Modeling in R to safeguard U.S. agricultural and natural resources from invasive pests

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The “DDRP” model for biosecurity

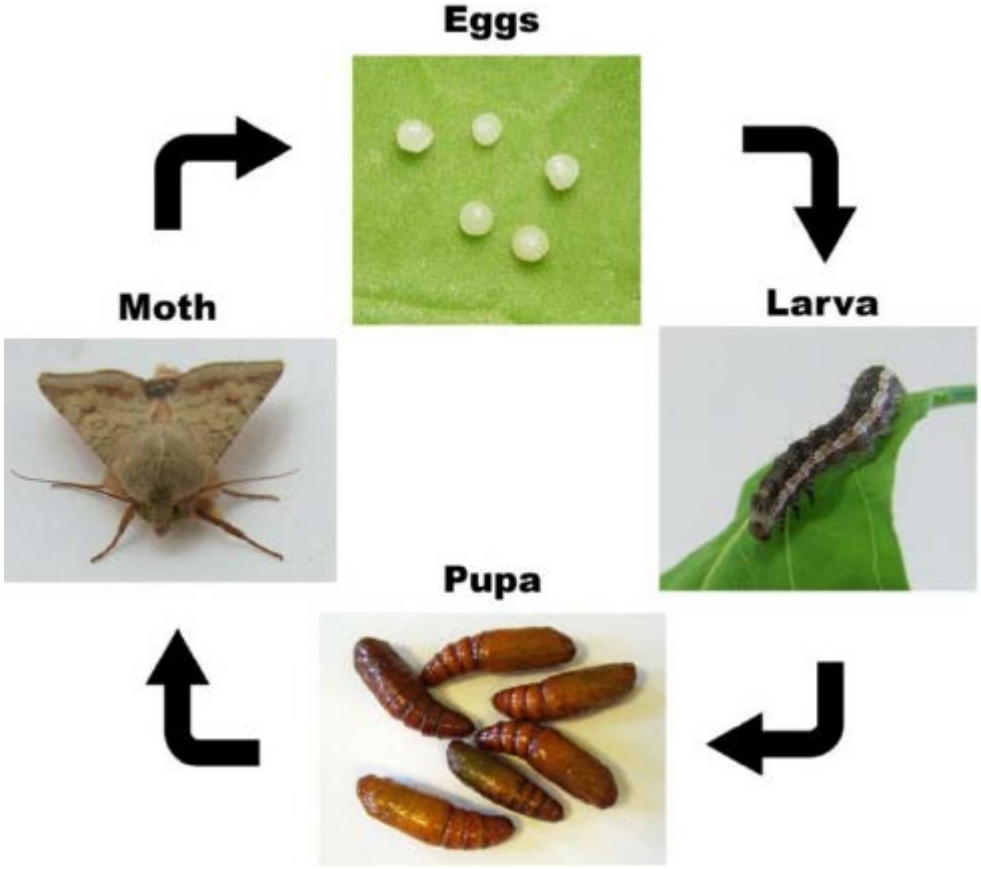
- **Goal**: provide USDA with products to help detect and monitor US agricultural and natural resources against harmful pests
- **Why?** US crop and forest production losses from invasive insects >$40 *billion* per year
- **How?** Use data on insect life cycle and climate to model their distribution and activities
- Written entirely in **R**



Input data

(1) Species of interest

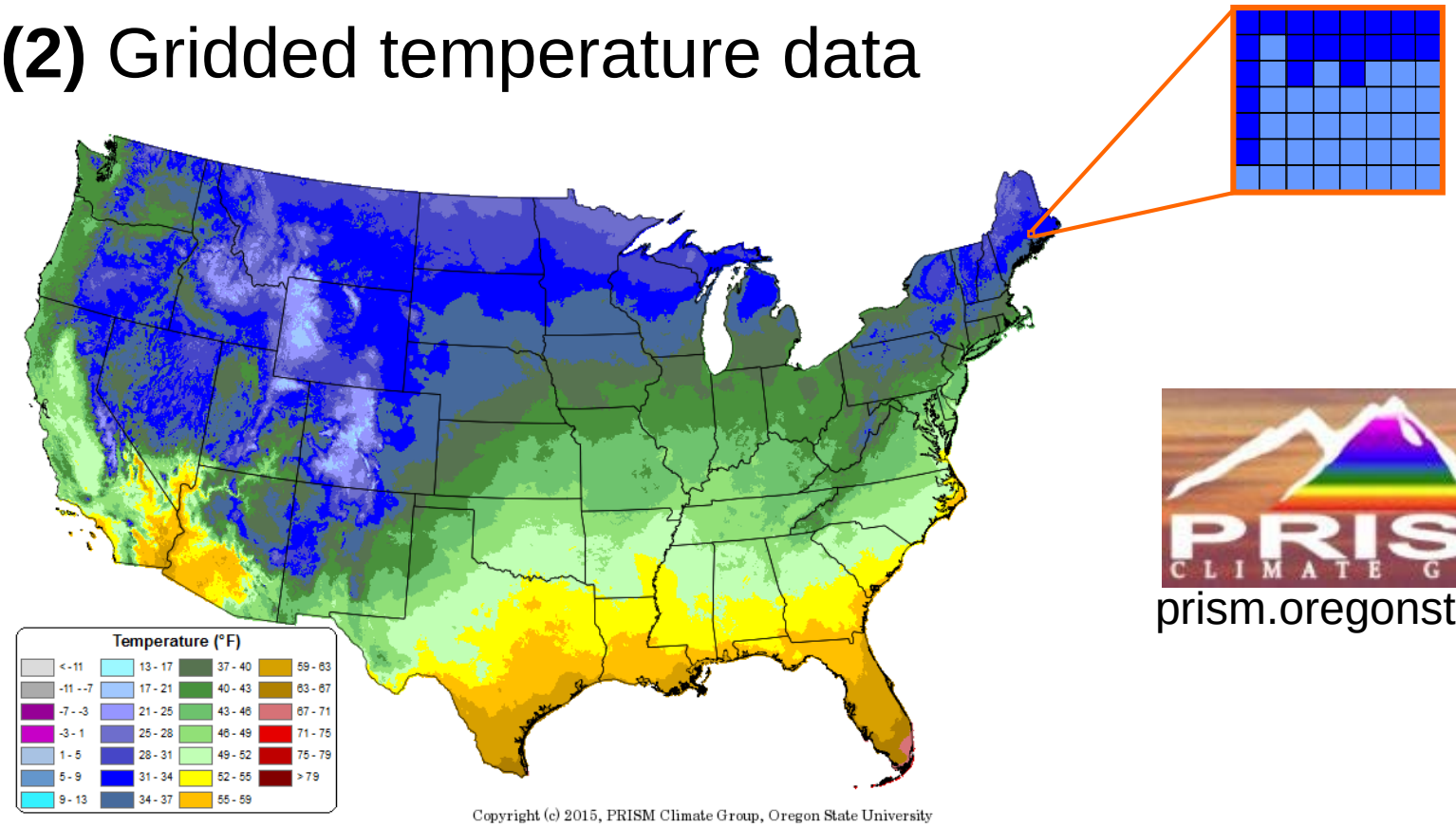
- Temp requirements
- Duration of life stages
- Lethal temps



The model simulates development through stages to predict timing of pest activities (emergence, egg hatch, etc.)

Input data

(2) Gridded temperature data

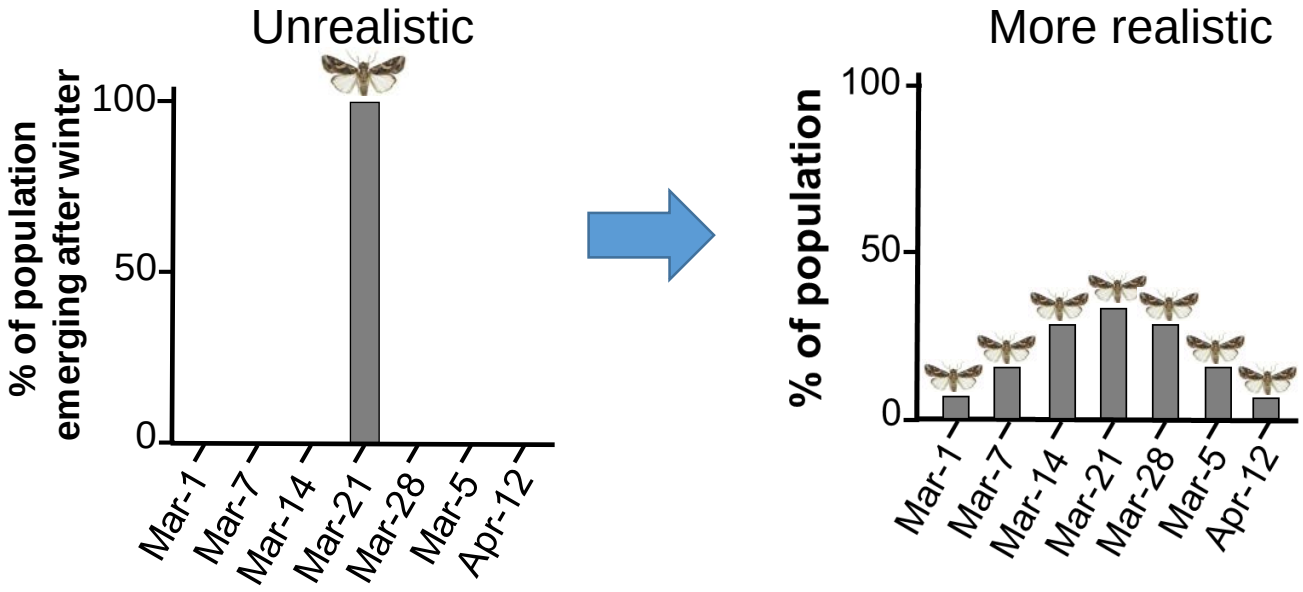


PRISM CLIMATE GROUP

prism.oregonstate.edu

Pest activities (emergence, egg hatch, etc.) are predicted at each grid (raster) pixel

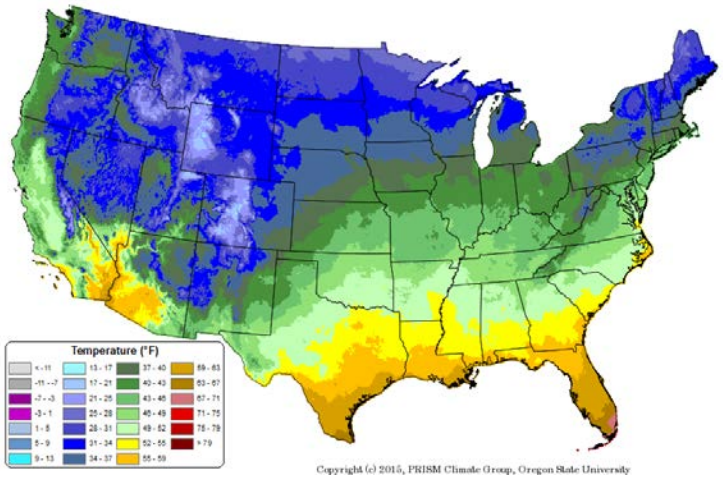
Computational overload

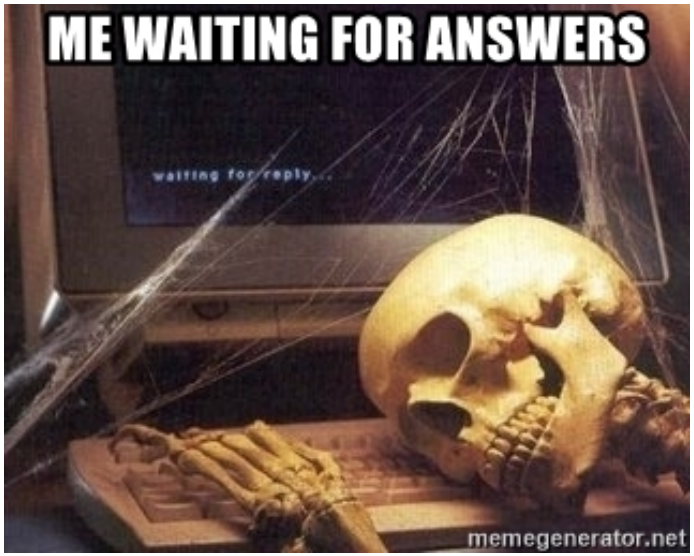


15+ species!

Run time: 1 hour
(per species)

1 hour x 7 = ***7 hours***





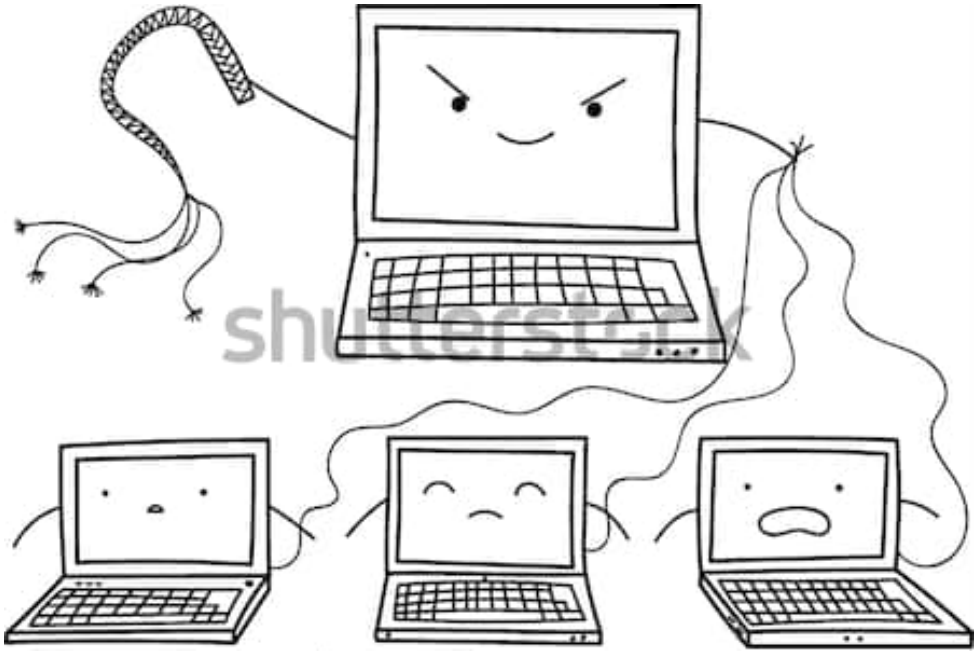
Parallel processing in R

1) `foreach` package
   - `doParallel` – "parallel backend"
   - executes `foreach` loops in parallel

2) `parallel` package
   - `mclapply` and `mcmapply` functions

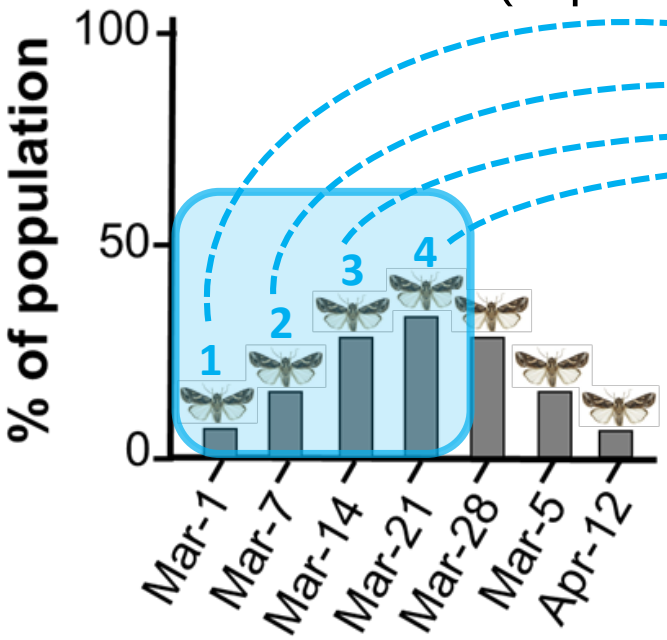
Scientific Linux 7.3

CPUs = 48



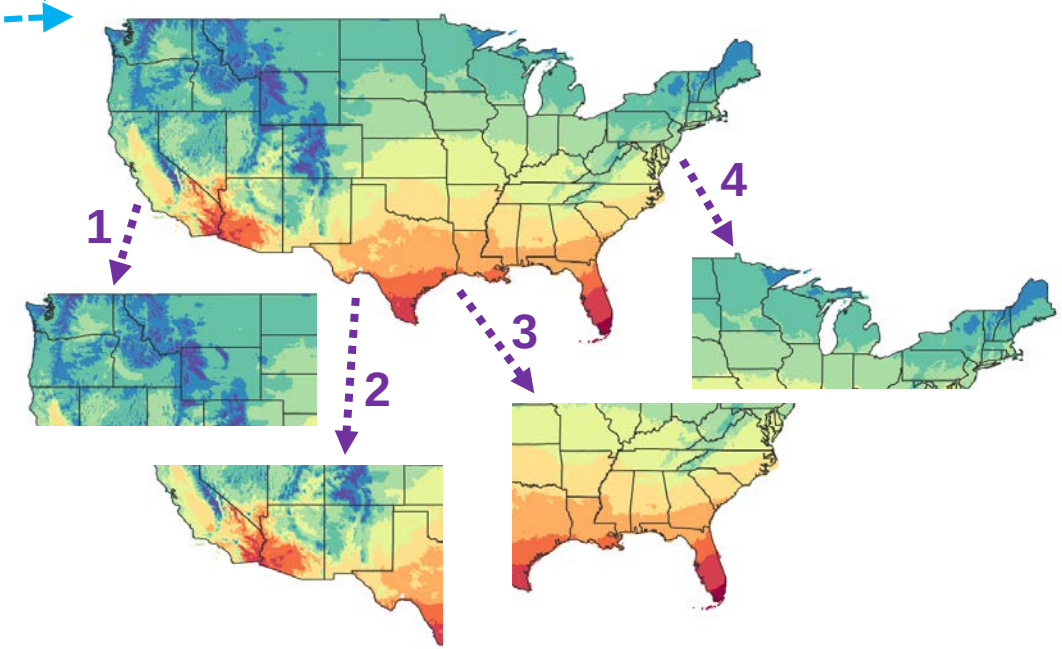
Running the model

4 cohorts (in parallel)



For each cohort:

4 temperature raster tiles (in parallel)



For each tile:

- Est. dates of development for stages
- Est. dates of activities (e.g. egg hatch)
- Est. chill and heat stress

Data Processing

- Combine (7) results
- Analysis
- Save rasters
- Plot maps

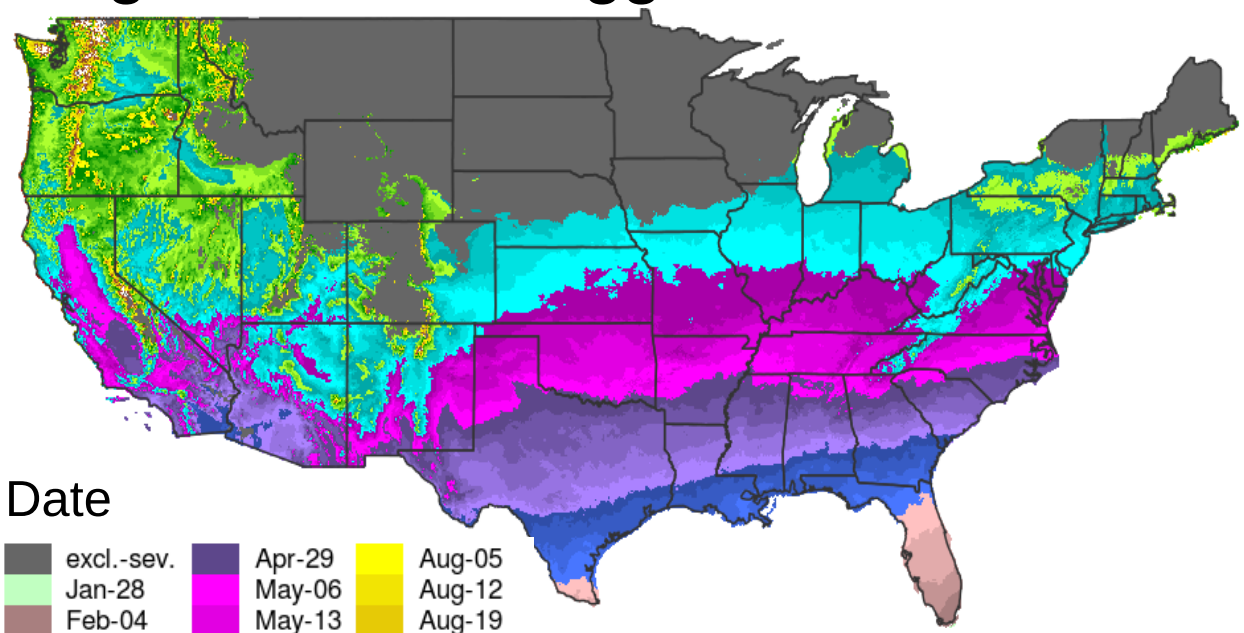
Run time = ~40 min

Example product (made in `ggplot`)

Threat to:

- Cotton
- Grains
- Soybeans
- Peppers
- Tomatoes

Avg. date of first egg hatch



Date

excl.-sev.	Apr-29	Aug-05
Jan-28	May-06	Aug-12
Feb-04	May-13	Aug-19
Feb-11	May-20	Aug-26
Feb-18	May-27	Sep-02
Feb-25	Jun-03	Sep-09
Mar-04	Jun-10	Sep-16
Mar-11	Jun-17	Sep-23
Mar-18	Jun-24	Sep-30
Mar-25	Jul-01	Oct-07
Apr-01	Jul-08	Oct-14
Apr-08	Jul-15	Oct-21
Apr-15	Jul-22	Nov-04
Apr-22	Jul-29	

Can be used to plan:

- Monitoring activities
- Chemical treatments

Thanks!

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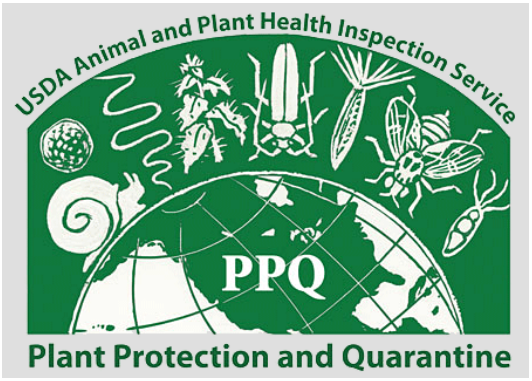

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