Earthworms and Soil Health

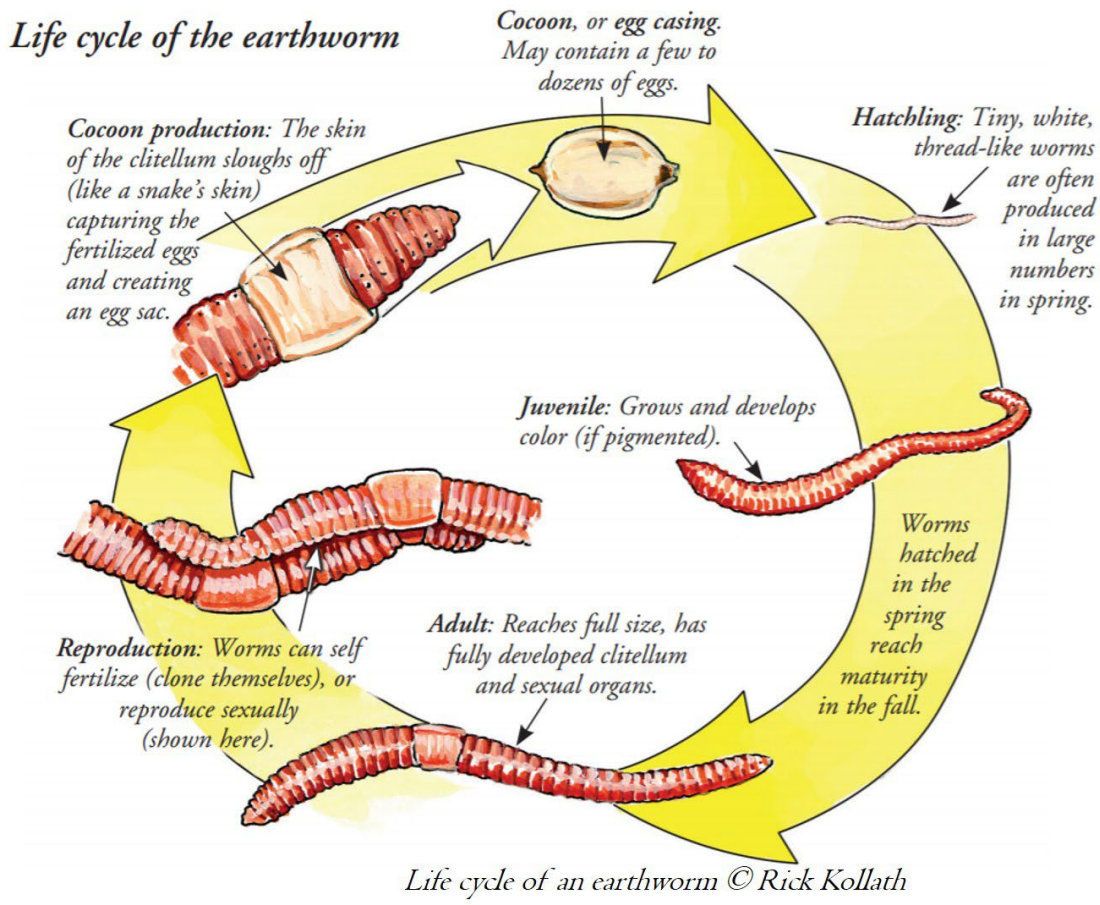
Farmers of the Sugar River Field Day June 18th, 2024

Quick fun facts:

- Earthworms are an invasive species. No native earthworms in Wisconsin! They came to the America's with the first European settlers. Over 9,000 species worldwide. About 20 in WI.
- A good earthworm population may number around 200 worms/m^2.
- Earthworms are annelids. Their bodies are composed of segmented rings, each with a specific role in worm survival and reproduction.
- Ingest over 100,000 lbs. of dry soil/ac/yr (Feller et al. 2003)
- Surface casting species move approx. 10,000 lbs. soil/ac/yr (Feller et al. 2003)
- Earthworm activity can increase crop yields by 25% and increase aboveground biomass by 23% (data from 58 studies published between 1910-2013; van Groenigen et al. 2014)
- TAKEAWAY: Conservation cropping practices aimed at sustainable intensification of agriculture should consider their effect on the earthworm population, because their presence stimulates crop production and will help to maintain or increase yield compared to "business-as-usual" practices.

Nightcrawler. An earthworm in the anecic functional group

1. Life cycle



Used with permission.

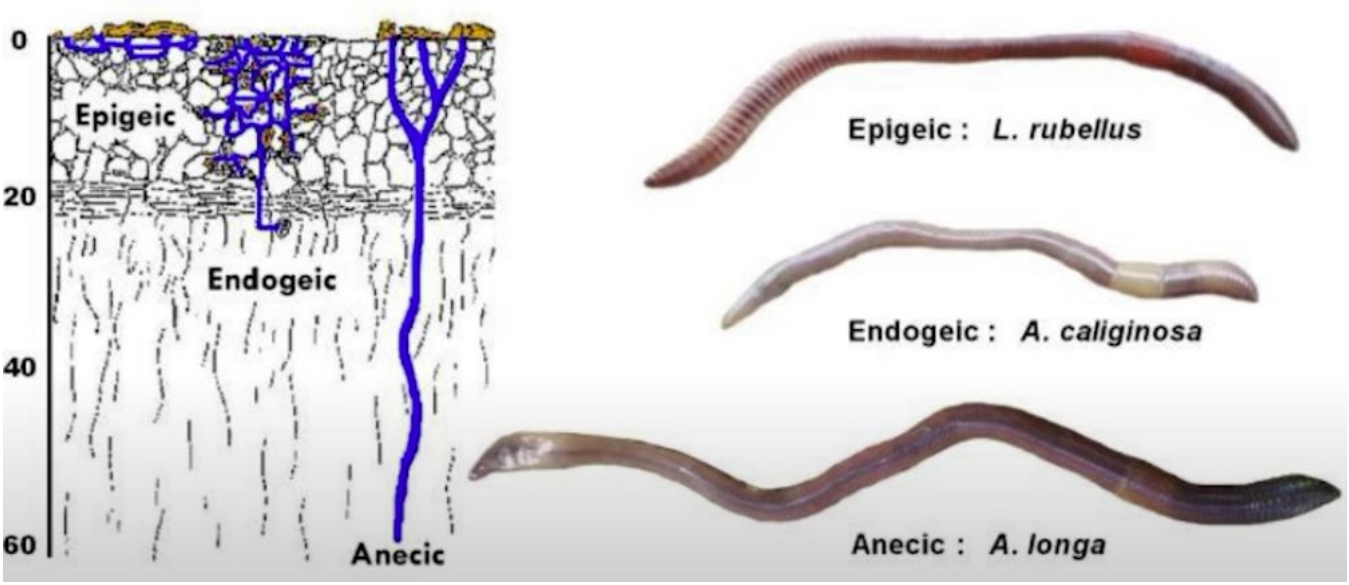
Earthworm cocoons tend to be "lemon" shaped but varies between species.

Cocoon recovered from field.

Cocoons in Petri dish for counting.

2. Earthworm ecological groups

Earthworms in the soil are divided into 3 major functional groups. They are detritivorous where they feed on decaying organic matter (e.g., crop residue) and are geophageous (eating soil) when feeding in the soil layers.

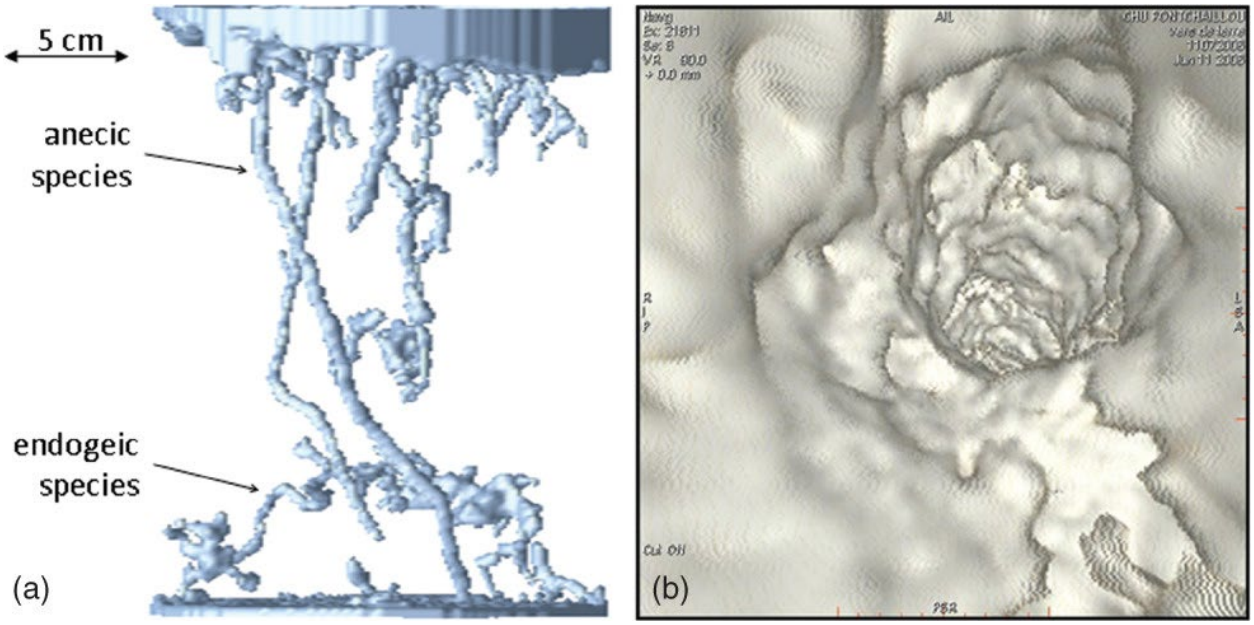


http://sciencelearn.org.nz/

Epigeic species: These species stay close to the surface. They live within the first 0.5" of the soil surface and feed on undecomposed litter. They are less than 4" in length and do not create permanent burrows. Usually pigmented.

Endogeic species: These species feed on soil and associated organic matter and burrow through the soil to obtain their food. They live in horizontal, non-permanent branching burrow-systems. They are between 4"-8" in length and primarily dwell in the top few feet of the soil. Usually not pigmented.

Anecic species: These species feed on surface litter and live in permanent vertical burrow-systems that may extend several feet beneath the surface (some up to 6'). They are typically greater than 6" in length and are soil dwelling. They remove litter from the soil surface, pulling it down into the mineral soil layers of their burrows. They deposit casts of mixed organic and mineral material on the soil surface. Usually dorsally pigmented.



A) A real burrow network created by anecic and endogeic earthworms. Visualized and constructed using X-ray tomography. B) Reconstruction of the interior of an earthworm burrow using medical software and X-ray tomography.

Images from Figure 4 in Blouin, M. Hodson, M.E., Delgado, E.A., Baker, G., Brussaard, L., Butt, K.R., Dai, J., Dendooven, L., Peres, G., Tondoh, J.E., Cluzeau, D., Brun, J.J. 2013. A review of earthworm impact on soil function and ecosystem services. European Journal of Soil Science. 62 (2): 161-182. https://doi.org/10.1111/ejss.12025

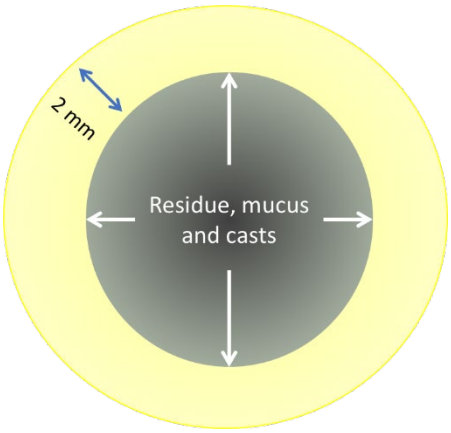
3. Earthworms and Soil Health

- Increase infiltration and reduce runoff (anecic)

- Increase the movement of air and water within the profile (anecic and endogeic)

- Casting enhances aggregate stability, stabilizes Carbon, increases the diversity of pore sizes (mesopores and micropores), promotes Nitrogen mineralization. (all functional groups)

- Drilosphere: the soil immediately surrounding earthworm burrows (anecic and endogeic; shown in yellow in the diagram). The drilosphere is enriched in Carbon and Nitrogen, has enhanced microbial activity compared to the bulk soils, has increased populations of protozoa, nematodes, and collembola (aka beneficial organisms), and increased Carbon and Nitogen mineralization resulting from enhanced microbial activity.



- **Takeaway:** There are general feeding and processing impacts, those associated with burrowing and the drilosphere, and those associated with casts. The overall impact of earthworms on soil health highly depends on the type of worm, the type of soil, and organic matter inputs.

4. Earthworm monitoring

To start to understand the potential for earthworms to impact soil health, we need to know the species present, their functional groups, activity periods, and typical density and biomass values. But the place best to start is just by monitoring their presence in different fields. Casts (earthworm poop), burrows, and middens signify the presence of earthworms.

Casts

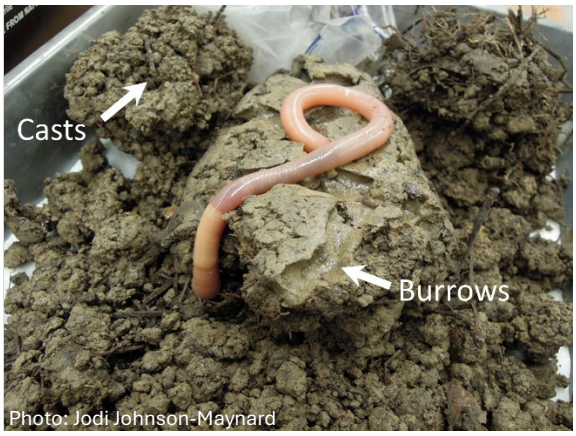


Photo: Jodi Johnson-Maynard


Photo: USDA-NRCS


Photo: Chelsea Walsh


Photo: Kendall Kahl

Middens

Middens are piles of plant residues and castings around the opening of burrows. They resemble partially eaten leaves or stems sticking out of the ground. They probably serve to protect the mouth of the burrow and as a food reserve. There is typically 1 worm per midden.

Burrows


Photo: Kendall Kahl

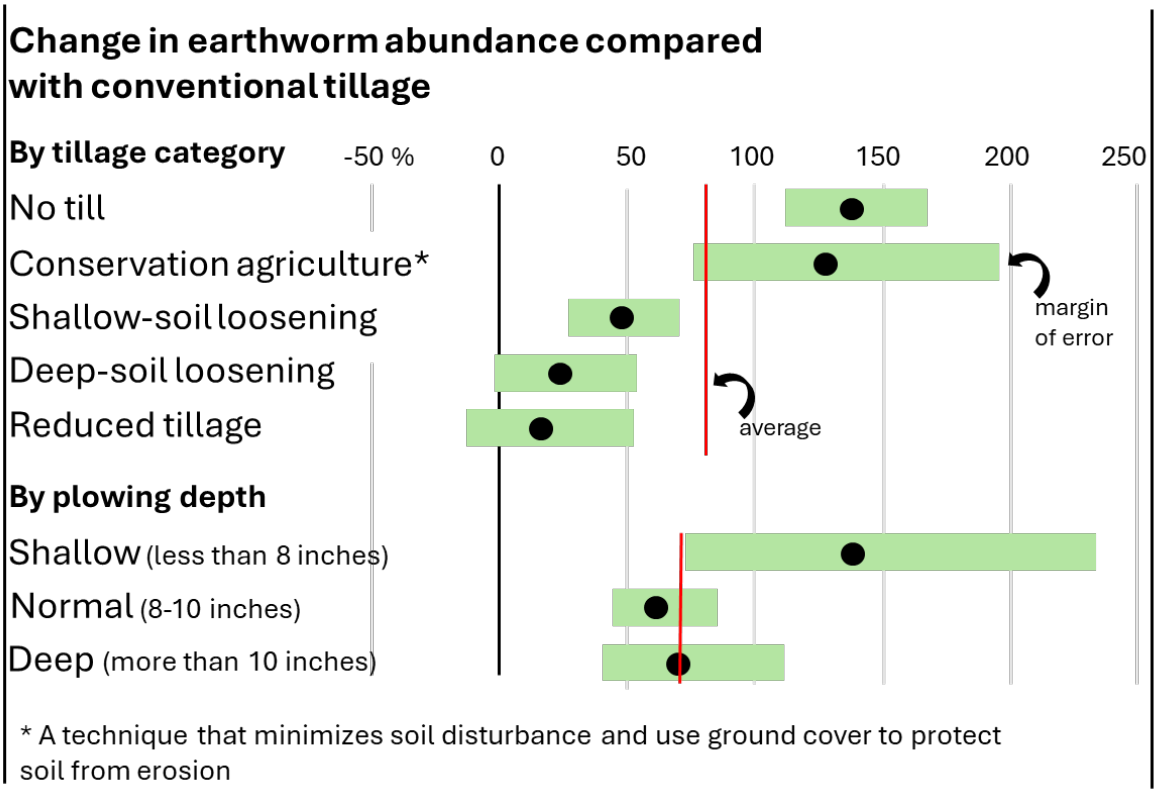

Photo: Kendall Kahl


Photo: Kendall Kahl


Photo: The Rodale Institute

5. Earthworms and Tillage

- Endogeic, and especially anecic, earthworms are sensitive to disturbance.
- Tillage operations impact large soil fauna, such as earthworms, directly by mechanical injury and indirectly by destroying their channels and burying surface plant residues.
- In 2017, scientists assembled primary research results from individual field experiments and analyzed them together in a meta-analysis, a statistical tool that allows one to look for (and quantify) common trends across many independent studies. Each study investigated earthworm populations under conventional tillage and other forms of reduced tillage.
- The findings show a systematic decline in earthworm populations in soils that are tilled every year. The deeper the tillage, the more harmful it is for the earthworms. Disturbing the soil less increased abundance up to 137%.



Adapted from Briones and Schmidt 2017

6. Further reading and references:

Briones MJI, Schmidt O. 2017. Conventional tillage decreases the abundance and biomass of earthworms and alters their community structure in a global meta-analysis. Global Change Biology. https://doi.org/10.1111/gcb.13744

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Hopwood, J., Frischie, S., May, E., Lee-Mader, E. 2021. Farming with Soil Life: A Handbook for Supporting Soil Invertebrates and Soil Health on Farms. 128 pp. Portland, OR. The Xerces Society for Invertebrate Conservation. https://www.xerces.org/publications/guidelines/farming-with-soil-life

van Groenigen, J.W., Lubbers, I.M., Vos, M.J.H., Brown, G.C., de Deyn, G.B., van Groenigen, J.K. 2014. Earthworms increase plant production: a meta-analysis. Scientific Reports. 4: 6365. https://doi.org/10.1038/srep06365

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