The Cereal Leaf Beetle and its Parasitoid under Projected Climates in the Pacific Northwest

Sanford D. Eigenbrode[1] Nathaniel Foote[1] and John T. Abatzolgou[2]
[1]Department of Plant, Soil and Entomological Sciences and [2]Department of Geography
University of Idaho, Moscow ID 83844

University of Idaho

REACCH Regional Approaches to Climate Change – PACIFIC NORTHWEST AGRICULTURE

Background

The cereal leaf beetle (CLB), *Oulema melanopus* L. (Fig. 1)

- Native to Eurasia
- Invaded North America 1962 to present
- Invaded Oregon, Utah, Montana, Idaho and Washington State 1990 to present

Tetrastichus julis (Walker) (Eulophidae) (Fig 2)

- Also native to Eurasia
- Released in USA and in PNW to control CLB
- Successfully established and evidenlty responsible for keeping CLB in check

Research Question

- How will projected climate change affect CLB and its parasitoid?

Objectives

1. Map suitability of projected climate in PNW for CLB
2. Map the phenologies of CLB and *T. julis* at fine spatial resolution (8 km) within the climatically heterogeneous PNW.
3. Map the number of overlap of the parasitoid and host under historical and projected climates for the region.
4. Incorporate published work on CLB biocontrol to refine projections

Methods

Climate: Multivariate Adaptive Constructed Analogs (MACA, Abatzoglou and Brown 2011, Abatzoglou 2012) used to model historical (1950-2005) and projected (2041- 2060) climates: 8km^2 resolution, CMIP5, RCP 4.5W/m^2. to mid-21st century.

CLB Suitability Index (SI): Calculated following methods modified from Olfert et al. (2004); calculated daily for downscaled historical and projected climate periods; historical and projected means mapped. Here we present maps of historical and 'delta' SI

CLB and *T. julis* phenology: Degree-day driven phenology based on published studies for CLB and *T. julis* used to map development of each species. Mean historical and projected number of days overlap between foraging *T. julis* and larval beetles mapped. Incorporated diapause initiation and termination requirements. Mean change in overlap days based on historical and projected climates mapped.

Warm Springs: Evans (2012) found that "warm springs" (> 320 DD by June 1) associated with reduced parasitism of CLB by *T. julis*. Historical, projected and projected change in frequency of warm springs mapped

http://ippc2.orst.edu/cgi-bin/ddmodel.pl?spp=clb) (Nechols et al. 1980, Gage and Haynes 1975)

This research is part of the *"Regional Approaches to Climate Change for Pacific Northwest Agriculture"* project, funded through award #2011-68002-30191 from the National Institute for Food and Agriculture.

Fig. 1. Top: cereal leaf beetle (CLB) adult, bottom left to right: eggs, larva, and larval feeding damage (credits: N. Foote, D. Roberts)

Fig. 2. Left: *Tetrastichus julis* ovipositing within CLB larva, right: parasitic *T. julis* larvae removed from dissected CLB larva (credits: N. Foote, Y. Wu)

Results: CLB index

CLB SI index ranges from single digits (blue) to close to 30 (red) (Fig. 3) across the region. Values above 15 indicate viable pest status can be achieved

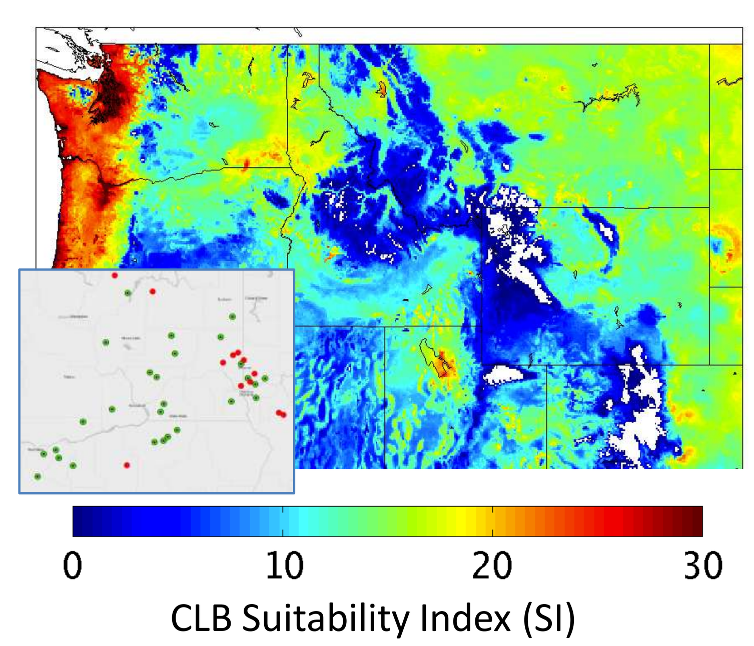

Figure 3. Map of current CLB SI values for NW region at a 8 km resolution (1979-2010). Inset: CLB occurrence (green markers = present; red = absent) within REACCH domain in 2013.

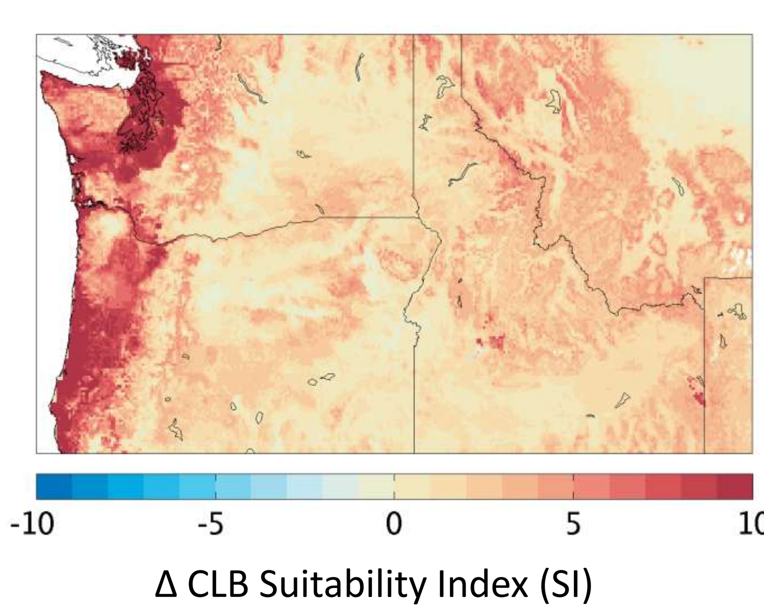

Figure 4. Map of the change in CLB SI values for NW region under projected climate change (RCP 4.5W/m^2) to mid 21st Century

United States Department of Agriculture National Institute of Food and Agriculture

Results: CLB phenology

CLB degree day models include the following developmental stages: peak and 90% egg laying, and hatch, early, peak and end larvae, overwintering and new adults Examples: diapause termination (Fig. 5) and and 50% egg hatch (Fig. 6) illustrate variation across the region

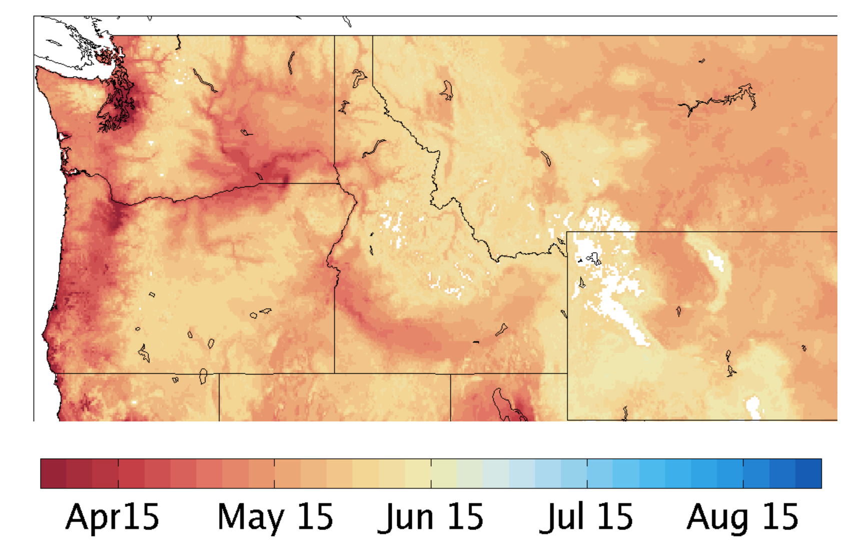

Figure 5. Historical (1979-2010) diapause termination for CLB

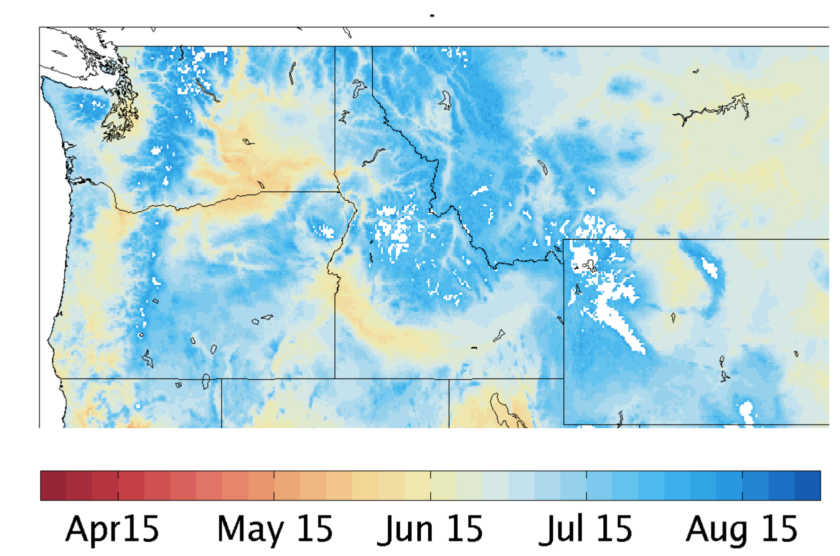

Figure 6. Historical (1979-2010) 50% egg hatch for CLB

Results: *T. julis* phenology

Phenology of *T. julis* also mapped; e.g. 1st generation emergence (Fig. 7)

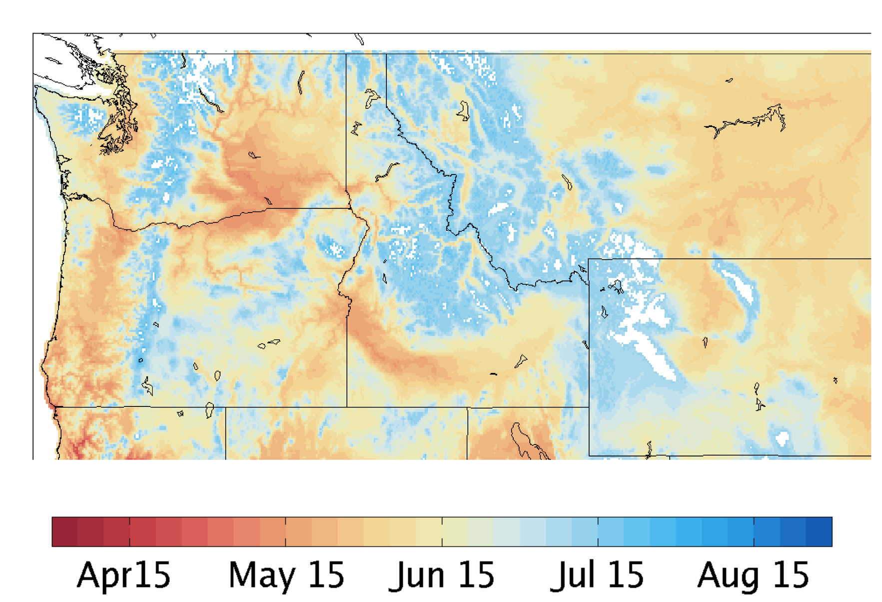

Figure 7. Historical mean date of emergence of 1st generation *T. julis*

Results: Phenological overlap

Phenology of CLB and *T. julis* at one location (Connell WA) based on mean historical climate (Fig. 8)

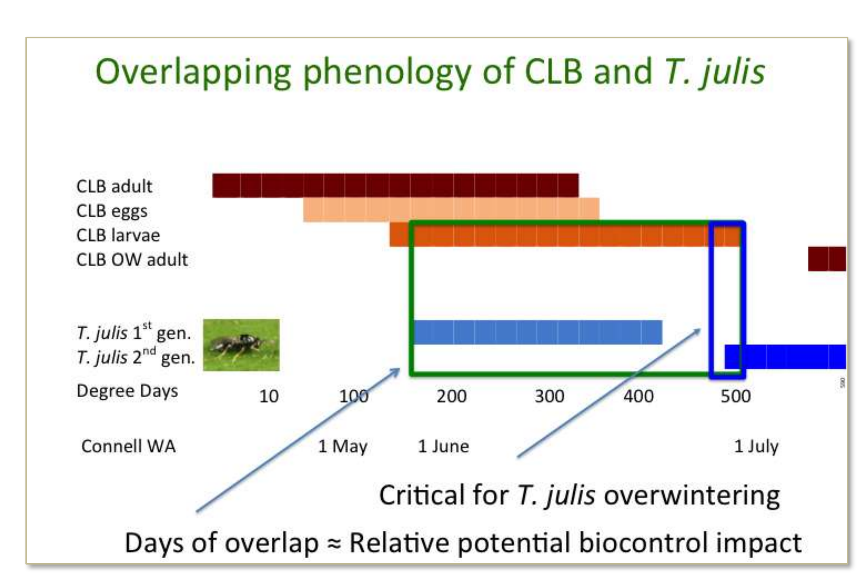

Figure 8. CLB and *T. julis* phenologies, Connell WA

Results: Projected changes in overlap

The projected changes in days of overlap between CLB larvae and *T. julis* in mid 21st century (both stages, Fig. 9 A; 2nd generation, Fig. 9B) indicate overlap generally will remain similar but increase slightly in some areas and decrease in

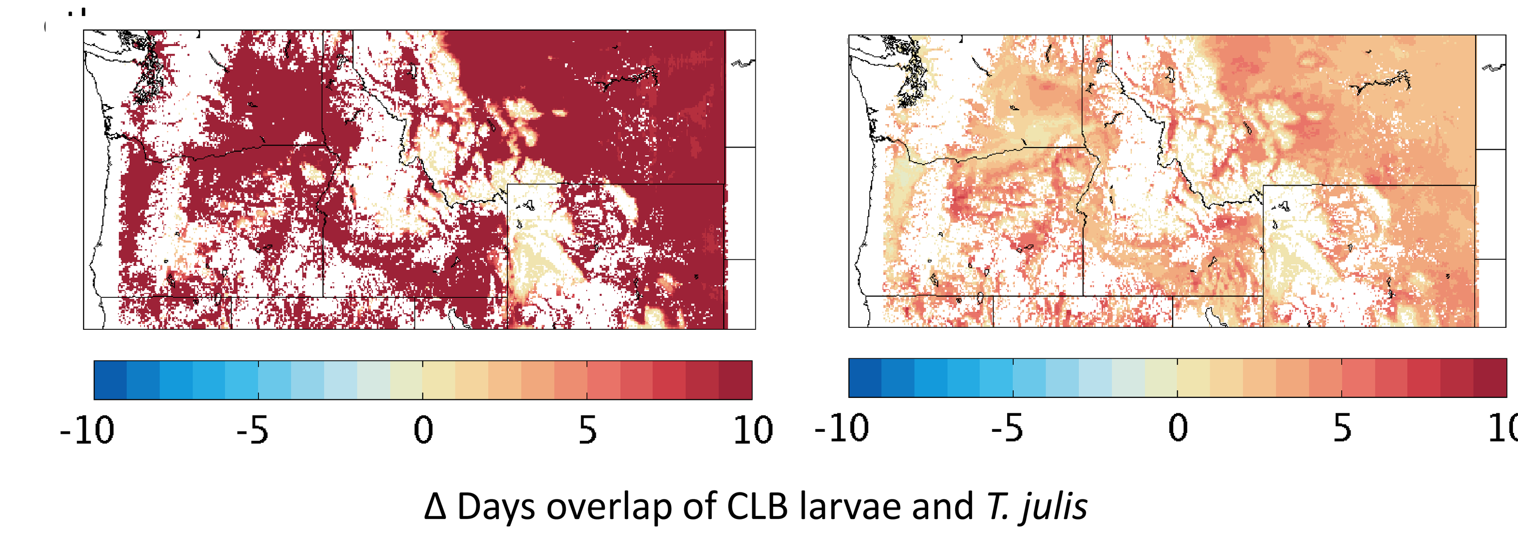

Figure 9. Mean change (days) in overlap of CLB larvae and *T. julis* A = total and B = *T. julis* 2*nd* generation between (1950-2005) and (2041-2060) (RCP 4.5W/m^2) (white areas = no CLB development in ≥20% of years)

Results: Warm springs

Warm springs are associated with reduced parasitism of CLB by *T. julis* (Evans et al. 2012) (Fig. 10). This is evidently due to different responsiveness of CLB and *T. julis* to spring temperatures – the beetle can develop more quickly in cool springs by selecting microclimates; *T. julis* is confined to soil during this period. The frequency of cold springs is projected to increase and warm springs to increase by mid century (Fig. 11).

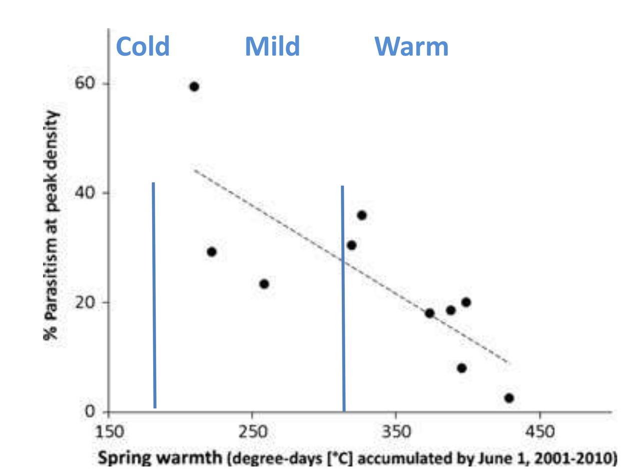

Fig. 10. Percent parasitism of CLB as function of spring warmth (Evans et al. 2012)

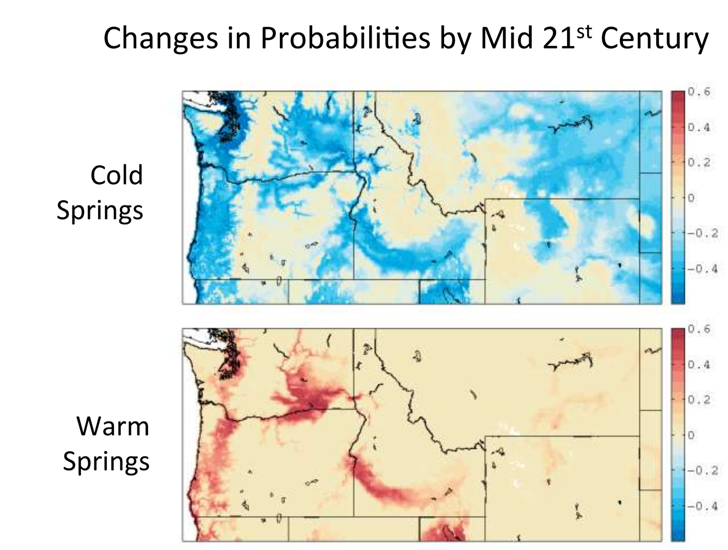

Fig. 11. Change in frequency of cold and warm springs by mid 21st century

Summary and Conclusions

- CLB SI (suitability index) generally increases by mid century, indicating potential increase in pest potential of this species.
- Based on simple degree-day models, phenological overlap of CLB and *T. julis* is projected to increase in most parts of the region, indicating biological control should remain effective to mid 21st century.
- However, warm springs, which are projected to increase generally in the PNW, are associated with reduced parasitism by *T. julis*. This suggests that biological control of CLB by *T. julis* could be compromised as temperatures warm.
- The increased frequency of warm springs is most pronounced where CLB SI is also expected to increase most strongly (compare Figs. 4 and 10).

Context

- This is a component of a larger project designed to anticipate and develop adaptation to effects of climate change on agriculture throughout the PNW region (REACCH PNA, http://www.reacchpna.org/

References Cited

Abatzoglou, J. T., and T. J. Brown. 2011. International Journal of Climatology. **32**: 772
Abatzoglou, J. T. 2013. International Journal of Climatology. **33**:121-131
Blodgett, S., C. I. Tharp, and K. Kephart. 2004. Montana State University Extension Service, Bozeman, MT.
Coop, L. 2009. Cereal leaf beetle – degree-day/phenology model summaries
Evans, E. W., N. R. Carlile, M. B. Innes, and N. Pitigala. 2012. J. Applied Entomology 137: 321-400.
Fulton, W. C. and D. L. Haynes. 1975. Economic Entomology **4**:357-360.
Nechols, J. R., M. J. Tauber, and R. G. Helgesen. 1980. Canadian Entomologist **112**:1277-1284.
Olfert, O., and R. M. Weiss. 2006. Agriculture Ecosystems & Environment 113: 295-301.
Olfert, O., R. Weiss, S. Woods, H. Philip, and L. Dosdall. 2004. The Canadian Entomologist 136: 277-287.
Phillips, C. R., D. A. Herbert, T. P. Kuhar, D. D. Reisig, W. E. Thomason, and S. Malone. 2011. Journal of Integrated Pest Management **2**: C1-C5.
Parkinson, S. C., R. L. Stoltz, J. Karren, and M. E. Cooper. 2001. Cereal leaf beetle, CIS 994, Idaho Agricultural Experiment Station, Moscow Idaho.
Roberts, D., T. Miller, K. Pike, S. Miller, and M. Klaus. 2008. Washington State cereal leaf beetle infestations and biological control summary; 1999-2008, Pullman, Washington.