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Evaluation of a Late Summer Imazapyr Treatment for Managing Giant Reed (*Arundo donax*)

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ABSTRACT

Giant reed has invaded riparian habitats throughout California and the United States. Imazapyr, which can be used for California habitats with an appropriate application regime, has only been recently approved for use in controlling this species in California; therefore, little published data exists on its efficacy. We monitored a site where imazapyr had been applied with the purpose of testing the hypothesis that a 1.5% solution of imazapyr applied as a foliar spray was effective at killing giant reed. Plants treated with 1.5% imazapyr had reduced leaf chlorophyll content less than 30 days after treatment but recovered the following spring. Treatment with 1.5% imazapyr did not significantly reduce the proportion of living stems or prevent the production of new stems during the spring following treatment.

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INTRODUCTION

Giant reed (*Arundo donax* L.) has invaded riparian habitats throughout the United States (Bell 1997). It is a perennial reed that may grow in or near freshwater and is listed as an emergent aquatic plant by Cook (1990). Giant reed appears similar to common reed (*Phragmites australis* (Cav.) Trin.), except that it is taller and the stems are more robust. It forms clumps that may be several meters across, containing up to several hundred stems per clump, and stems may reach 8 m in height (DiTomaso and Healy 2003). Giant reed biomass may be abundant (Perdue 1958, Sharma et al. 1998, Spencer et al. 2006) and quite flammable at the end of the growing season. In some Californian riparian zones giant reed's presence has changed control of ecosystem processes from flood- to fire-regulated processes (Rieger and Kreager 1989). In these systems it seems to fit the description of a transformer species proposed by Richardson et al. (2000). Giant reed is considered a "noxious weed" in Texas (Office of the Secretary of State 2007, http://info.sos.state.tx.us/fids/200701978-1.html) and California (Department of Food and Agriculture 2007, http://www.cdfa.ca.gov/phpps/ipc/encycloweedia/pdfs/noxiousweed_ratings.pdf).

Giant reed may be controlled by mechanical treatments (Lowrey and Watson 2004), covering plants with tarps, treating the plants with herbicides (Finn and Minnesang 1990, Jackson 1994, Bell 1997, Brenton 2002, Spencer et al. 2008), or by combinations of these approaches, such as treating cut stems with herbicides (Team Arundo del Norte 2007, http://www.ceres.ca.gov/tadn/). At this writing there are no biological control agents available for use in the United States (Tracy and DeLoach 1999), but potential agents are being evaluated at a USDA ARS laboratory in Weslaco, TX.

The herbicide most frequently used for giant reed control in California is glyphosate. Imazapyr has recently been approved for this purpose (Brenton 2002, 2003); however, there is little published data on imazapyr's effectiveness at controlling giant reed in California habitats. Additional information on the effects of imazapyr would help managers select a treatment approach. The purpose of this study was to test the hypothesis that a 1.5% solution of imazapyr applied as a foliar spray was effective at killing giant reed plants.

MATERIALS AND METHODS

The experiment was conducted at Gray Lodge Wildlife Area located about 16 km west of Gridley, California. The imazapyr treatment (1.5%; Habitat®) was applied as spot treatments (i.e., giant reed plants were treated directly) from a helicopter by a private contractor (arranged by the California Department of Fish and Game) using the surfactant R-11 (5 ml/L). Treatments were applied 28 July 2006 when the study wetland was dry. We collected pre- and post-treatment measurements from eight treated giant reed plants within Gray Lodge Wildlife Area and three un-treated control plants adjacent to Gray Lodge Wildlife Area.

Prior to and following herbicide treatments we visited each site on multiple dates to collect plant data. To assess plant condition we measured leaf greenness using a Minolta 502 SPAD meter (Spencer et al. 2007). We collected readings from 10 leaves within each plant on each sampling date. The SPAD readings were the average of three readings made at the base, midpoint, and tip of each leaf and are strongly correlated with leaf chlorophyll content for giant reed (Spencer et al. 2008). We measured the number of living and dead stems present in 20×30 cm quadrats randomly placed within the giant reed clumps. Data from five quadrats were collected for each plant on each sampling date. In the absence of leaves, living stems were distinguished from dead stems based on the presence of a green patch adjacent to nodes. The proportion of living stems was calculated by dividing the number of living stems by the total number of stems within each quadrat. Beginning spring 2007 we also counted the number of newly emerging stems within each quadrat.

To further characterize the plants, we measured the width of each plant at its base to the nearest 0.01 m. We measured the height of five stems from each plant with a telescoping fiberglass measuring rod. We used stem height to estimate stem weight using previously determined allometric equations (Spencer et al. 2006) and then used this information in conjunction with the number of stems per square meter to estimate giant reed biomass.

The proportion of living stems per quadrat, the mean SPAD reading, and the number of newly emerging shoots were analyzed statistically to detect treatment effects using SAS software. Data were checked for homogeneity of variances and normality of error distributions prior to further analysis. When necessary, an appropriate transformation was applied before performing analysis to remove heterogeneity of variance. A mixed model analysis was fitted using SAS software, PROC MIXED (Litell et al. 2006), considering treatment and date as fixed effects and plant as a random effect. Because the time intervals between measurements were variable, we used the spatial power variance structure. Significance testing was performed for all fixed effects and all possible interactions among them. Count variables (number of new stems per plant), which could not meet the normal distribution assumption, required a Generalized Linear Mixed Model, and were fitted with SAS PROC GLIMMIX (SAS Institute Inc. 2004). Tests were considered significant at a probability level below 0.05; however, exact probability levels for fixed effect tests are shown in the results.

RESULTS AND DISCUSSION

Giant reed plants used in these experiments were typical of giant reed throughout the United States. Plants at Gray Lodge averaged 2.5 m in width at the base of the clump (range 0.5 to 6.8 m); 122 stems/m^2 (range 33 to 400 stems/m^2); 4.0 m mean stem height (range 0.6 to 9.6 m); and 27.6 kg/m^2 aboveground biomass (range = 0.6 to 83 kg/m^2). Thus, these plants were similar to those used in previously reported glyphosate experiments (Spencer et al. 2008) and to plants from other sites in North America. Spencer et al. (2006) reported that giant reed plants at California, Mississippi, and Texas sites averaged 3.4 m tall (range 1.7 to 5.46 m), 75 stems/m^2 (44 to 178 stems/m^2), and biomass values of 17.12 kg/m^2 (range 3.07 to 39.97 kg/m^2).

At Gray Lodge Wildlife Area, a reduction in leaf chlorophyll content was evident for treated plants within a month after treatment (Figure 1; Table 1). Leaf chlorophyll content continued to decrease through November, but began to increase the following spring. There was a consistent treatment effect on leaf chlorophyll content, however, as indicated by the lack of a statistical interaction term between date and treatment in the analysis of variance (Table 1). In contrast, the proportion of living stems did not show a significant reduction for treated plants, although there were significant changes over time (Figure 1; Table 1). The number of new stems produced the spring following treatment increased over time but was not affected by the imazapyr treatment (Tables 2 and 3). The current results differ somewhat from Brenton (2002), who did not provide data but reported that the effects of 3 to 5% solutions of imazapyr applied with back pack sprayers were evident in the upper part of the shoot two to three months after application. We first observed reduced chlorophyll content one month after treatment. Brenton

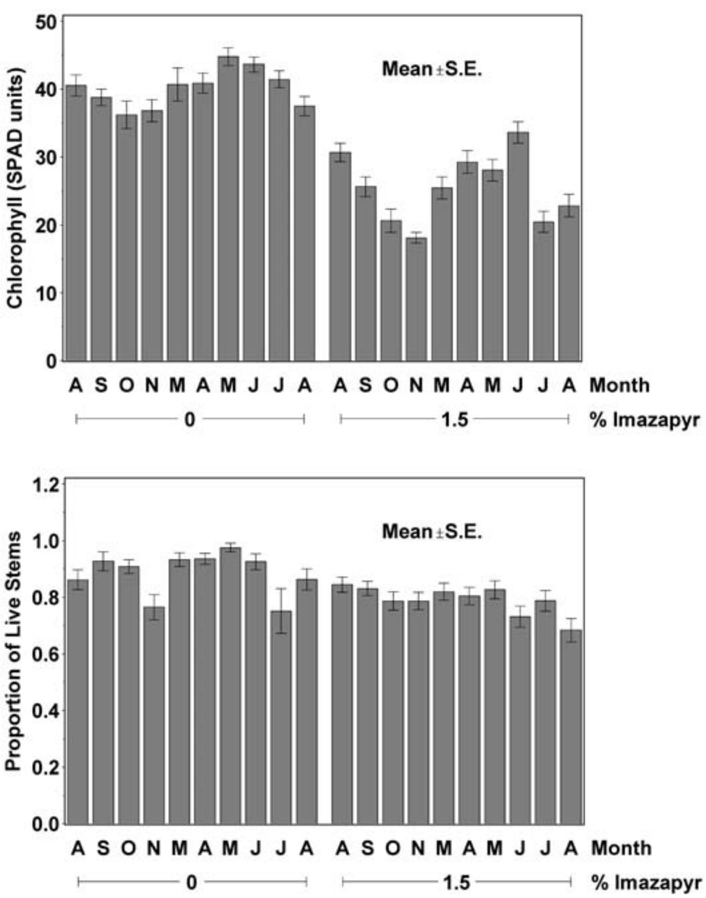

Figure 1. Leaf chlorophyll content (SPAD units) and proportion of live stems for giant reed at Gray Lodge receiving either 0 or 1.5% Imazapyr herbicide. In this figure the control is designated as "0." Imazapyr was applied as Habitat herbicide. The order of months shown on the horizontal axis is August 2006, September 2006, October 2006, November 2006, March 2007, April 2007, May 2007, June 2007, July 2007, and August 2007. Values are the mean ± the standard error of the mean (S.E.). Three plants served as controls and eight plants received the herbicide treatment; 10 leaves were measured for each plant for each date.

TABLE 1. RESULTS OF ANALYSIS OF VARIANCE USING A MIXED MODEL FOR CHARACTERISTICS OF GIANT REED RECEIVING IMAZAPYR TREATMENTS (CONTROL, 1.5%) AT GRAY LODGE, CALIFORNIA.

SPAD Reading—Gray Lodge

Effect	Num DF	Den DF	F Value	Pr > F
Treatment	1	9	24.63	0.0008
Date	9	80	2.48	0.01
Treatment*Date	9	80	1.21	0.30

Proportion of stems that are alive—Gray Lodge

Effect	Num DF	Den DF	F Value	Pr > F
Treatment	1	9	1.09	0.32
Date	9	80	2.07	0.04
Treatment*Date	9	80	1.93	0.06

TABLE 2. NUMBER OF NEW STEMS EMERGING PER SQUARE METER IN 2007 FOR GIANT REED AT GRAY LODGE WILDLIFE AREA. CONTROL PLANTS ARE DESIGNATED AS RECEIVING 0% HERBICIDE. VALUES ARE THE MEAN ± THE STANDARD ERROR OF THE MEAN. GRAY LODGE WILDLIFE AREA HAD EIGHT TREATED PLANTS AND THREE UN-TREATED CONTROL PLANTS, AND FIVE QUADRATS WERE MEASURED FOR EACH PLANT FOR EACH DATE.

		Imazapyr (%)	
Site	Date	0	1.5
Gray Lodge	3/22/07	8.9 ± 4.3	1.3 ± 0.9
Wildlife	4/20/07	16.7 ± 2.3	0.8 ± 0.6
Area	5/18/07	36.7 ± 4.1	4.6 ± 2.0
	6/19/07	42.2 ± 5.1	25.4 ± 8.9
	7/19/07	36.6 ± 6.5	49.9 ± 12.4
	8/16/07	46.7 ± 6.9	52.9 ± 14.0

TABLE 3. RESULTS OF ANALYSIS OF VARIANCE USING PROC GLIMMIX FOR NUMBER OF NEW STEMS PRODUCED IN THE SPRING FOLLOWING TREATMENT BY GIANT REED RECEIVING IMAZAPYR TREATMENTS (CONTROL, 1.5%) AT GRAY LODGE, CALIFORNIA. SIMILAR ANALYSIS FOR DATA FROM SONOMA CREEK AND SYCAMORE ISLAND RANCH IS NOT AVAILABLE BECAUSE MOST PLANTS TREATED WITH GLYPHOSATE IN THESE EXPERIMENTS DID NOT PRODUCE NEW SHOOTS.

Gray Lodge

Effect	Num DF	Den DF	F Value	Pr > F
Treatment	1	9	3.10	0.11
Date	5	44	3.81	0.006
Treatment*Date	5	44	2.29	0.06

(2002) did not specify the time of application but indicated that, while giant reed would remain, it would be non-competitive for light, and that after one year the plants could be removed by cutting. Results of the present study indicate that chlorophyll levels in the leaves began to recover in the spring following a late summer treatment and that new stem production by treated plants was not statistically distinguishable from control plants. These results also indicate that a late summer treatment with imazapyr was not as effective as treatment with 1.5% glyphosate applied in September (Spencer et al. 2008). The present results also differ with our own experience with imazapyr using a different application technique later in the year, which killed giant reed stems (Spencer unpublished data). The difference we observed at Gray Lodge may be due to both timing of application or the amount of material applied.

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