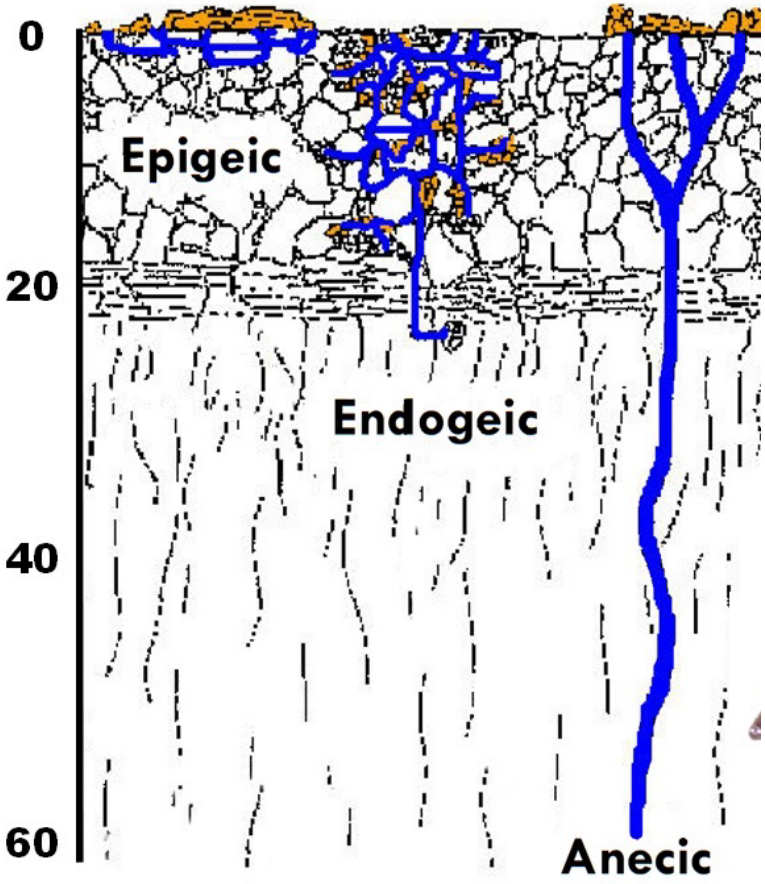
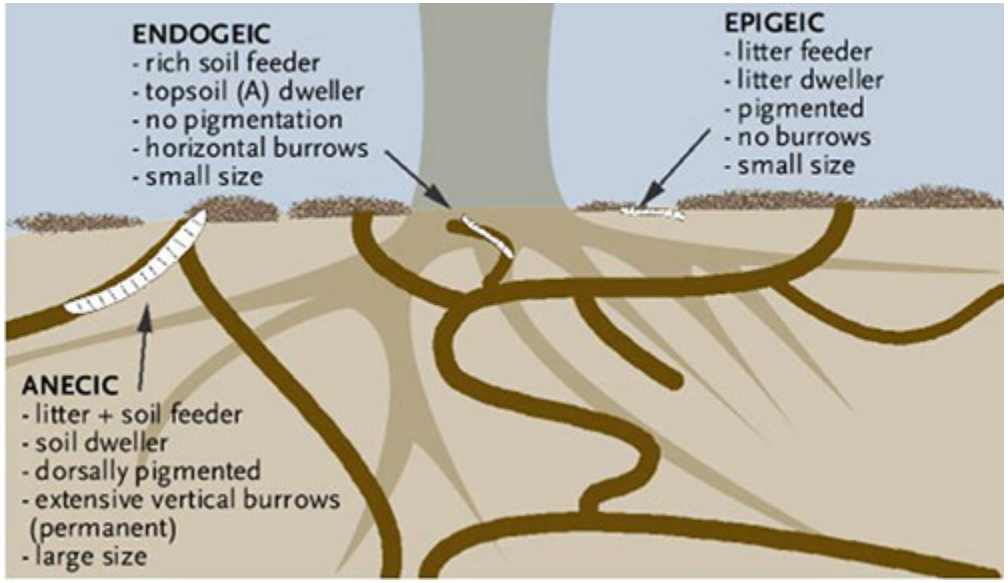
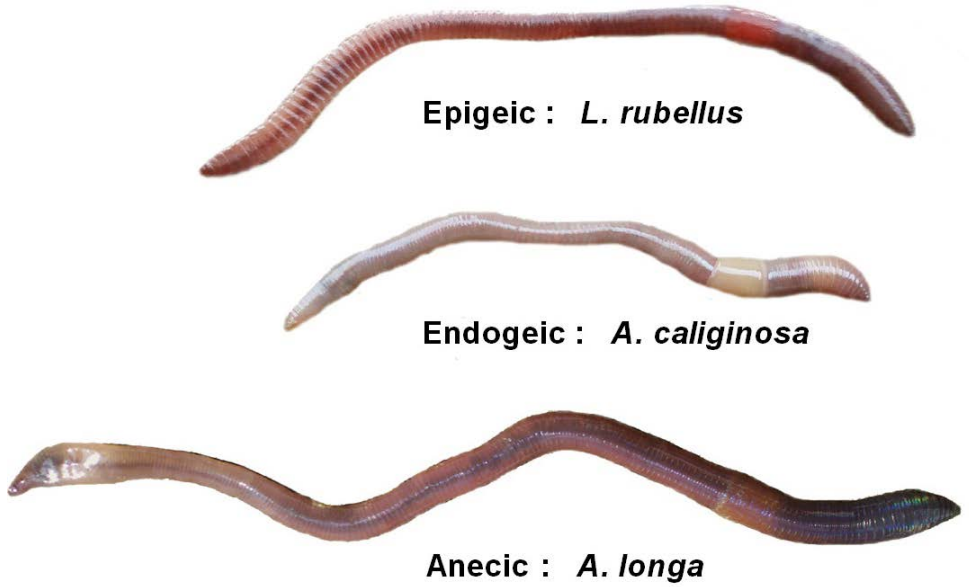


Diagram courtesy of the Science Learning Hub. Figure adapted from Fraser and Boa

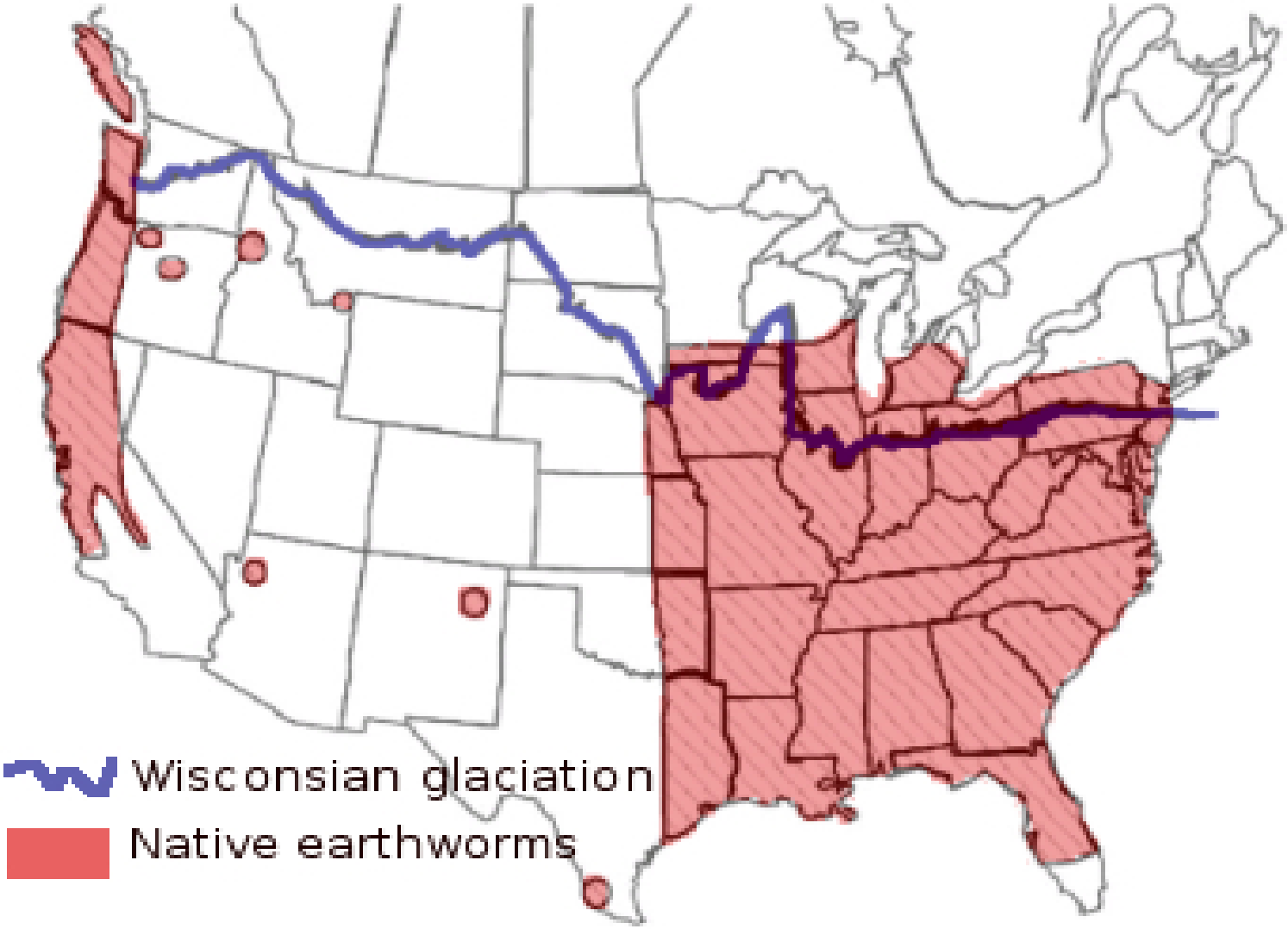


Colorado State Agricultural extension



Science learning hub

Where are worms supposed to be?



Map based on Callaham et al., 2006.

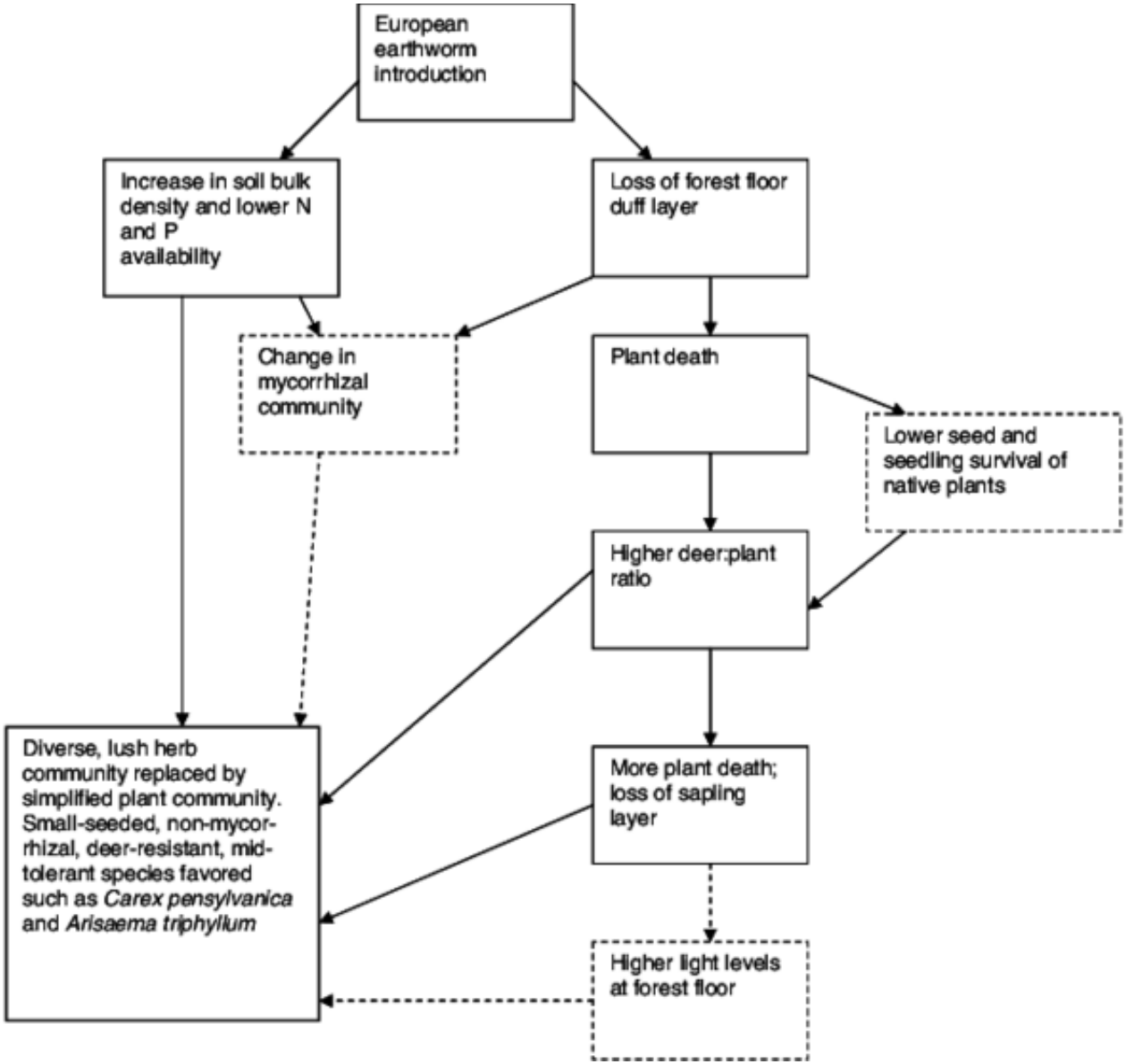
Not every worm is everywhere

- Some sites have no anecic
- Or they have mostly epigeic

- Slow or Stop the Spread!

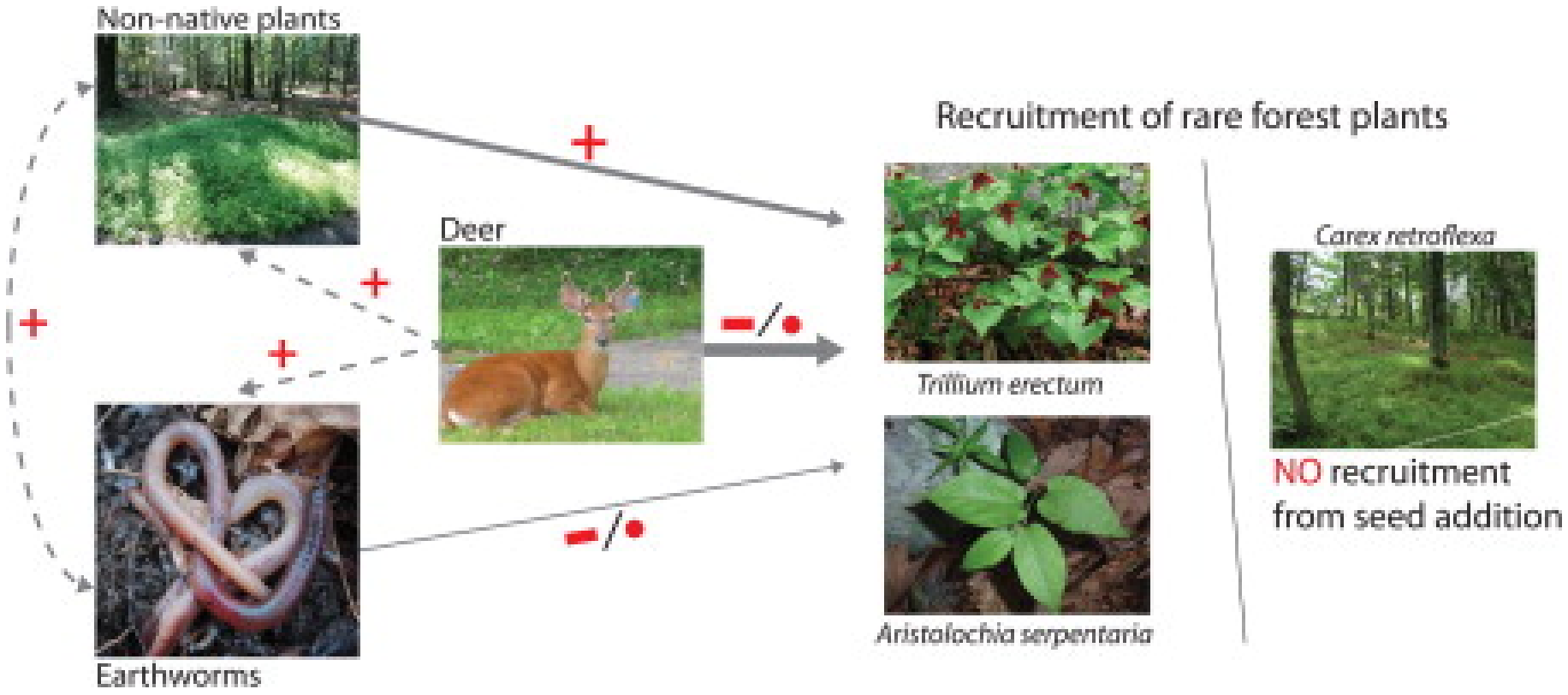
- Multiple introductions
  - new species
  - genetic variability
  - more impacts

Fig. 1 Conceptual diagram for changes in plant community composition caused by European earthworms in Minnesota, USA, hardwood forests. Dashed boxes and arrows indicate hypothesized processes and connections with little data at this time



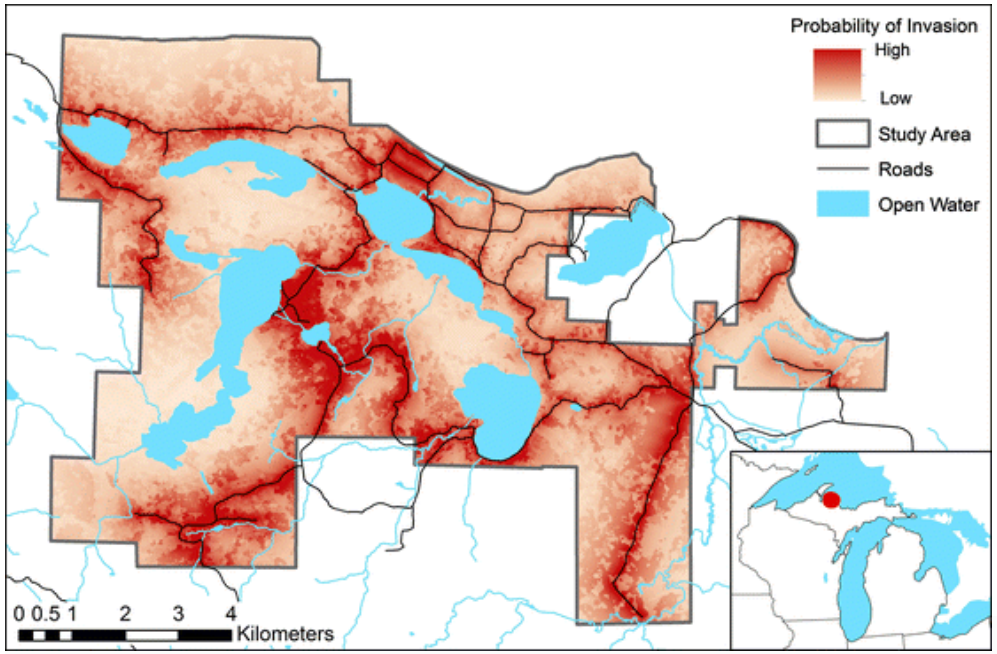
Frelich et al 2006 earthworm invasion into previously earthworm-free temperate and boreal forests

Deer + Worms + exotic = not good…



Davalos et al 2015 Interactive effects of deer, earthworms, and non-native plants on rare forest plant recruitment

Mapping Invasions



Current predicted probability of invasion for *L. terrestris* across the Huron Mountains, Upper Peninsula, Michigan. Model parameters include *road proximity*, *soil pH*, *and land cover*

Shartell et al 2013

Predicting Invasions

"91.7% and 98.9% of sugar maple habitat" 100-year invasion distance of roads or harvests, respectively

Gundale et al 2005

Some worms to look for

INVASIVE SPECIES

Jumping Worms

Cornell University Cooperative Extension

Master Naturalist Program

Amynthas spp. and *Metaphire spp.*

Also known as crazy snake worm, Alabama jumper, Asian worm

This mature jumping worm can be identified by its characteristic smooth, often milky white clitellum (band near the head of the worm). PC Susan Day/ UW- Madison Arboretum

Not to be confused with:

Common invasive European species have a raised or saddle-shaped, segmented clitellum.

PC Holger Casselmann

What to look for:

Worms are smooth, glossy gray or brown; 1.5 to 8 inches long

- **Crazy behavior!** They jump and thrash wildly when handled, moving more like a threatened snake. They can also shed their tails in defense.
- **Clitellum** (the narrow band around their body) is smooth to the body, unlike most other species which have a raised and pink colored clitellum. Their clitellum completely encircles the body and is often cloudy white to gray colored. Body looks metallic.
- **Soil signature** Jumping worms leave distinctive grainy soil full of worm castings. The soil becomes granular and looks like dried coffee grounds.
- **Timing** Best time to find them is late August or September when they are largest.

Jumping worms threaten forest health

Nearly all earthworms in the Northeast today are non-native, and these European and Asian invasives are altering the soil structure and chemistry of our forests. They consume the critical layer of organic matter that supplies vital nutrients for plants and provides food, protection and habitat for wildlife. However, jumping worms are especially concerning. These Asian exotics devour organic matter more rapidly than their European counterparts, stripping the forest of the layer critical for seedlings and wildflowers. Jumping worms grow twice as fast, reproduce more quickly and can infest soils at high densities. In areas of heavy infestation, native plants, soil invertebrates, salamanders, birds and other animals may decline. Jumping worms can severely damage roots of plants in nurseries, gardens, forests and turf. By disturbing the soil, jumping worms help facilitate the spread of invasive species. Jumping worms are widespread across much of the Northeast, Southeast and Midwestern US, and the first records date to the late 19th century. Unfortunately, relatively little is known about them compared to European earthworms.

Jumping worms are PROHIBITED by the New York State Dept. of Environmental Conservation. Prohibited invasive species cannot be knowingly possessed with the intent to sell, import, purchase, transport or introduce.

Jumping worms confirmed in 5 counties

Jumping worms, an invasive species, were discovered in Wisconsin for the first time in Dane County in the fall of 2013. Since then, they have been confirmed in five counties, including Milwaukee and Waukesha. The DNR says the worms may be present in a total of 14 Wisconsin counties.

Jumping worms

- Native to: East Asia
- Length: 1.5 inches to 7 inches
- Identifying features: Milky-white clitellum; jumps and thrashes when handled
- Problem: They turn soil dry and grainy.

Source: Wisconsin Department of Natural Resources

Journal Sentinel

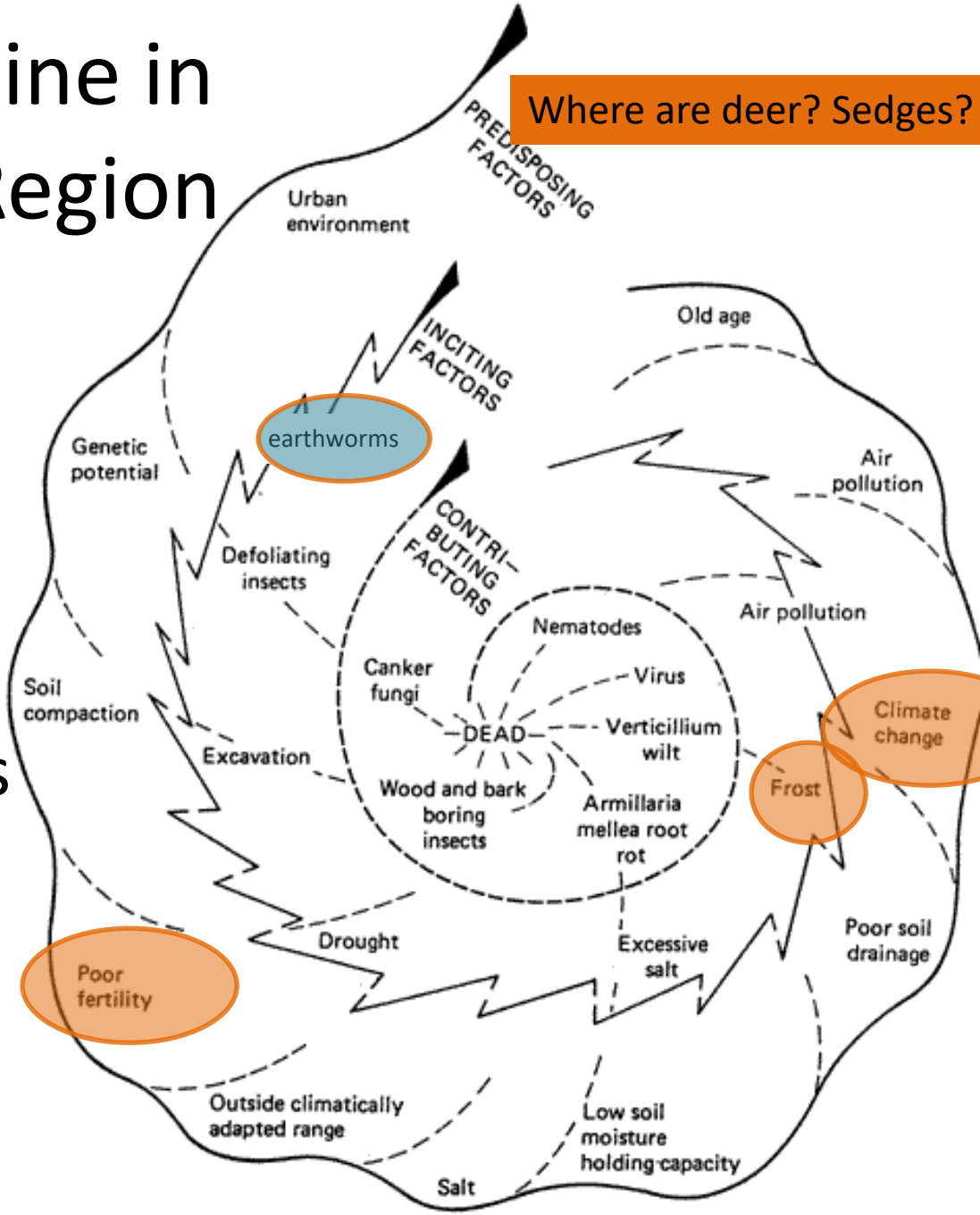
Different Combinations of Interactions

- Intensive forest management and high deer density alters tree species density and diversity
- Deer presence may facilitate higher earthworm populations
- Earthworms facilitate sedge mats, invasive plants, expose soil, disturb moisture, temperature, nutrient regimes
- Disturbed nutrients, earthworms, impact seedling mycorrhizae
- Poor soil fertility predisposing trees to additional stress

Key: Regeneration impacts are Context-Dependent

Sugar maple decline in the Great Lakes Region

- Progressive dieback
- Reduced, static growth rates
- Mature & regeneration cohorts
- Multiple, interacting factors
- Stand Level



Management Strategies

- Site Selection becomes critical
  - *Does it need to convert?*
- Long term single tree selection
  - Dependable
  - Alters species diversity, Sugar maple dominance increasing over time, but if regeneration is failing?
  - *Change to even-aged?*
- Canopy gaps, strip clearcuts, shelterwoods?
  - Quickly releases cohorts into sapling size classes
  - Sugar maple is not always tolerant of these, maybe better for other underrepresented species, alters microenvironment…i.e. what is the optimum gap size?
  - *Allow canopy to close to reduce invasive plants before continuing uneven aged? Could promote other species?*

Potential Silvicultural Management Decision Tree for Sugar Maple Stands

Unhealthy

(>10% average dieback, or regeneration failures)

Heavy Harvest

-remaining trees not likely to increase growth rates

Healthy

(<10% average dieback, adequate regen)

Limit earthworm spread

-contracts should include washing equipment, and using local road fill
- Even with earthworm disturbance present, precautions should still limit spread of additional species

No earthworm disturbance

-harvest as normal

Yes earthworm disturbance

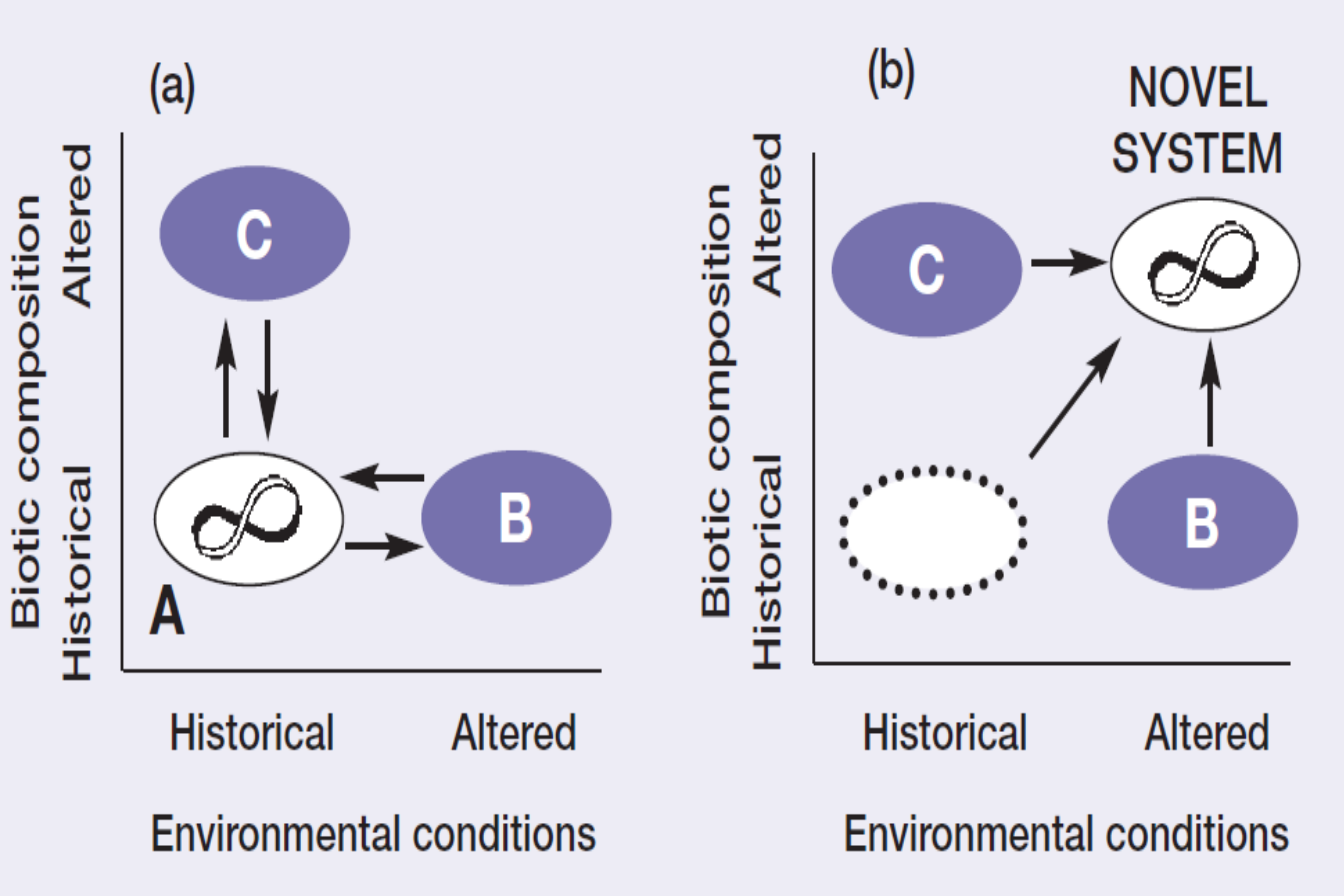
-thin lightly & monitor

Management Strategies

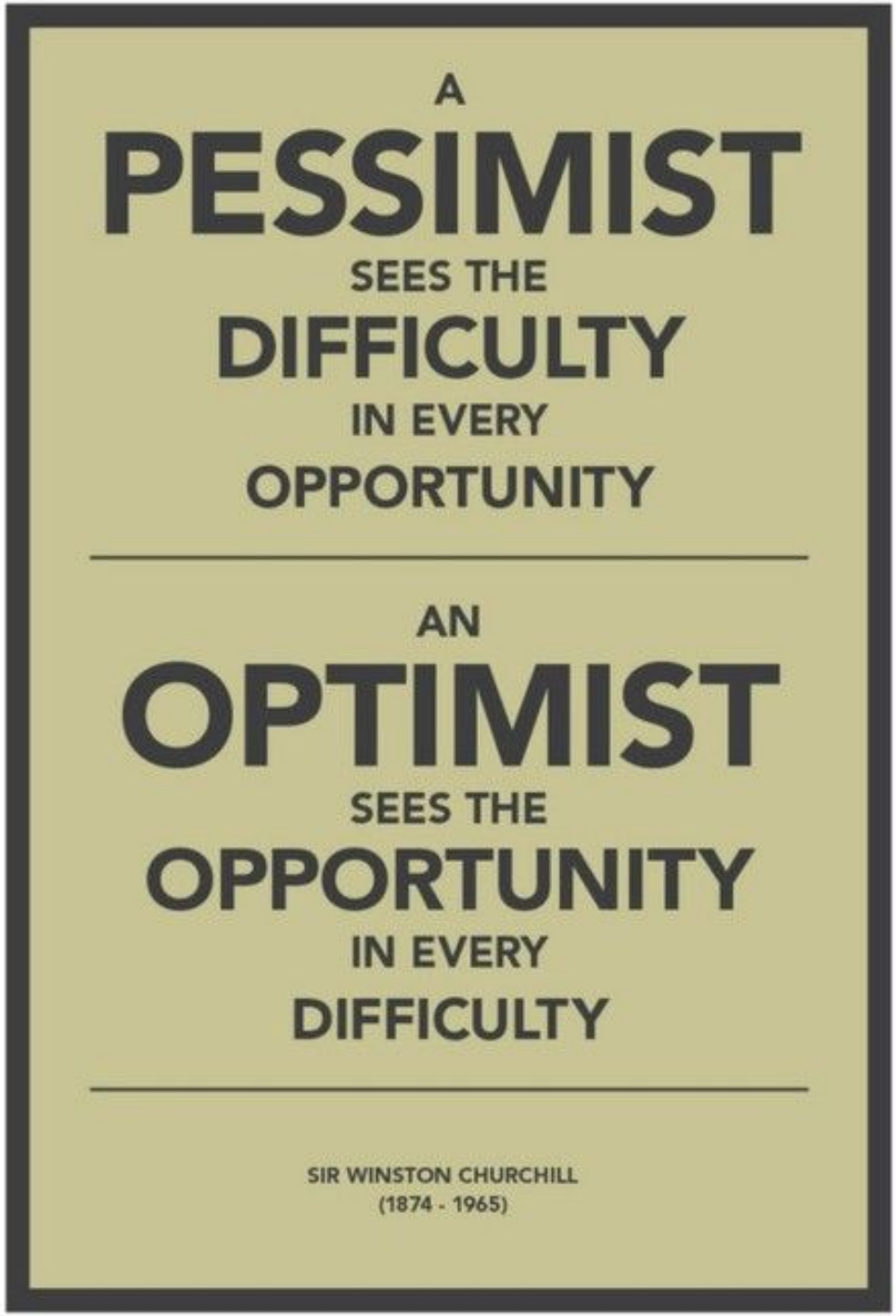
- Scarification, Herbicides
  - Typically reduces invasives and tree regeneration
  - *May be necessary with any invasive plant species (?= <worms)*
- Fertilization, reversing soil acidification, liming
  - Issues doing this over large scale
    - $, timing, method, nutrient interactions, declining legacy effects…
  - Likely practical only in small areas
  - *Fertilize sugarbushs?*
- Earthworm BMPs
  - *Powerwash equipment, use local road grading materials*

Bottom Line: Options available to attempt resolving issues but uncertainty exists

Traditional vs Novel Systems



Seastedt, Hobbs, Suding (2008) **Management of novel ecosystems: are novel approaches required? *Front Ecol Environment* 6(10): 547–553**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PESSIMIST
SEES THE
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SIR WINSTON CHURCHILL
(1874 - 1965)

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- Andrew Storer, Marty Jurgensen, Dana Richter, Michael Amacher
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- Funding: GMO Renewable Resources LLC., Forest Service, Forest Health & Monitoring Program, MTU School of Forest Resources & Environmental Science, Ecosystem Science Center

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Questions?

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Forest Floor Condition, Earthworm Impact Rating Scale (Lilleskov, USFS)

Rating	Description of class characteristics
1	No forest floor. Previous year's litter over mineral soil. Worm sign abundant.
2	No humus, large old leaves under litter. Worm sign present or absent. Roots absent.
3	No humus. Small leaf fragments, larger old leaves present. Sparse roots. Some worm sign , but rare large casting piles.
4	Humus patchy, may be mixed in soil. Some roots, but not thick. Small worms may be found in the forest floor, but no large castings or middens.
5	Humus fully intact. Roots present in humus and leaf fragments. Forest floor coherent when picked up with intact recognizable layers. No worms or worm sign present.

Example: KBIC genetic diversity trials

- 230acres, Baraga County, MI
- Partners: U.S. Forest Service, Michigan Tech, State Nurseries
- Expected outcomes include:
  - Establish sugar maple seedlings from various plant hardiness zones in the Upper Peninsula of Michigan.
  - Determine if variants are capable of competing with local sugar maple.
  - Determine if variants can outperform local sugar maple on a warmer and drier site.
  - Enhance genetic diversity of the local sugar maple population.

http://forestadaptation.org/KBIC_demo