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

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Results
- All regression models except 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).

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 “Agricultural Zones” of the region, as described by Douglas et al. (1992) (Fig 2).

Figures
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 of that species. Unidentified immature instars were pooled as “nymphs” in this paper. 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 on-plant 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, Phylloxeraphis padi, Sitobion avenae, Metopolophium 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.

Conclusions
- Significant relationships between 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 that zone (Fig 5), which might cause a wide reduction 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.

References
Estevez, D. et al. (2010) REACCH Fourth annual meeting report, Moscow, Idaho

Acknowledgement
The research was supported by National Institute of Food and Agriculture competitive grant, award number: 2011-68002-30919