The Nudge of a Worm

Invasive European earthworms change Alaskan forests

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Alaska's earthworms

map from [1].
Currently known Alaskan distribution
(all lumbricid earthworms)

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

- Eisenia foetida [10]
- Eisenia hortensis [11]

native!

- Bimastos rubidus [6, 7, 9]

uncertain origin

- Arctiostrotus sp. [6]
- Sparganophilus sp. [12]

$\sum = 18$ species
How nightcrawlers get around

- Extremely slow natural dispersal (5–10 m/yr), slower than glaciers typically move [13]!

- Long distance dispersal by humans [14]
  - Gardening / agriculture
  - Bait abandonment

On Kenai Refuge, nightcrawlers occur only at boat launches [9].
Alaskan distribution of Lumbricus terrestris, the nightcrawler

map from [15].
What earthworms do

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

- ↑ crop production by 25% average [16]!
- improve soil structure [17]
- ↑ aeration [17]
- ↑ water infiltration [17]
- ↑ nutrient cycling [17]

image from https://www.extension.purdue.edu/extmedia/ay/images/AY-279.fig1.gif
What is wrong with this picture?
Ramifications of earthworm infestations

- Can completely remove litter and duff layers (up to 10 cm/yr!)
- Reduction or loss of organic layers
- Formation of a well-developed A horizon
- ↑ aeration
- ↑ water infiltration
- ↑ nutrient cycling
• ↓ species dependent on a thick organic layer, mycorrhizal symbionts

• ↓ native plant species diversity overall [18]

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

• ↑ non-native plant species diversity overall [18]
Invasional Meltdown—where invasive species interact positively [19]. In this case, earthworms alter soil properties in ways that favor exotic plants [18, 20].
Earthworms alter seed bank and germination

- Earthworms eat seeds(!) preferring small seeds (e.g., birch) [21]
- ↑ emergence of grasses [22]
- ↓ survival of white spruce seedlings [23]
The nudge of a worm:
Where they establish, invasive earthworms will change Alaskan forests.

- Earthworms ↑ graminoids [18]
- Can ↓ tree seedling survival [24]
Stormy Lake, Kenai Peninsula, 2018

Before invasion:
14-20 cm thick O horizon

After invasion:
No O horizon.
10 cm thick A horizon
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 [25, 26])

- 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 [27])
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 [28])
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 [29]). For example, ethoprop and carbaryl have been shown to drastically reduce earthworm populations (by 90–97% in 1 wk.! [30] and are both approved for use in Alaska [31, 32] (as a nematicide and insecticide, respectively).

- Due to their surface-feeding behavior, nightcrawlers are more sensitive to pesticides than most other earthworm species [29].
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.
Acknowledgments

- John Morton, USFWS Kenai NWR—for his support
- Deanna Saltmarsh, Alaska Pacific University; Megan Booysen, University of Alaska Fairbanks; and Robin Andrews, University of Alaska Fairbanks—for their work on Alaskan earthworm biogeography.
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