GRASS SEED AGRICULTURE AND INVERTEBRATE COMMUNITIES OF SEASONAL WETLANDS IN THE SOUTHERN WILLAMETTE VALLEY

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Introduction

In the lowlands of the upper Willamette River Valley, Oregon, winter flooding is an annual phenomenon driven by the seasonal precipitation regime of the Pacific Northwest (Hamlet and Lettenmaier 1999). Predictable inundation of river floodplains and expansion of stream networks like these are major processes influencing entire aquatic communities (which include fish, frogs, salamanders, insects, clams, snails, and crustaceans-such as crayfish and small shrimp like organisms) (Tockner and Stanford 2002). During the past 150 years in the Willamette River Valley the cumulative effects of navigation improvement and flood control projects, agricultural activities and urban development have altered the hydrology of the system, removed miles of side channels, and eliminated acres of floodplain that were regularly connected to the main river channel (Boag 1992; Hulse et al. 2002). Flood control and improved drainage has been achieved through channel straightening, wetland filling, dike construction and ditch development (Benner and Sedell 1997). Channel straightening alone eliminated meanders and secondary channels in the Willamette River and reduced the length of its main stem. Along a portion of the Willamette River, between the McKenzie River confluence and the city of Albany, the main channel is approximately 45% to 50% shorter than it was in 1850 (Benner and Sedell 1997; Hulse et al. 2002). Also, lowland floodplains have been partly drained through ditches and underground tile systems for agriculture. These floodplains sustain 95% of Oregon's grass seed production, and represent approximately 50% of the tillable land (some 2,000 sq km) in the entire Willamette River Valley (Gohlke et al. 1999).

Flood control efforts, however, are not effective enough to keep many grass seed producing fields in the Willamette Valley from becoming partly submerged on an annual basis. Intermittent watercourses, which include both altered stream channels and dug-out drainage ditches, have replaced most natural channels and could be considered a vestige of the larger pre-existing floodplain-river complex, one that encompassed the entire upper valley (Boag 1992). An estimated 99% of native wet prairie has been converted or lost (Daggett et al. 1998, Hulse et al. 1998, Taft and Haig 2003); but many seasonal wetlands traditionally associated with the prairie ecosystem remain on privately owned lands dedicated to grass seed production. Hydrogeomorphically, these seasonal wetlands are classified as Flats (Adamus 2001). Conservation practices associated with grass seed production are known to influence water quality and nutrient levels in streams; however, there has been little work to understand how those practices might influence the community of organisms that live in seasonal wetlands. Therefore, the goal of our study was to determine whether invertebrate community composition (i.e., species present) and biomass (i.e., mass of living organisms in a given area at a given time) differed between wetlands in grass seed fields and wetlands in native wet prairies as a result of the frequency of soil disturbance from tillage.

Methods

We collected samples of aquatic invertebrates (i.e., insects, crustaceans, mollusks, etc.) from 30 seasonal wetland sites (Figure 1). These sites were selected *a priori* based on three wetland habitat types: 1) annual grass seed fields, 2) perennial grass seed fields, and 3) remnant native wet prairie. Annual grass seed fields are plowed every year if conventional farming methods are used. Perennial grass seed fields can have established crops from three to over twenty years depending on the species of grass. Native wet prairie has never been tilled and was used as a reference for most natural conditions. We predicted invertebrate communities would have lower diversity (i.e., species numbers), density (i.e., number of individuals per unit of area), and biomass estimates in the annual grass seed wetlands than in the perennial grass seed wetlands and native wet prairie. We also predicted both grass seed wetland communities would have lower diversity, density, and biomass than native wet prairie.

Ten wetlands were sampled in each habitat type during spring 2009. In spring 2010, 28 of the same 30 sites were re-sampled; two annual grass seed field sites were not revisited. The two sampling years were analyzed separately although they were not independent, but variation between years was not a main objective for our study. We compared community composition among wetland habitat types using multi-response permutation procedures (MRPP), indicator species analysis, and non-metric multidimensional scaling (NMS) ordinations. One-way analysis of variance (ANOVA) was also used to test for differences of the measured community metrics among wetland habitat types, and pair-wise comparisons were made using Bonferroni adjustments.

Results

All of the results we report here are preliminary and estimates are displayed as non-transformed mean values that are followed by standard errors (± SE).

Invertebrate community composition differed between wetlands on native wet prairie sites and both types of grass seed sites in 2009 as well as 2010 (p-values < 0.001). NMS ordinations indicated that differences were correlated with higher diversity of invertebrate species and families, greater percentage of vegetation cover, and lower water conductivity and turbidity values for native wet prairie sites (i.e., lower amounts of fine material suspended in water). MRPP analysis for 2009 revealed a difference between annual and perennial grass field invertebrate communities as well (p-value = 0.024). Seven groups of organisms (i.e., species to families) were indicative of native wet prairie (p-values <0.05). This was based on the analyses of indicator species values that averaged over 50 for both years. In particular, the presence of a flightless beetle *Apteraliplus parvulus*, two kinds of zooplankton organisms (a cladoceran, *Dumontia oregonensis*, and a Calanoid copepod), as well as snails in the family Lymnaeidae were almost exclusively found in those reference conditions.

Native wet prairie mean Shannon-Wiener diversity values were significantly higher (p-values <0.001) than both grass seed wetland sites in 2009 (3.0 ± 0.1) and in 2010 (3.1 ± 0.04). Mean diversity values were low and differed significantly (p-value = 0.048) between annual (1.7 ± 0.2) and perennial (2.2 ± 0.1) grass seed field sites in 2010; they were lower than in 2009. Mean invertebrate density did not differ among habitat types, but perennial grass seed sites contained the highest mean density in both 2009 (18,145 ± 4,845 individuals/m^2) and 2010 (16,948 ± 3,473). Perennial grass mean invertebrate biomass (1,587 ± 309 mg/m^2) in 2009 was significantly higher than native wet prairie and annual grass seed sites. In 2010, mean invertebrate biomass of perennial grass sites (960 ± 224 mg/m^2) and native wet prairie sites (737 ± 109 mg/m^2) were higher compared to annual grass sites (395 ± 148 mg/m^2) (p-value = 0.016 and 0.036 respectively), but there was no significant difference between perennial grass and native wet prairie sites in that year. Figure 2 represents mean abundance contribution of each group, expressed as percentage, to the entire invertebrate community by land-use practice and year.

Conclusions

Our findings confirmed some, but not all of our predictions. As we predicted, aquatic invertebrate communities in native wet prairie contained the highest diversity of species and a different composition than grass seed fields. Annual grass seed wetlands had the lowest values in all of the metrics we measured in both years. However, invertebrate communities in perennial grass wetlands had the highest biomass and density estimates. These were associated with very abundant and large Ostracoda dominating most communities. Ostracoda dominance could be explained by the lowered abundance, or absence of certain types of organisms that either compete for food resources or predate upon them. Certain Ostracoda are more tolerant of higher water conductivity levels associated with increased organic inputs from fertilizer. Thus, increased organic inputs to perennial grass seed wetlands could have resulted in more abundant food availability with subsequent larger ostracod populations and body sizes. These micro-crustaceans also develop drought resistant eggs to persist in seasonal habitats (Williams 1987). The decreased frequency of tillage in perennial grass seed fields may increase the successful viability of eggs and add to the population size.

Although aquatic invertebrate communities in agricultural landscapes were less diverse than in less disturbed systems, most agricultural seasonal wetland sites were fairly complex and provided habitat for aquatic invertebrates. Perennial grass seed wetland communities were characterized by some groups of organisms more closely resembling native wet prairie, particularly larval and adult beetles (Order Coleoptera). This suggests that these habitats have more predictable wet phases. Winged insects, especially predators, were in low abundances in wetland habitat types, but present in many agricultural seasonal wetlands. The lowered abundance and absence of winged insects in many annual grass seed wetlands during 2010 compared to 2009 suggests there may be variability associated with the duration of the annual wet phase. Differences in abundances could be associated with random active (flight) colonization events, or perhaps some types of invertebrates are not selecting annual grass wetlands as often. Increased soil disturbance and field leveling in annual grass fields could cause habitats to be more unpredictable. Therefore, invertebrates with life history strategies adapted to survive dry phases in the soil and colonize wetlands from drought resistant eggs on the soil would be more successful in perennial grass seed fields.

Seasonal and annual variations in Willamette Valley grass seed-growing landscapes affect diverse strategies among aquatic invertebrate communities living in these wetland habitats. Because these wetlands support substantial food resources for aquatic and avian wildlife as well as contribute to the region's biodiversity, they should be considered in plans for regional conservation of its agricultural lands.

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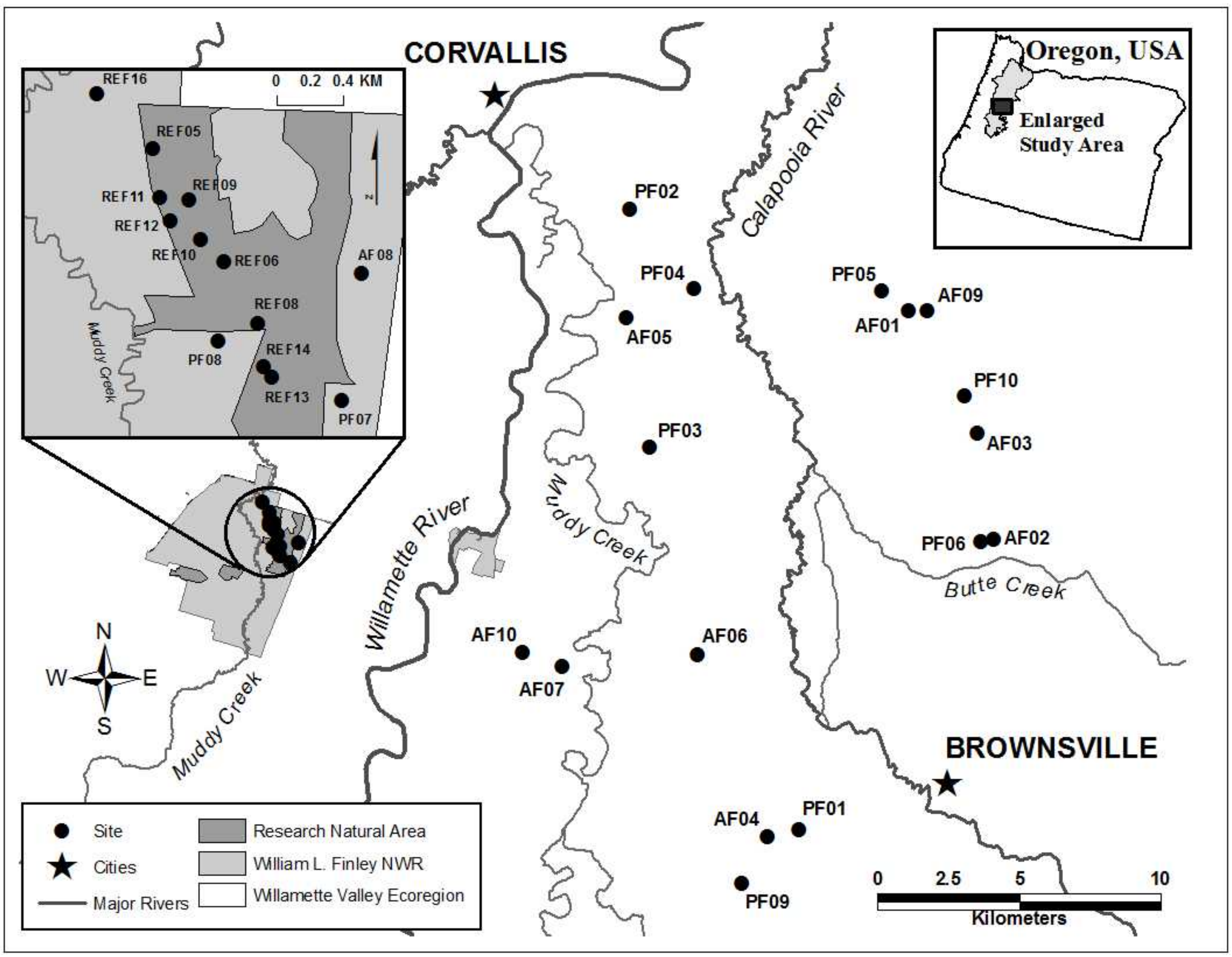

Figure 1. Map of the southern Willamette Valley study area (2009-2010). The enlarged box in the upper left-hand corner contains sites sampled at William L. Finley National Wildlife Refuge.

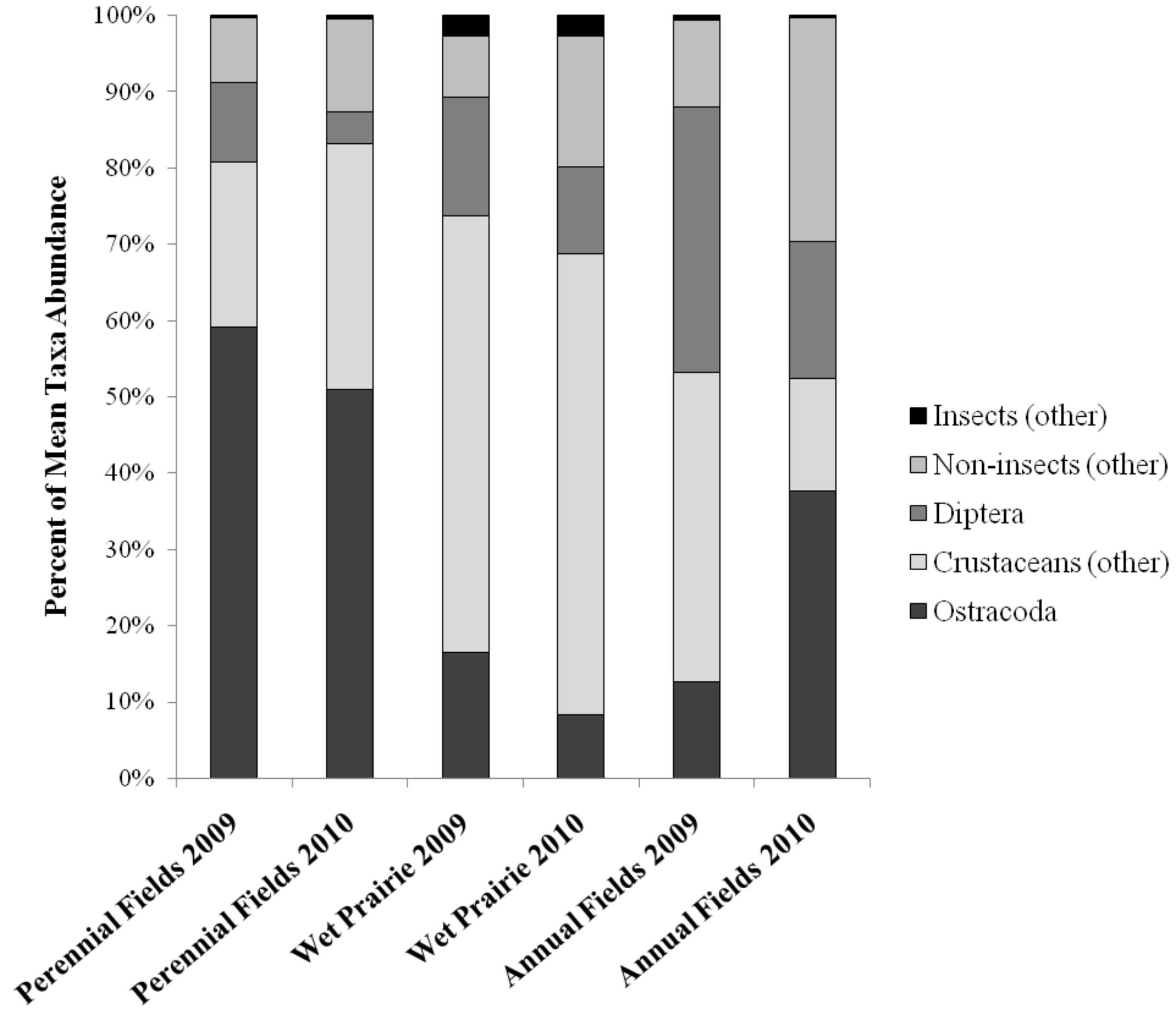

Figure 2. Similar aquatic invertebrate types were grouped together to compare group percent mean abundance contributions to entire communities, and display differences among land-use practices and years. *Note*: Ostracoda group was stacked closest to the horizontal axis and remaining groups were stacked on top by order they appear in the legend.