Hemlock Woolly Adelgid Biology and Management in the Southeastern U.S.



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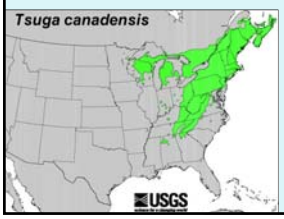
Outline

- Hemlock and HWA biology
- Effects of HWA on forests
- Management options
- Specific treatment details
  - Soil drench
  - Soil injection
  - Trunk injection
  - Trunk spray
  - CoreTect
- Imidacloprid dosage
- Environmental concerns (throughout)

Eastern Hemlock

- Range from Canada to northern Georgia
- Distinctive ecological niche



Hemlock Ecology

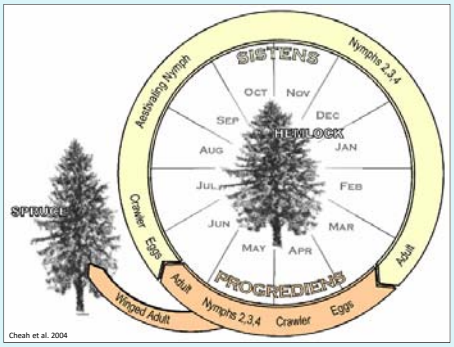
- Shade tolerant conifer
- Creates dense shade
- Habitat for wildlife
- Regulates stream water temperatures and discharge rates
- Affects soil pH
- Ecological role cannot be replaced

Orwig and Foster 1998, Ward et al. 2004, Ford and Vose 2007, Huddleston 2011

Hemlock Woolly Adelgid

Adelges tsugae **(Annand) (Hemiptera: Adelgidae)**

- Native to Japan
- Rapid spread in 1980's
- Two generations each year
- Females lay 50+ eggs
- No effective native natural enemies
- Widespread hemlock mortality



Cheah et al. 2004

Eggs under “wool”

Crawler

Crawler

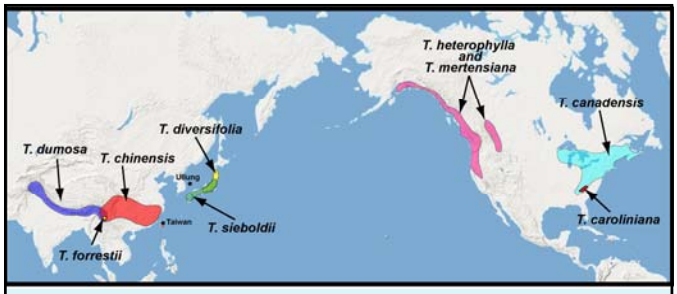
Crawler has settled and begins feeding

- Graying foliage
- Canopy thinning
- Dead branches
- Dead hemlock

Hemlock Woolly Adelgid

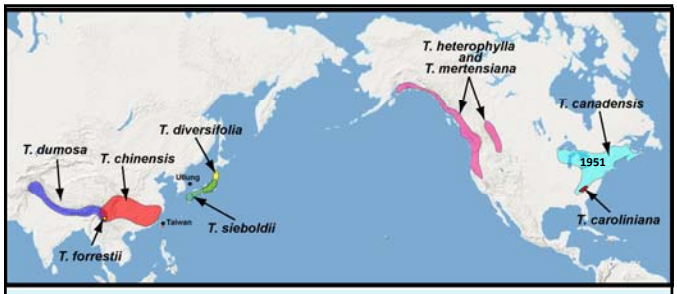
- Depletes hemlock carbohydrate reserves
- Reduces photosynthetic activity
- Reduces growth
- Causes water stress symptoms
- Many other physiological changes

Young et al., 1995; Radville et al., 2011; Gonda-King et al., 2014; Nelson et al., 2014



- Nine species of hemlock worldwide
- HWA is present in China, Japan, Taiwan, and eastern & western North America

Havill et al. 2006. Annals of the Entomological Society of America 99: 195-203
Havill et al. 2008. Systematic Botany 33: 478-789.



- Western North American population – endemic
- Eastern North American population – introduced from Japan

Havill et al. 2006. Annals of the Entomological Society of America 99: 195-203
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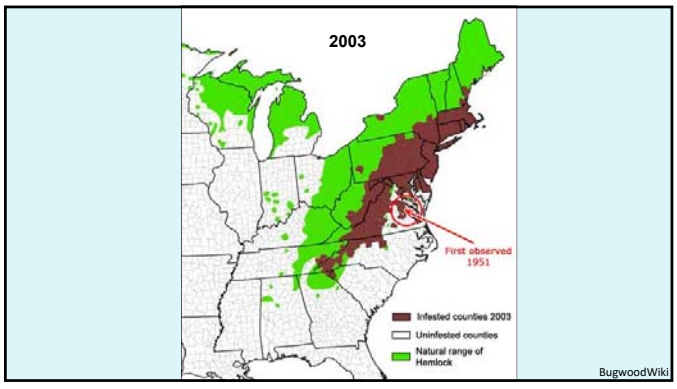
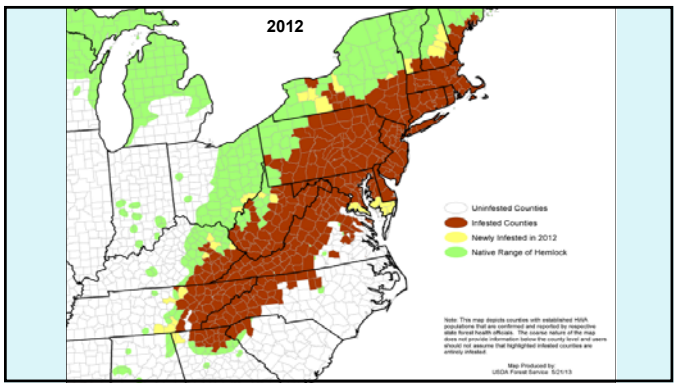




Post-HWA Forests

What do we see in forests after HWA-induced mortality?

- Opens canopy gaps
- Rapid vegetation response
- Changing plant communities
- Changes in soil nutrients
- Altered wildlife habitat
- Forest fire intensity
- Increased *Rhododendron* density

Orwig and Foster 1998; Jenkins et al. 1999; Spaulding and Rieske 2010; Krapfl et al. 2011

What is the REAL resource?

What is the REAL resource?

The entire hemlock system




Healthy Hemlock Forests






What is the management goal?

- Eradication?
- Suppression?
  - Lowest possible HWA abundance?
  - HWA populations low enough to maintain hemlock crown health?
  - HWA populations high enough to support predator complexes?

What tools are in the tool box?

- Horticultural oil
  - No residual control

What tools are in the tool box?

- Horticultural oil
- Biological control

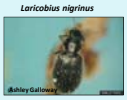
Biological Control

Sasajiscymnus tsugae

Sasajiscymnus coniferarum

Leucopis spp.

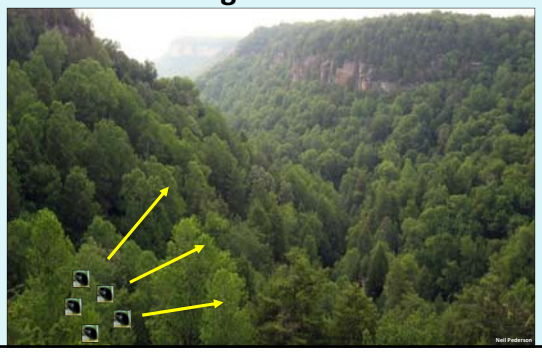
Laricobius nigrinus



Laricobius osakensis

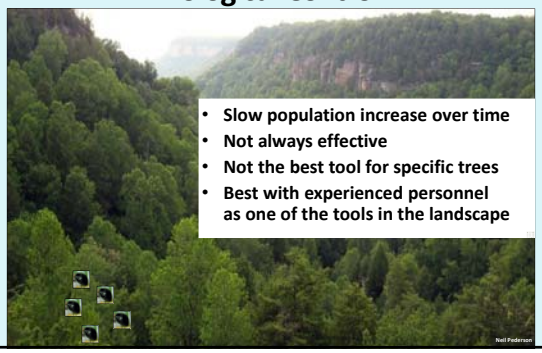
Biological Control

Biological Control



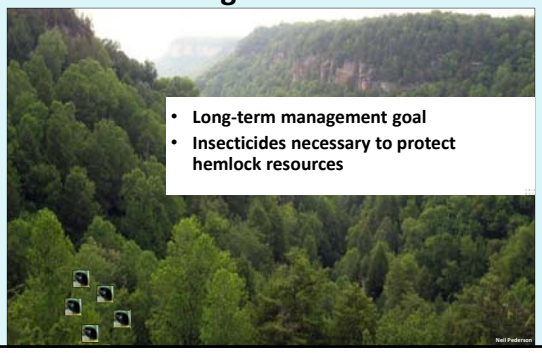
Biological Control

Biological Control



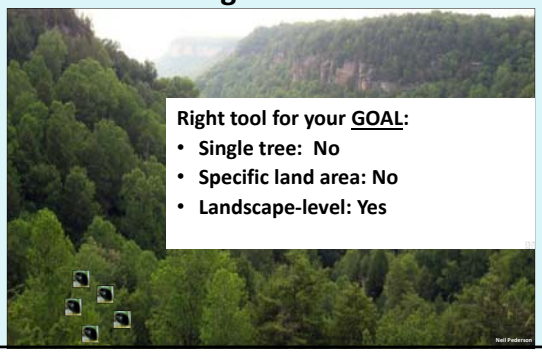
- Slow population increase over time
- Not always effective
- Not the best tool for specific trees
- Best with experienced personnel as one of the tools in the landscape

Biological Control



- Long-term management goal
- Insecticides necessary to protect hemlock resources

Biological Control



Right tool for your <u>GOAL</u>:

- Single tree: No
- Specific land area: No
- Landscape-level: Yes

What tools are in the tool box?

- Horticultural oil
- Biological control
- Do nothing
  - Often the only choice for some management programs

What are the consequences of doing nothing?

What tools are in the tool box?

- Horticultural oil
- Biological control
- Do nothing
- Neonicotinoid insecticides
  - Dinotefuran
  - Imidacloprid

Let's think about insecticides.

Let's think about insecticides.

Insecticide – a chemical substance that is used to kill insects

Hazard

Hazard

Risk = Hazard x Exposure

Hazard

Risk = Hazard x Exposure

Minimize Risk

Non-target impact – negative effect on things that are not the intended target

Trade-off – a situation in which you must choose between or balance two things that are opposite or cannot be had at the same time

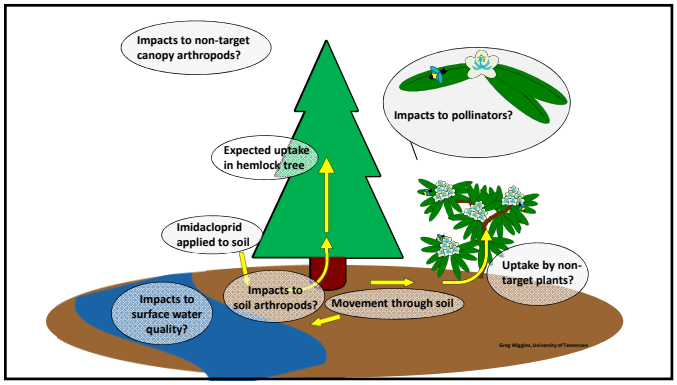
Non-target impact – negative effect on things that are not the intended target

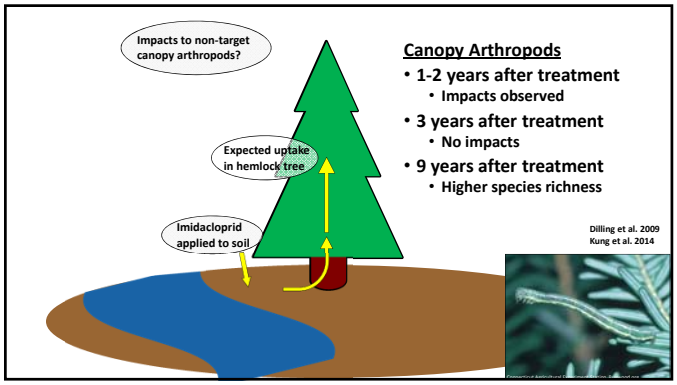
Trade-off – a situation in which you must choose between or balance two things that are opposite or cannot be had at the same time

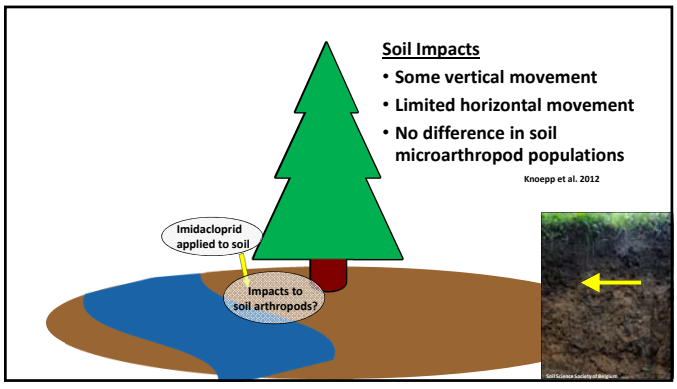
Every management decision involves a trade-off.

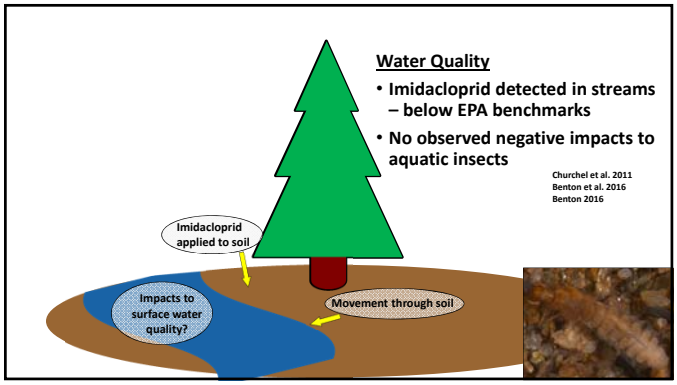
Trade-off?

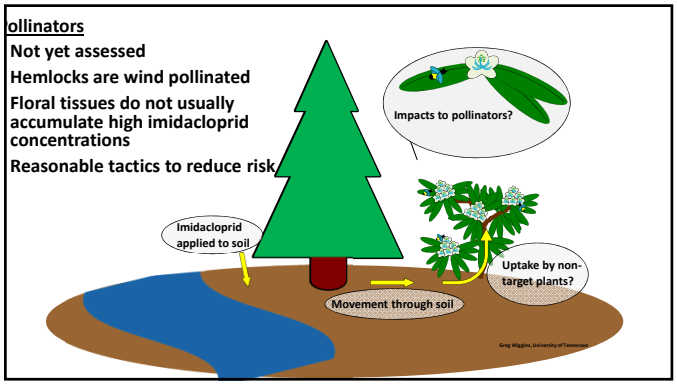
Wallace and Hain 2000; Buck et al. 2005; Lynch et al. 2006; Dillon et al. 2007, 2009; Mallis and Bjerke 2011; Coots et al. 2012


Impacts to non-target canopy arthropods?
Impacts to pollinators?
Expected uptake in hemlock tree
Imidacloprid applied to soil
Uptake by non-target plants?
Impacts to surface water quality?
Impacts to soil arthropods?
Movement through soil
Greg Wiggins, University of Tennessee


Impacts to non-target canopy arthropods?
Canopy Arthropods
• 1-2 years after treatment
• Impacts observed
• 3 years after treatment
• No impacts
• 9 years after treatment
• Higher species richness
Expected uptake in hemlock tree
Imidacloprid applied to soil
Dilling et al. 2009
Kung et al. 2014


Soil Impacts
• Some vertical movement
• Limited horizontal movement
• No difference in soil microarthropod populations
Knoepp et al. 2012
Imidacloprid applied to soil
Impacts to soil arthropods?





Advocating pesticide use?

Advocating pesticide use?

Responsible use

What tools are in the tool box?

- Horticultural oil
- Biological control
- Do nothing
- Neonicotinoid insecticides
  - Dinotefuran
  - Imidacloprid

Neonicotinoids

- Newer class of insecticides
- Licensed in more than 100 countries
- $26 billion global market
- 41% imidacloprid
- Other neonicotinoids include:
  Acetamiprid, Thiamethoxam, Thiacloprid, Clothianidin

Imidacloprid Use for HWA Suppression

- Widely used for HWA suppression
- Systemic applications
- Persists in hemlock tissue for many years

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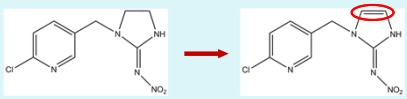


Imidacloprid

Olefin

Dinotefuran

- Moves to the canopy <u>quickly</u>

Imidacloprid

- Moves to the canopy <u>slowly</u>

Dinotefuran	Imidacloprid
• Moves to the canopy quickly • Effective 1 - 2 years	• Moves to the canopy slowly • Effective 5 - 7+ years

Dinotefuran	Imidacloprid
• Moves to the canopy quickly • Effective 1 - 2 years • Quick short-term reduction of HWA	• Moves to the canopy slowly • Effective 5 - 7+ years • Provides longer-term reduction of HWA

Dinotefuran	Imidacloprid
• Moves to the canopy quickly • Effective 1 - 2 years • Quick short-term reduction of HWA • Best for heavy infestations	• Moves to the canopy slowly • Effective 5 - 7+ years • Provides longer-term reduction of HWA • Best for light to moderate infestations

Dinotefuran

- Moves to the canopy quickly
- Effective 1 - 2 years
- Quick short-term reduction of HWA
- Best for heavy infestations
- More expensive

Imidacloprid

- Moves to the canopy slowly
- Effective 5 - 7+ years
- Provides longer-term reduction of HWA
- Best for light to moderate infestations
- Less expensive

Dinotefuran and imidacloprid used together

- Apply both products at the same time
- Caution – same insecticide class
- Apply Dinotefuran first for quick HWA population reduction – follow with imidacloprid the next year for longer-term suppression
- Product choice and timing is dependent on *resources* and management *goals*

Dinotefuran Application Methods

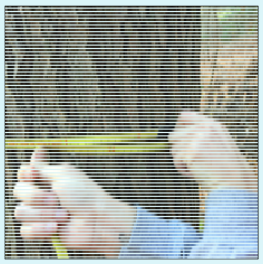
- Soil drench
- Soil injection
- Trunk injection
- Bark spray

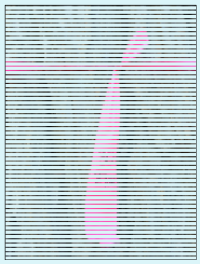
Imidacloprid Application Methods

- Soil drench
- Soil injection
- Trunk injection
- Bark spray
- CoreTect pellets

Dilling et al. 2010. Journal of Economic Entomology 103: 368 – 373.

What is the tree diameter?





How much insecticide should be applied?

Labeling and Mixing Instructions

- Sometimes labels are not very clear
- Example: 1.6 oz WSP has 34 g active ingredient (a.i.)
  Product label: apply to 12 – 48 inches DBH

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  0.7 – 2.8 grams a.i. per inch DBH

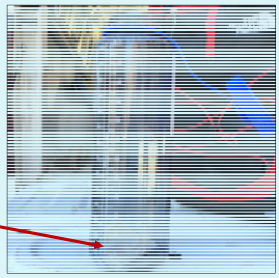
$$\frac{34 \text{ grams a.i.}}{12 \text{ in DBH}} = 2.8 \text{ grams a.i./inch DBH}$$

$$\frac{34 \text{ grams a.i.}}{48 \text{ in DBH}} = 0.7 \text{ grams a.i./inch DBH}$$

Labeling and Mixing Instructions

- Sometimes labels are not very clear
- Example: 1.6 oz WSP has 34 g active ingredient (a.i.)
  Product label: apply to 12 – 48 inches DBH
  0.7 – 2.8 grams a.i. per inch DBH
- For HWA: 0.7 – 1.4 grams a.i. per inch DBH
- Double dose for larger trees (some labels)
- Optimized dosage for DBH – covered later

Start with insecticide

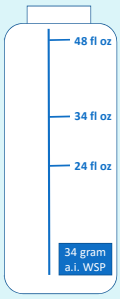


Add water to final suspension volume

Start with insecticide

Start with insecticide

Add water to final suspension volume



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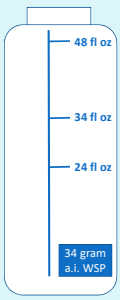
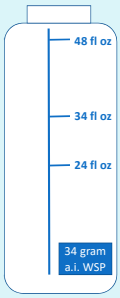


48 fl oz = 0.7 gram a.i./fl oz suspension

34 fl oz = 1 gram a.i./fl oz suspension

24 fl oz = 1.4 gram a.i./fl oz suspension

Start with insecticide



Add water to final suspension volume

48 fl oz = 0.7 gram a.i./fl oz suspension

34 fl oz = 1 gram a.i./fl oz suspension

24 fl oz = 1.4 gram a.i./fl oz suspension

Concentration of the suspensions determines how many ounces used for the treatment.

Soil Drench

Remove the "duff" layer

Fine roots around trunk are exposed

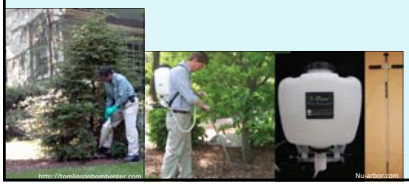
Soil Drench

Pour suspension

Check volume

Soil Injections

- Kioritz → 6 pumps = 1 oz
- 1-Two root injector → 4 pumps = 1 oz



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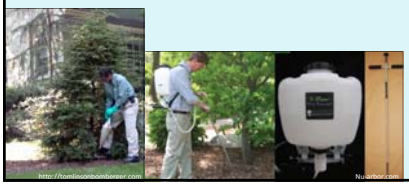
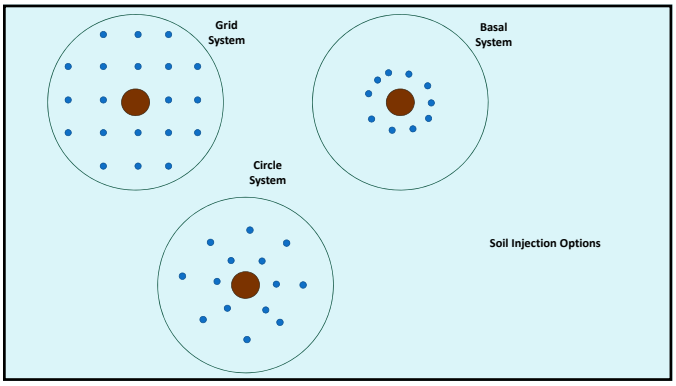
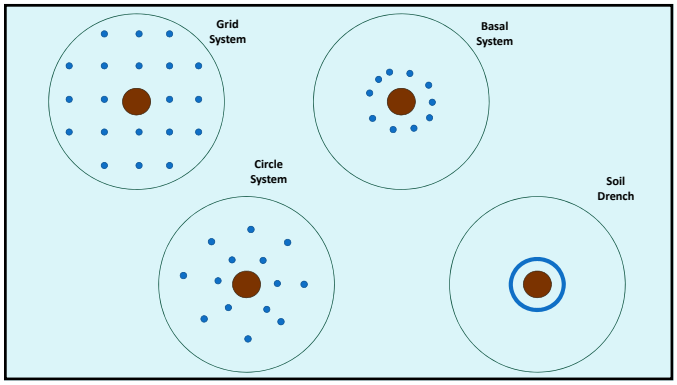


10 oz suspension
Kioritz → 60 pumps
1-Two → 40 pumps





Trunk Injection

For applications near water.

Applications should be made by properly trained professionals.

Basal Bark Spray

1:10 dilution → 1 quart imi flowable to 9 quarts water

0.75 gai/in DBH - 1.5 fl oz per inch DBH → wet trunk to 3.5 ft
1 gai/in DBH - 1.5 fl oz per inch DBH → wet trunk to 4.5 ft
1.4 gai/in DBH - 1.5 fl oz per inch DBH → wet trunk to 6 ft

Use a controlled flow valve with a backpack sprayer.
Calibrate applications with a stopwatch.

Richard S. Cowles, The Connecticut Agricultural Experiment Station

CoreTect Pellets

Make holes in soil

2 – 3 pellets/in DBH

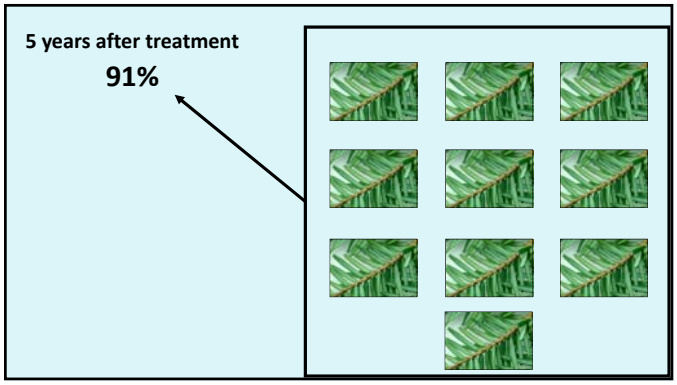
Label rate

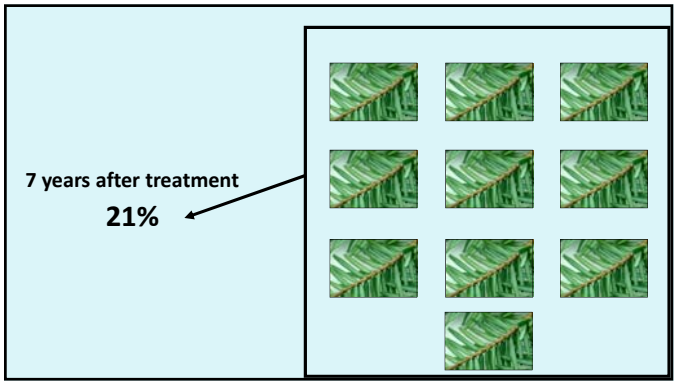
Place pellets in holes

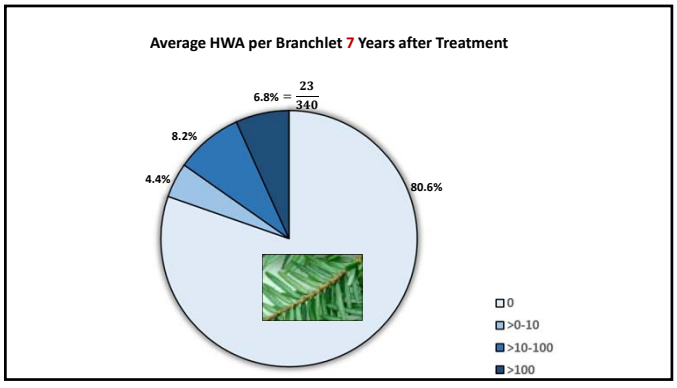
102 hemlocks sampled for two years

10 branchlets collected from each hemlock

Benton et al. 2016. Journal of Economic Entomology 109: 2125 – 2136.

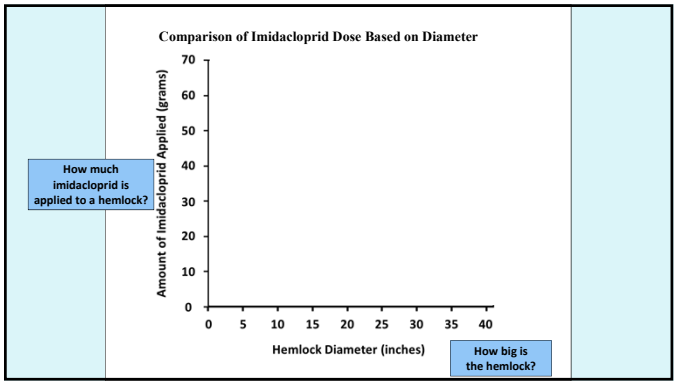

5 years after treatment
91%

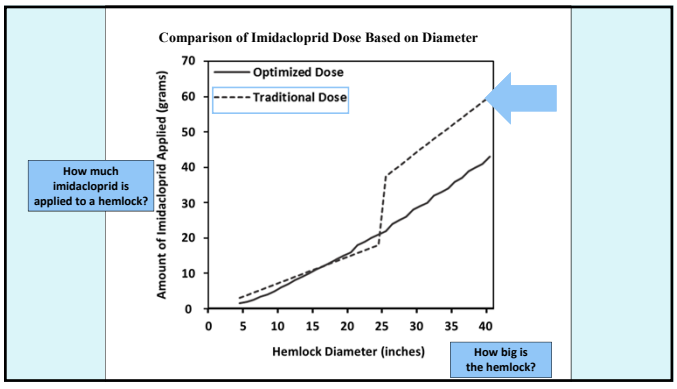

7 years after treatment
21%

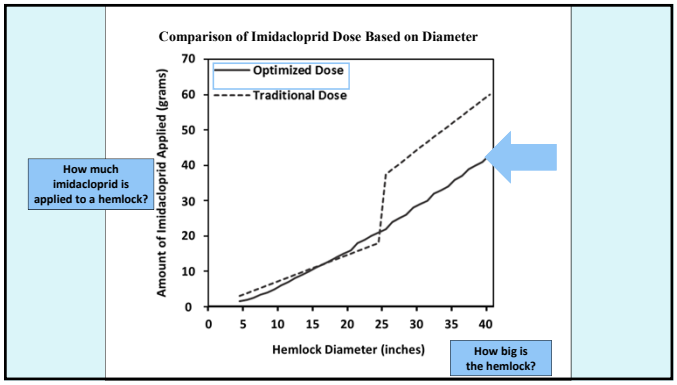

Average HWA per Branchlet 7 Years after Treatment
6.8% = 23/340
8.2%
4.4%
80.6%
0
>0-10
>10-100
>100

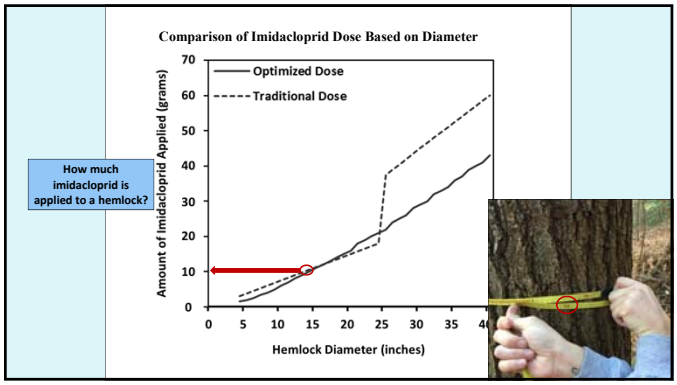
What about dosage?

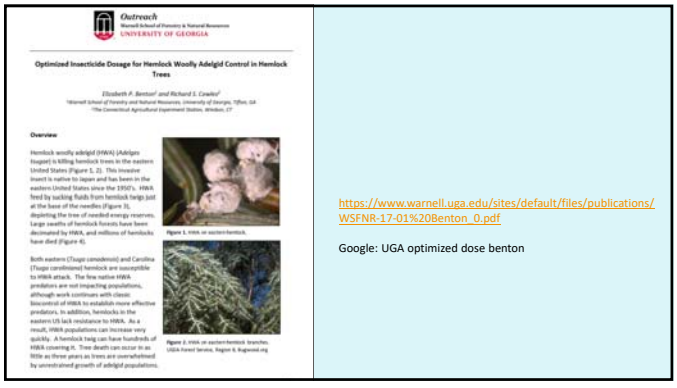
Benton et al. 2016. Forest Ecology and Management 370: 12-21.










Outreach
UNIVERSITY OF GEORGIA

Optimized Insecticide Dosage for Hemlock Woolly Adelgid Control in Hemlock Trees

Overview

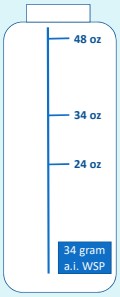
https://www.warnell.uga.edu/sites/default/files/publications/WSFNR-17-01%20Benton_0.pdf

Google: UGA optimized dose benton

Optimal Imidacloprid Dose
~~Water Soluble Packets~~

Inches DBH	Number of Fluid Ounces	Inches DBH	Number of Fluid Ounces
4	1.5	20	16
5	2	21	18
6	2.5	22	19
7	3.5	23	20
8	4	24	21
9	5	25	22
10	6	26	24
11	7	27	25
12	8	28	26
13	9	29	28
14	10	30	29
15	11	31	30
16	12	32	32
17	13	33	33
18	14	34	34
19	15	35	36
Maximum oz per acre		**181**	

Water soluble packet mixing instructions: Add a 1.6 oz. WSP to a container. Fill with water to form a final volume of 34 fl. oz. The final volume of the suspension in the container (WSP + water) should be 34 oz.
Application instructions: Brush away the top layer of organic material (the "duff" layer) in the immediate area where soil drench is being applied. Apply the imidacloprid suspension on the soil within 18 inches of the hemlock trunk. Pour the solution evenly around the base of the tree.



Optimal Imidacloprid Dose
~~Water Soluble Packets~~

Inches DBH	Number of Fluid Ounces	Inches DBH	Number of Fluid Ounces
4	1.5	20	16
5	2	21	18
6	2.5	22	19
7	3.5	23	20
8	4	24	21
9	5	25	22
10	6	26	24
11	7	27	25
12	8	28	26
13	9	29	28
14	10	30	29
15	11	31	30
16	12	32	32
17	13	33	33
18	14	34	34
19	15	35	36
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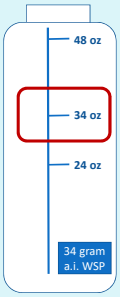

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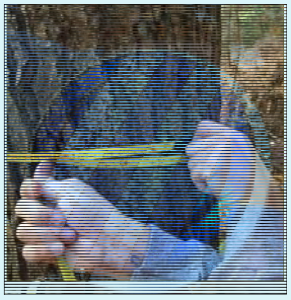
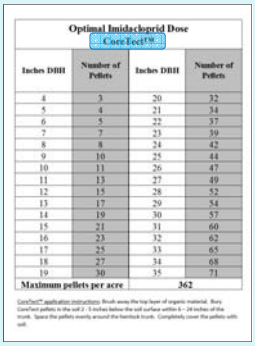




Optimal Imidacloprid Dose

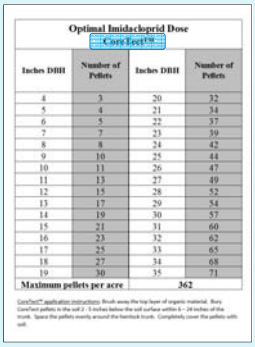
CoreTect™

Inches DBH	Number of Pellets	Inches DBH	Number of Pellets
4	3	20	32
5	4	21	34
6	5	22	37
7	7	23	39
8	8	24	42
9	10	25	44
10	11	26	47
11	13	27	49
12	15	28	52
13	17	29	54
14	19	30	57
15	21	31	60
16	23	32	62
17	25	33	65
18	27	34	68
19	30	35	71
Maximum pellets per acre		362	

CoreTect™ application instructions: Brush away the top layer of organic material. Bury CoreTect pellets in the soil 2 - 5 inches below the soil surface within 6 – 24 inches of the trunk. Space the pellets evenly around the hemlock trunk. Completely cover the pellets with soil.

CoreTect Comparison

DBH (in)	Label (2)	Label (3)
5	10	15
10	20	30
15	30	45
20	40	60
25	50	75
30	60	90
35	70	105



Optimal Imidacloprid Dose

CoreTect™

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CoreTect Comparison

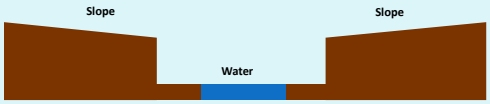
DBH (in)	Label (2)	Label (3)	New
5	10	15	4
10	20	30	11
15	30	45	21
20	40	60	32
25	50	75	44
30	60	90	57
35	70	105	71

Caution!!

- **Do not apply more than 181 grams (0.4 lbs) a.i. per acre**
- **Do not apply near water**

Caution!!

- Do not apply more than 181 grams (0.4 lbs) a.i. per acre
- Do not apply near water
- What is the correct surface water set back?



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- What is the correct surface water set back?

Healthy Hemlock Forests
Manage Responsibly






State-specific Pesticide Regulations

New York Pesticide Regulations

- **General use – Bayer Tree and Shrub**
- **Restricted use (licensed applicator)**
  - **Special Local Needs (SLN) registration**
    - **Dinotefuran – only basal bark sprays**
    - **Imidacloprid – basal bark sprays, soil drench, soil injection, trunk injection**

Check regulations in your state

Mark Whitmore, Department of Natural Resources, Cornell University

Sometimes obvious

Operating without one is a bad idea.

Sometimes VERY obvious

Follow the pesticide label.

Thank you for helping to preserve hemlock forest resources.

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