The Trustees of Reservations

Ecological Management of Grasslands:

Guidelines for Managers

Ecological Management of Grasslands

Contents:

Acknowledgments

These guidelines would not exist without the contributions of several individuals and organizations. Major contributors included:

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While these guidelines integrate the best available information, new information based on research and experience may suggest new approaches that should continue to be incorporated into The Trustees' management of grasslands.

1. Introduction

The Trustees of Reservations protects and manages thousands of acres of grasslands throughout Massachusetts. Much of this acreage is actively used for agricultural purposes while other lands are simply maintained as "open" grasslands. All of these grasslands contain cultural, scenic and ecological values and The Trustees can make a significant contribution to protect this important resource.

1.1. Purpose of Report

This report proposes guidelines for protecting and enhancing the ecological values of grasslands on The Trustees' reservations. These guidelines are based on conservation biology principles, known wildlife requirements (especially for birds), and the need to maintain positive working relationships with farmers, who are critical to the ongoing success of grassland management. With proper land management techniques, farmers join conservationists in the protection of open space in the state for generations to come.

For the purpose of this report, several kinds of grasslands will be considered:

A. **Hay Fields**: grasslands cut at least once annually for hay crop.
B. **Mowed Fields**: non-agricultural grasslands being maintained by mowing.
C. **Pastures**: grasslands being grazed by domestic livestock.
D. **Old Field**: non-agricultural grasslands that are reverting to wooded habitat; shrubs and small trees present.
E. **Sandplain Grassland / Heathland**: grasslands and heathlands found on glacial outwash; primarily found on Cape Cod and Islands.
F. **Cultivated Fields** (row crops): lands actively cultivated for row crops such as corn, beans, pumpkins, etc. (although these agricultural areas are not necessarily grasslands, they present similar ecological questions and opportunities that can be addressed in these guidelines.)

1.2. Summary of Ecological Significance

Since farm abandonment in the mid 1800s, agricultural grasslands have been rapidly disappearing in Massachusetts.[14] New England loses 80,000 acres of farmland annually by conversion to non-farm uses.[41] As a result of this loss, many species of plants and animals that depend on grasslands have also been rapidly declining, and many of these "grassland species" are now listed as "rare" and are protected under the state endangered species act. Some grassland species including the loggerhead shrike and regal fritillary butterfly have been extirpated from Massachusetts altogether.[2, 43, 54, 57]

A variety of grassland management regimes (i.e. haying, grazing, mowing, and burning) in conjunction with soil and climatic conditions have created a variety of grassland types, each of which supports a distinct community of plants and animals. **No one type of grassland management will meet the needs of all grassland species**. For

example, species such as the upland sandpiper require large areas of short, patchy grasses like those found around airports or in pastures, whereas bobolinks require taller grasses like those grown in hay fields.[4, 9] Likewise, frequently (3 times annually) mowed sandplain grasslands support fewer plant species and structural diversity than adjacent sandplain grasslands that are infrequently (1 time annually) mowed or burned.[7]

1.3 The Trustees' Approach to Grasslands Management

Since 1891, The Trustees has worked to preserve both natural and cultural landscapes within Massachusetts. While these guidelines emphasize grasslands' ecological values, The Trustees also works to preserve the cultural, scenic, and historical values associated with grasslands and will continue to work closely with farmers to encourage environmentally sound agriculture throughout the state.

As a starting point in developing a grassland management plan, The Trustees will first consider the ecological values of the grassland and, based on the guidelines set forth in this report, will develop programs to promote the protection of those ecological values. However, via a consistent decision-making process, one or a combination of the other values (i.e., historical, cultural, economic) may suggest a management program that is less than ecologically ideal.

2. General Principles in Grassland Management

GRASSLANDS REQUIRE MANAGEMENT

Grasslands in the northeast are typically a result of human management (e.g. farming). Without frequent disturbance such as cutting or grazing, grasslands will revert back to forest and grassland habitat will disappear.

KNOW THE GRASSLAND THAT IS BEING MANAGED

With continuous observation, managers will understand the specific ecological assets and issues associated with an individual grassland. Inventories for plants, birds and butterflies would be extremely valuable. This information will provide a firm foundation for ecologically-sound management.

MAINTAIN LARGE GRASSLANDS

Large tracts of contiguous grassland will support a greater diversity of grassland wildlife, especially birds and invertebrates (e.g. butterflies)[5, 28, 29, 37, 55] Some species (e.g. upland sandpiper and northern harrier) require large tracts of grassland; typically a single pair needs more than 100 acres. Thus grasslands of 500 acres or more may be necessary to support populations of some species. Because very few of The Trustees' properties contain extensive grasslands, it is important that these large grasslands be managed for grassland species. Although smaller grasslands of less than 5 acres frequently support grassland-nesting species, species diversity decreases as grassland size decreases. [21, 29, 55] Smaller grasslands that are near non-forested communities (e.g., cultivated lands or airports) will often support grassland wildlife.[29] For example, bobolinks frequently use

small (< 10 acres) grasslands on The Trustees' reservations that are near or adjacent to salt marsh. Grasslands under 10 acres should be evaluated for wildlife habitat on a case-by-case basis.

MINIMIZE FRAGMENTATION OF GRASSLANDS

Tree lines disrupt the continuity of grasslands, reducing the overall extent and quality of habitat for area-dependent species. Woody borders and tree islands also attract nest predators and parasites such as cowbirds.[29] Old fields, which typically have shrubs and small trees scattered throughout rather than concentrated as borders or islands, should be maintained since they can support greater plant species richness and small mammal abundance than native grasslands or hayfields.[45]

DELAY CUTTING

Cutting grasslands during the early part of the growing season is detrimental to grassland wildlife, particularly birds.[4, 21] To reduce nest and fledgling mortality, cutting should be delayed until nesting activity has finished. Typically, mid-July has been given as a safe first cut date in the northeast. This date, however, does not consider late nesting birds, other wildlife, or the needs of plants, and therefore should not be relied upon. Studies have shown that a mid-July cut date can result in a 15% mortality of bobolink young and that a cut date of mid-August is better.[4, 21] Other species such as Henslow's sparrow, an endangered species in Massachusetts, may continue to use fields into August and cutting fields prior to late August is not recommended.[15, 22, 48] If grassland birds are the primary management concern, grasslands should be checked for nesting birds and only cut when nesting is complete. If hay production is not an issue, grasslands can be left uncut until late in the year or even cut only once every two or three years. The latter would benefit small mammals but may allow woody plants to invade.[60] If woody plants are an issue, grasslands should be cut annually or portions of fields cut annually on a rotational schedule.

AVOID CONVERTING FIELDS AND PASTURE TO ROW CROPS

Cultivated lands have little ecological value and often receive chemical applications. Cultivated lands provide little habitat for grassland birds and are partly responsible for the decline of grassland bird species.[3, 5, 29, 58] Although a few species will occasionally utilize cultivated lands, particularly for foraging (e.g. horned lark, harrier, upland sandpiper), the majority of grassland species prefer non-cultivated grasslands for breeding.[3, 5, 9, 25, 26, 44, 47, 52, 54] Likewise, small mammal diversity is higher in grassland habitat than in cornfields which support few species.[30] Therefore, converting grasslands to row crops should be avoided.

PROTECT STREAMS, PONDS AND WETLANDS

Agricultural runoff of silt, nutrients and pesticides is one of the greatest problems affecting wetlands.[33] Best management practices (BMPs) which have been developed to reduce runoff should be included in grasslands management. Agricultural BMPs include cover cropping, conservation tillage, contour plowing, strip cropping and establishment of vegetated buffer zones. The New England Small Farm Institute has produced a guide for On-Farm Strategies to Protect Water Quality. This guide describes BMPs and

should be used as a starting point for agricultural land management. Additional information regarding BMPs can be found at the Environmental Protection Agency (EPA), National Resource Conservation Service (NRCS), Massachusetts Department of Environmental Protection (DEP) and the Massachusetts Department of Conservation and Recreation (DCR).

Perhaps the easiest BMP to implement that protects wetlands includes the establishment of vegetated buffer zones or filter strips free of chemical applications and which restrict livestock between grasslands and wetlands. Buffer zones are low-cost solutions that require little to no technical assistance.[42] Vegetated buffers protect wetlands by minimizing sedimentation, help contain runoff of pesticides and excess nutrients in general, and help protect shoreline areas.[1, 6, 36] Woody vegetation, however, should be kept in check within these buffer zones to reduce grassland habitat fragmentation where continuous grassland habitat is critical. Buffer zones should be established between grasslands and wetlands.

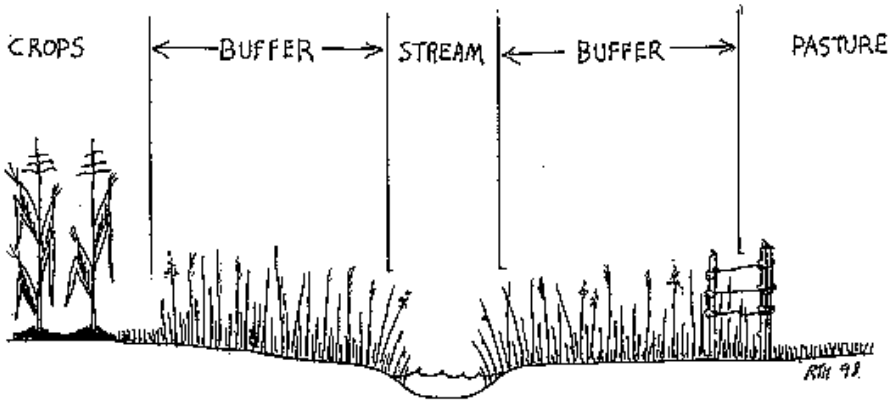

Figure 1: Example of grassland buffer between agricultural activities and wetland

Recommendations on the width of buffer strips vary greatly depending on land use and slope of land. DCR recommends buffers of 100 meters (approximately 300 feet) to minimize the impacts of chemical and nutrient runoff on lakes and ponds while the Massachusetts Forest Practices Cutting Act requires 50 feet.[1, 32] While buffers greater than 50 feet may not always be practical or economical, buffers smaller than 50 feet are not recommended.[42] New agricultural projects located near rivers and streams may require a 100 foot buffer. For example, new agricultural activities are subject to jurisdiction within 100 feet of rivers under the Rivers Protection Act. The width of buffer zones will likely vary with the type of grassland management but should not be less than 50 feet on lands with little to no slope. Lands with steeper slopes should have buffers greater than 50 feet.

MINIMIZE CHEMICAL USE

Broad, non-selective application of pesticides can reduce insect diversity in northeast grasslands and thus should be avoided.[56] Where control of invasive plants using herbicides is desirable, selective application (e.g. stem application) should be used. Chemical use on commercial agricultural lands should be reduced where possible by conducting soil testing and seeking alternatives such as organic farming and integrated pest management (IPM). Soils should be tested to determine specific needs for fertilizer (nutrient) application. IPM is the combined use of cultural, biological and chemical strategies to address pests and diseases. The IPM process puts more emphasis on changing cultural practices which might be causing or exacerbating a problem and reserves chemical applications for a last resort. Reduction in chemical application should focus on minimizing excess nutrient runoff in grasslands near wetlands. Excess nutrients typically encourage plant growth and eventually lead to eutrophication, the process where the decay of dead plant material depletes the water of oxygen and leads to reduced biological diversity. Coastal wetlands are typically nitrogen limited while fresh water wetlands are generally phosphorus limited.[35] Managers should strive to reduce nitrogen application and runoff at coastal properties, especially where grasslands (including lawns) occur adjacent to saltmarsh and coastal waters. In contrast, managers should strive to reduce phosphorous application and runoff where grasslands occur near fresh water ponds, streams and wetlands.

MINIMIZE HUMAN ACTIVITY DURING BIRD NESTING

Locate trails along field edges and post signs during nesting season asking people to stay on marked trails to prevent disturbance and trampling of nests. Close trails that bisect grassland habitat during nesting season if relocation is not possible.

RESTRICT PETS FROM FIELDS DURING NESTING SEASON

Require dogs to be leashed during the nesting season and work with neighbors to educate them on the ecological impacts of cats. Alternatively dogs can be prohibited from fields during nesting season.

CONTROL INVASIVE EXOTICS

Certain non-native species can rapidly invade and colonize natural communities, thus degrading wildlife habitat and crowding out native species.[59] Although grassland habitat in Massachusetts is typically dominated by exotic grasses and herbs, control of invasive species is critical for grassland habitat maintenance. For a list of invasive plants visit the Massachusetts Invasive Plant Advisory Group http://www.massnrc.org/mipag/

USE THE RIGHT TOOLS IN AN ECOLOGICALLY FRIENDLY WAY

Many tools, including mowing, burning, and grazing, can help managers achieve grassland objectives. Depending on objectives and individual grassland features (e.g. soil types, rare species, economic importance, etc.), not all tools are necessarily appropriate. Managers will need to consider available options and consult with regional ecologists and directors to determine the most appropriate tools and adopt techniques that benefit wildlife.

Examples:
When using fire, consider impacts on wildlife. Burning all of a habitat at one time can eliminate species.[43, 46] Burning only a portion of a grassland will leave some habitat that can provide a refuge in which wildlife and plants can survive to recolonize the burned area.

When mowing, grasslands should be cut in a series of parallel lines from the inside out if possible (figure 2). Circular cuts that proceed from the perimeter to the center of the grassland should be avoided since this practice 'herds' small mammals towards the center where they may be killed by the mower.

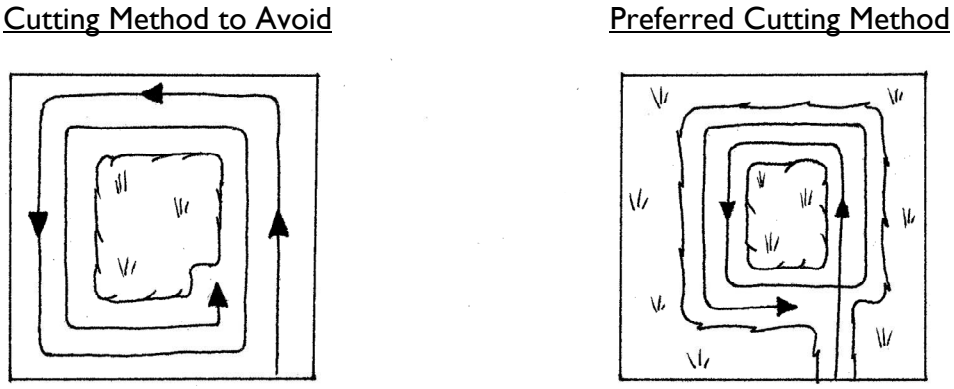

Figure 2: Avoid conventional cutting method on the left which herds wildlife to the center of the field. Cutting fields using the method on the right allows wildlife to escape to the field edge. (Drawing adapted from RSPB Conservation Management Advice)

Research has documented some turtle species, especially box and wood, seek out fields seasonally as preferred habitat resulting in high mortality rates during mowing. For further details on preventing turtle mortality see guidelines developed by the Massachusetts Natural Heritage and Endangered Species Program.
http://www.mass.gov/dfwele/dfw/nhesp/conservation/herps/turtle_tips.htm

MAINTAIN BIODIVERSITY

Management of grasslands should strive to maintain biological diversity. While rare species are important and should be considered at all times, management of grasslands should also strive to maintain the greatest number and variety of plants and animals. For example, leaving unmowed strips and edges throughout the year will provide cover for small mammals and wildflowers for butterflies. Common grassland plants native to New England such as goldenrods, asters, milkweeds, bush-clovers and violets should be encouraged since these species provide nectar for adult butterflies and may serve as important host plants for butterfly larvae. Many species of butterflies are dependent on specific plants for larval development and survival. The monarch butterfly's association with milkweed is perhaps the best known example. Other examples include the pearl

crescent and asters, great-spangled fritillary and violets and the black swallowtail with plants of the parsley family.[31, 50, 57]

The timing and frequency of mowing or haying can influence plant species diversity and composition. Frequently mowed grasslands typically support fewer plant species and support less structural diversity than grasslands mowed infrequently. Likewise, rotational grazing will maintain plant diversity and structure while continuous grazing will typically reduce plant diversity and structure. For example, in pastures where livestock are kept for long periods, plant height is closely cropped to within inches of the ground with bare patches typically common throughout.

3. Specific Management Guidelines by type of Grassland

3.1 HAY FIELDS (Lands cut at least once annually for a hay crop)

Hay fields represent the most common type of grassland maintained by The Trustees of Reservations. In Massachusetts, fields managed for hay are typically dominated by dense, cool-season grasses and can include species such as alfalfa and clover.[4, 24] Typically these grasses are European in origin (e.g. orchard grass and timothy). Hayfields provide breeding habitat and cover for many wildlife species.[14] The guidelines below are primarily based upon the needs of grassland nesting birds.

Timing of Cut: The major threat to grassland nesting birds using hay fields is the early cutting of fields before young birds have fledged. The options below minimize bird mortality while still allowing haying, and are listed in the order that provides the greatest reproductive success for grassland birds.

> Approach 1: Cut only once annually and as late as possible, but before the first frost in order to get one crop of hay that can be sold as mulch. In addition, invasion of fields by woody plants is reduced to a minimum with annual cutting.
>
> Approach 2: Cut after all ground-nesting birds have fledged their young. Mid-July will allow the majority of bobolinks time to fledge their young, although late nesting or re-nesting birds may not have fledged young by this time. Fields may be cut earlier in the season if no nesting birds are present. Managers and/or regional ecologists should walk the fields to determine nesting status.
>
> Approach 3a: Set aside 50% of the field around nests from cutting until mid-July, or until the field is clear of birds. The area to be set aside should be determined by the property manager and staff ecologist. The unrestricted half can be cut anytime. Second cuttings could take place at the farmer's discretion on both the restricted and unrestricted halves.
>
> Approach 3b: Set aside 25% of the field from cutting until mid-July or until bird nesting is complete and continue as described in Approach 3a.

Approach 4: In some cases (as with certain small fields), fields may not support species that are affected by early cutting and hay can be cut at any time. However, the fields should be monitored for grassland birds annually and managed accordingly if grassland birds are present. It is also important to note that several animals (e.g. deer, snakes, butterflies and wild turkey) may use the tall grass in these smaller fields for cover or food and will therefore be affected by early cutting.

3.2 MOWED FIELDS (Non-agricultural grasslands being maintained by mowing)

Mowed fields provide similar wildlife benefits as hay fields do except hay production is no longer an issue. Thus, the need to cut these fields early and often is eliminated. Management will still be necessary to maintain grassland habitat and may include various options depending on the management goal. In fields supporting grassland birds, mowing should wait until after the breeding season (Approach 1 & 2 for hay field management above). Management should also consider small mammals and butterflies. Since mowing fields close to the ground can eliminate small mammals from fields, mower height should be adjusted to leave a minimum of 8-10 inches of grass standing to provide habitat for small mammals.[11] Leaving fields unmowed or cutting only a portion of fields on a rotating schedule to keep woody invaders in check will benefit butterflies by providing flowers for adult butterflies throughout the growing season as well as allowing larvae and pupae time to develop.

While fire can be useful for grassland management, potential ecological impacts need to be carefully considered before fire is used (see the discussion on fire under Sandplains below for more information). Young hayfields less than eight years old support fewer grassland birds than older, established hayfields; thus plowing and reseeding should be avoided.[4] Herbicides can have negative ecological impacts. Restricting herbicide use to spot applications (e.g. applying herbicide to individual cut stems to prevent resprouting), will allow more control of herbicide and reduce overall amounts needed. Grassland-wide applications should be avoided. While frequent mowing throughout the growing season may reduce woody cover, it will likely impact wildlife and reduce plant diversity. Unless grassland conditions demand these more aggressive methods, they should be avoided.

3.3 PASTURES (Lands being primarily grazed by domestic livestock)

Grazing by livestock can impact wildlife and natural systems.[53] Overgrazing can degrade grasslands, adversely affect wetlands by eliminating vegetation, and degrade water quality by increasing sedimentation, water turbidity and nutrient loading through runoff of animal wastes.[33] When managed properly, however, grazing can be beneficial to many plants and wildlife.[13, 29] Grazing, therefore, on The Trustees' properties should be conducted with care.

Grazing management that will typically reduce negative impacts by livestock on grasslands include planned manipulation of stocking rates, breed selection, rotation of livestock, and establishment of buffers around ecologically sensitive areas. Understanding how breeds graze will help managers and farmers achieve economic as well as ecological objectives. For example, cattle typically prefer grasses while sheep prefer forbs and goats prefer woody browse.[23] This is important because as time progresses, selective grazing from any breed may lead to a shift in plant species composition and structure. Prescribed grazing, where livestock are actively managed, can reduce selective grazing impacts and improve pasture quality.[24]

While general guidelines are suggested here, the development of a livestock management plan is recommended for each location where livestock are maintained or are being considered. Development of a plan will require site visits by farmers, professionals familiar with livestock management, and The Trustees' staff including ecologists. The NRCS will work with managers to develop grazing management plans based on physical and biological characteristics of the land. Plans can be tailored to meet specific objectives. The ecological objectives of The Trustees will need to be carefully considered along with the primary livestock production objective of farmers. A few general guidelines for maintaining livestock on The Trustees' properties should be followed and include:

- Establish buffer zones around streams, ponds and wetlands: In general livestock should be restricted from streams, ponds and wetlands unless they are being used too directly manage wetland habitat. A buffer zone of at least 50-100' should be maintained between wetlands and pastures to reduce nutrient loading from animal waste, erosion and sediment runoff, and destruction of wetland vegetation and wildlife habitat. Where pastures are steep and heavily grazed, buffers may need to be greater or herd size reduced. Livestock access to water, however, needs to be maintained. This access should be designed to minimize erosion and prevent animals from lingering around water. Where wetland impacts are unavoidable, the placement of an alternative water source away from the impacted area should help alleviate the problem.

- Stocking rates: It is important to maintain a density of livestock on any given acreage that balances forage supply with forage demand.[23] Exceeding forage supply can lead to shifts in vegetation, degrade grassland quality, and ultimately lead to reduced productivity of both the grassland and livestock. Alternatively, when forage supply exceeds demand (e.g. when a few animals have access to large grazing areas), grazing may have little impact on preventing woody plants from invading. Exceeding forage supply for short durations, therefore, may be necessary if livestock are used as a biological control for habitat manipulation and maintenance.[23] Two forms of stocking methods exist, rotational and continuous, which will help managers control grazing impacts.

  Rotational Stocking utilizes multiple pastures that are alternately grazed and rested throughout the grazing period. Pastures are monitored for grazing impact and

livestock are moved to adjacent pastures before regrowth is grazed, preventing overgrazing. Under rotational stocking, selective grazing is reduced, helping to maintain plant species diversity over time.[24]

Continuous Stocking allows a set number of livestock to have continuous access to a pasture throughout the year or until the forage supply is depleted. This method requires little management but unfortunately allows little control over grazing impacts. Under continuous stocking, livestock will selectively graze, leading to a reduction and possible elimination of preferred species while less desirable species increase. Ultimately pasture plant diversity and production can decline.[24]

Where possible, grazing on The Trustees' properties should follow rotational stocking since this practice reduces impacts to any one specific location, allows grazed plants to recover before being grazed again, and maintains species diversity. Regardless of method, special attention will need to be given to proper stocking rates. Proper stocking rates can be determined by estimating forage supply and demand. Ecology staff can help managers develop grazing management plans based on proper stocking rates.

- Waste management: Farm animal management generates several waste products, which, if poorly managed, can ultimately pollute water resources. Waste storage systems should be designed and managed properly to prevent the leaching of nutrients into groundwater or the washing of nutrients into surface water. These practices also help farmers to recycle on-farm nutrients to enhance field production while at the same time reducing the reliance on fertilizers. Waste storage should only be an issue for dairy operations or where livestock are housed. The NRCS can assist land managers in the proper design and placement of waste storage facilities.

- Breed Selection: Breed selection will rarely be an issue in existing operations where decisions regarding the type of livestock to be raised have already been made. In cases where a change in breed is an option, or the opportunity arises for the establishment of livestock where none currently exist, efforts should be made to select the most appropriate breed. Ecological factors that may influence breed choice include an animal's food preferences (i.e., is it a browser or a grazer?), potential physical impacts (i.e., trampling, erosion, and compaction), and the breed's ability to withstand threats from local predators.

3.4 OLD FIELD (Non-agricultural grasslands which are reverting to wooded habitat: shrubs and small trees are present)

Old field habitat is characterized by grassy openings with shrubs and small trees scattered throughout. This habitat is transitional and typically a result of forest succession on abandoned agricultural land. Old fields can provide many species with preferred habitat, including rare species such as the golden-winged warbler.[12] Although forest clearcutting can also provide open, early successional habitat, clearcuts soon

develop into dense young forest that is unsuitable for most species characteristic of old field habitat. In contrast, the more open habitat associated with old field succession persists much longer, providing habitat benefits for more years.[14]

Maintaining old field habitat requires some control of invading woody vegetation. Woody plant species invade fields that are infrequently cut, compromising grassland habitat and management. While species that prefer early successional habitat (e.g. field sparrow) will benefit from woody plants invading fields, woody plants generally compromise grassland habitat. Fields that are not well suited for grassland wildlife (e.g. small fields surrounded by forest) may provide greater benefits to wildlife if they are managed for early successional habitat. Managing for early successional habitat will typically require leaving fields uncut for several years to allow woody plants to colonize and then mowing around woody plants annually or mowing and or burning the fields on a rotational schedule. Early successional habitat could also be incorporated into larger fields to provide grassland habitat diversity. Areas within larger fields could be managed on a rotational schedule that allowed early successional plants to develop for a few years and then converted back to grassland, leaving another area to develop as early successional habitat. Small fields may also be allowed to revert to woodland where forest fragmentation is a concern.

3.5 SANDPLAIN GRASSLAND/COASTAL HEATHLAND (Open grasslands and heathlands found on glacial outwash deposits)

See *Sand Barrens Habitat Management: A Toolbox for Managers* for additional information on managing sandplain grasslands.

Sandplain grasslands and coastal heathlands occur throughout Cape Cod and the Islands Region. These natural communities are typically associated with each other; thus, they are considered together here.[49] Both communities are globally rare.[b] Furthermore, maintenance and restoration of these communities will be critical for many state-listed rare species (e.g. short-eared owl, bushy rockrose, and sandplain gerardia). These communities together once covered many thousands of acres and were maintained by fire and livestock grazing, primarily sheep.[16, 17, 20, 38] With the decline in sheep grazing and the increase in home construction, many of these communities have either been developed or reverted to shrublands or forest. Management of the remaining habitat is critical.

Management will likely include one or more of the following tools: fire, mowing, grazing and herbicides. Both mowing and fire have been used to restore or maintain sandplain communities and are likely the most viable options.[19, 20, 34] Frequent mowing, however, during the growing season reduces the plant diversity in these communities.[7] Maintaining livestock can be expensive and difficult. Use of herbicides should be restricted to spot application of problematic species and should be used only in conjunction with other more viable tools (i.e. fire and mowing). Widespread application of herbicides should not be considered.

[b] Massachusetts Natural Heritage and Endangered Species Program

Historically fire played an important role in maintaining these communities and in recent years fire has been used at several of The Trustees' coastal properties. Although fire is discussed here under sandplains, the following discussion can be applied to all grassland types.

Fire:
Using fire as a management tool requires a trained crew, equipment, permits and appropriate weather conditions. In addition to economic and logistical considerations, fire has ecological considerations as well. Several species of grassland birds (e.g. grasshopper sparrow, Savannah sparrow, and bobolink) prefer recently burned grasslands, while other species (e.g. Henslow's sparrow, sedge wren) clearly avoid recently burned areas.[8, 28] Invertebrates such as butterflies and moths are particularly sensitive to burning and can be eliminated from burn areas.[27, 43, 46, 51] Where invertebrates, especially butterflies, are a management concern, mowing and grazing may be better options since eggs and larvae are destroyed with burning. Mowing, however, may eliminate certain plants by smothering them with plant residue (i.e. thatch), thus threatening butterfly species dependent on these plants.[43] Fire is a tool that should only be used where there are clear ecological benefits and where other more practical tools will not meet the objectives. To avoid unwanted impacts the following should be considered:

Timing of Burn: The time of year when grasslands are burned can influence the ecological impacts. Summer burning has a greater impact on woody growth than spring burning and can remove more humus than spring fires.[20, 38] Summer fires also burn more deeply, killing the roots of woody plants.[39] Late spring and summer burns, however, will also impact grassland birds; thus burning should take place before or after nesting if birds are present. Seasonal timing of burns can also influence invertebrate diversity and density.[18]

Size of Burn: To avoid eliminating species from a grassland, it is recommended that only a portion of any grassland habitat be burned in any given year.[10, 46] Leaving a portion of habitat unburned allows species from these unburned areas to recolonize adjacent burned areas. Staggering burns within a grassland also allows for the development and continuous availability of different age structures within a grassland, adding to habitat and species diversity. Burning 20-30% of habitat annually is recommended for bird species that prefer recently burned grasslands.[28] Whether birds are present or not, no more than 30% of habitat should be burned during any year.

Frequency of Burn: Frequent burning may eliminate fire sensitive species (e.g. insects with poor dispersal abilities and plants intolerant of fire). Thus, the frequency that a grassland is burned should allow for the recolonization of desirable species. The frequency that a habitat is burned will also depend on the management objectives. For example, The Nature Conservancy recommends burning native grasslands at least once every 3-4 years while heathlands may only need to be burned every 10-15 years.[38] Where fire is used in conjunction with grazing, livestock may need to be restricted from

burn units for at least one full growing season to allow plants to recover before being grazed.

3.6 ROW CROPS (Land being actively cultivated for row crops such as corn or beans)

These lands are commonly used for the production of agricultural commercial monocrops typically require tilling of the soil and application of chemicals (e.g. fertilizers, pesticides, herbicides, and fungicides). While row crops provide the least ecological value of all grassland types, they are important to local farmers and for other agricultural landscape values. Where cultivation is determined to be desirable or necessary, BMPs should be used to reduce non-point source pollution. Alternatives such as mixed cropping and organic farming should also be investigated and encouraged. In particular, managers should adopt integrated pest management practices to address pests and disease problems.

To preserve their ecological values, however, grasslands should not be converted to row crops. Where possible, existing cultivated lands should be considered for conversion to non-cultivated grasslands (e.g. hayfield, mowed field).

4. RARE SPECIES AND CRITICAL HABITAT

Any grassland that is critical habitat for a rare species should not be altered until the property superintendent, regional supervisor, and regional or state ecologist agree upon a suitable management plan. Managers should consult the Massachusetts Natural Heritage Atlas produced by the Massachusetts Natural Heritage and Endangered Species Program or The Trustees' ecologists for rare species locations and information.

On reservations that seem exceptionally well suited to grassland wildlife, consideration should be given to making wildlife management the priority. If there are unprotected grasslands near existing reservations that are believed to influence grassland wildlife on The Trustees' reservations, then protection of these grasslands should be investigated. Where acquisition of grasslands is not possible, conservation restrictions that prevent development should be considered and those that allow management preferred.

5. INVASIVE EXOTIC SPECIES

Introduced species constitute approximately one third of the Massachusetts flora.[59] While most of these exotic plants are not problematic, some are highly invasive, crowding out native species, and threaten grassland habitat. Multiflora rose (*Rosa multiflora*), autumn olive (*Elaeagnus umbellata*), honeysuckles (*Lonicera spp*.), buckthorns (*Rhamnus cathartica, R. frangula*), bittersweet (*Celastrus orbiculatus*), swallowwort (*Cynanchum rossicum and C. louiseae*) and spurge (*Euphorbia cyparissias, E. esula*) are among the most serious invaders in grasslands. These species should be monitored and

controlled where possible. Control and eradication of these species may include hand pulling, mowing, cutting, controlled burning and use of herbicides.

6. LEASE LANGUAGE AND FORMAT

While contracts with farmers will likely vary in format and content, all agricultural leases should include language that outlines The Trustees' ecological goals, and should include the involvement of a staff ecologist.

7. IMPACTS FROM CLIMATE CHANGE

There is a strong consensus in the scientific community that anthropogenic climate change induced by greenhouse gas emissions is occurring and it is expected that the earth will warm an average of between 2.5 degrees and 10.5 degrees Fahrenheit by the end of the 21st century.[63] Climate change presents a threat to grassland ecosystems.

The loss of biodiversity is a large concern for grassland ecosystems over the next century. With the earlier onset of spring greenness each decade, invasive species like honeysuckle have the potential to gain the competitive advantage over native grassland species.[62] Warming temperatures will likely shift the range of native grassland species northward, while other exotic and invasive species, diseases, and pests take hold of the grassland ecosystem.[64] Furthermore, fragmentation may prevent many species from migrating north naturally with the changing climate.[65] Warmer and earlier springs have been shown to cause migrating bird species to nest earlier in the year, a trend that will likely continue to expand through the century.[61]

The climate system is complex and uncertain and the effects of climate change on grassland ecosystems do not occur in isolation but rather co-occur with many other dynamic global factors. The following guidelines offer specific suggestions to address the threats associated with climate change and promote resiliency in grassland ecosystems.

Recommendations for sustaining the integrity of grasslands include:

- Continue following grasslands management guidelines already in place
- Manage for resiliency (e.g., provide various habitats and promote habitat for native pollinators)
- Conduct further studies and surveys on the direct impacts of climate change where possible (e.g., monitoring butterfly populations)
- Target large fields and field complexes (landscape scale) for protection and expansion efforts
- If the integrity of grassland properties deteriorates, those properties should be used as examples to engage the public in the adverse effects of climate change

- Recognize that in many cases the effects of climate change may be beyond controllable or maintainable means

- Be willing to adapt to and accept some changes the new climate produces

- Remain up to date on the latest scientific studies associated with the effects of climate change on grassland ecosystems

- Adjust grassland cutting with changing nesting dates of obligate grassland birds or other wildlife

- Control invasive species at the present and attempt to predict how invasive species will respond to climate change to possibly stop the invasives *before* they become a problem.

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