

Phenology Models for BMSB

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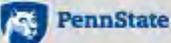
NC State Asheville



Funding

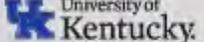
 United States Department of Agriculture National Institute of Food and Agriculture
Specialty Crop Research Initiative

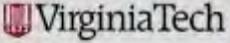
Collaborating Institutions

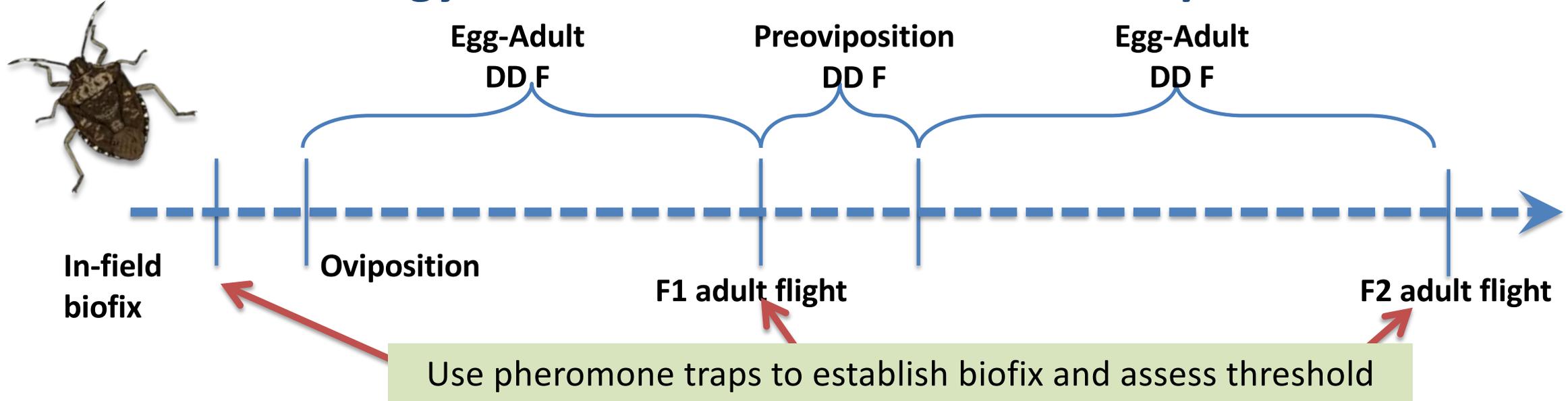
  

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Model Phenology to Make Predictions about Populations

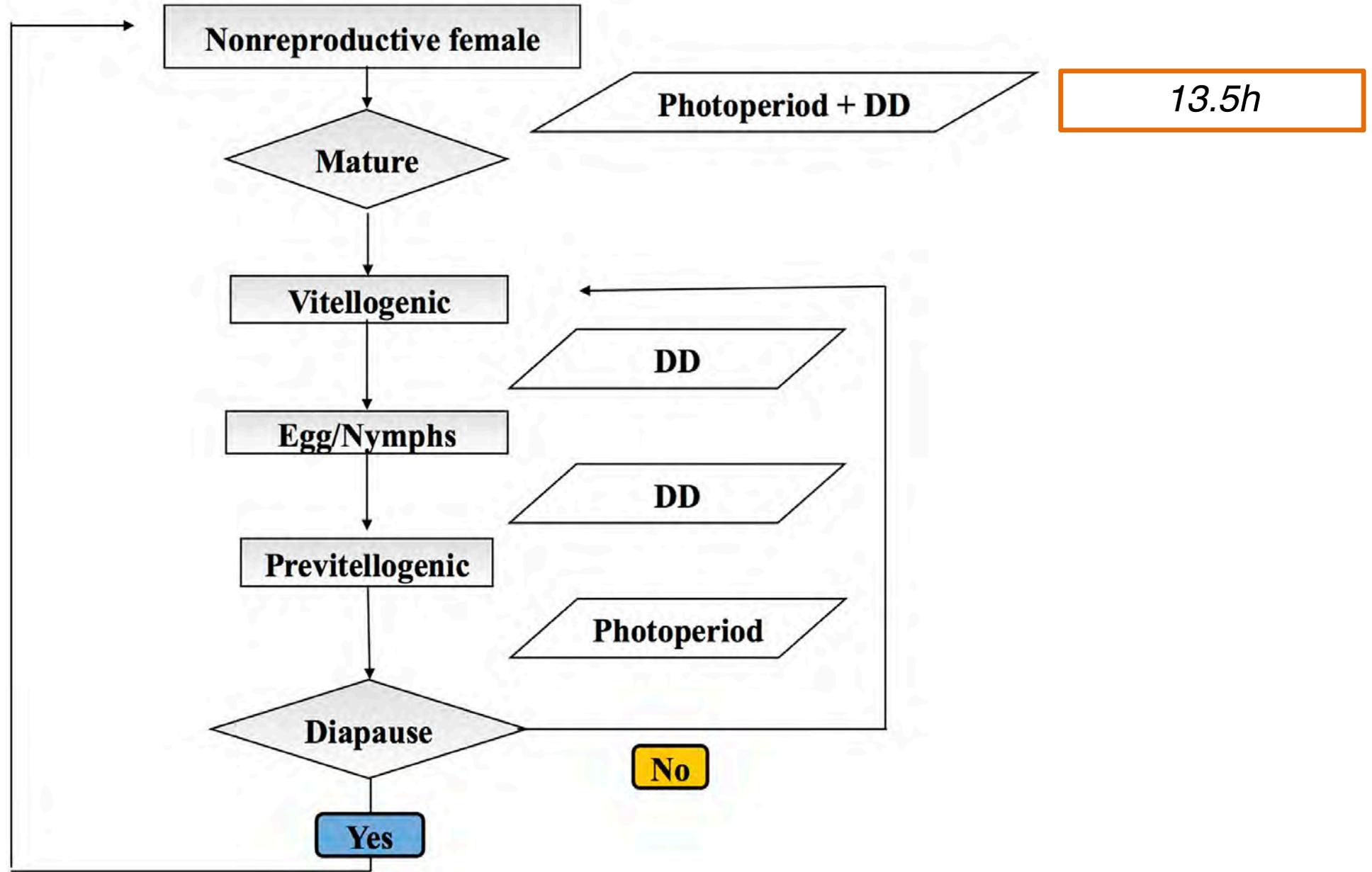


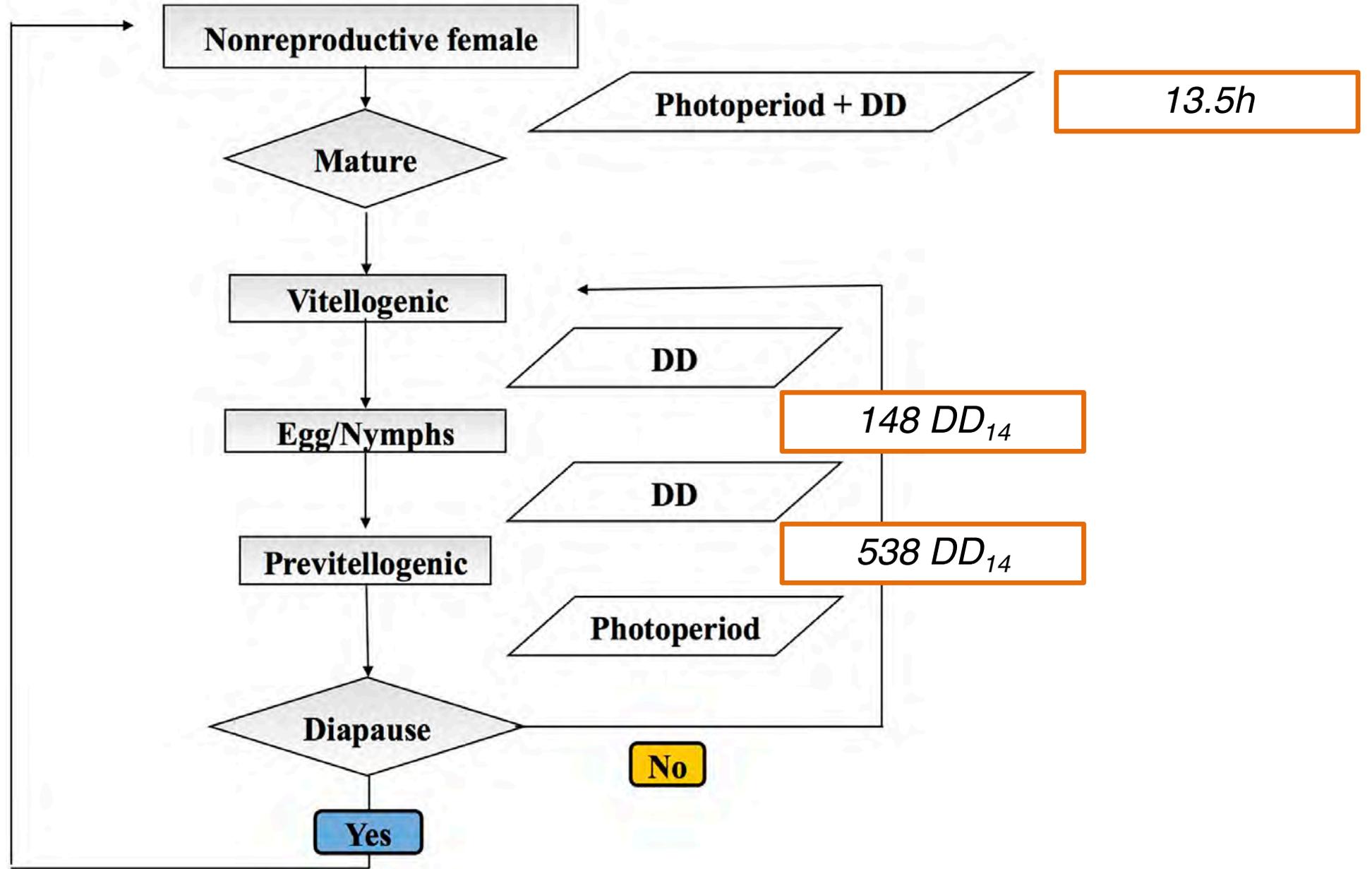
- *Extreme* overlap among life stages
- Traditional DD models lose accuracy for insects with overlapping life stages
- Traditional DD models don't incorporate mortality or physiological variation
- Simple to use and interface with weather-based software

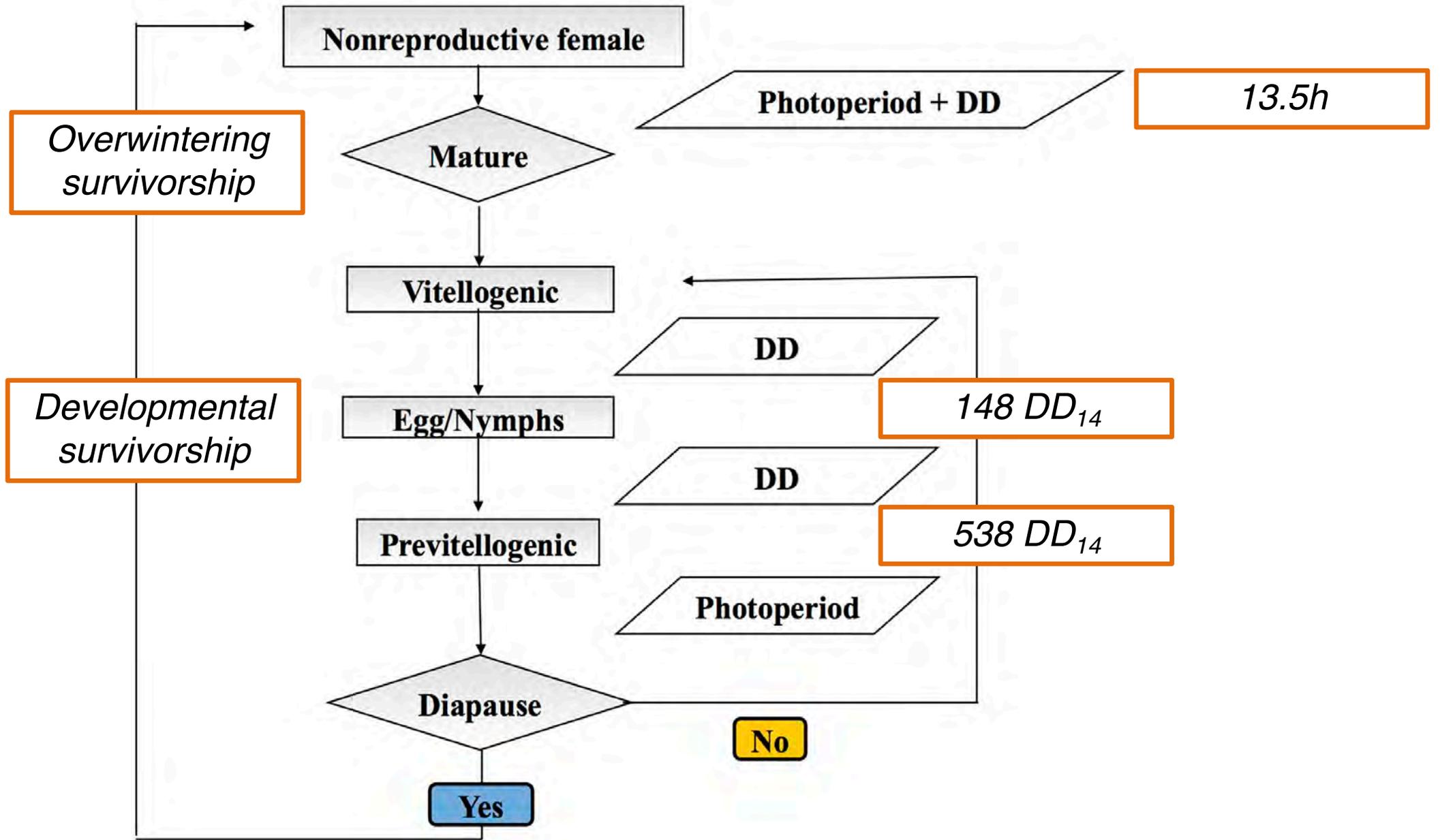
Develop an Individual Based Stage-Specific Phenology Model

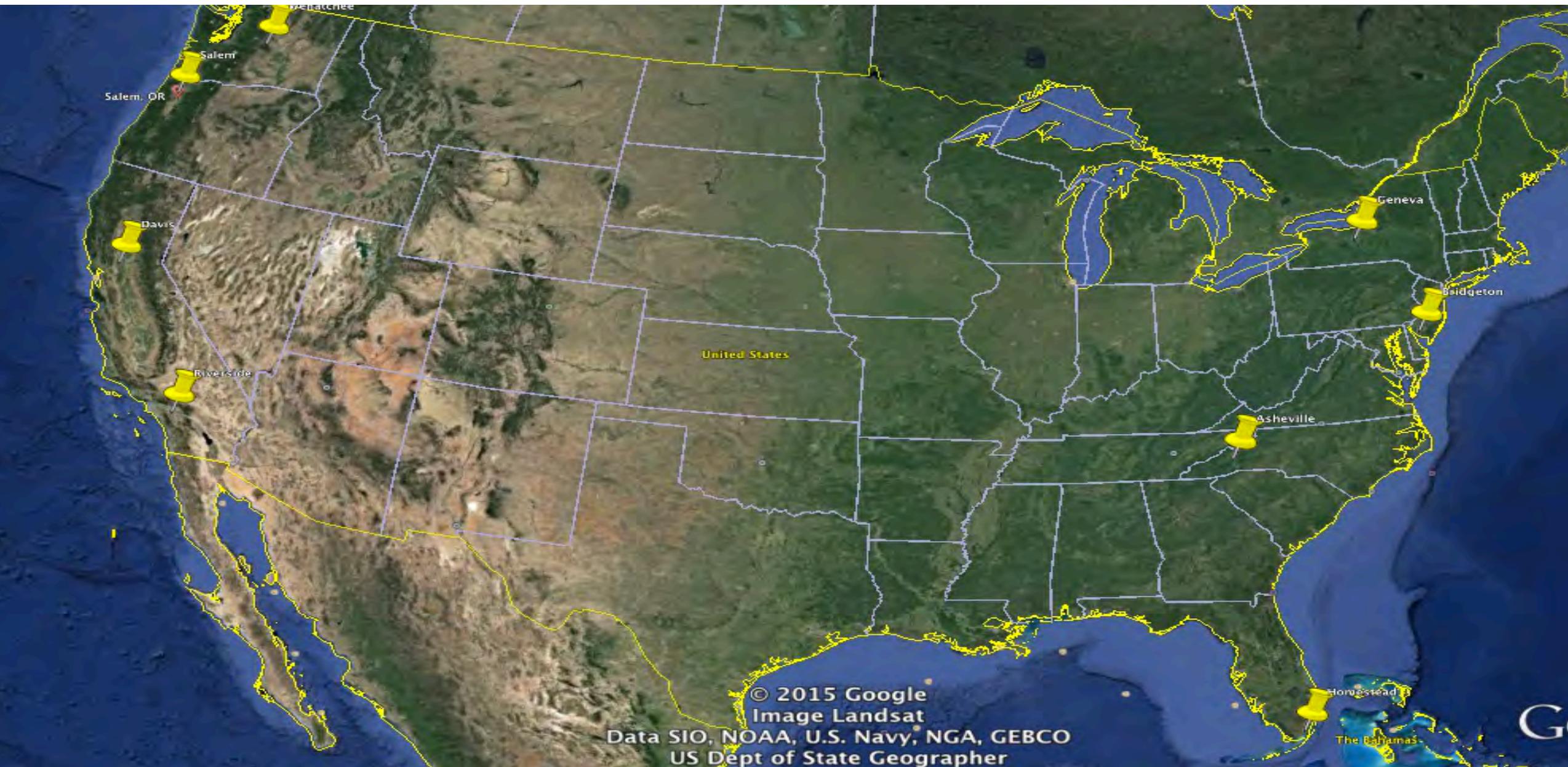
| Life Stage | Process | Stochastic | Drivers |
|-----------------|---|------------|----------------------|
| Adult | Overwintering survivorship | X | Time |
| | Diapause termination and induction | | Photoperiod |
| | Preoviposition | | Temperature |
| | Fecundity (clutch size, interval, number) | | Time |
| | Sex Ratio | | |
| Eggs and Nymphs | Survivorship | X | Temperature and Time |
| | Development Rate and Thresholds | X | Temperature and Time |

1000 individuals, Results pooled from 100 runs per simulation









Salem, OR

Salem

Weiratchee

Davis

Riverside

United States

Asheville

Geneva

Bridgeton

Homestead

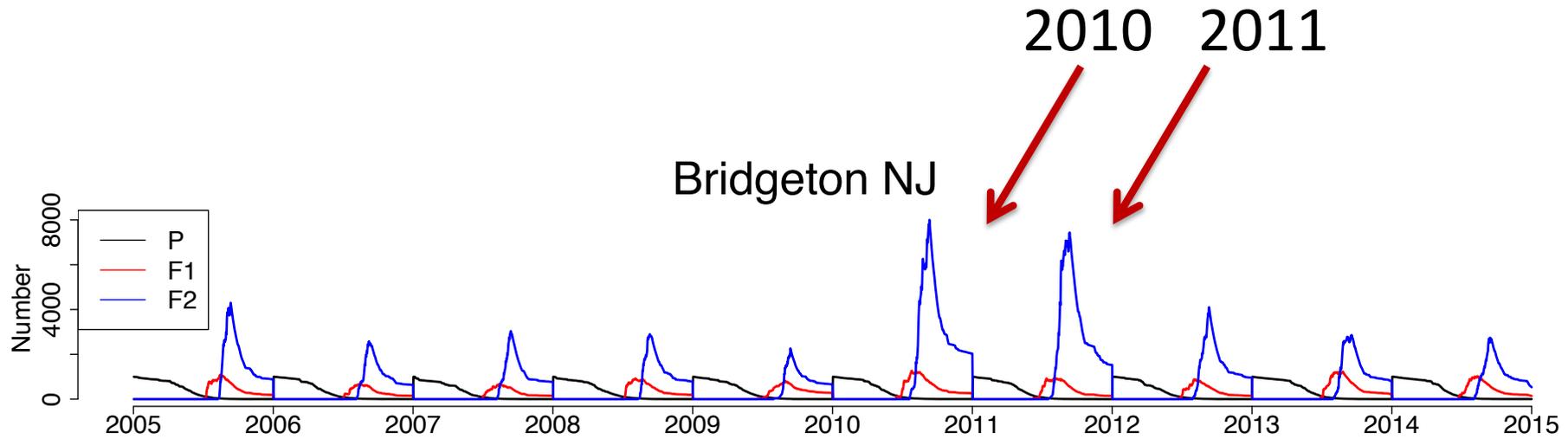
The Bahamas

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Data SIO, NOAA, U.S. Navy, NGA, GEBCO
US Dept of State Geographer

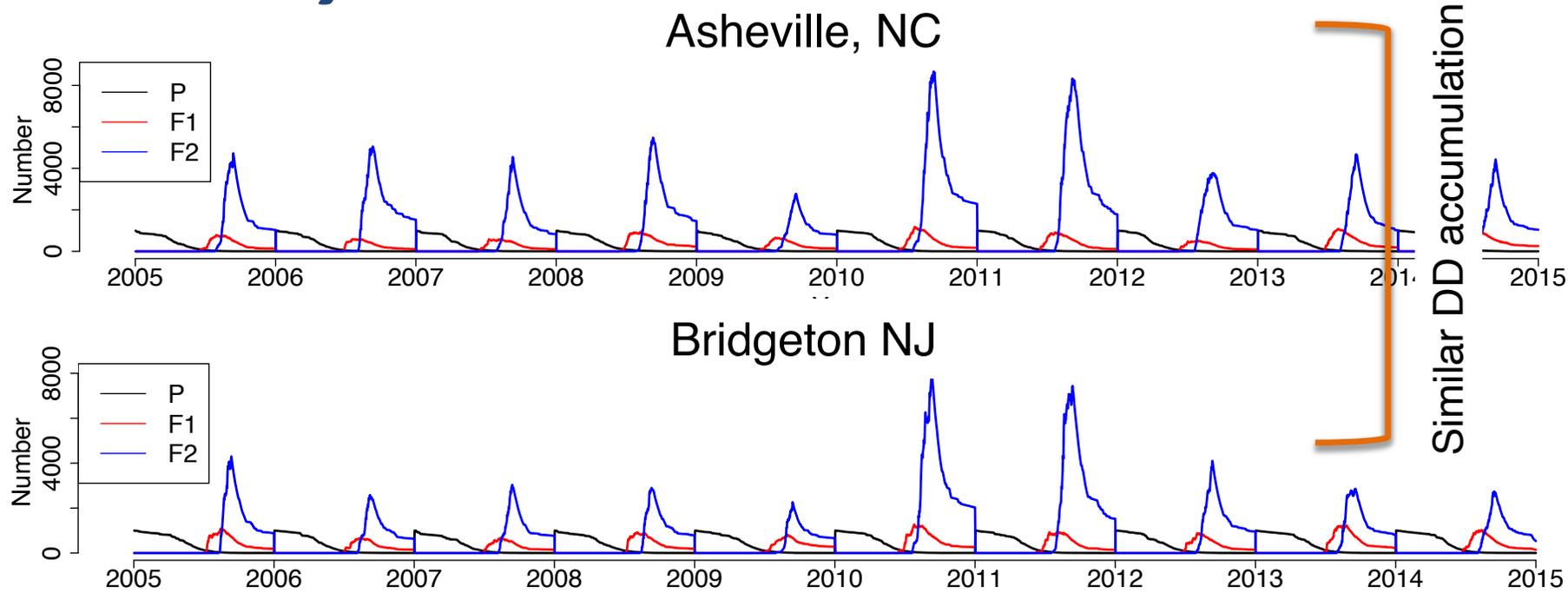
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Population Dynamics in Bridgeton, NJ

Years with high damage and populations had higher simulated populations

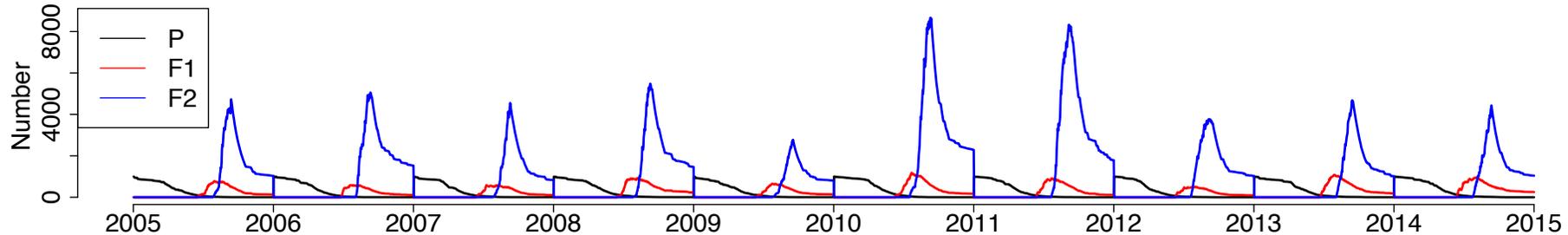


Population Dynamics – Same DD

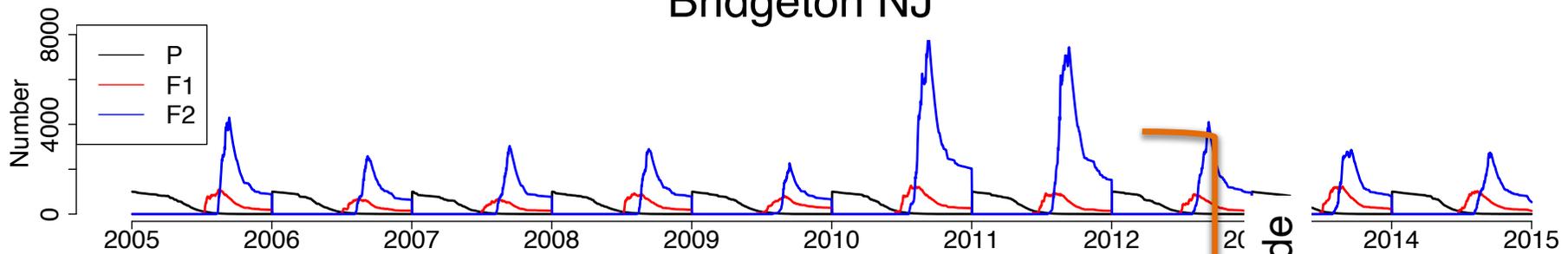


Population Dynamics – Same Biofix

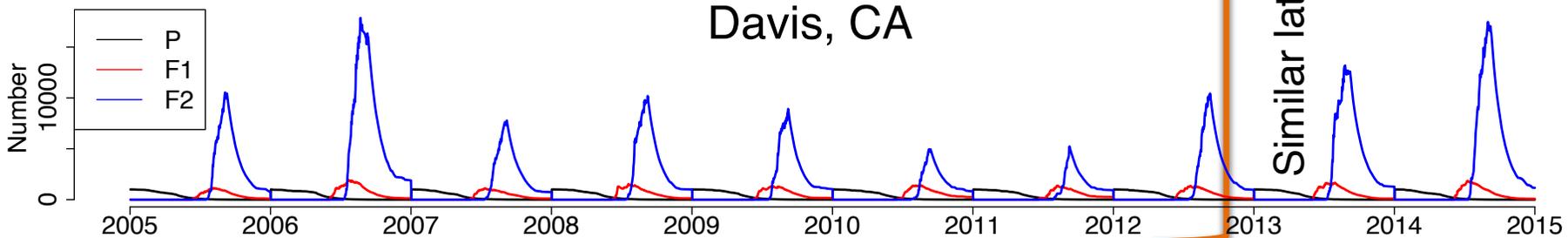
Asheville, NC



Bridgeton NJ



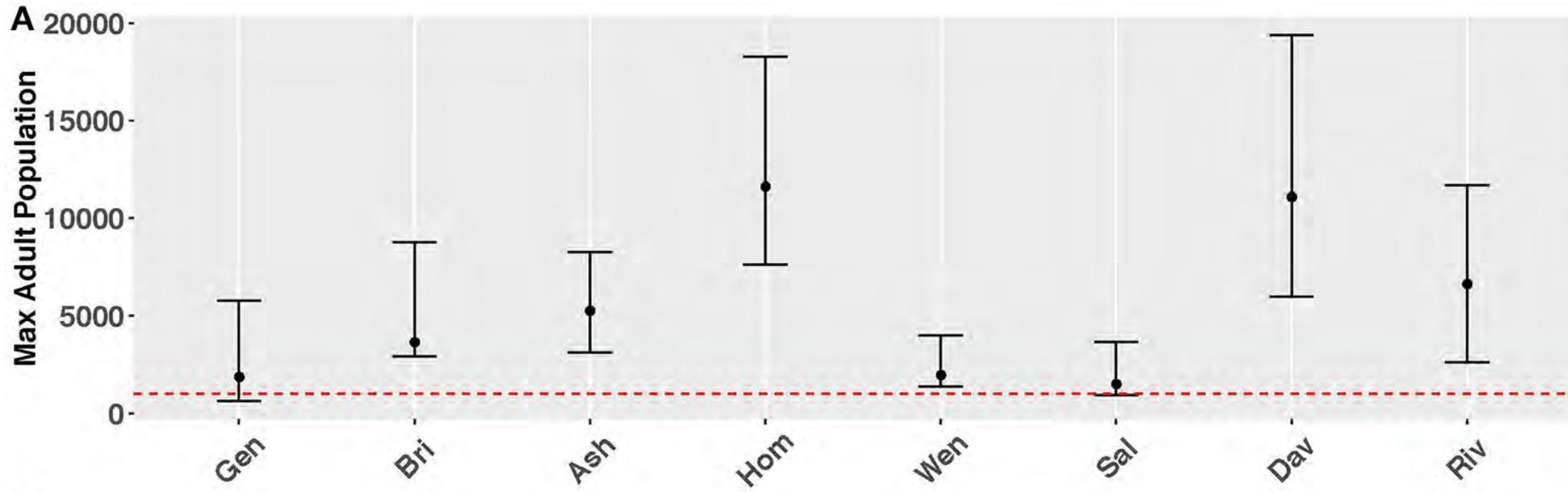
Davis, CA



Similar latitude



Adult Population Size, 2005 - 2015



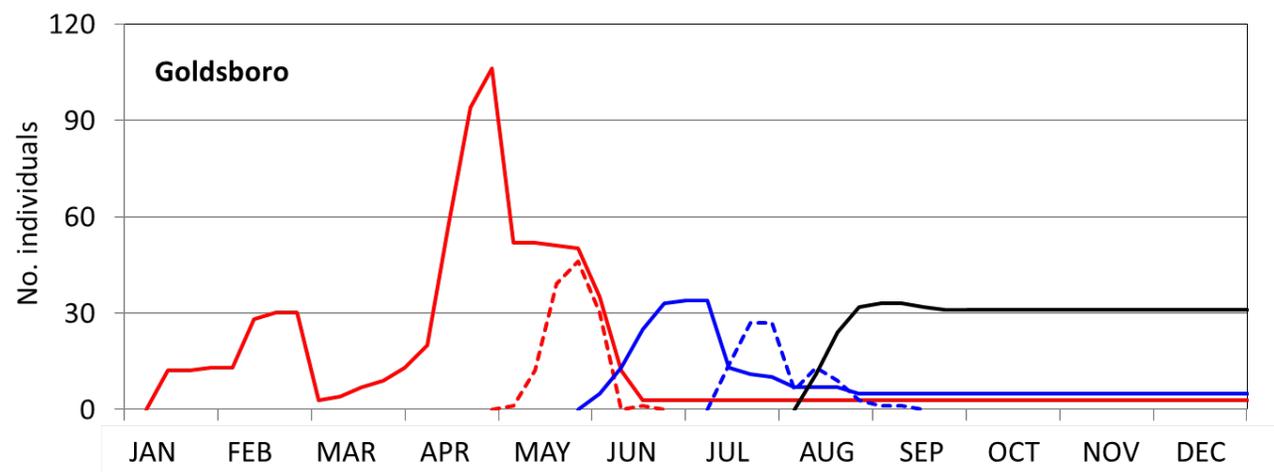
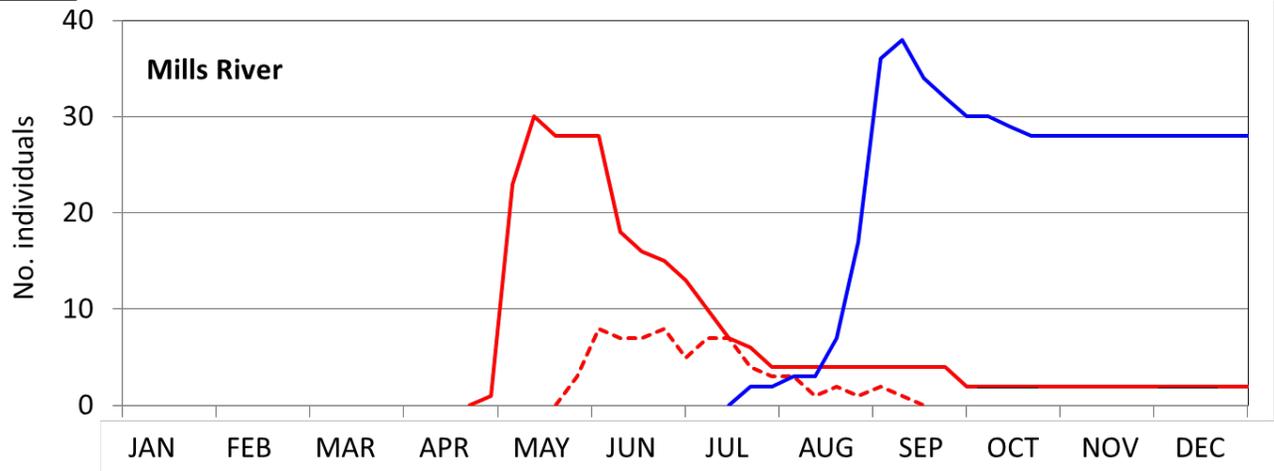
- Differences in stage structure between locations
- Population size differs between geographic populations
- + Suggests landscape features may play an important role as well as population haplotype

Peak Population Periods in Pheromone Trap Captures and Phenology Model Simulations

| State | Adults | | Days between population peak dates (vs. phenology models) | Nymphs | | Days between population peak dates (vs. phenology models) |
|-------------------|--------|--------|---|--------|--------|---|
| | t | P | | t | P | |
| Pyramid trap | | | | | | |
| Michigan | 2.14 | 0.1131 | 16.67 | 4.88 | 0.0099 | 37.67 |
| Maryland | -0.53 | 0.6301 | 7 | 3.02 | 0.0422 | 31 |
| Georgia | 2.46 | 0.072 | 15.67 | -0.86 | 0.4667 | 20 |
| Oregon | 0.92 | 0.4382 | 12.33 | 4.33 | 0.0444 | 37 |
| Clear sticky trap | | | | | | |
| Michigan | 2.14 | 0.1131 | 16.67 | 1.76 | 0.3051 | 31.83 |
| Maryland | -0.09 | 3.9894 | 1.33 | 1.66 | 0.1731 | 14.67 |
| Georgia | -0.93 | 0.4417 | 18 | -1.01 | 0.3937 | 19.33 |
| Oregon | -1.97 | 0.1638 | 27.67 | 1.89 | 0.1970 | 27 |

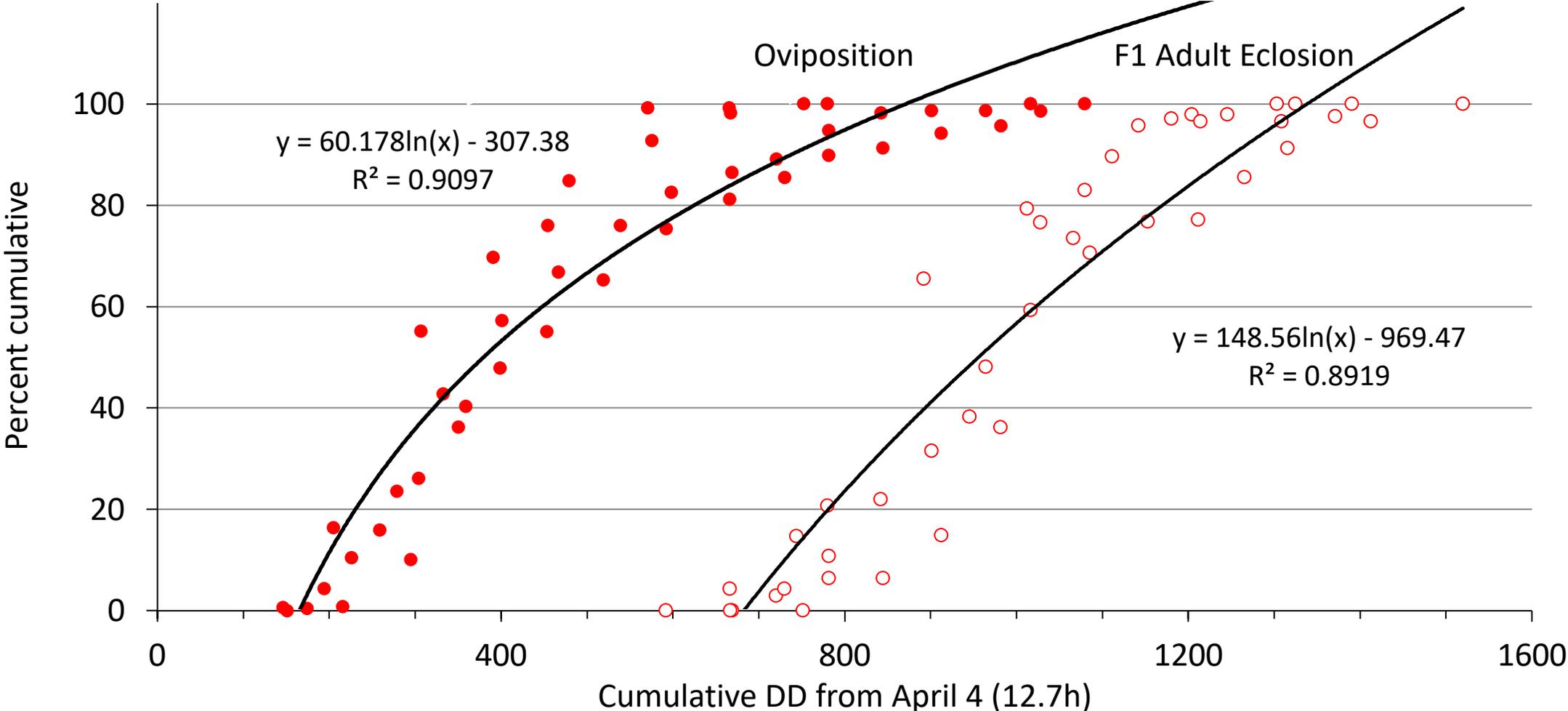
NC State: Number of Living Adults and Eggs Laid

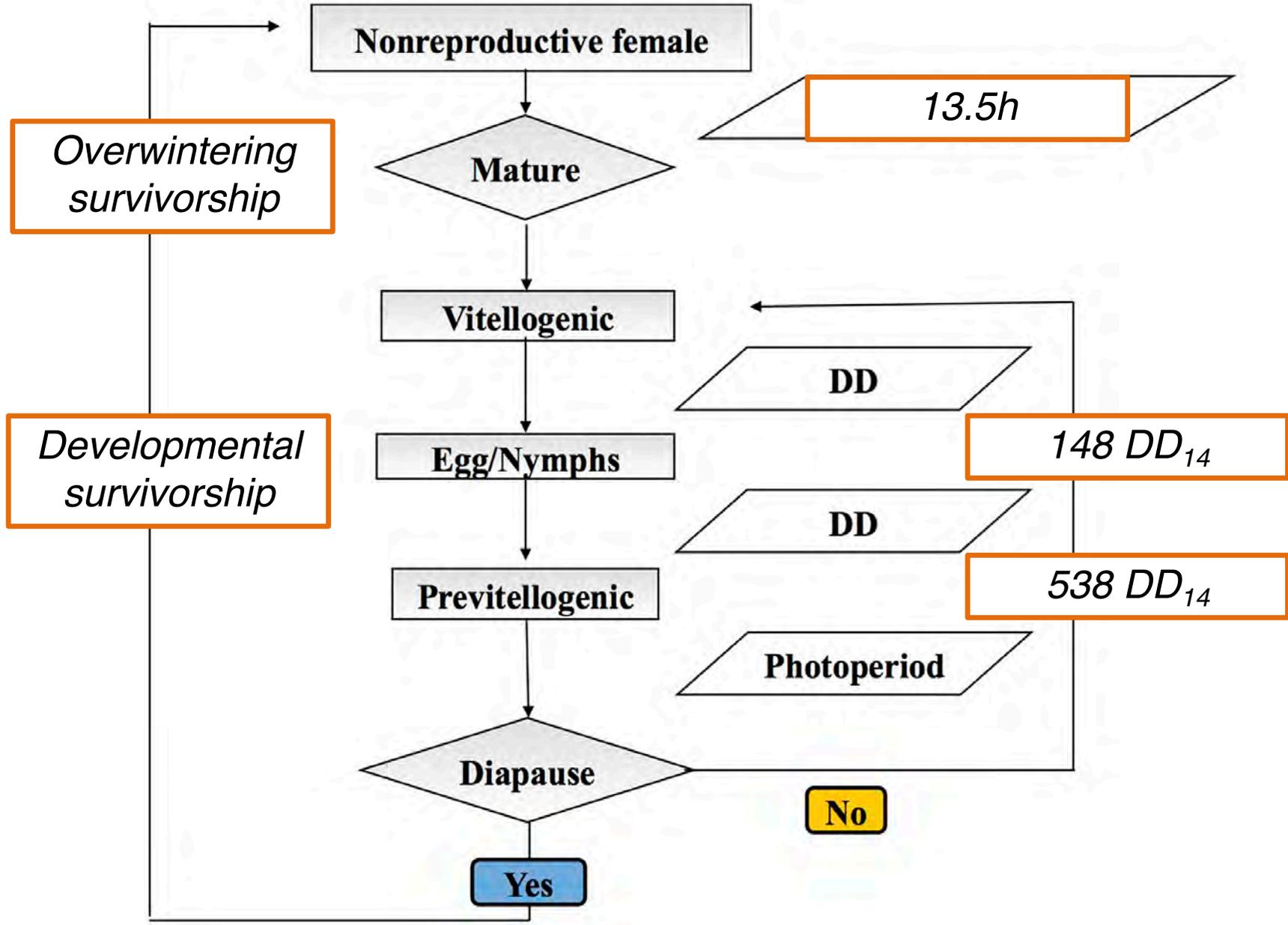
2019



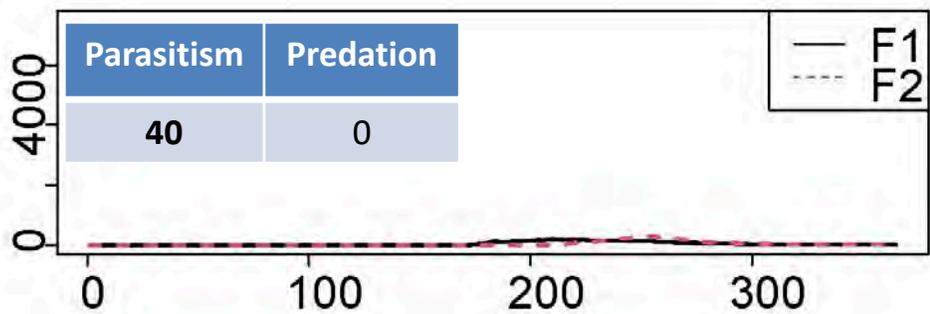
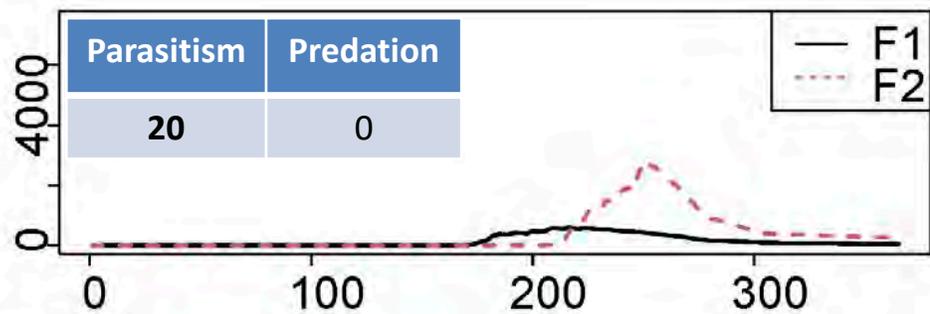
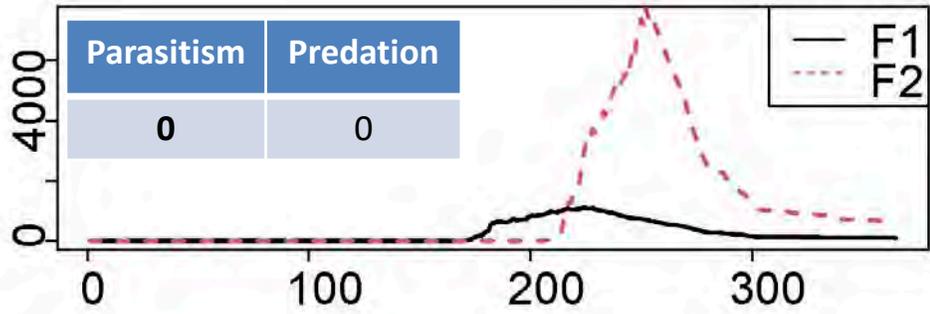
- Empirical model based on developmental data of cohorts of bugs from winter through fall.
 - Western NC (Mills River, 2067 ft elevation)
 - Eastern NC (Goldsboro, 79 ft elevation)
- Using DD accumulations, predicts cumulative oviposition and eclosion of adults from each generation.
- Biofix – Initiation of reproductive development (Nielsen et al. 2017)
 - 12.7 hr photoperiod (4 April in NC)
- Temperature thresholds (Nielsen et al. 2008)
 - 14.2 and 35.6 °C

Cumulative Oviposition and Adult Eclosion vs. Degree-Day Accumulations

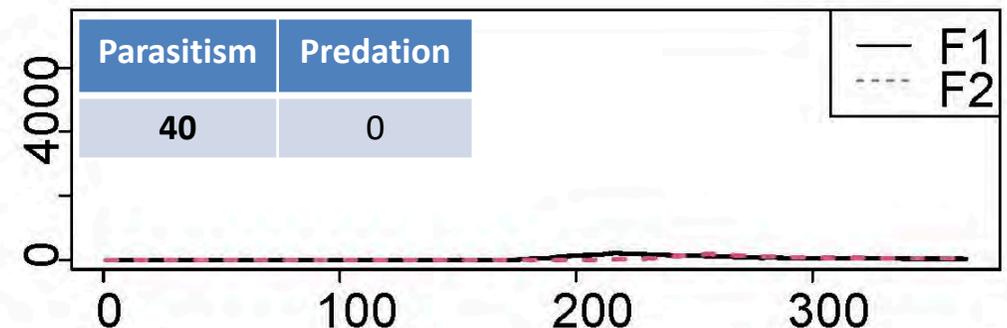
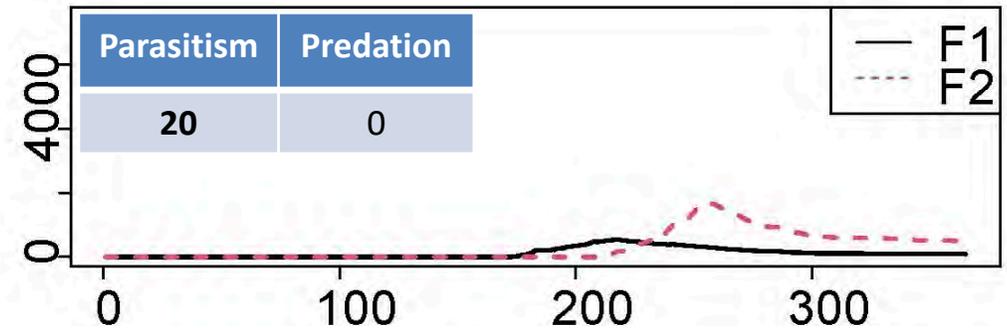
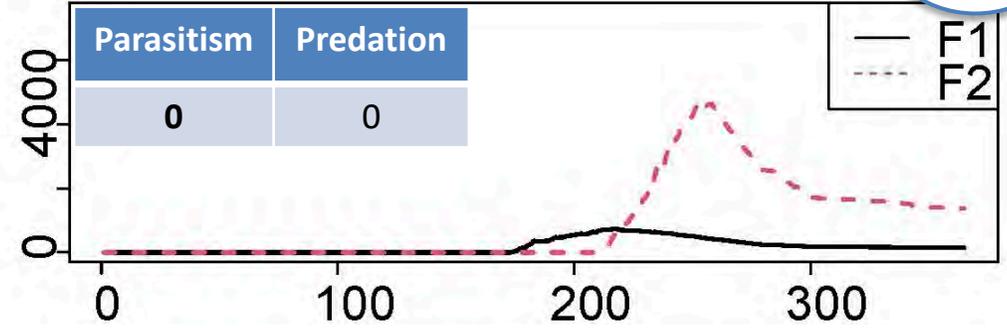




Bridgeton, NJ 2012 - Adults



Asheville, NC 2012 - Adults



Next Steps

- Incorporate any geographic differences in phenology
 - Overwintering survivorship
 - Critical diapause cues
- Refine impact of biotic factors
- Incorporate landscape influences
- Develop a decision aid system with BMSB model
- Increase parasitism!