INFLUENCE OF INVASION OF PERENNIAL PEPPERWEED ON SOIL PROPERTIES

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Problem Statement: Perennial pepperweed (*Lepidium latifolium*) is a weed native to southeastern Europe and Asia that has become widely distributed in western North America and in coastal New England. A survey conducted during the summer of 1993 revealed that perennial pepperweed is a major weed pest in wetlands in all western states except Arizona. Since that time, perennial pepperweed has encroached into Arizona. The weed is found in all but three counties in California, and in a contrasting environment, all but two counties in Nevada. Perennial pepperweed was reportedly introduced into California as a contaminant of sugar beet seed. Perennial pepperweed is also a serious weed concern in northern Europe and now characterizes virtually every landfill there. This weed is also a problem in Australia.

Perennial pepperweed has not generated a lot of interest among regulatory weed suppression agencies as it initially invaded riparian areas rather than agronomic cropland. By the time it was recognized, the infestations were so well established that eradication was considered impossible.

During the last decade, wetlands and riparian habitats have become recognized as extremely important components of ecosystems. Knowledgeable individuals have suddenly realized that perennial pepperweed has completely altered the species diversity, structure, and function of these riparian areas all over the western United States. Moreover, it has spread along irrigation structures and now is a major problem in irrigated pastures, native hay meadows that are an essential part of livestock production systems, agronomic fields, and urban landscaping.

What was done? Our main study area is north of Honey Lake, California and encompasses the Honey Lake Wildlife refuge. We compared, in similar landscapes and soils, perennial pepperweed invaded areas with non-invaded controls. Soil pits were excavated to compare the soil's visual characteristics and collect samples for laboratory analyses.

RESULTS AND DISCUSSION

The study area is on the flat post-pluvial basin of Lake Lahontan. The soils are slightly saline and sodic, generally fine-textured, with compact and hard natric subsoils. Examination of soil profiles revealed striking differences between perennial pepperweed infested areas and similar non-invaded areas (Table 1). Perennial pepperweed invaded areas have thick organic and debris-rich O horizons lacking in native hayland. Most interesting is the modification of the compact subsoil to a friable black subsoil. It appears that perennial pepperweed can, in some situations, ameliorate deleterious soil properties.

Table 1. Soil descriptions and selected attributes for perennial pepperweed infested and non-infested control.[1]

Horizon	Depth	Structure	EC	% C	C:N	Horizon	Depth	Structure	EC	% C	C:N
	cm						cm				
	Infested						Non-infested				
					O1	0-+5			1.3	32.71	13.3
.A	0-5	granular	5.4	14.0	14.2	A	0-15	granular	5.8	14.24	9.2
Btn	5-18	columnar	3.4	3.48	12.9	Bty	15-28	prismatic	8.0	3.75	11.1
Bt1	18-33	prismatic	2.5	0.50	18.8	Bt	28-56	prismatic	12.0	0.42	15.1
Bt2	33-48	prismatic	2.4	0.43	111.0	BC	56-76	blocky	11.8	0.29	12.8
BC	48-68	blocky	3.6	0.42	59.7	C	76-106	blocky	22.0	0.33	10.4

[1] Soil described at the Mapes Ranch just north of Honey Lake, CA on July, 1992. Non-infested area is used as native hayland.

This ameliorative influence is supported by data collected on the Honey Lake Wildlife refuge (Table 2). In this study samples were collected, by depth, from the center of perennial pepperweed colonies that were no older than four years. The lower depth corresponds to the top of the natric subsoil. These samples were paired with adjacent non-invaded areas occupied by tall wheatgrass planted in 1989. In the top of the natric horizon, both water-soluble sodium and the sodium absorption ratio (SAR) were significantly less on perennial pepperweed invaded areas. Decreased sodium content and lowered sodium absorption ratios would lead to more favorable soil structural properties, which corroborate physical evidence from soil pedons.

The decrease in sodium in the subsoil appears to be partially offset by plant uptake and deposition at the soil surface in perennial pepperweed invaded areas (Table 2). This increase in sodium content of surface soil as well as an increase in several other solutes (Table 2) cautions that long-term invasion by perennial pepperweed may increase the osmotic potential of the soil surface, which will negatively impact seed germination and growth of salt-intolerant species.

A key in long-term control of invasive weeds such as perennial pepperweed would be to understand how it is so competitive. Perennial pepperweed is both a prolific seed producer and can rapidly expand via a creeping rhizome. Moreover, it's ability to spread and form dense monocultural stands that retard light penetration to the soil surface would be another competitive advantage. A most important aspect in perennial pepperweed competitiveness is its rapid growth rate compared to native flora. This rapid growth must occur in concert with rapid nutrient uptake, especially uptake of nitrogen. It appears that a mechanism to assure adequate nitrogen uptake of the species occurs via elevated enzyme activities in the soil (Table 3). If we can determine how perennial pepperweed modifies the soil environment to elevated nitrogen enzyme activities (root exudates, modification of soil microbial populations) we may be able to target a specific pathway to decrease nitrogen uptake of perennial pepperweed. In this scenario, more nitrogen-efficient native plants would be able to elevate their competitive profile relative to perennial pepperweed.

Table 2. Solutes in saturation extracts from intact soil cores, by depth, of perennial pepperweed invaded and adjacent non-invaded areas planted to tall wheatgrass (four replicates).[1]

	Depth 2-10 cm		Depth 22-30 cm	
Attribute	Grass	P. pepperweed	Grass	P. pepperweed
Potassium (mg kg^{-1})	8.1[a]	30.3[b]	7.6[a]	23.1[b]
Calcium (mg kg^{-1})	21.1[a]	68.8[b]	18.4[a]	88.3[b]
Nitrate (mg kg^{-1})	13.9[a]	35.0[b]	9.3[a]	22.2[b]
Sodium (mg kg^{-1})	377.0	775.0	2275.0[a]	436.0[b]
SAR	4.9[a]	2.7[b]	9.3[a]	3.0[b]

[1] Material collected on the Honey Lake Refuge, June 13, 1996. For each depth increment, significant ($P \leq 0.05$) differences between grass and perennial pepperweed microsites were deduced by ANOVA with mean separation using Duncan's test. Means followed by different letters are statistically different at $P \leq 0.05$ level.

Table 3. Soil enzyme activities, 0-20 cm, of asparaginase and urease in perennial pepperweed invaded and non-invaded control.[1]

Enzyme		Grass	Perennial pepperweed
Asparaginase activity	μmoles g^{-1} h^{-1}	0.70[a]	2.91[b]
Urease activity	μmoles g^{-1} h^{-1}	2.71[a]	5.10[b]

[1] Material collected June 13, 1996 at Honey Lake Wildlife Refuge. Significant ($P \leq 0.05$) differences between grass and perennial pepperweed microsites are deduced by ANOVA with mean separation using Duncan's test. These enzymes cleave amine groups from asparagine and urea, respectively. Means followed by different letters are statistically different at the $P \leq 0.05$ level.