



Forest Service  
U.S. DEPARTMENT OF AGRICULTURE

# Seed Orchard Pests



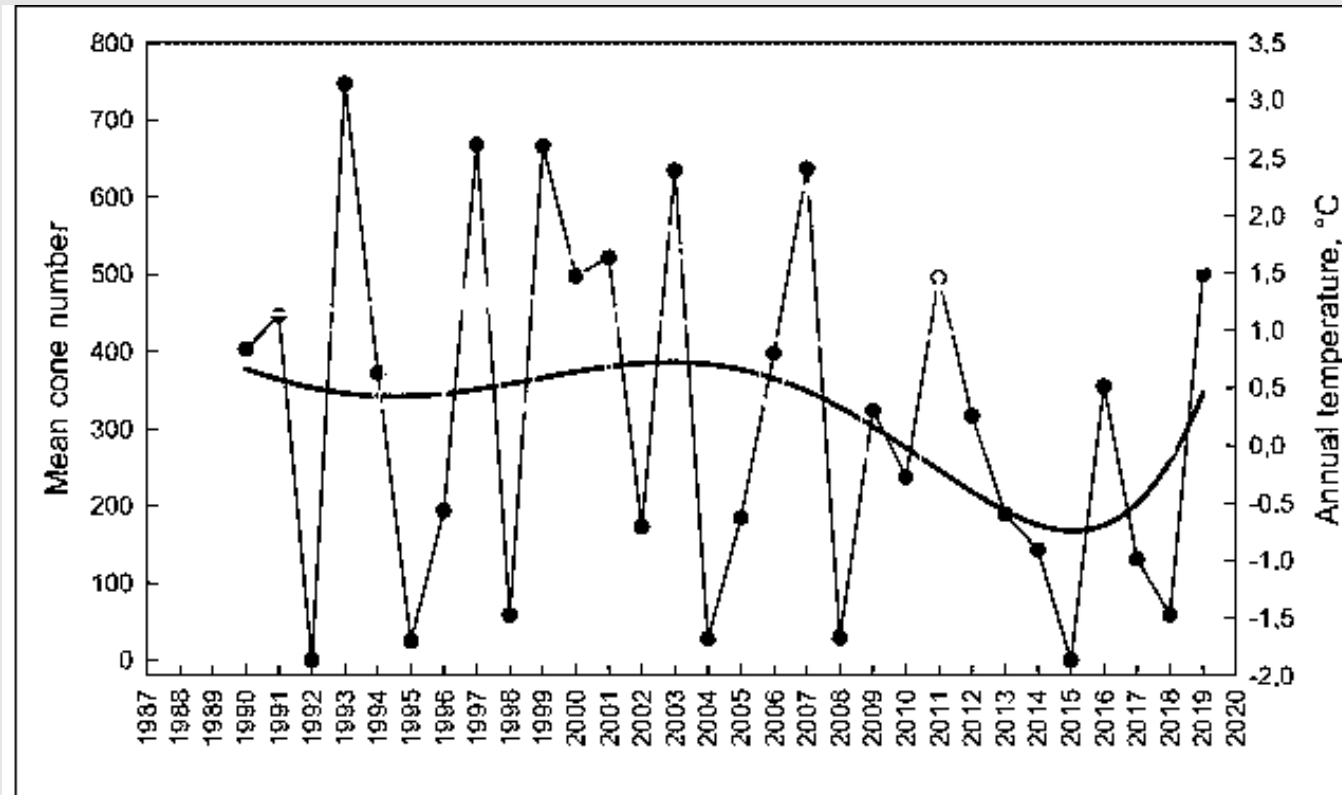
**Paul Rhoades & Colin Bonser**

# Plant seeds are highly nutritious and valuable

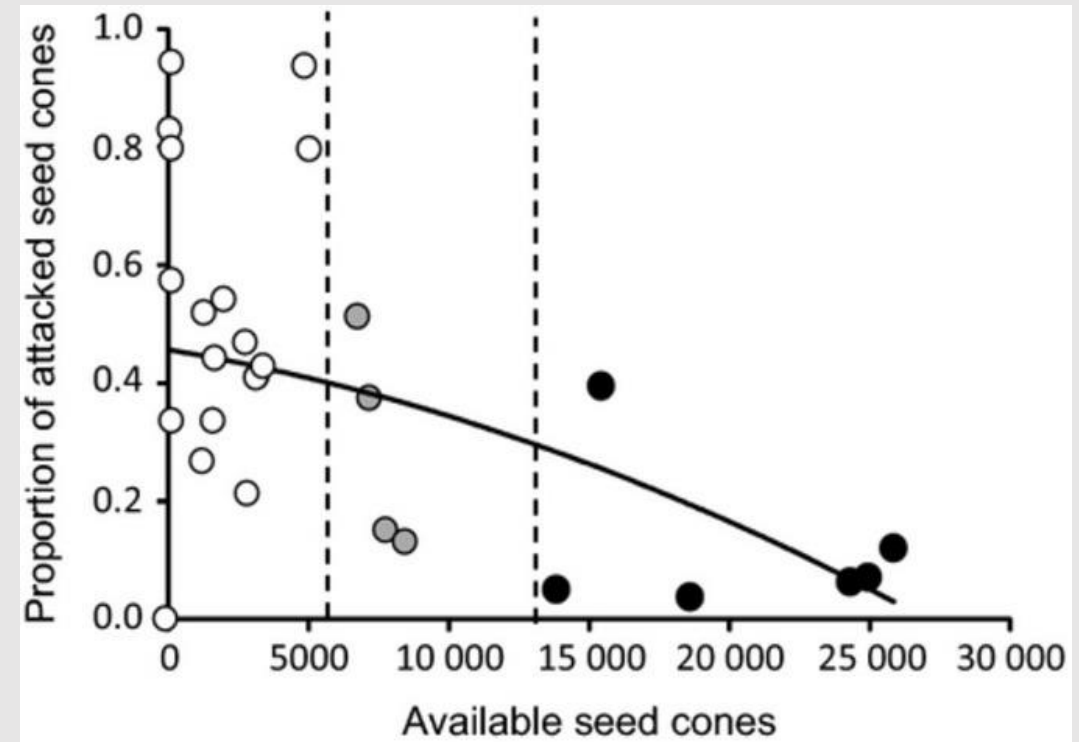
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- About 1.4 billion forest seedlings were grown last year. Most of these originated as seed.
- Seeds are among the most economically valuable plant parts
- Plant reproductive structures are highly nutritious
  - Whitebark pine seeds contain 52% fat, 21 % carbohydrates, and 21% protein
  - Grey pine seeds contain 49% fat, 18% carbohydrates, and 25% protein
  - Lodgepole pine needles ~5% protein
- Cones are hard and resinous, but insects have adapted to evade plant defenses

# Masting and seed predation

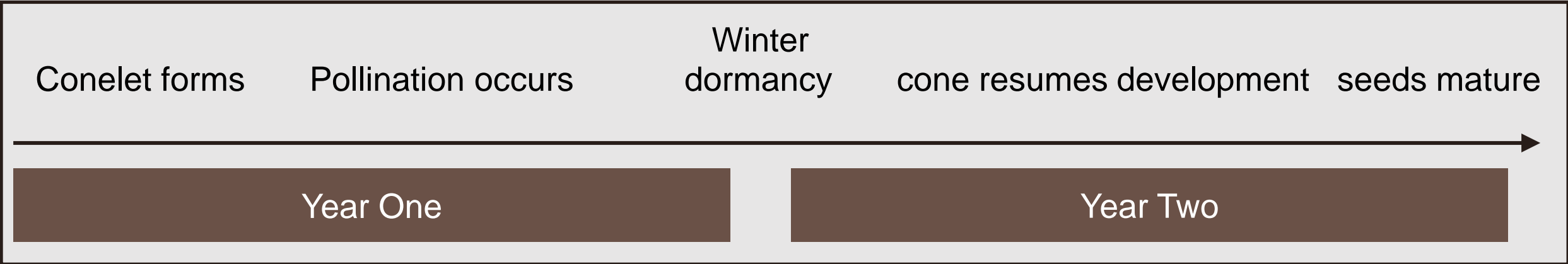


Goroshkevich et al. 2021



Linhart et al. 2014

# Cone development often takes 2 years



First year conelet

Maturing second year cone

Photo: J. M. Guldin

# Key Pests

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- **Southern Pines**

- *Leptoglossus corculus*—leaffooted pine seed bug
- *Dioryctria amatella*—southern pine coneworm
- *Cecidomyia bisetosa* – Southern cone gall midge

- **Western/Northern Pines**

- *Leptoglossus occidentalis*—western conifer seed bug
- *Conophthorus* spp.—pine cone beetles
- *Dioryctria* spp.—pine cornworms

- **Douglas-fir**

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- *Megastigmus* spp.—seed chalcids

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Photo: S. Smith, Smithsonian Institution

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Photo: Gaëlle Rouault

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Photo: Didier Descouens

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Photo: W. Strong, Forest Genetics Council of British Columbia

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UGA0907001

Ronald S. Kelly, Vermont Department of Forests, Bugwood.org

# ***Conophthorus spp.*** – Cone beetles

- About 12 species in North America.
- In subfamily Scolytinae along with well known pine beetles and *Ips*



Photo: Canadian Forest Service



Photo: S. Smith, Smithsonian Institution

# ***Conophthorus spp.*** – Cone beetles

- About 12 species in North America.
- In subfamily Scolytinae along with well known bark beetles and *Ips*
- Attacks pines including eastern and western white pine, ponderosa, and many others
- Significant pest in western and northern North America as well as parts of Mexico
- Two most important species in North America:
  - *C. ponderosae* – Ponderosa pine cone beetle
  - *C. coniperda* – White pine cone beetle



Photo: S. Smith, Smithsonian Institution

# *Conophthorus spp.* – Cone beetles

- Adult females tunnel into base of second year cones in late spring or early summer
- The entry point may be marked by a small pitch tube.



Pitch tube on cone of  
Western white pine

Photo: Ward Strong, BC Ministry of Forests

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Pitch tube on cone of ponderosa pine

Photo: Forest Health Protection, Region 1, Coeur d'Alene

## ***Conophthorus spp.*** – Cone beetles

- Adult females tunnel into base of second year cones in late spring or early summer
- The entry point may be marked by a small pitch tube.
- The female extends a tunnel (gallery) along the central axis of the cone where eggs are laid.



Excavated egg gallery in a western white pine cone

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- The entry point may be marked by a small pitch tube.
- The female extends a tunnel (gallery) along the central axis of the cone where eggs are laid.
- Eggs are less than 1 mm wide
- Larvae consume seeds and other cone tissue throughout the summer



*Conophthorus ponderosae* eggs

# ***Conophthorus spp.*** – Cone beetles

- Affected cones are stunted
- Pupation occurs during summer
- Adults overwinter within the cone
- One generation per year
- Some adults may remain in diapause for multiple years



Photo: Forest Health Protection, Region 1,  
Coeur d'Alene

# *Conophthorus spp.* – Cone beetles – Monitoring and treatment

- Treatment is challenging because beetles spend only a short period of time outside the cone.
  - Treatment must occur early in the year
  - Pyrethroids and carbamates
- Beetles overwinter in pinecones, so dead cones should be collected from the ground or removed during harvest and burnt
  - Burning cones on the ground
- Lures are available for monitoring and treatment timing
  - Other Scolytid beetles can appear similar



Photo: Forest Health Protection, Region 1,  
Coeur d'Alene

# Megastigmus spp. – Seed chalcids



Photo: Alain Roques

- About 30 species in North America
- Attack a variety of conifers, particularly fir, in western and northern North America
- Adults 2-4 mm in length



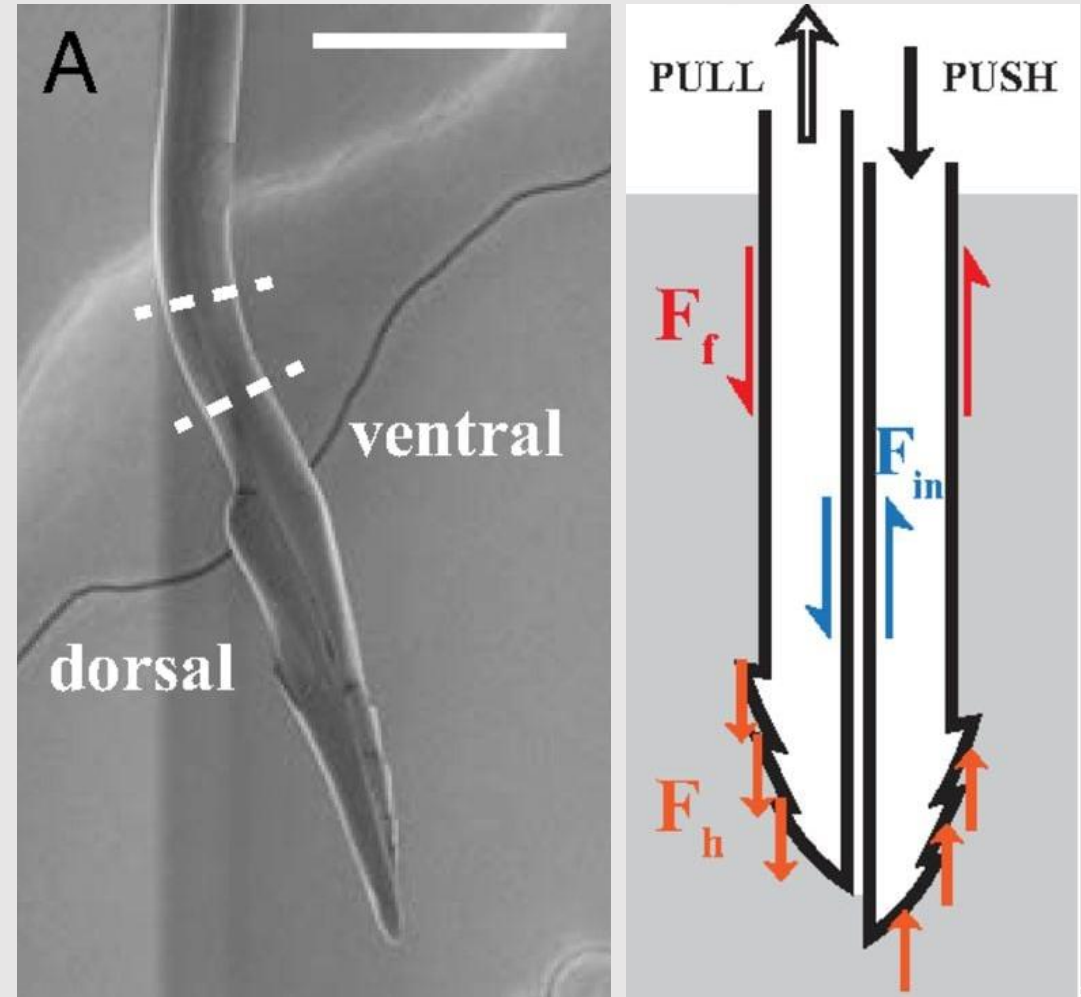
Photo: USFS

# Megastigmus spp. – Seed chalcids



Photo: Alain Roques

- Long flexible ovipositor used to drill into cone



Photos: Cerkvénik et al. 2017

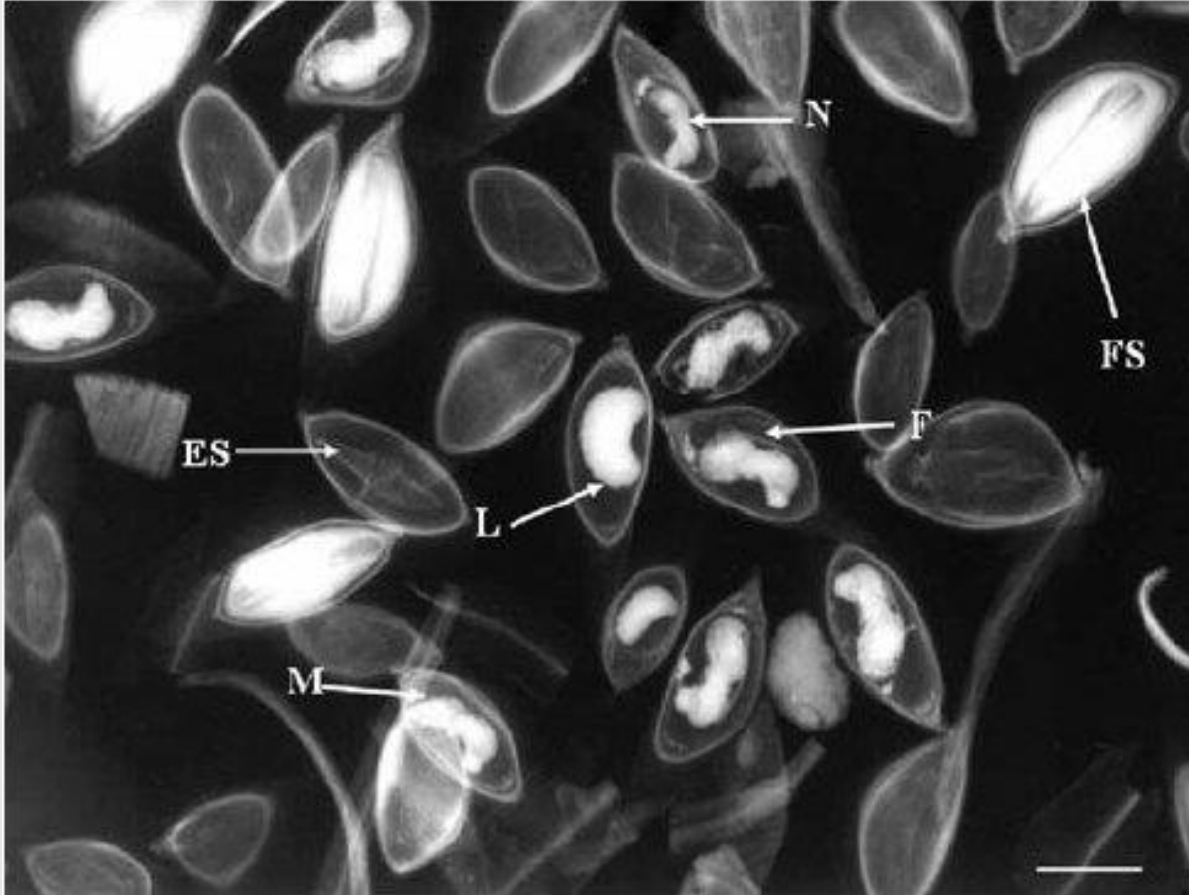
# Megastigmus spp. – Seed chalcids



Photo: Gaëlle Rouault

- Each larvae feeds within a single seed of its host plant
- No external evidence of seed damage

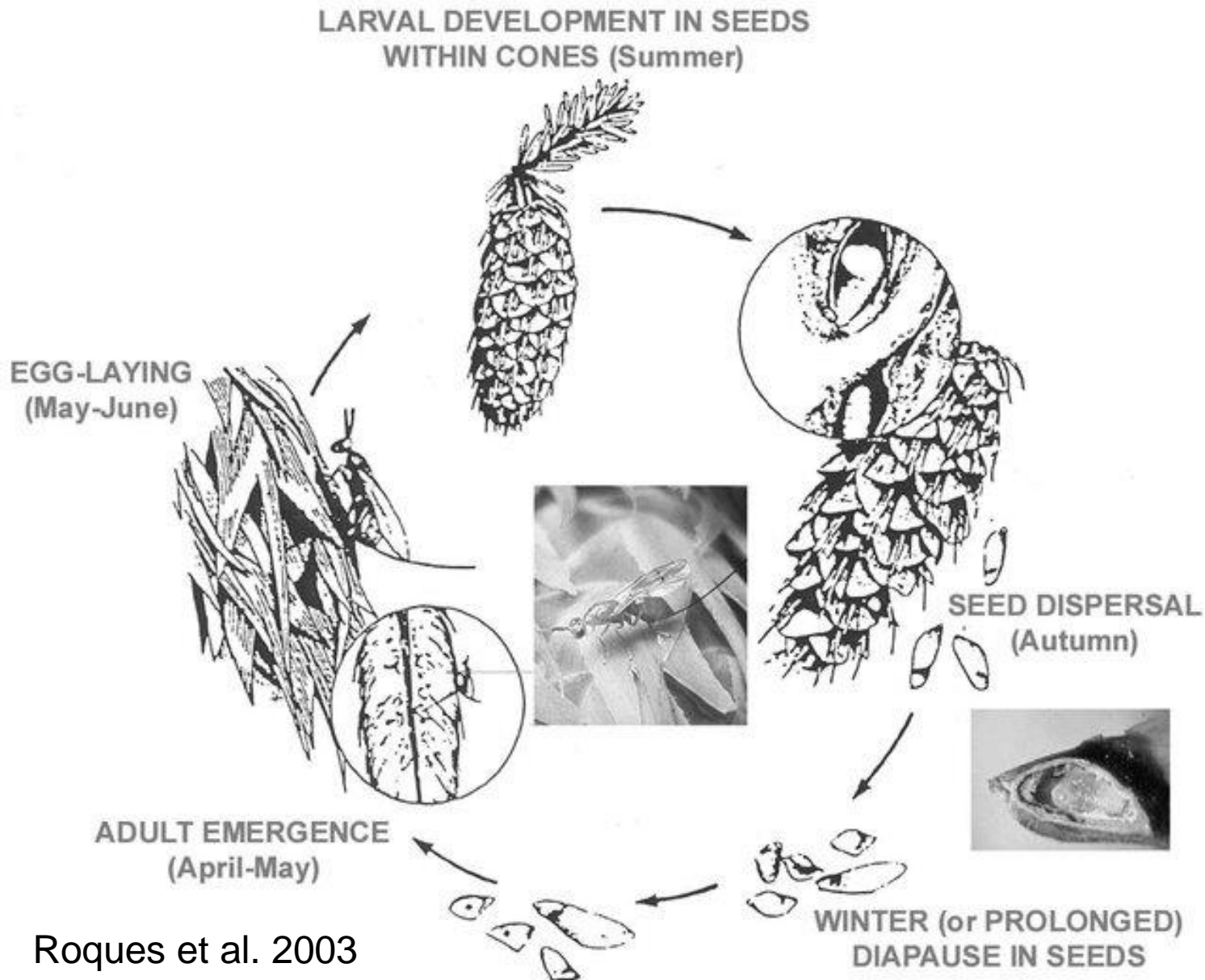
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- Each larvae feeds within a single seed of its host plant
- No external evidence of seed damage
- X-ray necessary to identify damaged seed
- Reduce purity of viable seed due to challenge of removing damaged seed

Photo: Gaëlle Rouault

# Megastigmus spp. – Seed chalcids – Life Cycle



# *Leptoglossus* spp.—Leafooted bugs

*Leptoglossus corculus* – leafooted pine seed bug (LPSB)



Photo: Evan M. Raskin

*Leptoglossus occidentalis* – western conifer seed bug (WCSB)

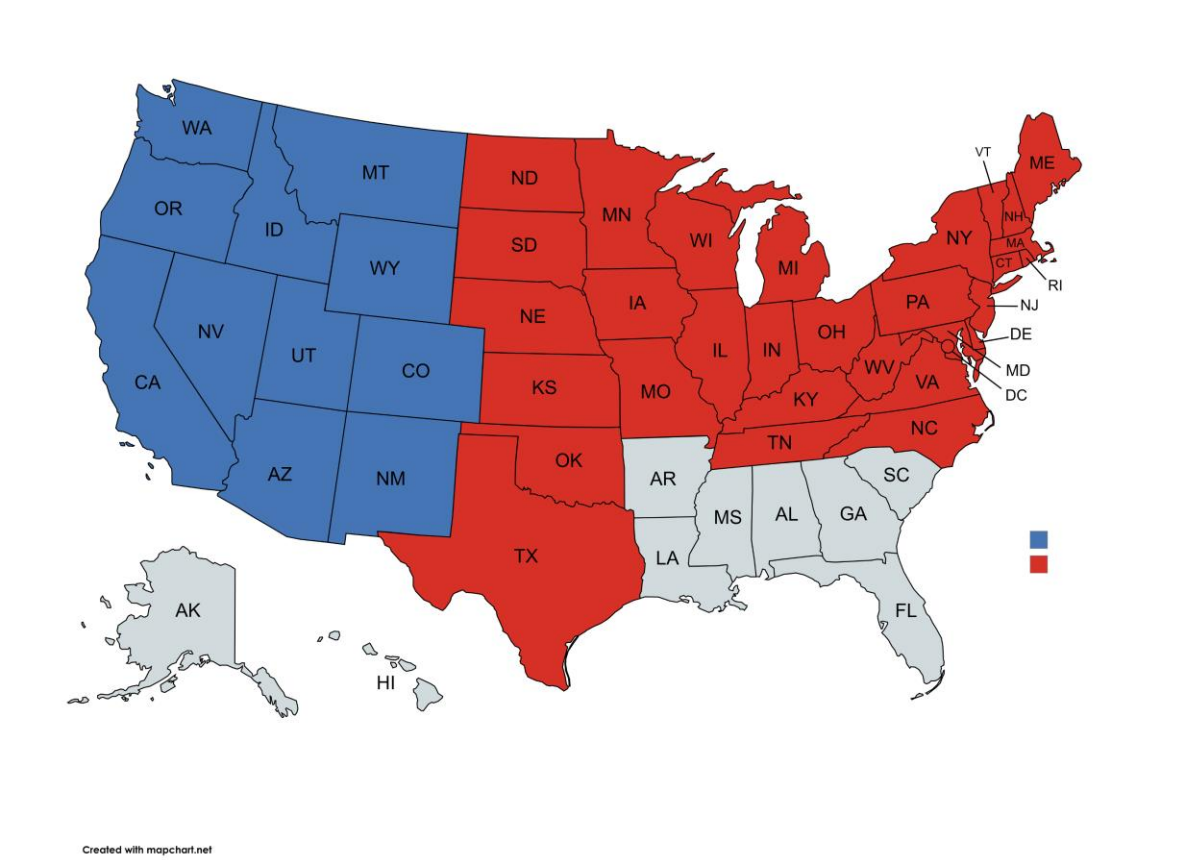
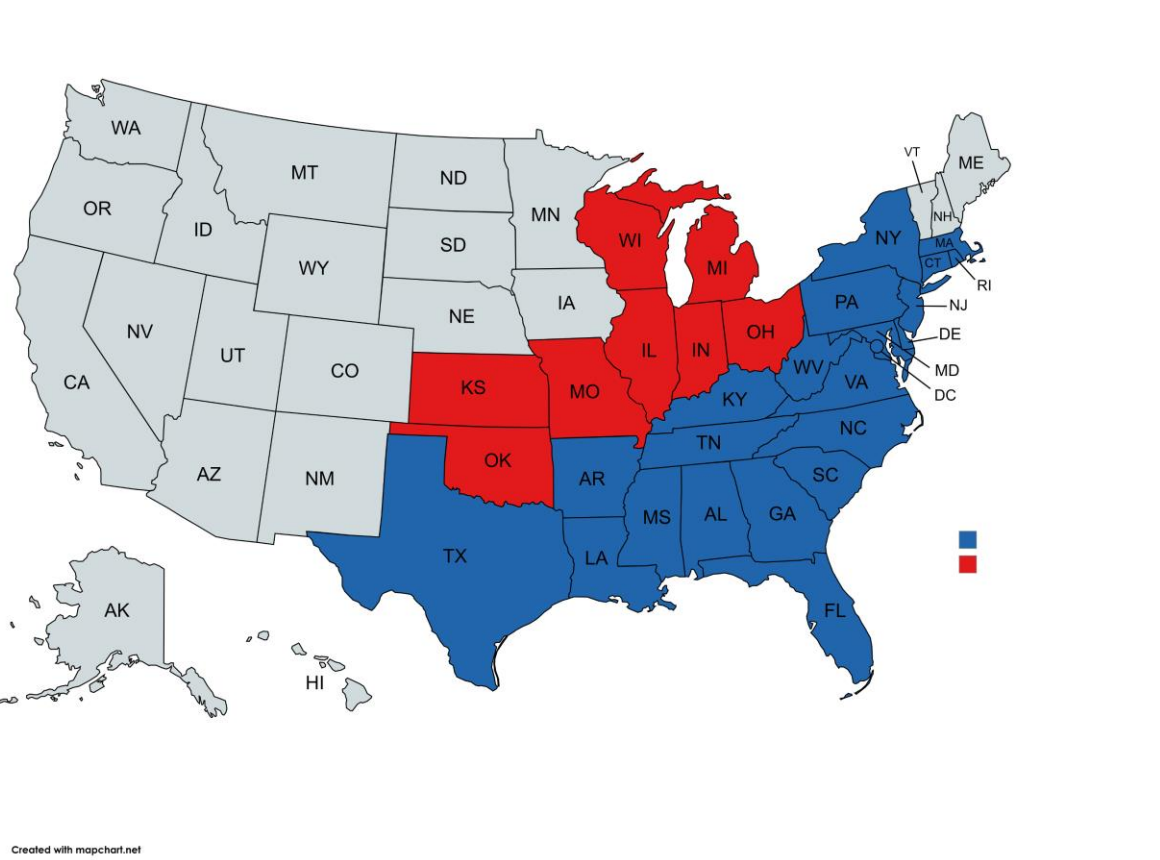


Photo: Didier Descouens

# Leptoglossus spp.—Leafooted bugs

*Leptoglossus corculus* – leafooted pine seed bug (LPSB)

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Historic range

Current range

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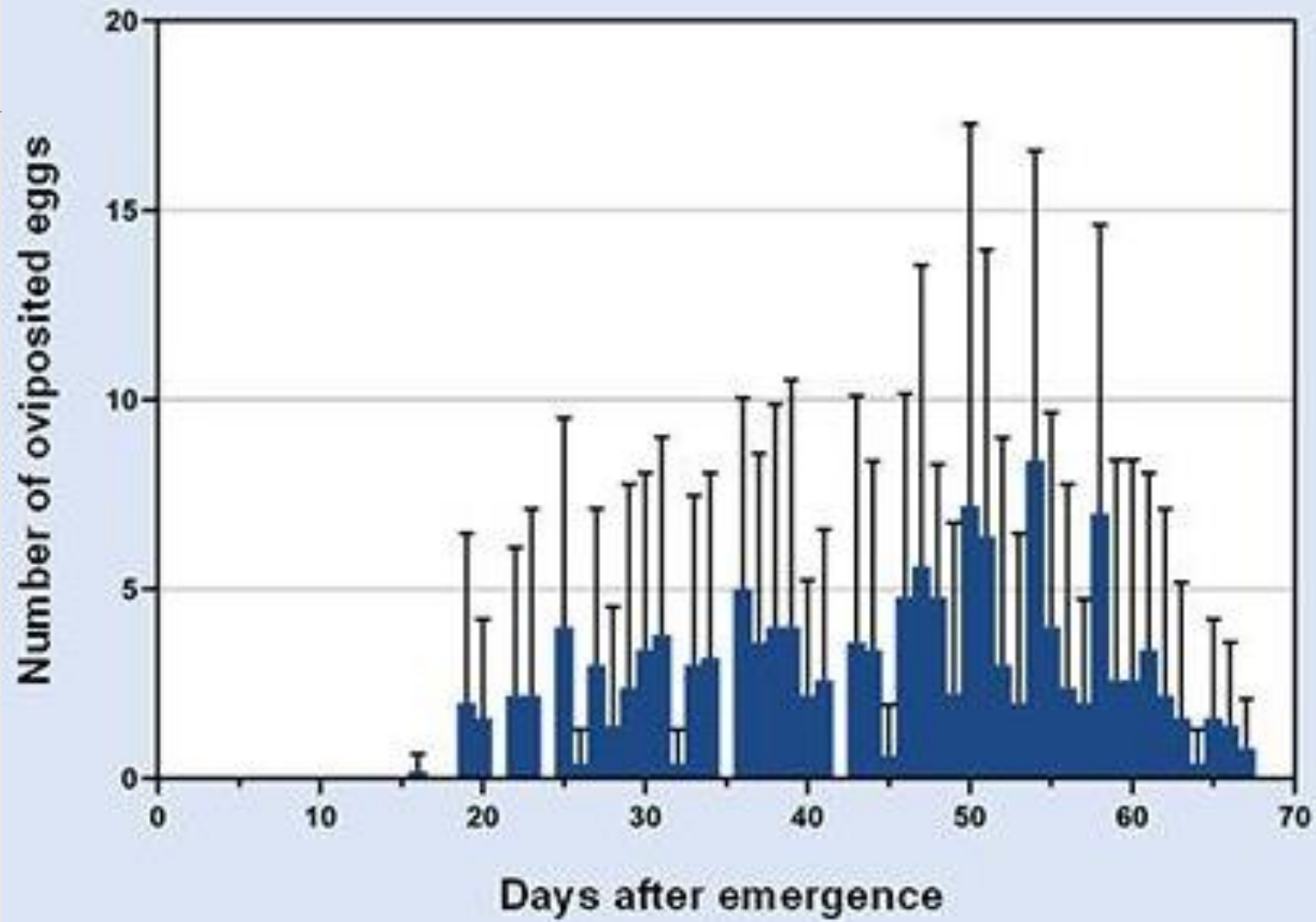
# *Leptoglossus sp.* – life cycle



*Leptoglossus occidentalis* (LEPLOC) - <https://gd.eppo.int>

Photo: Gilles San Martin

- Adults overwinter in sheltered locations
- Overwintered adults emerge about the time of pollen flow
- Egg laying begins



## Female fecundity

Lee et al., 2023

# *Leptoglossus sp.* – life cycle



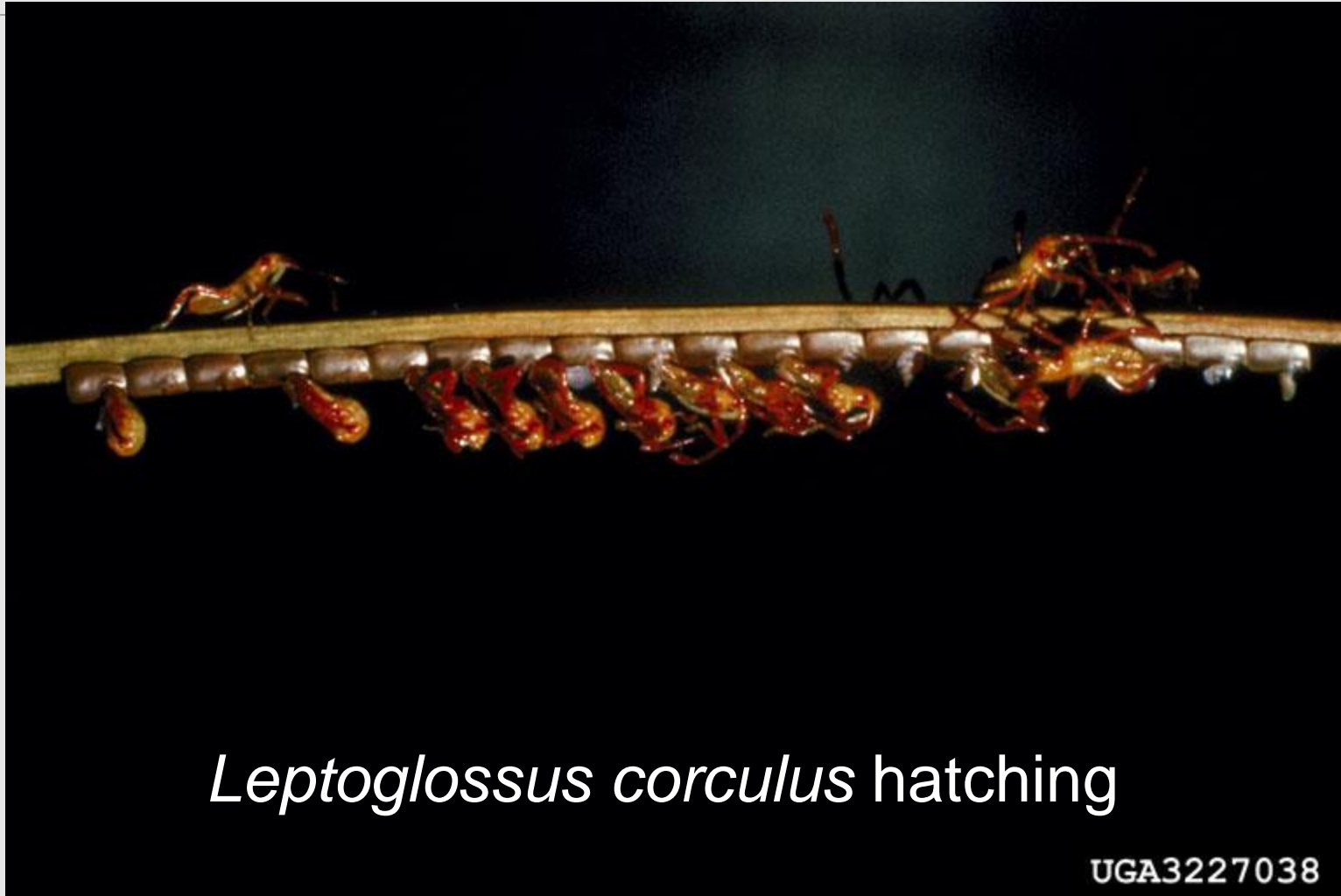
*Leptoglossus occidentalis* (LEPLOC) - <https://gd.eppo.int>

Photo: Iris Bernardinelli

- Adults overwinter in sheltered locations
- Overwintered adults emerge about the time of pollen flow
- Egg laying begins and continues for 2-3 months



*Leptoglossus zonatus* hatching



*Leptoglossus corculus* hatching

UGA3227038

Photo: Ronald F. Billings, Texas A&M Forest Service , Bugwood.org

# Second instar *Leptoglossus occidentalis*



*Leptoglossus occidentalis* (LEPLOC) - <https://gd.eppo.int>

Photo: Gilles San Martin



## ***Leptoglossus corculus*—LPSB**

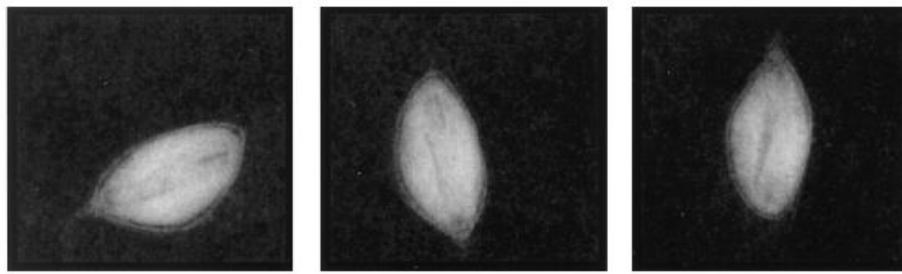
- Hosts: all southern pines with the possible exception of sand pine
- **Damage:**
- Young nymphs attack conelets destroying ovules and causing conelet abortion

## ***Leptoglossus occidentalis*—WCSB**

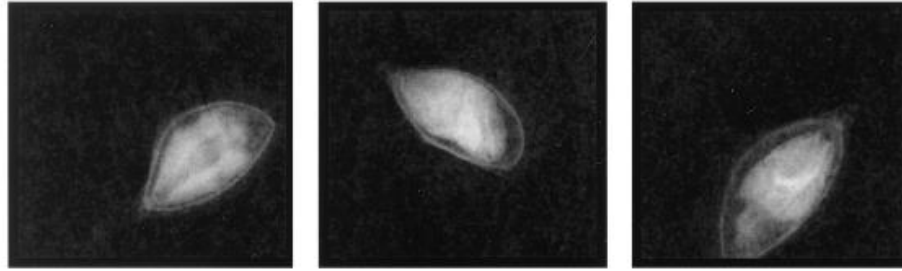
- Hosts: Most pines as well as Douglas fir, true fir, spruce, hemlock, dogwood, sumac
- **Damage:**
- Young nymphs prefer second year cones

- Older nymphs and adults feed on seeds in second year cones
  - If feeding occurs before seed coat formation seed is shriveled and misshapen
  - After seedcoat formation seeds can appear whole but be hollowed out
  - Even lightly damaged seed that appears full can have greatly reduced germination

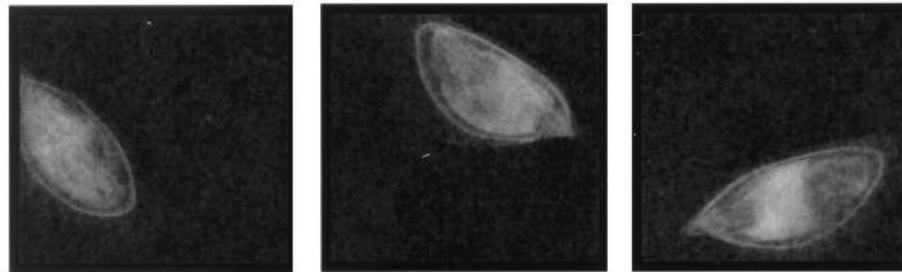
**FULL**



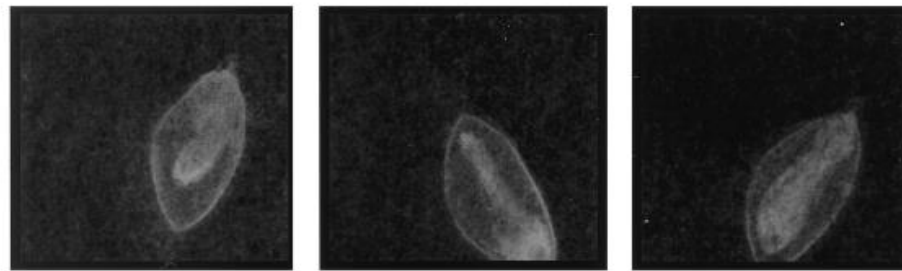
**LIGHT**



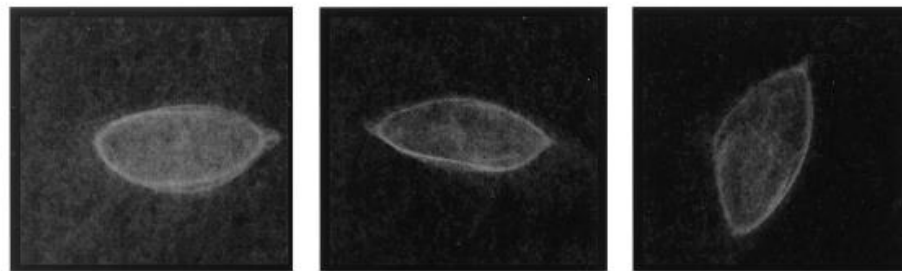
**MODERATE**



**SEVERE**

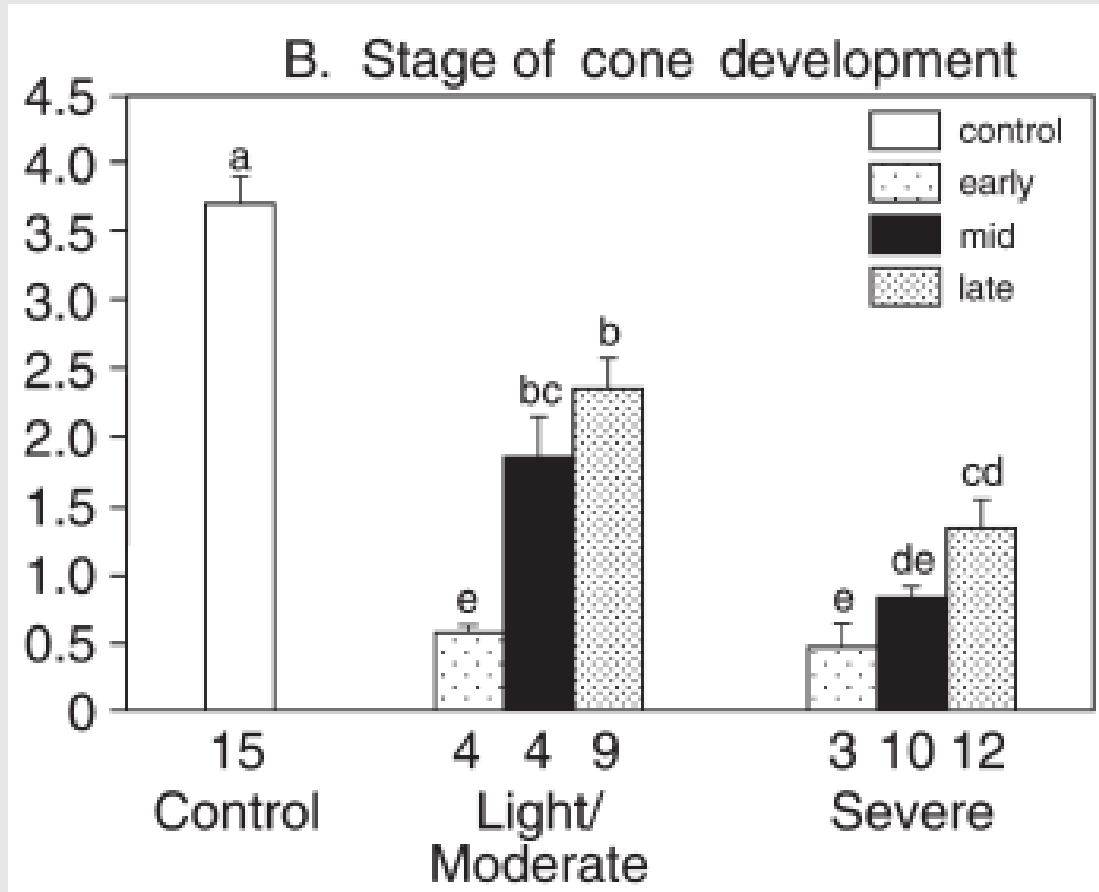


**EMPTY**

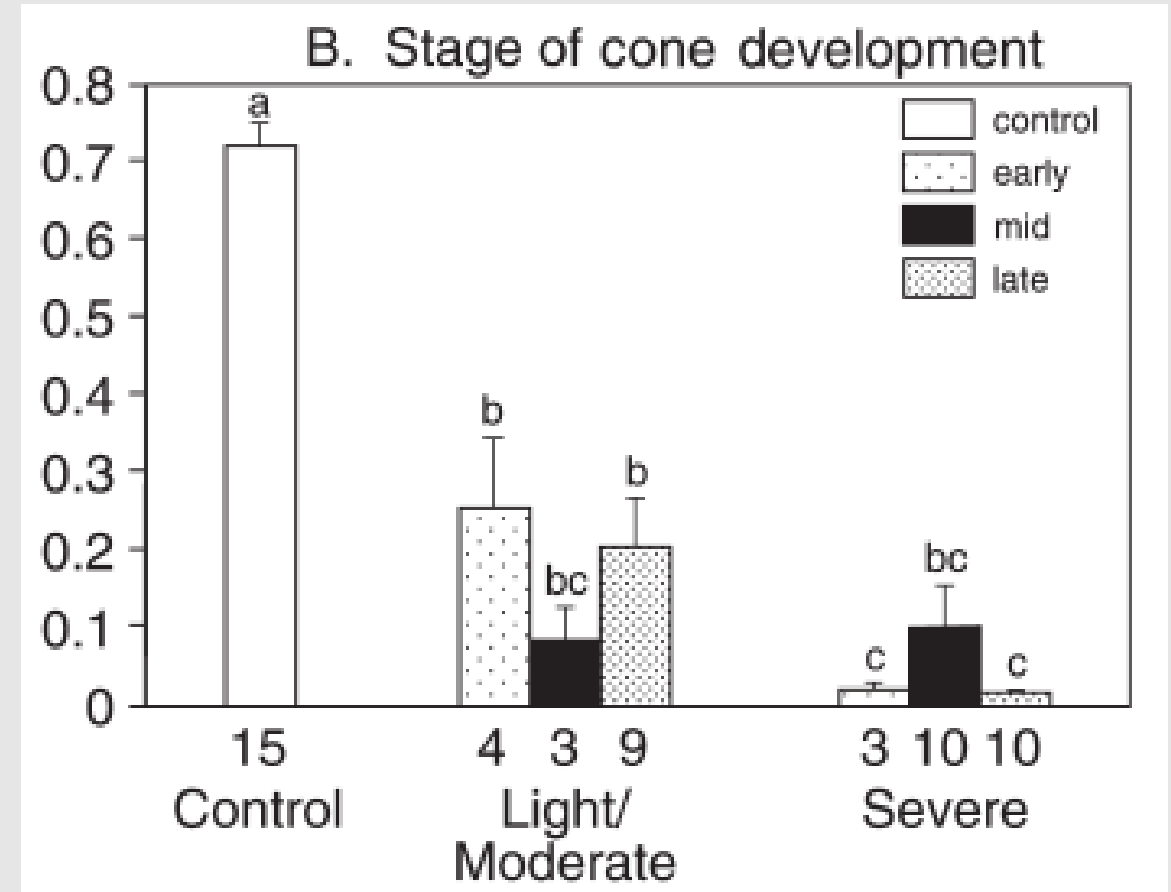


# Effect of *L. occidentalis* feeding damage on Douglas fir seed composition

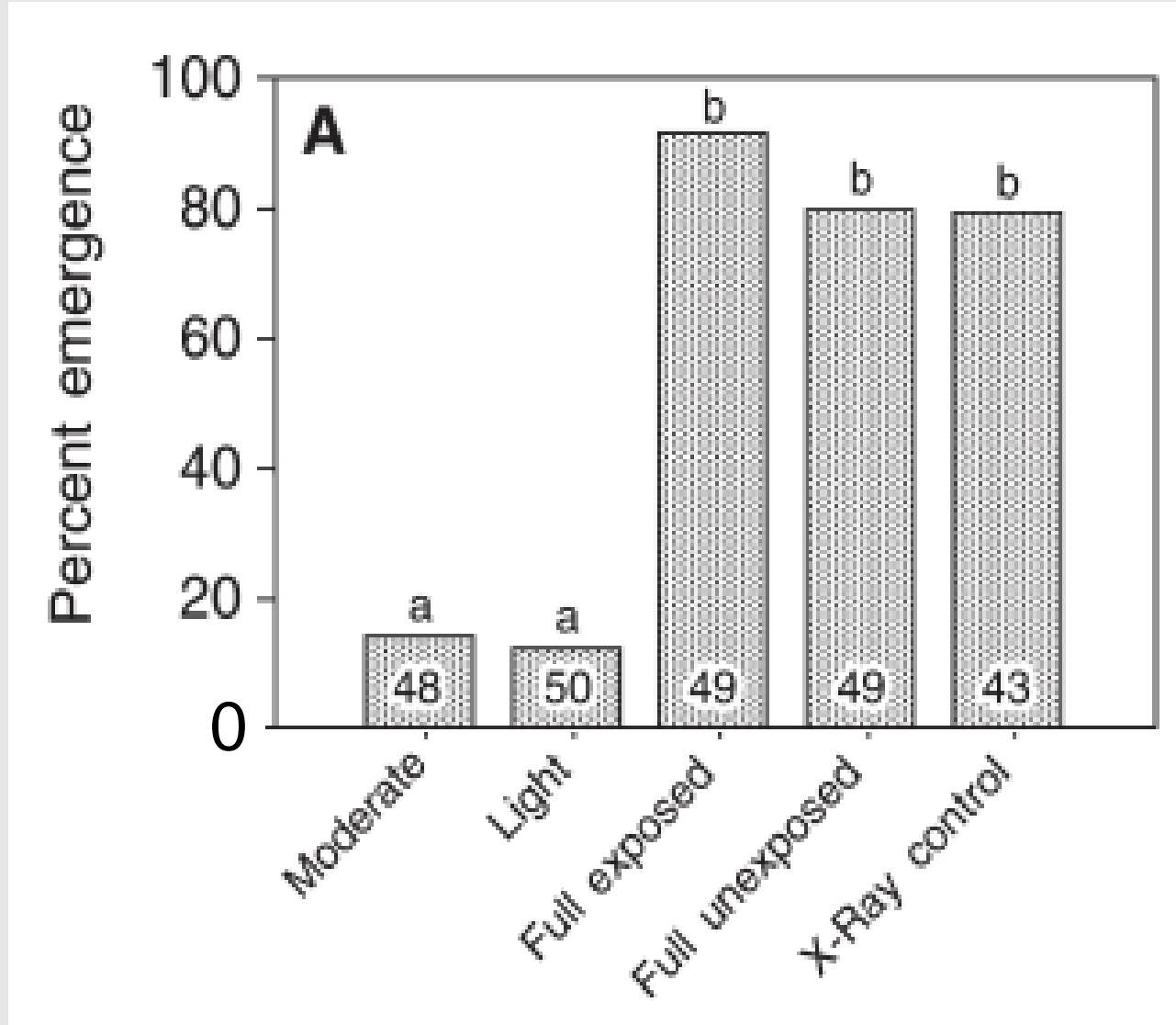
Lipid remaining in seed at harvest



Crystalline protein remaining in seed at harvest



# Effect of *L. occidentalis* feeding damage on Douglas fir seed germination



# *Leptoglossus occidentalis*—Invasive Species in Europe

- Arrived in Italy in 1999 and spread throughout Southern and Central Europe
- Damages pine seeds, trees that are important for Mediterranean forest habitats
- Stone pine (*Pinus pinea*) seeds are grown for edible seeds—pine nuts
- Decrease in cone production and cone yield, with WCSB suggested as the cause
- Spain: 7000 MT (2012) to 500 MT (2020)
- Kernel per cone yield dropped by half



# Seed Bug Management

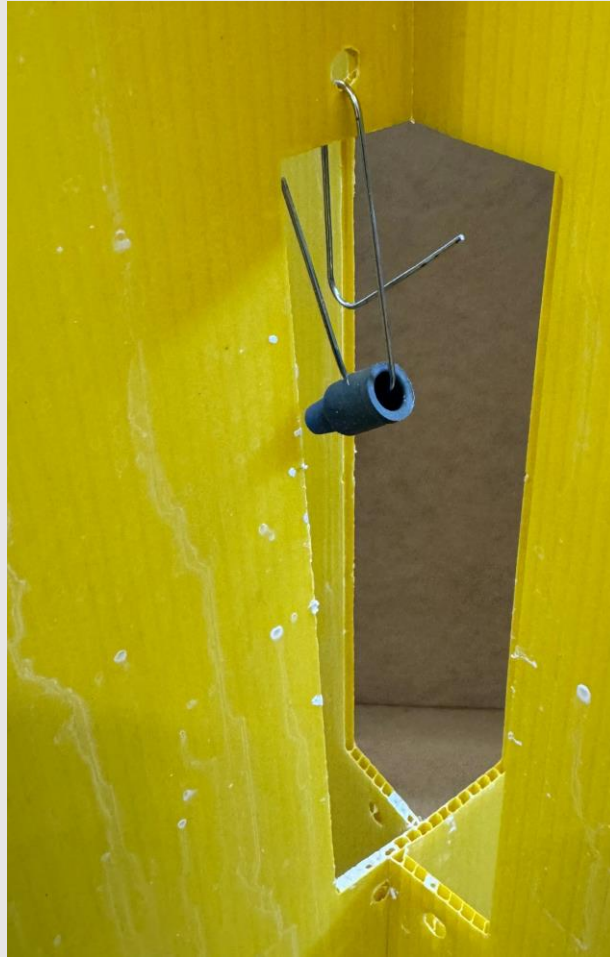
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- Easier to control than boring insects
  - Seed bugs spend most of their time **on needles and cones**
  - Make **repeated contact with treated surfaces**
  - Good control of seed bugs with reduced rates
- First- and second-instar stages are most vulnerable
- Small, not as mobile as adults
  - Meaning, the lethal dose is small and will be exposed for longer periods
- **Pyrethroids** commonly used
- Frequently in conjunction with **emamectin benzoate** injections to control coneworms
  
- Will cover more on seed bug control when discussing coneworms

# Seed Bug Management

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- Newly developed lure



## *Dioryctria* spp.—Coneworms



Photo: W. Strong, Forest Genetics Council of British Columbia

# *Dioryctria* spp.—Coneworms

- Taxonomy
  - Order: Lepidoptera (butterflies and moths)
  - Family: Pyralidae (snout moths)
  - 40 species in North America
    - 17 feed on cones
- Hosts
  - Most Pinaceae in North America, especially Douglas-fir (*Pseudotsuga menziesii*), pines (*Pinus* spp.), spruces (*Picea* spp.), and true firs (*Abies* spp.).
  - Virtually all conifers but thujas



Photo: W. Strong, Forest Genetics Council of British Columbia

# *Dioryctria spp.*—Coneworms

- Distribution
  - Widespread throughout North America
- Damage
  - Larvae tunnel through cones feeding on seeds and other cone tissues.
  - Frass and webbing and exit holes may be visible on exterior
  - Caterpillars can also feed on male and female flowers, branches and stems, in and on buds, and conelets (first year cones)



Photo: W. Manastyrski, Forest Genetics Council of British Columbia

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  - Larvae feed indiscriminately on seeds and scales.
  - Damage is very clear in cross section



Photo: D.S. Ruth, Canadian Forestry Service

# *Dioryctria amatella*—Southern Pine Coneworm

- Widespread throughout the U.S. Southeast
- Several overlapping generations annually
- Infests flowers, stems, cones, fusiform galls, and other pitchy wounds
  - Larvae move to cones to complete development
- *Dioryctria amatella* is attracted to volatiles from tree wounds



Photo: Mark Dreiling, Bugwood.org

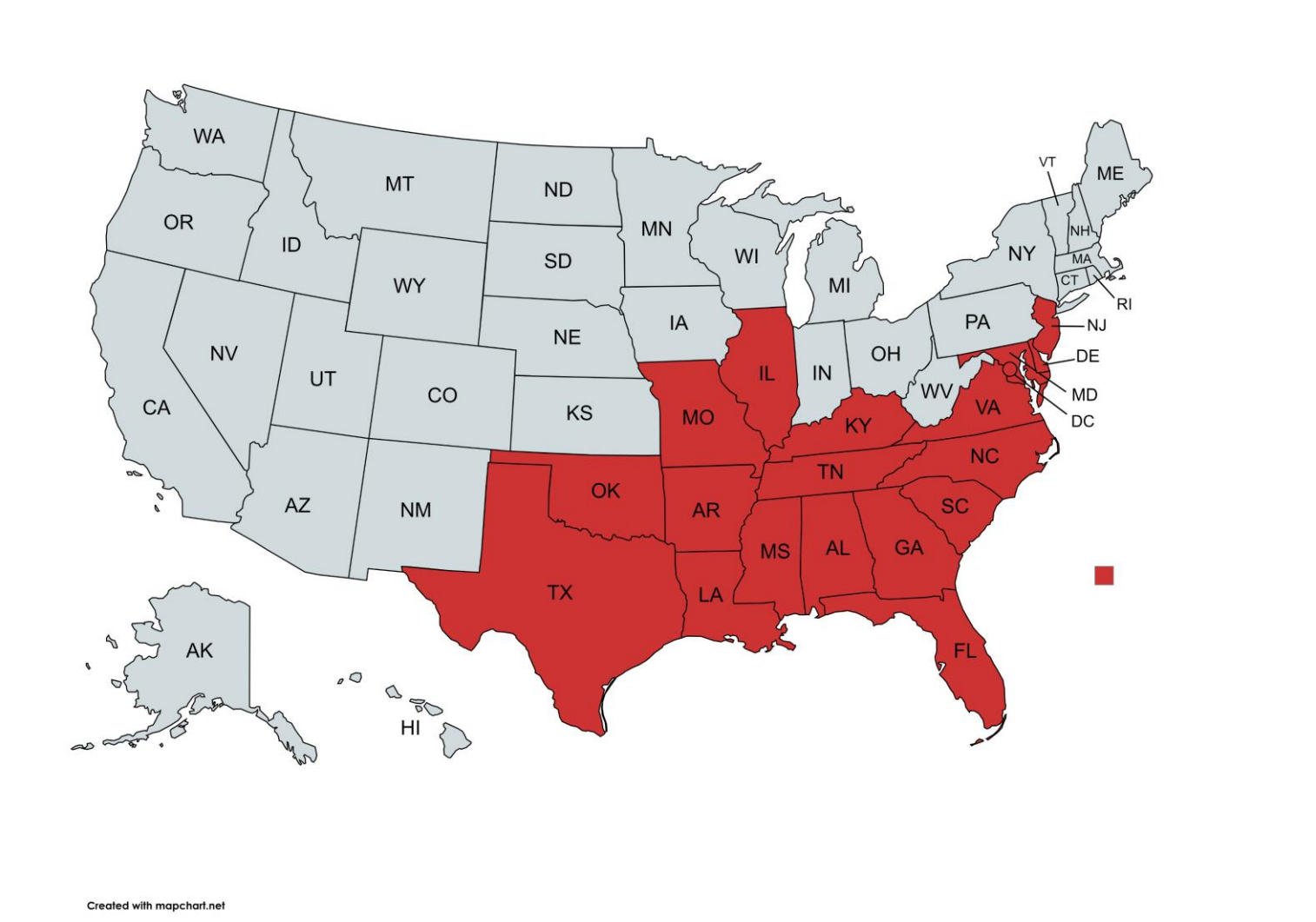
# *Dioryctria amatella*—Southern Pine Coneworm

- Serious pest of southern pine cones
- Hosts include loblolly, longleaf, shortleaf, slash, Virginia pines, and likely other regional pine species
- The most damaging coneworm and may be the most damaging pest to seed orchards in the Southeast
- Distinguished by presence of boring holes and a mixture of both resin and frass (no webbing)
  - Resin usually scant

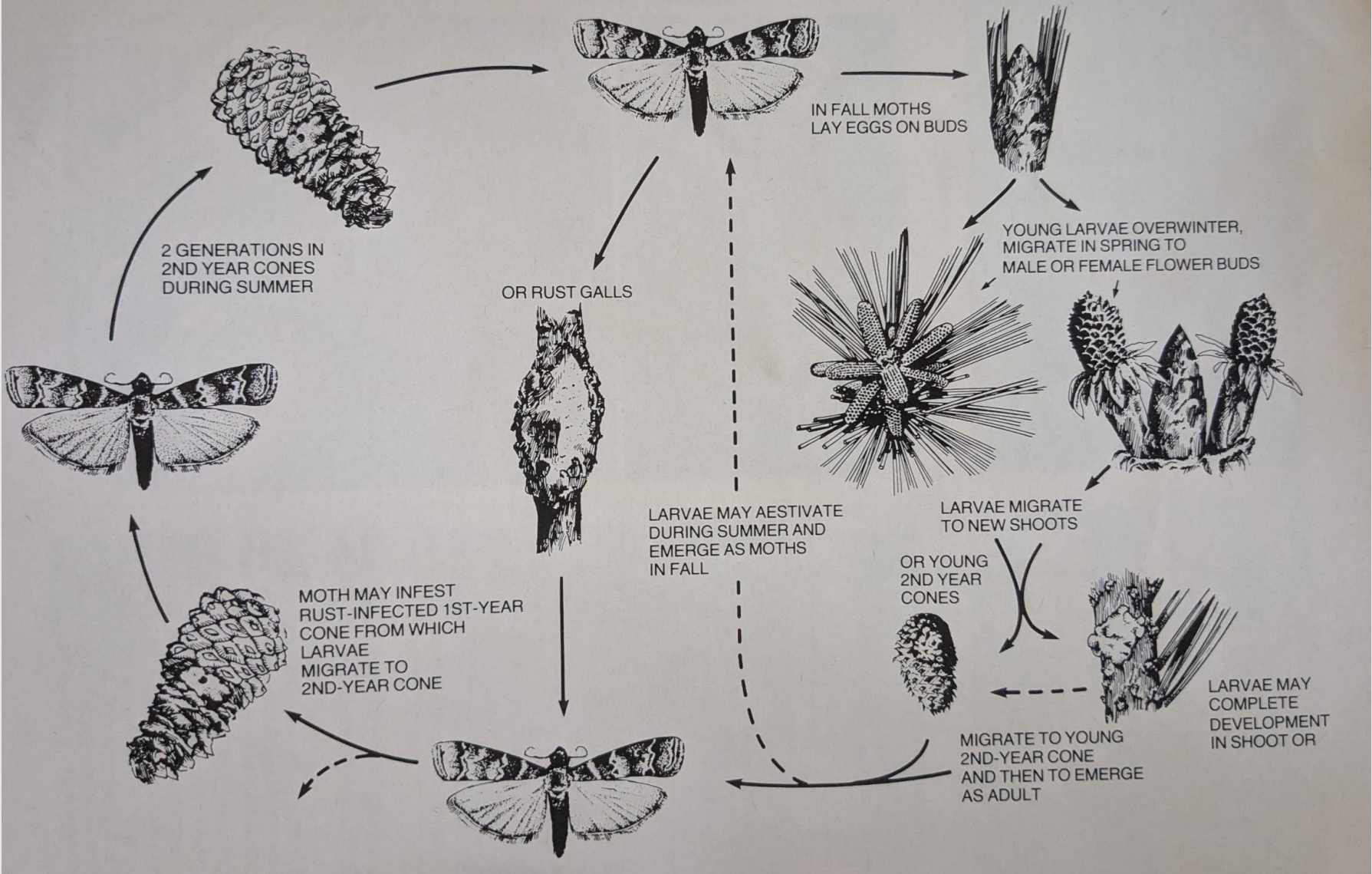


Photo: Harry O. Yates III, USDA Forest Service, Bugwood.org

# *Dioryctria amatella*—Southern Pine Coneworm



# *Dioryctria amatella* – Southern Pine Coneworm – lifecycle



# Coneworm Management

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- Control of coneworms is difficult
  - Coneworm larvae hidden in cone/conelet most of lives
- Larvae are exposed only during
  - **Spring**—before young larvae enter cones
  - **Later in season**—developing larvae move from one cone to another
- Small, early instars are most vulnerable for control
- Insecticide must be present when larvae are exposed—outside the cone
  - Time sprays and residuals to be in contact with larvae
- **Best time to spray:** when small larvae are active in the spring
- **The only time to kill coneworms is between first activity (overwinter) and before the enter cones/conelets**
- **MAKE SURE INSECTICIDE IS ON TREES WHEN LARVAE ARE EXPOSED**

# Coneworm & Seed Bug Management

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- **Applications for coneworms will also impact seed bugs**
- Early season sprays for coneworm larvae—kill overwintering adult bugs are new first instars
- Tebufenozide (Mimic™ 2LV)—controls coneworms only—use low-rate or pyrethroid in the mix
- Impacts seedworms (*Cydia*; Lepidoptera: Tortricidae) as well

# *Gnaphothrips fuscus*—Slash Pine Flower Thrips

- Major pest of slash pine orchards
- Assumed to be widespread throughout the East
- Can sometimes damage other pines
  - Loblolly, jack, sand, and Austrian pines
- Three overlapping generations yearly in north Florida
- Very small and inconspicuous on the plant



Photo: István Mikó NCSU

# *Gnophothrips fuscus*—Slash Pine Flower Thrips

- Attacks first-year conelets before or just after pollination
  - After pollination occurs, flowers become less succulent and resist additional feeding
  - Small beads of resin may mark feeding site



Photo: Bernard Ebel, USFS

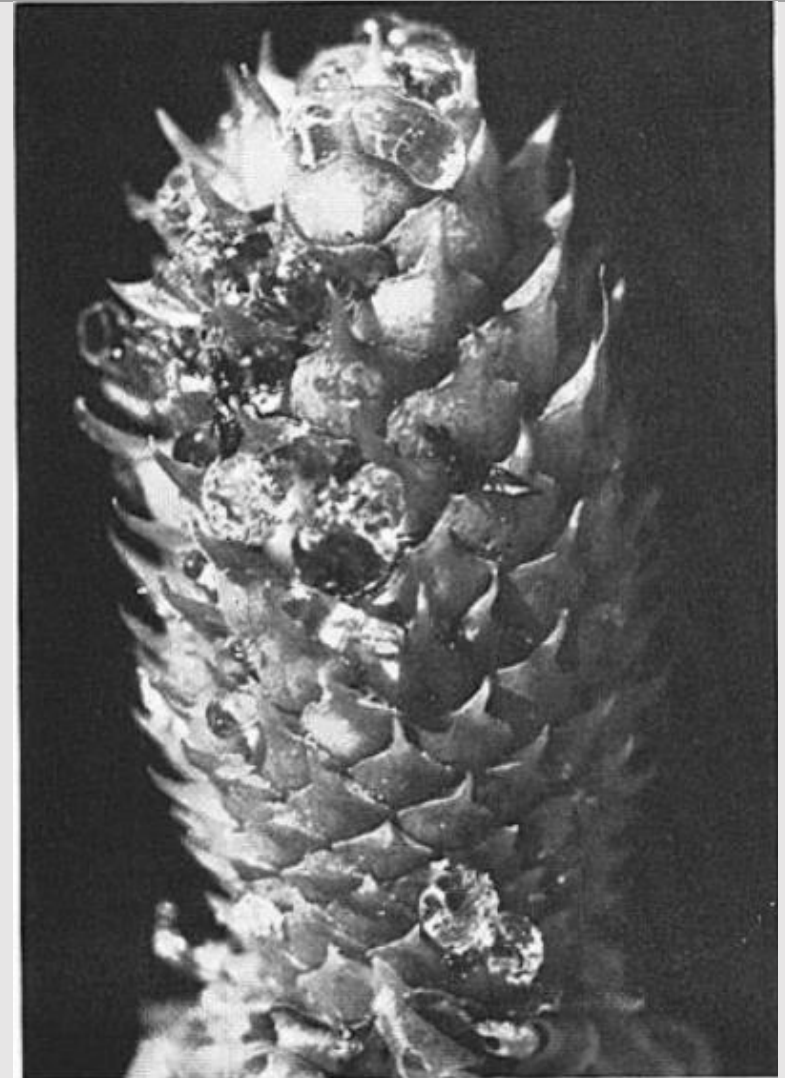


Photo: Gary DeBarr

# *Gnaphothrips fuscus*—Slash Pine Flower Thrips

- Attacks first-year conelets before or just after pollination
  - After pollination occurs, flowers become less succulent and resist additional feeding
  - Small beads of resin may mark feeding site
- Attacked conelets may abort
- Less heavily damaged conelets display distorted growth and reduced seed yields.
- Deformed, crooked, and gnarled cones with areas of deformed scales
- Populations knocked back when controlling for *Leptoglossus*



# Gall Midges—(Diptera: Cecidomyiidae)

- Tiny and fragile, short-lived adult flies
  - Long-legs and reduced venation
- Larvae (maggots) can be long-lived
  - Usually brightly colored (e.g., pink, orange, yellow)
- While many form galls in plants, others feed on plants (without galls), are predacious, or are parasitoids
- Economic estimates within midges is not certain, but observations suggest non-issue
- **Gall:** an abnormal swelling of plant tissue



*Paradiplosis tumifex* Gagné

Ronald S. Kelly, Vermont Department of Forests, Bugwood.org

# *Cecidomyia bisetosa*—Southern Cone Gall Midge



Jeffrey W. Lotz, Florida Department of Agriculture and Consumer Services, Bugwood.org



Jeffrey W. Lotz, Florida Department of Agriculture and Consumer Services, Bugwood.org

# *Cecidomyia bisetosa*—Southern Cone Gall Midge

- Very small midge (adult ~2mm; larvae 2–3 mm)
- Weakly veined, long legs, long antennae
- Empodia longer than claws
  - Genus characteristic
- Southern Georgia, South Carolina, and Florida, range probably overlapping with slash pine
- Infests cones of slash pine (*Pinus elliottii*)



Jeffrey W. Lotz, Florida Department of Agriculture and Consumer Services, Bugwood.org

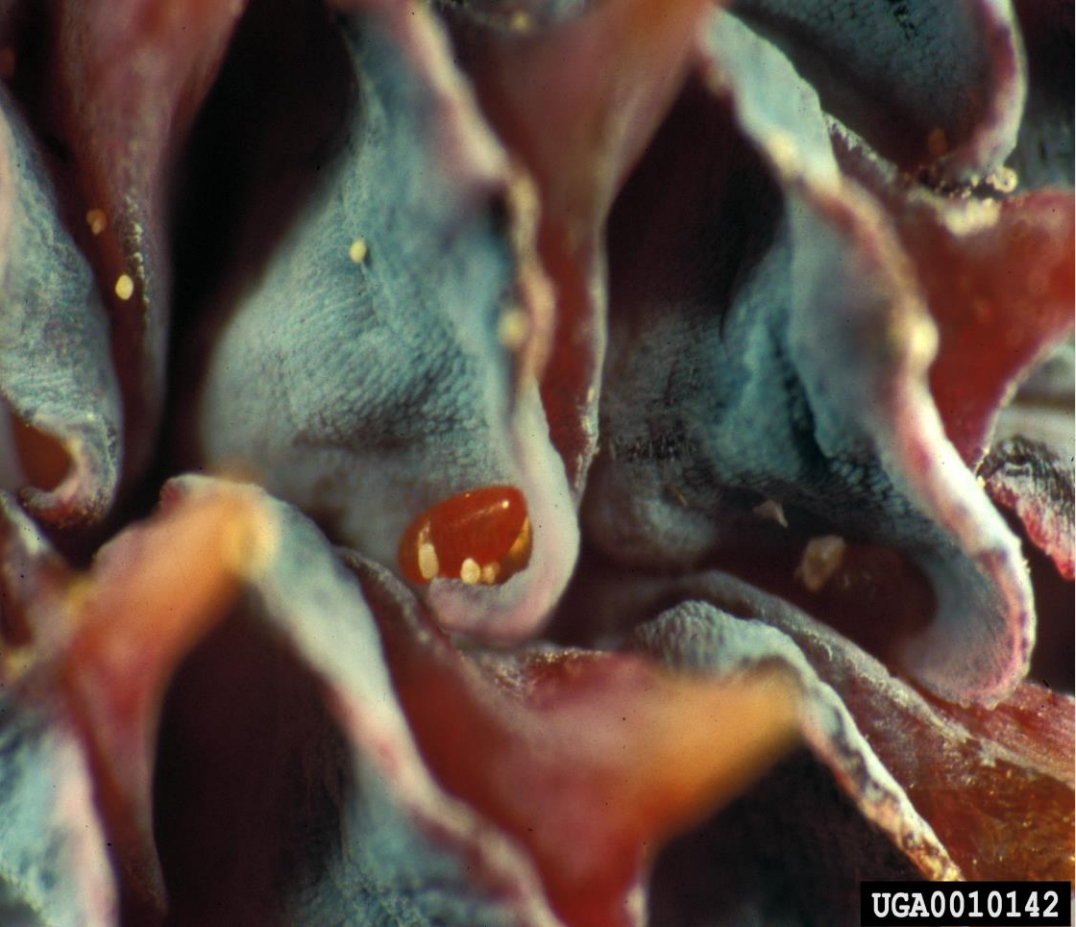
# *Cecidomyia bisetosa*—Southern Cone Gall Midge

- Adults emerge from infested conelets during flower pollination and lay eggs on the cone
- Maggots feed between conelet scales, causing enlargement of adjacent scales.
- Maggots develop between the scales over the summer, creating galls
- Larvae mature late summer and pupate in the conelet mid-winter
- There is probably only one generation annually
- If cones survive to maturity, they will fail to release seeds from the galled portions



Jeffrey W. Lotz, Florida Department of Agriculture and Consumer Services, Bugwood.org

# *Cecidomyia bisetosa*—Southern Cone Gall Midge



Jeffrey W. Lotz, Florida Department of Agriculture and Consumer Services, Bugwood.org

# *Contarinia oregonensis*—Douglas-Fir Cone Gall Midge

- Occurs in western North America from central B.C. to northern Mexico
- **May be the most serious pest of Douglas Fir Seed orchards**
  - Severe infestations can destroy all seeds in a cone
- Similar to the SCGM, but galls are much less conspicuous
- Maggots are pinkish-orange
- Empodia as long as claws
  - Genus characteristic



Photo: D. Manastyrski, Forest Genetics Council of British Columbia

# *Contarinia oregonensis*—Douglas-fir Cone Gall Midge

- Adults emerge in spring during pollen flight
- Eggs are laid in clusters underneath conelet scales; galls fuse seeds to scales
  - Seed development restricted
- Larvae feed throughout the summer
- In the fall, larvae drop to the forest floor and pupate in the leaf litter
- Some individuals may remain in diapause for multiple years



Photo: D. Manastyrski, Forest Genetics Council of British Columbia

# *Contarinia oregonensis*—Douglas-Fir Cone Gall Midge

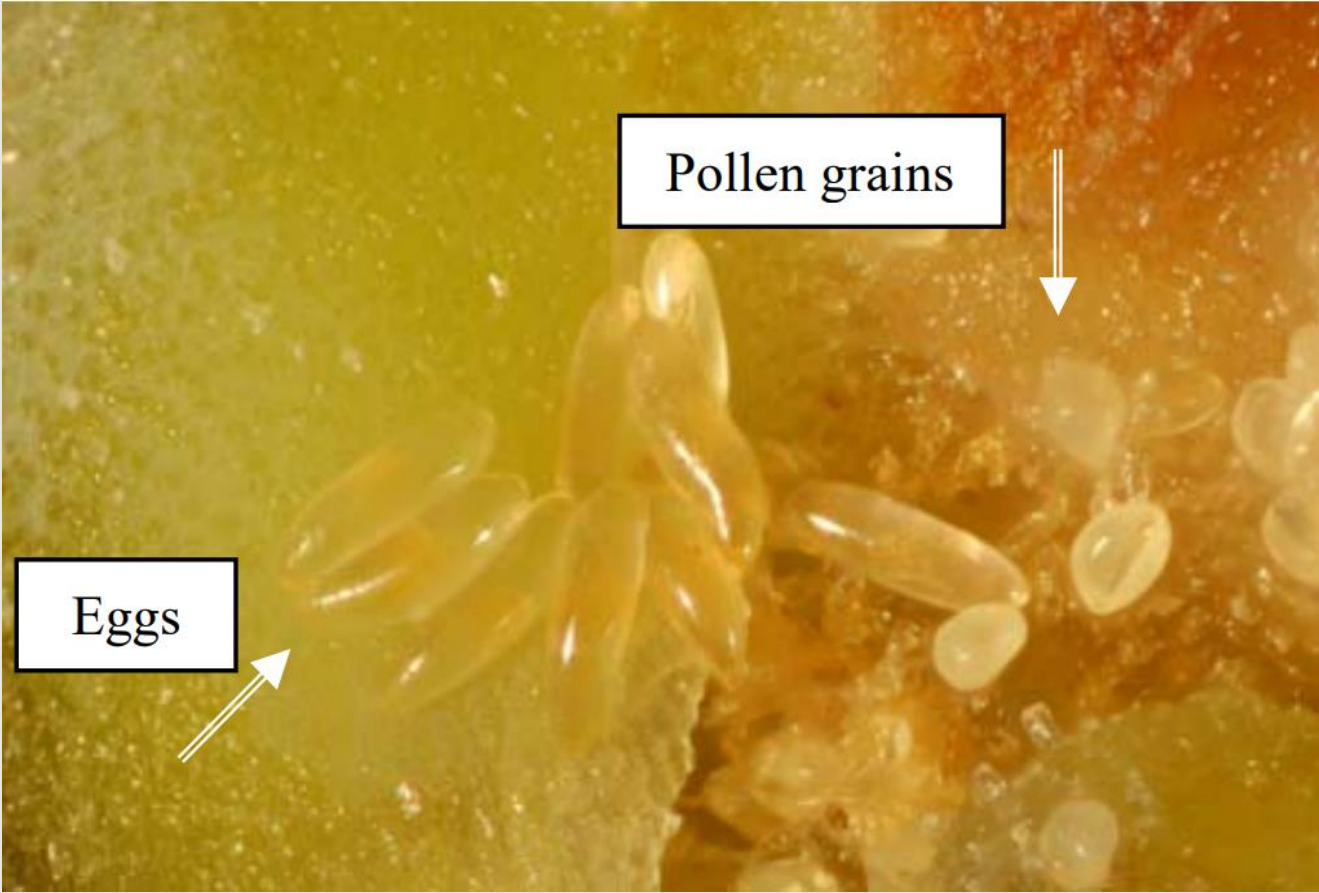
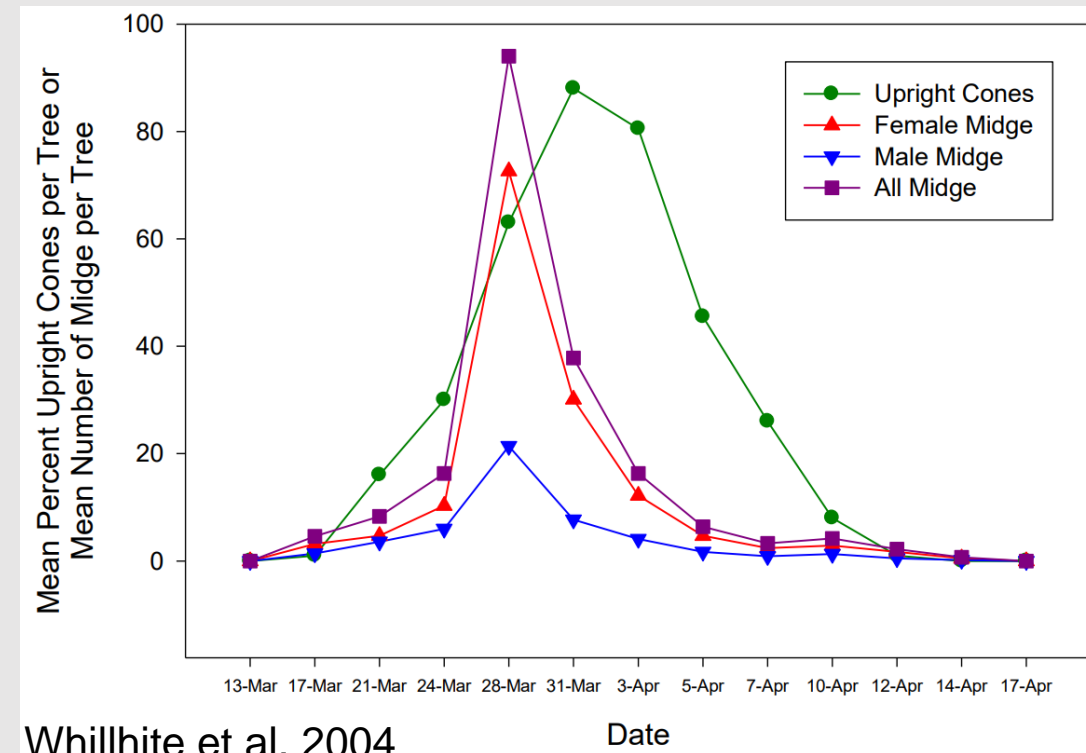


Photo: D. Manastyrski, Forest Genetics Council of British Columbia

Photo: D. Manastyrski, Forest Genetics Council of British Columbia

# Douglas-fir Cone Gall Midge Management

- **Application timing of control is critical**
- Target adult females when they emerge—the same time as flowers are receptive to pollen
- Monitoring is critical—applications **MUST** be made to coincide with female activity  
Minimize oviposition
- Imidacloprid (systemic) works!



Whillhite et al. 2004

Date

# Pesticide Use

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- Try to use them judiciously—planned program
- No known resistances to insecticides
- Good selection of products available
  - Several pyrethroids (Bifenthrin, Permethrin,
  - Organophosphates (...some are being phased out)
  - Two biologicals (*Btk*, Spinosad)
  - One growth regulator (Tebufenozide)
  - Emamectin benzoate

# Integrated Pest Management

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- As defined in 7 U.S.C. § 136r, IPM is “a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks.”
- PM uses knowledge of pest and host biology, as well as biological and environmental monitoring, to respond to pest problems with management tactics and technologies designed to:
  - Prevent unacceptable levels of pest damage.
  - Minimize the risk to people, property, infrastructure, natural resources, and the environment.
  - Reduce the evolution of pest resistance to pesticides and other pest management practices

# Seed Orchard IPM—Problems

- Heavily **dependent on pyrethroids**—some use them exclusively
- Disadvantages
  - Highly toxic to aquatic organisms and pollinators
  - Risk of accident—spill or drift—fish kills
  - Requires restricted-use license—added costs
  - EPA—periodic review—future restrictions
  - Potential for resistance—coneworms or seed bugs
- Secondary insects—mealybugs, scale insects
- Need to use Foray<sup>®</sup> (Btk) Mimic<sup>®</sup> (Tebufenozide), Spinosad more!
- No new products are being evaluated!
- All our “...**ovules are in one flower**”!!!!



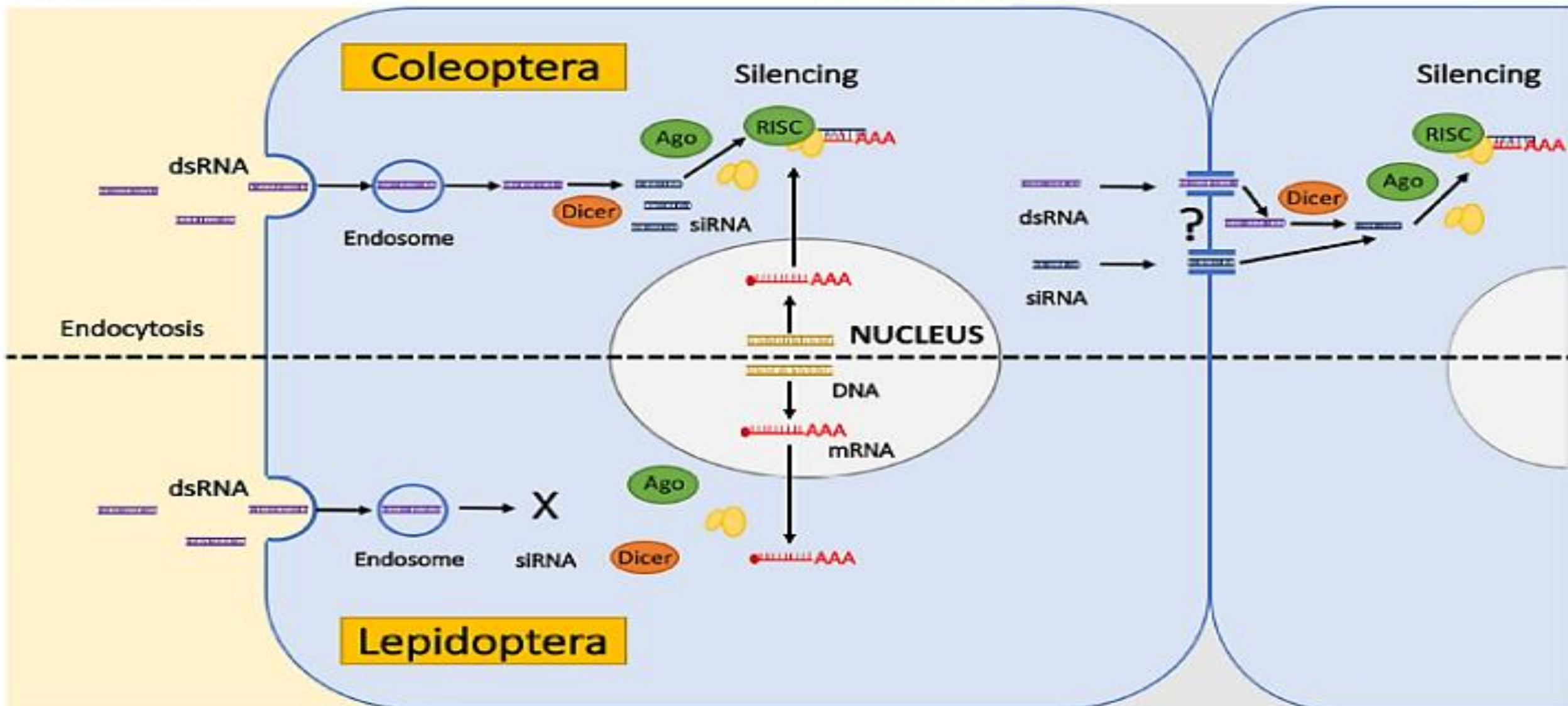
# Seed Orchard IPM—Suggestions

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- (emphasis on Southern Orchards)
- Systemic (injectable) product for seed bug control
- Plant for invasive seed and cone insects—they will be here eventually!!
- Evaluate new generation insecticides
- Test Spinetoram—newer version of Spinosad—it needs testing!
  - Not yet registered
  - More effective than Spinosad against Leps
  - Minimal effect on non-target pollinators and beneficial insects
- **RNAi-based Insecticides**

# MIDGUT

# CYTOPLASM



Cell Uptake



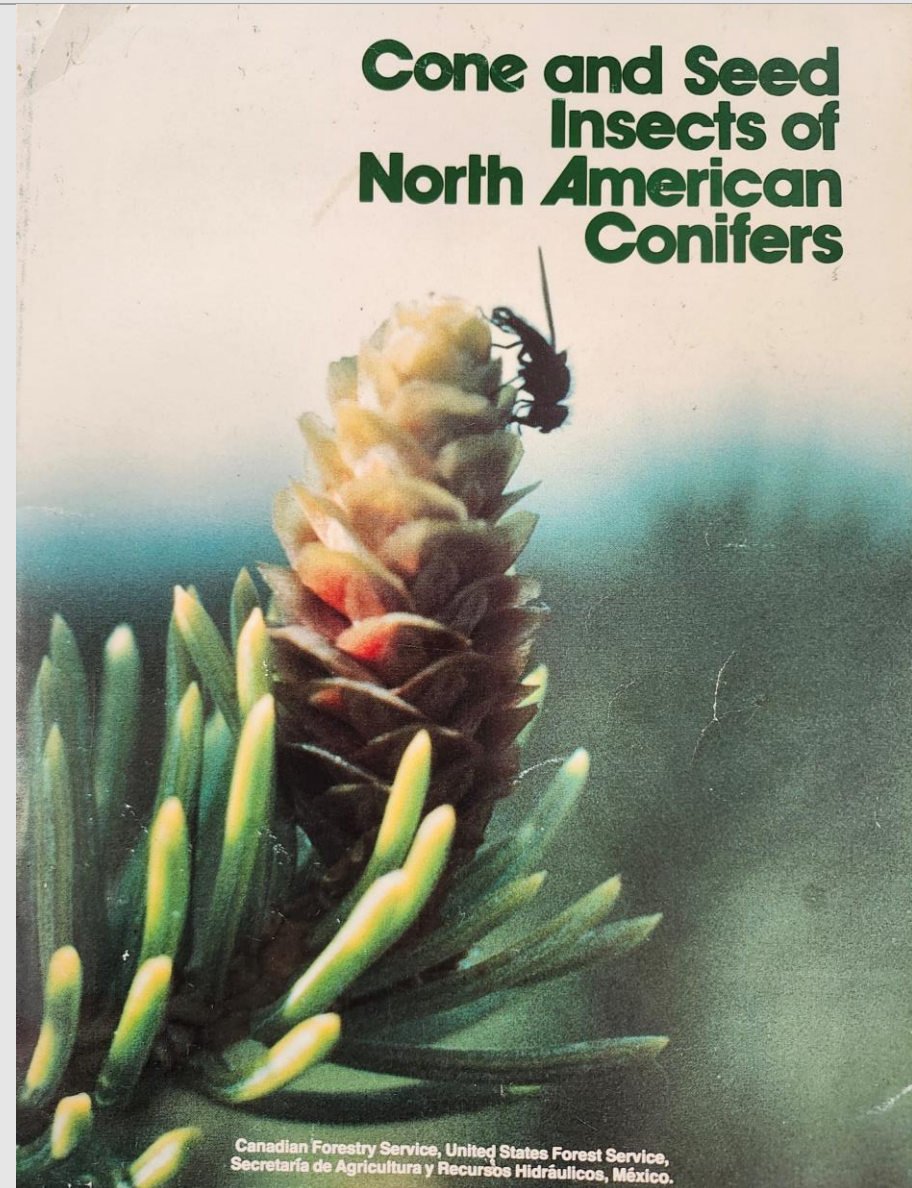
Core Machinery



Systemic Spread

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