Flowering Rush Control Project for Lake Pend Oreille, Idaho: Preliminary Summary on Mesocosm and Field Evaluations

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Introduction

Flowering rush (*Butomus umbellatus*) was found north of the Clark's Fork delta in both 2007 and 2008 and represents a unique population for Lake Pend Oreille (Ling Cao 2009). The majority of flowering rush in the Lake Pend Oreille system is located in the Clark Fork River delta area. This area is owned by the USACE and serves as a source of infestation to other parts of the lake and Columbia River system. Small populations have been found taking hold throughout the lake and downstream of Albeni Falls Dam on the Pend Oreille River in Washington. Flowering rush is an expanding problem in this region and currently there are no proven tools to effectively kill it.

As part of the normal water management regime, Lake Pend Oreille undergoes a drawdown (≥ 11 ft) every fall and winter for flood control and to help protect infrastructure from ice damage. During this time, flowering rush plants are exposed and are easily accessible to implement management techniques. To date there is no published peer reviewed literature that can provide reliable control recommendations for flowering rush. Anecdotal reports suggest that foliar herbicide applications will control emergent plants; however, submersed plants are typically not controlled. There has been no attempt to our knowledge of conducting subsurface herbicide applications to target submersed flowering rush plants but given water exchange characteristics and the overall water volume to treat, this may be unfeasible in Lake Pend Oreille. Thorough evaluations of management techniques are needed to determine a viable approach to managing flowering rush in Lake Pend Oreille and other lakes in this region. Treatment of flowering rush during times of lake drawdown represents a potential opportunity to effectively treat this plant. Due to concerns regarding endangered species in the Lake Pend Oreille system, only a small number of herbicides were applied to the drawdown area "in-field". Additional herbicides were screened in a mesocosm facility under more controlled conditions. The drawdown plots and the replicated mesocosm experiment will provide information necessary to improve the future management of this problematic invasive aquatic plant.

Objectives

1. Evaluate bare ground herbicide applications under simulated drawdown conditions in a mesocosm facility.

2. Compare benthic barrier, digging, hand pulling, and bare ground herbicide application efficacy under field conditions in Lake Pend Oreille.

Methods

Mesocosm Evaluation

The study was conducted as a completely randomized design in 68, 100 gallon tanks. Flowering rush was obtained from field locations in Lake Pend Oreille, ID or Detroit Lakes, MN and propagated in a mesocosm facility at Mississippi State University. In August and September 2010, after a sufficient stock population was established, two rhizome sections (approximately 10 cm in length) were planted into 1 gallon containers filled with soil and amended with Osmocote® (19-6-12) fertilizer at rate of 2 g/L. Six pots of planted flowering rush were placed into each tank. An additional 20 pots were planted to assess pretreatment belowground biomass. Plants were allowed to grow through the remainder of 2010. The water in each tank was slowly drained to coincide with the drawdown in Lake Pend Oreille beginning in November 2010. In March 2011, any remaining aboveground biomass was clipped at the sediment surface and Pretreatment belowground biomass harvested by removing the rhizomes from the additional 20 pots prior to herbicide applications.

Table 1. Herbicides and treatment rates used in the mesocosm bare ground evaluation.

Treatment	**Half-Maximum Rate (fl oz/acre)**	**Maximum Rate (fl oz/acre)**
Untreated Reference	N/A	N/A
Acetic Acid[1]	5%	10%
Aminopyralid	3.5	7.0
Flumioxazin[2]	1.5	3.0
Imazamox	32	64
Fluridone	32	64
Imazapyr	48	96
Penoxsulam	2.8	5.6
Triclopyr	128	256

[1]*Rate expressed as a percentage*
[2]*Rate expressed as dry weight (ounces) per acre*

Herbicides were applied in March 2011 to coincide with applications made during the field study in Lake Pend Oreille. Herbicides consisted of seven compounds (acetic acid, aminopyralid, flumioxazin, imazamox, imazapyr, penoxsulam and triclopyr) (Table 1). Herbicides were applied to the bare soil of the pots in respective tanks using a CO_2 pressurized single nozzle spray system. Applications were made using a spray volume comparable to 100 gal/acre. A 1% v:v non-ionic surfactant was added to the spray solution. Each treatment including an untreated reference was replicated in four tanks. Two weeks after treatment, water was incrementally (approximately 8 in. per week) added to each tank to coincide with water returning to Lake Pend Oreille. The final water level in each tank was 16 in. or approximately 8 in. from the top of the containers.

At 12 weeks after treatment (12 WAT), 3 pots in each tank were harvested by sorting plants to above and belowground tissues. At 24 WAT, the remaining 3 pots in each tank were harvested in a similar manner. Once harvested, plant samples were dried and weighed to assess treatment effects on both above and belowground mass.

Mass data were analyzed using a general linear model in SAS to determine herbicide treatment effects. If a treatment effect was observed, a Dunnett's test was used to compare herbicide treatments to the untreated reference plants. Mass data were analyzed within time period at a $p<0.05$ significance level.

Field Evaluation

The field evaluation was conducted in 3 m x 3 m plots that were established in March 2011, in Lake Pend Oreille during the winter drawdown period. Plots were delineated using a frame constructed from PVC pipe and held down with sandbags. Additionally, the coordinates of each corner of every frame were recorded using a GPS device. Once the plots had been established, management techniques were randomly assigned to each plot and pretreatment belowground biomass was collected using a PVC coring device (Madsen et al. 2007).

Management techniques included the maximum labeled rates for bare ground applications of imazapyr, triclopyr, fluridone, imazamox, and acetic acid; other techniques included hand pulling, digging, and benthic barrier (deployed for 4, 6, and 12 months, only 4 month barrier data are included in this report). Each treatment including an untreated reference was replicated in 4 plots. Herbicides were applied using a CO_2 pressurized backpack spray system with a 5 nozzle boom and 8002 flat fan spray tips. Applications were made using a spray volume of 100 gal/acre. Hand pulling consisted of pulling only visible plants within the designated plots; no attempt was made to excavate underground plant structures. Manual digging was completed using a shovel. Benthic barriers were affixed to a PVC frame and placed on the sediment in respective plots. Sand bags were used to hold the benthic barrier in place. In addition to biomass data, the total time of utilizing each management technique was recorded in each plot to assess labor for each technique.

At 16 WAT, the 4 month benthic barriers were removed and two biomass samples collected in all plots for each management technique using a PVC coring device ($0.10\ m^2$). All biomass samples were separated into above and belowground tissues, dried, and weighed to determine biomass. Percent control, stem density, and biomass were determined pretreatment and 16 WAT. Field data were subjected to a Kruskal-Wallis non-parametric Analysis of Variance to determine treatment effects. Time data for each management technique were averaged and reported.

Results and Discussion

Mesocosm Evaluation

Pretreatment belowground mass was 13.19 g DW. At 12 and 24 WAT, belowground mass in the untreated reference tanks was 19.68 and 81.41 g DW respectively; indicating plants were actively growing throughout the study. At 12 WAT, fluridone at both rates, imazamox at both rates, imazapyr at both rates, penoxsulam at 5.6 oz/acre, and triclopyr at 256 oz/acre resulted in a decrease ($p<0.01$) in aboveground biomass as compared to untreated reference plants (Figure 1). There was no difference ($p=0.53$) in belowground biomass with respect to herbicide treatments and untreated reference plants at 12 WAT. It is unclear as to why belowground biomass was unaffected by herbicides at 12 WAT. Plausible explanations include, high variability in belowground samples thereby reducing the ability of detecting a difference or a longer time period is necessary for herbicides to be taken up by rhizome tissue and begin to inhibit plant growth.

In fact, by 24 WAT, fluridone at both rates and triclopyr applied at 256 oz/acre reduced ($p=0.02$) belowground biomass of flowering rush when compared to untreated reference plants (Figure 2). There were no reductions ($p=0.05$) in aboveground biomass at 24 WAT, which is likely due the life stage of the plants. At 12 WAT, plants were still growing new leaves from rhizomes and emerging from the water surface and thus were susceptible to herbicides. However, by 24 WAT plants had flowered, which likely stopped growth as plants began re-allocating resources to belowground tissues as senescence began though a thorough evaluation of life history characteristics are needed to confirm this hypothesis.

Based on this mesocosm evaluation, fluridone applied at 32 and 64 oz/acre and triclopyr applied at 256 oz/acre were efficacious at reducing plant foliage at 12 WAT and belowground rhizomes by 24 WAT. These results suggest that these herbicides should be effective under field conditions. Acetic acid, aminopyralid, and flumioxazin were not effective at reducing flowering rush mass during any harvest time. Imazamox and imazapyr reduced aboveground mass by 12 WAT.

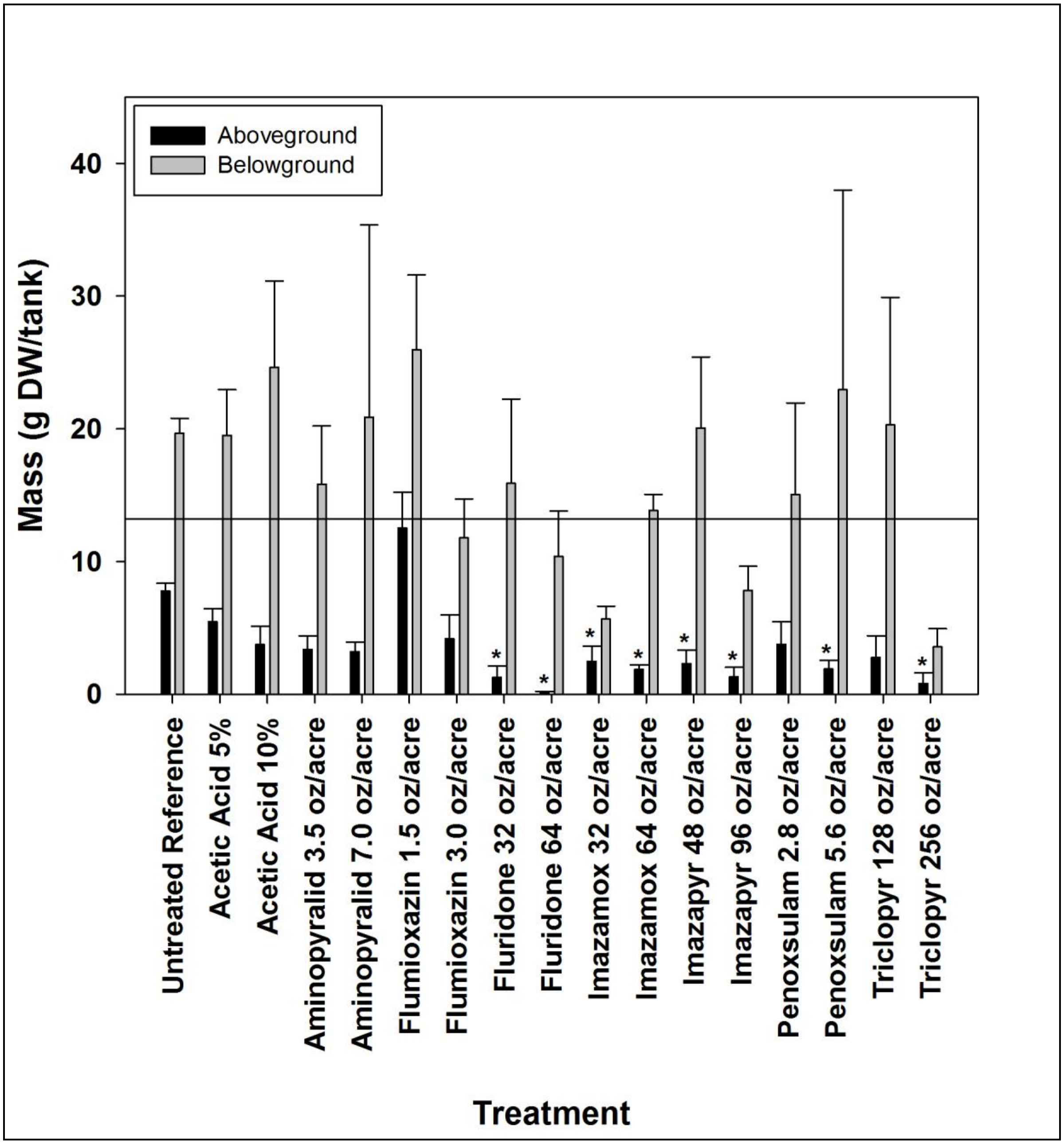

Figure 1. Mesocosm study mean (± 1 SE) flowering rush mass 12 weeks after treatment following bare ground applications with selected herbicides under simulated drawdown conditions. An asterisk denotes a significant difference from untreated reference plants as determined by a Dunnett's test a $p<0.05$ significance level. The solid horizontal line represents pretreatment belowground mass.

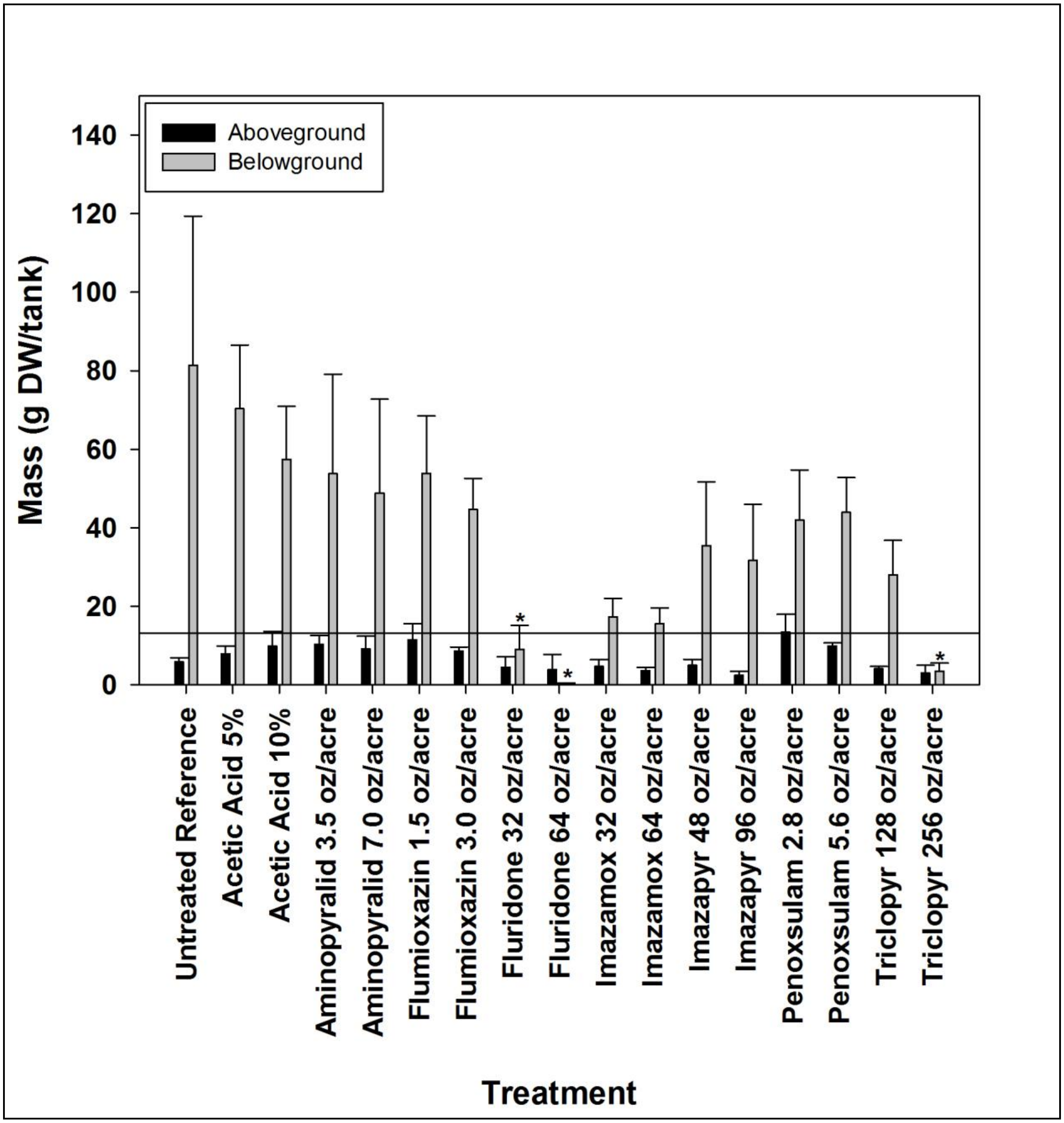

Figure 2. Mesocosm study mean (± 1 SE) flowering rush mass 24 weeks after treatment following bare ground applications with selected herbicides under simulated drawdown conditions. An asterisk denotes a significant difference from untreated reference plants as determined by a Dunnett's test a $p<0.05$ significance level. The solid horizontal line represents pretreatment belowground mass.

Field Evaluation

Flowering rush biomass was not reduced by any management technique with respect to untreated reference plots in the field treatment plots (aboveground p=0.46, belowground p=0.12) (Figure 3). Belowground biomass of all management techniques was lower than pretreatment belowground biomass (635.03 g DW/m^2); although, biomass in reference plots were also lower. High variability in the results is likely due to the clumped growth pattern of the flowering rush population in the Clark Fork Delta area of Lake Pend Oreille, the sampling intensity utilized in the study (i.e. 2 samples per plot), and pretreatment samples were collected during the winter drawdown whereas the 16 WAT samples were collected when there was 5-7 ft. of water on the plots; all of which likely increased the variability in biomass samples.

The lack of efficacy may be attributed to the environmental conditions in the area following treatment. Due to a high snowpack and high projected runoff for the spring of 2011 the water levels in Lake Pend Oreille were kept low for a longer period of time than was originally projected. As a result, plots were treated three weeks prior to the lake level rising to the point of inundating the plots. This time lag between treatment and inundation accompanied with cold rainy conditions may have led to delayed plant growth and lack of observed efficacy in the field evaluation.

The time in implementing management techniques is depicted in Table 2. The application of herbicides took on average 38 seconds for each plot, whereas the other techniques required 12-30 minutes per plot. If differences in efficacy were detected, the differences in implementation time could have implications for cost effectiveness and labor requirements.

Table 2. Average time of management technique implementation in field plots in Lake Pend Oreille, ID.

Management Technique	**Average Time (Minutes)**	**Number of People**	**Person-Minutes**
Herbicide	0.6	1	0.6
Hand Pulling	23.2	2	46.4
Digging	12.6	1.5	18.9
Benthic Barrier	30.0	2	60.0

Additional samples need to be collected 1 year after treatment in all plots to assess belowground biomass during the same time and conditions when the initial pretreatment samples were collected.

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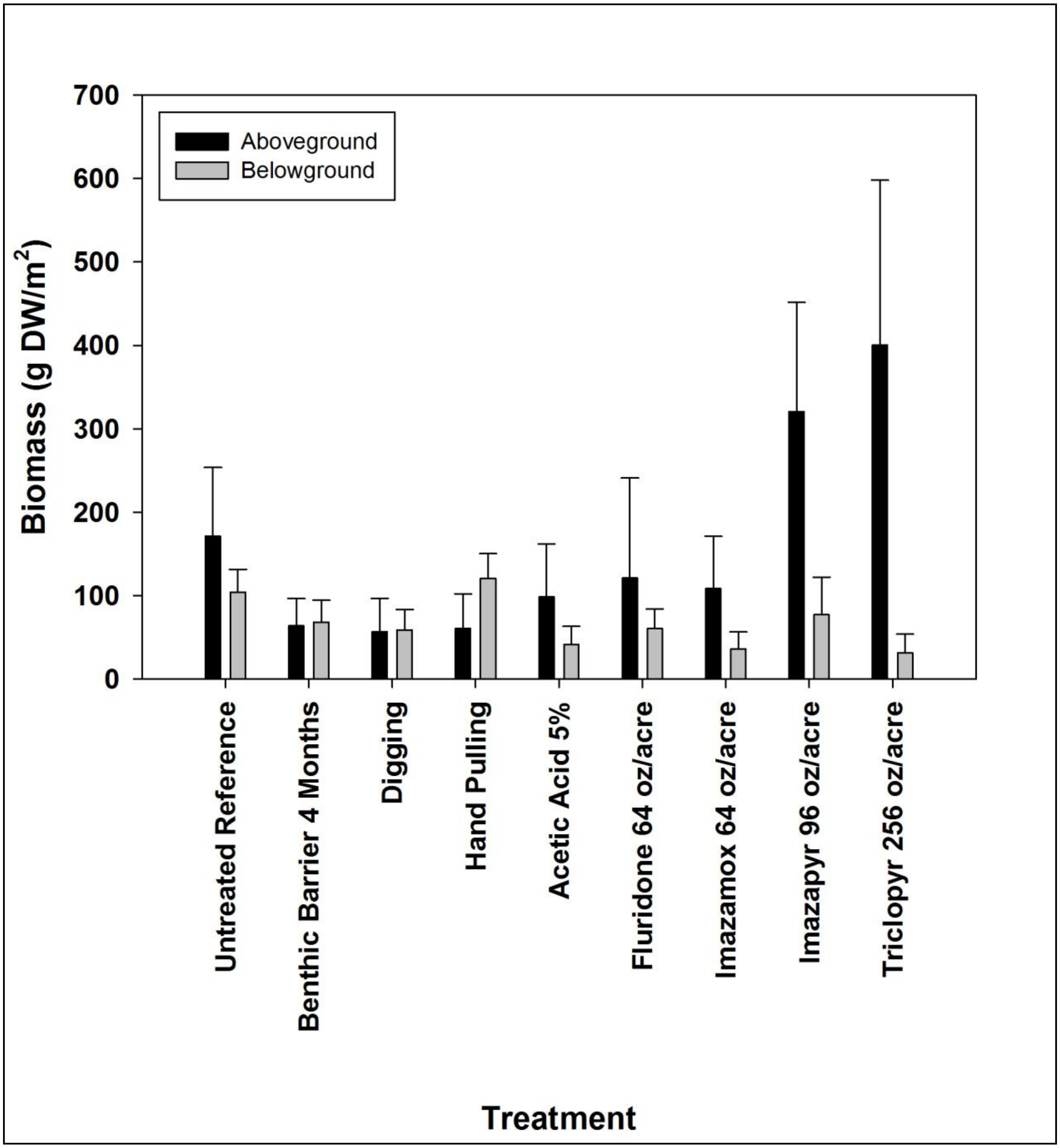

Figure 3. Field plot mean (± 1 SE) flowering rush biomass 16 weeks after implementation of management techniques in field plots in Lake Pend Oreille, ID.

Literature Cited

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