# Emerald Ash Borers :Biological controls & Agent based model





Jenny Liu, Camilla Chen, Amelie Wu

## Contexts

- Biocontrols
- Agent Based Model for EAB Population
- What's next

#### Parasitism as Biocontrol method

Parasitoid: T. planipennisi





# **Basic Nicholson & Bailey model**

H<sub>t</sub>:Adult EAB density P<sub>t</sub>: Adult parasitoid density

 $H_{t+1} = R H_t \exp(-c P_t)$  $P_{t+1} = K R H_t [1-\exp(-c P_t)]$ 

R: EAB growth rate in ash

K: Progeny of parasitoid per larval in ash

exp(-c P<sub>t</sub>): "Escape probability" of EAB in ash

C: Attack rate of the wasps

# **Basic Nicholson & Bailey model**

H<sub>t</sub>:Adult EAB density P<sub>t</sub>: Adult parasitoid density

R: EAB growth rate in ash

K: Progeny of parasitoid per larval in ash

exp(-c P<sub>+</sub>): "Escape probability" of EAB in ash

C: Attack rate of the wasps

$$H_{t+1} = R H_t \exp(-c P_t)$$
$$P_{t+1} = K R H_t [1-\exp(-c P_t)]$$

# **Basic Nicholson & Bailey model**

H<sub>t</sub>:Adult EAB density P<sub>t</sub>: Adult parasitoid density

$$H_{t+1} = R H_t \exp(-c P_t)$$
$$P_{t+1} = K R H_t [1-\exp(-c P_t)]$$

R: EAB growth rate in ash

K: Progeny of parasitoid per larval in ash

exp(-c P<sub>+</sub>): "Escape probability" of EAB in ash

C: Attack rate of the wasps

# Stability

Model:

$$H_{t+1} = R H_t \exp(-c P_t)$$

$$P_{t+1} = K R H_t [1 - exp(-c P_t)]$$

Equilibrium:

Set 
$$H_{t+1} = H_t = H^* P_{t+1} = P_t = P^*$$
  
 $H^* = \frac{\ln(R)}{(R-1) K c} P^* = \frac{\ln(R)}{c}$ 

Stability occurs if and only if



Large and unstable oscillations lead to the extinction of parasitoid while EAB population is still active,  $dH^*/dR < 0$  when it's unstable.



# Refuge Model

Model:

$$\begin{split} & \mathsf{H}_{\mathsf{t}+1} = \mu \; \lambda \; \mathsf{R} \; \mathsf{H}_{\mathsf{t}} \; + \; (\mathsf{1} - \mu) \; \; \mathsf{R} \; \mathsf{H}_{\mathsf{t}} \; \mathsf{exp} \; (-\mathsf{c} \; \mathsf{P}_{\mathsf{t}}) \\ & \mathsf{P}_{\mathsf{t}+1} = \; (\mathsf{1} - \mu) \; \; (\mathsf{1} - \mathsf{exp} \; (-\mathsf{c} \; \mathsf{P}_{\mathsf{t}}) \; ) \; \star \mathsf{k} \; \mathsf{R} \; \mathsf{H}_{\mathsf{t}} \end{split}$$

Equilibrium:

$$H^{*} = \frac{1}{kc} * \frac{\left(\log\left(\frac{(1-\mu)R}{1-\mu\lambda R}\right)\right)}{(R-1) - (1-\lambda)\mu R}$$
$$P^{*} = (1-\mu) k R H^{*} (1 - \exp(-cP^{*}))$$

Stability condition : 
$$\frac{d}{dR}H^* > 0$$
  
Implies stable positive equilibrium



#### Partial Refuge model

 $\begin{aligned} & \mathsf{H}_{t+1} = \lambda \,\mu \,\mathsf{R} \,\mathsf{H}_{t} \,\exp\,\left(-\mathsf{c} \,\mathsf{P}_{t} \,\nu\right) \,+\,\,\left(\mathbf{1} - \mu\right) \,\mathsf{R} \,\mathsf{H}_{t} \,\exp\,\left(-\mathsf{c} \,\mathsf{P}_{t} \,\left(\mathbf{1} - \nu\right)\right) \\ & \mathsf{P}_{t+1} = \lambda \,\mu \,\left(\mathbf{1} - \exp\,\left(-\mathsf{c} \,\mathsf{P}_{t} \,\nu\right)\right) \,\mathsf{kf} \,\mathsf{R} \,\mathsf{H}_{t} \,+\,\left(\mathbf{1} - \mu\right) \,\left(\mathbf{1} - \exp\,\left(-\mathsf{c} \,\mathsf{T} \,\mathsf{P}_{t} \,\left(\mathbf{1} - \nu\right)\right)\right) \,\mathsf{ka} \,\mathsf{R} \,\mathsf{H}_{t} \end{aligned}$ 



### Parameter space for $\mu \& v$







## **Basic Settings & Data Monitor**







#### Life Cycles are not synchronized



# Next step

#### LIFE CYCLE OF THE EMERALD ASH BORER **Emerald Ash Borer** (enlarged view) Female ash borers lay 40 to 70 eggs on the bark of an ash tree. After hatching, the larvae bore into the tree layers just below the bark to feed. They remain there for 1 or 2 years, then pupate into adults. Actual size 1/2 in. long 1/8 in. wide Adults, which can fly, The adults then chew a telltale 3 then seek out new D-shaped exit hole in the bark. trees, and the process begins again.

• Break the model into a more detailed version based on the life stages of Emerald Ash Borer.

• Examine the effects of biological controls through agent.

• Merge published life-cycle data with the Nicholson-Bailey model

