National Park Service
U.S. Department of the Interior

Northeast Region
Boston, Massachusetts

Study Design for Assessing the Effects of Knapweed Control on Grassland Birds at Saratoga National Historical Park

Natural Resources Report NPS/NER/NRR--2007/015

ON THE COVER
Knapweed at Saratoga NHP
Photograph by: Greg Shriver

Study Design for Assessing the Effects of Knapweed Control on Grassland Birds at Saratoga National Historical Park

Natural Resources Report NPS/NER/NRR--2007/015

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August 2007

U.S. Department of the Interior
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Background

Saratoga National Historical Park (SARA; 43°00'N, 73°78'W) in northeastern New York encompasses 1,130 ha, including over 320 ha of managed grassland habitat (Figure 1; Berthiaume 2001). The importance of SARA to obligate grassland species was formally recognized when the Park was designated as a New York State Important Bird Area (Wells 1998), primarily due to presence of many obligate grassland bird species.

The legislative mandate of Saratoga National Historical Park is to preserve and protect sites associated with the battles, siege, and surrender of British forces at Saratoga, which were decisive in events leading up to American independence (SARA Draft General Management Plan, NPS 2003). Goals for resource management at SARA include protecting, preserving, and maintaining the landscapes significant to the 1777 battles, siege, and surrender, and managing the park's natural resources within the context of a cultural park (SARA Draft General Management Plan, NPS 2003). The recently completed General Management Plan for SARA seeks to base decisions on the best available scientific information and to conserve grasslands in support of cultural landscapes, as well as critical habitat.

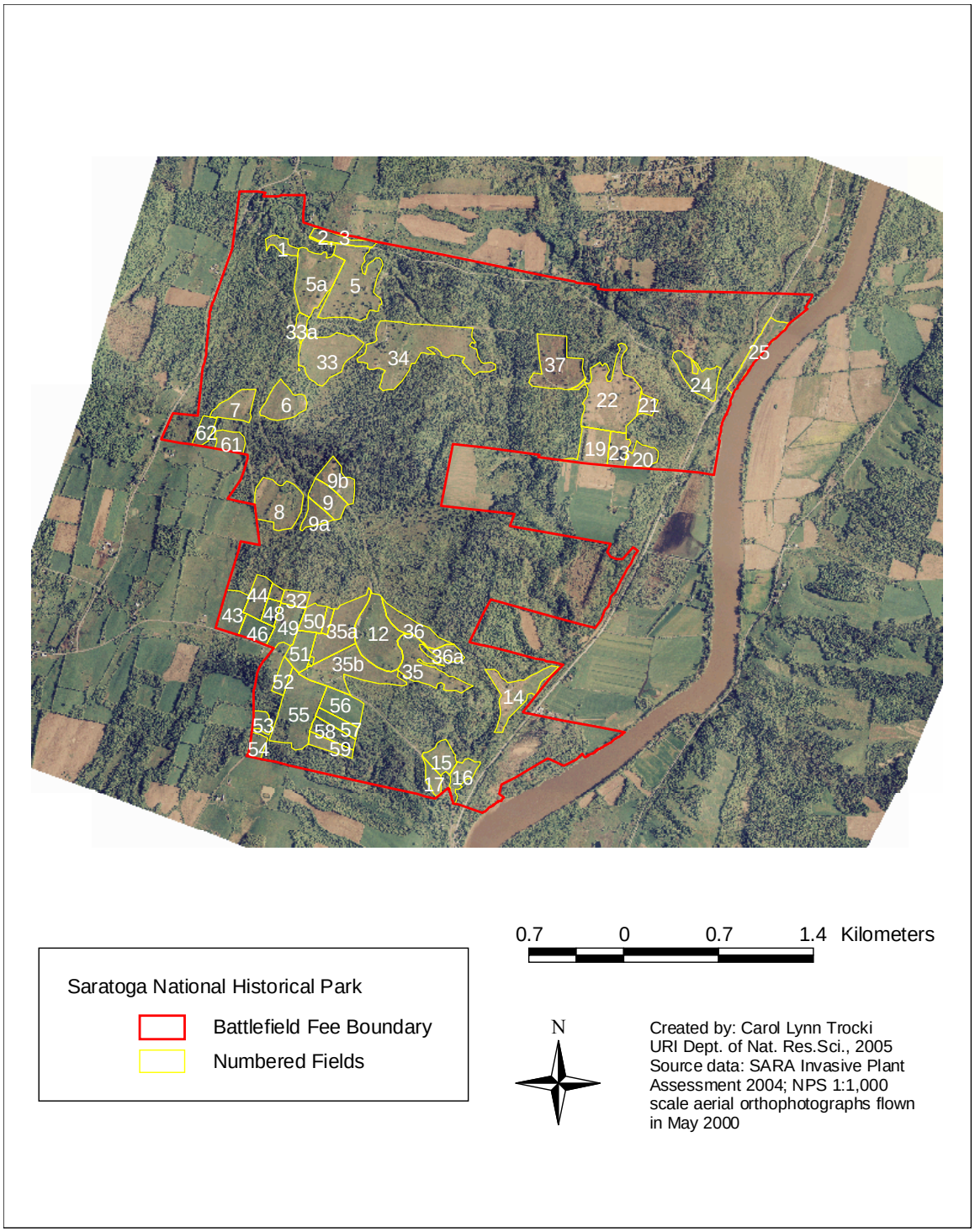

Figure 1. Grassland fields delineated into management units (n = 52) of the Battlefield Unit of Saratoga National Historical Park (SARA) in 2000 (Berthiaume 2001a).

Knapweed in Saratoga NHP

Invasive plants are one of the primary management issues for land managers at Saratoga National Historical Park (SARA; Trocki and Paton (2005)). Canham (2004) inventoried the spatial distribution of invasive plant species in SARA in 2003 and detected 17 invasive species in the park, several of which pose concerns for grassland field management. In particular, park natural resource staff have identified knapweed (*Centaurea sp.*) as the greatest threat to field management. According to SARA's Invasive Species Assessment (Canham 2004), knapweed was found in 69% (43/62 fields) of the fields in the park. In addition, Purple Loosestrife (*Lythrum salicaria* L.), Reed Canary Grass (*Phalaris arundinacea* L.**)**, and Japanese Knotweed (*Polygonum cuspidatum* Sieb. & Zucc.) were also found in field habitats.

There is some slight controversy over which species of knapweeds occur in SARA. Canham (2004) found that Brown Knapweed (*Centaurea jacea* L.) was more common in SARA than Spotted Knapweed (*Centaurea maculosa* Lam.). However, the New York State Invasive Plant Council does not list *Centaurea jacea* as occurring in the Park, but does list *Centaurea maculosa*. Both species are considered invasive in the region (Trocki and Paton 2005; Appendix B).

Knapweed is a biennial or short lived perennial with a stout taproot that mainly reproduces by seed, but individual plants may produce up to 25,000 seeds each and seeds may remain viable for up to 8 years (Mauer et al. 2004). Seeds are generally dispersed passively in the late summer and fall, and have likely spread throughout SARA with the help of wind, fire, animals, and people moving about the park. Knapweed also gives off an allelopathic compound called cnicin that is capable of retarding the root growth of neighboring plants, which gives it a competitive advantage once established (Invasive Plant Atlas of New England 2003).

Field vegetation at SARA is dominated by Knapweed (*Centaurea* spp.), Brome Grass (*Bromus* spp.), Goldenrod (*Solidago* spp.), Bluestem (*Andropogon* spp.), Sedges (*Carex* spp.), Bedstraw (*Galium* spp.), and Dogwood seedlings (*Cornus* spp; Trocki and Paton 2005). Invasive species encroachment into grassland habitats (particularly by knapweed) is a serious concern for park managers because the changes in vegetation structure and composition caused by the knapweed invasion may influence grassland bird species, contributing to declines (Chris Martin and Linda White, SARA Natural Resource Staff, pers. comm.). Each grassland field within the Park has a unique management history and most have been subject to haying, burning, mowing, and occasional manual shrub removal. Currently, the Park also has an agricultural lease program whereby certain fields are leased to local farmers for hay cutting (Trocki and Paton 2005).

Based on the decline of grassland birds within the park, regionally, and at a continental scale, management strategies to enhance habitat for grassland birds at SARA should be a top management priority for the Park. Grassland bird populations are declining throughout North America at a dramatic rate (Vickery et al. 1999a). Analysis of data from the North American Breeding Bird Survey (BBS) indicates that of 28 species of grassland-dependent breeding birds detected throughout North America, 68% (19 species) show a significant negative trend from 1966-2003 (Sauer et al. 2004). Among northeastern North American bird groups, grassland and shrubland dependent birds are exhibiting the most pervasive and steady declines in abundance (Witham and Hunter 1992; Askins 1993, 2000).

In the BBS analyses of the Northeast Region (US Fish and Wildlife Region 5) from 1980 to 2003, ten obligate grassland species were detected (Sauer et al. 2004). Of these, Vesper Sparrow (*Pooecetes gramineus*), Grasshopper Sparrow (*Ammodramus savannarum*), Eastern Meadowlark (*Sturnella magna*), Savannah Sparrow (*Passerculus sandwichensis*), and the non-native Ring-necked Pheasant (*Phasianus colchicus*) all had documented significant negative trends (Sauer et al. 2004). Henslow's Sparrow (*Ammodramus henslowii*), Upland Sandpiper (*Bartramia longicauda*), Northern Harrier (*Circus cyaneus*), and Bobolink (*Dolichonyx oryzivorus*) all had documented non-significant trends at the regional level, but significant declines continentally (Sauer et al. 2004). Horned Lark (*Eremophila alpestris*) appears to be increasing regionally, but declining nationally during this same time period (Sauer et al. 2004).

Partners in Flight (PIF) lists three of these species (Henslow's Sparrow, Upland Sandpiper, and Bobolink) as conservation priorities in the Northern Ridge and Valley Physiographic Area 17, a region that includes SARA (Rosenburg and Robertson 2003; for a map of this Physiographic Area, see http://www.blm.gov/wildlife/pl_17sum.htm). PIF's ranking system (detailed in Carter et al. 2000) lists Henslow's Sparrow as a continental conservation priority, both Upland Sandpiper and Grasshopper Sparrow as high regional priorities, and Bobolink as a US National Watchlist species (PIF Species Assessment by Rocky Mountain Bird Observatory 2002). Although the northeast region of the United States may not support a large percentage of North America's obligate grassland nesting species overall, it may be critically important for species with a greater proportion of their breeding population in this region, such as Henslow's Sparrow (>20.0%), Grasshopper Sparrow (4.0%), Bobolink (13.7%), and Eastern Meadowlark (5.4%) (Wells and Rosenburg 1999).

At least one obligate grassland subspecies is already extinct in the Northeast. The endemic Heath Hen (*Tympanuchus cupido cupido*) was extirpated from Martha's Vineyard, Massachusetts in 1932 due to habitat loss (Askins 2000). Without immediate conservation measures and active management of remaining grassland habitat, several

other obligate grassland bird species may also be extirpated from the region (Wells and Rosenberg 1999).

Among obligate extant grassland species in decline throughout North America, Henslow's Sparrow had the greatest rate of decline, estimated at 8.8% annually from 1966-1996 (Peterjohn and Sauer 1999). The rate of decline in Henslow's Sparrow populations has increased from 6.0% annually during 1966-1979 to 10.4% annually from 1980-1996. A recent summary of population trends suggests that regionally, Henslow's Sparrows are declining at 12% annually, resulting in a 50% decline in just a 6-year period (Sauer et al. 2004). Henslow's Sparrow has a limited breeding distribution range restricted to the northeastern and north-central United States (Herkert et al. 2002), with SARA at its eastern extent.

Knapweed Control Strategies

Control of knapweed is difficult, but several management options for the Park exist. The Nature Conservancy recommends over seeding with a native competitor that has a similar growth period (Mauer et al. 2004). Mowing before seed set can be an effective technique for controlling populations, but will not eradicate them, and may conflict with the bird nesting season as seed set generally begins in mid-summer. Grazing is not always an effective management technique because the presence of cnicin makes knapweed unpalatable for some species, and it may be passed over by grazing animals in favor of natives, resulting in a further competitive advantage for knapweed. However, some research now shows that sheep will feed on knapweed with no ill effects and that grazing may be effective at controlling knapweed, if conducted early and late in the growing season during critical growth periods for knapweed when native plants should be dormant (Zouhar 2001).

Because Knapweed has become a major management issue in the northwestern United States, there is considerable research that has focused on control techniques for knapweed there (Appendix A). Since it is still unclear which knapweed control techniques will be successful in SARA, the park should begin to develop a plan to assess the effectiveness of various techniques listed in Appendix A that are compatible with current management strategies for this historical park. The study should be designed to simultaneously evaluate the effectiveness of restoration efforts on native plant species and the reduction of invasive species cover. In addition, the study design should assess the short and long-term impacts of knapweed control efforts on native grassland bird species. It is not the purpose of this report to design knapweed control efforts. Rather once the park has decided which techniques to explore, we hope managers will follow our guidelines below to assess impacts on grassland birds.

Monitoring Grassland Birds

It is quite likely that the spatial scale of knapweed control will be relatively small (e.g., 1-5 ha patches) while different management techniques are being tested in the field in SARA. We assume for the purposes of this report that chemical options will be the first tested by the park. Using only fire to control knapweed has had limited success (see Appendix A), thus we assume that only fire in combination with chemical applications will be attempted, although mechanical control is another option. When Park managers decide to initiate an invasive species control program, they should consult with a Park Service statistician to insure that the design is statistically robust. Controlling knapweed in only one small section of the Park will not provide useful information. A replicated Before-After-Control Impact (BACI) design would be the best strategy and would be of the most benefit to local managers and land managers throughout the region.

Assuming the Park initiates some type of integrated management scheme on a series of patches throughout park, how can impacts on grassland birds be assessed? We suggest using double-observer variable-radius point counts to assess the short- and long-term impacts of knapweed control on grassland birds. Point counts are the accepted method for monitoring birds in grassland habitats, and have been used by the National Park Service for Inventorying and Monitoring schemes and by the US Fish and Wildlife Service for long-term monitoring plans (Appendix B).

In 2002, the US Fish and Wildlife Service established field protocols for monitoring grassland breeding bird use of managed grasslands on National Wildlife Refuges within the Northeast region (USFWS Region 5; see Appendix C; Mitchell et. al. 2002), which could provide a basis for comprehensive grassland bird monitoring at SARA. Whenever a monitoring protocol is established, careful attention should be given to locating survey points in a scientifically defensible manner, controlling survey effort, and incorporating methods that facilitate the estimation of detection probabilities for use in density estimation, such as recording distances to birds for use in Program DISTANCE (see Buckland et al. 1993; also Dieffenbach et al. 2003, Rotella et al. 1999, Vickery 1995; online resource for distance sampling can be found at www.colostate.edu/depts/coopunit/download.html). In addition, it is imperative that careful records of field management (i.e., burning, mowing, and/or shrub removal) continue to be maintained in a spatially explicit manner on an annual basis.

Budgetary considerations will determine the number of experimental plots (i.e. plots where integrated invasive species control takes place). We suggest that plot locations either be randomly located on centers of grid cells (less desirable) or a Generalized random tessellation stratified (GRTS) sampling (more desirable) is used to pick a spatially-balanced sample from the gird system we have established (see http://www.west-inc.com/reports/grts.pdf for a description of a GRTS sampling scheme). We have established a 100-m grid over all grasslands in the park (Figure 2; Appendix D). These points could be numbered and using a random number table, random points could

be generated. An alternative scheme would be to number each field, and randomly select x fields (where x depends on the number of experimental plots to be established). This would disperse the experimental plots across the Park. Within a field, points could be numbered and randomly located. We suggest ratio of at least one control plot for each experimental plot, with control plots located in the same field as experimental plots. For example, if the Park established 10 experiment plots, then we suggest that 10 control plots also be identified for future monitoring.

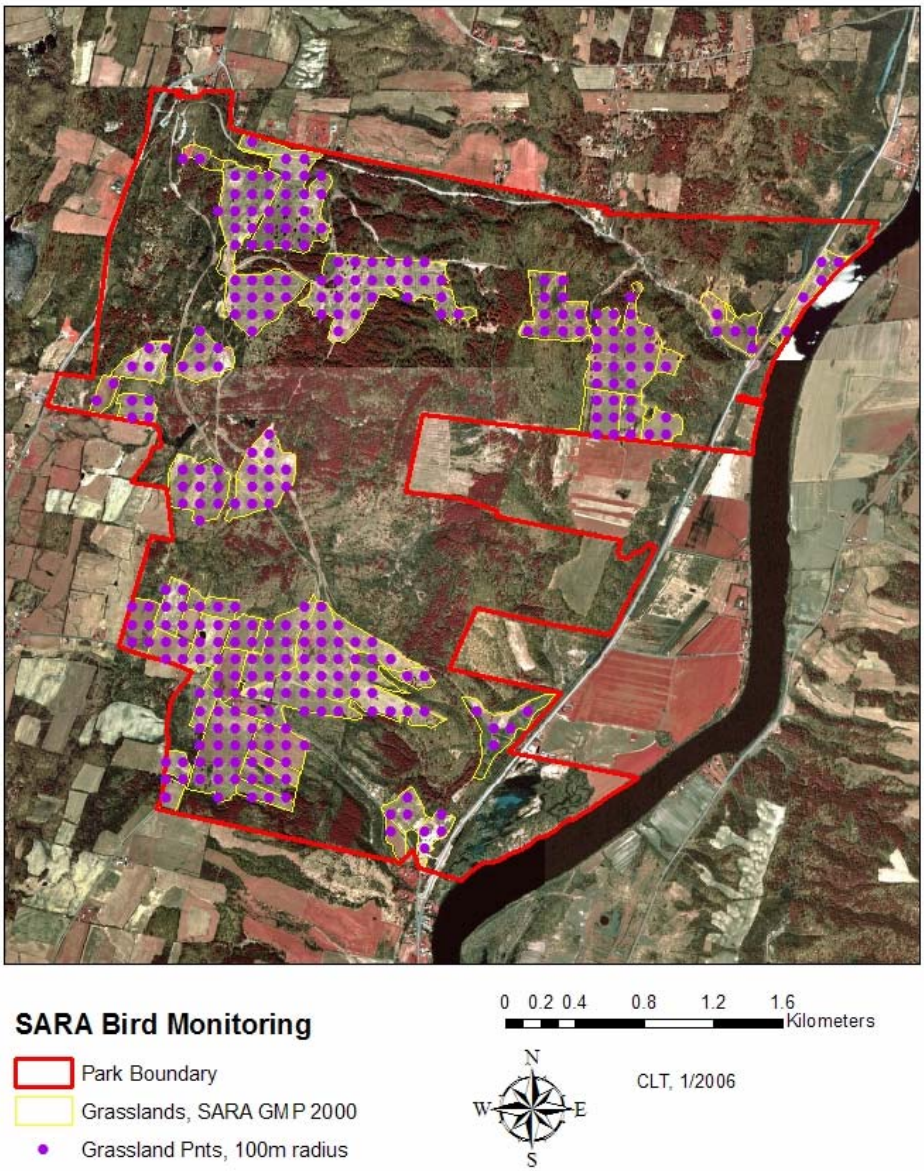

Figure 2. Location of potential point count stations in grasslands in Saratoga NHP.

After the experiment has been initiated, the centers of experimental and control plots should be clearly marked (e.g. 10 cm metal stake with a flag, however stake should be a small diameter to prevent birds from perching on them) to facilitate relocation for subsequent point counts. In addition, observers should record point count plot centers with an accurate GPS, so the plot center could be relocated if necessary.

Following a slightly modified US Fish and Wildlife Service guidelines (Appendix B), we suggest using 50-m radius point counts at both experimental plots and control plots. Plots of this size, 7,852 m^2, would account for 79% of the area of 1-ha experimental and control plots. General guidelines for point counts (see Appendix B for details):

Overview of Avian Point Counts

1. Order of points: The order that points or surveys are conducted should vary among days and alternate between starting with an experimental or control plot.
2. Length of surveys: Arrive at points and stand silently for 2 min before conducting a 5-min count. All birds detected (visual, calling, singing) within the 50-m radius should be recorded.
3. Time of day: A three-hour survey window, 06:00 to 09:00.
4. Time of year: 25 May to 25 June.
5. Two observers record independent observations at each point count station, thus they do not talk and preferably do not face each other. Immediately after each 5-min survey period, observers should reconcile differences.
6. Each plot should be surveyed three times during the 1-month long survey period. Observations at a given station should be a minimum of 5 days apart.
7. Observations should take place for at least 2 years before experiments are initiated, and then experimental and control plots followed for 5 years after experiments have been initiated.

Overview of Vegetation Sampling at Experimental Plots and Control Plots:

1. The same sampling intensity should take place in experimental and control plots; vegetation sampling will be the same in control and experimental plots.
2. Archival photos: Take a photo of each experimental and control plot: take photo of Robel pole, 4 m from pole at 1 m height, make sure to record plot number and coordinates for each plot.
3. Vegetation height-density: With a 50-m tape, locate 4 transects in the cardinal directions from plot center. Record Robel pole height at 25 m and 50 m along each transect, which would result in 8 Robel pole measurements per plot.
4. Percent frequency and litter depth: Using a meter tape at least 50 m long, anchor the tape in plot center. Place the tape in the N direction and stake it down. Every 5 m along transects, place a metal rod (4 mm diameter-2 m long) next to the tape. Record the occurrence of three vegetation categories: live graminoid, live forb, and standing dead vegetation, and also bare ground. Measure litter depth at 15, 30 and 45 m along transects. Then using the same procedures, record vegetation and litter depth along

transects in other three cardinal direction (South, East,West). This will result in 40 measures of vegetation structure and 12 measurements of litter depth in each plot.

5. Dominant vegetation: Using a 1-m^2 sampling frame described below, record dominant plant species in each plot. Place 50 m long transects in 4 cardinal directions. Using a random number table, select 4 numbers between 1 and 50 for each transect. Place the frames down at these randomly selected points along each transect, which will result in 16 dominant vegetation plots per experimental plot.
6. Vegetation sampling should take place in August when vegetation is more readily identifiable.
7. Vegetation sampling should take place for a minimum of 5 years for experimental controls to see how quickly invasive species become reestablished in experimental control plots.

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Appendix A. Current techniques used to control knapweed in North America.

Appendix A 1: Integrated Management Techniques
http://www.montana.edu/wwwpb/pubs/knapweed/circ311.html

Successful management of large-scale knapweed infestations requires integrating several weed management methods in a well-planned, coordinated and ecologically based approach. The goal of a management program should be to develop healthy plant communities that are weed-resistant and meet other land-use objectives such as livestock forage, wildlife habitat or recreation.

Inventory, monitoring and public education are vital components of an integrated weed management program. However, this publication limits discussion to prevention and control techniques.

Prevention

Early detection and treatment is the key to preventing the spread of knapweeds and starthistle onto non-infested range and pasture sites. People and their motorized vehicles are a major cause of knapweed spread in Montana. Vehicles driven several feet through a knapweed site can acquire up to 2000 seeds, 200 of which may still be attached after 10 miles of driving. It is imperative to wash the undercarriage of vehicles that have been in weed-infested areas. Dispersal of weed seeds can be minimized by not driving, walking or trailing livestock through weed-infested areas. Only certified weed-seed free seed and hay should be purchased. Livestock should not be grazed in knapweed-infested sites during flowering and seeding, and livestock should be held for seven days before moving to uninfested pastures.

Herbicides

Selective herbicides provide good control of the knapweeds and starthistle, and are often the most cost-effective treatment for small or new infestations. Herbicide treatments on large infestations are most effective when combined with other management methods that enhance the competitive ability of desirable forage species. The most effective herbicides for controlling knapweeds are picloram (Tordon 22K[1]); clopyralid (Transline[1]); clopyralid plus 2,4-D (Curtail[1]); clopyralid plus triclopyr (Redeem[1]); and dicamba (Banvel[2]). [1]

Each herbicide has special characteristics that make it useful in specific situations. The "amine" formulation of 2,4-D can be applied along rivers and riparian areas but provides the most inconsistent control of these weeds. Both picloram and clopyralid tend to stay in the upper portion of the soil horizon and provide effective long-term control of knapweeds on upland sites.

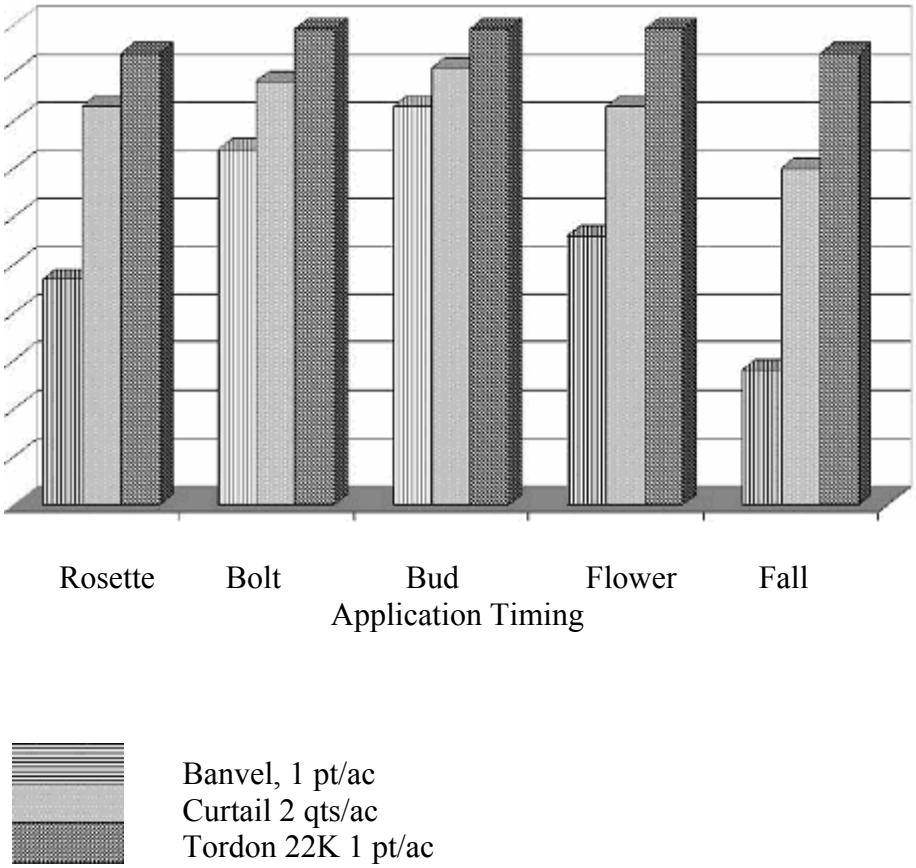
[1]Trademark of Dow AgroSciences LLC; [2]Trademark of BASF

Spotted, diffuse, and squarrose knapweed and yellow starthistle

Tordon 22K applied at rates of 0.25 pounds active ingredient (ai) per acre (1 pint) provides from two to seven years of control depending on site conditions, and is the most cost-effective herbicide treatment. Control tends to be shorter in duration on coarse-textured soils and on sites with an annual rather than perennial grass understory. Timing of application with Tordon 22K is not critical for controlling spotted or diffuse knapweed (Appendix 1A Figure 1), but applications must be made prior to late bud growth stage to stop or reduce seed production that year. Since yellow starthistle is an annual, applications should be made no later than bud stage. Tordon 22K applied at 0.125 lbs a.i. per acre (1/2 pint) can be combined with hand pulling to extend the effectiveness of the herbicide application (Appendix A 1 Table 1).

Transline at 0.25 lbs a.i. per acre (2/3 pint) or Curtail at 1.19 lbs a.i. per acre (2 quarts) provide good to excellent spotted knapweed control for one to three years when applied during bolt or bud growth stages. Control with Curtail declines to less than 83%when applied at rosette, flower and after-flowering growth stages (Appendix A 1 Figure 1). Curtail and Transline applied at these rates will remove knapweed from the plant community with limited impact on non-target broadleaf plants. Redeem at 0.56 to 0.75 lbs a.i. per acre (1.5 to 2 pints) provides good control of spotted knapweed.

Banvel applied alone at 1 lb a.i. per acre (1 quart) and 2,4-D at 2 lbs a.i. per acre (2 quarts) provides inconsistent control of the knapweeds. Banvel at 0.5 lbs a.i. per acre (1 pint) in combination with 2,4-D at 1 lb a.i. per acre (1 quart) provides control similar to that of Curtail when applied at the bud growth stage (Appendix A 1 Figure 1). Applications of 2,4-D alone must be made annually at the rosette to mid-bolt growth stage, until no viable seed remain in the soil.



Appendix A 1 Figure 1. Percent control of spotted knapweed two years after treatment (2 YAT) with Banvel, Curtail and Tordon 22K applied at five different application times.

Appendix A 1 Table 1. Cost and effectiveness of various treatments for controlling spotted knapweed (Brown et.al. 1999).

Treatment	Rate per acre and number of times applied	Plant Growth Stage	Application Date Year 1 Month/Day	Application Date Year 2 Month/Day	Plant Control two years after treatment %	Cost/Acre[1] two years after treatment Cost
Hand-pull (bolted plants)	2 times / year	Early and late bud	6/20 7/20	6/20 7/22	25	$13,900.00
Tordon 22K + Hand-pull	½ pint, 1 time	Bolt (spray) Late bud (pull)	6/2 --	-- 7/21	94	$97.90
Mowing alone	2 times / year	Early and late bud	6/20 7/20	6/19 7/17	0[2]	$200.00
Mowing + Curtail	1 time mowing; 1 quart sprayed 1 time	Late bud (mow) Fall regrowth (spray)	7/16 9/29	-- --	91	$77.67
Curtail	1 quart, 1 time	Fall regrowth	9/29	--	68	$27.67
Tordon 22K (standard)	1 pint, 1 time	Bolt	6/2	--	95	$30.75
Curtail	2 quarts, 1 time	Bolt	6/2	--	89	$35.37

[1] Costs based on the following information: Hand pulling ? wages $9/hour; mowing - $50/acre; Tordon 22K - $86/gallon; Curtail - $30.70/gallon; ground application - $20/acre.
[2] Data from Rinella et.al., shows an average of 52% control after mowing in the fall for three consecutive years.

Appendix A 2: Management of Knapweed from
http://extension.oregonstate.edu/catalog/html/ec/ec1559/

Timing is important for effective control. Unfortunately, most people do not recognize a knapweed species until it is flowering. By that time, hand removal and chemical control are less effective than they are against younger plants.

Practicing a combination of mechanical, cultural, chemical, and biological control is by far the most effective way to manage these species. The key to control is a sustained, continuous effort.

Mechanical control

If you have large areas of spotted knapweed, diffuse knapweed, or yellow starthistle, you can initiate control by burning, mowing, or pulling by hand.

Prescribed or controlled burning can be a very successful way to control noxious weeds. Fire quickly destroys all aboveground parts of knapweed plants. In some cases, heat from the fire may stimulate rapid seed germination, resulting in quick emergence of a great number of weeds. By speeding up the germination process, the seed bank is reduced more quickly and you can manage these weeds sooner rather than later.

For spotted and diffuse knapweed, burning is effective any time during the growing season. For yellow starthistle, burning is most successful at the very early flowering stage. Burning is not as effective against Russian knapweed, which spreads by roots.

Spotted knapweed, diffuse knapweed, and yellow starthistle can be mowed repeatedly depending on the time of year and plant growth stage. Mowing is effective until the plant reaches the flowering stage; after the plant flowers, mowing will spread new seeds. Mowing is not as effective against Russian knapweed.

All four species can be pulled by hand anytime throughout the year. Be sure to wear gloves.

All of these weeds can be left on the ground once pulled or mowed, as long as they are not flowering and have not gone to seed. If the plant is flowering or setting seed, remove the flower or seed head. Place it in a plastic bag and dispose of it in your garbage.

Moderate grazing by livestock (except horses) is effective for suppression of yellow starthistle, spotted knapweed, and diffuse knapweed in pastures.

Cultural control

Once you have cleared an area of knapweed, consider how you want to use the land and how to prevent reinfestation. Planting and managing competitive grasses and wildflowers

is one of the best ways to prevent new weeds from establishing. Native or perennial grasses are a good choice in most areas.

Be sure to consider your planting site, soil, and amount of available irrigation when selecting plants. The following grasses are well-adapted to the high desert environment.

• For an area with 9 to 15 inches of annual precipitation, you could use several of the wheatgrasses, including crested (Agropyron desertorum), bluebunch (Agropyron spicatum), Sherman big (Poa ampla 'Sherman'), western (Pascopyrum smithii), thickspike (Elymus lanceolatus), Siberian (Agropyron sibiricum), intermediate (Agropyron intermedium), and streambank (Elymus lanceolatus 'Sodar'). Indian ricegrass (Oryzopsis hymenoides), sheep fescue (Festuca ovina), Idaho fescue (Festuca idahoensis), and Canada wildrye (Elymus canadensis) also can be used in these locations.

• Grasses that could be used in areas with greater annual precipitation (15 to 20 inches) include bromes (Bromus spp.), orchardgrass (Dactylus glomerata), Idaho fescue (Festuca idahoensis), tall fescue (Festuca arundinacea), and meadow foxtail (Alopecurus pratensis).

Chemical control

Several herbicides are effective against diffuse knapweed, Russian knapweed, spotted knapweed, and yellow starthistle. Current herbicide options are listed in the annual edition of the Pacific Northwest Weed Management Handbook (preview only). Be sure to read the label and follow all instructions when using a pesticide!

Successful weed treatment with herbicides depends upon timing and appropriate chemical use. Herbicide effectiveness varies depending on the growth stage of the weed. For example, some knapweed species are more susceptible to certain herbicides as a young plant in the rosette stage than they are in the flowering stage. The herbicide label will indicate directions for use and the best time to apply the product to the targeted weed.

Consider whether to use a selective or a nonselective herbicide based on the location of the knapweed species. (Selective herbicides target only specific kinds of weeds, whereas nonselective herbicides target a broad range of weeds with few exclusions.) Special consideration should be given to herbicide use in a pasture; some selective herbicides will target a knapweed species without killing desirable grasses.

Do not add chemically treated plants to your compost pile.

Biological control

Several biological control agents such as weevils and flies are being introduced for knapweed management. In drier parts of Oregon and Washington, *Larinus minutus* (lesser knapweed flower weevil) is effective in reducing the production of new diffuse

and spotted knapweed seeds by attacking the flowers. This insect is providing excellent control in these areas. Other insects, such as the hairy weevil (*Eustenopus villosus*), provide effective control of yellow starthistle.

These biological control methods still are being evaluated. They seem to be showing success; however, the result is slow control, not immediate eradication. A list of biological control agents for knapweed is available in the current edition of the Pacific Northwest Weed Management Handbook.

Appendix A 3. Management of Knapweed Control Methods
http://www.cdfa.ca.gov/phpps/ipc/weedinfo/centaurea.htm

Prevention

Diffuse and spotted knapweed are excellent pioneer species and rapidly establish in disturbed roadside, rangeland, wildland, or recreation areas. Seed production may range from 1,000 to 18,000 seeds per plant and dispersal occurs by numerous methods. For diffuse knapweed, wind dispersal occurs by a "tumbleweed effect" and seed may be released over long distances. Spotted knapweed primarily spreads by peripheral colonization of infested areas. Both species have spiny seedheads which may be transported on animal hair or fur. Plant fragments also become attached to vehicles and equipment and spread seed for hundreds of miles. Off-road or recreational vehicles may damage existing vegetation and increase soil disturbance. Hikers and hunters can spread seed by picking the flowers or transporting contaminated hay for horse feed. These human dispersal mechanisms can be controlled. Avoid driving vehicles or equipment through infested areas and clean vehicle undercarriages when necessary. Use pelleted feed or certified weed free hay for horses in backcountry areas. Minimize recreational vehicle use in sensitive areas near infestations. For ranchers and rangeland managers, good grazing practices and early detection of new infestations are essential to reduce diffuse knapweed invasion. Avoid overgrazing and allow competitive forage to recover by implementing grazing rotations. Use weed free certified hay to winter feed animals and rotate feeding areas to prevent soil compaction and trampling of newly emerged grasses and forbs. Where intensive management is economical, pasture fertilization and irrigation will greatly reduce the chances of knapweed invasion.

Mechanical

While not a significant problem in agricultural cropping areas, knapweeds proliferate in non-crop areas of soil disturbance. Therefore, tillage in non-crop areas is not recommended. Hand pulling of small infestations of diffuse knapweed has shown considerable success. Since resprouting from the crown can occur, the entire plant must be removed. Hand pulling must be repeated 2-4 times a year and is easiest when the plants have begun to bolt in the late spring and the soil is still moist. Hand pulling of large infestations is very labor intensive and may not always be feasible. Proper disposal of removed plants is important to prevent spread. Piling and burning in a hot fire is a proven method of disposal. Hand pulling spotted knapweed may be less effective, since

vegetative reproduction from short lateral roots can occur for several years. Mowing will reduce, but not eliminate seed production of either species. Timing of mowing is critical. Rosettes are robust to mowing and generally too low to be successfully cut. A single mowing in the bud to early flower stage has been most effective, reducing seed production by greater than 75%. Mowing more mature plants will facilitate seed dispersal and is not recommended.

Fire

The use of fire has demonstrated mixed results for managing diffuse knapweed. Fire followed by vigorous grass regrowth can reduce knapweed stands. However, crown resprouts and increased seedling germination may eliminate any benefits from burning. An integrated approach using fire and herbicides may be more successful than herbicides alone. Applying the correct herbicide to newly emerged plants following a burn is an effective approach.

Biological

The bronze knapweed root borer (*Spenoptera jugoslavica*) and the banded gall fly (*Urophora affinis*) are the only two insects currently established in California for control of diffuse and spotted knapweed. They are both compatible for dual release in infested areas. There are several other insects which have been released in the United States for knapweed control, and they are listed in Appendix A 3 Table 1. These biocontrol agents greatly vary in their ability to reduce knapweed seed and vegetative reproduction. Successful establishment may take from one to several years. They will not eradicate knapweeds. However, they may be effectively utilized to reduce knapweed populations over time.

Appendix A 3 Table 1: Insect species which have been introduced into the United States for the control of *C. diffusa, C. maculosa*, and *C. virgata*, and certain other related weedy species.

Species name	**Common name**	**Stage, Damage**	**Species attacked**	**Habitat**	**Establishment**	**Current availability**
Sphenoptera jugoslavica	Bronze knapweed root borer	Larvae, root feeding; some adult leaf damage	C. diffusa, C. maculosa	Warm, dry areas	CA, ID, MT, OR, WA	OR, WA
Urophora affinis	Banded gall fly	Larvae, developing seed heads	C. diffusa, C. maculosa, C. virgata,	Northwestern US in infested areas	CA, ID, MT, OR, UT, WA	Northwestern US
Agapeta zoegana	Sulfur knapweed moth	Larvae, root feeding,	C. maculosa, C. diffusa	Moderately humid and temperate	CA, MT, OR, WA	Limited due to collection difficulty
Bangasternus fausti	Broad-nosed seed head weevil	Larvae, seed head feeding	C. diffusa, C. maculosa, C. virgata,	Areas with hot, dry summers	CA, MT, OR, UT	Limited
Chaetorellia acrolophi	Knapweed peacock fly	Larvae, seed head feeding	C. maculosa, C. calcitrapa, C diffusa, C. leucophaea, C. vallesiaca, C. virgata	Moist habitats	MT, OR	Currently not available for general redistribution
Cyphocleonus achates	Knapweed root weevil	Larvae, root vascular tissue	C. maculosa, C. diffusa	Well drained soils with dense knapweed	CA, CO, MT, OR, WA	OR, Europe
Larinus minutus	Lesser knapweed flower weevil	Larvae, seed head; adult, rosettes and flowers	C. diffusa, C. maculosa	Hot, dry areas	CA, MT, OR, WA	Limited in OR and WA

Appendix A 3 Table 1: Insect species which have been introduced into the United States for the control of *C. diffusa, C. maculosa*, and *C. virgata*, and certain other related weedy species (continued).

Species name	**Common name**	**Stage, Damage**	**Species attacked**	**Habitat**	**Establishment**	**Current availability**
Larinus obtusus	Blunt knapweed flower weevil	Larvae, seed head	C. maculosa, C. diffusa	More moist areas than L. obtusus	WA	Currently unavailable
Metzneria paucipunctella	Spotted knapweed seed head moth	Larvae, seed	C. maculosa, C. diffusa	Sites with good winter snow cover	ID, MT, OR, WA	ID, OR, WA
Pelochrista medullana	Brown winged root moth	Larvae, root cortex	C. diffusa, C. maculosa	Dry sites with high plant density	None currently found	Currently unavailable
Pterolonche inspersa	Grey winged root moth	Larvae, root vascular tissue	C. diffusa, C. maculosa, C. virgata	Mediterranean climate, no harsh winters	MT	Limited
Terellia virens	Green clearwing fly	Larvae, seeds	C. maculosa, C. diffusa	Wide range	CA, MT, OR	Limited in OR
Urophora quadrifasciata	UV knapweed seed head fly	Larvae, seed head	C. diffusa, C. maculosa, C. virgata	Western US	CA, ID, MT OR, UT, WA	Northwestern US

Chemical: Herbicides can be used to control existing stands of *C. diffusa* and *C. maculosa* and substantially reduce seed production. However, since the seed of both species is viable in the soil for up to seven years, retreatment will be necessary. Long term reductions in the seed bank must be the goal for effective knapweed management with herbicides. Proper timing of herbicide applications is critical to effective control. In California, there are three herbicides important for knapweed management: 2,4-D, dicamba, and clopyralid. All three are most effective when applied in the spring, when plants are beginning to bolt. 2,4-D should be applied at 2 lb ae/A; dicamba at 1 lb ae/A; and clopyralid at 0.25 lb ae/A. Clopyralid and dicamba are the most effective treatments. Both will provide some residual control, particularly clopyralid, and retreatments may be necessary in the second, third, or fourth years. Dicamba will injure or kill most other broadleaves it contacts, including desirable forage and native broadleaf species. Clopyralid is more selective, but will injure legumes such as clovers. 2,4-D is the least expensive treatment, but is less effective than dicamba and clopyralid, and retreatment will be required every year. 2,4-D will also injure other broadleaves, similar to dicamba. The most effective knapweed treatment is picloram applied at 0.25 lb ae/A. However, it is not labeled for use in California. Picloram will provide 100% residual control of *C. diffusa* and *C. maculosa* for 2-5 years after treatment. This herbicide will kill or severely injure most other broadleaf species it contacts in the soil or on the foliage including trees, forbs, and shrubs. No resistance to these herbicides has been documented in *C. diffusa* or *C. maculosa*. However, any herbicide management program should integrate rotation between herbicides to prevent the development of resistance.

Integrated management strategies: Seed production by *C. diffusa* or *C. maculosa* is typically 1000 times greater than required to maintain infestations. Thus, relatively few plants per acre are needed for rapid reinfestation. Management must be continuous or reinfestation is inevitable. Reseeding and establishment of competitive grasses or other native species is critical. Native bunchgrass communities are generally very resistant to knapweed invasion. However, almost any form of disturbance (including inclement weather such as hailstorms) may open a niche for invasion. Research has also shown that areas receiving 10-14 inches of precipitation annually are most susceptible to knapweed invasion, even in established perennial bunchgrass communities. The severity of knapweed infestations in other states such as Montana and Wyoming should serve as an indicator of the potential economic and environmental problems that knapweeds pose to California.

Below are some general field protocols for monitoring grassland birds that could be used as a starting point to develop a monitoring protocol for experimental manipulations. However, we suggest modifications, such as 50 m radius plots rather than 100 m plots. Also, surveys should take place only in June to reduce probability of counting migrants. Finally, some sections are not relevant to this protocol (contact info and methods for establishing point count station locations).

Appendix B. Grassland Breeding Bird Use of Managed Grasslands on National Wildlife Refuges within Region 5.

Region 5 Grassland Bird Study, Protocols (5/14/02), FINAL Revision for 2002 Field Season

FIELD PROTOCOLS

This document describes the field protocols to be used by refuge personnel at refuges participating in the Region 5 Grassland Bird Project. This document only contains the protocols for collecting field data, other details of the experimental design (selection of experimental units, treatments, etc.) are described elsewhere. The first page gives an overview of the data collection process, subsequent pages describe the specific techniques.

<u>Overview</u>

Timing Protocol

2 Weeks Ia. Grassland bird surveys: Maximum density sampling
Ib. Grassland bird surveys: General procedures
Ic. Grassland bird surveys: Double-observer technique

Surveys will be made from late May through late June. The surveys will be 2 discrete, 5-day periods, separated by a period of 2 weeks when no bird surveys will take place. The first survey period will take place during the historic peak of breeding grassland bird activity at each refuge. A double, simultaneous, independent observation procedure will be used (Ic). Survey points within the fields have been selected according to a maximum point density procedure (Ia).

Once/season II. Vegetation sampling: Location of random points
IIIa. Vegetation sampling: Archival photographs
IIIb. Vegetation sampling: Height-density
IIIc. Vegetation sampling: Percent frequency and litter depth
IIId. Vegetation sampling: Dominant species

Protocols II - IIIc need to be made only once per season in each study field. Protocol IIId is completed twice. Sampling points within the fields have been selected according to a random sampling procedure (II). At each point, vegetation measurements (IIIa - IIId) are taken. All vegetation sampling should be accomplished during the 2-week gap between the two bird survey periods (with an exception for Protocol IIId, dominant species, which also needs to be repeated in mid-summer to identify dominant, warm season plants).

Contacts

Regional Fire Ecologist	Laura Mitchell 302 684-5401, Laura_Mitchell@fws.gov
Patuxent Scientists	Michael Runge, 301 497-5748, Michael_Runge@usgs.gov
	Bill Kendall, 301 497-5868, William_Kendall@usgs.gov

General Notes:

(1) Please record data in blue or black pen (*not pencil*). We need a permanent record that we can easily copy. Write legibly and boldly.

(2) Record all data on all sheets. Don't leave any items on the data sheets blank. In particular:

a. Put the date, refuge, field, and point *on every sheet*.

b. Record 0's (zeros). Don't leave blanks.

(3) Please treat the data sheets as archival material. *Don't fold, bend, tear, or staple*.

Protocol Ia: Grassland bird surveys: Maximum density sampling

Goal: To place sampling circles, of 50 m and 100 m radius, within each study field for avian surveys, maximizing the number of points per field.

Personnel: Selection and mapping of avian survey points will be carried out by study coordinators (Mitchell and Runge). Field observers will be responsible for finding survey points using provided coordinates and maps.

Equipment: GPS receiver.

Steps:

The refuges provide study coordinators with topographic maps and aerial photographs of the study fields as well as UTM locations of the field boundaries/corners. If a refuge does not have a GIS, the study coordinators will collect UTM locations of field boundaries during refuge site visits.

The study coordinators will select avian survey points within each field, using the following three-step process, using ArcView®:

1. Overlay field boundaries on photos or DOQQs, checking that boundaries are correct.
2. Place as many 100 m radius circles as possible within each study area. The circles have to be entirely within the field, and the circles cannot overlap. The edge of a 100 m radius circle may touch the edge of the study area. There is no randomization here, just optimal placement of circles. There should be at least 2 large sampling circles per field, preferably 3 to 5.
3. After placement of 100 m radius circles, if there are areas within the field that are not being sampled because they are too narrow to fit a 100 m radius circle, fill them with 50-m radius circles. The circles have to be entirely within the field, and these small circles cannot overlap with each other or with any large circles.

The UTM (NAD83 datum) locations of the sampling points will be provided along with a map of the study fields and avian survey points. Avian observers should locate the points using the GPS unit. Points may be marked with short flags (~7 cm), provided they do not provide a perch for birds. Observers should locate points in advance of the first count, and mark them, to save time on count days (see Protocol Ib, below).

Protocol Ib: Grassland bird surveys: General procedures

Goal: Measurement of the density of obligate grassland breeding birds present in each field, during two, separate, 5-day survey periods.

Personnel: Two individuals per refuge to conduct all grassland bird surveys during the study period. This two-person team will conduct all of the surveys. Ideally, the same two-person team will be used each year of the study (2001-2003).

Equipment: Good optical equipment (binoculars), clipboards, timer, compass, flagging, a measuring tape, thermometer, anemometer (Kestrel®) and a random number table.

Steps:

The surveys will be conducted between late May and late June, beginning during the week designated as the peak breeding period for the Refuge (see Table 1). Surveys will be conducted for two "bouts", with 5 consecutive survey days per bout. The first bout will begin on the first Monday of the first survey week. The second bout will begin 3 weeks after the first day of the first survey (21 days later). All study fields at the refuge (treatment and controls, where applicable) will be surveyed during each survey day. *Note* that in the 2nd and 3rd years of the study, the first bout should begin the same week as it was conducted during the 1st year. The remainder of the sampling days should follow accordingly. If days were missed (due to weather) during the 1st year, that pattern of observations does not need to be recreated in subsequent years.

Surveys will not be conducted during periods of rain or thick fog, or when winds >10 mph create sounds, such as moving vegetation, that interfere with the observers' ability to detect songs. If precipitation or wind develops during a survey, the observers should suspend the survey until the next day with acceptable weather conditions. Observers will continue in this fashion until 5 complete survey days have been completed, per bout. If weather conditions are such that two weeks pass without the completion of 5 full survey days, the bout should be terminated. Retain all data from partial surveys (days aborted because of a change in weather), so that they can be analyzed in the event of an incomplete set of surveys.

In each field, several (4-6) survey points will be identified (see Ia). A point count will be conducted at each of these points each day of the survey. Prior to the first survey bout, the observers should visit each sampling point, and become familiar with the settings. A site map should be prepared for each survey point, noting landmarks, with measured

distances (see Data Form for Protocol Ib, "Bird Survey Site Reconnaissance"). Note also whether each survey point is a 50-m sampling circle, or a 100-m sampling circle. The observers need to determine readily if a bird is within 50 m, or within 100 m, so landmarks at these distances are particularly useful. If there is a need for additional visual aids to help with distance estimation, small pieces of flagging may be tied to vegetation. Each morning, prior to the survey, observers should practice estimating 50 m and 100 m distances.

Randomization: (1) Order of fields. If there are two fields being studied at a Refuge, flip a coin to determine the first field to visit on the first day. For the rest of the bout, rotate the order of fields visited each day. Start the process over for the second bout. If there are three fields being studied at a Refuge (say, fields A, B, and C), note that there are six different orders of visitation (A/B/C, A/C/B, B/A/C, B/C/A, C/A/B, and C/B/A). Use a regular die (6-sided) to choose the order of visitation on the first day. Do the same for the rest of the days of a bout, but don't repeat a particular order of visitation. Start the process over for the second bout. If there are more than 3 fields under study at a Refuge, talk to a local statistician or call Michael Runge for advice on randomization. (2) Order of points within a field. The first point surveyed in a field should be randomly selected each day (use a table of random numbers, assigning a number to each point). The order of visitation of the remaining points in each field should be determined based on considerations of minimizing disturbance to the birds in the field, and conducting the survey efficiently. Make an effort not to tread the same path each day.

Data will be collected between 0600 and 1000 hrs, using a 5-minute observation period at each survey point, following a 2-minute period of silence.

Weather measurements: at each point, one observer will measure and record temperature and wind data. Temperature will be measured in ºF. Wind direction will be recorded. An anemometer (Kestrel® pocket weather meter) will be used to measure wind speed (in mph). To do this, use the "average wind speed" setting. Since this takes the average from the time the unit is turned on, the meter should first be held aloft facing the wind, then turned off and turned back on (to reset the average), and held for approximately 1 minute before taking the reading. (*Make sure* to set the units to mph!) If a weather meter is temporarily unavailable, the wind meters in the Refuge Fire Weather Kits can be used to measure wind speed on the Beaufort scale.

An independent double-observer point count technique (Ic) will be used to conduct the bird surveys. This method estimates and adjusts for the probability of detecting birds.

Grassland breeding birds will be surveyed within two ranges: a) less than 50 m from the survey point, and b) greater than 50 m, but less than 100 m from the survey point. Individuals seen or heard within those two ranges will be recorded by location, species, and sex (where possible). All obligate grassland breeding birds (see Table 2) seen or heard within the observation period will be recorded, including individuals passing through the area during the count. In addition, the observers should record all other birds

that are *using* the field in some way. A list of grassland generalists is included for reference (Table 3).

An effort should be made *not* to count the same individual more than once, either at a sampling point, or between sampling points within the same field. This will require careful judgment on the part of the observers. However, if study fields are adjacent, and the same bird shows up in two different *fields*, its presence should be included in the counts for *both* fields. Make a notation to this effect, if it occurs.

In the event of flyovers (birds passing over the sampling circle, but not landing in the field), the observers should count the birds if they are *using* the field in some way. For instance, Tree Swallows foraging above a field, or a Northern Harrier skimming a field, should be counted, but a Red-tailed Hawk soaring high above a field should not.

No attracting devices or means of any kind will be used. Survey points will be located using a Global Positioning System receiver, and checked with a map of the refuge study fields and survey points. Survey points will not be marked with posts that allow for perching; points may be temporarily marked with a short (~7 cm) wire flag or stake.

Observers must be capable of identifying all obligate grassland breeding birds (Table 2) by sight and sound (100%). Observers should be familiar with grassland generalists (Table 3) in the survey area. Accurate identification of vocalizations is essential, since many individuals will be detected only by sound during the breeding season. Additionally, observers need to hear high frequencies in order to detect high-pitched calls, such as those of Grasshopper Sparrows. Observers must be thoroughly familiar with the survey protocol and be capable of recording data accurately.

Table 1. Peak breeding bird period for each Refuge. Reflects when observations were made during the 2001 field season.

Refuge	**Contact**	**1st Observation Period (2002)**
Bombay Hook NWR	Frank Smith	last week May (May 27)
Prime Hook NWR	Annie Larsen	last week May (May 27)
Eastern Neck NWR	Susan Talbott	1st week June (June 3)
Eastern Virginia Rivers NWR Complex	Sandy Spencer	last week May (May 27)
Patuxent Research Refuge	Holly Obrecht	last week May (May 27)
Erie NWR	Norma Kline	1st week June (June 3)
Iroquois NWR	Chris Norment	last week May (May 27)
Montezuma NWR	Tracy Gingrich	4th week May (May 20)
Canaan Valley NWR	Ken Sturm	4th week May (May 20)
Missisquoi NWR	Al Zelley	1st week June (June 3)
Rachel Carson NWR	Graham Taylor	1st week June (June 3)
Supawna Meadows NWR	Linda Ziemba	last week May (May 27)
Wallkill River NWR	Kevin Holcomb	1st week June (June 3)

Table 2. Obligate grassland breeding birds.

Common Name	**Scientific Name**	**Code**
Northern Harrier	*Circus cyaneus*	NOHA
Upland Sandpiper	*Bartramia longicauda*	UPSA
Short-eared Owl	*Asio flammeus*	SEOW
Horned Lark	*Eremophila alpestris*	HOLA
Sedge Wren	*Cistothorus platensis*	SEWR
Bachman's Sparrow	*Aimophila aestivalis*	BMNS
Vesper Sparrow	*Pooecetes gramineus*	VESP
Savannah Sparrow	*Passerculus sandwichensis*	SAVS
Grasshopper Sparrow	*Ammodramus savannarum*	GRSP
Henslow's Sparrow	*Ammodramus henslowii*	HESP
Dickcissel	*Spiza americana*	DICK
Bobolink	*Dolichonyx oryzivorus*	BOBO
Eastern Meadowlark	*Sturnella magna*	EAME

Table 3. Grassland generalists (birds generally breeding in hedgerow and/or old-field habitats). Observers should record all birds using the field, whether they are on this list or not.

Species	**Common Name**	**Code**
Red-tailed Hawk	*Buteo jamaicensis*	RTHA
American Kestrel	*Falco sparverius*	AMKE
Ring-necked Pheasant	*Phasianus colchicus*	RPHE
Northern Bobwhite	*Colinus virginianus*	NOBO
American Woodcock	*Philohela minor*	AMWO
Mourning Dove	*Zenaida macroura*	MODO
Barn Owl	*Tyto alba*	CBOW
Willow Flycatcher	*Empidonax traillii*	WIFL
Unknown Empidonax	*Empidonax* sp.	XXEM
Eastern Phoebe	*Sayornis phoebe*	EAPH
Eastern Kingbird	*Tyrannus tyrannus*	EAKI
Loggerhead Shrike	*Lanius ludovicianus*	LOSH
White-eyed Vireo	*Vireo griseus*	WEVI
Tree Swallow	*Iridoprocne bicolor*	TRES
House Wren	*Troglodytes aedon*	HOWR
Eastern Bluebird	*Sialia sialia*	EABL
American Robin	*Turdus migratorius*	AMRO
Gray Catbird	*Dumetella carolinensis*	GRCA
Brown Thrasher	*Toxostoma rufum*	BRTH
Blue-winged Warbler	*Vermivora pinus*	BWWA
Golden-winged Warbler	*Vermivora chrysoptera*	GWWA
Yellow Warbler	*Dendroica petechia*	YWAR
Prairie Warbler	*Dendroica discolor*	PRAW
Common Yellowthroat	*Geothlypis trichas*	COYE
Unknown Warbler	*?*	XXWA
Yellow-breasted Chat	*Icteria virens*	YBCH
Eastern Towhee	*Pipilo erythrophthalmus*	EATO

Table 3. Grassland generalists (birds generally breeding in hedgerow and/or old-field habitats). Observers should record all birds using the field, whether they are on this list or not (continued).

Species	**Common Name**	**Code**
Chipping Sparrow	*Spizella passerina*	CHSP
Clay-colored Sparrow	*Spizella pallida*	CCSP
Field Sparrow	*Spizella pusilla*	FISP
Song Sparrow	*Melospiza melodia*	SOSP
Unknown Sparrow	*?*	XXSP
Blue Grosbeak	*Guiraca caerulea*	BGBK
Indigo Bunting	*Passerina cyanea*	INBU
Red-winged Blackbird	*Agelaius phoeniceus*	RWBL
Western Meadowlark	*Sturnella neglecta*	WEME
Brown-headed Cowbird	*Molothrus ater*	BHCO
Orchard Oriole	*Icterus spurius*	OROR
American Goldfinch	*Carduelis tristis*	AMGO

Protocol Ic: Grassland bird surveys: Double-observer technique

Goals: Estimate the density of grassland birds, by species, correcting for detection probability.

Personnel: See Protocol Ib.

Equipment: Binoculars for each observer, a timer for each pair (capable of indicating by sound when a certain amount of time has elapsed), a thermometer, a weather meter, clipboards, and data forms (2 copies per sampling point per day). A rangefinder may also be useful.

Steps: (see "Grassland Bird Point Count Data Sheet")

(1) After arrival, wait 2 minutes for the birds to settle down before counting. Agree on a direction to coincide with "up" on the printed form. Use the range-finder, pre-set flags, and landmarks to estimate the bounds of the 50 m and 100 m radii. You may find that the range-finder is difficult to rely on in a grassland situation, because the grass does not present a "hard" surface to the observer at ground level. Be aware of whether you are at a 50-m or 100-m sampling point. If you are at a 50-m sampling point, you only need to record observations within 50 m. If you are at a 100-m sampling point, you need to record observations within 50 m, and between 50 m and 100 m.
(2) During the waiting period, record the weather information. This data should be measured at each point.
(3) Set the timer to 5 minutes. As much as possible, the two sets of observations should be independent, so the observers may want to begin facing in opposite directions. As sounds or clues direct their attention in various directions, however, the observers should scan the entire area as if they were doing the count alone. By standing a few feet apart, the observers can avoid interacting with each other (or seeing the other's activity) during the count.
(4) The data sheet has 12 individual circles ("targets") for the bird observations. Use one circle for each species (use more than 1 data sheet per sampling point, if needed). In the box indicated, record which circle is for which species (using the standard codes, Tables 2 and 3). You may wish to prepare the data sheets in advance of field work, by putting in the codes of the species that are most commonly encountered at your Refuge. If the order of species is the same on the data sheets of both observers, the reconciliation phase may be more efficient.
(5) For each bird detected, mark the location (including direction, and whether inside or outside the 50 m circle) on the appropriate printed target. Mark the position with an "x" if a song was heard; "•" if the bird was seen. If the bird seems beyond 100 m but not by much, put () around the mark—this is in case your partner has put it closer than 100 m. But in no case record birds which are clearly outside the field (e.g., in the surrounding woods). See Table 4 for other notation that should be used.
(6) At the end of the 5-minute count period, reconcile your records with your partner's. Often, both observers will have detected birds jointly, even if directions and distances

disagree somewhat. Use your diagrams along with your best judgment to separate the numbers detected jointly and separately. Be careful not to ascribe separate individuals to records differing only slightly in direction or distance. For each species, record the **N**umber detected by you ("N") for both distances $d < 50$ m, and $50 \text{ m} < d < 100$ m. Also record the **D**ifference ("D"), that is, the birds seen by you but not the other observer, by species and distance. Both parties may have entries for D, even if both detected the same number of birds, because different individuals may have been missed, i.e., "D" are the numbers other than those detected jointly. It should always be, then, that $N_1 + D_2 = N_2 + D_1$, where the subscripts (1,2) refer to each observer. This is a useful check.

(7) Make every effort to come to an agreement on the distance range of the birds seen jointly, in cases where the observers put them on different sides of the 50 m or 100 m circle. If both observers put a bird outside the 100 m bound, then it is not to be counted. If one observer saw a bird and the other only heard it, use the distance indicated by the person who saw it. If both observers detect the same bird, but cannot agree about the distance (perhaps because the bird moved and they each saw it first at a different distance), then the observations should be recorded in different distance categories for each observer, but the "D" entries should nevertheless be 0. (For instance, a NOHA first seen by observer 1 at 75 m, and by observer 2 at 40 m should be recorded as: Observer 1, 50-100 m, N = 1, D = 0; Observer 2, 0-50 m, N = 1, D = 0.) *Note*: with regard to distance in case of movement, the relevant point is *where the bird was first seen* by each observer.

(8) If you detect a bird that you cannot identify, record it with as much detail as you can. For instance, an unidentified sparrow may be denoted as "XXSP". During the reconciliation phase, if your partner detected the same bird but was able to identify it to species, you may use this information. If, after the count has ended, you hear or see the bird again, and can now identify it, it is also permissible to use that information.

(9) It may happen that there is a disagreement in the identification of a bird. In this case, first make a conscientious effort to resolve the conflict. It is permissible to revise your identification if honestly persuaded by the evidence (such as hearing the bird again, or the greater certainty of your partner). If so, mark your record accordingly. But if the disagreement remains, each observer should add a note to his mark for that bird (on the target) with the other party's identification (e.g., in the case where you have CHSP and the other observer has FISP, the two of you should write "=FISP" and "=CHSP", respectively). In this case, the bird at issue can't be included in the totals for that species. Instead, each observer must add a new "species" to his sheet, writing his own ID and that of the other observer, and filling in the count number for the bird(s) in question. Here, of course, the "D" line will be 0 since both observers detected the same bird. This way, the bird will be included in the totals for that field.

(10) It will happen that there is disagreement about the number of birds seen of a particular species. **The number of birds seen by an observer should not be altered during the reconciliation phase, except in one notable circumstance**: if one observer has information that indicates the other observer double-counted a bird. In this case, the latter observer should remove his second observation of the bird. There is no circumstance when an observer should *add* observations after the

counting period. *Example 1.* Suppose a flock of TRES were present, one observer recorded 10, the other recorded 12, and, in fact, a careful count afterward indicated there were 15 birds. You should record this as $N_1 = 10$, $D_1 = 0$; $N_2 = 12$, $D_2 = 2$. The second observer saw 2 birds that the first observer missed. The after-the-fact information is irrelevant here, because no birds should be added to totals. *Example 2.* Suppose one observer indicates she heard 2 EAMEs (1 to the NE, 1 to the NW), and the second observer indicates he heard 1, which he subsequently saw fly from the NE to the NW. During reconciliation, his information convinces her that she double-counted. The results should be recorded as $N_1 = 1$, $D_1 = 0$; $N_2 = 1$, $D_2 = 0$. *Example 3.* Suppose one observer heard 4 HOLAs and the other heard 2. During reconciliation, the first observer convinces the second that he actually heard 3. The second observer *cannot change the number he recorded* as a result of this. During the actual count period, the second observer either failed to detect or failed to record an individual bird—this is exactly the sort of detection error we want to estimate, so it should not be corrected after the fact.

(11) If any disagreement resulted in a change to what an observer would have recorded if alone, that observer should put an asterisk in the bottom left corner of the relevant species code box. For instance, if a species identification or distance determination was modified as a result of consulting with the other observer, indicate there was a change. **Emphasis:** During the reconciliation phase, observers may use after-the-fact information to change species identification or distance estimates, *but not the number of birds detected* (except if it involves double-counting).

(12) If there are questions about any aspects of this procedure, *do not hesitate* to contact Michael Runge. Clarifications to the protocol based on questions from the field will be posted to the ListServ set up for this study.

Table 4. Symbols used on the point count data sheet for bird observations. The first 7 symbols are used when the observations are taken. The last two symbols are used during the reconciliation phase.

Symbol	Meaning	Comment
•	Seen	Bird seen, could be % or &. If you were able to determine the sex by sight (e.g., as in NOHA), indicate it.
×	Heard (song)	Bird heard singing, must be %.
$\times_c$	Heard (chip)	Only a chip was heard, could be % or &.
•□→	Flight	Bird seen flying from one point in the field to another. Indicate the point where first seen with a dot, then draw arrow to where it moved.
♉	Flying only	Bird never landed in the field, was only seen flying over it.
•×	Seen & Heard (song)	Bird was both seen and heard singing, must be %.
( )	Uncertain Distance	Used to indicate uncertainty about whether the bird was within the 50-m or 100-m circle.
○	Question	Use a circle around an observation to indicate some question or dispute about its location, identification, number, etc. For instance, if you realize you double-counted a bird, circle the second observation.
*	After-the-fact modification	Put this notation in the bottom left corner of the species code box to indicate that some modification was made to the observation as a result of consulting with the other observer.

Appendix C. Grassland Breeding Bird Use of Managed Grasslands on National Wildlife Refuges within Region 5 Vegetation Sampling.

Region 5 Grassland Bird Study, Protocols (5/14/02), FINAL Revision for 2002 Field Season

Protocol II: Vegetation sampling: Location of random points

Goals: To choose random points within each study field as anchor-points for vegetation sampling.

Personnel: Selection and mapping of vegetation sampling points will be carried out by study coordinators (Mitchell and Runge). Field observers will be responsible for finding survey points using provided maps and refuge GPS equipment.

Equipment: GPS receiver.

Steps:

The refuges provide study coordinators with topographic maps and aerial photographs of the study fields as well as UTM locations of the field boundaries/corners. If a refuge does not have a GIS, the study coordinators will collect UTM locations of field boundaries during refuge site visits.

The study coordinators will select vegetation sampling points within each field, using the following three-step process, using ArcView®:

1. Overlay field boundaries on photos or DOQQs, checking that boundaries are correct.
2. Run an Avenue script, "random_p.ave", to place 4-6 sampling points randomly within each field. Each point should be at least 30 m from the edge of the field, and 125 m from all other points.
3. The program is re-run until at least 4, and preferably 5-6, sampling points lie within each field.

The UTM locations of the sampling points will be provided along with a map of the study fields and avian survey points. Vegetation sampling personnel should locate the points using the GPS unit.

At each vegetation sampling point, 4 measurements need to be made: an archival photograph (IIIa), height-density (IIIb), percent frequency and litter depth (IIIc), and dominant species (IIId).

Protocol IIIa: Vegetation sampling: Archival photographs

Goal: To visually characterize each study field.

Personnel: Only one person is needed.

Equipment: A digital camera, Robel pole, sight pole, 4-m tape measure.

Steps: (see DATA FORM for Protocol IIIa, "Vegetation Point Photographs")

Place a Robel pole at each vegetation anchor point. Place the sight pole 4 m to the north. Take a single photograph of the Robel pole from a height of 1 m, alongside the sight pole (being careful not to include the sight pole in the photograph). Note that this photograph should be taken of undisturbed vegetation, so it is advisable to take the picture before doing the other vegetation measurements (IIIb – IIId). Use only a digital camera (set at its highest resolution, and widest view). Record the vegetation sampling point number (for which you know the UTM coordinates), field name, and date. If for some reason, you cannot take the photograph facing south, record the direction you were facing.

When you download the photographs from the camera, give them names that contain the Refuge, Field, and Vegetation point (e.g., BMH_101_v1.jpg for Bombay Hook, Field 101 vegetation point 1). Provide the make, model, resolution, and focal length (or magnification) for the camera used.

All photographs, as well as all vegetation measurements, should be made in the two-week period between the two avian survey bouts. The rationale for this timing is that we would like to measure the vegetation structure at about the same time the birds are establishing territories, but we don't want to disturb the birds during the weeks of the avian point counts. The window in which to do the vegetation surveys is narrow to control for vegetation growth. If this narrow window will pose logistical problems due to availability of personnel, please contact Laura or Michael as much in advance as possible to discuss alternatives.

Continue with Protocol IIIb.

Protocol IIIb: Vegetation sampling: Height-density

Goal: To obtain an index of height-density at each sampling point within each study field.

Personnel: Only one person is needed, but a team of two will be more efficient.

Equipment: Robel pole, sight pole, 25-m tape, 4-m tape, clipboard.

Steps: (see DATA FORM for Protocol IIIb, "Robel Pole")

Locate four height-density stations, each 25 m and in a cardinal direction (N, S, E, W) from the vegetation sampling point. At each height-density station, plant the Robel pole firmly in the ground. Take four readings of the Robel pole, each 4 m and in a cardinal direction from it. Thus, there should be 16 measurements made at each vegetation sampling point (4 at each of 4 stations). To make a reading, place your eye at the 1 m mark on the sight pole. A Robel pole is marked in ¼-decimeter intervals for the first 2 decimeters, and ½-decimeter intervals thereafter. Height-density measurements are taken at the lowest interval where the pole can be seen, at least partially, through the vegetation.

The Robel poles that were prepared for this study are labeled a little differently than standard Robel poles. Fig. 1 indicates how the readings should be recorded. *Example 1.* Suppose the vegetation completely obscures the white interval with the "3" in it, but only partially obscures the black interval above that. This should be recorded as 3.5. *Example 2.* Vegetation obscures the lowest white interval, but the first black interval is partially visible. This should be recorded as 1.25. *Example 3.* Note that bare ground with no vegetation obscuring the pole would be recorded as 1.00.

Continue with Protocol IIIc.

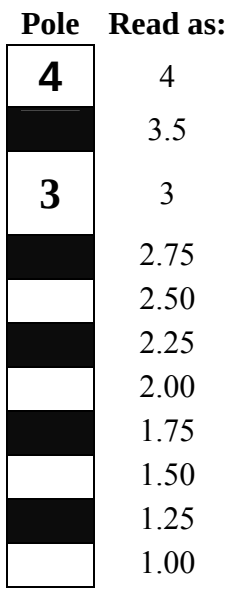


Figure 1. Diagram of the Robel pole used for this study, and how it should be read.

(*The astute reader will note that our readings are all exactly 1 dm greater than they should be. We will deal with this during analysis.* Do not correct *this in the field, as it will likely result in confusion. If you are using a Robel pole that was not created for this study, please send a diagram of your pole with your data sheets, and indicate how you read it.*)

Protocol IIIc: Vegetation sampling: Percent frequency and litter depth

Goal: To obtain the percent frequency of several general categories of vegetation structure at each sampling point within each study field.

Personnel: Only one person is needed, but a team of two will be more efficient.

Equipment: Field tape measure (minimum 30 m), a pin or stake to anchor the tape, a 4 mm diameter metal rod (~2 m in length), a random number table (random list of numbers 1 through 360), a compass, a collapsible tape measure, and fluorescent pin-flags.

Steps: (see DATA FORM for Protocol IIIc, "Percent Frequency, Litter Cover, Litter Depth")

Prior to the start of vegetation sampling, permanently mark the field tape at 0.5-m intervals from 0 m to 30 m. Make every third mark (starting at 1.5 m) a double mark, for litter depth readings.

To establish the transect, anchor one end of the 30 m field tape at the survey point. For each sampling point, choose and record a random bearing. Use the compass to orient the tape on this bearing. [*Note:* for the 2nd and 3rd years of the study, use the same bearing as selected for the 1st year.] Place fluorescent pin-flags at both ends of the transect, to assist you in relocating this transect in late summer. Ensure the flags do not extend above the tallest vegetation in the plot.

At each of the 60 systematically spaced points, place the metal rod directly next to the field tape, perpendicular to the ground. Make an attempt to avoid "aiming" the rod at any particular plant; simply allow the rod to drop next to the tape.

Determine all vegetation that touches the metal rod. Record the presence or absence of interceptions by each vegetation category, at each point. A vegetation category is counted as intercepting the rod only once, per point, no matter how many plants from that category intercept the rod (this is a frequency measure, not dominance). Record interceptions with tally marks on the data sheet. Vegetation categories are: shrub >0.5 m, shrub <0.5 m, live graminoid, live forb, and standing dead vegetation. *Live graminoid* is defined as plants with aboveground live tissue, that are members of the families *Poaceae*, *Juncaceae,* or *Cyperaceae*. *Live forb* is defined as all other live herbaceous plants, including, for the purposes of this study, prostrate vines. *Standing dead vegetation* is dead plant material that stands at an angle greater than 45° from the ground.

Where the rod touches the ground, note if the ground is bare (as opposed to being covered by litter). This should be a visual estimate made from above; do not move vegetation aside to determine this. If the ground is bare, make a tally mark in the appropriate data column.

Measure litter depth to the nearest 0.5 cm at every third point along the transect. Place the tape measure directly next to the metal rod, and gently work the end of it to the soil surface. Measure the depth of litter at this point. *Litter* is dead plant material that is horizontal, or is leaning at an angle less than 45° from the ground and part of a continuous layer to the ground.

Continue with Protocol IIId.

Protocol IIId: Vegetation sampling: Dominant species

Goal: To determine the dominant species of vegetation at sampling points within each study field.

Personnel: Only one person is needed, but a team of two will be more efficient.

Equipment: 1-m^2 frame, table of random numbers (random list between 1 and 30), zip-lock bags (gallon size).

Steps: (see DATA FORM for Protocol IIId, "Dominant Species")

Prior to the start of vegetation sampling, mark two sides of the 1-m^2 frame (quadrat) in the manner shown in Fig. 2 (at distances of 0.224 m and 0.5 m along the side). These provide references for estimating the cut-off points of the cover class scale (5%, 25%, 50%, 75%, and 100%).

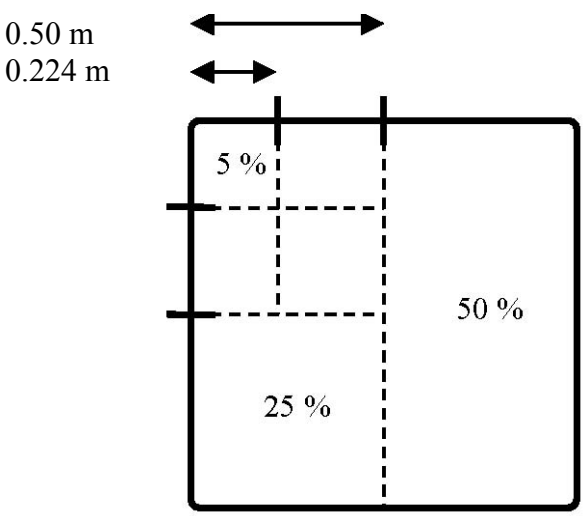


Figure 2. Diagram of 1-m^2 sampling frame (quadrat). The marks are placed on the two sides at 0.224 m and 0.5 m. The areas circumscribed by invisible lines at the various marks correspond to the cut-off points for the cover classes. Comparison of aerial cover of plants to these references should help with cover class determination.

Use the same sampling transect as in Protocol IIIc, walking it a second time.

At four random points per transect (random numbers between 1 m and 30 m), place the 1-m^2 frame on the ground, over the vegetation. Use different random numbers for each transect. [*Note*: for the second and third years of the study, use the same placement of quadrats as in the 1st year.] Place the frame parallel to and flush with the transect tape, on the side opposite of where you have been walking. Use the 0.5-m mark on the frame to align the frame with the random locations on the measuring tape. Place fluorescent pin-flags at the upper left-hand and lower right-hand corners of the quadrat. Ensure that the flags do not extend above the tallest vegetation in the plot. These flags will help you relocate the quadrat in late summer.

In each frame, visually estimate cover per plant species, using a modified Daubenmire scale (Table 5). Record dominant species in the following manner:

1. Note the total number of species of live, vascular plants in the square. You *may not have to* identify all of them. You may need to look quite carefully to find them all. It is permissible (advisable!) to move vegetation aside to conduct this search.
2. Make a quick visual estimate of the ranking of species by cover class.
3. Beginning with the plant species with the greatest percent cover, identify the plant, and estimate the cover class (Daubenmire scale). This is a measurement of aerial cover, so consider how much light is intercepted by each species from above.

   NOTE: *We have modified the Daubenmire scale this year. Specifically, we have split the cover class "B" (5-25%) in to two classes, "B_1" (5-15%) and "B_2" (15-25%). Be sure to use this modified Daubemire scale, including these more finely defined cover classes, in making your cover estimates.*

   Continue this process with the plant species with the next greatest percent cover. Keep a running total of the sum of the midpoints of the cover classes.

4. Continue until the sum of the midpoints of the cover classes for each species exceeds 50% AND until there are no more species that are in cover class B_1, B_2, C, D, or E (5-15% or above).
5. In addition, note the presence of any noxious weeds of concern to Region 5 Refuges (Table 6), and estimate the cover class. If one of the dominant species already identified is a noxious weed, put an asterisk by it on the data sheet.

For the species noted in the total in step 1, but not included in the dominance list (i.e., the incidental *"A"* species), it is not necessary to identify the plant.

Table 5. Modified Daubenmire Cover Classes.

Class	Cover	Midpoint
A	1 – 5 %	2.5 %
B_1	5 – 15 %	10.0 %
B_2	15 – 25%	20.0%
C	25 – 50 %	37.5 %
D	50 – 75 %	62.5 %
E	75 – 100 %	87.5 %

Table 6. Invasive plants of management concern to National Wildlife Refuges, Region 5. Plants are listed alphabetically by scientific name. Only plants likely to be found in open fields are listed.

Scientific Name	Common Name	Likely Distribution in Region 5
Ampelopsis brevipedunculata	porcelain-berry	throughout
Celastrus orbiculata	Asian bittersweet	throughout
Centaurea biebersteinii	spotted knapweed	throughout
Cirsium arvense	Canada thistle	throughout
Coronilla varia	crown-vetch	throughout
Elaeagnus angustifolia	Russian olive	throughout
Elaeagnus umbellata	autumn olive	throughout
Euphorbia esula	leafy spurge	ME to MD
Lepidium latifolium	perennial pepperweed	coastal MA and NY
Lespedeza cuneata	Chinese lespedeza	NY, MA and south
Lonicera japonica	Japanese honeysuckle	throughout
Lonicera morrowii	Morrow's honeysuckle	throughout
Lonicera tartarica	tartarian honeysuckle	throughout
Lythrum salicaria	purple loosestrife	N. England, NY, PA, NJ
Microstegium vimineum	Japanese stilt grass	NY, CT and south
Polygonum cuspidatum	Japanese knotweed	throughout
Polygonum perfoliatum	mile-a-minute weed	PA, MD, WV, DE, VA
Rhamnus sp.	buckthorn	throughout
Robinia pseudoacacia	black locust	Considered invasive north of PA
Rosa multiflora	multiflora rose	throughout
Sorghum halepense	johnsongrass	throughout except ME
Trifolium lappaceum	burdock	throughout
Vincetoxicum nigrum	black swallow-wort	NJ, PA and north

All plants included in the dominance list should be identified to species except graminoids and late-season flowering forbs (i.e., *Solidago* spp.), which *may* be identified to genus only. However, please identify any of these plants to species if you are familiar with them. If there is a *forb* species that you cannot identify, collect appropriate botanical samples, store them in zip-lock bags, and arrange to have them identified, either through botanical keys in the office, if you are qualified, or else by a local expert. As a last resort, arrange to mail or transport plant samples in moist zip-loc bags to Laura Mitchell at Prime Hook (please contact her in advance). *Please ensure that all plants are identified with their scientific names on the data sheets.*

Cool-season grasses should be flowering, and readily identifiable. Warm-season grasses will be difficult to identify, because they do not form an inflorescence until mid-to-late summer. In the burned fields, there will be no above-ground material from last year to help identify WSG grasses. If you can identify warm-season grasses with other clues (such as habit, or the presence of dead material from the previous year), do so. If there are warm-season grasses you cannot identify at the time of the survey (and we fully expect there will be), you should name these plants on your data sheet, "unidentified WSG #1," "unidentified WSG #2," etc.

NOTE: In August, you will need to revisit all fields, and repeat Protocol IIIc for all live (aboveground tissues) plants in the quadrats. You do not need to collect additional information on invasive species. Follow the procedure for sampling dominant species, as outlined above, recording information on all of the green, late-season plants in the quadrat. Do not count cool season plants that are dormant. Warm-season grasses and forbs will be readily distinguishable from cool season species, since the mature plant will be present, the culms/stems and leaves will be green, and the plant will be close to flowering, flowering, or forming seeds. Culms, leaves, and inflorescences of cool season plants will be dry, brown, and most of the seeds of these plants will have fallen off of the plants.

Appendix D. Coordinates of potential point counts stations in Saratoga National Historical Park.

ID	X-UTM	Y- UTM	ID	X-UTM	Y- UTM
1	610473	4763056	45	610573	4762256
2	610073	4762956	46	610673	4762256
3	610173	4762956	47	610873	4762256
4	610673	4762956	48	610973	4762256
5	610773	4762956	49	611073	4762256
6	610373	4762856	50	611173	4762256
7	610473	4762856	51	611273	4762256
8	610573	4762856	52	611373	4762256
9	610673	4762856	53	611473	4762256
10	610773	4762856	54	611573	4762256
11	610873	4762856	55	612173	4762256
12	610373	4762756	56	612273	4762256
13	610473	4762756	57	613773	4762256
14	610573	4762756	58	610373	4762156
15	610673	4762756	59	610473	4762156
16	610773	4762756	60	610573	4762156
17	610873	4762756	61	610673	4762156
18	610273	4762656	62	610873	4762156
19	610373	4762656	63	610973	4762156
20	610473	4762656	64	611073	4762156
21	610573	4762656	65	611173	4762156
22	610673	4762656	66	611373	4762156
23	610773	4762656	67	611573	4762156
24	610373	4762556	68	612173	4762156
25	610473	4762556	69	612273	4762156
26	610573	4762556	70	612673	4762156
27	610673	4762556	71	613673	4762156
28	610773	4762556	72	610373	4762056
29	610873	4762556	73	610473	4762056
30	610373	4762456	74	610573	4762056
31	610473	4762456	75	610873	4762056
32	610573	4762456	76	610973	4762056
33	610673	4762456	77	611073	4762056
34	610773	4762456	78	611573	4762056
35	610973	4762356	79	611673	4762056
36	611073	4762356	80	612173	4762056
37	611173	4762356	81	612273	4762056
38	611273	4762356	82	612373	4762056
39	611373	4762356	83	612473	4762056
40	611473	4762356	84	612573	4762056
41	613773	4762356	85	612673	4762056
42	613873	4762356	86	613173	4762056
43	610373	4762256	87	610173	4761956
44	610473	4762256	88	610473	4761956

ID	X-UTM	Y- UTM	ID	X-UTM	Y- UTM
89	610973	4761956	138	612473	4761356
90	612073	4761956	139	612573	4761356
91	612173	4761956	140	612673	4761356
92	612273	4761956	141	612773	4761356
93	612373	4761956	142	612873	4761356
94	612473	4761956	143	610473	4761256
95	612573	4761956	144	610573	4761256
96	612673	4761956	145	610073	4761156
97	612773	4761956	146	610173	4761156
98	613173	4761956	147	610273	4761156
99	613273	4761956	148	610473	4761156
100	613373	4761956	149	610573	4761156
101	613573	4761956	150	610673	4761156
102	609873	4761856	151	610073	4761056
103	609973	4761856	152	610173	4761056
104	610173	4761856	153	610273	4761056
105	610273	4761856	154	610473	4761056
106	612473	4761856	155	610573	4761056
107	612573	4761856	156	610673	4761056
108	612673	4761856	157	610073	4760956
109	612773	4761856	158	610173	4760956
110	613373	4761856	159	610273	4760956
111	609773	4761756	160	610373	4760956
112	609873	4761756	161	610473	4760956
113	610073	4761756	162	610573	4760956
114	610173	4761756	163	610173	4760856
115	610273	4761756	164	609973	4760456
116	612473	4761756	165	610073	4760456
117	612573	4761756	166	609773	4760356
118	612673	4761756	167	609873	4760356
119	612773	4761756	168	609973	4760356
120	612873	4761756	169	610073	4760356
121	609673	4761656	170	610173	4760356
122	612473	4761656	171	610273	4760356
123	612573	4761656	172	610373	4760356
124	612673	4761656	173	610773	4760356
125	609573	4761556	174	610873	4760356
126	609773	4761556	175	609773	4760256
127	609873	4761556	176	609873	4760256
128	612473	4761556	177	609973	4760256
129	612573	4761556	178	610073	4760256
130	612673	4761556	179	610173	4760256
131	609773	4761456	180	610273	4760256
132	609873	4761456	181	610373	4760256
133	612473	4761456	182	610473	4760256
134	612573	4761456	183	610573	4760256
135	612673	4761456	184	610673	4760256
136	612873	4761456	185	610773	4760256
137	610573	4761356	186	610873	4760256

ID	X-UTM	Y- UTM	ID	X-UTM	Y- UTM
187	610973	4760256	236	610873	4759856
188	609773	4760156	237	610973	4759856
189	609873	4760156	238	611073	4759856
190	609973	4760156	239	611173	4759856
191	610073	4760156	240	610173	4759756
192	610173	4760156	241	610273	4759756
193	610273	4760156	242	610373	4759756
194	610373	4760156	243	610473	4759756
195	610473	4760156	244	610573	4759756
196	610573	4760156	245	610773	4759756
197	610673	4760156	246	610873	4759756
198	610773	4760156	247	610973	4759756
199	610873	4760156	248	611173	4759756
200	610973	4760156	249	611273	4759756
201	611073	4760156	250	611373	4759756
202	611173	4760156	251	611473	4759756
203	609973	4760056	252	611773	4759756
204	610073	4760056	253	612073	4759756
205	610173	4760056	254	610173	4759656
206	610273	4760056	255	610273	4759656
207	610373	4760056	256	610373	4759656
208	610473	4760056	257	610473	4759656
209	610573	4760056	258	610573	4759656
210	610673	4760056	259	610673	4759656
211	610773	4760056	260	611873	4759656
212	610873	4760056	261	611973	4759656
213	610973	4760056	262	610173	4759556
214	611073	4760056	263	610273	4759556
215	611173	4760056	264	610373	4759556
216	611273	4760056	265	610473	4759556
217	610273	4759956	266	610573	4759556
218	610373	4759956	267	610673	4759556
219	610473	4759956	268	610773	4759556
220	610573	4759956	269	611873	4759556
221	610673	4759956	270	609973	4759456
222	610773	4759956	271	610073	4759456
223	610873	4759956	272	610173	4759456
224	610973	4759956	273	610273	4759456
225	611073	4759956	274	610373	4759456
226	611173	4759956	275	610473	4759456
227	611373	4759956	276	610573	4759456
228	611473	4759956	277	610673	4759456
229	610173	4759856	278	609973	4759356
230	610273	4759856	279	610073	4759356
231	610373	4759856	280	610173	4759356
232	610473	4759856	281	610273	4759356
233	610573	4759856	282	610373	4759356
234	610673	4759856	283	610473	4759356
235	610773	4759856	284	610573	4759356

ID	X-UTM	Y- UTM
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286	609973	4759256
287	610273	4759256
288	610473	4759256
289	610573	4759256
290	610673	4759256
291	611373	4759256
292	611273	4759156
293	611373	4759156
294	611573	4759156
295	611273	4759056
296	611473	4759056
297	611573	4759056
298	611473	4758956

As the nation's primary conservation agency, the Department of the Interior has responsibility for most of our nationally owned public land and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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National Park Service
U.S. Department of the Interior

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