

Invasive earthworm impacts on ground-nesting songbirds in northern hardwood forests

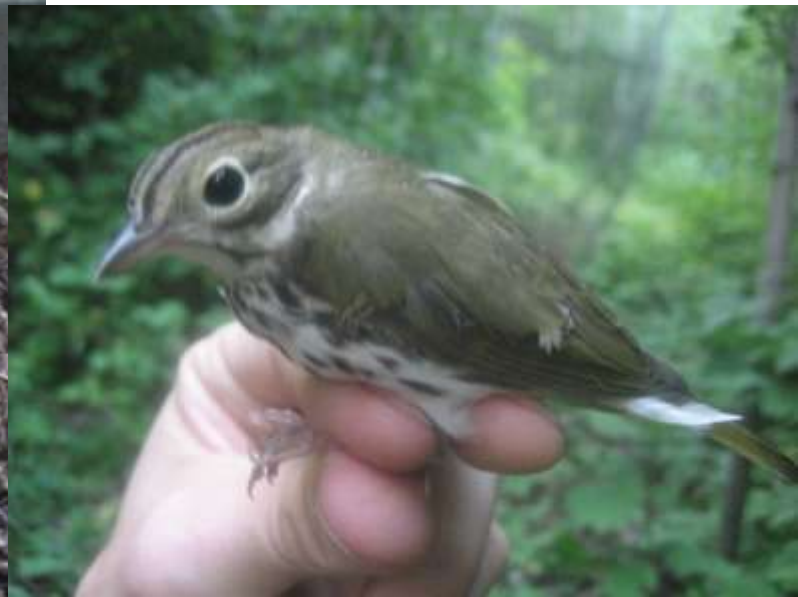
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Outline

- Invasive earthworm effects to forest habitats
- Study design and methods
- Results
- Implications & future directions

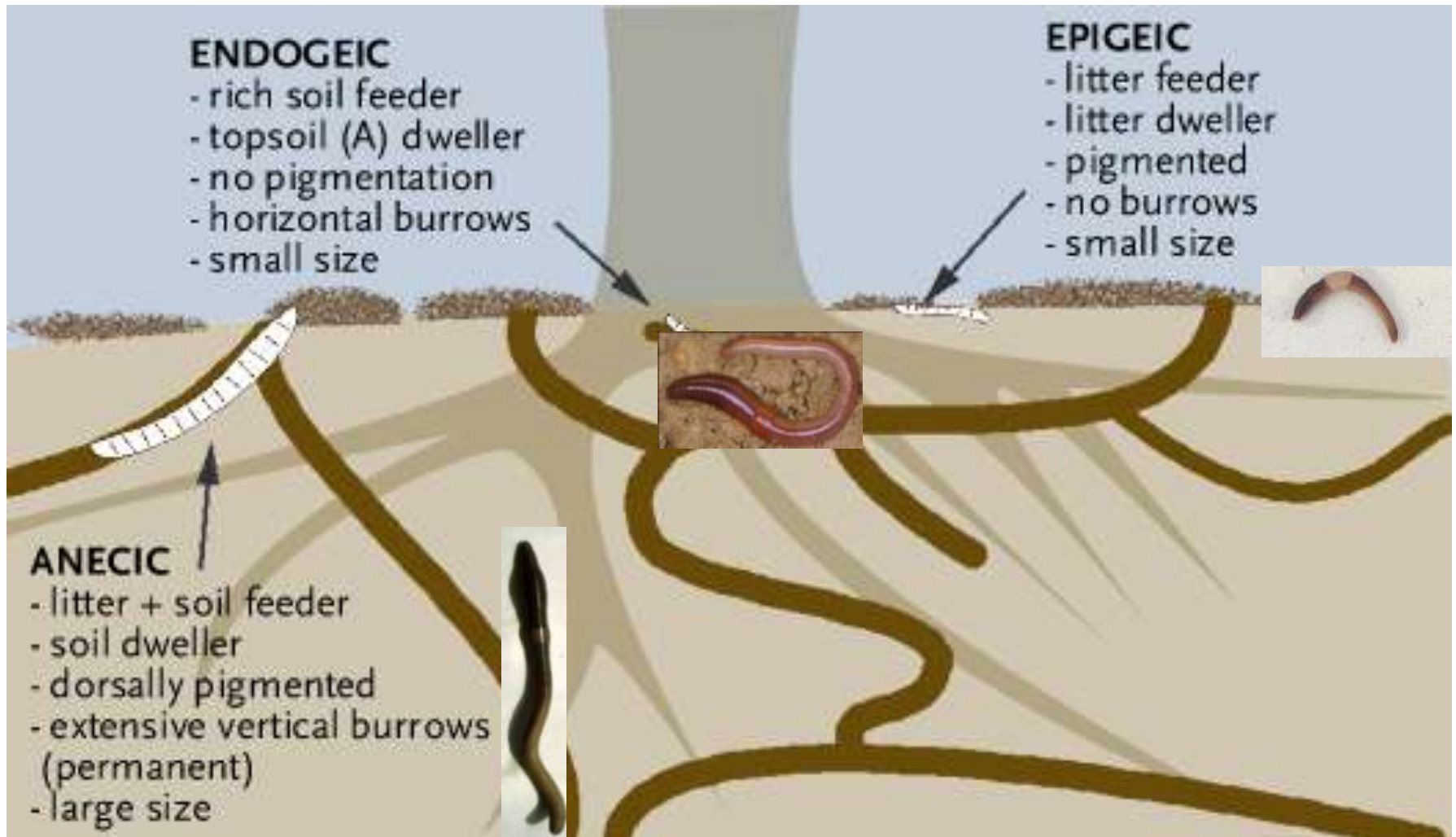
“Earthworms aren’t native?”

- Not native to previously glaciated areas of North America
- Dispersal thought to be primarily human-aided
 - Fishing bait (Cameron et al. 2007; Keller et al. 2007)
 - Tire treads (Dymond et al. 1997)



Map based on Callahan et al., 2006.

Earthworm Ecological Groups



Source: Great Lakes Worm Watch (<http://www.nrri.umn.edu/worms/>)

Earthworm impacts to soil

- Significant changes to previously earthworm-free soils
 - Removal of litter/organic layers
 - Increased soil density
 - Vertical mixing of soil horizons
 - Increased nitrogen leaching and runoff

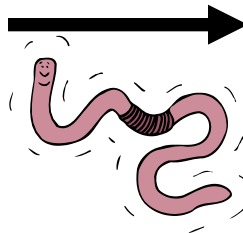


Photo Source: Great Lakes Worm Watch

Earthworm impacts to soil & understory biota

- Reduced diversity / abundance of:
 - Mycorrhizal fungi (Lawrence et al. 2003)
 - Soil Invertebrates (Migge-Kleian et al. 2006)
 - Native ground-layer plants (Hale et al. 2006, Holdsworth et al. 2007)
- Local extirpation of a rare plant (Gundale 2002)
- Reduced salamander populations (Maerz et al. 2009)



Goblin Fern

Source: US Forest Service







Impacts to birds?

- Hypothesized link between exotic earthworms, litter depth, and nesting success of Ovenbirds in northern MN (Mattson and Niemi 2006)
- No explicit study of earthworm impacts to birds



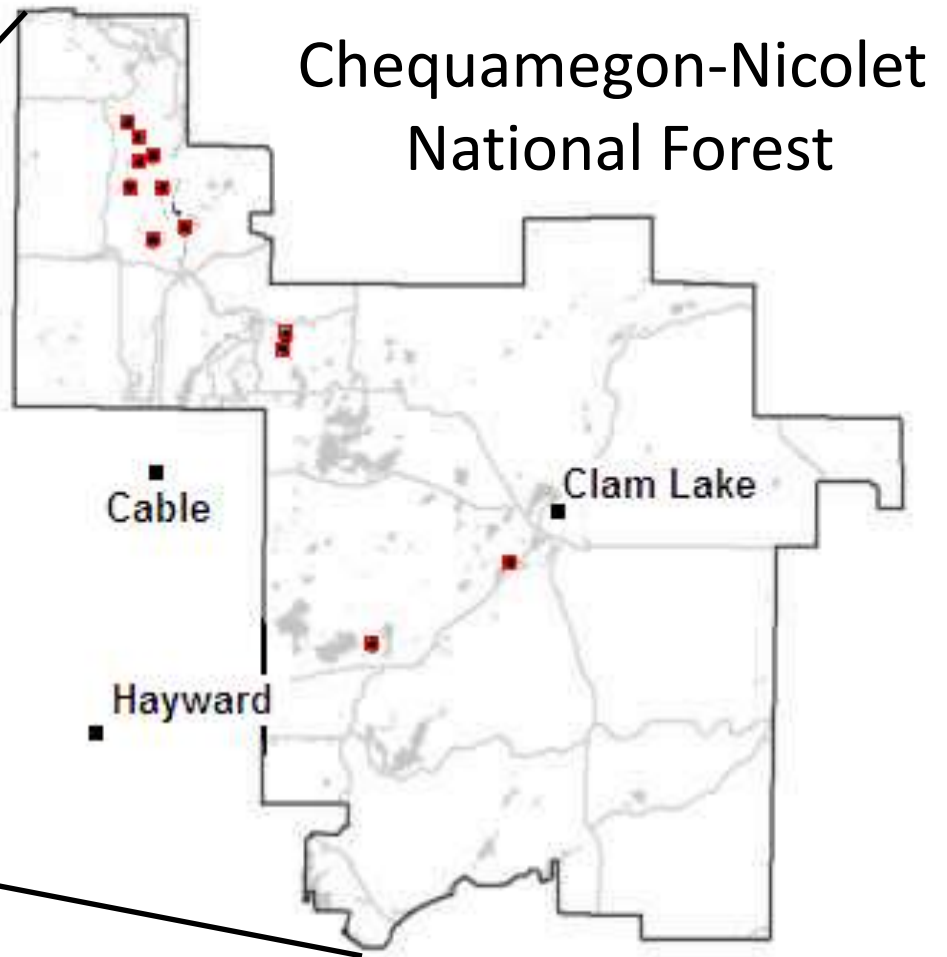
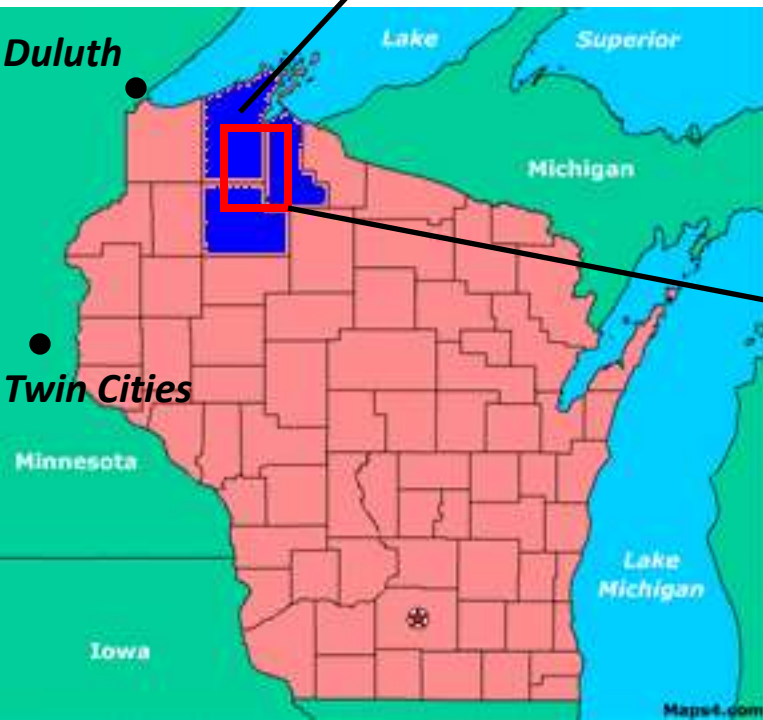
Research Questions

1. Does earthworm invasion reduce density of ground-nesting birds?
2. Is nest mortality related to earthworm invasion, especially invasion by *Lumbricus* spp.?
3. Do earthworms pose a regional threat to populations of ground-nesters?



Lumbricus rubellus

Study area



Study design – site characteristics

(Holdsworth et al. 2007)

- Upland-mesic hardwoods (maple-basswood)
- Similar soil types
- No timber management within 40 years
- > 70 years old
- Earthworm invasion categories for study sites
 - Earthworm-free (n = 3)
 - Earthworm-invaded (n=6)

Focal species

- Ovenbird (*Seiurus aurocapillus*)
- Hermit Thrush (*Catharus guttatus*)
- Most common ground nesting - foraging species in hardwood forests of study area
- Both declined in region in previous 18 years (Niemi et al. 2009)



2008-09 bird survey methods

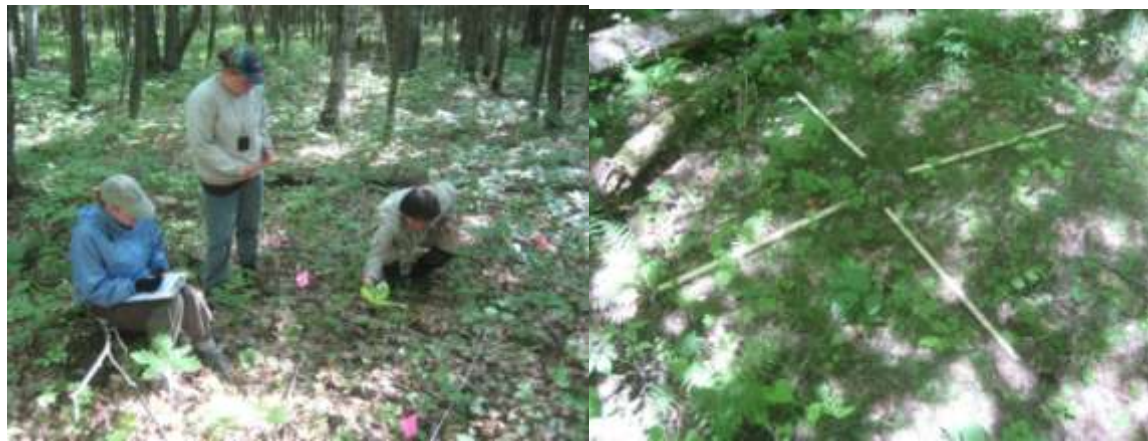
- Point count surveys to estimate density (June-July)
 - Five randomly placed points in each site
 - Five site visits in 2008; three in 2009
 - Distance estimates used to calculate density (Program Distance 6.0)

Earthworm sampling

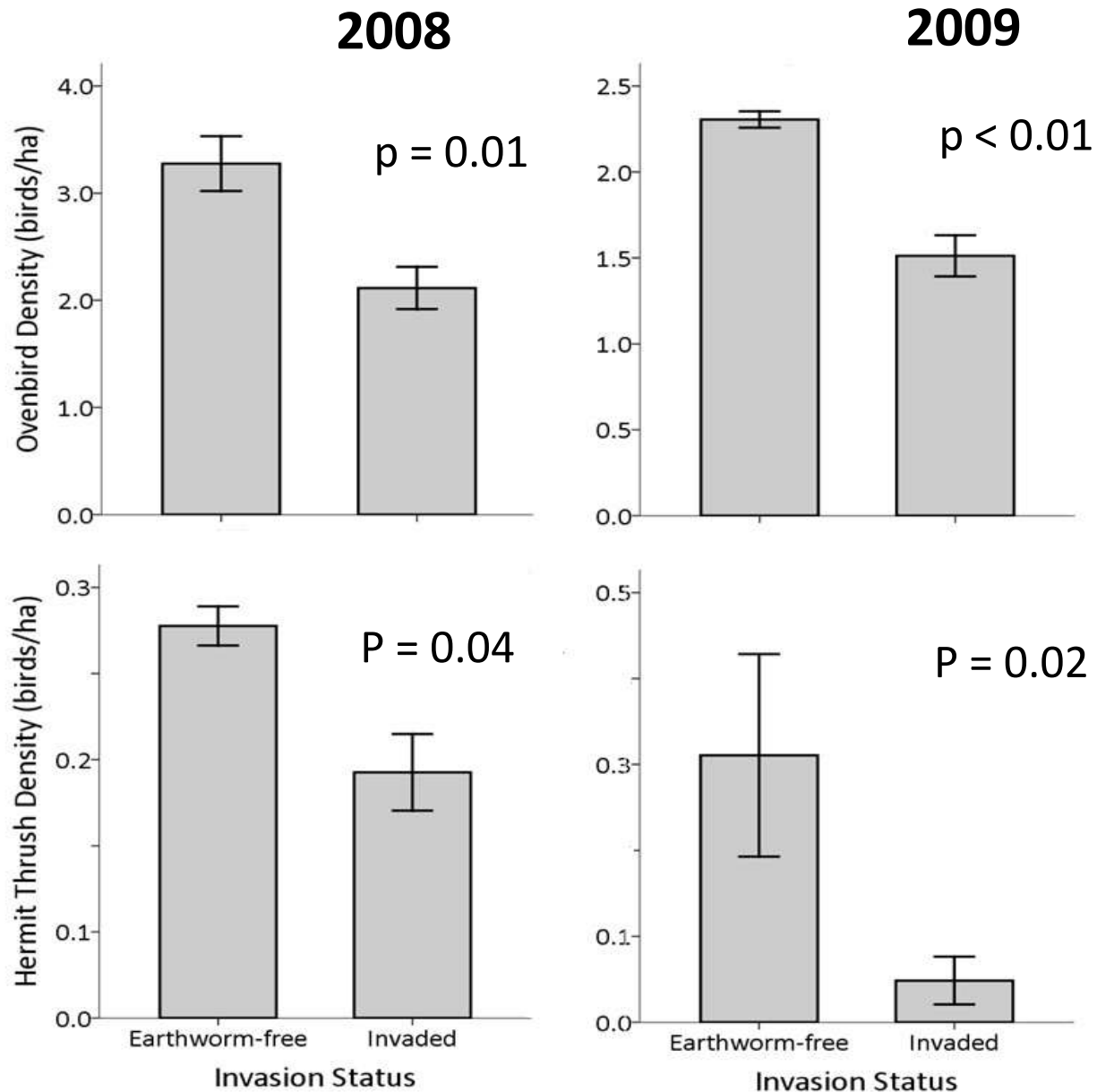


Nest searching in summer 2009-10

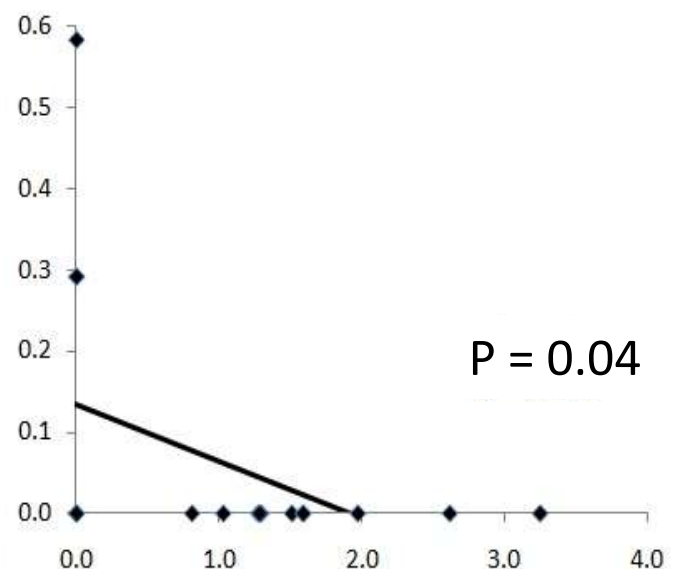
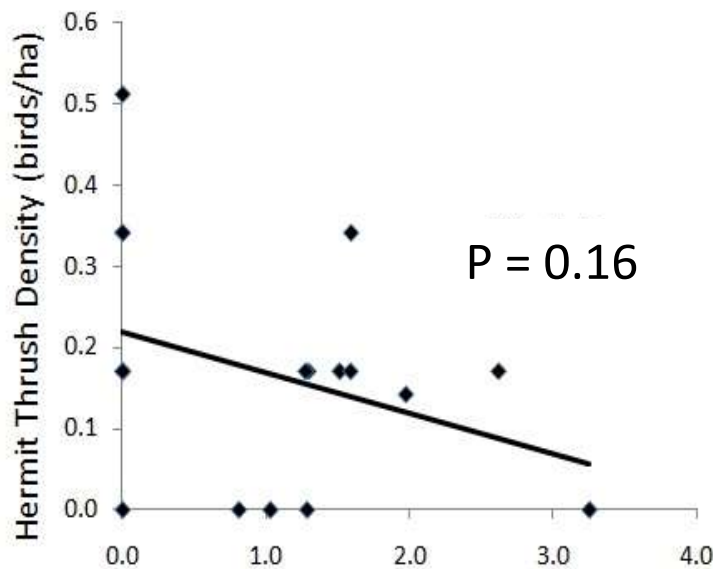
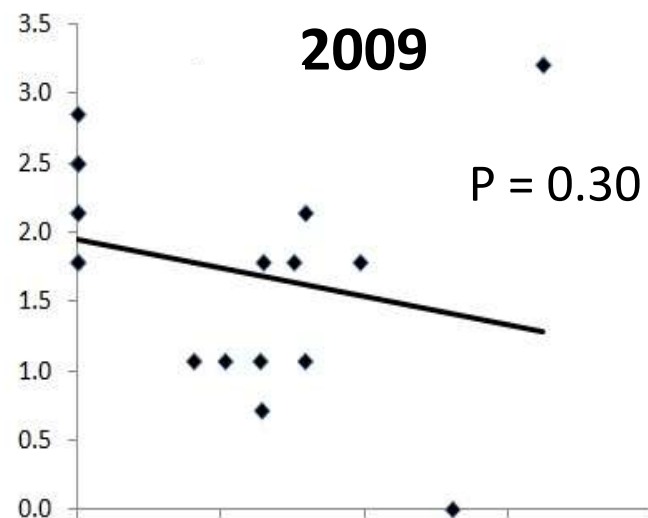
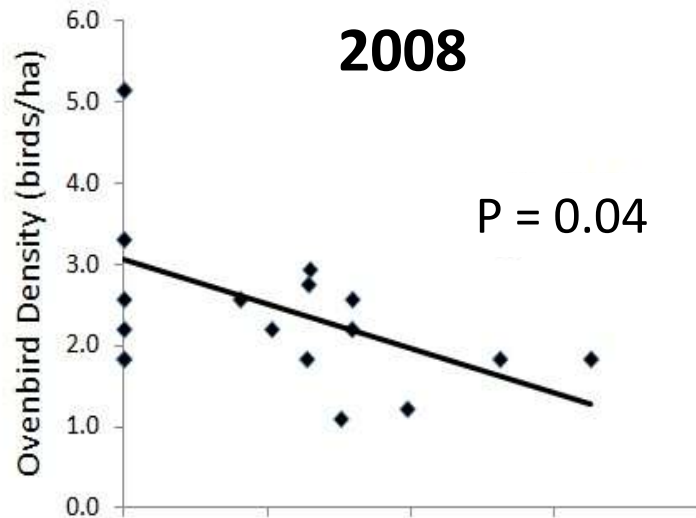
- Trained technicians searched for nests of focal species
- Nests monitored every 3-4 days to determine fate
- Vegetation sampling at nests (July)
 - Litter depth, % cover sedge, maple, total ground veg.
- Earthworm sampling (total mass, mass of ind. species)
- Analysis of relationship between veg/earthworm covariates and nest survival using program MARK (AICc selection) – Dinsmore & Dinsmore 2007)



Site-scale bird survey results



Survey point-scale bird survey results



Total Mass (g) of Lumbricus spp. Earthworms

2009-10 Nest searching results

- 236 total nests found!
 - 165 Ovenbirds
 - 71 Hermit Thrushes
- Significantly greater abundance of ground nests in earthworm-free sites compared to invaded (after correcting for searcher effort; $P = 0.04$)
- Only Ovenbird nests used for remaining analyses



Ovenbird Nest Survival Analysis

Model selection using AIC

- Tested all 6 single-variable models, Null model & Global (all variables) model

Strongly supported variables

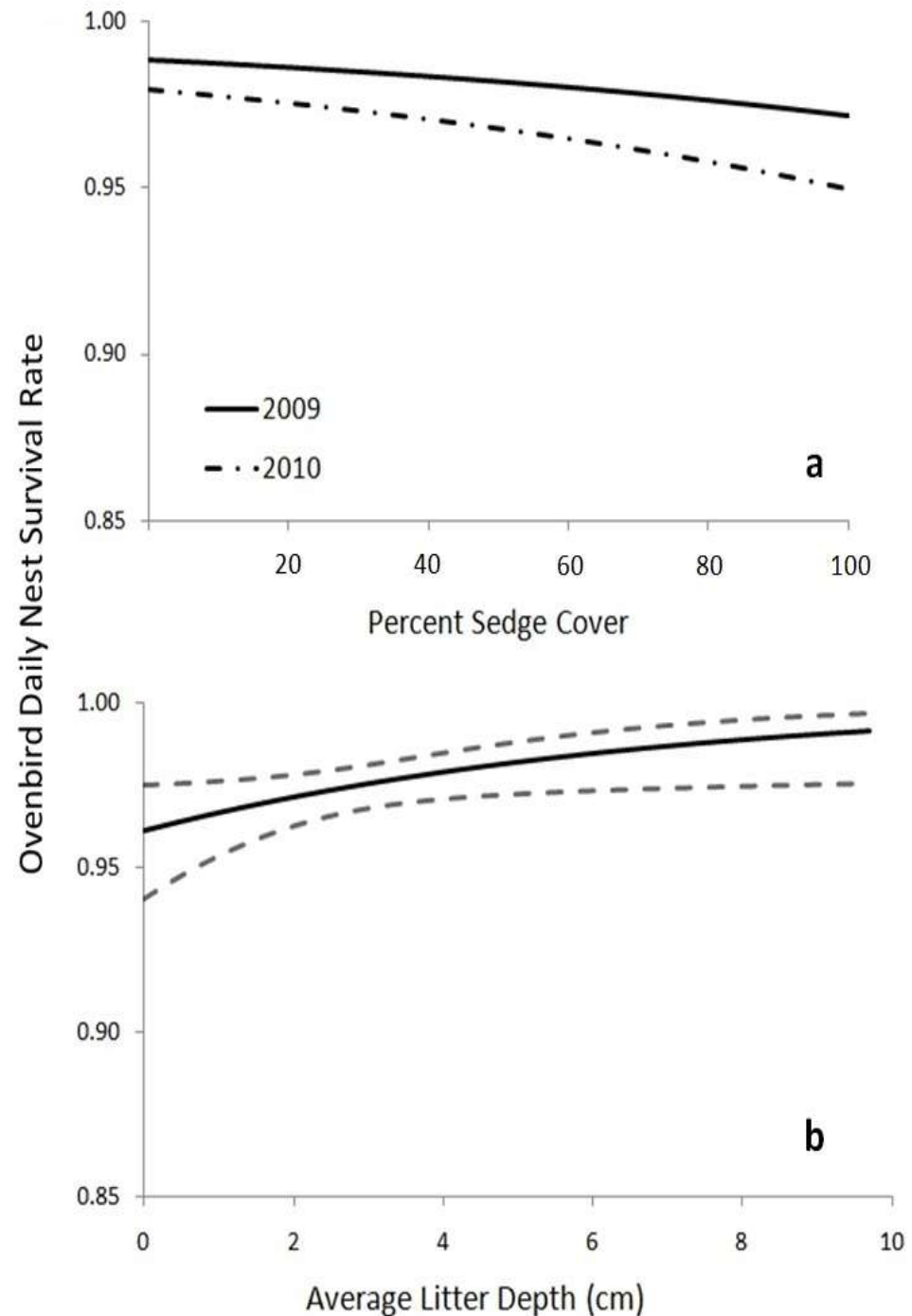
- Sedge cover
- Year

Moderately supported variables

- Litter Depth

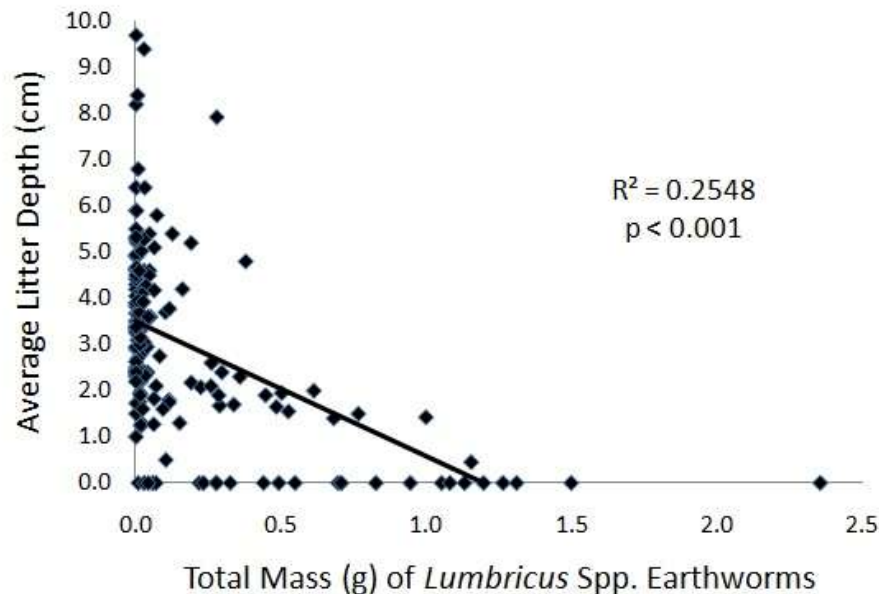
Relationships between Ovenbird survival and supported variables

1. $\uparrow$ Sedge = $\downarrow$ Nest survival
2. $\uparrow$ Litter depth = $\uparrow$ Nest survival
3. Nest survival lower in 2010 than 2009



Ovenbird Nest Survival Analysis

1. Significant positive relationship between *Lumbricus* spp. mass & SEDGE COVER ($P = 0.01$)
2. Significant inverse relationship between *Lumbricus* spp. mass & LITTER DEPTH ($P < 0.01$)

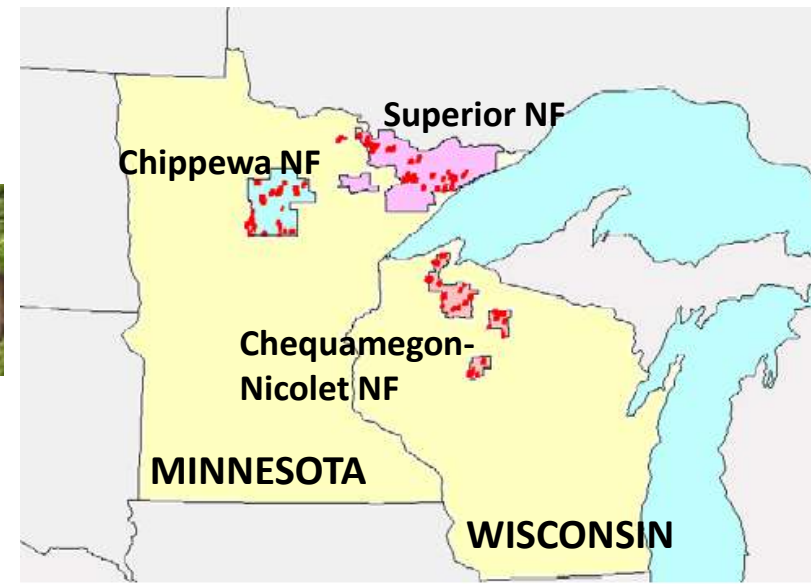


Summary of results

- Strong evidence that earthworm invasions are impacting populations of ground-nesting songbirds
 - Decreased densities at two spatial scales
 - Decreased nest survival rates due to indirect impact of *Lumbricus* spp. earthworms on Ovenbird nesting habitat (increased sedge cover & decreased litter depth)
- Mechanisms for impact
 - Nests less concealed in sedge “carpets”?
 - ↓ Litter depth = ↓ Invertebrate food supply (Haskell 2000)
 - ↓ Food = ↓ Nest attentiveness and ↑ Predation (Pease et al. 2003)
 - Further mechanistic research will clarify these links

Are earthworms serious threat to bird conservation?

- Small-scale work suggests significant adverse effect of earthworms to ground-dwelling songbirds
- Management & conservation of ground-nesters should include consideration of earthworms
- Prevention is still best
- Regional scale research project



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