What is hemlock woolly adelgid and who is eating them?

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USDA FOREST SERVICE

Forest Service Research Work Unit (NRS-03): Ecology and Management of Invasive Species and Forest Ecosystems

My Focus: Genetics and evolution of invasive insects, their natural enemies, and host trees

What is hemlock woolly adelgid?

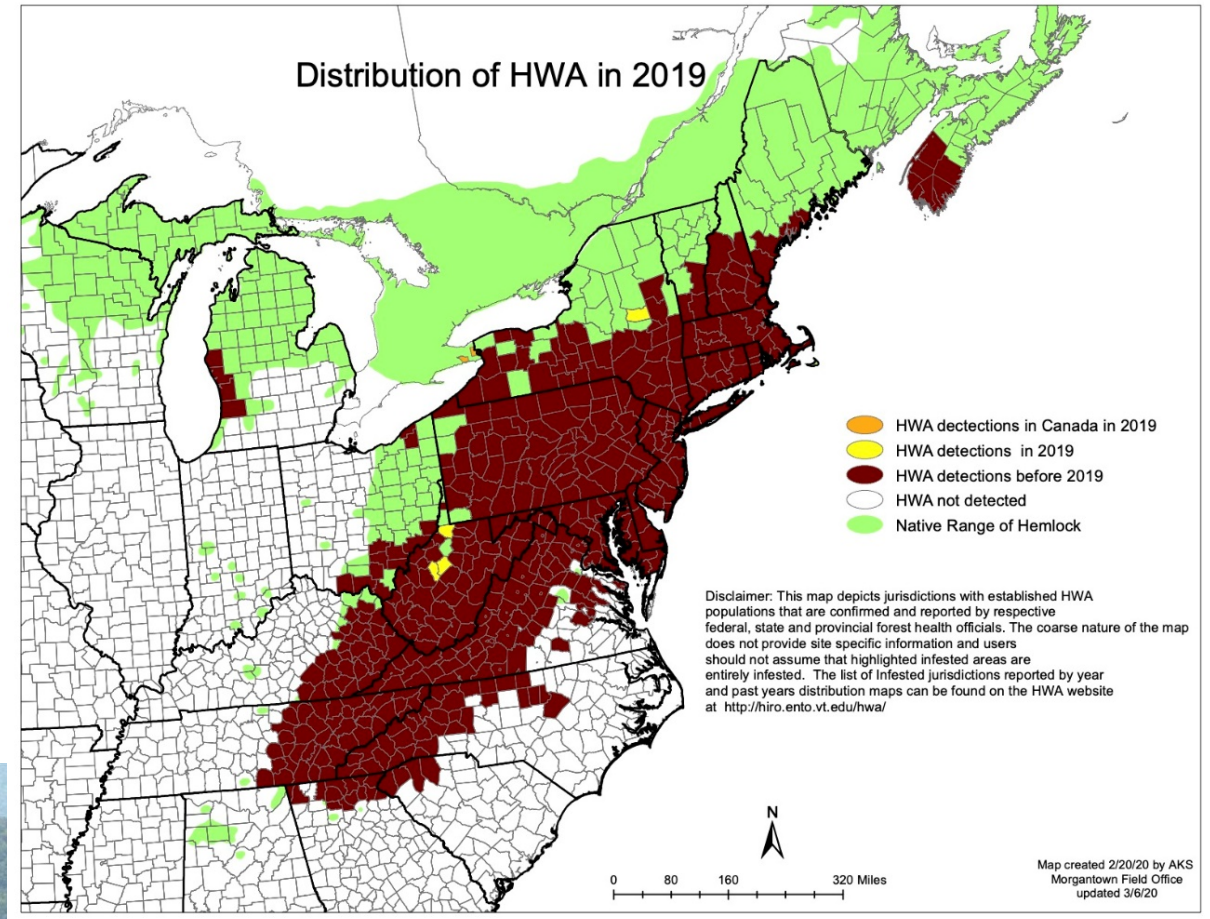
- **Species name: *Adelges tsugae***
- **Major pest of eastern and Carolina hemlocks in the eastern U.S. and Canada**

First instar

Adult

Ovisacs on eastern hemlock

HWA damage and distribution



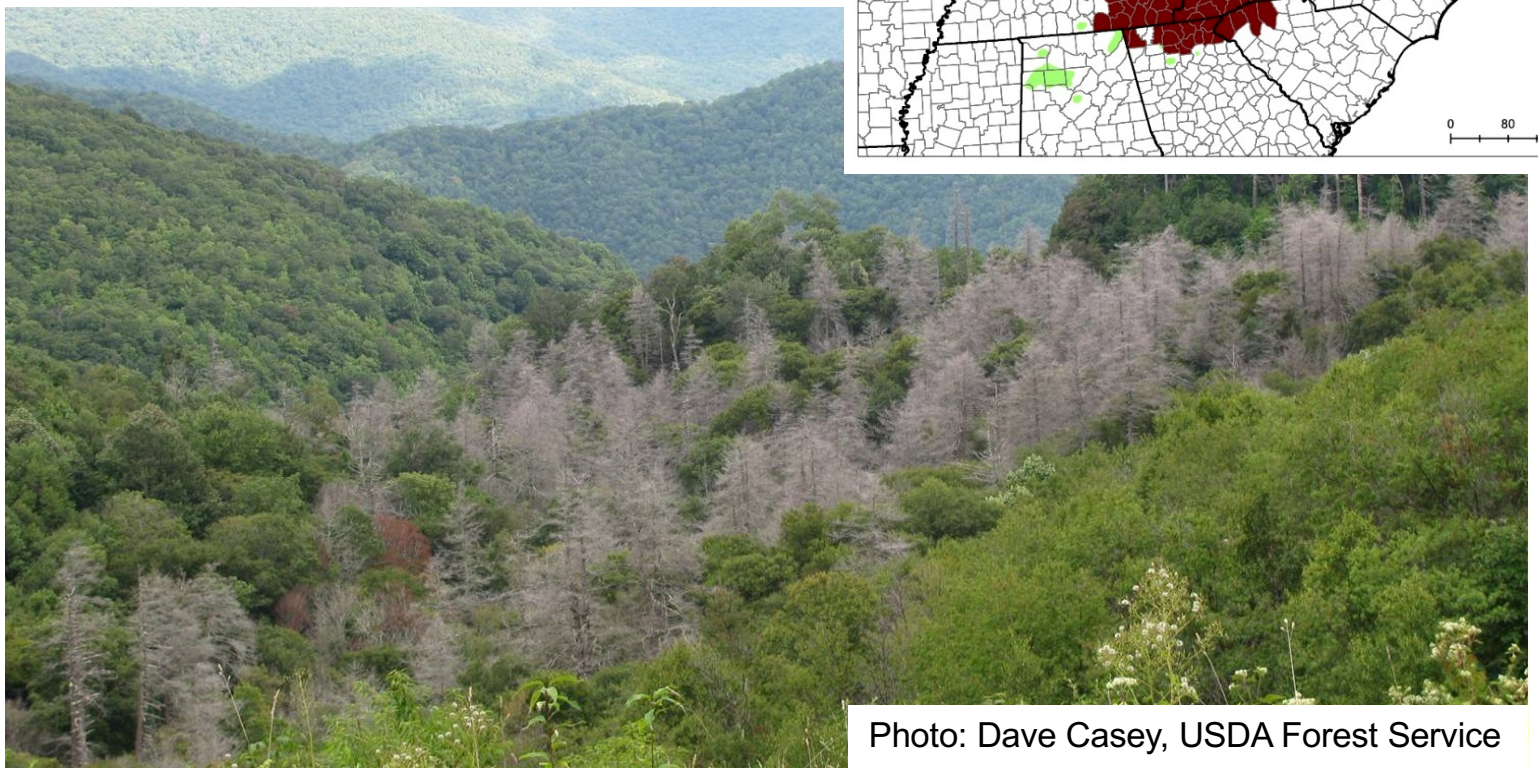
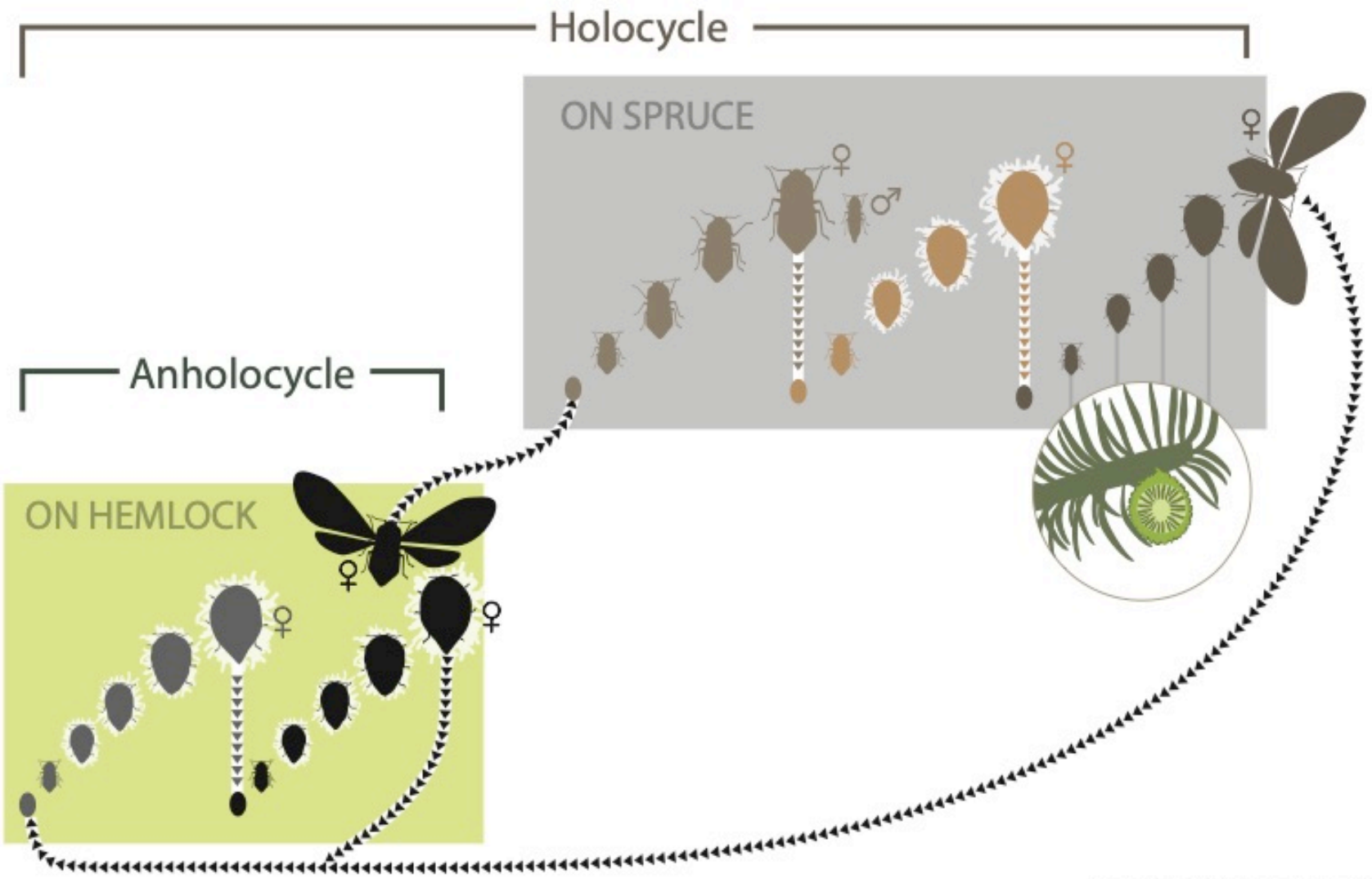


Photo: Dave Casey, USDA Forest Service

Complex life cycle in Asia

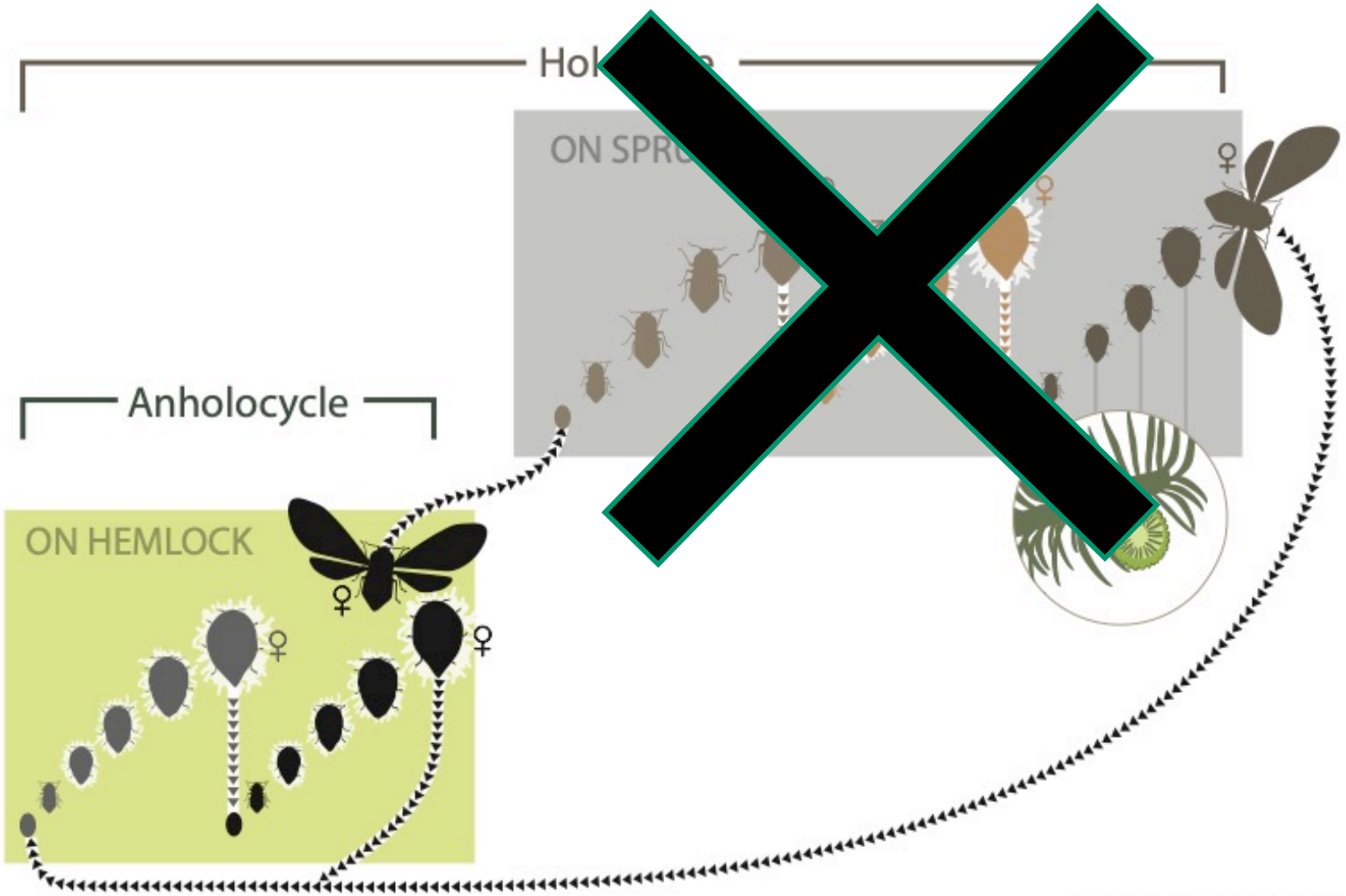
- **Can alternate between hemlock (*Tsuga*) and spruce (*Picea*)**



Hemlock wooly adelgid gall on *Picea polita* in Nikko, Japan.
Up to 1200 winged adelgids inside!

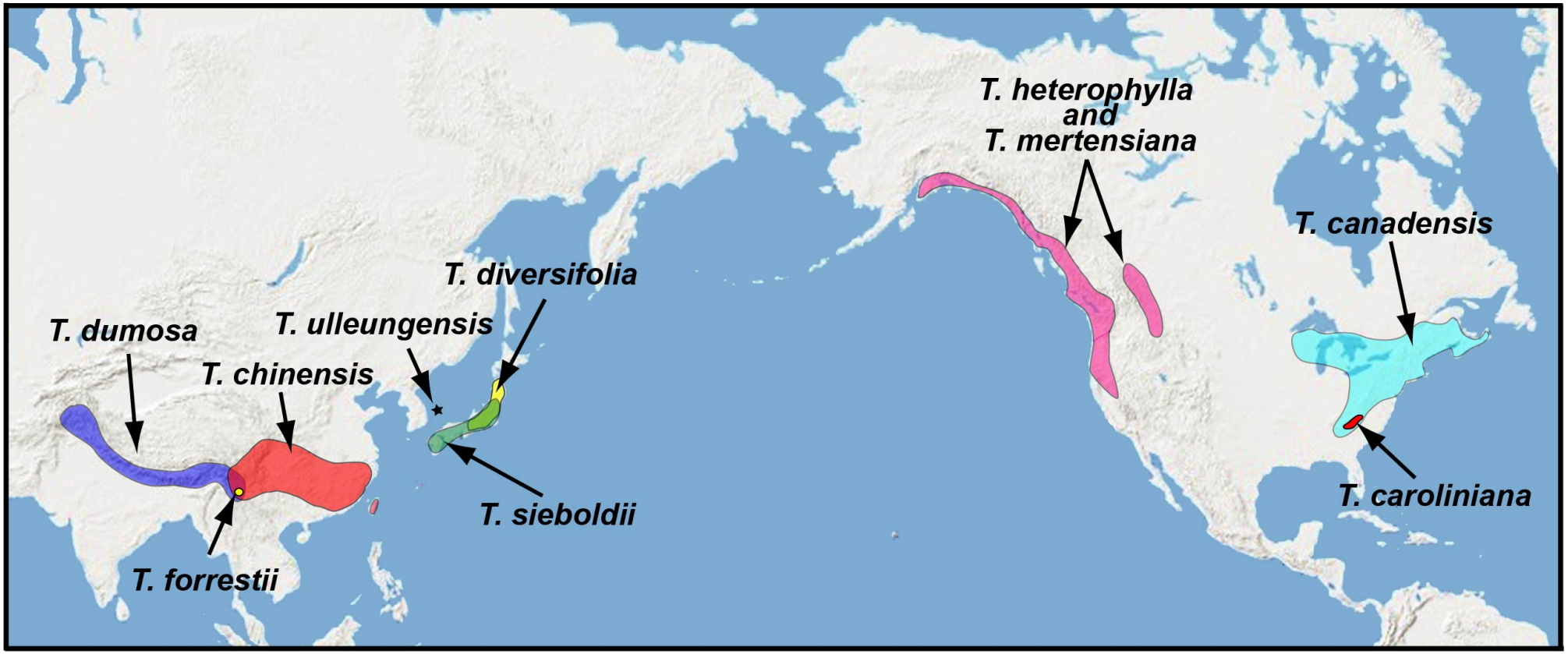
Life cycle in North America

- **Only on hemlock (*Tsuga*). No suitable spruce species**



Where did hemlock woolly adelgid come from?

- **Ten species of hemlock worldwide**
- **Adelgids found on all of them**

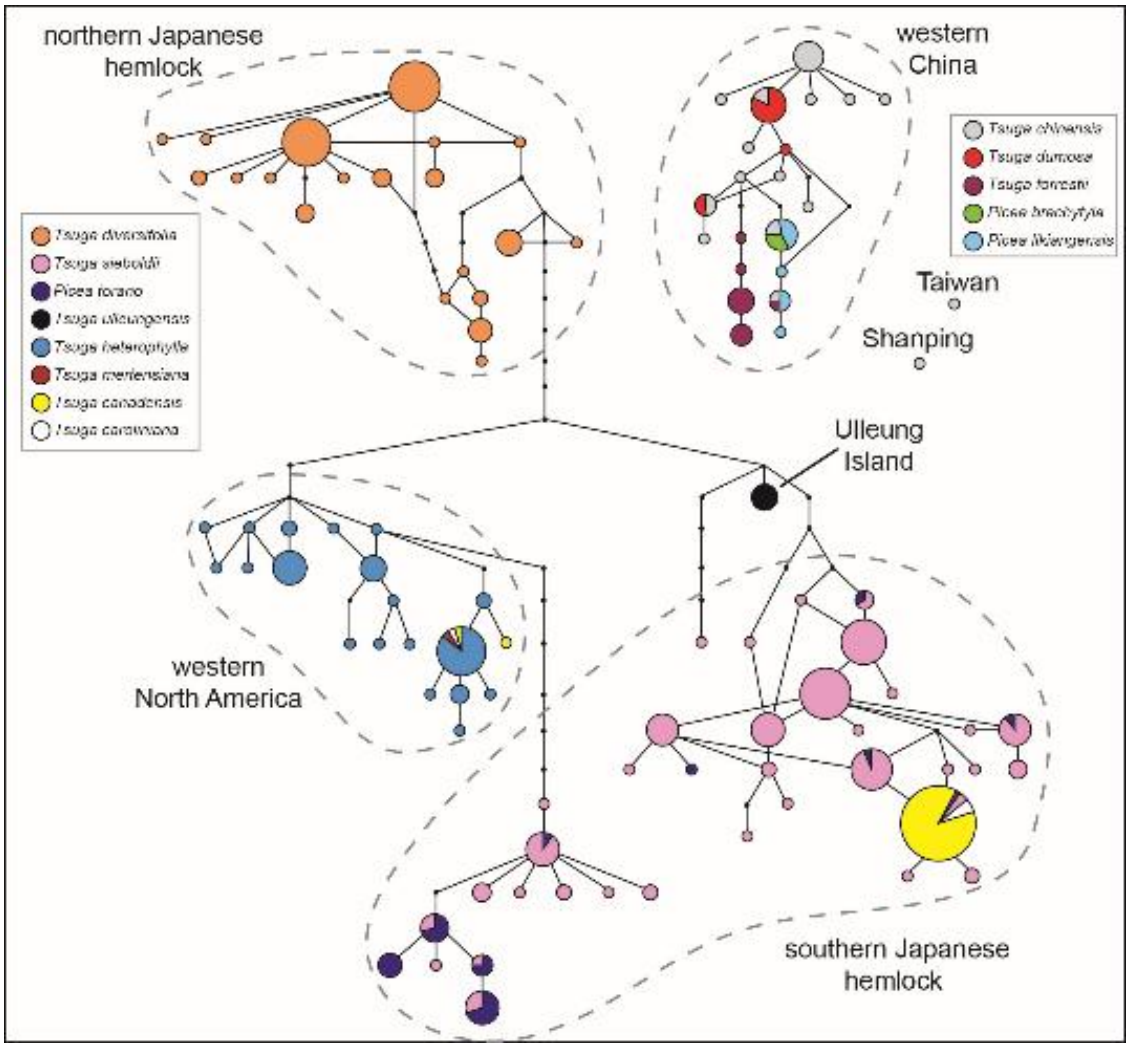


After: Havill, N. P., Campbell, C. S., Vining, T. F., LePage, B. A., Bayer, R. J., & Donoghue, M. J. (2008). Phylogeny and biogeography of *Tsuga* (Pinaceae) inferred from nuclear ribosomal ITS and chloroplast DNA sequence data. Systematic Botany, 33(3), 478–489.

Collecting HWA samples in Japan

Not all hemlock adelgids are the same

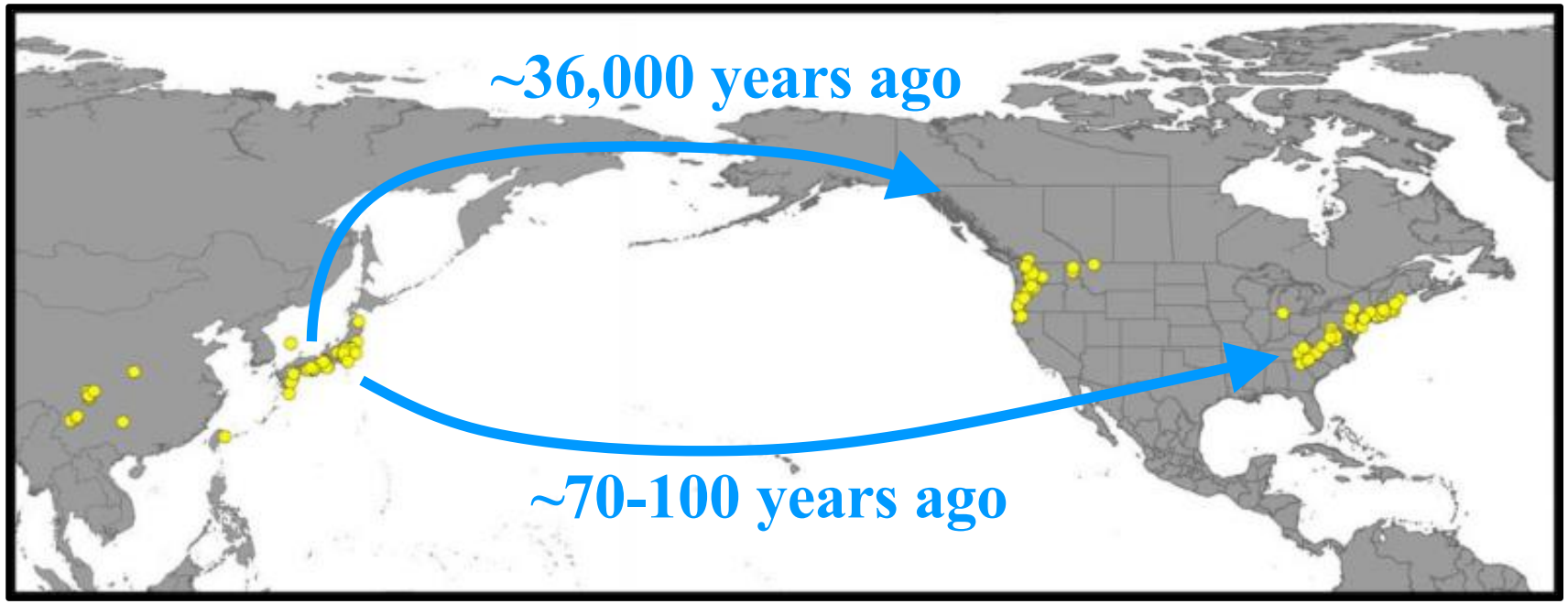
- **Distinct genetic groups in Asia and western North America**
- **A single clone (!) in eastern North America that came from southern Japan**



From: Havill, N.P., Shiyake, S., Lamb Galloway, A., Foottit, R.G., Yu, G., Paradis, A., Elkinton, J., Montgomery, M.E., Sano, M., & Caccone, A. (2016) Ancient and modern colonization of North America by hemlock woolly adelgid, *Adelges tsugae* (Hemiptera: Adelgidae), an invasive insect from East Asia. Molecular Ecology 25, 2065-2080.

Ancient and modern colonization of North America

- **Molecular dating estimated that HWA in western North America migrated from Asia about 36,000 years ago across Beringia**
- **The introduction into the eastern US came directly from southern Japan 70-100 years ago**
- **The native HWA lineage in western North America is distinct from the invasive lineage in eastern North America that came from Japan**
- **Western North America has specialist predators that feed on HWA while eastern North America does not**



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Who is eating HWA?

- **Biological control has focused on beetles from where HWA is native**

Sasajiscymnus tsugae

- From Japan
- 100's of thousands released
- Established
- Little evidence of impact

Scymnus nignshanensis* and *Scymnus sinuanodulus

- From China
- A few 100 released
- Not established

Photo: Nick Dietschler, Cornell Univ.

Laricobius osakensis

- From Japan
- 53,000 released
- Established
- Impact not yet clear

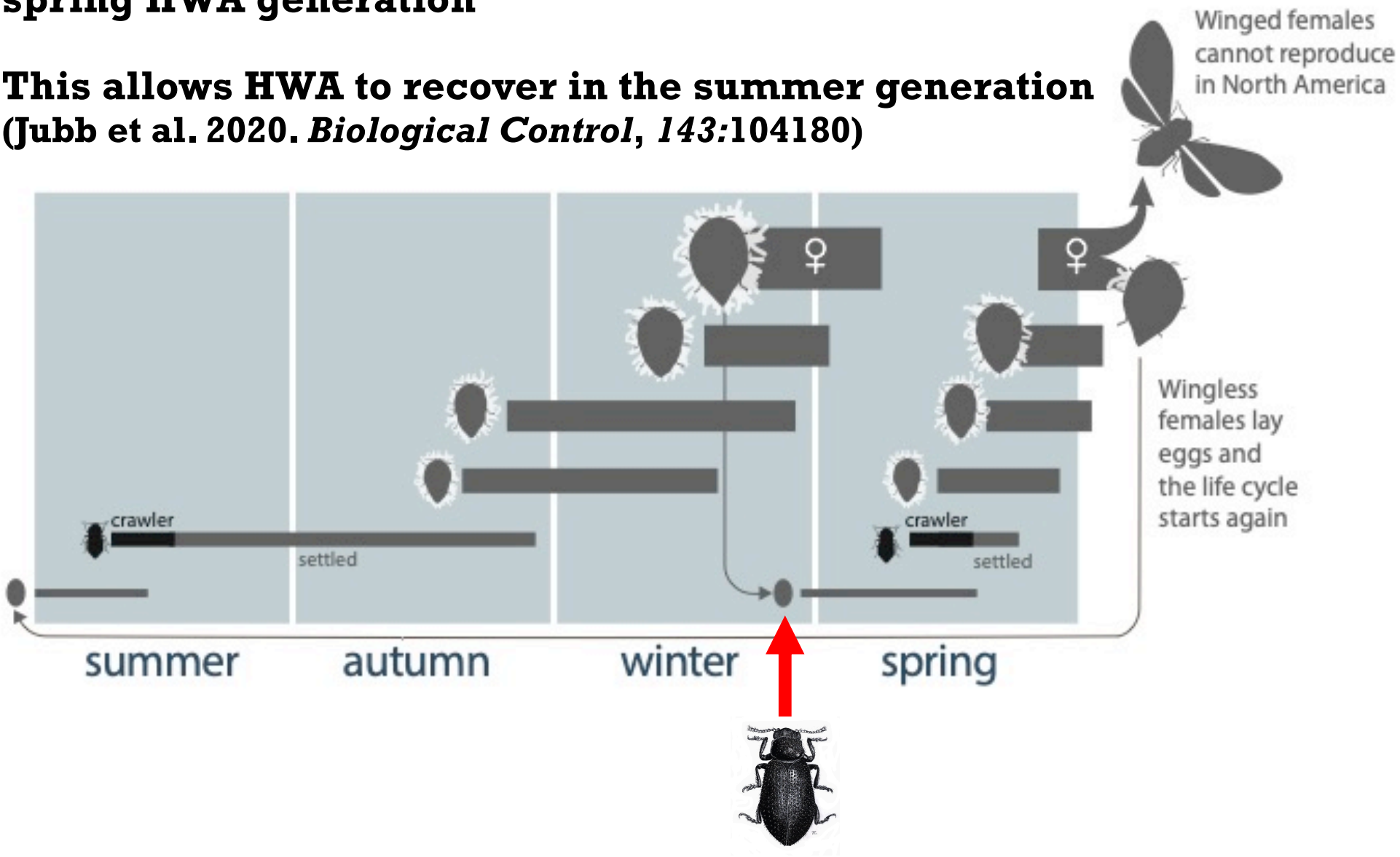
Laricobius nigrinus

- From Pacific Northwest
- Over 400,000 released
- Widely established
- Some impact on the first HWA generation

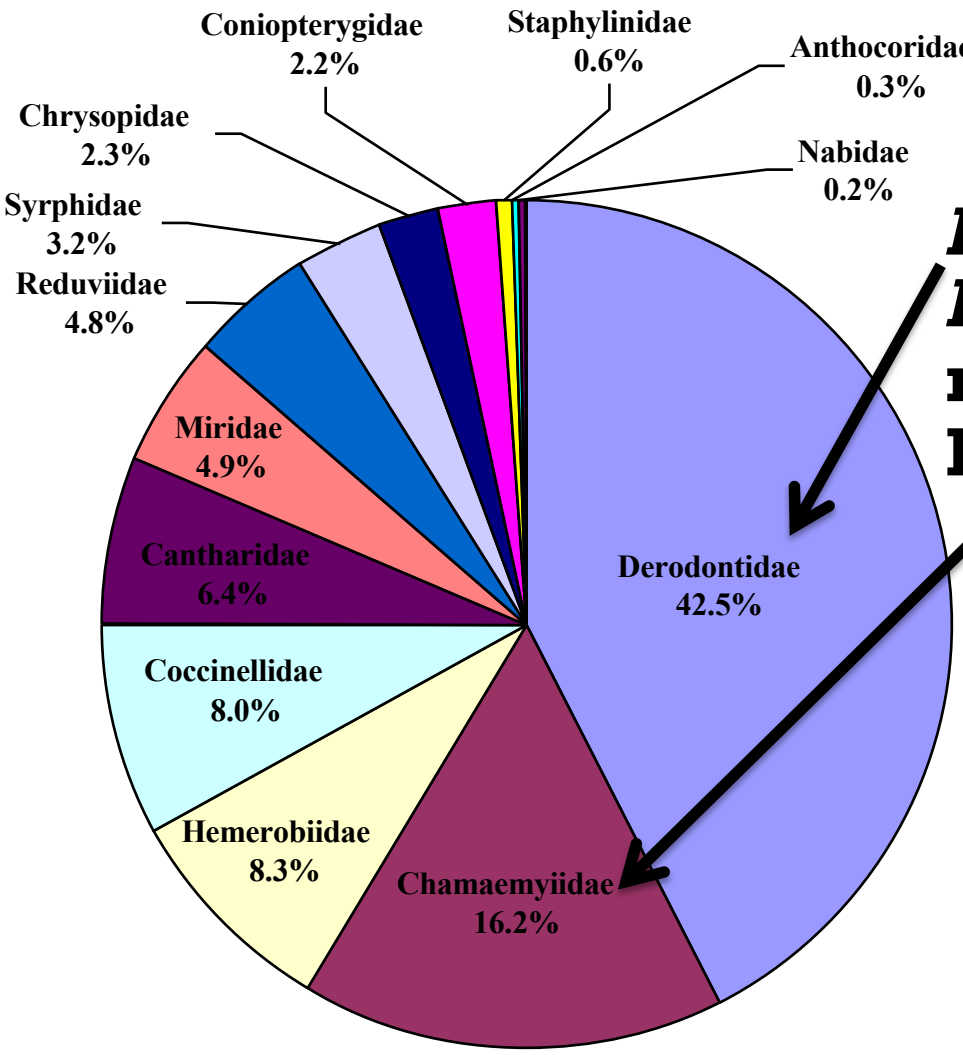
Who is eating HWA?

- ***Laricobius*** **beetles feed mainly on the eggs of the spring HWA generation**

- **This allows HWA to recover in the summer generation (Jubb et al. 2020. *Biological Control*, *143:*104180)**



Who is eating HWA?



***Laricobius nigrinus* and *Leucopis* silver flies are the most abundant predators on HWA in the Pacific Northwest**

Leucopis sp.

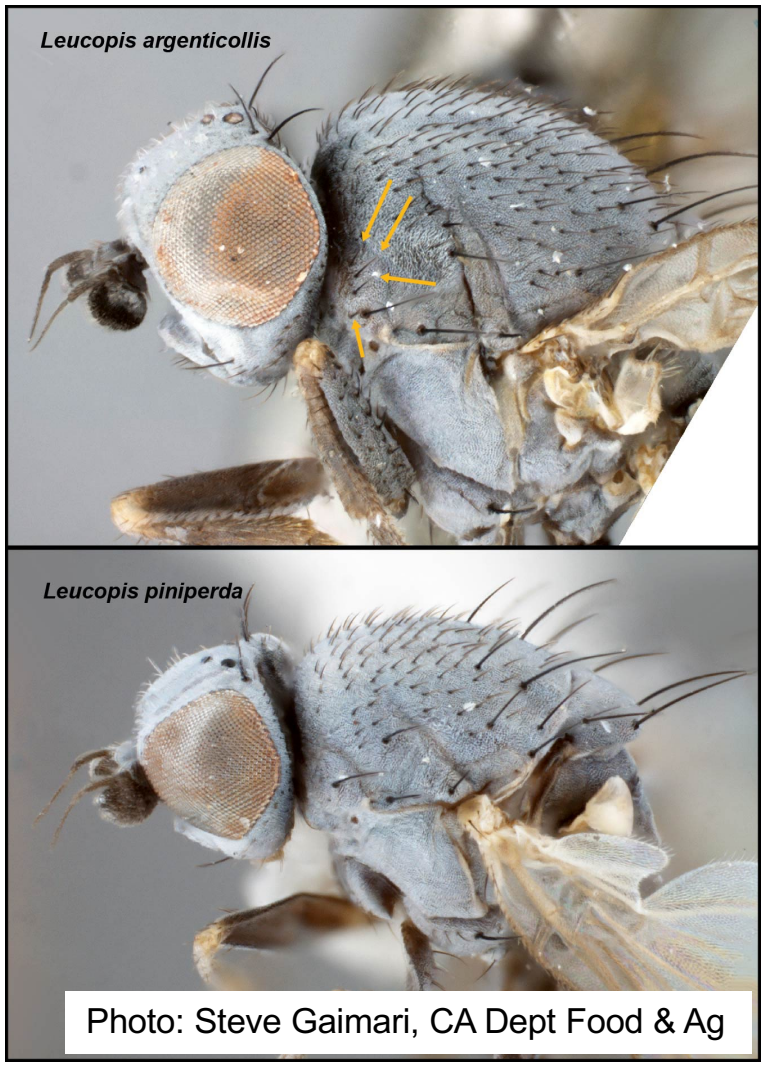
Laricobius nigrinus

From: Kohler, Stiefel, Wallin, Ross (2008) *Environmental Entomology* ***37, 494-504.***

Who is eating HWA?

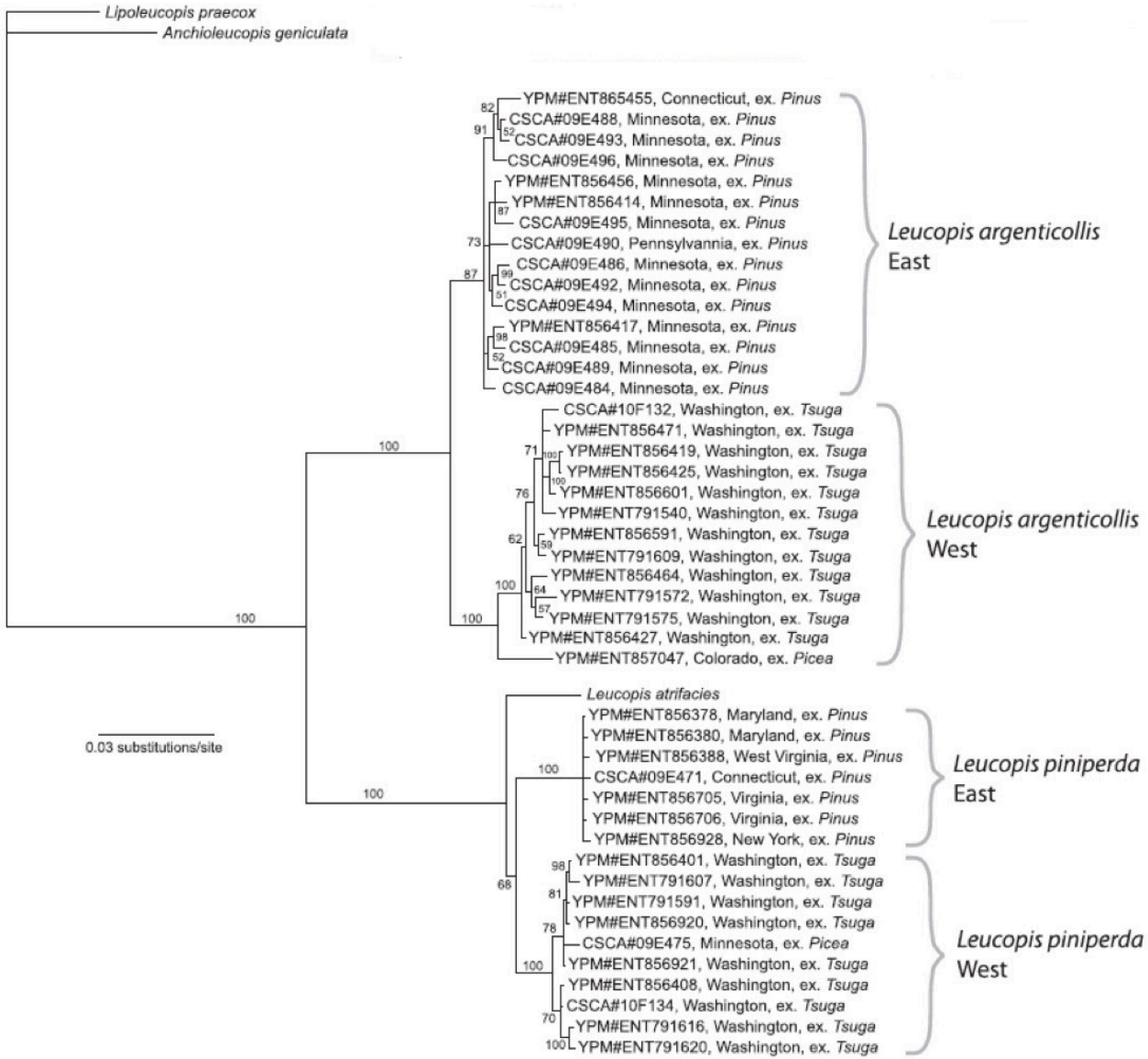
What about the flies??

Silver flies



- **Two species: *Leucopis argenticollis* and *L. piniperda***
- **Both are present in the West and East**
- **Abundant on western HWA where it feeds on both HWA generations**
- **Eastern flies not found on Japanese HWA in the East**

Silver flies



- **Within each species, two genetic lineages that specialize on different adelgid prey**

Havill NP, Gaimari SD, Caccone A. 2018. Cryptic east-west divergence and molecular diagnostics for two species of silver flies (Diptera: Chamaemyiidae: *Leucopis*) from North American being evaluated for biological control of hemlock woolly adelgid. Biological Control 121: 23-29.

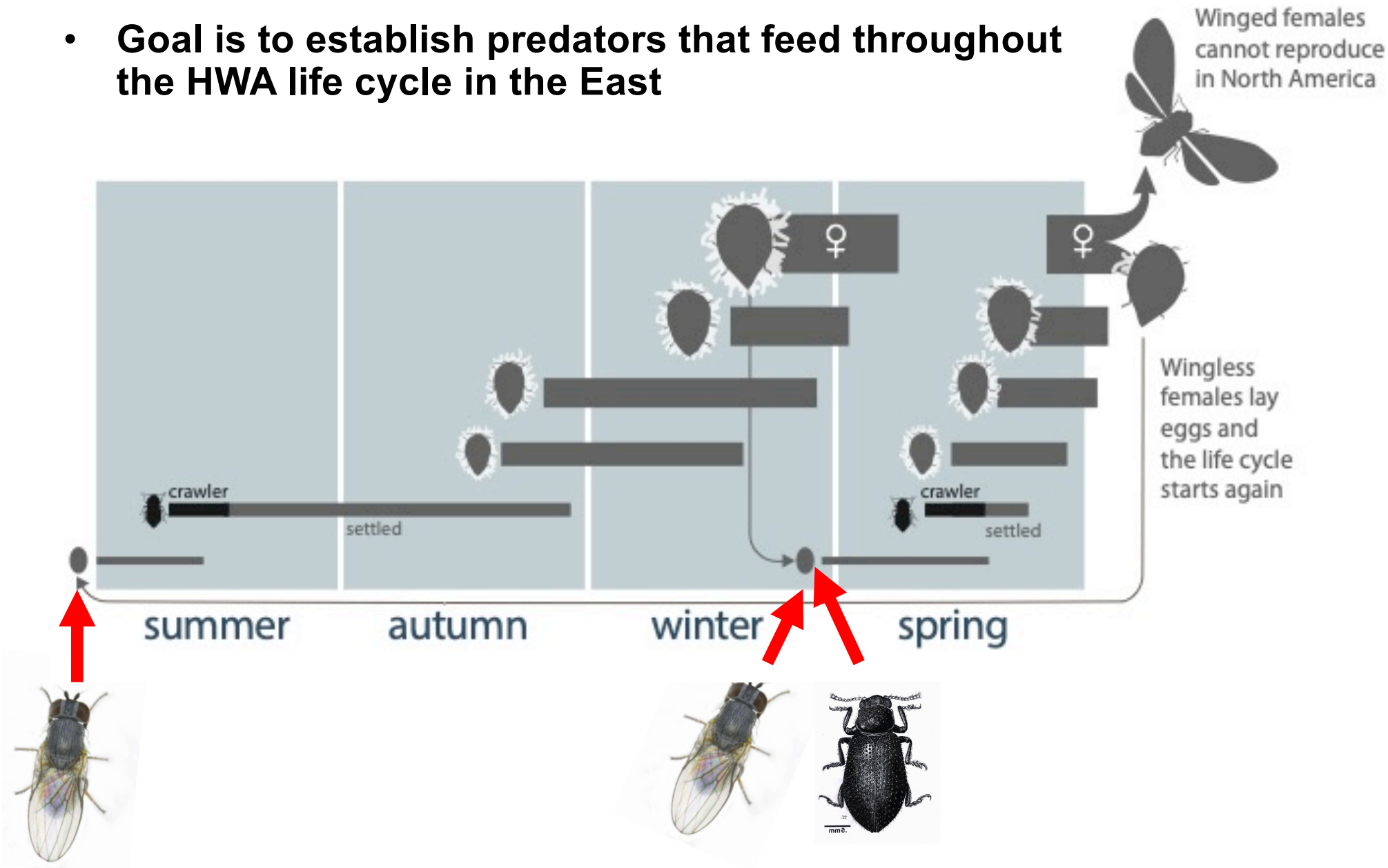
Silver flies

- **16,830 released since 2017 in NY by New York State Hemlock Initiative**
- **~1,600 released in TN, NC, and SC since 2015 by USDA Forest Service, Southern Research Station**
- **Establishment not yet observed**

Photos: Bud Mayfield, USDA Forest Service

Who is eating HWA?

- **Goal is to establish predators that feed throughout the HWA life cycle in the East**



Hemlock Woolly Adelgid Resources

Forest Service "Balance and Barrier" Podcasts about Invasive Species
https://www.nrs.fs.fed.us/podcast/1/

Northern Research Station HWA pages
https://www.nrs.fs.fed.us/disturbance/invasive_species/hwa/

Virginia Tech HWA Information
http://hiro.ento.vt.edu/hwa/

New York State Hemlock Initiative
https://blogs.cornell.edu/nyshemlockinitiative/

"Integrating chemical and biological control of the hemlock woolly adelgid: a resource manager's guide"
https://www.srs.fs.usda.gov/pubs/59529

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