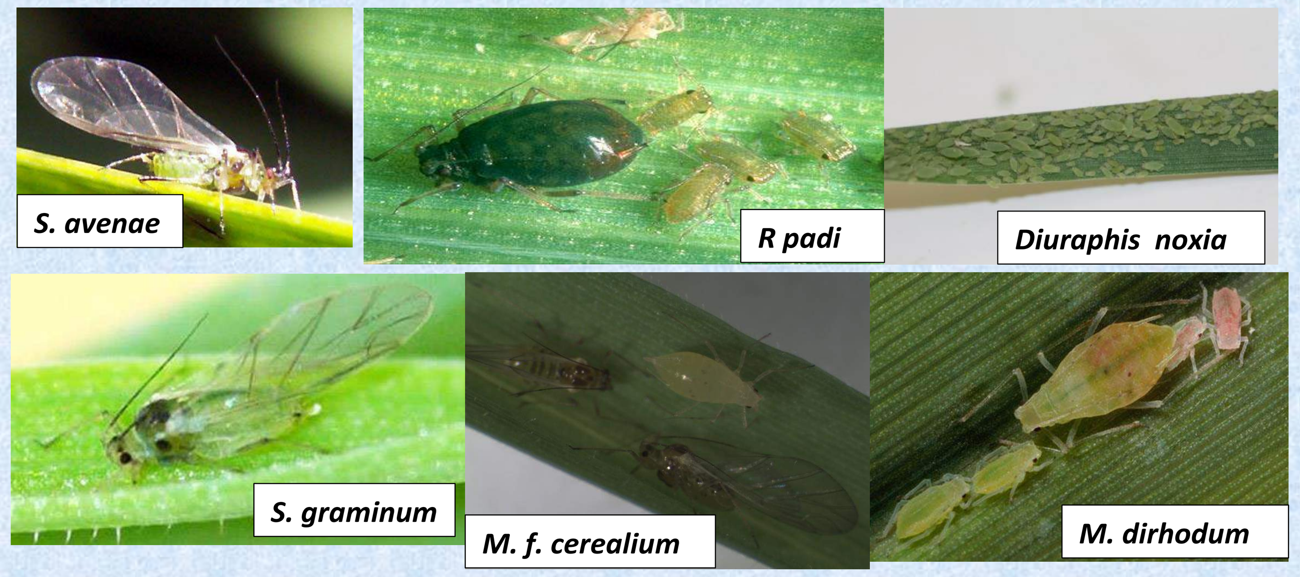
# Impacts of climatic and landscape factors on cereal aphid populations in the inland Pacific Northwest USA

S. Ebrahim Sadeghi[1]; Thomas. S. Davis[1]; Y. Wu[1], Bahman Shafii[2] , Abatzoglou, J[3] & Sanford D. Eigenbrode[1]

1- Plant, Soil and Entomological Sciences, University of Idaho
2- Statistical Programs, College of Agricultural and Life Science, University of Idaho
3 – Department of Geography, University of Idaho

## Introduction

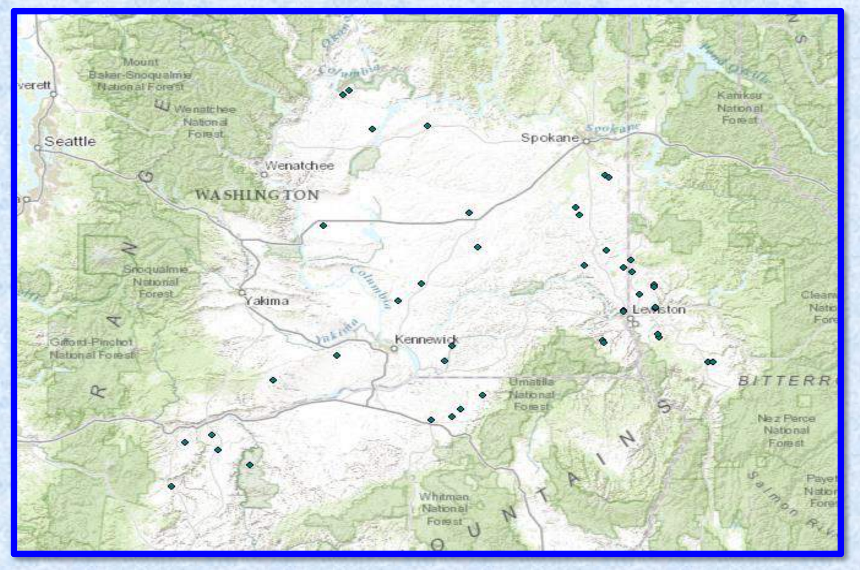
Understanding the relative influence of density-dependent and density-independent processes affecting pest populations is crucial for the application of ecology to pest management and also to understand community structure. Landscape ecology approaches can provide tools to manage agro-ecosystems in terms of sustainable crop protection against insect pests (Estevez *et al*., 2000), and epidemiology of viral diseases (Fabre *et al*., 2005). At least ten aphid species occur in cereal crops and on perennial and annual grasses in Pacific Northwest USA (PNW) (Halbert *et al*., 2013; Davis *et al*., 2014). Characteristics of aphids such as short generation times, multiple modes of reproduction, low developmental threshold temperature and efficient dispersal capabilities make them serious pests in many systems and enable them to readily respond and adapt to climate stress (Finlay and Luck, 2011) This study aimed to evaluate the hypothesis that population densities of each of four dominant aphid species in PNW cereal systems are associated with climatic factors, PNW agroclimatic zones and surface area covered with cereal crops and/or perennial grasses.

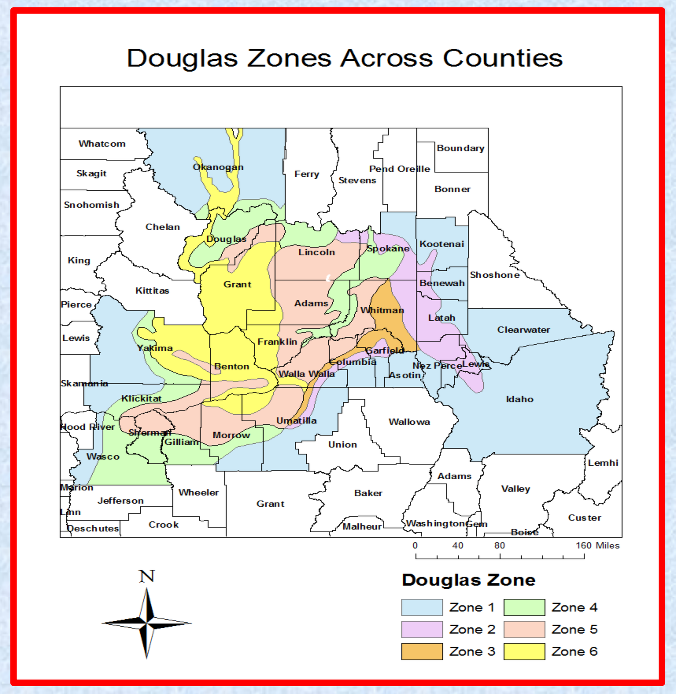



.

## Materials and Methods

Aphid samples were collected during wheat booting/early heading stage by standardized sweep netting at multiple sites within the study region of the Regional Approaches to Climate Change (REACCH) project from May to July 2011-2014. Coordinates were recorded at sampling using GPS (Fig. 1). The sites are distributed among the published "Agroclimatic Zones" of the region, as described by Douglas et al. (1992) (Fig. 2).






**Figs. 1 (above) and 2 (right). Collection sites and agro-ecological zones of the REACCH region**

Winged and wingless individuals of ten aphid species in the samples were identified based on morphological characteristics using a stereomicroscope. The number of individual aphids in each species was recorded for each collecting site and date. The sum of winged and wingless individuals within each aphid species was considered the density for that species. Unidentified immature instars were pooled as "nymphs" in this poster. Climatic metrics for each site were cumulative degree days (base 4°C) (CDD) and cumulative precipitation (CP) within the calendar year up to sampling date, and cropland cover types within some radius (500- 4000m). Aphid population densities were regressed on CDD and CP. For this study, these analyses were carried out for the four consistently most abundant aphid species pictured above, *Rhopalosiphum padi, Sitobion avenae, Metopolophim dirhodum*, and *M. festucae cerealium.* Aphid densities were converted to *ln*(x) prior to running regression models. Residuals were tested for normality using PROC univariate in SAS. Although sampling aimed for collections during the wheat booting/early heading stage, CDD differed. The data were therefore trimmed to remove extremes in CDD, including only sites sampled between 300-650 CDD.

## Results

- All regression models except for those for *R. padi* were significant (Table 1).
- Average estimated model residuals for each of aphid species, in each zone, were uniformly, randomly distributed around zero (Fig 4).
- Parameter estimates for CDD and CP were positive except for *R. padi*, indicating greater aphid abundance with increasing temperature and precipitation among the REACCH sites (Table 1).
- Mean residuals differed among agroclimatic zones; those for zone 1 notably lower than zero for all aphid species, suggesting underestimation of the model in that zone; those in zone 6 were notably greater than zero for *S. avenae* and total aphids, suggesting overestimation (Fig. 4).

**Table 1: Regression summary with parameter estimates, standard errors and significance levels for three cereal aphid species; *S. avenae, M. dirhodum, M. festucae cerealium*, total aphid, and total nymphs (pooled data: 2011-2014).**

| Variable | Parameter Estimates | SE | t Value | Pr > \|t\| |
|---|---|---|---|---|
| **Parameter Estimates for *S. avenae*** | | | | |
| Intercept | -2.97629 | 0.55752 | -5.34 | <.0001 |
| CDD | 0.00937 | 0.00104 | 9.04 | <.0001 |
| CP | 0.00389 | 0.00070426 | 5.53 | <.0001 |
| **Parameter Estimates *for M. dirhodum*** | | | | |
| Intercept | -2.21500 | 0.50322 | -4.40 | <.0001 |
| CDD | 0.00926 | 0.00093597 | 9.90 | <.0001 |
| CP | 0.00400 | 0.00063574 | 6.30 | <.0001 |
| **Parameter Estimates for *M. festucae cerealium*** | | | | |
| Intercept | -2.07260 | 0.52988 | -3.91 | 0.0001 |
| CDD | 0.00774 | 0.00098549 | 7.85 | <.0001 |
| CP | 0.00117 | 0.00066935 | 1.74 | 0.0829 |
| **Parameter Estimates for Total aphid** | | | | |
| Intercept | -2.21500 | 0.50322 | -4.40 | <.0001 |
| CDD | 0.00926 | 0.00093597 | 9.90 | <.0001 |
| CP | 0.00400 | 0.00063574 | 6.30 | <.0001 |
| **Parameter Estimates for Nymph** | | | | |
| Intercept | -2.16434 | 0.55866 | -3.87 | 0.0001 |
| CDD | 0.00499 | 0.00104 | 4.80 | <.0001 |
| CP | 0.00274 | 0.00070578 | 3.88 | 0.0001 |

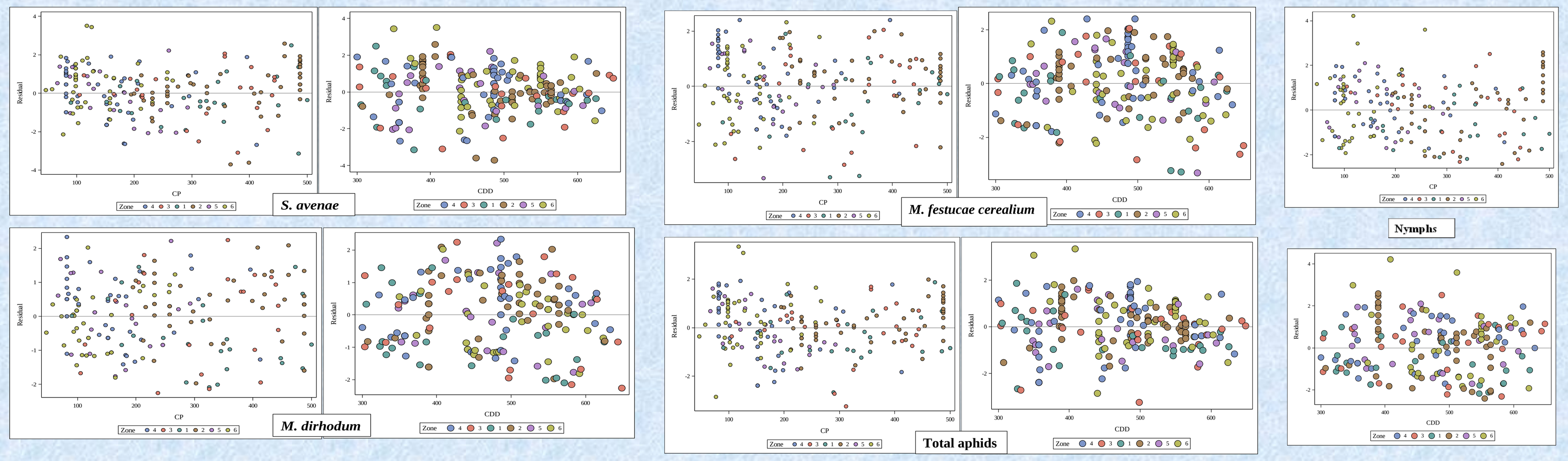



**Fig 3. Residuals for the regression *ln* (density) = Cumulative degree days (CDD) and cumulative precipitation (CP) for three cereal aphid species; *S. avenae, M. dirhodum, M. festucae cerealium*, total aphids and aphid nymphs (all species pooled)**

.

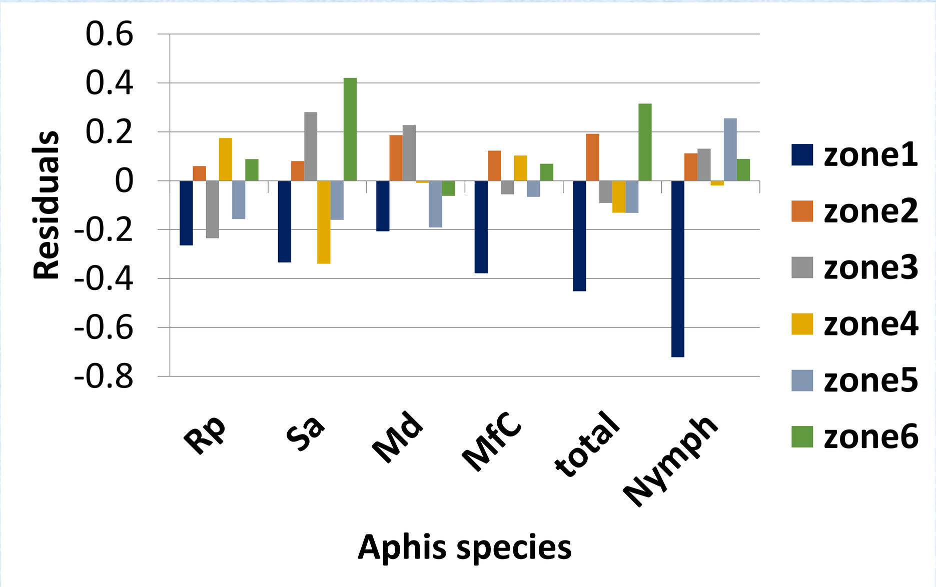



**Fig 4. Average estimated model residuals for each of the four aphid species; *R. padi, S. avenae, M. dirhodum, M. festucae cerealium*, nymph and total aphids in six agroclimatic zones**

## Conclusions

- Significant relationships between densities of aphid densities and cumulative degree days (CDD) and cumulative precipitation (CP) were detected based on regression. Positive coefficients indicate aphid densities increase with temperature and spring precipitation across the REACCH region.
- These relationships can be used as a tool for cereal aphid IPM and prediction of interannual aphid abundances in cereal fields in the inland PNW.
- The pattern also suggests increasing aphid populations with projected climate change in the region, which includes projected warmer mean temperatures and greater cool season precipitation (Mote and Salathé 2010).
- Residuals for CDD and CP in agroclimatic zone 1 indicated underestimation of the model for all species (Fig 4). This may be explained by the relatively low proportion of surface area covered by winter wheat in in that zone (Fig 5), which might cause a wide reductions in cereal aphid densities. This requires verification for other years and locations.
- By comparison, residuals are more uniform and randomly distributed in zone 2. This implies that cereal aphid population densities are not systematically different from those expected based on accumulated thermal units.
- In zone 6, where winter wheat is abundant, the residuals of *S. avenae* and total aphids suggest overestimation (Fig 4). Irrigation, which only occurs in this zone may also affect aphid populations, but mechanisms are unclear.
- Land use patterns at the landscape scale can affect insect densities (Estevez *et al*., 2000). Our previous work showed that *M. festucae cerealium* and *M. dirhodum* densities are more associated with perennial grasses than with cereal crops, whereas *S. avenae* density is more associated with cereal crop (fig 6).
- Aphid populations are evidently influenced by a combination of climatic and landscape scale patterns.

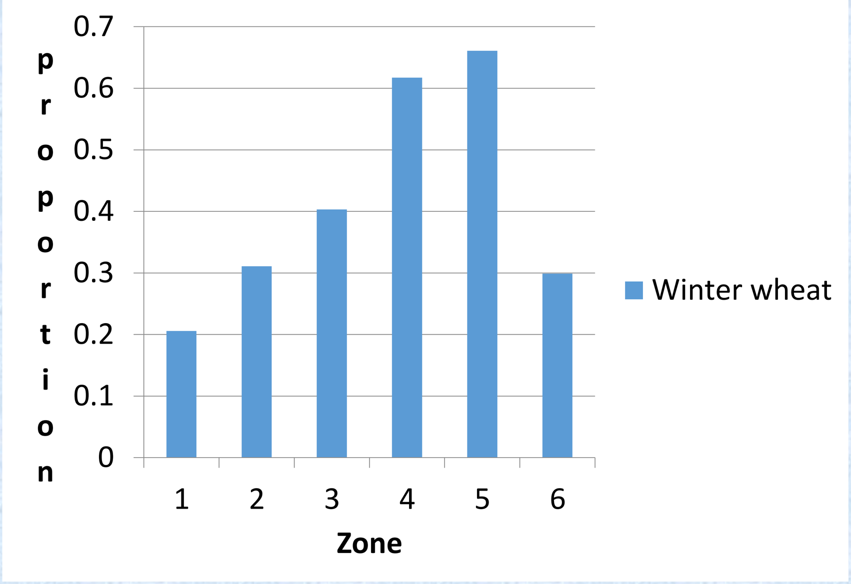



**Fig 5. Proportion of surface area covered by winter wheat in six ecological zones of PNW inland (2011)**

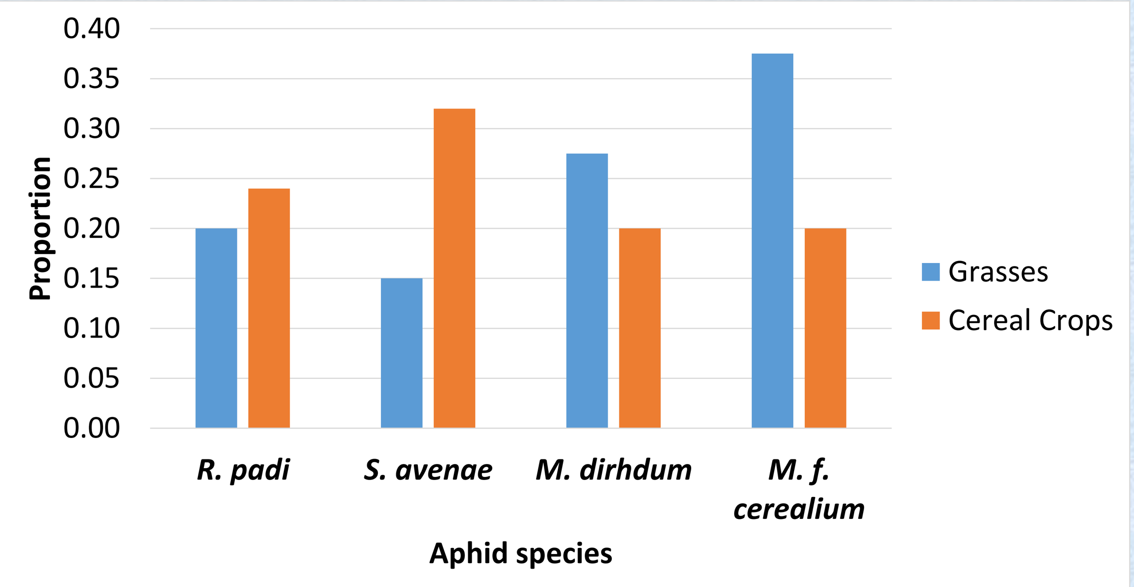



**Fig. 6. Response of *M. festucae cerealium* to perennial grasses is more apparent than the other three aphid species. Grasses include (grasslands, wild grasses, hay_ non alfalfa, Sod grasses, pastures grasses); Cereal crops include ( cereal crops, wheat, corn, sweet corn, oat, triticale, spelt ); Poaceae (Cereals + Grasses).(After Sadeghi et al., 2015)**

## References

Davis, T. S., et al. (2015 ) J. Appl. Ecol., doi: 10.1111/1365-2664.12484
Davis, T. S., et al. (2014). Ecological Entomology, DOI: 10.1111/een.12134
Douglas, C.L., et al. (1992) Northwest Science 66: 26-34.
Eigenbrode, D. S et al., (2015) REACCH Fourth annual meeting report, Moscow, Idaho
Estevez, B., et al., (2000). Phytoprotection, 81: 1-14.
Fabre, Fet al.,(2005) Agriculture, Ecosystems and Environment 106: 49-55
Finlay, K. J., and Luck, J. E. (2011) Agriculture, Ecosystems and Environment 144: 405-421
Halbert, S. E.et al. (2013). Insecta Mundi 301, 295-302.
Mote, P. W., and E. P. Salathé Jr. (2010) Future climate in the Pacific Northwest. Climatic Change DOI 10.1007/s10584-010-9848-z.
Sadeghi et al. (2015). The 99th Annual Meeting of the Pacific Branch of the Entomological Society of America.

## Acknowledgement

The research was supported by National Institute of Food and Agriculture competitive grant, award number: 2011-68002-30191