INTENSIVE ROTATIONAL GRAZING OF ROMNEY SHEEP AS A CONTROL FOR THE SPREAD OF *PERSICARIA PERFOLIATA*

A Final Report of the Tibor T. Polgar Fellowship Program

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Girard, C.B. and Kleppel, G.S. 2011. Intensive Rotational Grazing of Romney Sheep as a Control for the Spread of *Persicaria perfoliata.* Section III: 1-22 *In* D.J. Yozzo, S.H. Fernald and H. Andreyko (eds.), Final Reports of the Tibor T. Polgar Fellowship Program, 2009. Hudson River Foundation.

ABSTRACT

The invasive species *Persicaria perfoliata* (mile-a-minute) is threatening native plant communities by displacing indigenous plant species in 10 of the coterminous United States including New York. This study investigated the effectiveness of a novel protocol, intensive rotational targeted grazing, for controlling the spread of *P. perfoliata*. Three Romney ewes (*Ovis aries*) were deployed into a system of four experimental paddocks, each approximately 200 m^2, at sites invaded by *P. perfoliata* in the Ward Pound Ridge Reservation (Cross River, Westchester County, NY). The ewes were moved from one experimental paddock to the next at 2-3 d intervals. Four adjacent, ungrazed reference paddocks were also delineated for comparison with the experimental paddocks. A suite of plant community attributes (cover classes, species richness and composition), as well attributes of individual *P. perfoliata* plants (stem density, inflorescence) were monitored in the experimental and reference paddocks from June 24 to August 7, 2009. *P. perfoliata* cover in the experimental (grazed) paddocks was reduced on average 18.69 ($\pm$ 14.6) percent relative to the reference paddocks. *P. perfoliata* inflorescence was significantly lower ($t=29$; $df=1$; $p=0.022$) in experimental than reference paddocks after completion of the grazing phase of the study. Recovery of native and naturalized species was also evident. These results suggest that intensive rotational targeted grazing of livestock may be useful in the management of *Persicaria perfoliata*.

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INTRODUCTION

Biological invasion is considered second only to habitat loss as a threat to biodiversity in the United States. NOAA's National Estuarine Research Reserve System (NERRS) has identified 85 invasive species among its 27 reserve sites (Wasson et al 2002). Among the species of greatest concern in the Hudson Valley is *Persicaria perfoliata* (mile-a-minute weed). Mile-a-minute, named for its ability to spread rapidly across a landscape (at rates as high as 15 cm d^{-1}), is currently found on Long Island and in the Lower Hudson Valley (Fig. 1). At current rates of dispersal, it seems possible that *P. perfoliata* will spread throughout the Hudson Valley within the decade.

Figure 1: Counties in New York State experiencing invasion by *Persicaria perfoliata*

As with most efforts at invasive plant control and eradication, attempts to manage the spread of *Persicaria perfoliata* have included the use of herbicides, e.g., glyphosate (Johnson 1996; Binion 2005), and mechanical removal. These techniques have met with limited success. Biological control, i.e. insect deployment, is being studied (Hough-Goldstein et al. 2008). *Rhinoncomimus latipe,* a weevil native to Asia, has been introduced on a limited basis to infestations in New Jersey, Delaware, Pennsylvania, West Virginia, Maryland, and New York. As with any effort at biological control of invasives with microbial or insect agents, there is a risk that the control agent will adapt to non-target hosts and become a nuisance itself. It is estimated that between 16-22% of biological control species have had negative impacts on non-target species (Funasaki et al 1988; Hawkins and Marino 1997).

Alternatively, targeted grazing by livestock (Launchbaugh and Walker 2006), notably sheep, goats and to some extent beef cattle, has proven effective at controlling several invasive species, including leafy spurge (*Euphorbia esula*), multiflora rose (*Rosa multiflora*), spotted knapweed (*Centairea biebersteinii*), and cheatgrass (*Bromus tectorum*) (Popay and Field 1996; Severson and Urness 1994). Targeted grazing protocols allow the livestock to graze-down the nuisance or unwanted plant, after which the cleared ground can be replanted with desirable species. This approach may obviate the natural recovery of native plant species at natural distributions.

The foraging protocol used in this study, intensive rotational targeted grazing (IRTG) differs from conventional targeted grazing protocols. Conventional grazing methods involve the release of livestock onto landscapes for extended periods of time. Stocking rates are typically on the order of 2.2 tonnes/hectare. Herds generally spread out across the landscape and remain on it for weeks to entire seasons. This frequently results in overgrazing, and may explain why livestock grazing has been considered to have negative effects on grasslands and rangelands, particularly in wild systems (Saberwal 1996). IRTG, on the other hand, mimics the spatial and temporal distributions of wild, herd-forming grazers and browsers on the landscape. The technique seems to reduce the risk of overgrazing and rapidly restores pasture quality. When wild herbivores graze a landscape they tend to (1) pack relatively tightly (outliers are susceptible to predators) and (2) remain for only a brief time (to stay ahead of predators).

In the summer of 2008, ecologists at the University at Albany, SUNY, began studying the use of specific targeted grazing protocols for nuisance species management. The results of those initial efforts have been promising, particularly the extension of IRTG to disturbed and invaded wild and semi-wild landscapes. Kleppel and LaBarge (2008) reported on the use of IRTG to remove pasture grasses from a wet meadow and restore standing water and native wet meadow vegetation on an agricultural landscape outside of Albany, New York. Kleppel and LaBarge (2009; ms. in review) also studied IRTG as a method of managing purple loosestrife (*Lythrum salicaria*) and other invasives in a wet meadow on an agricultural landscape in East Berne, New York. They observed a significant reduction in inflorescence by the invasive and a 31.5% increase in species richness. Vegetative spreading by *L. salicaria* was reduced by 40.7% in grazed paddocks while changes in *L. salicaria* cover in reference paddocks were not significant. Studies continued during the summer of 2009.

The present study involves the use of sheep for controlling *Persicaria perfoliata*. Sheep are well suited to projects involving targeted grazing invasive plant management, as well as to research on herbivore-plant community interactions (Kleppel and LaBarge 2009, ms in review). Sheep, though generally more discriminating foragers than goats, are easily fenced, and most breeds can be moved efficiently with a dog. There are approximately 244 breeds of domesticated sheep globally (each adapted to a specific set of environmental conditions) and the Hudson Valley with over 20,000 head of sheep provides a rich variety of breeds for management and research projects.

The goals of this study are to assess IRTG for its management and native plant community restoration, and to use IRTG as a tool to study the relationships between herbivores and plant communities and the relationships between native and invasive species in plant communities. The hypothesis addressed in this study is that intensive rotational targeted grazing can reduce *Persicaria perfoliata* to non-dominant status permitting competitive gains in the abundances of native and naturalized plant species. The specific objectives include: (1) document the changes to the plant community by the foraging of Romney sheep (*Ovis aries*); (2) ascertain the rates at which these changes occur and; (3) determine if sheep transport viable seeds in the digestive tract.

METHODS

Study Site

This experiment was performed at the Ward Pound Ridge Reservation (WPRR), in the Town of Cross River in northern Westchester County, New York. Ward Pound Ridge Reservation is a 4700-acre park managed for passive recreation and conservation of natural landscapes by the Westchester County Department of Parks, Recreation and Conservation. Managers first became aware of the invasion of *Persicaria perfoliata* within the park in (ca.) 1998. Since that time, *P. perfoliata* has spread to numerous sites (the exact number is unknown) throughout the park. Park managers have used several approaches to manage the spread of *P. perfoliata*, including hand-pulling, application of organic herbicides and the release of the weevil, *Rhinocomimus latipe*, in the summer of 2009 (B. Bates, pers com). The present study is the first evaluation of the effectiveness of targeted grazing as a potential *P. perfoliata* management strategy within the park. It is also a novel investigation of plant community-herbivore ecology on managed parklands.

Experimental Design

The objectives of the study were to; (1) document the changes to the plant community by the foraging of Romney sheep; (2) ascertain rates of change within the plant community; and (3) determine if sheep transport viable seeds in the digestive tract. It is important to note that it was neither the goal of the project nor the expectation of the researcher to affect a transformation of the invaded areas to a native community. Rather, the experiment was designed to permit evaluation of changes in plant communities dominated by *Persicaria perfoliata* as a result of grazing. The results, however, might inform invasive plant management strategies in the future.

Four experimental paddocks and corresponding reference paddocks were selected on the reservation (Fig. 2). These were chosen in areas where *Persicaria perfoliata* was, at a minimum, clearly present. Paddocks E1, E2, R1 and R2 were selected in part for their proximity to the barn used to house the ewes at night, to allow the sheep, dog and researcher to acclimate to the landscape and protocol. Paddocks E3, E4, R3 and R4 were selected largely for the dominance of *P. perfoliata* at the sites and the interest of park managers in controlling *P. perfoliata* cover in these sites.

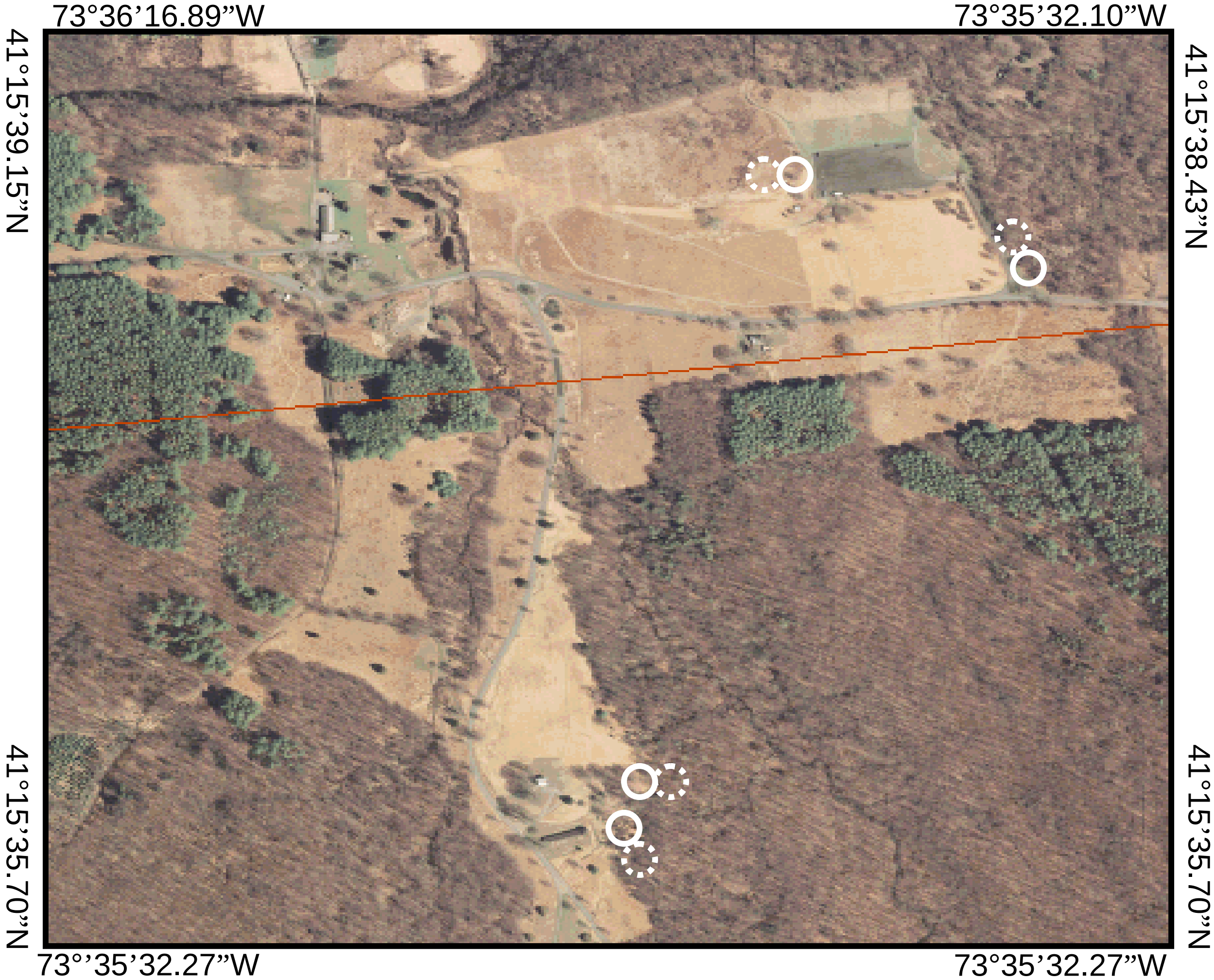

Figure 2: Orthoimage of experimental (solid white) and reference (dashed) sites used in the *Persicaria perfoliata* targeted grazing study at Ward Pound Ridge Reservation.

Each experimental paddock was surrounded by 50 m of temporary electric fencing (ElectroNet® model 9/35/12, Premier-1 Supply Company), enclosing an area of approximately 200 m^2. An equivalent area was demarcated with flags at reference paddocks. A 12-amp/12-volt battery attached to a fence charger equipped with solar recharge (IntelliShock®, model 20B, Premier-1 Supply Company) was available to charge the electric fencing (0.27 joules; 4000-8000 V) around the experimental paddocks; however, given the public locations of the paddocks, a charge was never applied to the fence. Three early gestational phase Romney ewes, ages 1, 2 and 8 years, were deployed into the first paddock giving a stocking rate equivalent of approximately 8.97 tonnes/hectare (ca. 4 times the standard stocking rate). The stock was rotated through the paddock system over approximately 12-d.

Sheep were moved to experimental paddocks at 0530-h each morning and removed to upland pasture prior to dusk. Sheep were housed in a barn at night to minimize risk of predation and to allow for supplemental feedings, reducing potential of nutritional deficiencies. The physical condition of each ewe was assessed weekly.

Two rotations were completed through the paddock system between June 24 and July 22, after which the livestock were removed from paddocks E1 and E2 to allow recovery of native species. Two additional rotations were performed in paddocks E3 and E4 due to the more extensive infestation of P. perfoliata at these sites. Grazing at all sites terminated on August 7.

Data Set

Before the animals entered a paddock and after they were moved to the next paddock, vegetation height within the experimental and reference paddocks was measured with a sward stick and cover class analysis was performed in each of 25 randomly selected 0.25 m^2 quadrats. A detailed species survey was performed in each experimental paddock and in the reference paddock prior to sheep deployment and again approximately one month after the end of the final rotation. The detailed species survey encompassed the entire experimental and reference paddock. All plants encountered were identified to species where possible and grouped into functional groups (e.g., graminoids, forbs) and their proportional coverage was estimated. Prior to deployment and following livestock removal during each rotation, inflorescence (presence of flower clusters), stem density, and vine length were ascertained in each of 25 randomly selected *Persicaria perfoliata* plants in each experimental and reference paddock. *P. perfoliata* assessments ceased on Aug. 3 in order to prevent disturbance to the plants as *P. perfoliata* vines became difficult to disentangle.

Seed Transport Experiments

An evaluation of potential transport of viable *Persicaria perfoliata* seeds in the digestive tracts of the ewes will be undertaken during spring 2010. The protocol for treatment of seeds is based on the work of Colpetzer and Hough-Goldstein (2004). Feces were collected daily from the three ewes between 6 and 8 August, following grazing in paddock E4, when ripe seeds were observed in the paddock. Feces were transferred to plastic freezer bags and stored at -20^{o}C within 48 hours of collection.

In the spring of 2010, the seeds will be thawed and dried at room temperature for several weeks. They will then be refrigerated under moist conditions for 18 weeks. Following refrigeration, the seeds will be planted in potting soil and monitored for the sprouting of *Persicaria perfoliata* vines. Following the experiment, the feces, seeds and emergent plants will be soaked in acetic acid, transferred to black plastic bags and disposed of in a landfill.

During the grazing experiment the ewes were removed from experimental paddocks nightly and returned to a barn at the research site. Composting of bedding material and fecal droppings in the barn is currently under way. The compost material will be examined for the presence of *Persicaria perfoliata* vines in the spring of 2010.

Statistical Analysis

Statistical analysis was performed with StatCrunch Data Analysis (2009). Student's t-test was used to identify between group (experimental, reference) differences in mean inflorescence, species richness and stem density. Differences in the magnitude of change in *P. perfoliata* cover in experimental and reference paddocks were identified with a sign test performed by binomial expansion (Downie and Heath 1970).

RESULTS

The sheep began grazing on *Persicaria perfoliata* on June 24, immediately upon contact with the plant (Fig. 3). Consistent with observations by others (Frost et al. 2008; G. Kleppel pers. comm.) the yearling was least discriminatory and most willing to ingest novel foods (e.g., *P. perfoliata*).

Figure 3: Romney ewe (tag #: 0245) grazing on *Persicaria perfoliata*.

The clearest evidence of the impact of grazing was obtained in the most heavily invaded site, paddocks E3 and R3. Differences between *Persicaria perfoliata* cover in E3 and R3 were observable by July 22, after the second grazing rotation (Fig. 4a, 4b). Observations following grazing revealed that *P. perfoliata* cover was reduced in all experimental paddocks, relative to its cover in the reference paddocks (Fig. 5). In paddocks E1, E2, and E3, *P. perfoliata* cover was lower than both the initial cover in these paddocks and the final cover in the reference paddocks. In paddock E4, *P. perfoliata* cover increased between the initial and final assessment in that paddock. However, the magnitude of increase in *P. perfoliata* cover in E4 (1.88%) was far smaller than in R4 (32.68%). In fact, the terminal *P. perfoliata* cover in the reference paddocks was always greater than in the corresponding experimental paddocks, a result not expected solely as a function of chance (sign test, $p<0.05$).

(a) (b)

Figure 4(a): Experimental paddock 3 following the second grazing rotation July 22, 2009.
(b): Reference paddock 3 following the second grazing rotation July 22, 2009.

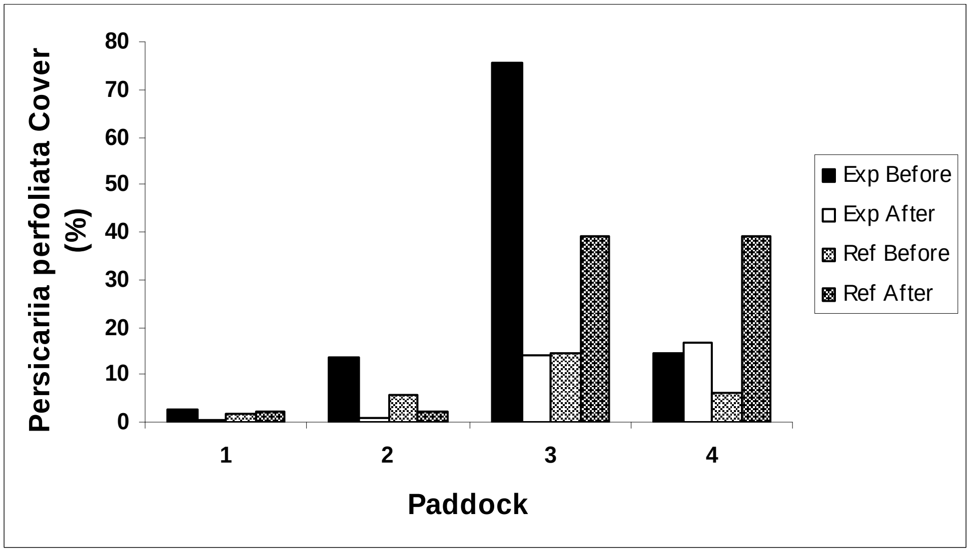

Figure 5: *Persicaria perfoliata* cover in experimental and reference paddocks before sheep deployment and after final grazing rotation. Terminal *Persicaria perfoliata* cover in the reference paddocks was always greater than in the corresponding experimental sites (sign test, $p<0.05$).

Flowers were detected on *Persicaria perfoliata* in two of the four experimental and reference paddocks (E3/R3 and E4/R4). Flowers were first observed on July 5, in E3/R3 and on July 9, in E4/R4. Between group (exp and ref) differences in mean inflorescence were not significant ($t=-2.00$; $df=1$; $p=0.30$) initially in the experimental paddocks and reference paddocks (Fig. 6a). However, mean inflorescence was significantly lower ($t=29.00$; $df=1$; $p=0.022$) in the experimental paddocks relative to the reference paddocks after the final grazing rotation on August 7 (Fig. 6b). After the fourth rotation, only a single flower head was detected in paddock E3.

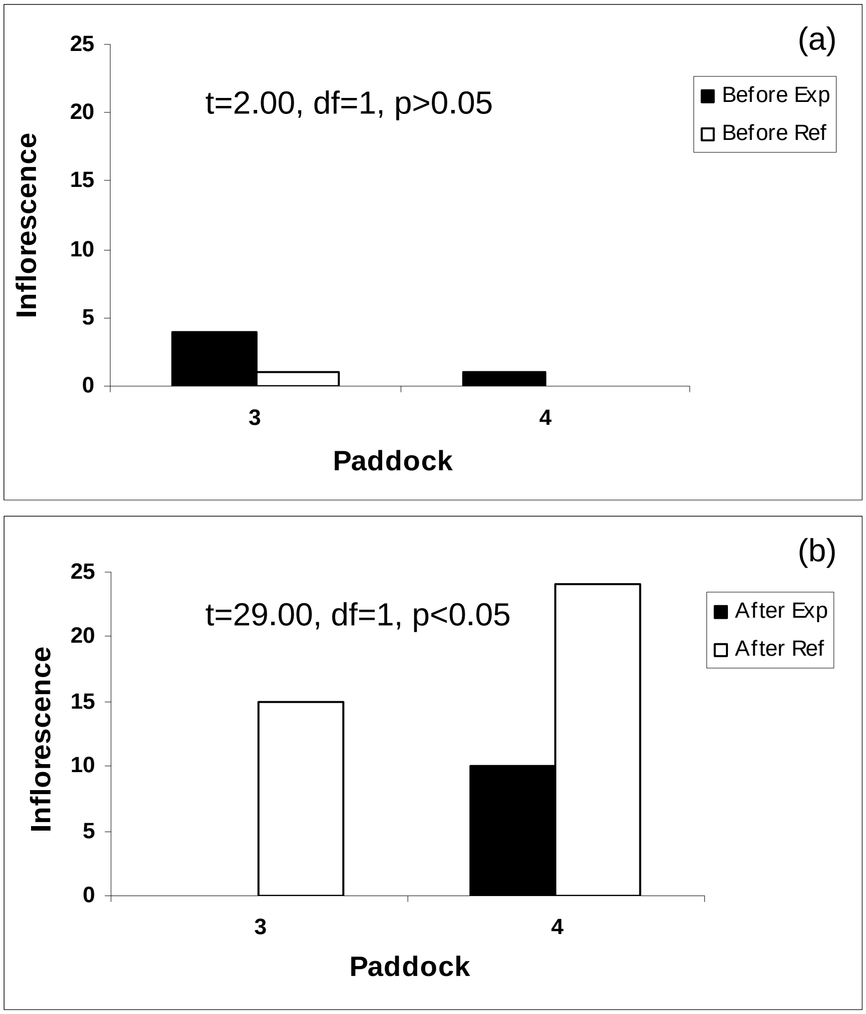

Figure 6(a): Inflorescence in experimental paddocks E3, E4 and reference paddocks on the day flowers were first observed. (b): Inflorescence in experimental paddocks E3, E4 and reference paddocks after fourth rotation of sheep grazing.

Between group differences in mean stem density were not significant before (t=-0.13; df=3; p=0.90; Fig 7a) or after (t=-0.05; df=3; p=0.96; Fig. 7b) sheep deployment.

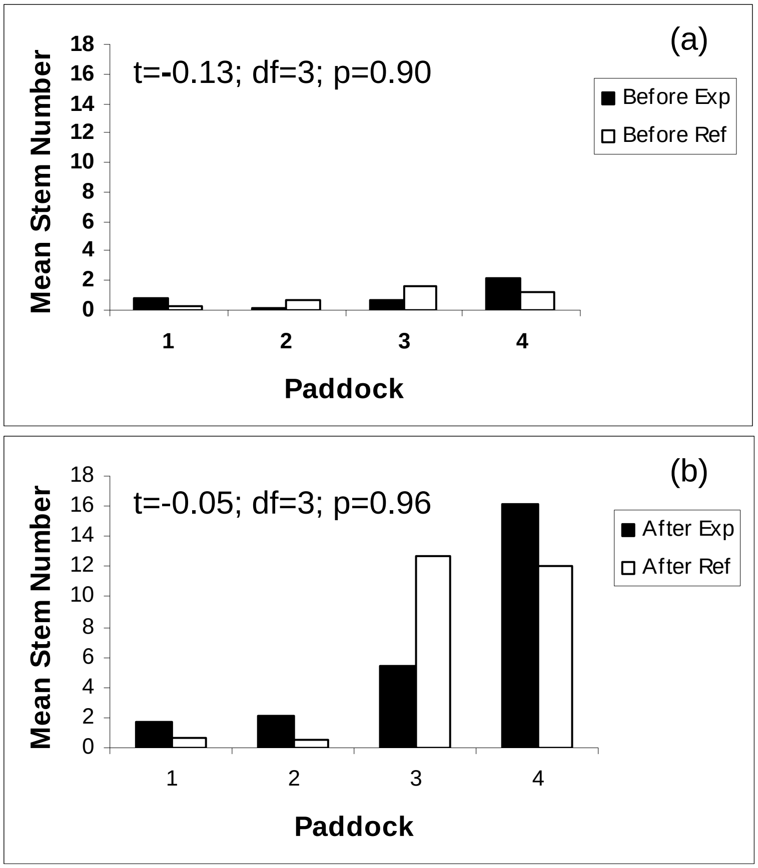

Figure 7(a): Mean number of *Persicaria perfoliata* stems in experimental paddocks and reference paddocks before sheep deployment. (b): Mean number of *Persicaria perfoliata* stems in experimental paddocks and reference paddocks after sheep deployment.

Fig. 8a shows that between group differences in mean species richness were not significant prior to sheep deployment (t=0.57; df=6; p=0.29). Following the final grazing rotation, however, mean species richness in the experimental paddocks was significantly higher (t=3.03; df=6; p=0.01) than in the reference paddocks (Fig 8b). The mean number of species present before grazing was 19 .5 in experimental and 18 in reference paddocks. The mean number of species present after grazing was 24 in experimental and 16.75 in reference paddocks.

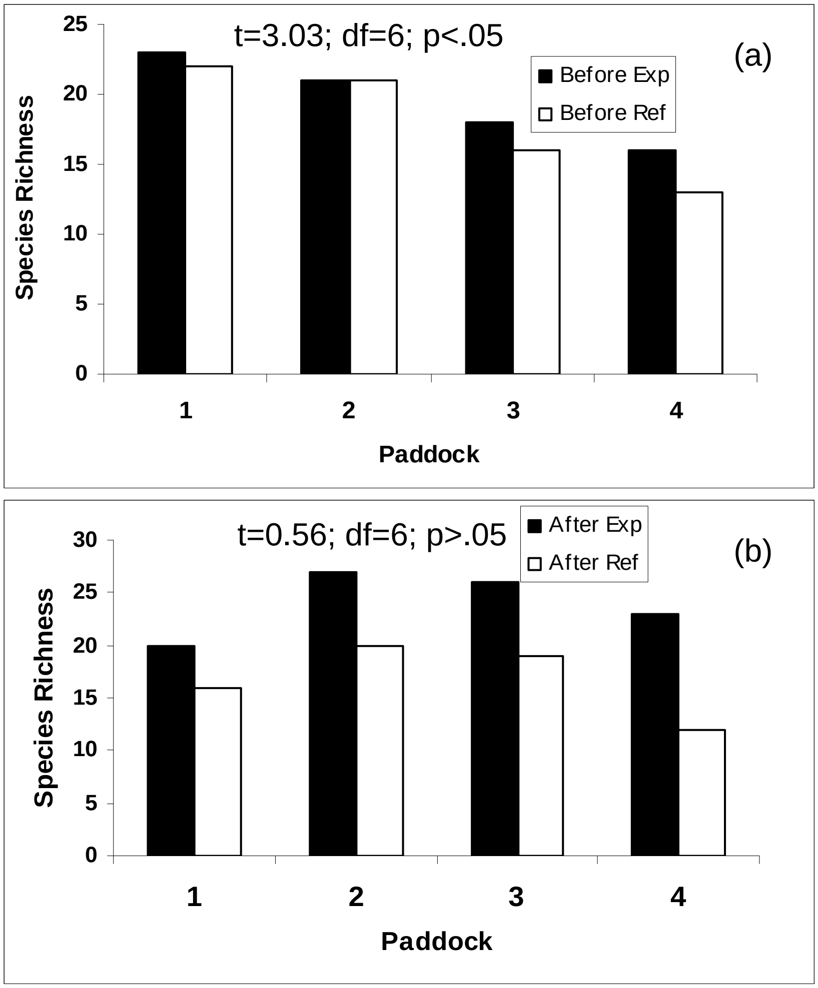

Figure 8(a): Species richness in experimental and reference paddocks before sheep deployment. (b): Species richness in experimental and reference paddocks after final grazing rotation.

Between group differences in mean graminoid species richness were not significant before sheep deployment (t=0.2; df=3; p=0.85) (Fig. 9a). Following the final rotation, differences were significant (t=3.7; df=3; p=0.04) (Fig. 9b).

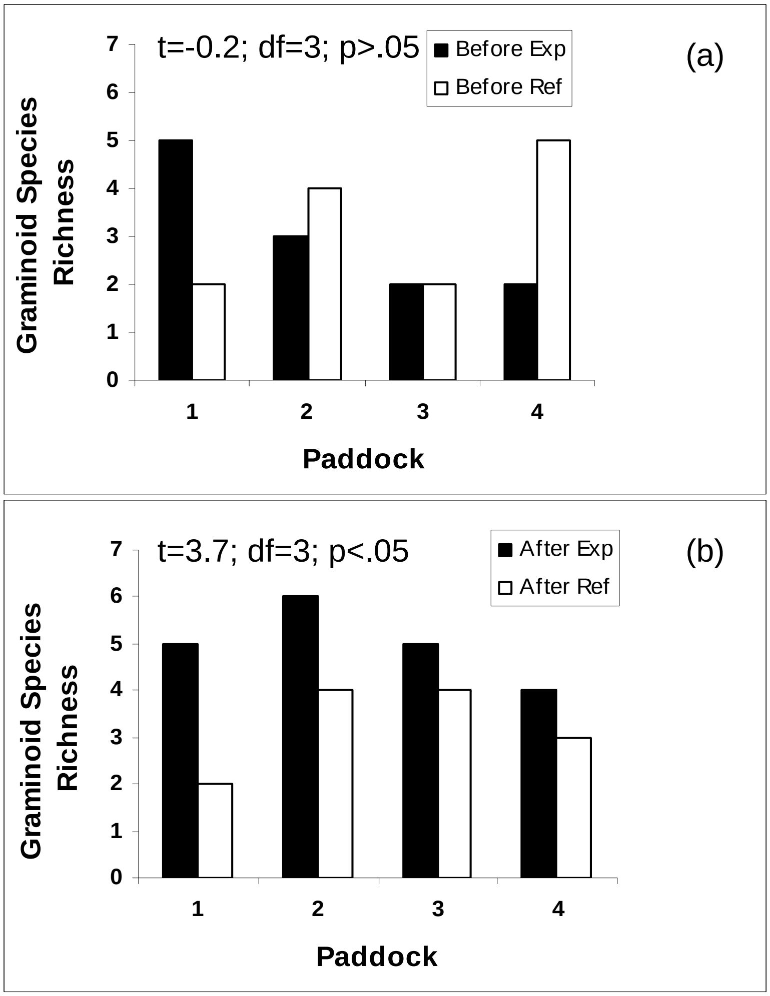

Figure 9(a): Graminoid species richness in experimental paddocks and reference paddocks before sheep deployment. (b): Graminoid species richness in experimental paddocks and reference paddocks after final grazing rotation.

DISCUSSION

With the growing awareness and concern for the negative impacts of *Persicaria perfoliata* in native plant communities, the availability of a variety of methods to control the spread of this species is promising. The purpose of this study was to evaluate the effectiveness of using intensive rotational targeted grazing (IRTG) to reduce the cover of *P. perfoliata* and begin the recovery of native and naturalized plant biodiversity in affected areas. The results of this study suggest that IRTG has potential as a biocontrol protocol. A reduction in the relative cover and inflorescence of *P. perfoliata* was observed, and, perhaps of equal importance, species richness, particularly among graminoids, increased significantly. It is unclear why the plant community responded as it did, though compensatory responses (McNaughton 1983) provide at best, only part of the answer. Research to address this question is needed.

The decrease in *Persicaria perfoliata* inflorescence caused by grazing is significant and speaks to the potential of intensive rotational targeted grazing for controlling the spread of this invasive plant. By reducing the number of flowers and hence seed production, grazing nearly eliminated the sexual reproductive contribution to future generations of *P. perfoliata* within the grazed paddocks. This is especially significant in an annual species, in which a long term grazing strategy may ultimately result in eradication. As an annual, the *P. perfoliata* vines that grow each year originate from seeds. As the seedbank of an area is depleted, so is the potential for growth of vines in future years.

Of at least equal interest is the response of the plant community to grazing. Targeted grazing is an ecosystem-based technique and should be considered as much a method of restoring and managing communities as it is a technique for controlling and sometimes eliminating individual nuisance species. In fact, with few exceptions, herbivory is a community-focused activity. Thus, the sheep foraged on numerous species and yet, consistent with findings from other studies (Kleppel and LaBarge 2009) species richness increased in grazed, relative to reference, paddocks. Research in the future will focus on explaining how grazing might alter compensatory and interspecific competitive responses among the native and invasive species within plant communities.

Control of invasive species is often labor intensive (hand-pulling), expensive (testing of biocontrols for host specificity) and associated with potentially deleterious impacts to the environment (herbicides). Although targeted grazing also has limitations, the benefits of the approach certainly suggest its usefulness as part of any comprehensive invasive species management program. Manpower requirements, for example are relatively small. One, trained, individual can manage flocks at several locations without difficulty. Costs associated with permitting and testing of control agents (i.e., livestock) are trivial compared with insect or microbial bio-control or with herbicide use. Infrastructure (fencing) and maintenance (food supplements, medicine) costs vary with livestock species and breeds, but tend to be lower than for other invasive species control methods.

Most important, is the ecosystem-based nature of targeted grazing. While tens to hundreds of thousands of dollars are not spent developing agents to attack one single species, targeted grazing simultaneously addresses many species and permits one to think about managing ecosystems rather than individual populations. Livestock interact with the entire plant community, foraging as naturally as any herd-forming population of herbivores will within that community. Currently available foraging models may be helpful in predicting the outcome of grazing within a plant community of a particular structure (MacArthur and Pianka 1966; Coppolillo 2004) and the versatile intensive rotational grazing protocol can be adjusted to increase the probability of desirable outcomes or decrease the risk of undesired impacts. Thus, while *Persicaria perfoliata* was the target species in this study, several other invasive and nuisance plant species, including *Rosa multiflora*, *Dichanthelium clandestinum* and *Microstegium vimineum*, were eaten as well. Then as desirable species recruited into a grazed site, grazing pressure was relaxed to facilitate their displacement of the invasives.

As with many invasive species management techniques, intensive rotational targeted grazing of livestock, when used in conjunction with other management techniques may be even more effective at managing *Persicaria perfoliata* than when used alone. For instance, the weevil, *Rhinocomimus latipe,* while expensive and potentially difficult to manage can be released into areas that are not easily accessed by livestock. In the future, research will focus on adapting multiple management techniques into coordinated strategies of invasive plant control.

ACKNOWLEDGEMENTS

Funding for this research was provided by the Tibor T. Polgar Fellowship Program. G. and P. Kleppel of Longfield Farm for provided additional support as well as training and assistance with the animals and equipment used in the project. I am grateful to the Westchester County Parks Department for allowing this experiment to take place at Ward Pound Ridge Reservation. J. Davis provided assistance with map production. B. Bates, B. Herr and R. Rogers of WPRR provided valuable field support and assistance during the experiment. R. Embler helped to locate and provide culled ewes and B. Aramata helped to identify and train a border collie for the study. Finally, I am grateful to Sarah, the Border collie, who made it possible to move the sheep.

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