Herbicide treatment of invasive *Elodea canadensis* in Alaska: impacts on macrophyte-associated aquatic insects

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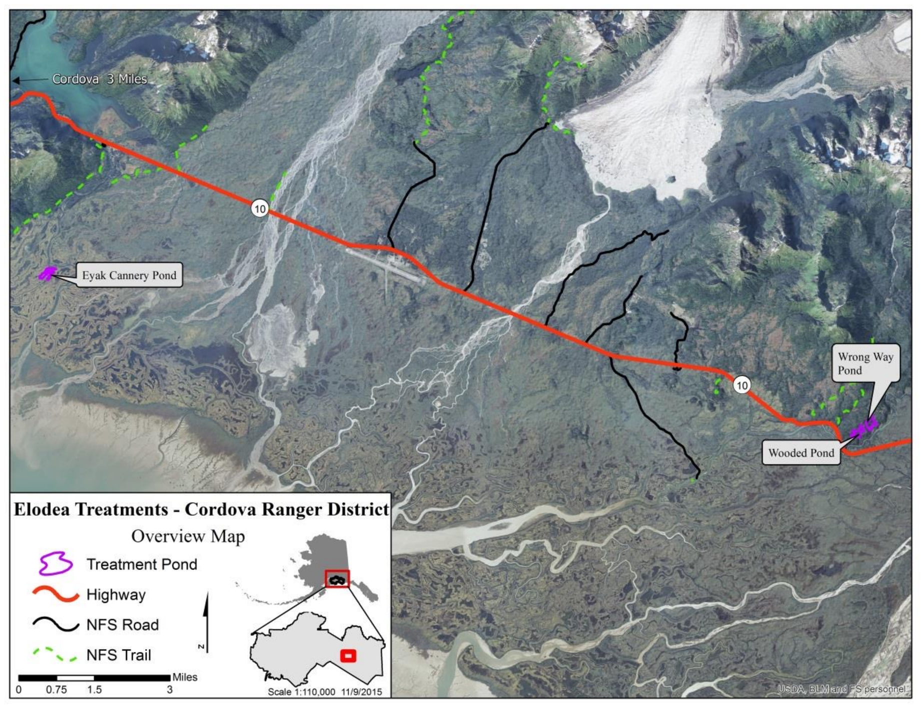
Introduction

The herbicide fluridone has been used to treat an invasive aquatic macrophyte, *Elodea canadensis* (Canadian Waterweed), on the Copper River Delta (CRD) of southcentral Alaska. The CRD is considered an important wetland complex and conservation region on the Pacific Coast. The CRD provides critical habitat for salmon and migratory birds, both of which rely on aquatic insects and other macroinvertebrates as a major food resource. To assess possible effects of fluridone on macroinvertebrate communities, aquatic vegetation, and fish, the USDA Forest Service (USFS) initiated a study on the CRD in 2016. The goal of the present study was to quantify the effects of fluridone on aquatic insect communities by using a paired design consisting of a treated and untreated pond.

Study Site

- Two ponds, an herbicide-treated (Wrongway Pond) and an untreated control (Wooded Pond) were sampled monthly from June through September 2021.
- The two ponds are adjacent to one another and are located along the Alaganik River approximately 53 km east of Cordova, Alaska.
- Both ponds contain salmonid species such as Coho Salmon and Cutthroat Trout.



Map showing location of Wooded Pond and Wrongway Pond within the Copper River Delta, Alaska

Wooded Pond

Wrongway Pond

Left: Map showing location of Copper River Watershed, Alaska

Canadian waterweed (*Elodea canadensis*)

Pond Lily (*Nuphar lutea polysepala*)

Mare's Tail (*Hippuris vulgaris*)

Methods

Sampling Equipment: 250 µm D-net and sieve

Sampling with D-net

1 m² sampling quadrat

- Aquatic insect samples were collected monthly from each pond in two types of native vegetation, Pond Lily (*Nuphar lutea polysepala*) and Mare's Tail (*Hippuris vulgaris*), and from beds of invasive Canadian Waterweed (*Elodea canadensis*).
- Replicate samples from three beds of each species were collected by sweeping a 250 µm D-net within a 1 m² quadrat for 30 seconds in each bed.
- Samples were preserved in 70-80% ethanol and insects were picked under a dissecting microscope in the laboratory.
- Insects were identified to the lowest possible taxonomic level using Merritt *et al.* (2019).
- Differences in aquatic insect densities among months, ponds, and macrophyte species were analyzed using Analysis of Variance (ANOVA).

Results

Oxyethira

Enallagma

Haliplus

Chironomidae larvae

Order/Class	Family	*Genus species*
Bivalvia	Sphaeriidae	
	Unionidae	
Gastropoda	Planorbidae	
	Lymnaeidae	
Trichoptera	Hydroptilidae	*Oxyethira*
	Leptoceridae	*Oecetis*
	Limnephilidae	*Glyphopsyche irrorata*
		Nemotaulius hostilis
	Molannidae	*Molannodes*
	Phryganeidae	*Agrypnia*
		Phyrganea cinerea
	Polycentropodidae	*Polycentropus*
Diptera	Ceratopogonidae	*Bezzia/Palpomyla/Probezzia*
	Chironomidae	
	Dixidae	*Dixella*
	Empididae	
Amphipoda	Crangonyctidae	*Crangonyx*
	Hyalellidae	*Hyalella*
Odonata	Aeshnidae	*Aeshna*
	Corduliidae	*Cordulia*
		Somatochlora sahlberg
	Coenagrionidae	*Enallagma*
Coleoptera	Chrysomelidae	*Donacia*
	Dytiscidae	*Agabus/Ilybius/Platambus/Ilybiosoma*
	Haliplidae	*Haliplus*
Oligochaeta		
Collembola	Isotomidae	
	Poduridae	*Podura*
	Sminthuridae	
Gasterosteiformes		
Hemiptera	Corixidae	*Callicorixa vulnerata*
Ephemeroptera	Caenidae	*Caenis*
Hymenoptera		
Homoptera		

Table 1. Taxonomic Composition of Macroinvertebrates in study ponds of 2021.

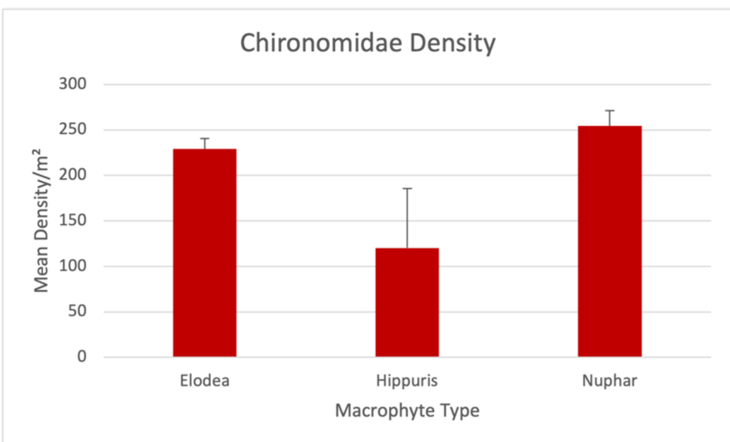


Figure 1. Chironomidae densities (mean number/m² + S.E.) across macrophyte species in two ponds (pooled) on the Copper River Delta, AK.

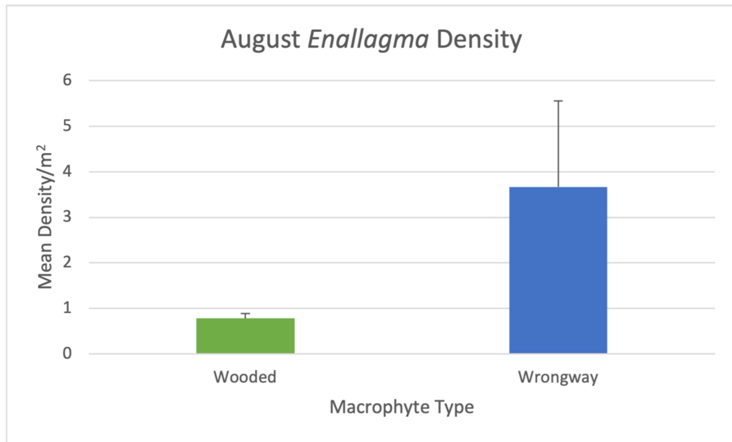


Figure 2. *Enallagma* densities (mean number/m² + S.E.) in August across ponds in three macrophyte species (pooled) on the Copper River Delta, AK.

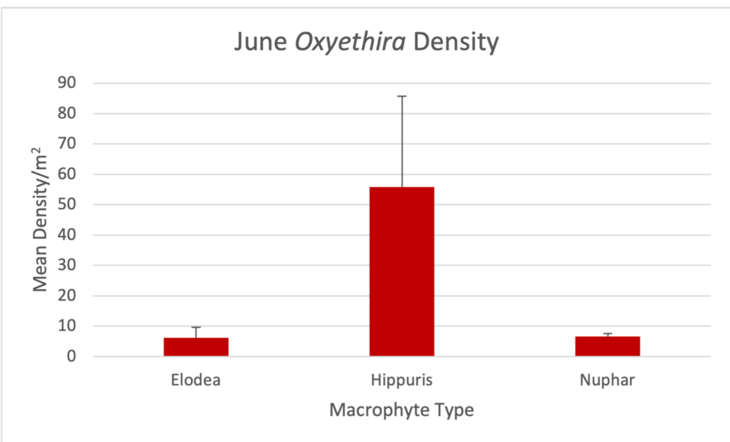


Figure 3. *Oxyethira* densities (mean number/m² + S.E.) in June across macrophyte species in two ponds (pooled) on the Copper River Delta, AK.

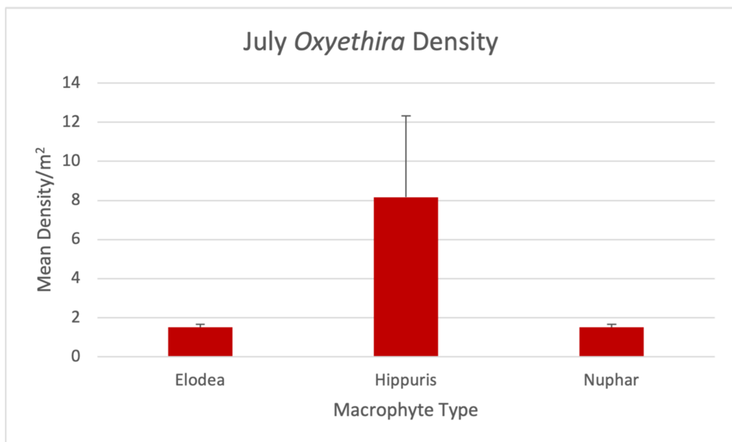


Figure 4. *Oxyethira* densities (mean number/m² + S.E.) in July across macrophyte species in two ponds (pooled) on the Copper River Delta, AK.

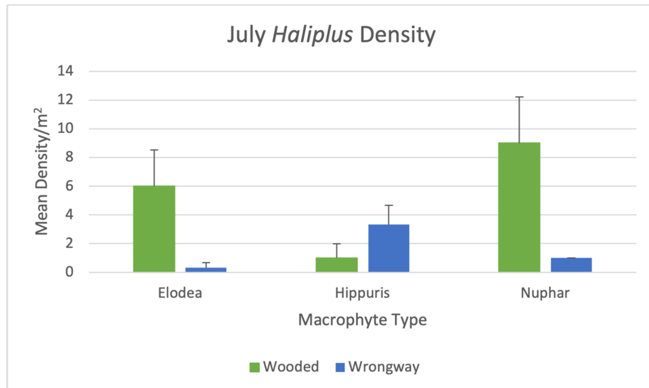


Figure 5. *Haliplus* densities (mean number/m² + S.E.) in July across macrophyte species in two ponds on the Copper River Delta, AK.

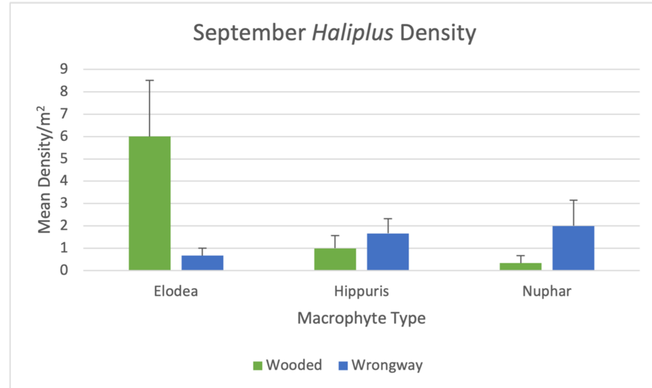


Figure 6. *Haliplus* densities (mean number/m² + S.E.) in September across macrophyte species in two ponds on the Copper River Delta, AK.

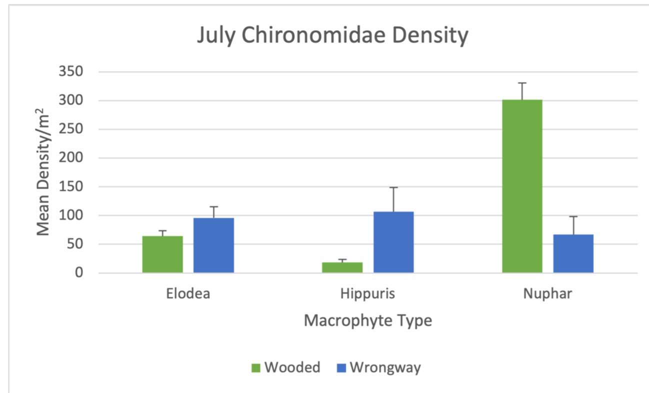


Figure 7. Chironomidae densities (mean number/m² + S.E.) in July across macrophyte species in two ponds on the Copper River Delta, AK.

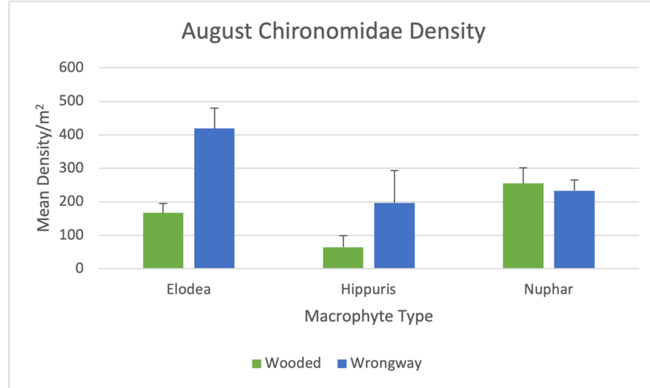


Figure 8. Chironomidae densities (mean number/m² + S.E.) in August across macrophyte species in two ponds on the Copper River Delta, AK.

- More than 22,000 macroinvertebrates were collected, counted, and identified with insects comprising 15,000 (68 %).
- Eight orders and 18 families of insects were represented (Table 1).
- Chironomidae (non-biting midges) was the most abundant taxonomic group.
- The most common insect taxa identified were Chironomidae (Diptera), *Enallagma* (Odonata: Coenagrionidae), *Haliplus* (Coleoptera: Haliplidae), and *Oxyethira* (Trichoptera: Hydroptilidae).
- Chironomidae densities were significantly different among macrophyte types (One-way ANOVA: $F_{2,18}$=4.78, p = 0.022) with significantly higher densities on *Nuphar* than on *Hippuris* (Tukey's HSD: p=0.024) (Figure 1).
- *Enallagma* densities in August were significantly higher in Wrongway Pond than in Wooded Pond (One-way ANOVA: $F_{1,12}$=6.22, p=0.028) (Figure 2).
- *Oxyethira* densities were significantly different between macrophyte species in June (One-way ANOVA: $F_{2,12}$=8.69, p=0.005) and July (One-way ANOVA: $F_{2,12}$=10.67, p=0.003). Tukey's HSD tests revealed that *Hippuris* beds had significantly higher densities of *Oxyethira* in both months compared to *Elodea* and *Nuphar* (June: p=0.008, 0.011, July: p=0.005, 0.007) (Figures 3 and 4).
- *Haliplus* densities were influenced by both pond and macrophyte in July and September as indicated by a significant interaction: July (Two-way ANOVA interaction: $F_{2,12}$= 7.20, p=0.009) and September (Two-way ANOVA interaction: $F_{2,12}$=5.15, p=0.024) (Figures 5 and 6).
- A significant interaction between pond and macrophyte species revealed that chironomid larval densities were influenced by both pond and macrophyte in July (Two-way ANOVA interaction: $F_{2,12}$=15.19, p<0.001) and August (Two-way ANOVA interaction: $F_{2,12}$=4.08, p=0.038) (Figures 7 and 8).

Conclusions

- Chironomid larval densities were significantly higher on *Nuphar* compared to *Hippuris* during the summer. Densities of chironomids on *Elodea* and *Hippuris* were not significantly different.
- Mean densities of *Oxyethira* were significantly higher on *Hippuris* when compared to both *Nuphar* and *Elodea* during June and July.
- *Enallagma* mean densities were significantly higher in Wrongway Pond in August, where invasive *Elodea* was treated, than in Wooded Pond, the untreated control.
- In July and September, the pond site influenced the response of *Haliplus* density to different macrophyte types.
- In July and August, the pond site influenced the response of chironomid larval density to different macrophyte types.
- Results of this study examining the effects of fluridone on aquatic insects were inconclusive as some taxa had higher densities in the treated pond, whereas other taxa were more difficult to interpret as a result of an interaction between pond and macrophyte species.

Acknowledgements

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