LARGE WORMS AT LARGE

Nightcrawlers change Alaskan forests

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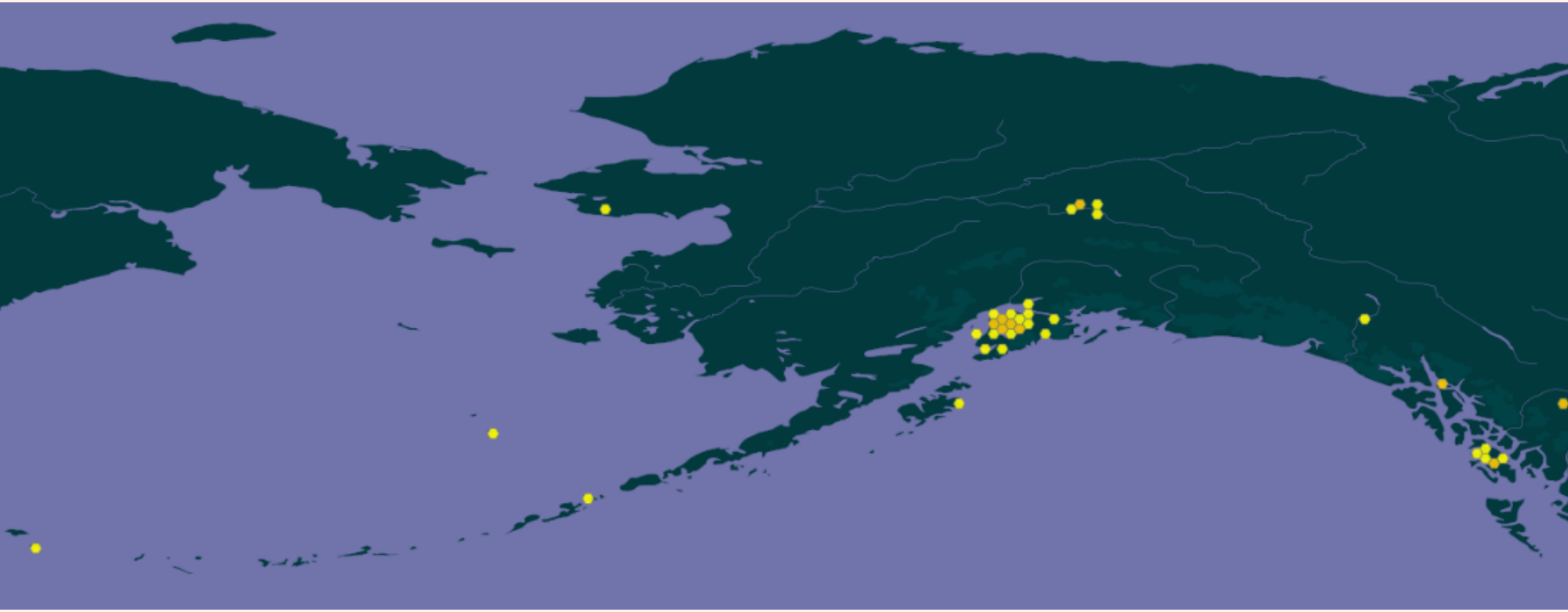
Alaska's earthworms

map from [1].

Currently known Alaskan distribution

(all lumbricid earthworms as of 4.Feb.2019)



map from [2].

Alaska's earthworm diversity

exotic, feral

Allolobophora chlorotica [3, 4]
Allolobophoridella eiseni [5]
Aporrectodea caliginosa [6, 7]
Aporrectodea rosea [6]
Aporrectodea trapezoides [4, 8]
Aporrectodea tuburculata [4, 8]
Dendrobaena octaedra [6, 7, 9]
Eiseniella tetraedra [6, 7]
Lumbricus castaneus [4]
Lumbricus rubellus [6]
☞ ***Lumbricus terrestris*** [7, 9]
Octolasion cyaneum [6]
Octolasion tyrtaeum [6]

exotic, domestic

Amynthas sp. [10]
Eisenia andrei [10, 11]
Eisenia fetida (?) [12]

native

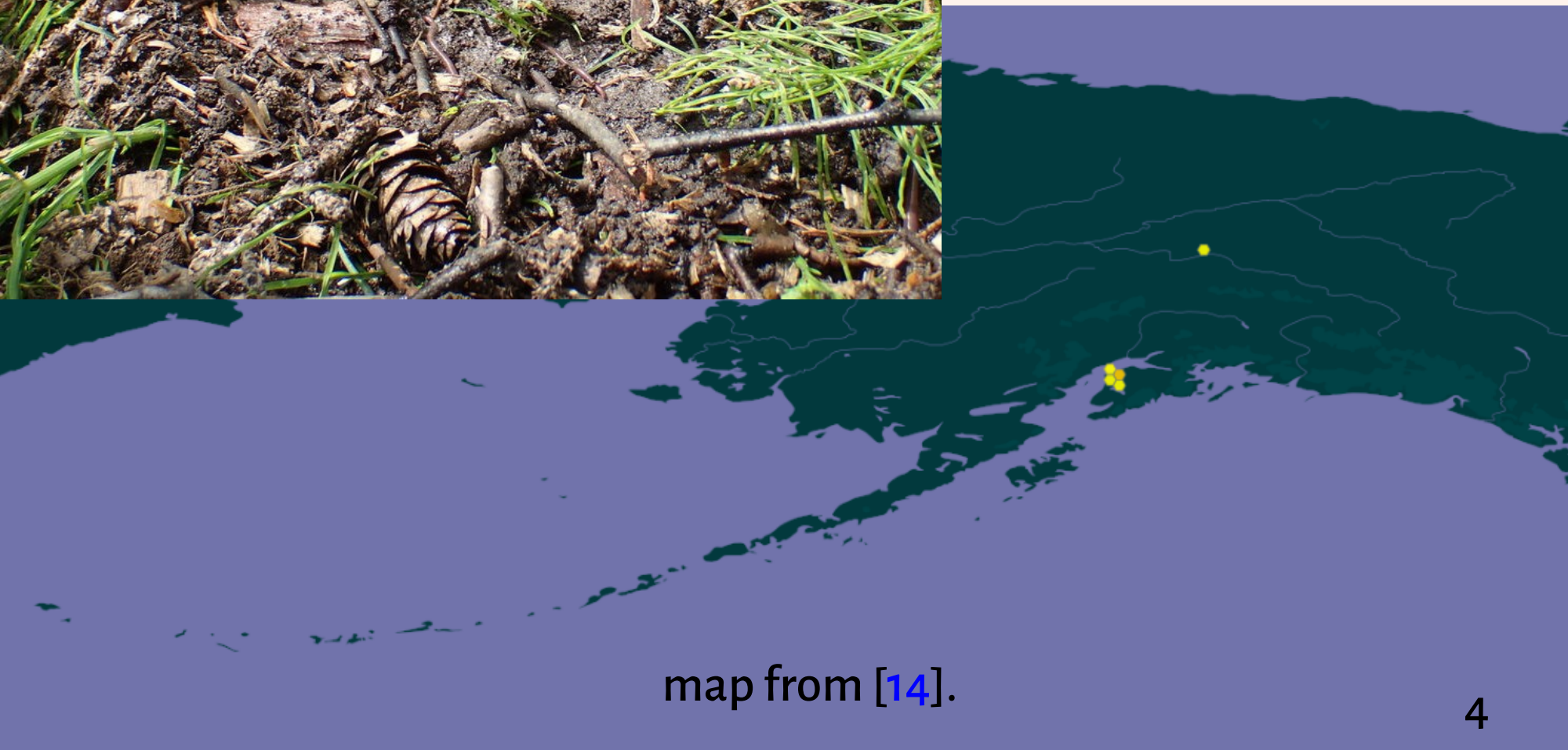
Bimastos rubidus [6, 7, 9]

uncertain origin

Arctiostrotus sp. [6]
Sparganophilus sp. [13]

$\sum = 19$ species

Alaskan distribution of Lumbricus terrestris, *the nightcrawler*



map from [14].

How nightcrawlers get around

- Extremely slow natural dispersal (4–9 m/yr) [15], slower than glaciers typically move [16]!
- Long distance dispersal by humans [17]
  - Gardening / agriculture
  - Bait abandonment

On Kenai Refuge, nightcrawlers occur *only* at boat launches [9].

image from https://thewormlady.ca/resources/night_crawlers_in_plastic_tub.jpg.opt504x28300%2Cos504x283.jpg

What earthworms do

That earthworms increase plant productivity in *agricultural systems* is generally accepted.

- ↑ crop production by 25% average [18]!
- improve soil structure [19]
- ↑ aeration [19]
- ↑ water infiltration [19]
- ↑ nutrient cycling [19]

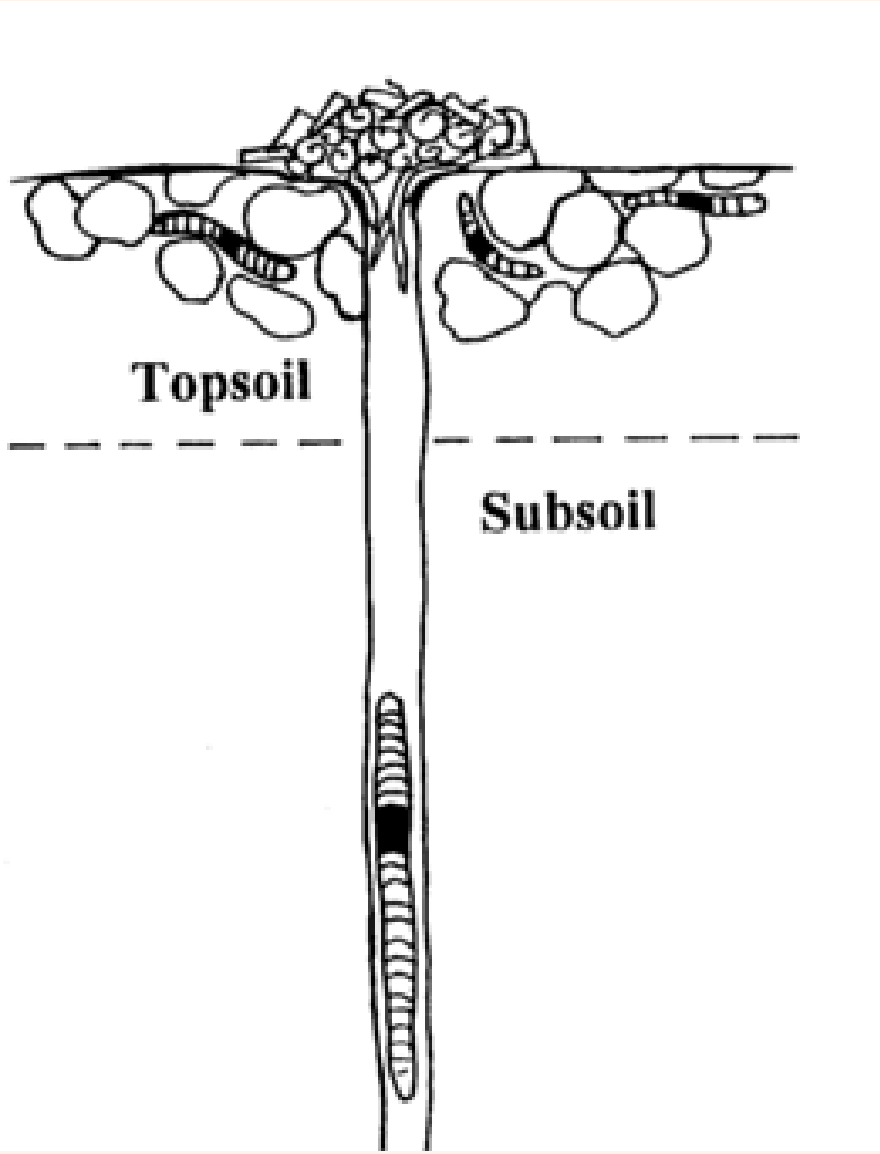


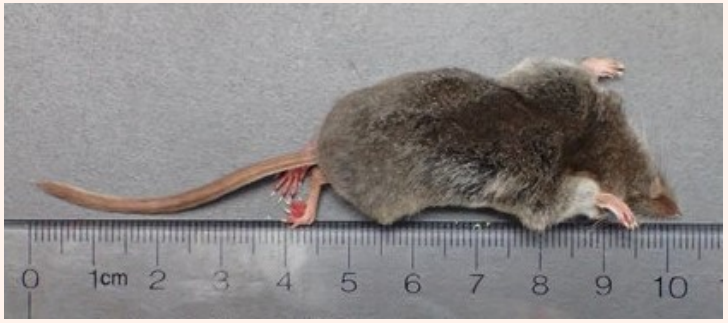
image from https://www.extension.purdue.edu/extmedia/ay/images/AY-279.fig1.gif


What is wrong with this picture?

Ramifications of earthworm infestations

- Reduction or loss of leaf litter/organic layers [20–22]
- Formation of a well-developed A horizon [21]
- ↑ aeration [23]
- ↑ water infiltration [24]
- Alter nutrient cycling [20, 21]

- ↓ species dependent on a thick organic layer, soil fungi [25], mycorrhizal fungi [26, 27], mycorrhizal symbionts [28]



- ↓ native plant species diversity overall [29]

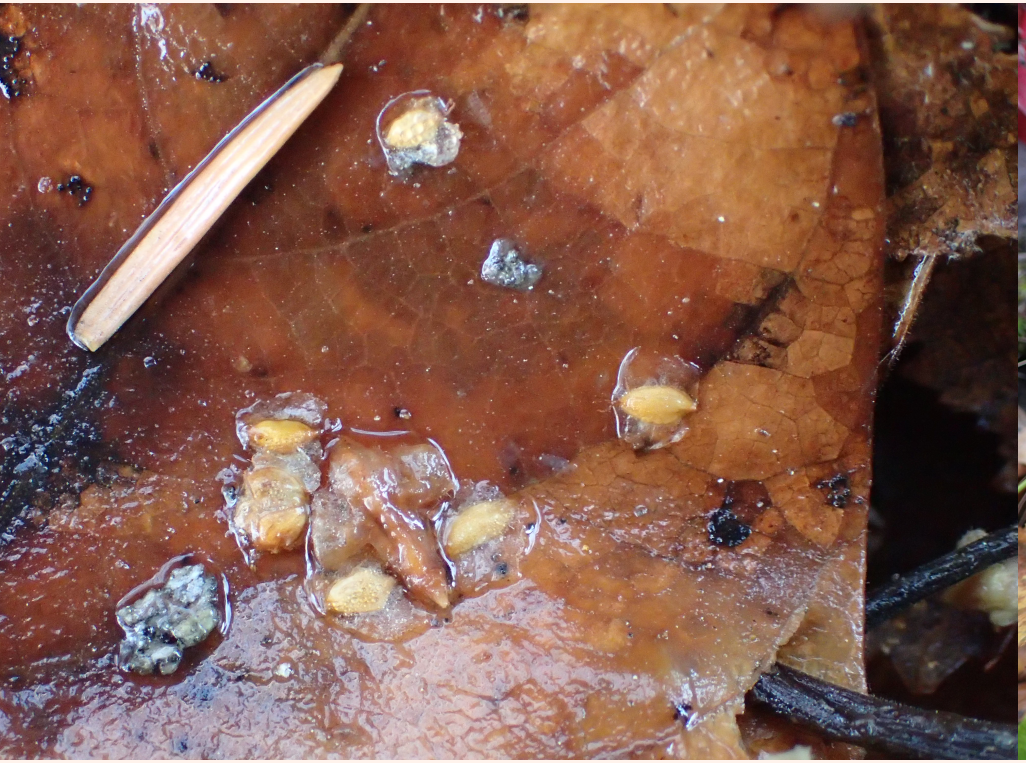
- ↑ species adapted to soils worked by earthworms; non-mycorrhizal species...

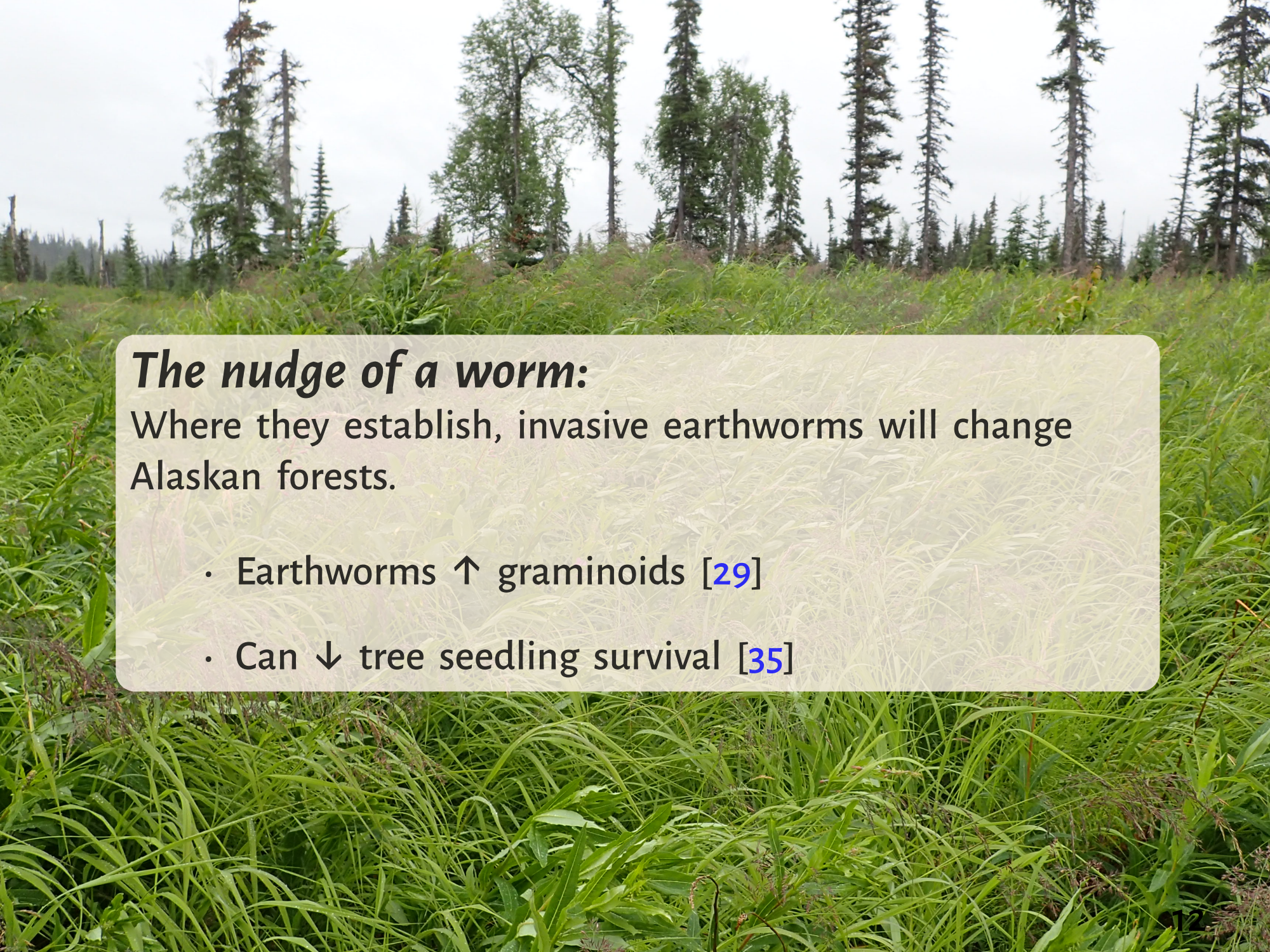
- ↑ non-native plant species diversity overall [29]

Invasional Meltdown—where invasive species interact positively [30]. In this case, earthworms alter soil properties in ways that favor exotic plants [29, 31].

Earthworms alter seed bank and germination

- Earthworms eat seeds(!) preferring small seeds (e.g, birch) [32]
- ↑ emergence of grasses [33]
- ↓ survival of white spruce seedlings [34]





The nudge of a worm:

Where they establish, invasive earthworms will change Alaskan forests.

- Earthworms ↑ graminoids [29]
- Can ↓ tree seedling survival [35]

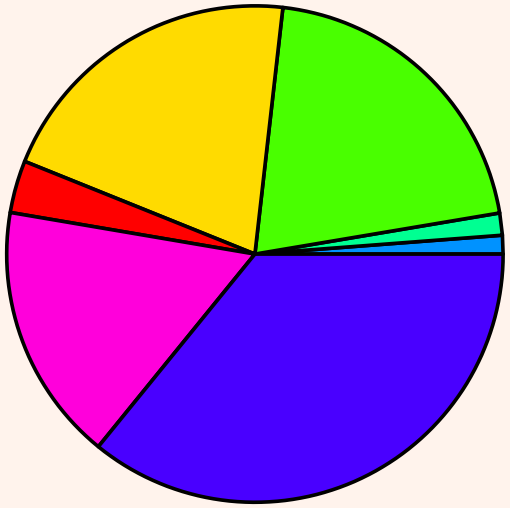
Stormy Lake, Kenai Peninsula

Early invasion

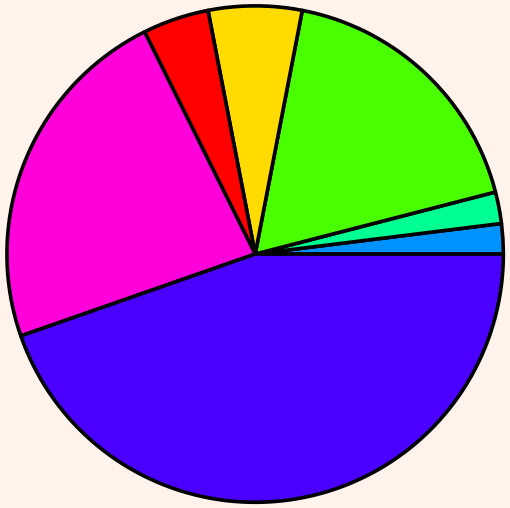
Late invasion

Soil fungal communities at Stormy Lake

Lumbricus absent



Lumbricus present



- endophyte or parasite
- endophyte, mycorrhizal, parasite, or saprotroph
- endophyte, parasite, or saprotroph
- mycorrhizal
- mycorrhizal or saprotroph
- saprotroph
- unknown

Mycorrhizal fungi decreased from 21% to 6% of soil fungi reads after invasion by *Lumbricus*! (unpublished data)


What should we do?
Should any action be taken?

Prevent spread of worms to new locations.

(Recall that nightcrawlers currently are absent from the overwhelming majority of their potential range in Alaska and will remain so for centuries unless people move them around).

- Outreach / education (see [36, 37])

Alberta WORM INVASION Project

GREAT LAKES WORM WATCH

- Laws and / or regulations limiting transport and use of certain earthworms?
  (e.g., Voyageurs National Park prohibits live bait partly to prevent the spread of invasive earthworms [38])

A time to kill?

Is there a scenario in which to consider eradication?

Control options exist (e.g., to reduce worm castings in turf grass [39])

image from

https://kentuckypestnews.files.wordpress.com/2014/04/invasive-earthworm-casts-fig-1.jpg

We are not aware of any previous attempt to eradicate an established earthworm population, but...

- A number of pesticides are acutely toxic to earthworms (see [40]).
- Can drastically reduce earthworm populations (by 90–97% in 1 wk.!) [40]
- Due to their surface-feeding behavior, nightcrawlers are more sensitive to pesticides than most other earthworm species [41].

Image from [42].

Candidate chemicals for eradicating earthworms

chemical name	toxicity to earthworms	registered in Alaska?	references
carbaryl	extremely toxic	yes	[40, 41]
chlorpyrifos	very toxic	yes	[41]
clothianidin + bifenthrin	extremely toxic	yes	[42]
ethoprophos	very toxic	yes	[40, 41, 43]
tea-seed saponins	very toxic	no	[39, 42–45]
thiophanate-methyl	very toxic	yes	[41, 43]

Note: No pestides are currently approved for the purpose of controlling or eradicating earthworms in the United States, including Alaska. The chemicals listed as registered in Alaska in the table above are approved for use on organisms other than earthworms.

A time to kill?

Is there a scenario in which to consider eradication?

Disclaimer

The contents of this presentation are the work of the authors and do not necessarily represent the views of any organization. Specifically, we are not making recommendations for the use of pesticides.

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Image from [46]

Image from [47].

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