



United States Department of Agriculture

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Natural
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Controlling Slugs & Voles in Cover Crops & No-till

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*NRCS does not make chemical or biological pest suppression recommendations or change pesticide label instructions.

NRCS is only permitted to provide producers with the most current biological and chemical pest suppression references.





Macrofauna NT Slug Control

Ground beetles = lions of no till fields



Slide from John Tooker, PSU



Will eat:

- Black cutworm
- True armyworm
- Stalk borer
- Wireworm
- Slugs



Beneficial Ground Beetles



Carabus lateralis (Carabinae: Carabini)



Notiophilus substriatus (Nebriinae: Notiophilini)



Dixus sphaerocephalus (Harpalinae: Harpalini)



Clivina fossor (Scaritinae: Clivinini)



Figure 1. Threadlike antennae and 5-5-5 tarsal "formula" (circles) typical of carabid beetles. Photo by Henri Goulet, Agriculture & Agri-Food Canada.



Pennsylvania ground beetle, *Harpalus pensylvanicus* (actual size 5/8th inch)



Pedunculate ground beetle, *Scarites quadriceps* (actual size 3/4 inch)



Vivid metallic ground beetle, *Chlaenius sericeus* (actual size 5/8th inch)



False bombardier beetle, *Galerita* sp. (actual size 4/5th inch)



Amblytelus sp. (Amblytelinae: Amblytelini)

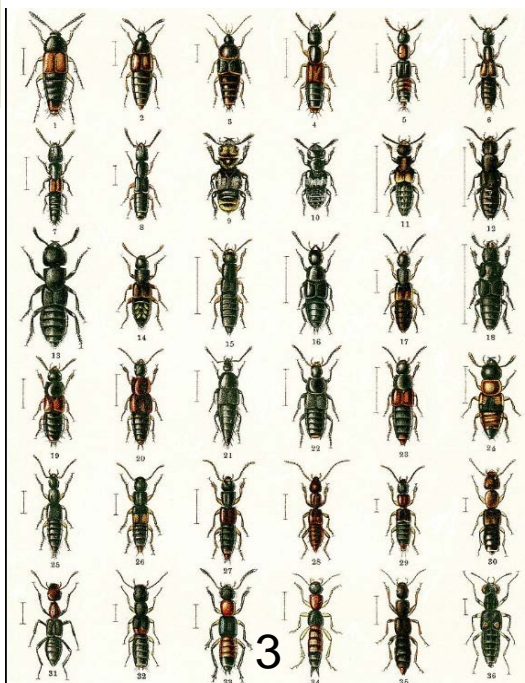
40,000 species
2,000 in USA
450 in Midwest
Live 1-3 years
Nocturnal

Slide designed by James Hoorman
NRCS Soil Health Specialist



Other Beneficial Slug Insects

- 1) Centipedes
- 2) Fireflies
- 3) Rove Beetles
- 4) Soldier Beetle
- 5) Wolf Spider
- 6) Daddy Long Legs
- 7) Other



1. *Bryocharis anala*. 2. *Mycetopus splendens*. 3. *Tanygnathus terminalis*. 4. *Othius punctulatus*. 5. *Eptolus affinis*. 6. *Xantholinus gracilipes*. 7. *Eulissus fulgidus*. 8. *Leptacinus batychnus*. 9. *Emus hirtus*. 10. *Crochius maxillosus*. 11. *Stachinellus fovear*. 12. *St. setipes*. 13. *St. caesareus*. 14. *St. orens*. 15. *St. compressus*. 16. *Philonothus cyanipennis*. 17. *Ph. dimidiatipennis*. 18. *Veileius dilatatus*. 19. *Quedius brevis*. 20. *Q. nigripes*. 21. *Acylobius glaberinus*. 22. *Euryoporus microps*. 23. *Astragalinus ulmi*. 24. *Oxyoporus rufus*. 25. *Cryptobium tricolor*. 26. *Doliceon biguttatus*. 27. *Scimballium anale*. 28. *Lathrobium bicolor*. 29. *Medon propinquus*. 30. *Scopaeus rubellus*. 31. *Stilicium testaceus*. 32. *Actonus hilliformis*. 33. *Paeceus caligatus*. 34. *Oedichirus paederinus*. 35. *Procterus lefebvrei*. 36. *Stenus guttula*.

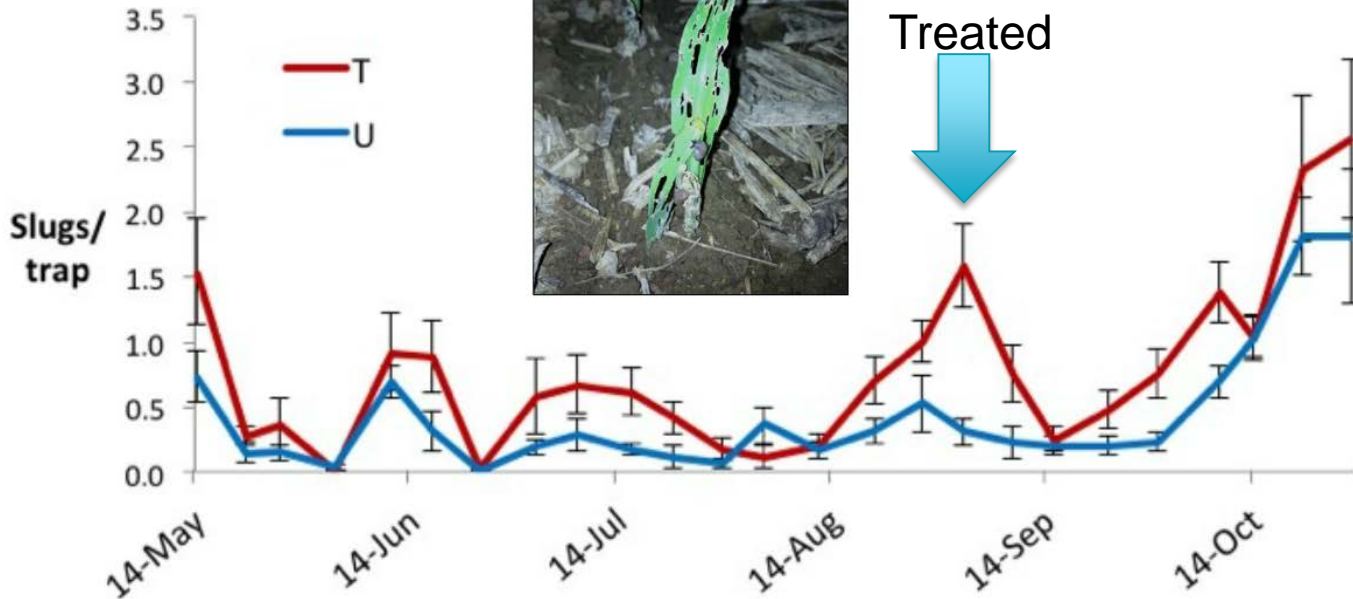


- Frogs and Toads: Could be 25% of their diet
- Ants, Worms, Nematodes (*Phasmarhabbitis hermaphrodita*), Snakes
- Birds: owls, robins, blackbirds, thrushes, starlings, rooks, crows, jays, ducks, chickens, sea gulls
 - 6% of starling diet are slugs (Symondson, 1996)
- Mammals: moles (not voles), shrew, badgers, fox, raccoons, possum.
- Parasites: Trombidiid mites, sporoza, ciliates, and cestodes parasitize slugs (Wade & Thomas, 2001).
- Schomyzid flies (Oregon State University)
- Fungal Disease (*Arthrobotrys*)





Neonic seed treatments exacerbate slug problems



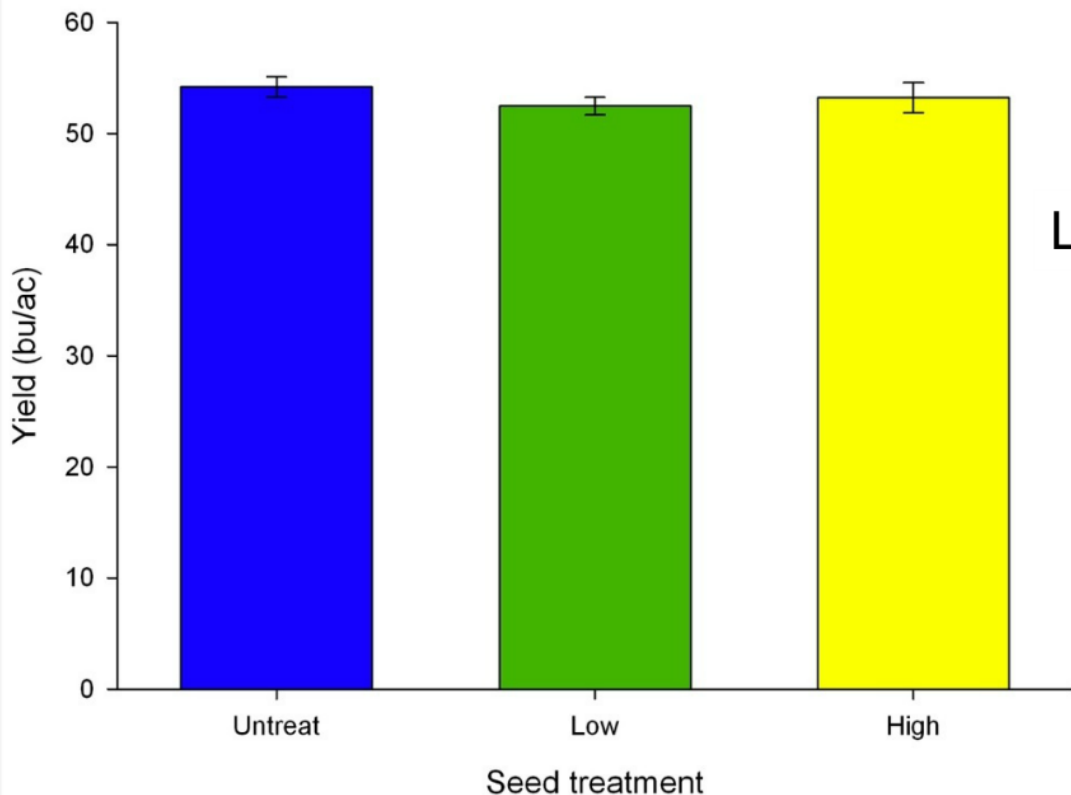
Slugs release chemical into slime and kills predators.

Neonicotinoids as a seed treatment are deadly to most beneficial insects: spiders, ants, ground beetles, etc.



Do not guarantee a higher yield

Cruiser in soybeans in 2011



Low pest populations

Study on Slugs in Soybeans

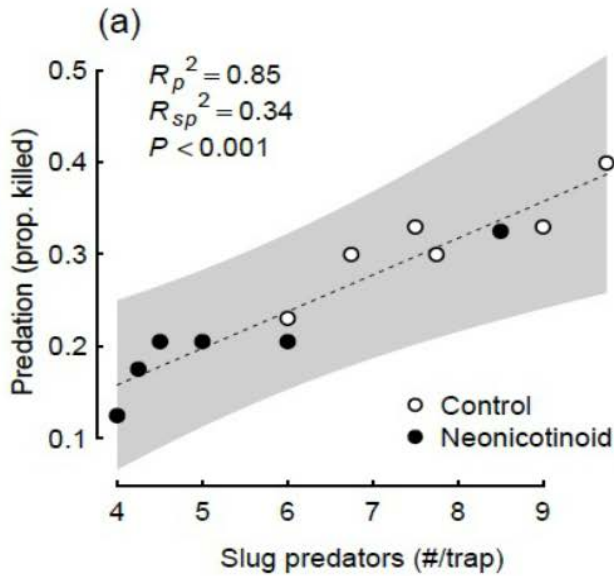
Do we really need insecticide on soybeans???

Douglas and Tooker, unpub.

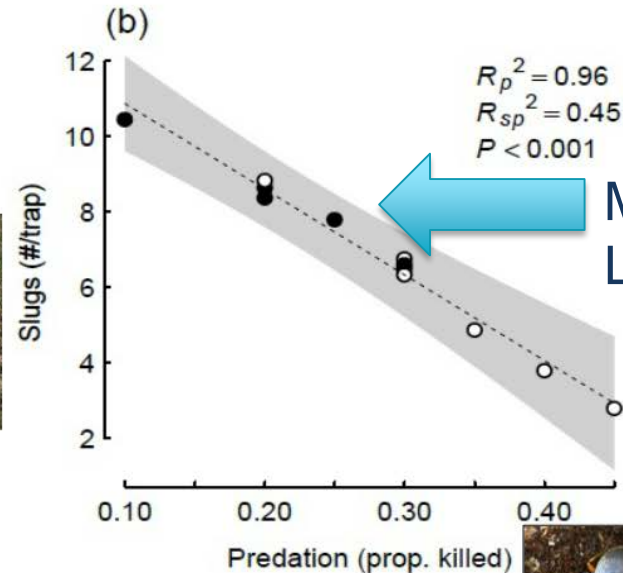




Predators control slug populations



As Neonicotinoid increased:
Beneficial Predators decreased
along with **LESS** slug death.



Soybean density -19%
Soybean Yield -5%

Douglas et al. 2015, J. Applied Ecol.



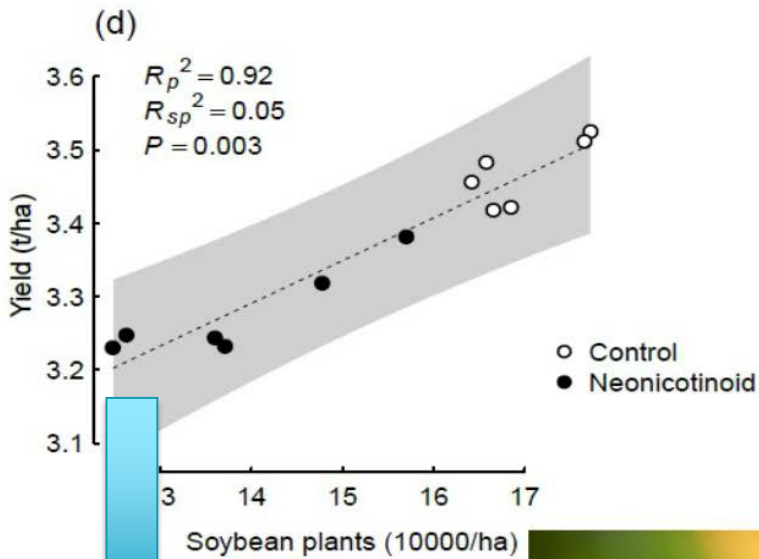
Predation is measuring how well beetles kill slugs



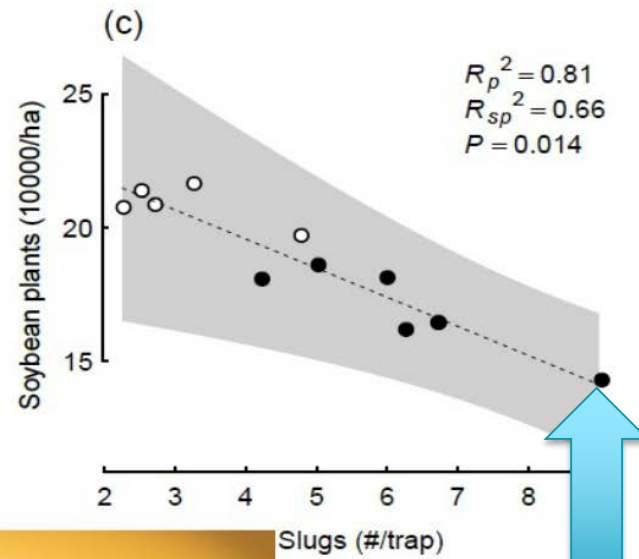
Slugs in Soybeans



Slugs decrease soybean yield



Less yields with more neonic.



Higher slugs/plant with neonic.



Soybean Study on Slugs:

Neonic. are deadly. Only 0.000003 ppm to kill a bee (3-5 ng/bee)

A 96% neonic. concentration reduction is still deadly

Managing Cover Crop Insects

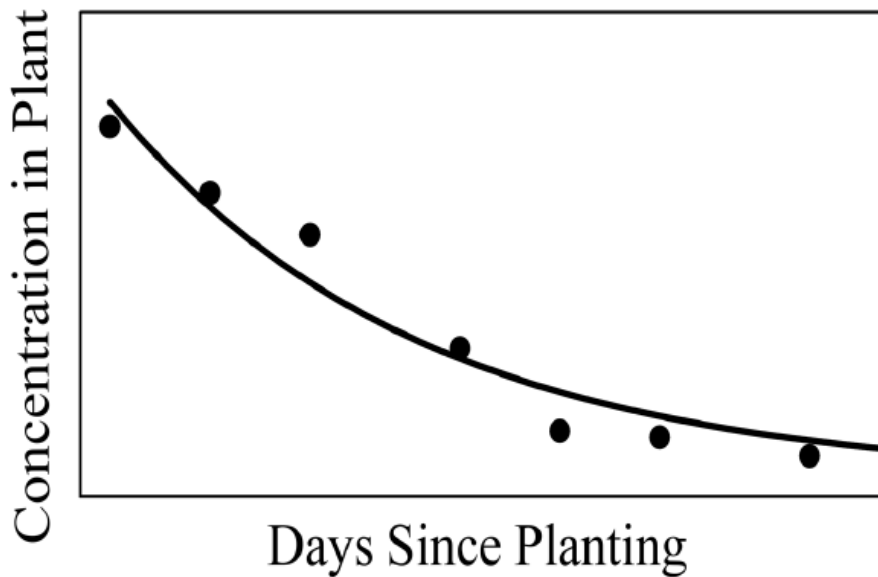
- Seed-applied insecticides have limitations

Product	CRW	WG	WW	SCM	BCW	OC	AW
(thiamethoxam) Cruiser (0.25 mg)	n/a	F	F	G	F	P	P
Cruiser (1.25 mg)	F	G	G	G	F	P	P
(clothianidin) Poncho 250 (0.25mg)	n/a	F	F	G	F	P	P
Poncho 1250 (1.25 mg)	G	G	G	G	F	P	P

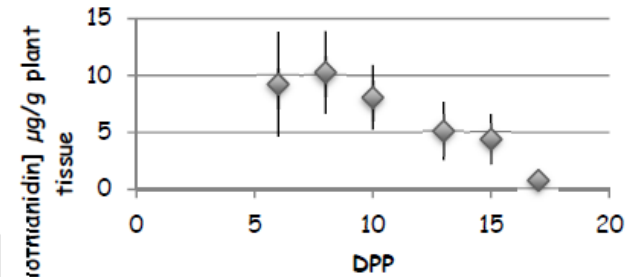


Neonic. only last short period of time in plant!

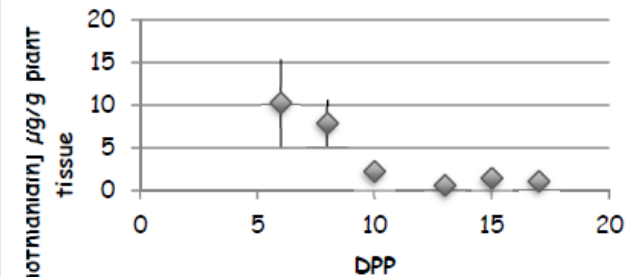
Neonicotinoid concentrations in plant follow exponential decay curve



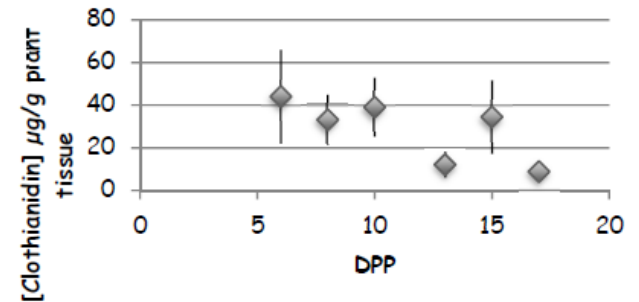
Shoot P1250



Root P1250



Seed P1250





- Reduce/eliminate soybean neonicotinoid seed treatment. Dr. Kelley Tilman OSU research: Neo's are Overused, not cost effective on soybeans, gone from plant after 21 days.
- Major Soybeans Pests: Seed corn maggot & wireworms
- Use alternative insecticide or untreated seed (you have to ask for it in the fall) because this may allow beneficial insects to recover.





- Soybeans are typically seeded at 140-210K seeds/acre and lower soybeans populations may compensate for yield.
- Corn is typically seeded at 30-36K seeds/acre.
- Corn seed typically costs more \$ and has more major pests.





Voles are a favored diet of owls, hawks, kestrels, snakes, foxes, and coyotes.



Photo courtesy of ODNR



Photo courtesy of ODNR



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Other Predators

- Gulls
- Herons
- Blue Jays
- Crows
- Ravens
- Eagle
- Raccoon
- Skunks
- Possum
- Shrews
- Mink
- Weasels
- Badgers
- Turtle
- Bull Frogs
- Salamanders
- Garter Snakes
- Gopher Snakes
- Yellow Bellied Racer
- Large Mouth Bass
- Trout



- Shrews are 3 inches with grayish brown or red-brown thick fur. Pointed snout & short tail.
- Prefer to live in wetter environments in grasslands and meadows, also exist on hills that are drier.





...voles are also eaten by hawks:

Red-tailed Hawk



Rough-legged Hawk



A photograph of a hawk perched on a nest of twigs and leaves. The hawk's head is severed from its body, and the severed head is held in its beak. The hawk's body is covered in brown and white mottled feathers. The background is a blurred natural setting with some green and brown plants.

Oh No!
I just lost my head!
(Mr. Bill)

James Hoorman, NRCS
Soil Health Specialist



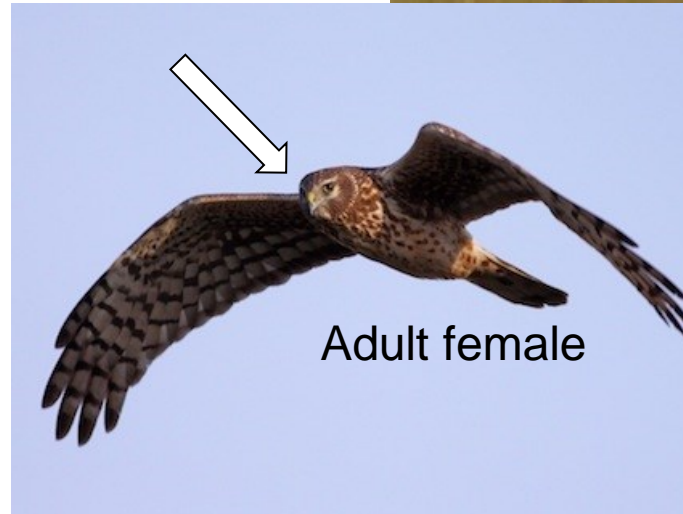
Kestrels and harriers eat voles...



American Kestrel

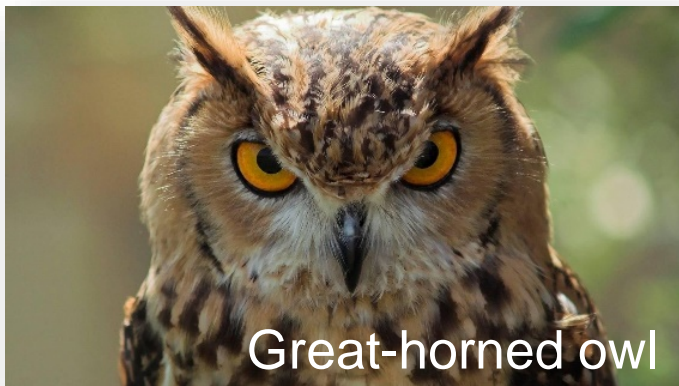


Northern Harrier





Several owl species eat voles....



Great-horned owl



Eastern Screech owl



Barred Owl



Barn owl



Short-eared owl

In WI: 95% of short-eared owl diet was voles.
In OH: 90% of long-eared owl.





Can Predators Control Voles?

Species	Voles per Adult	Voles per Acre per "Family"
Coyote	211	0.7
Red fox	394	2.9
Great Horned Owl (low vole diet)	196	0.3
Great Horned Owl (high vole diet)	902	1.1
Barred Owl	267	0.7
Barn Owl	488	0.1
Short-eared Owl	102	no data
Red-tailed Hawk	174	0.4
Rough-legged Hawk	120	0.1
Northern Harrier	398	1.2
American Kestrel	257	3.6
Total	2959	10.5



American Kestrel

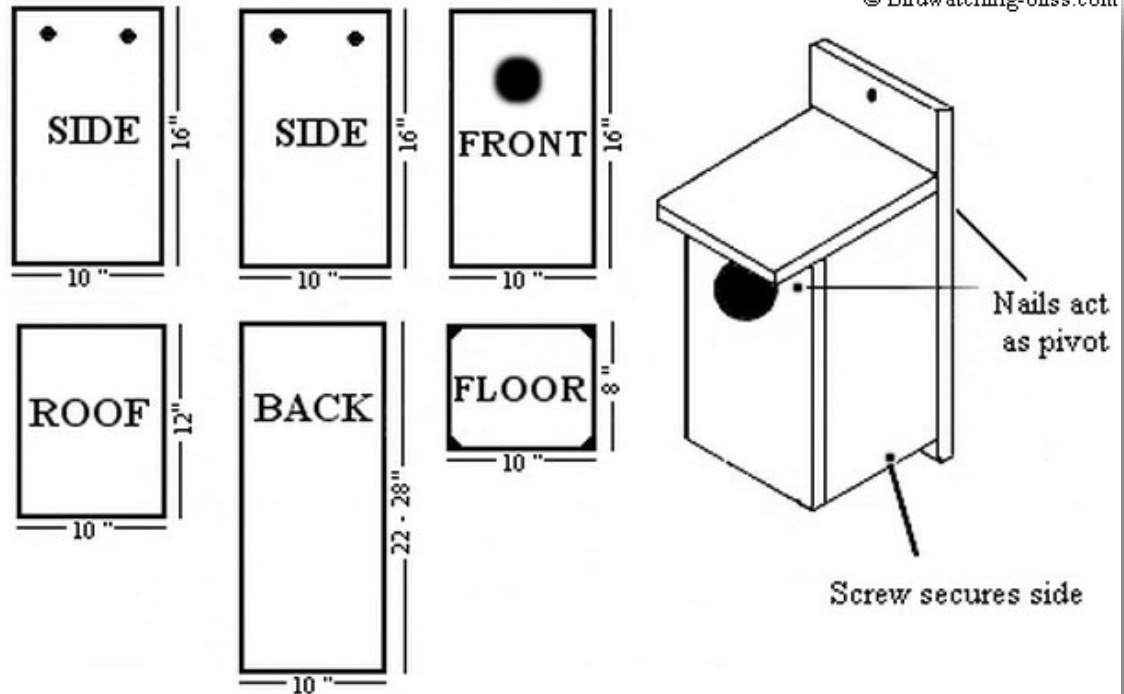
- Relatively small
- Hunt 365 days/year
- Eat many insects and voles



Kestrel and Screech Owl Nesting Boxes

- Face South or East (not west)
- Place 10' to 30' high.
- Use predator guards on poles.
- Drill 3" entrance hole.

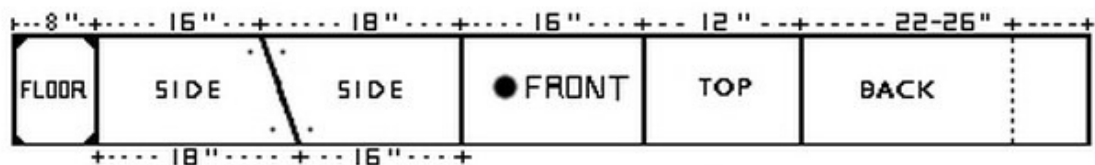
© Birdwatching-bliss.com



Option 1 - Flat Roof



Board (3/4 or 1) in thick X 10 in X 8 ft



Option 2 - Sloping Roof



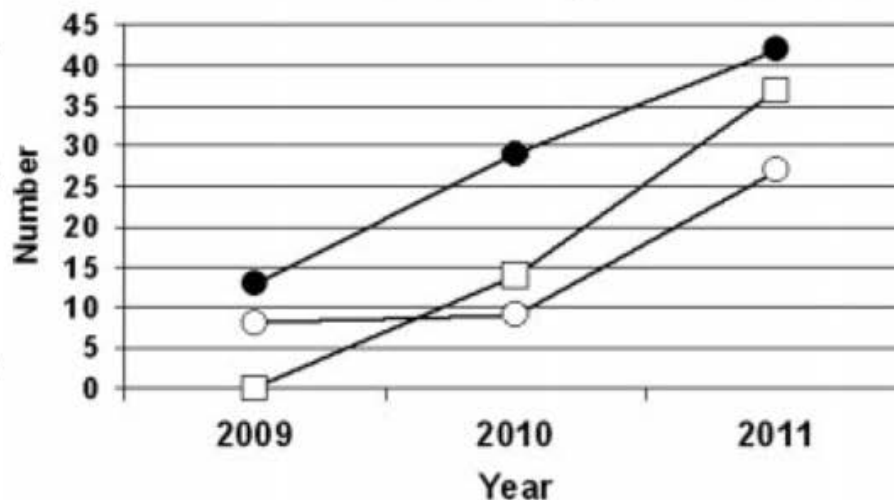
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Vole Population Dynamics

- Artificial perches increased kestrel visitation.
- 11 fold increase in Oregon (Wolff et. al 1999)
- Kestrels used perches in open Texas landscape. (Kim et. al 2004)
- 3-30X increase in kestrel breeding pairs. (Paz et. al 2013)



Number of kestrel breeding pairs in nest boxes





at critical times:

- Voles are most active at night so nocturnal predators like owls, fox, and coyotes are the most effective.
- Providing habitat (perches like 10' fence post and den trees), and
- Protection (**reduced depredation** etc.) for these predators should be also part of the overall rodent control program. Limit hunting fox and coyotes!
- Keep a map or GPS where fence post are installed. Paint a bright color to minimize equipment damage!



10' Fence post with a wood bar as a perch. **Beware:** Deer will scratch & knock down the post.





These are huge predators of voles! Do not overhunt these guys!

- High vole numbers attract predators
- A family of fox eat 2.9 voles per acre or 10-15 voles/day!
- A family of coyotes eat 0.7 voles per acre or 10-20 voles/day!
- Coyotes are free ranging and have a large territory. Foxes are more localized.

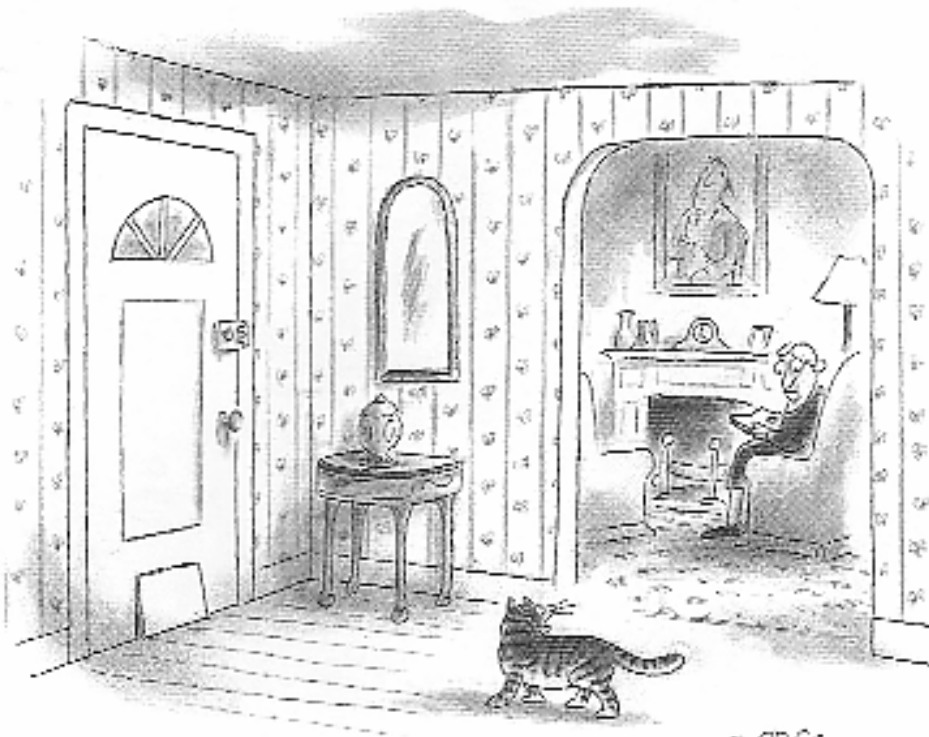




Feral Housecats

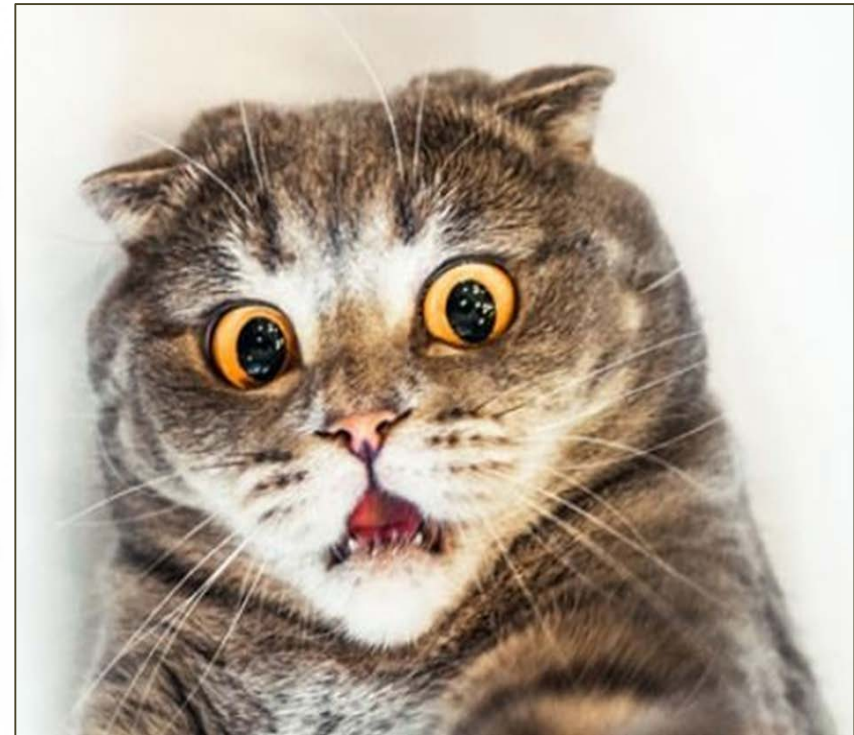


- Not reliable
- Eat many beneficial song birds and other mammals beneficial to agriculture that eat insect pests & weeds.



S. GROSS

"I'm going out. Do you need any voles?"





Top 10 Dog Breeds for Catching Rats & Voles

- Rat Terrier
- Cairn Terrier
- Yorkshire Terrier
- Norfolk Terrier
- Jack Russell Terrier
- West Highland White Terrier
- Dachshund
- Miniature Schnauzer
- Lakeland Terrier
- German Pinscher



1) Rat Terrier Rat Terrier



2. Cairn Terrier



3. Yorkshire Terrier

4. Norfolk Terrier



5. Jack Russell Terrier



Jack Russell Terrier | Source



Yorkshire Terrier | Source

Focus on these things...

- **Food:** Plant crops or plants that slugs dislike OR use plants they like as trap crops.
- **Shelter:** Alter the time of planting or the density and diversity of crops. Mowing and grazing are management strategies. Alter moist, wet, cool habitat.
- **Predators:** Reduce Insecticides, promote predators.
- **Cultural Practices:** Rotary hoe, harrow, zone tillage, chaff spreaders, row cleaners, draper heads, harvesting height.
- **Trap Crops/Baits/Chemicals:** Utilize trap crops, baits, and chemicals to reduce slug populations.

**Effective slug control requires a combination of practices.
Maximum control is only 60% with one practice.**

Purdue University

Slugs Considerations

- Plant Early
- Get crops growing quickly
- Avoid matted, grassy cover crops
- Tillage
 - Zone/strip
 - Field hot spots



Oregon State Extension





- Use a good crop rotation and diverse cover crop species to increase predators.
- To reduce cereal rye seeding rate, add another cover crop like kale, or radish. Soil dries out better. Or add oats or 50% cover crops species that die out. Less dense stands equal less food/shelter.
- Aerial seeded/broadcast cover crops are a food source. Drilled seed is better.
- Kill cover crop early (30 days before planting) in the spring to reduce slug food and shelter OR
- Use cover crop as a trap crop, plant later for faster emergence, and kill cover crop late after main grain crop has grown enough to out-compete the slugs.





...at critical times and locations:



- For no-till soybeans
- Drilling literally kills more voles simply having additional knives in the ground (this also goes for drilling cover crops)



RONCO's Volamatic



Makes me Smile!

CC



Row Cleaners or Zone Tillage



- Row cleaners or sweeps move residue away from row.
- May reduce slug or vole damage due to warmer, drier soil and faster plant growth
- Zone tillage warms the soil and improve crop growth.
- Does not appear to reduce slug or vole population.

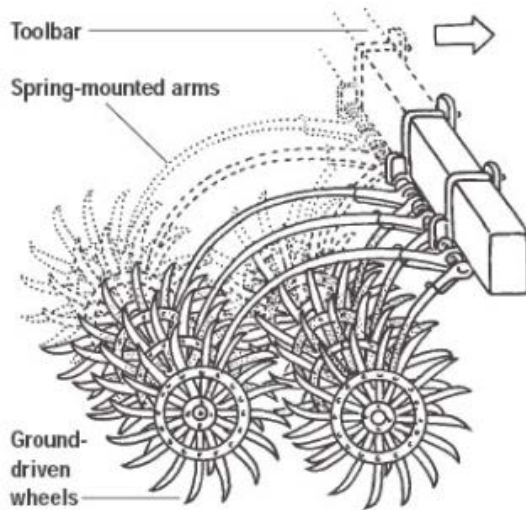


Slide by James Hoorman, NRCS Soil Health Specialist



Rotary Hoe/Harrow: Dries out slug habitat

Slide by: James Hoorman, NRCS Soil Health Specialist



Ouch!

- Rotary hoes or harrow move a lot of residue and dries out slug & vole habitat
- Rotary hoe or harrow in fall, if major slug or vole population
- Rotary hoe or harrow in spring before planting crop



Slide by James Hoorman, NRCS Soil Health Specialist



Pests like residue and grain
reduce habitat at harvest

Spread chaff out thin – full width
to reduce slug & vole habitat



Draper heads do a better job of spreading residue. **Harvest corn plants higher and keep corn stalk standing to reduce slug & vole habitat.**

Also allows soil to dry out faster by keeping stalks upright.



Not Necessarily...



If there...

- Are low slug or vole numbers based on scouting
- Is no crop damage
- Is high predation

Your system is *ecologically* balanced!

Don't mess with success!!



Terminating cover crop 30 days before planting may not be needed or even a concern!



Fig 9

Figure 9: Shingles, old boards, newspaper, and cardboard may be used to monitor slug numbers in the fall and spring. From Penn State: Slugs as Pests of Field Crops



**Slug & Vole Economic Damage
(Unknown for Ohio & Midwest)**

Oregon State University

- 1) 1-2 slugs Low**
- 2) 2-3 slugs Medium**
- 3) 4-5 slugs High**

Put shingles in 5 locations in each field. Check after 1 week. Get it close to soil surface. Put in lower areas with high SOM. Need young growing plants for slugs to eat. Slugs do not tolerate flooding.

For Voles > 5 vole colonies/A

and you're getting economic crop damage...



Consider....

- Reducing Neonicotinoids
- Increasing Predation Perches & Bird Houses
- Change cover crop mix
- Mowing? Other practices to reduce slugs.
- Wait for cold winter





Mowing/burning/disking

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Manage vole food and cover

Filter strips, field borders, grass waterways

- Low mowing < 8 inches*
- Prescribed fire
- Disking

In-field practices (no cover crops)

- Apply early preplant herbicide 30 days prior to planting

Purdue University is an equal access/equal opportunity institution.



- Burning has variable results
- Soil erosion is an issue!
- Mowing may effect other resource concerns (wildlife, rabbits, quail) & your government payment

Natural Resources Conservation Service

nrcs.usda.gov/



For NRCS government contracts, discuss these practices with your local representative before implementing!

Slug Cover Crop Trap Crop?

- Slugs have feeding preferences
- Like to eat some plant species; dislike others
 - They like cereal rye, winter peas, rape, and soybeans
 - Seem to dislike crimson clover, sunflower, chicory
 - Daikon Radish may be natural fumigant? High Sulfur content & High sugar content. Slugs attracted to sugar. Species and crop varieties with higher sugar content are attacked more often. (Spaull & Eldon, 1990)





USDA

United States Department of Agriculture

Bill Richards' Farm, Circleville, Ohio

Corn no-tilled into Austrian Winter Pea

Photos: July 6, 2009



Slug Trap Crops: Winter peas



Cereal rye as trap crop in 30 inch rows



- This field was planted in late spring.
- Used cereal rye in 30" rows as a slug trap crop.
- Corn has to emerge and grow faster than slugs.



- **Durham:** metaldehyde coated sand, non bait (attaches to slug foot) requires **DRY** weather and **DRY** soil. Best applied at planting or crop emergence.
- **Metarex:** metaldehyde bait for late fall, **Wetter** soils.
- **Slugfest:** liquid metaldehyde, best applied summer or early fall to **DRY** soil, but before **Heavy Rain**.
- **Sluggo:** iron phosphate food bait best applied summer-early fall to **DRY** soil, but before **Heavy Rain**.
- **Deadline M-P's:** pelleted metaldehyde best applied late fall or spring to **WET** soil.
- **Slugkil, Ferroxx, Iron-Fist:** sodium ferric EDTA, chelating agent releasing iron phosphate into slug digestive system, best applied in early fall.





- Commercial slug baits seldom suppress slugs below damaging levels, especially with high numbers.
- Space several bait applications several days apart.
- Field life of baits can be short (4-5 days active life).
- Effectiveness is only 60% first day and may drop off after 48 hours. Pick right night for scouting & baiting.
- Heavy slug migration may occur each night from borders or adjacent fields.
- Optimal conditions for baiting: 50-70°F, <5 mph wind, high humidity, light rain or ground moisture.
- Treat in Ohio: April-May or September-Early October



Slugs Considerations

- Metaldehyde (a.i.) bait failures
 - Metaldehyde is both a toxin *and* a feeding inhibitor
 - Need for the slug to feed enough and receive a toxic dose
 - If slug stops feeding before toxic dose received, slugs will recover





- Approved for broadcast application in corn and soybean
- Rarely give 100% control, only partial reduction
- May need to continue treatment for 2-3 years
- Need 4-5 (5-8) pellets/square foot (OSU, Purdue)
- Rates (Deadline MP)
 - Corn, 25 lbs/acre
 - Soybean, 10 lbs/acre
 - Cost is about \$25/Acre





Good coverage is important, but tricky



Even distribution is critical! Slugs finding pellets is random!

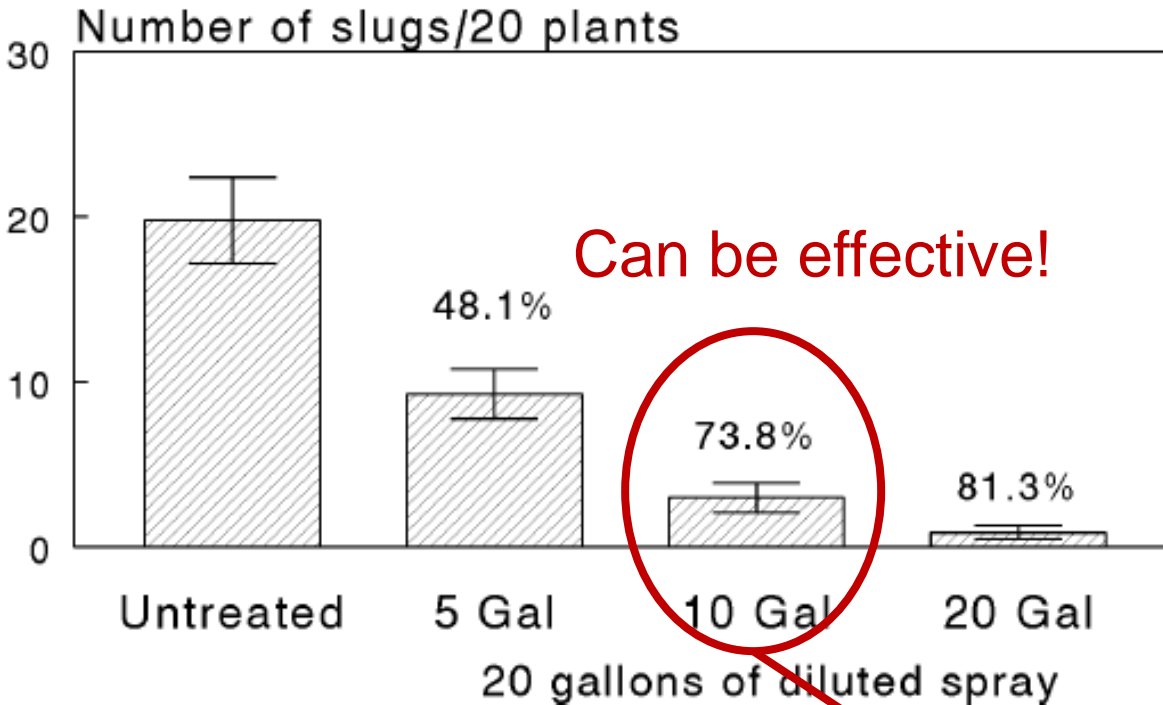


- Earthworms can reduce bait in field by 20% by pulling bait pellets below ground.
- In fields with high earthworms populations, 90% of bait may be depleted in 4-5 days.
- Only 25% of new seedlings are protected by bait when earthworms are active.
- Bait efficacy is reduced when soil temps are $<50^{\circ}\text{F}$ and better at $>63^{\circ}\text{F}$ (until it reaches above 80°F).
- Heavy rains or dews may reduce bait effectiveness.
- Cool damp night, followed by high temps (80°F) and sun will desiccate and kill slugs quicker.





Figure 4. Effect of 30% urea-based nitrogen applied as a broadcast spray at night on slug activity. Means \pm one standard error. Number over bar indicates % control. 1994.



Can be effective!

10 gal of urea in 10 gal water

3C's:

- 30% solution
- Spray at 3 AM
- 3x multiple applications

Risk of burning plants





Step 4. Intervention – Houston we have a problem

- Early termination?
- Alternative feeding
 - Toxicants Killing cover crop 30 days before planting gave best results!
 - Drilling vs. planting

Hyngstrom et al. 2000

Table 2
Mean vole populations, crop damage, and control costs in no-till cornfields^a relative to five rodent control treatments^b in southern IL, 1992–1994

Treatment	Active colonies ha ⁻¹	Corn plants ha ⁻¹	Percent damaged	Corn yield (kg ha ⁻¹)	Cost (US\$ ha ⁻¹)
Early pre-plant herbicides	116 a ^c	57062 a	6 c	10545 a	0.00
Whole-kernel corn	114 a	55772 a	8 c	9980 a	14.86
Zinc phosphide	138 a	52980 ab	13 bc	9917 a	14.82
Cracked corn	111 a	49783 b	18 b	9792 a	32.12
Untreated control	104 a	33316 c	45 a	6590 b	0.00



Repellants, Alternative Feeds Toxicants (baits)

- In soybeans, cotyledons are an attractive food
- Lorsban insecticide on corn acts as a repellent.
- Thiram insecticide for beans & corn
- Plant seed >2 inches deep
- Zinc phosphide pellets - Labeled for corn only
 - At planting, in furrow, 4-6 lbs/acre



- Active ingredient capsaicin (the hot in hot peppers) are taste repellents labeled for use against voles in field crops.
- Labeled for use in a spray that can be applied between crop emergence and when edible portions of the plant begin to form.
- Effectiveness is reduced during periods of wet weather. Usually used on soybeans since voles like to eat the emerging cotyledons.
- Some farmers mix 2 ounces of cayenne pepper in with the seed to reduce vole feeding. It masks the smell.
- Some voles may get use to the hot taste if hungry.





Step 4. Intervention – Houston we have a problem

- Alternative feeding
 - First 21-28 days after planting are critical
 - Broadcast on field 2 days before planting
 - 2 bushels/ac of whole corn
 - 4 bushels/ac of cracked corn
 - 2 bushels/ac whole soybeans



Must have enough seed to feed voles for 21 days

Does not work well with high vole numbers..

- Approved federal label for the application of 2 percent zinc phosphide pellets at planting in no-till or reduced tillage corn provides producers another rodent control option.
- Must be a licensed pesticide applicator to apply toxicants.
- The label is for the use of 4 to 6 pounds per acre of Prozap zinc phosphide pellets (1/8 inch). A restricted-use pesticide.
- This pelletized bait is labeled for the control of small rodents such as voles (field mice).
- Must be applied in-furrow and must not be crushed.
- One 50-pound bag of bait treats about 10 acres.
- This option is labeled only for corn. It may prove most beneficial for use on corn planted into high residue or grass sod/green cover crops that have the potential for being heavily infested with large rodent populations.



Promote Slugs & Voles

Jim Hoorman NRCS Soil Health Specialist	Issue	Slugs	Voles
	Plant Cover Crops too Early	X	X
	Dense, Thick, Tall Vegetation (fence lines, buffers, ditches)	X	X
	Seeds, Lush vegetation, emerging leaves, low C:N ratio	X	X
	No-till or Minimal Soil Disturbance	X	X
	Unharvested Seeds: Corn, Soybeans, Wheat	X	X
	Broadcast Cover Crop Seed	X	X
	Chaff not evenly spread	X	X
	Mild Winter, Wet Spring	X	X
	Open Trench at Planting	X	X
	Slow Spring Growth: Cold & Wet	X	X
	Grasses: Cereal rye, oats, wheat, annual rye grass	X	X
	Legumes and Forages: Soybeans, winter peas, clovers(red, white, sweet), alfalfa, red clover, canola	X	X
	Weeds: Dandelion, Ragweed, Lambsquarter, Plantain	X	X
	Lack of Predators	X	X

James Hoorman, NRCS Soil Health Specialist	Best Management Practices	Slug	Vole
Kill cover crop 30 days before planting		X	X
Mow (graze) cover crop or reduce height to <8 inches, mow field borders		X	X
Plant grain crops deep (>2 inches), close trench		X	X
Spread Chaff evenly in Fall		X	X
Prevent Pest Migration: Control weedy vegetation in fence rows & buffers		X	X
Rotary Hoe/Harrow in Spring (and Fall if needed) to avoid matted residue		X	X
Drill all grain crops and cover crops to get seed below soil surface		X	X
Drill higher populations of soybeans		X	X
Plant non-food source cover crops: crimson clover (radish? for slugs)		X	X
Plant 50% cover crops that winter kill/Promote Predators		X	X
Scout & Monitor in fall and 30-45 days before spring planting		X	X
Utilize Tools (shingles for slugs, perches for voles, bird houses)		X	X
Select Fast Emerging and Growing Grain Crops		X	X
Avoid Using Neonicotinoids especially on soybeans		X	
Avoid over hunting predators (fox, coyote)			X
Tillage		XX	XX

Best Baits or Repellants

James Hoorman, NRCS Soil Health Specialist	Slugs	Voles
Repellants	Lime, salt, vinegar, garlic	Lorsban, Thiram
Repellants	Cayenne pepper	Cayenne pepper
Chemicals	Sulfate, Copper, Nitrogen sprays	NA
Avoid Neonicotinoids	X	NA
Pest dislike or makes sick	Crimson Clover Radish?	Crimson Clover
Common Enemies	Birds: hawks, owls, gulls, blue jays, snakes, fox, shrew, raccoon, possum (spiders ground beetle, fireflies)	Birds: hawks, owls, gulls, blue jays, snakes, fox, shrew, raccoon, possum (coyote)
Baits	Metaldehyde (Deadline) Iron Phosphate (Sluggo)	Zinc Phosphide Pellets (Prozap)
Alternative Feeding Broadcast at planting	NA	2-4 Bu. Whole/Cracked Corn 1-2 Bu Whole Soybean
Trap Crops/Animals	Cereal rye, Winter peas	Rat Terrier



Take Home Message

- Healthy soils improve crop quality & productivity
- No-till, diverse crop rotations, cover crops
- Healthy soils are alive with all types of biological activity including bacteria, fungus, protozoa, nematodes, insects, predators, etc.
- IPM should guide pesticide use
- IPM builds soil health
- Pesticides (Insecticides, Fungicides) limit soil life.
- Good Soil Health = Healthy Soil Food Web



- Oregon State University
- Purdue University
- Penn State University
- Ohio State University
- Kentucky Extension
- Missouri Extension
- Tennessee Extension
- University of Illinois
- Michigan State University
- NRCS Agronomy Crib Notes
- Dakota Lakes Research Farm



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