POCKET GUIDE TO

SOIL INVERTEBRATES AS BIOINDICATORS

XERCES SOCIETY
for Invertebrate Conservation

INTRODUCTION

Bioindicators are species (spp.) or groups of spp. that can be used to help assess ecological health/quality or monitor change over time. The presence or absence of bioindicators, along with changes in their abundance, behavior, or physiology, provide useful information about the local environment, including how they respond to environmental disturbances.

Bioindicators can be measured and compared across many sites to assess differences in site conditions, or can be measured at a baseline and over time to assess environmental change at a single site.

Soil invertebrates have great potential as bioindicators of soil health, including habitat quality, soil nutrition, pollution, and other ecological or environmental properties. They are more diverse and abundant than vertebrates, and often more sensitive to environmental disturbance, responding quickly to changes in conditions.

COVER PHOTO: Sarah Foltz Jordan / Xerces Society

WHAT MAKES A GOOD BIOINDICATOR?

- Sensitive to environmental conditions.
- Easily recognized.
- Evenly distributed or generally not hard to find.
- Well studied. The more we understand about how spp. respond to their environment, the more we can learn about environmental health from observing change in their presence/abundance/behavior, etc.

However, indicators are only as useful and reliable as our understanding of them. Invertebrates can respond in complex ways to environmental disturbance, and we often lack data on how spp. or groups of spp. respond to disturbances like pesticide use or tillage, and how quickly their populations may recover from these events. Use of multiple indicators/taxa can sometimes help provide more well-rounded information on environmental quality.

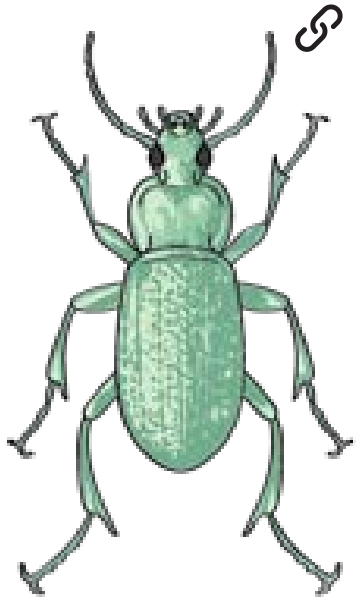
This guide provides profiles of invertebrates that have important roles in soil health and function and may be good candidates for measuring and monitoring to assess the state of the soil environment.

HOW TO SAMPLE

Soil invertebrates live in different levels in a soil profile—some live among plant residues on the surface, others in the first few centimeters deep and others live up to several meters deep. Where these animals live depends on the type of animal, and local conditions such as light, temperature, moisture, time of day, season of the year, the type (or lack of) of vegetation, and associated plant residues. The groups of invertebrates featured in this guide live on the surface or in shallow depths. See the organism profiles for more information on where to expect each group of invertebrates. Simple methods for observing soil invertebrates include:

- Note what you see when watching one area over several minutes.
- Use a pitfall trap to catch invertebrates as they move across the soil surface. See **page 17** of *Farming for Soil Life* for instructions.
- Use a Berlese funnel to observe smaller invertebrates that live in soil and surface organic material. See **page 18** of *Farming for Soil Life* for instructions.

CARABIDS » GROUND BEETLES



0.12–1.18" (3–30 mm)

HOW/ WHERE THEY LIVE: Found under debris, stones, and logs, in soil cracks and leaf litter, and on the soil surface or vegetation; live <4 years. Most are nocturnal, some spp. are day-active.

ROLE/IMPORTANCE: Predators as larvae and adults; important in controlling crop pests like slugs, caterpillars, aphids, and more; also contribute to weed control via seed predation. Some also eat detritus and fungi, contributing to decomposition and nutrient cycling.

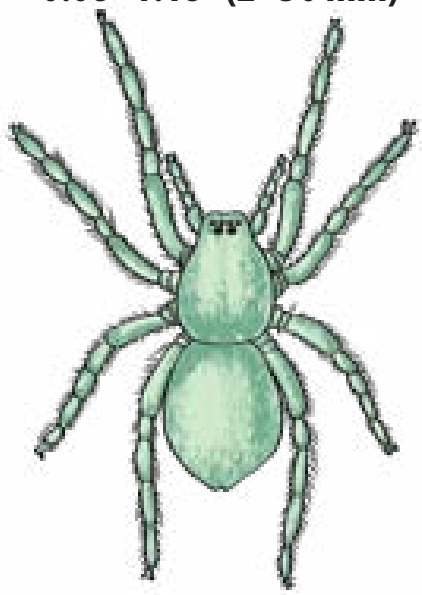
AS INDICATORS: Sensitive to disturbances, spp. abundance and composition of ground beetle communities can reflect stressors present; e.g., spp. that are poor dispersers decrease with disturbances such as pesticides, tillage, and fire.

HOW TO FIND THEM: Pitfall traps; Berlese funnels.

DESCRIPTION (ADULTS): Head narrower than thorax | Extended, oval-shaped abdomen with ridged wing covers (elytra) | Threadlike antennae | Prominent eyes with large mandibles (jaws) | Dark & shiny | Some spp. iridescent green, blue, or purple.

ARACHNIDS » SPIDERS

0.08–1.18" (2–30 mm)



HOW/WHERE THEY LIVE: Hunting spiders (wolf, ground, jumping) are found on the soil surface or in leaf litter, web-building spiders (dwarf sheet, sac, funnel weaver) are found within webs spun on/in the ground. 1 generation per year, live 1–3 years.

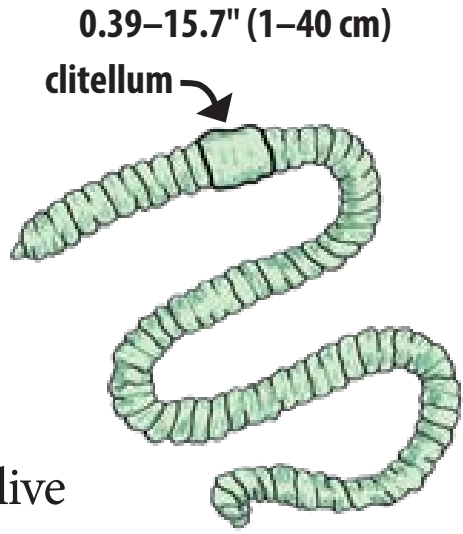
ROLE/IMPORTANCE: As predators that either hunt or spin webs to capture prey, spiders help regulate arthropod populations. As diggers, they also move and work the soil. Wolf and jumping spiders can contribute to control of crop pests.

AS INDICATORS: Easy to recognize and respond to disturbances like pesticides, tillage, and burns; e.g., tillage can reduce spider numbers, and spiders are sensitive to changes in habitat structure.

HOW TO FIND THEM: Pitfall traps; Berlese funnels.

DESCRIPTION (ADULTS): 8 long legs | 2 body segments with silk spinning organs at the end of the abdomen | 6–8 eyes | Chelicerae (jaws) to hold prey and inject poison | Many are dark in color; jumping spiders may have iridescent markings.

ANNELIDS » EARTHWORMS



HOW/WHERE THEY LIVE: Found in soil and leaf litter, with different spp. at different soil levels. Earthworms develop within a cocoon in the soil, young emerge looking like smaller adults (sans clitellum), and can live for 4+ years.

ROLE/IMPORTANCE: Earthworms influence soil structure by creating channels and mixing organic matter into the soil. Earthworm casts (digested materials) help make minerals and nutrients available to plants. Nearly ⅓ of spp. found in the US are introduced, some have negative ecological impacts (e.g., jumping worms, *Amynthas* spp.).

AS INDICATORS: Large in size and easy to recognize. Sensitive to pesticides and tillage (e.g., extensive or frequent soil disturbance reduces abundance). Can also be indicators of water infiltration.

HOW TO FIND THEM: Mustard extraction; hand digging and sorting; Berlese funnels.

DESCRIPTION: Soft, segmented, tubelike bodies | Brown, gray, or pink to reddish | A clitellum, a smooth, belt-like swelling near the front of the worm | Small bristles on each segment to help move through soil.

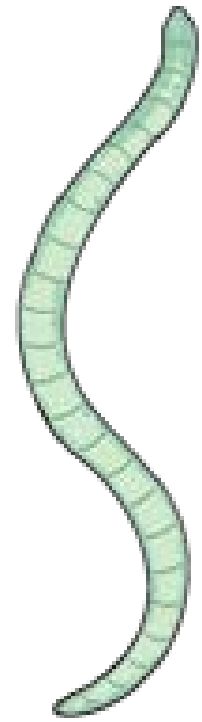
ENCHYTRAEIDS » POTWORMS

HOW/WHERE THEY LIVE: Most common in the leaf litter or upper soil layer; tend to prefer soils with lots of decaying matter.

ROLE/IMPORTANCE: Increase the integration of organic matter and minerals in soil as they feed, and may also increase soil porosity. Potworms are also important decomposers and consumers of plant material, fungi, and bacteria.

AS INDICATORS: Diversity and abundance are influenced by soil pH and moisture. Potworms are sensitive to tillage and pesticide applications.

HOW TO FIND THEM: Run soil core samples through a Baermann funnel.



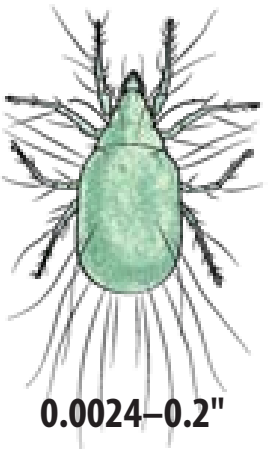
0.04–1.18" (1–30 mm)

DESCRIPTION: Soft, segmented, tubelike bodies (resemble small earthworms) | No pigmentation (appear whitish or translucent) | A bundle of bristles (visible under magnification) on each segment, used to anchor to surfaces.

ACARIDS » MITES

HOW/WHERE THEY LIVE: Soil mites are found at the soil surface, within soil layers, and even in deep soil horizons. Mites can live several weeks to <3 years; lifespan varies by spp.

ROLE/IMPORTANCE: Mites are critical in soil food webs as predators and are particularly important in their role as detritivores, breaking down leaf litter into pieces accessible to smaller decomposers. Mites also help disperse bacteria and fungi.



0.0024–0.2" (0.06–5 mm)

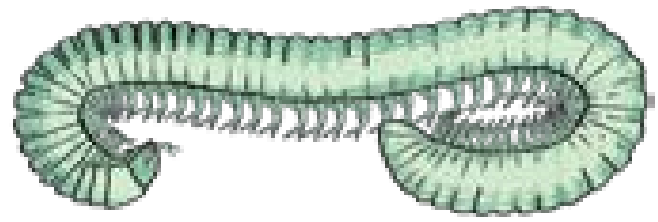
AS INDICATORS: Often the most abundant and diverse small arthropods in soil and are sensitive to land management (e.g., decrease with tillage). The proportion of mites to collembola can be used as an indicator of soil quality and habitat stability, with greater abundance of mites generally indicating high-quality soils. Different soil types can have unique mite communities, however, mite communities can be difficult to assess/identify to spp.

HOW TO FIND THEM: Pitfall traps; Berlese funnels.

DESCRIPTION: Rounded or pear-shaped bodies, typically dark in coloration | Cuticles of some spp. are hard, others are soft | Adults have 8 legs, larvae have 6 | Some spp. have simple eyes; others are blind and rely on hairlike setae for sensing.

MYRIAPODS » MILLIPEDES

0.08–11" (2–280 mm)



HOW/WHERE THEY LIVE: Millipedes live in moist habitats like under bark, logs, and stones, and in leaf litter and upper soil layers. Some excavate deep tunnels and are found in deep soil layers. Millipedes are long lived (<11 years) and females guard eggs within a nest.

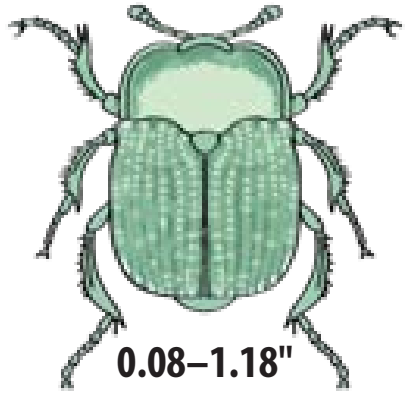
ROLE/IMPORTANCE: Primary decomposers and scavengers, making significant contributions to the decomposition of plant debris while also facilitating further decomposition by microbes.

AS INDICATORS: Soil moisture and vegetation structure influence millipede abundance and spp. diversity; may be useful indicators in ecological restoration.

HOW TO FIND THEM: Pitfall traps; Berlese funnels.

DESCRIPTION: Elongated, segmented body, often black, brown, or gray in color, and sometimes with bright, colorful legs or patterns | Many legs; 2 pair per body segment | 1 pair of antennae and chewing mouthparts.

SCARABS » DUNG BEETLES



0.08–1.18"
(2–30 mm)

HOW/WHERE THEY LIVE: Adults live <3 years in grasslands, forests, farmlands, deserts and elsewhere, within or near dung. Some spp. excavate tunnels in which to rear their young below dung piles, others lay their eggs within piles, and a few other spp. will form dung into a ball and roll it away from the main pat before burying it to feed to their young.

ROLE/IMPORTANCE: These beetles transform manure to humus, speeding up the process of returning nutrients to the soil. Their work enhances forage palatability for grazing animals, recycles nitrogen, reduces pest and parasite habitat, and reduces food-borne pathogens on crops.

AS INDICATORS: Used to detect effects of land and crop management decisions due to their sensitivity to habitat changes and disturbances.

HOW TO FIND THEM: Pitfall traps; traps baited with dung; dig into dung pat.

DESCRIPTION (ADULTS): Oval, convex bodies | Many spp. are dull black (some shiny); a few metallic green to copper | Clubbed antennae | Toothed or scalloped front legs.

ISOPODS » SOWBUGS AND PILLBUGS

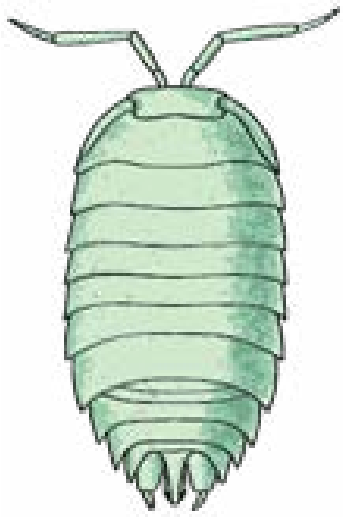
HOW/WHERE THEY LIVE: Isopods are active underneath logs, stones, and bark, leaf litter, and other moist habitats; they are mainly nocturnal in the upper soil layers in warm, dry areas. Adults live 2+ years. All pillbugs and about 25% of spp. of sowbugs in North America are introduced spp.

ROLE/IMPORTANCE: Isopods are decomposers that contribute significantly to nutrient cycling, fragmenting fresh plant debris and further breaking down decomposing plant materials

AS INDICATORS: Isopods are easily recognized; they accumulate heavy metals and so can serve as bioindicators of pollution, and also can serve as indicators of farm practices, due to their sensitivity to tillage and pesticides.

HOW TO FIND THEM: Pitfall traps; Berlese funnels.

DESCRIPTION: Gray or brown segmented bodies, with armor-like appearance | 7 pairs of legs | 2 pairs of antennae | Pillbugs (Armadillidiidae) can roll their bodies into a ball | Sowbugs (Porcellionidae) do not roll and have 2 short, tail-like appendages (uropods) on their hind end.



0.2–0.59" (5–15 mm)

COLLEMBOLANS » SPRINGTAILS

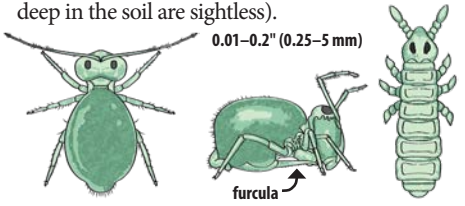
HOW/WHERE THEY LIVE: Many spp. live in soil surface litter and vegetation, decaying logs, and fungi, as well as under bark (Entomobryomorpha & Symphypleona), while others dwell within the soil (Poduromorpha & Neelipleona). Abundant and widespread, occuring in all terrestrial habitats, including Arctic soils, springtails can reproduce rapidly and live several weeks to a year.

ROLE/IMPORTANCE: As decomposers, springtails facilitate nitrogen mineralization and plant growth. Their selective consumption of fungi can also alter fungal communities.

AS INDICATORS: Abundance and diversity varies with changes in vegetation or soil conditions. May be good indicators of impacts of nontarget pesticides; they are more sensitive to pesticides than many larger arthropods. Can be used as indicators of soil disturbance and pollution; their numbers decrease due to tillage and heavy metal contaminants. High ratios of mites to collembola often indicate high-quality soils.

HOW TO FIND THEM: Pitfall traps; Berlese funnels.

DESCRIPTION: Elongate or globular and compact body shape | White to purple to brown or gray in body color | A furcula, a structure that looks like a tail and extends from the back of the body, is used to propel the springtail on the soil surface (spp. that dwell within the soil have a reduced or absent furcula) | Simple eyes (spp. that dwell deep in the soil are sightless).



HOW TO USE

This pocket guide is intended as a portable, accessible, basic guide for observing and learning about soil invertebrates and what their presence may indicate about soil health. It can be printed double sided and folded to fit in a pocket. In the PDF, clicking the 🔗 in the upper right of each profile opens the full profile in the *Farming with Soil Life Handbook* publication. This pocket bioindicator guide is part of Xerces' Soil LIfe project and resources. For more information, visit **xerces.org/soil-life**.

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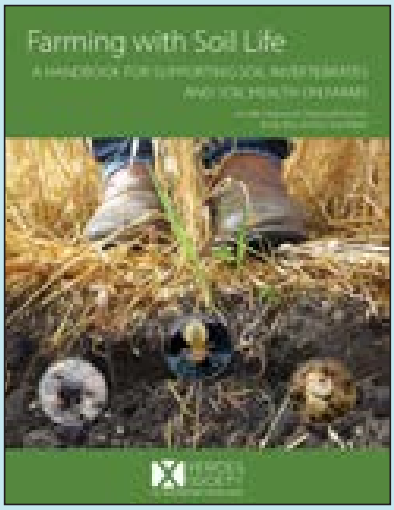

To learn more about how these and other invertebrates contribute to soil health, see **Farming with Soil Life**: *A Handbook for Supporting Soil Invertebrates and Soil Health on Farms*.

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