Effects of exotic earthworms on maple forests in northeastern states

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Why is it important for sugar makers to know about earthworm presence in maple forests?

No earthworms

Camels Hump, VT

Forest invaded by *Amynthas agrestis*

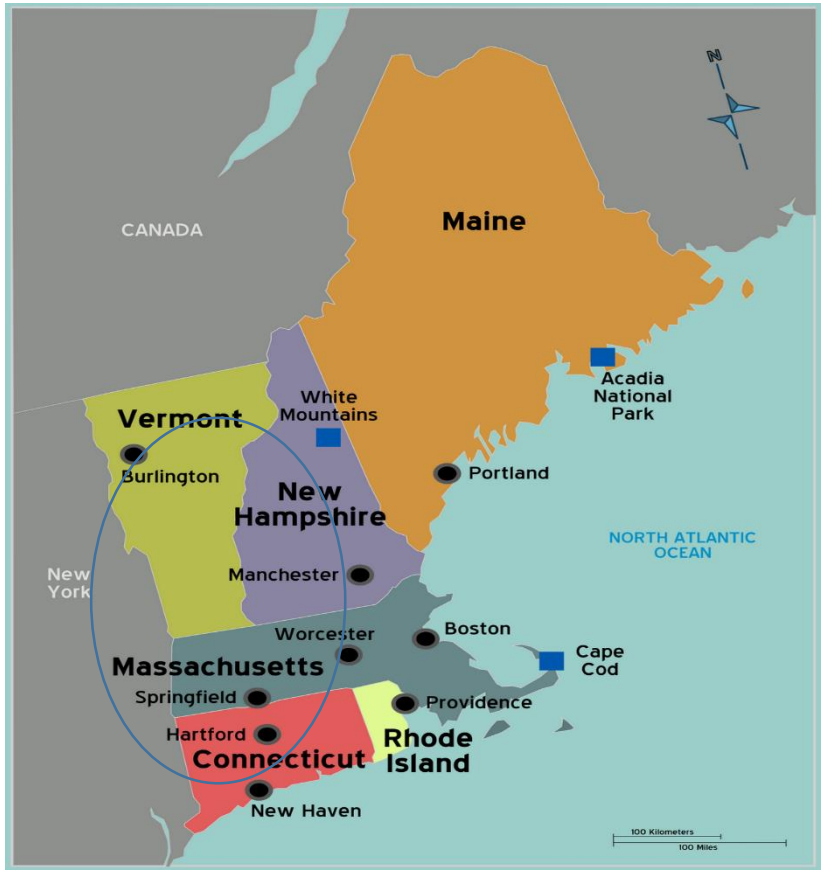
Shelburne, VT

Maple forest regeneration is threatened

Main Objectives:

- **Which worms are present?**

- **Where are the worms located?**



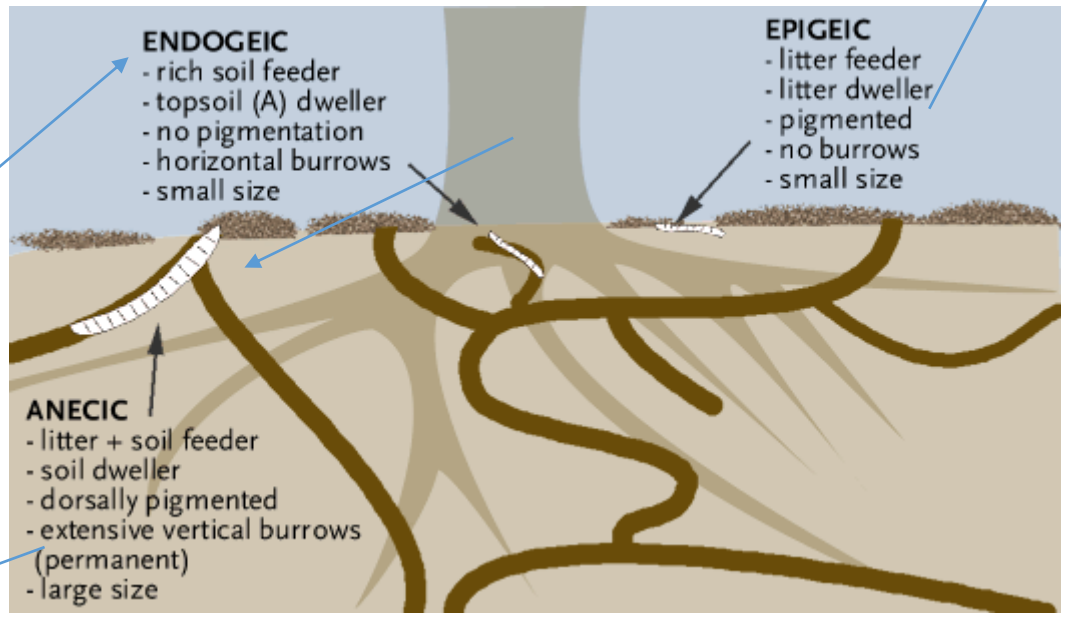
- **What are their effects on maple regeneration?**

Worm niches in forest floor:

EPI-ENDOGEIC
- surface feeder
- mix top layers into middle
- travel & live between top & middle
- small size
- pigmented

Amynthas sp.,
Lumbricus rubellus

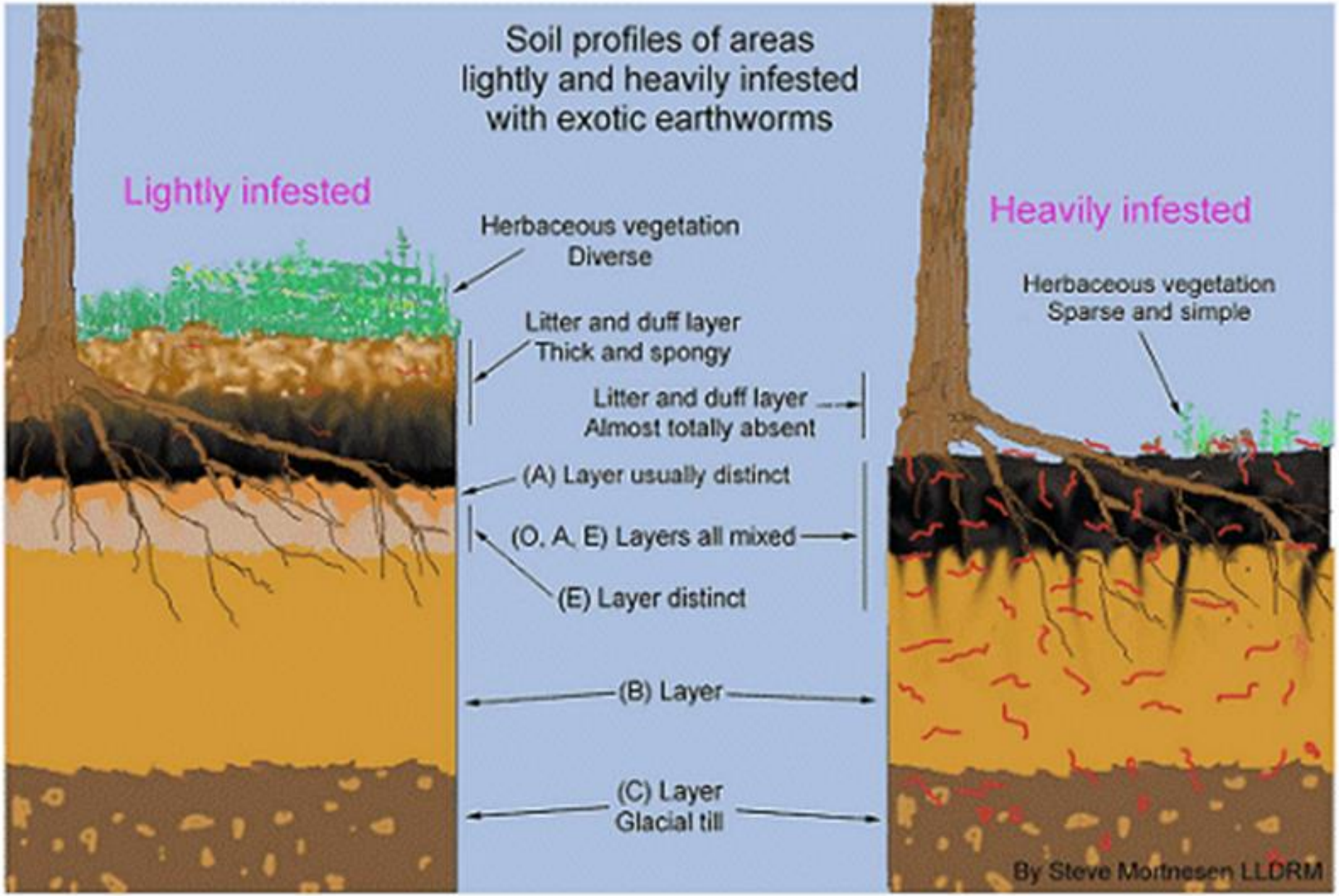
Eiseina fetida (red wriggler),
Dendrobaena



Octolasion,
Aporrectodea

Lumbricus terrestris (night crawlers)

How worms affect forest floor soil structure:



Examples of soil structure disturbance from this summer's sampling:

No damage, all organic horizons present IERAT class = 1

Litter Organic duff Layer:

- Oi: leaves intact from previous fall)

- Oe: fermented fragmented leaves greater than a year; fine roots present

- Oa: humic or decomposed organic matter

Mineral horizon:

- transition from O to upper mineral soil horizon
- less than 30% organic matter

Forest soil structure after worm invasion:

Maximum damage, no organic horizon left and lots of large earthworms, IERAT class = 5

Intact leaves from previous fall

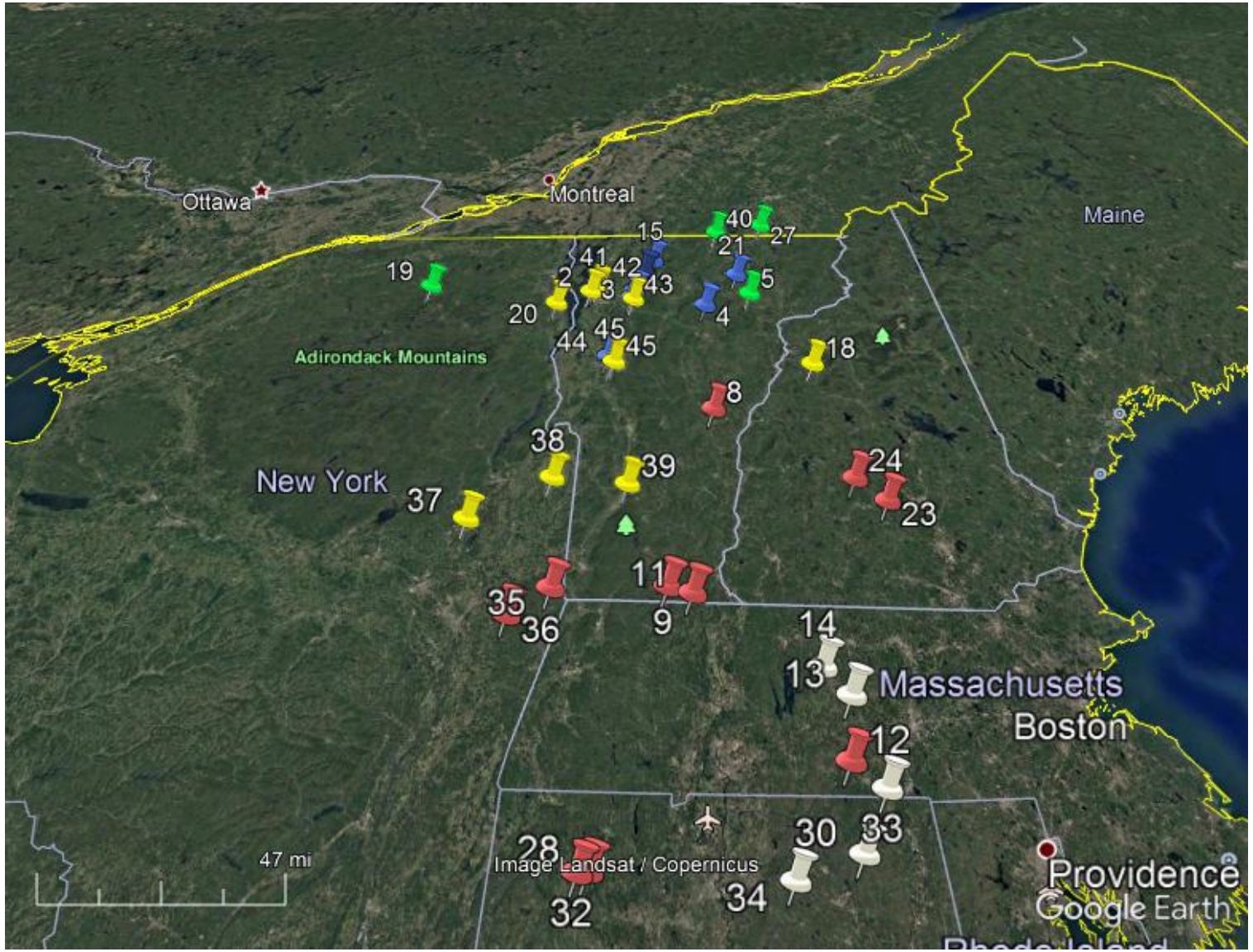
Oe and Oa layers missing. A soil horizon mineral soil and earthworm castings. Some roots remain but fine roots absent.

Transition from mineral soil to parent material

Methodology:

- 5 cold hardiness zones
- 5 states
- 35 sites
- all maple sugaring forests

Zones	States	Sites	Color
4a	VT, NY	6	Green
4b	VT	7	Blue
5a	VT, NY, NH	9	Yellow
5b	NH, MA, CT	6	Red
6a	MA, CT	7	White



Sampling Techniques:

<u>1 square meter:</u>

-overstory: trees

-understory: herbaceous species

<u>@5m:</u>

-nonnative plants

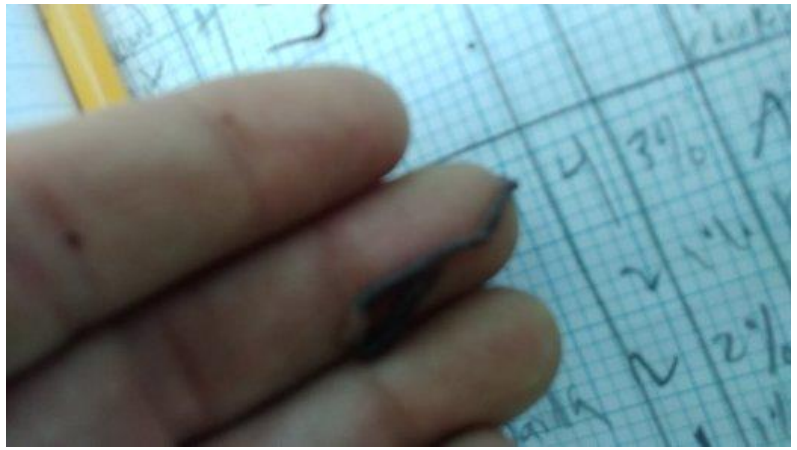
- maple seedlings

- maple saplings

<u>½ square meter:</u>

-forest soil structure

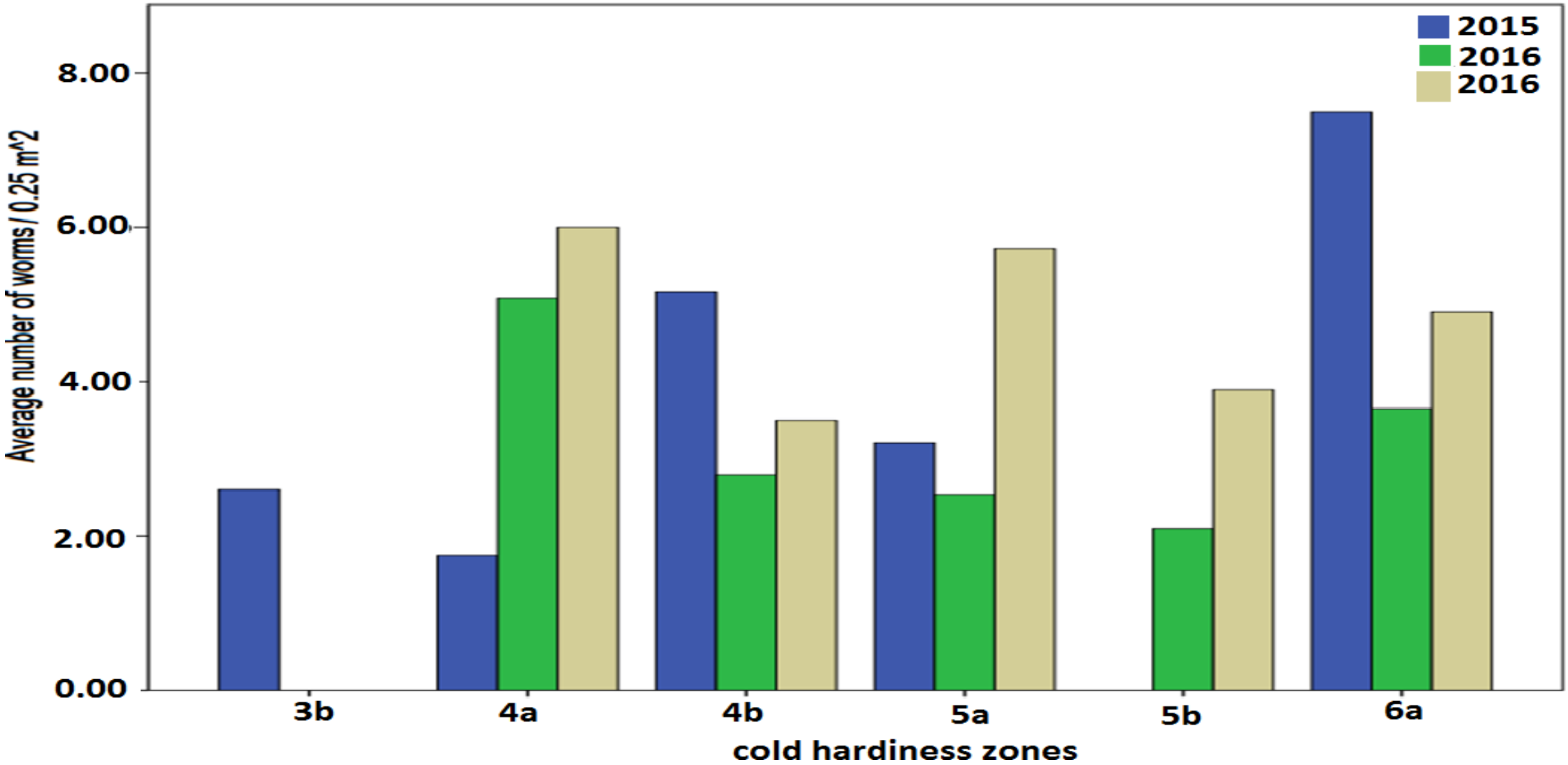
- worms



For 3 years UVM Entomology Lab gathered data to answer:

- In which USDA plant cold hardiness zones are worms present?
- Which worm species occur most frequently?
- How is worm presence related to forest damage?
  (using IERAT rating)
- Is there a correlation between:
  forest damage level & plant diversity?
- Does forest damage level affect maple regeneration?
- How does forest damage level affect nonnative plant presence?

Worms & plant cold hardiness zone correlation:



Worm families, genus, & species found:

Lumbricidae:

Aporrectodea**:** (*Aporrectodea rosea, A. turgida, A. tuberculata, A. caliginosa*)

Dendrobaena**:** (*Dendrobaena octaedra*)

Octolasion**:** (*Octolasion cyaneum)*

Lumbricus: (*Lumbricus terrestris*) night crawlers;
(*L. rubellus*) red worms

Megascolecidae:

*****Pheretimoids**:** (Amynthas agrestis, A. tokioensis, A. hilgendorfi)

Most concerning worms species found:

Amynthas (crazy snake worm) *(A. agrestis, tokiensis, hilgendorfi*)*

Known now as *Metaphire hilgendorfi (Chang, 2016)*

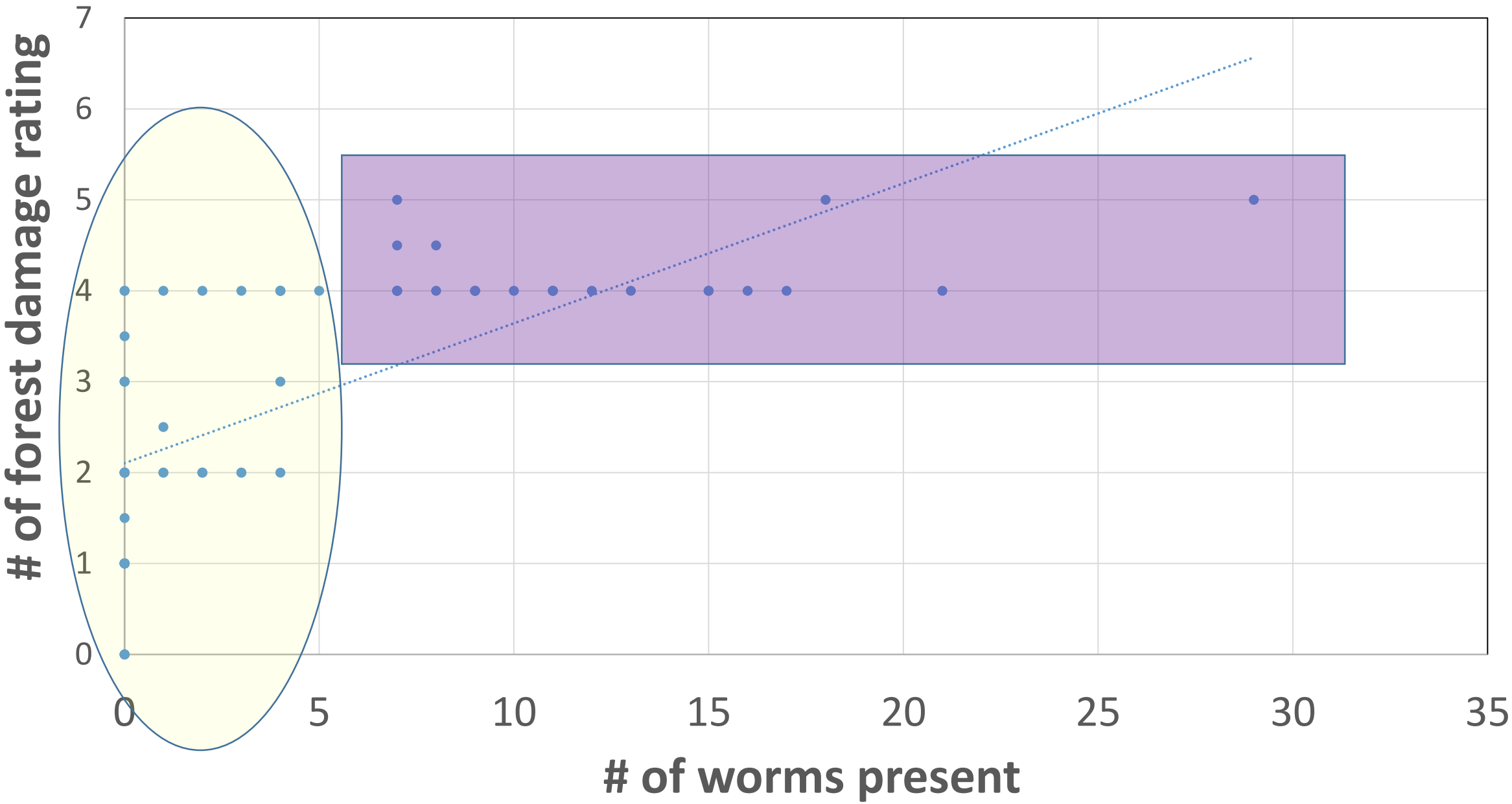
Most concerning Worms Species found:

Lumbricus: *(Lumbricus terrestris*, L. rubellus, L. castaneaus, L. festivus)*

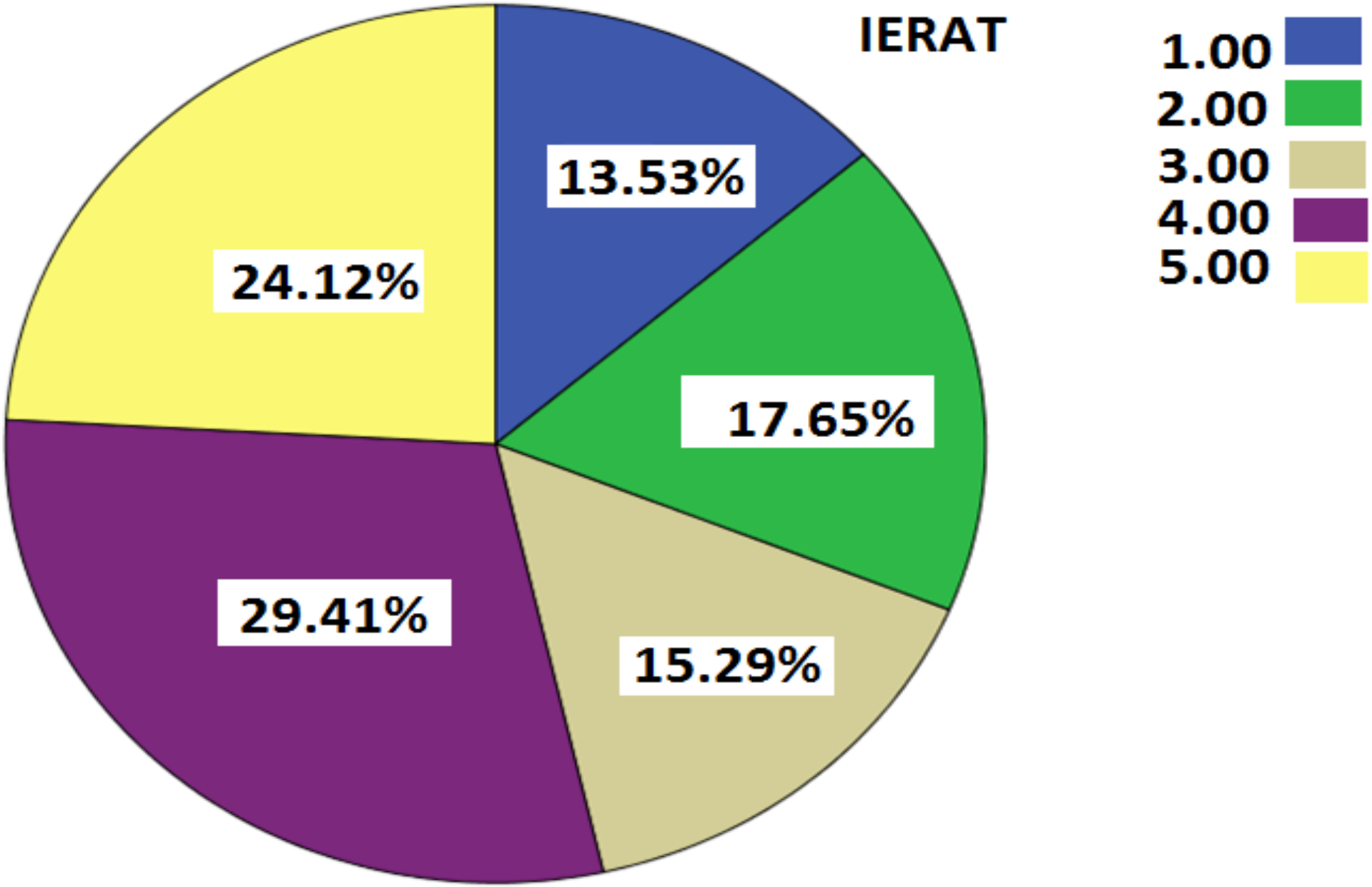
Notice the tunnels they make

*Commonly known as Night Crawlers: anecic, making burrows

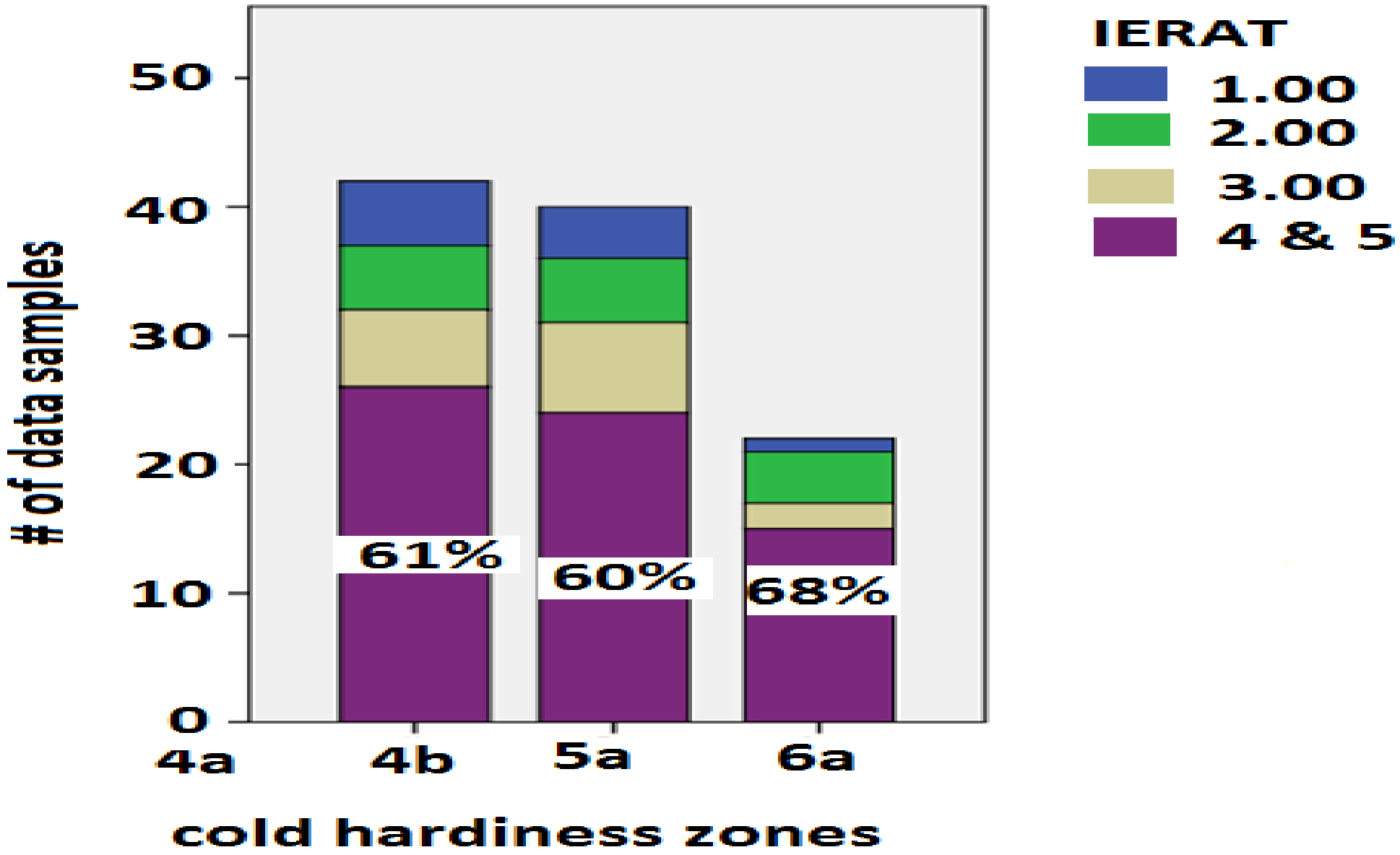
of worms present to forest damage level (according to IERT)



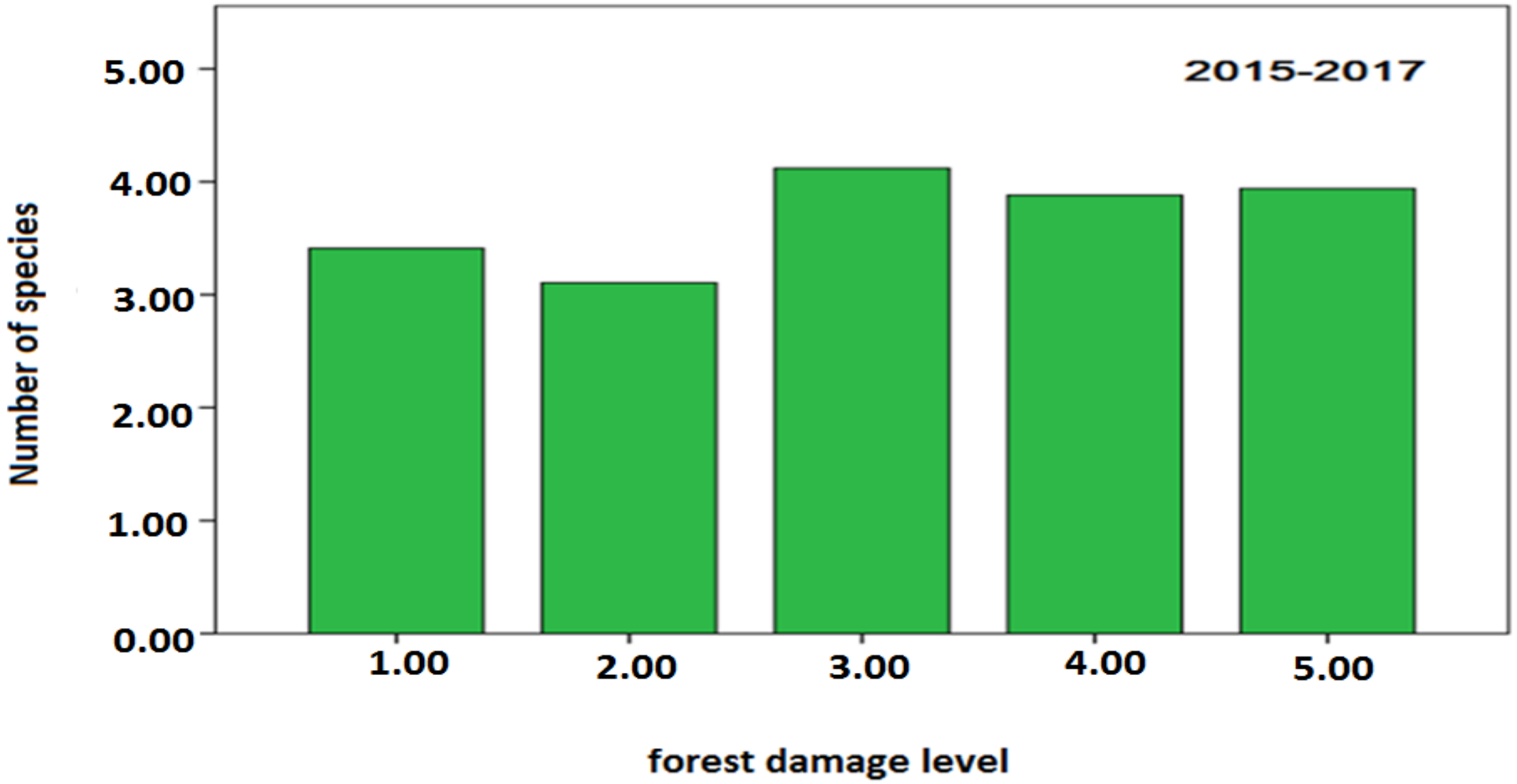
Patterns in 3 years of Data



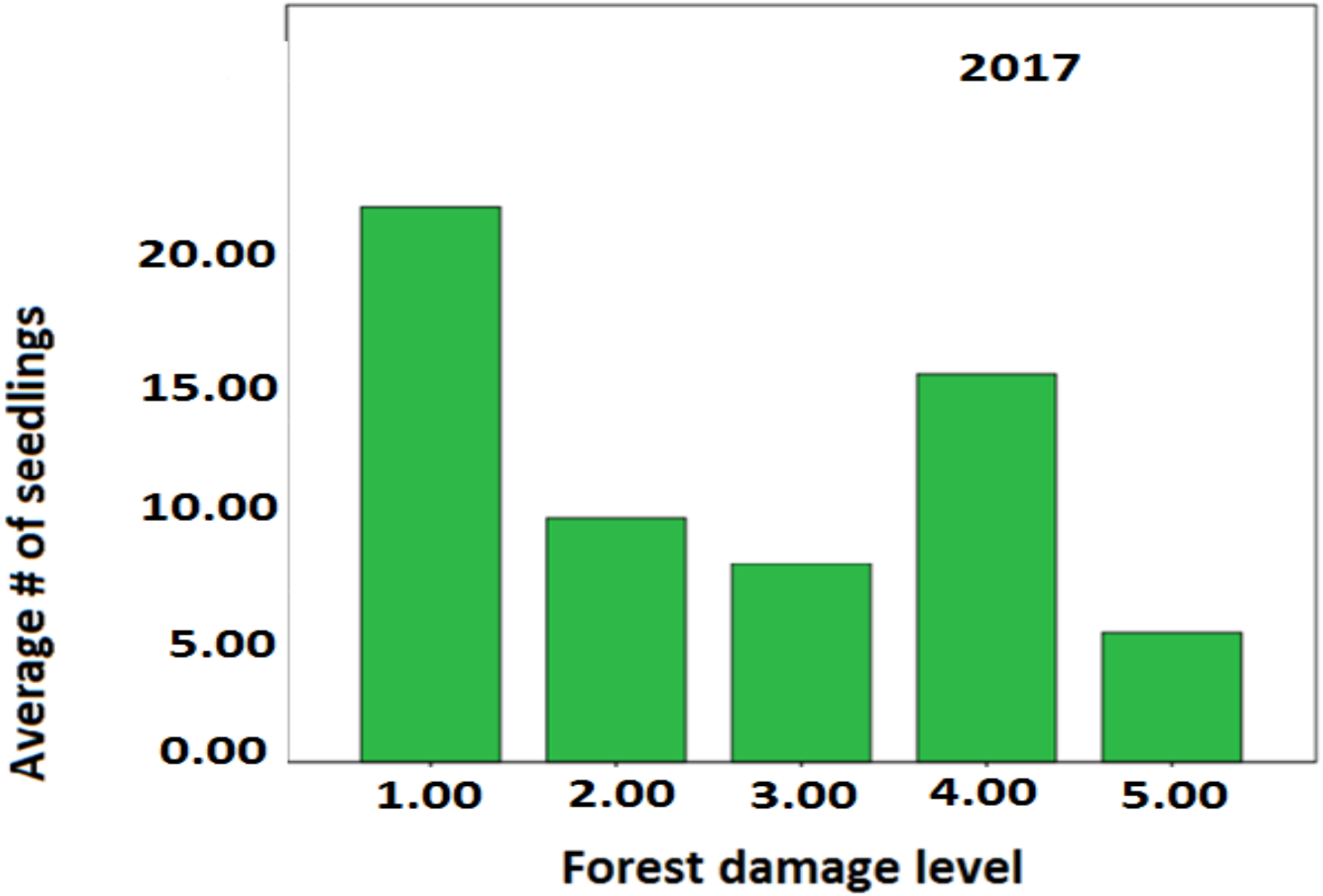
How many forests did we see that are damaged?



Forest damage in relation to to plant diversity

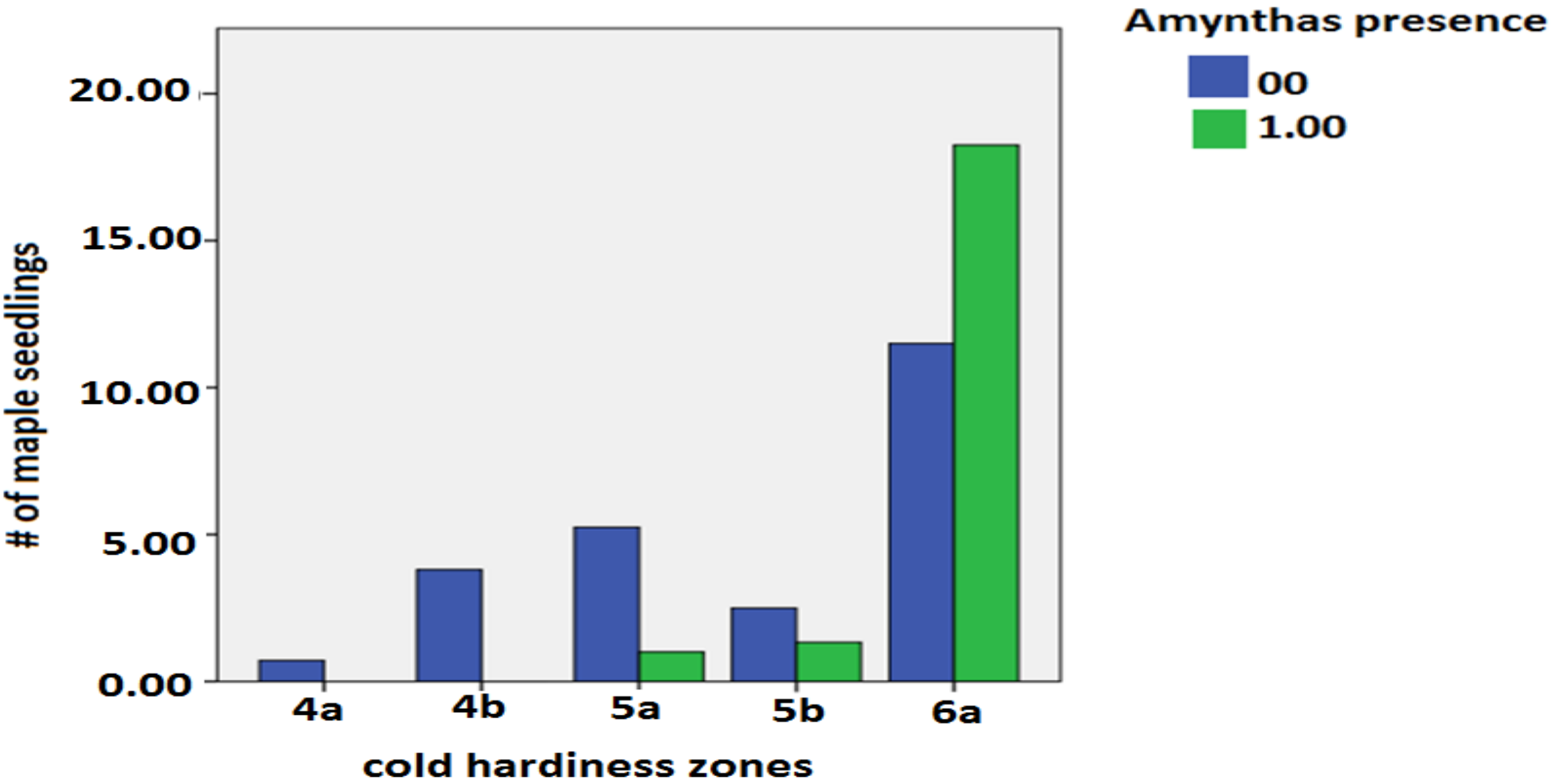


Regeneration via maple seedlings across forest damage levels

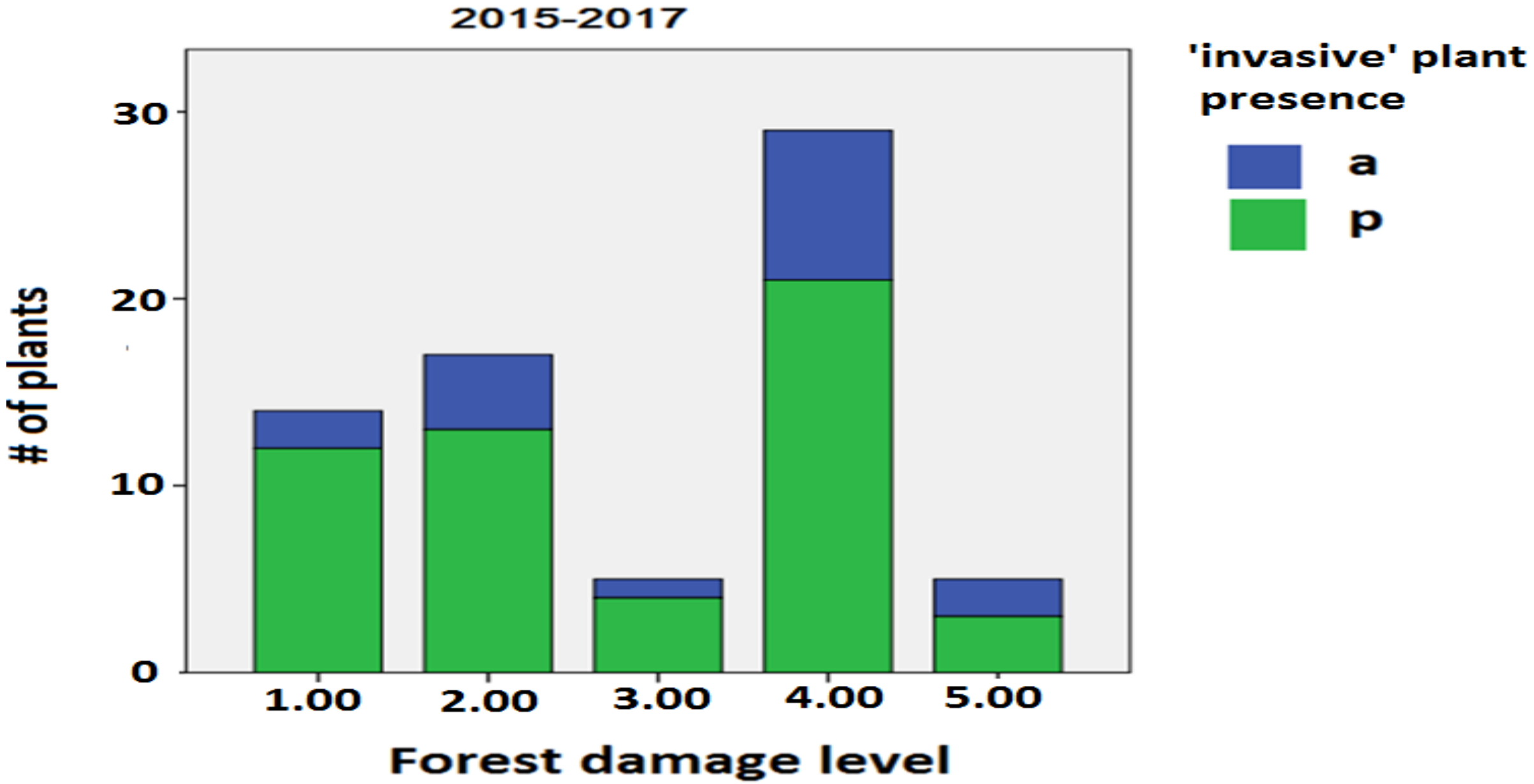


Effects of *Amynthas* on maple regeneration in 2017

What is the impact on Maple regeneration via seedling counts?



Relationship of ‘invasive’ plants & forest damage



Correlation between forest damage & ‘invasive’ plant presence:

Observed in the field:

higher forest damage → ‘invasive’ plants presence more likely

Species observed:

Common buckthorn *(Rhamnus cathartica)*

Garlic mustard *(Alliaria petiolata)*

Japanese barberry (*Berberis thunbergii*)

Japanese honeysuckle *(Lonicera japonica)*

Multiflora rose *(Rosa multiflora)*

Oriental bittersweet *(Celastrus orbiculatus*)

Winged Burning Bush *(Euonymus alatus)*

Potential Vectors of these worms:

- Horticultural exchanges
  - Mulch
  - Plant exchange
  - Soil fill
- Discarded fishing bait

Recent Case studies:

- UVM Master gardener called: commercial compost---→*Amynthas agrestis*.
- Home gardener of 20 years: worms appear, odd texture, spreading to woods around house

In Summary:

Findings:

- Plant cold hardiness zone seems irrelevant; earthworms are present in all zones
- Worm species most present & damaging were: *Amynthas* spp. & *Lumbricus* spp.
- Forest damage directly relates to earthworm presence
- Forest damage level does not indicate plant diversity
- Severe forest damage → low maple regeneration
- Forest damage does not always indicate 'invasive' plant presence

Recommendations if you do not yet have worms in your sugarbush:

Avoid vector introductions:

- Minimize horticultural material movement
- Inspect all nursery species root balls before planting
- Avoid exposure to aquatic areas where fishing bait may be discarded

Observe patterns in forests you tend:

- look for earthworm castings, diminished organic layers & decrease in understory plants

Inform and stay informed:

- share this information with your community & the public
- stay tuned for further recommendations

Recommendations if you do have worms in your sugarbush:

Support forest health:

- Promote deep taproots tree species, especially in sandy or low organic matter substrate, so they can hold trees in place as forest floor structure changes

Stay tuned for updates:

- Furthur research is being conducted on natural pathogens to explore biocontrols and Entomo-pathogenic fungi or other microorganisms

- Visit UVM Entomology lab for details

Resources

Worm Watch: a science-based education & national volunteer monitoring program used to identify ecological changes in the environment (field guides..)

Great Lakes Worm Watch: valuable resource of research, worm identification, forest ecology, resources..

Vermont Invasives: includes information about identification, biology, management, distribution, and citations for earthworms and many other species

UVM Entomology Lab: contact for UVM scientists working on this research

Peer reviewed scientific articles to read:

Bal, Tara L, Andrew J. Storer, Martin F. Jurgensen, “Evidence of damage from exotic invasive earthworm activity was highly correlated to sugar maple dieback in the Upper Great Lakes region.” *Biological Invasions, 2017:* p. 1-14.

Chang, Chih-Han Bruce A. Snyder & Katalin Szlavecz. “Asian pheretimoid earthworms in North America north of Mexico: An illustrated key to the genera Amynthas, Metaphire, Pithemera, and Polypheretima (Clitellata: Megascolecidae)” *Zootaxa 2016:* p. 495-529.

Gorres, Josef H. & Ryan D.S. Melnichuk. “Asian Invasive Earthworms of the Genus Amynthas Kinberg in Vermont.” *Northeastern Naturalist 19:2, 2012: p 313-322.*

Hale, Cindy M, Lee E. Frelich, Peter B. Reich. “Changes in Hardwoodforest Understory Plant Communities in Response to European Earthworm Invasions.” *Ecology Society of America 2006 Vol #87 Issue 7, 2006: p. 1637-1649.*

Resner, Kit, Kyungsoo Yoo, Stephen D. Sebestyen, Anthony Aufdenkampe, Cindy Hale, Amy Lyttle, Alex Blum. “Invasive Earthworms Deplete Key Soil Inorganic Nutrients (Ca, Mg, K, and P) in a Northern Hardwood Forest Kit.” *Ecosystems Vol #18* Issue l, 2014: p. 89-102.

Acknowledgements

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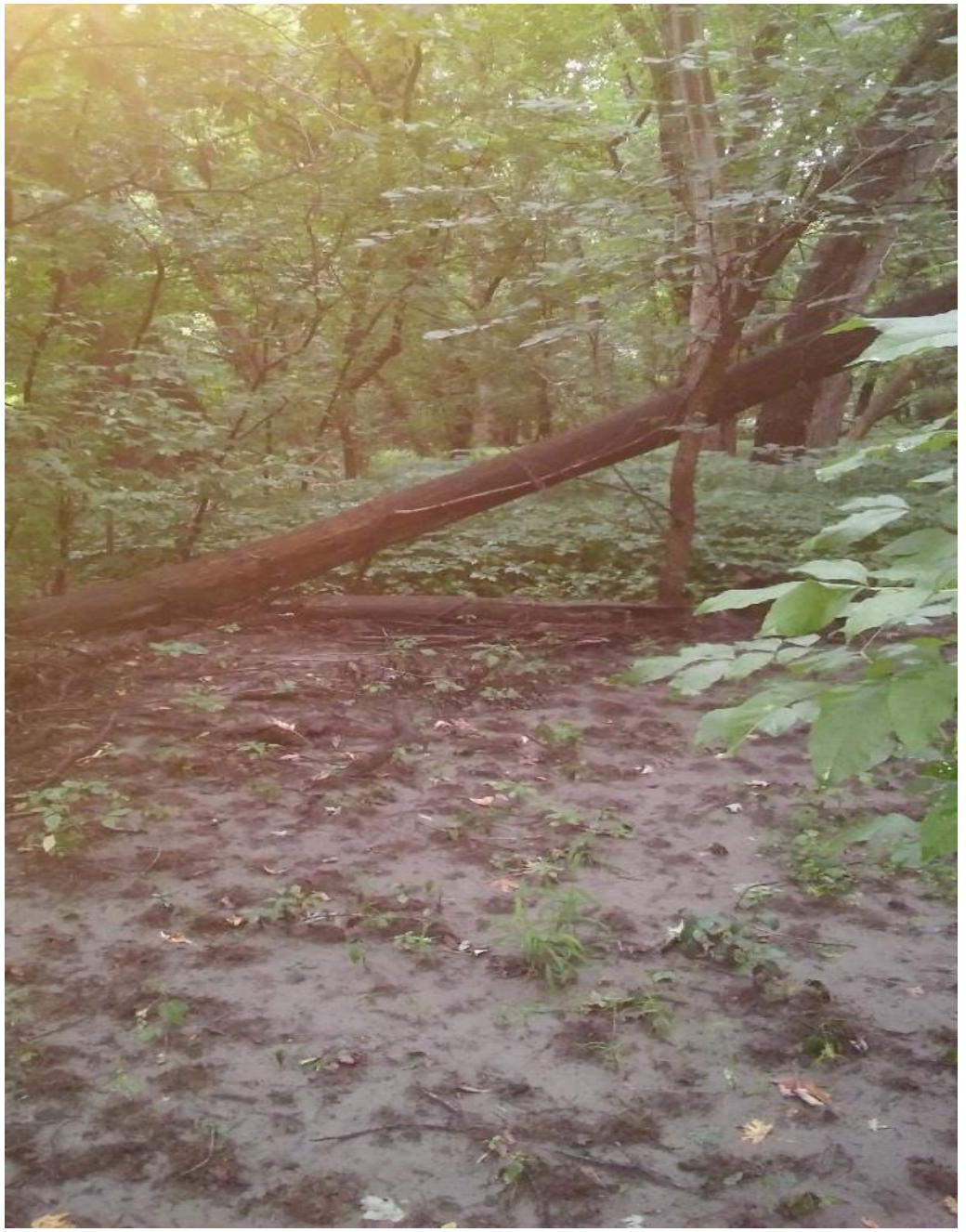
Questions, Comments…



Extra slides

These following slides cover more details:

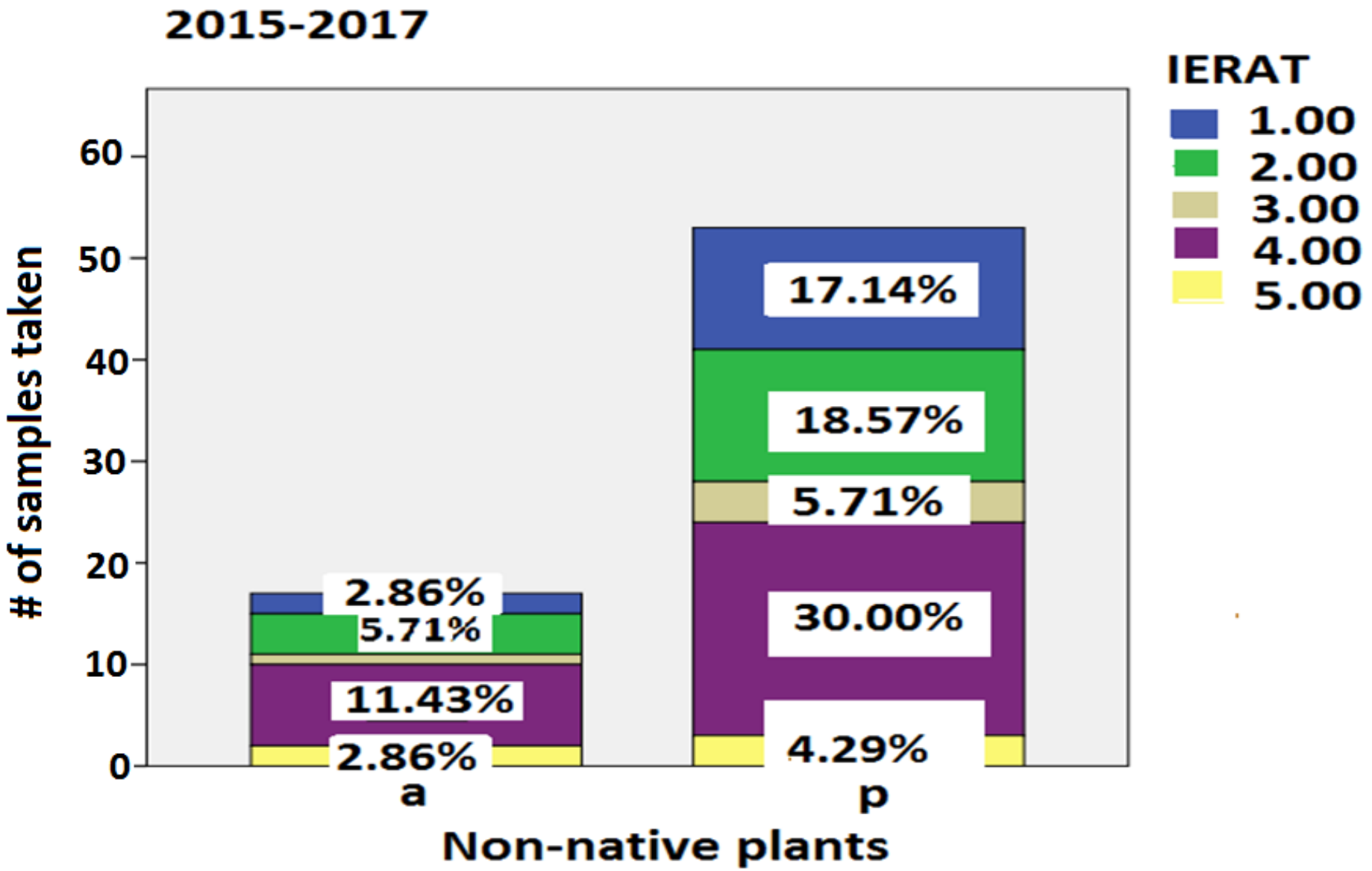
- More details on IERAT Protocol
- Breakdown across damage levels: percentages of ‘invasive’ plant presence
- Correlation of forest damage level across plant cold hardiness zones
- 2016 data on correlation of *Amynthus* presence and maple seedling regeneration
- Effects of *Lumbricus* on maple regeneration via seedling #’s 2015 & 2017
- Anomaly year data on *Lumbricus* effects on maple regeneration via seedling #’s
- Relationship of maple regeneration via saplings across forest damage levels
- Correlation between plant diversity and forest damage level across cold hardiness zones
- Maple regeneration via maple seedlings broken down into state

Examples of soil structure disturbance from this summer's sampling

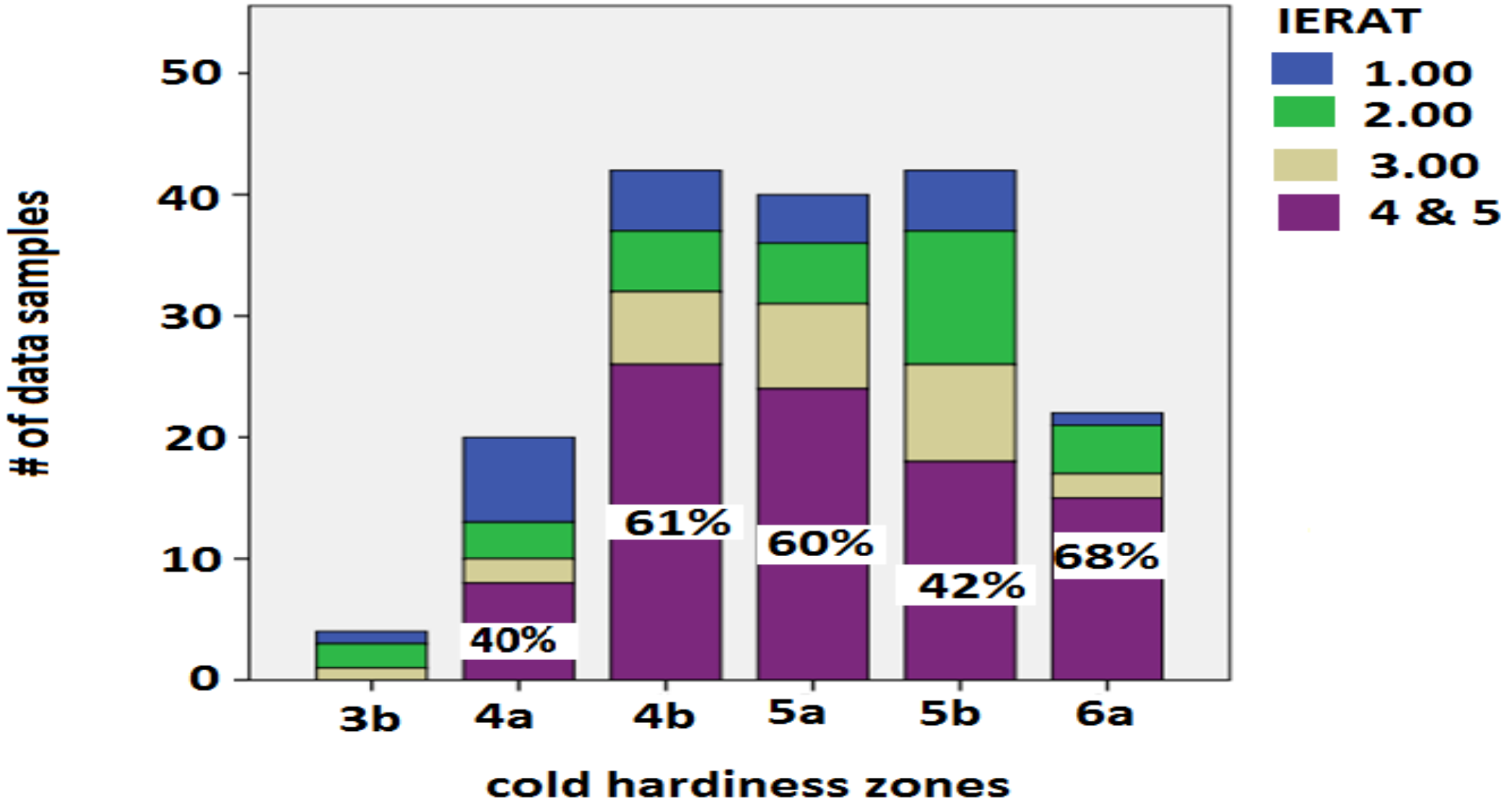
- Damage of forest floor assessed with:
  - the Invasive Earthworm Rapid Assessment Tool (IERAT).
    - No damage, all organic horizons present IERAT class = 1
    - Maximum damage, no organic horizon left and lots of large earthworms, IERAT class =5

Amynthas and L. terrestris (night crawlers)

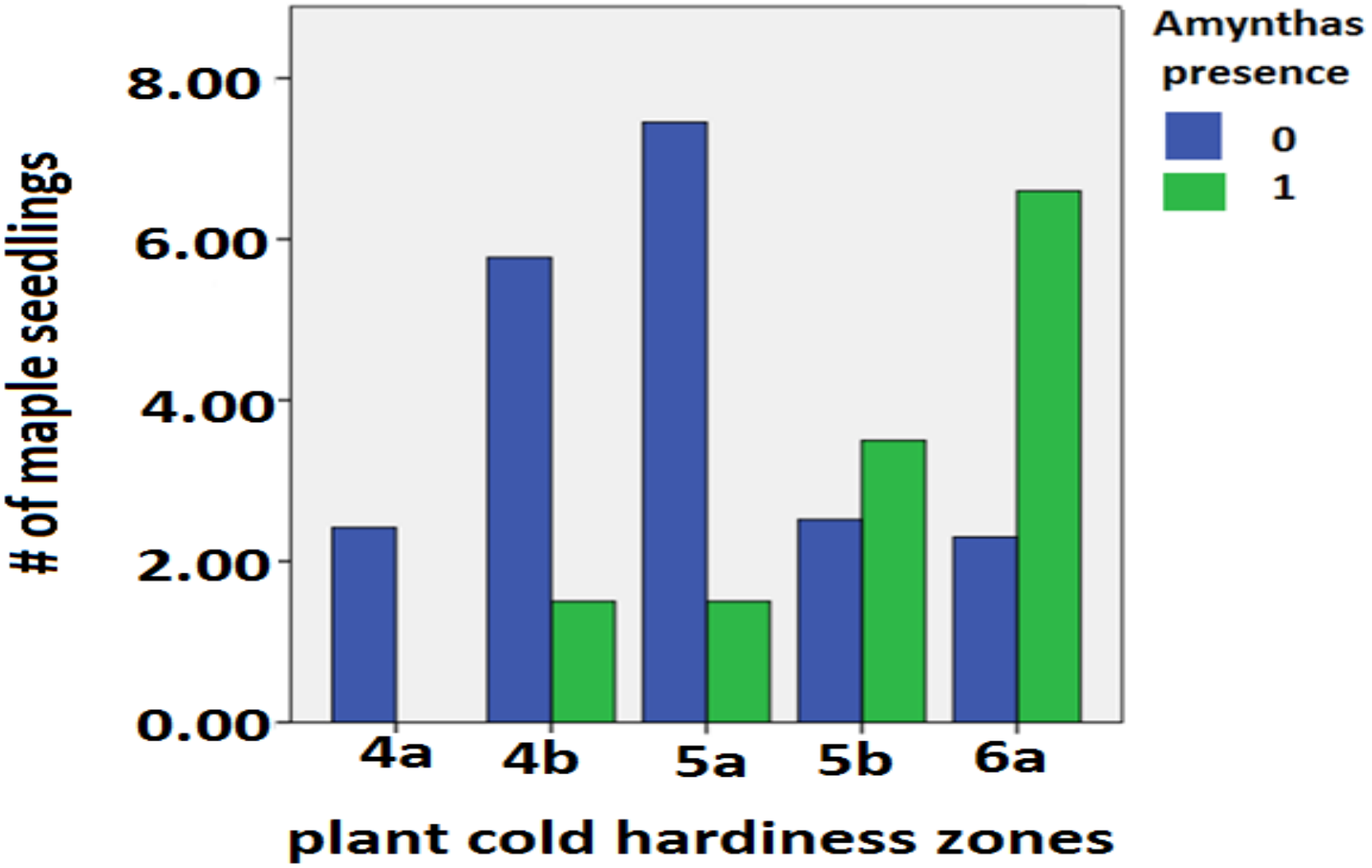
Breakdown across damage levels: percentages of ‘invasive’ plant presence



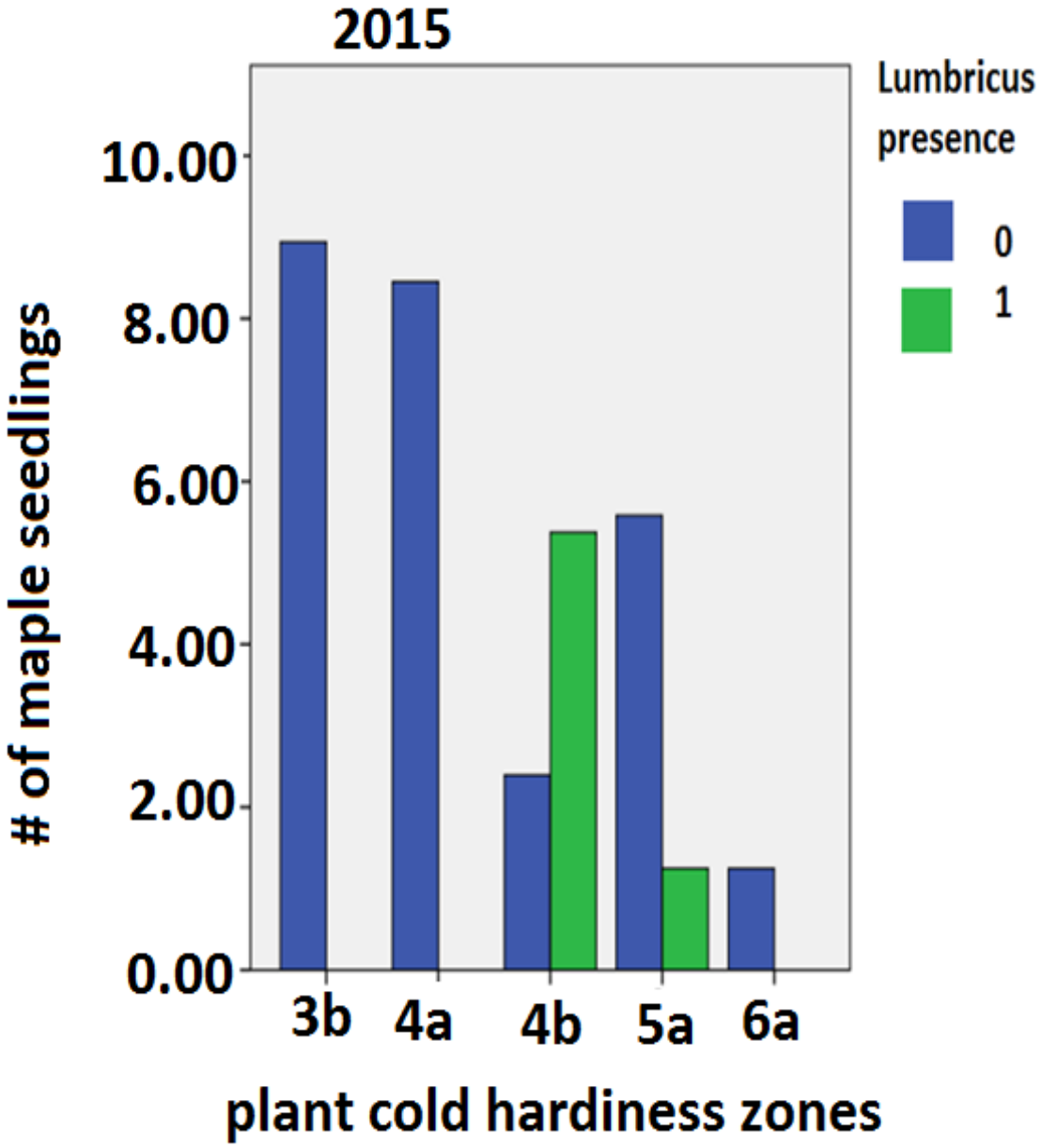
2015-2017 patterns of forest damage across plant cold hardiness zones

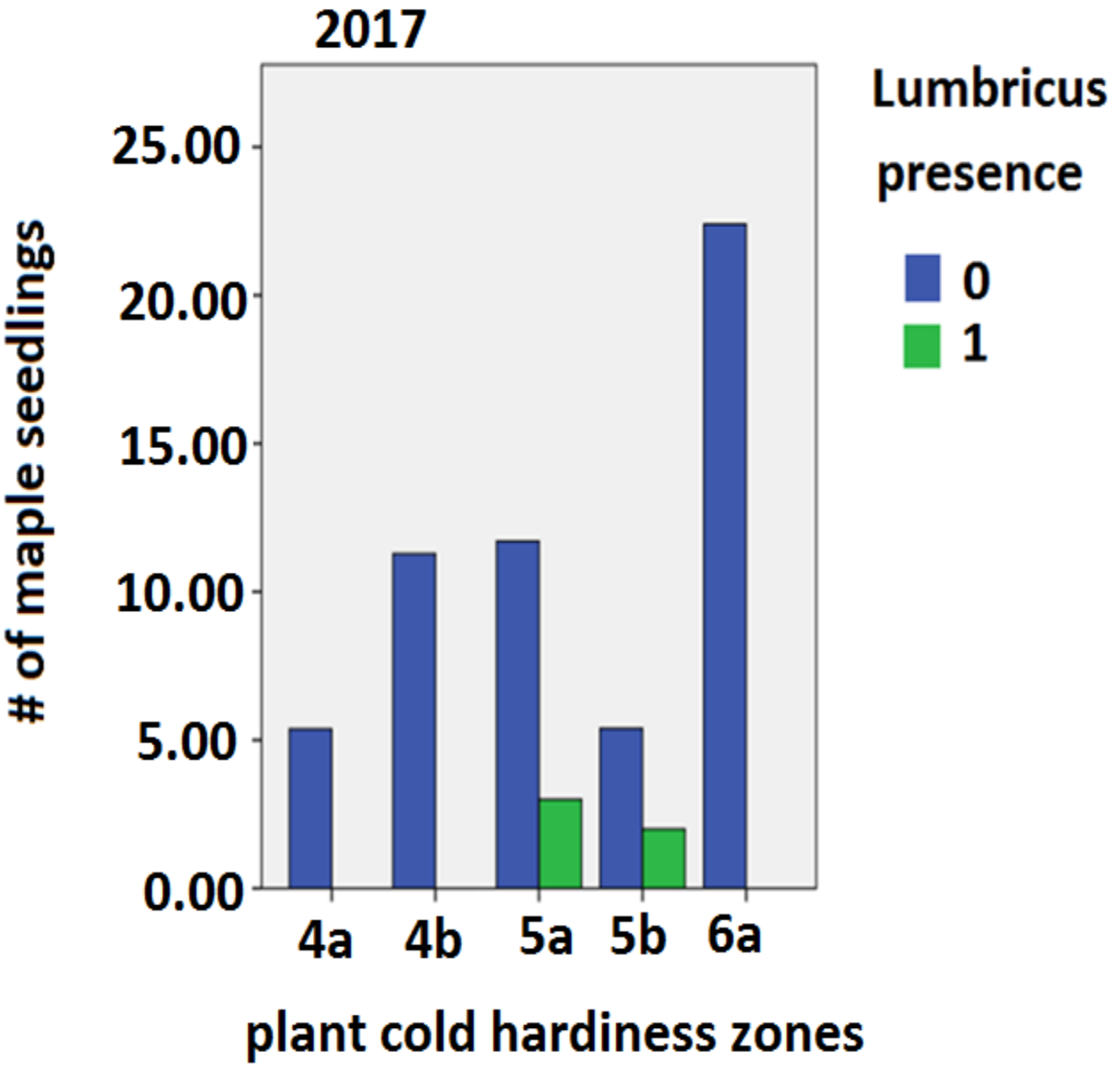


2016: Relationship of Amynthas maple regeneration via seedlings

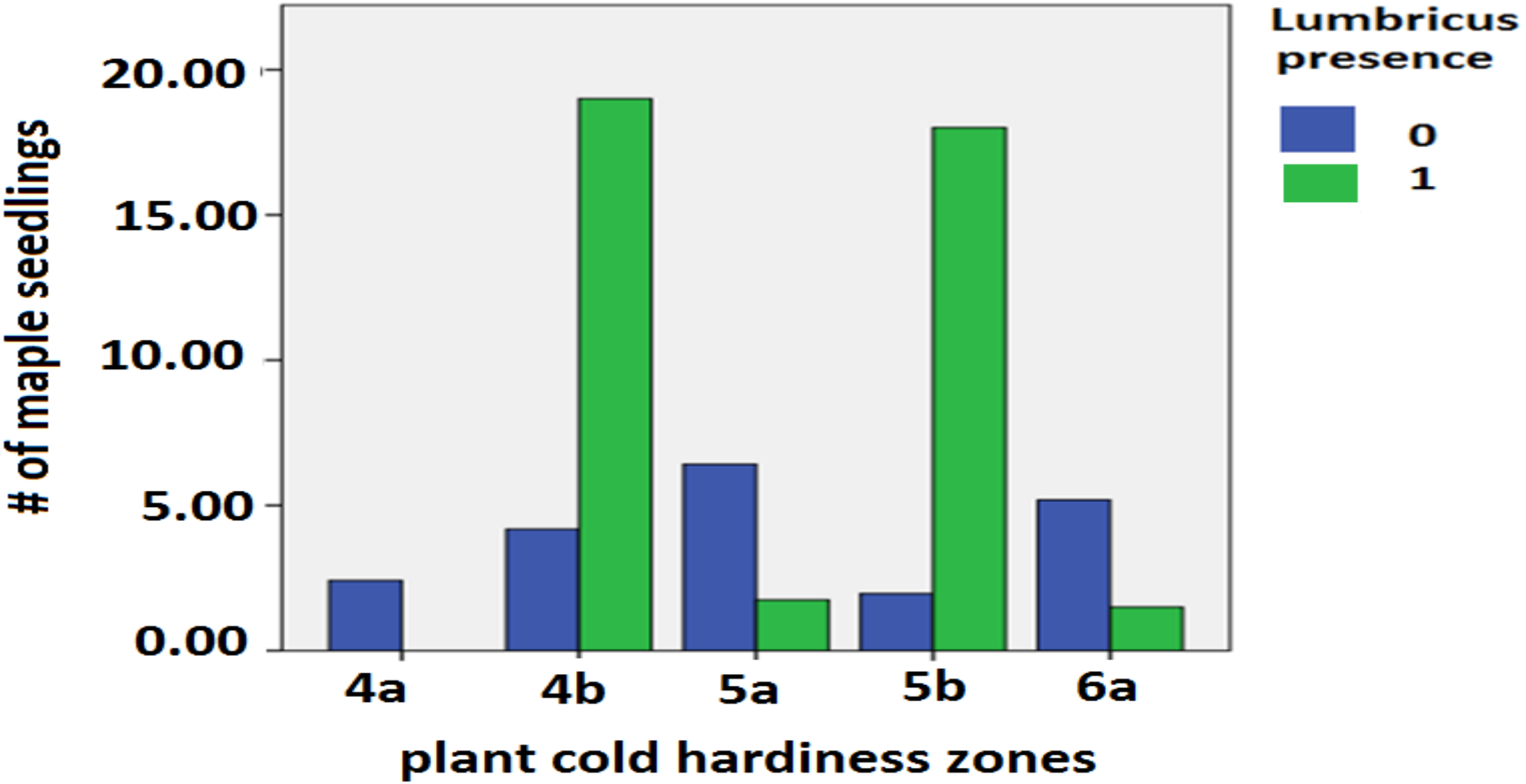


Effects of *Lumbricus* on maple seedling #'s in 2015 & 2017

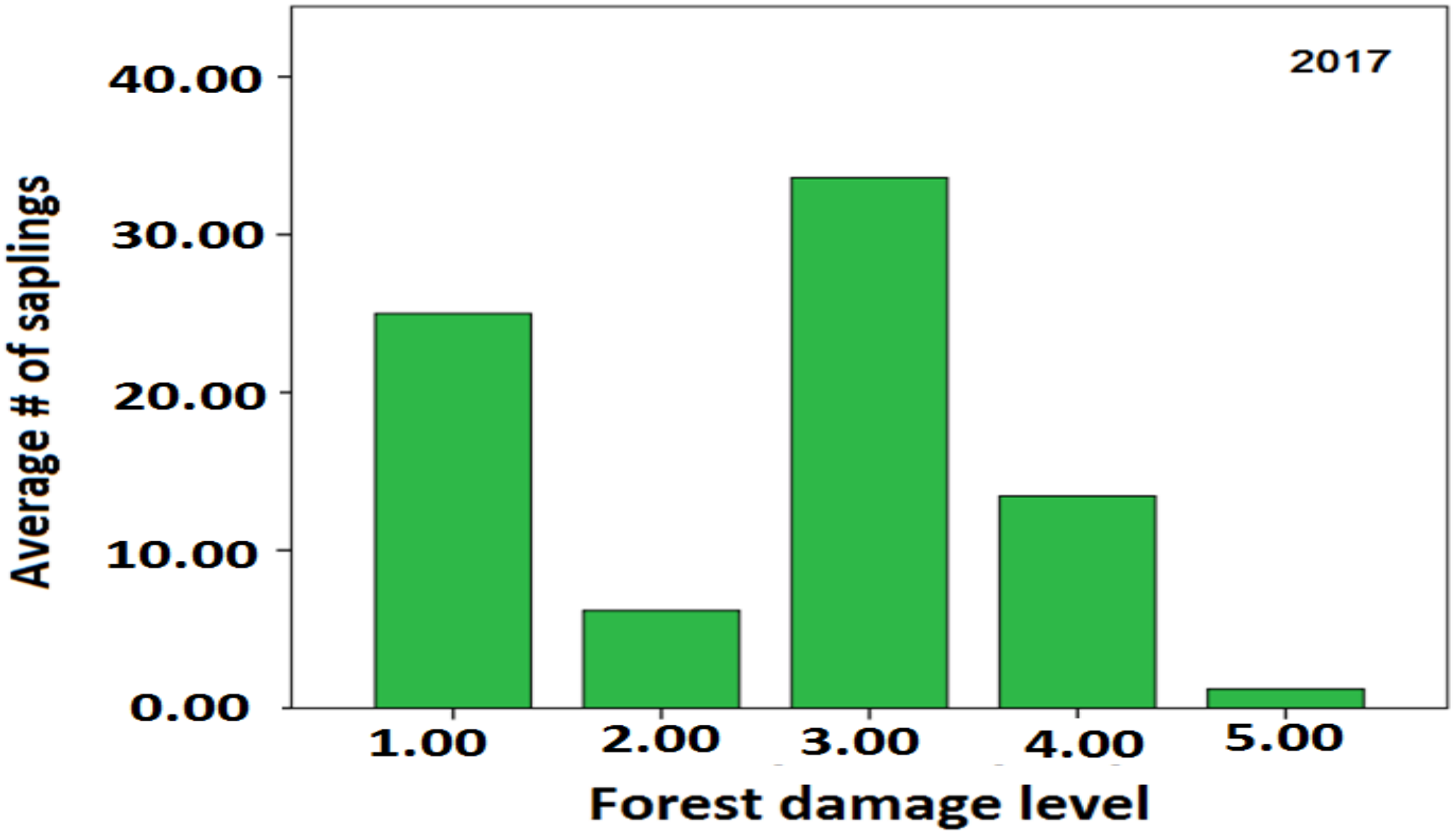




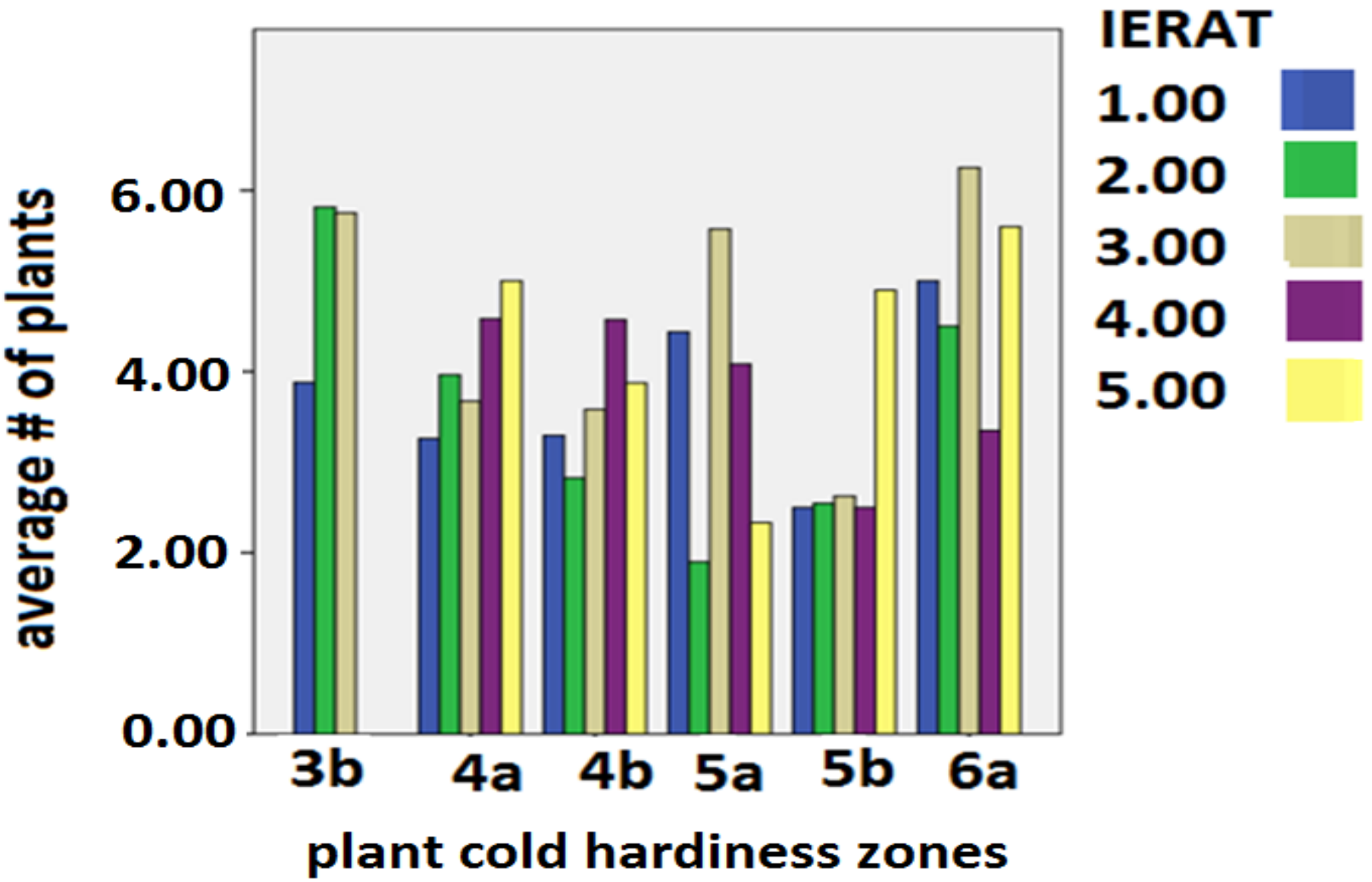
Anomaly year data on *Lumbricus* effects on maple regeneration via seedling #'s



Forest damage and maple regeneration via saplings:



Relationship of plant diversity and forest damage level according to plant cold hardiness zones



Maple regeneration via maple seedlings across states