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Restoration of Eastern Native Grasslands And The Repatriation Of The Eastern Regal Fritillary Butterfly Management Plan

Joseph Hovis / Fort Indiantown Gap

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Grassland Restoration and Management Plan for the Repatriation of the Regal Fritillary Butterfly (*Speyeria idalia*)

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Introduction

In 2007-2008, the Pennsylvania Department of Military and Veterans Affairs Wildlife Office (DMVA Wildlife) entered into an agreement with multiple landholding agency partners to restore native grasslands within an effort to repatriate the regal fritillary butterfly (*Speyeria idalia*). In an attempt to conserve this rare butterfly species an effort to repatriate (return a native species to an area from which it has been extirpated; see Reinert 1991) regal fritillaries to landholdings having a historic occurrence (Wright 2007) or probable occurrence (i.e. county record) was proposed and funded by both DCNR-WRCP and DOD Legacy Programs. Restoring native grasslands is an ongoing statewide goal of DCNR as grasslands are important for biodiversity and provide unique recreational and aesthetic benefits.

This large, orange and black butterfly once found commonly throughout the northeastern United States has declined drastically over the past 20 years, probably due to the loss of native, open grassy habitats (Glassberg 1999, Opler and Krizek 1984) resulting from increased urbanization and the changes in modern agriculture (Swengel 1993). Regals survive at Fort Indiantown Gap (FIG) possibly due to military activity because repeated soil disturbance and low intensity fires have maintained a large mosaic complex of grasslands dominated by native vegetation (Signell et al. 2005, Latham et al. 2007). FIG is the best example of PA warm season grasslands (dominated by little bluestem; *Schizachyrium scoparium*) in respect with quality (PA-ecotype; genetically adapted to PA's climate and environmental conditions) and quantity (Cal Ernst pers. comm. 2001 and Latham and Thorne 2007). The regal fritillary depends on three main habitat components commonly found in grasslands: food plants for larvae, adult nectar sources (Barton 1996, Kelly and Debinski 1998, Latham et. al. 2007) and native warm season bunch grasses for larvae, pupae, and resting adults (PANG 2002 and M. Swartz unpublished data). Each of these major components persists at FIG due to recurring disturbance such as military training, infrequent mowing of encroaching woody vegetation for range maintenance, periodic wildfires (Hovis et al. 2006 and Latham et al. 2007), and stewardship activities conducted by state and contracted employees.

Table 1. Rare Grassland and Early Successional Habitat Dependant Species Found at Fort Indiantown Gap in Areas Occupied by Regal Fritillaries.

	Scientific name	Common name	Federal Status	Proposed status	State Status	State Rank	Global Rank
Plants							
	Eupatorium godfreyanum	Vasey's eupatorium		TU	N	S2	G5
	Eupatorium rotundifolium	Round-leaf boneset		UTF	TU	S3	G5T5
	Gentiana villosa	Striped gentian		TU	PE	S1	G4
	Platanthera ciliaris	Yellow-fringed orchis		TU	PT	S2	G5
	Helianthus hirsutus	Sunflower		TU	N	S2	G5
	Lechea minor	Thyme-leaved pinweed		TU	N	SU	G5
	Paronychia fastigiata var. nuttallii	Forked chickweed		PE	TU	S1S2	G5T3T5
	Pycnanthemum verticillatum var. pilosum	Hairy mountain mint		TU	PX	SU	G5T5
Birds							
	Ammodramus savannarum	Grasshopper sparrow				S4B	G5
	Bartramia longicauda	Upland sandpiper*		PT	PT	S1S2B	G5
	Caprimulgus vociferus	Whippoorwill				S4B	G5
	Chordeiles minor	Common nighthawk				S3,S4B	G5
	Circus cyaneus	Northern harrier		CA		S3B,S4N	G5
	Colinus virginianus	Northern bobwhite*	(PS)	CA		S3	G5
	Dendroica discolor	Prairie warbler				S4B	G5
	Dolichonyx oryzivorus	Bobolink				S4B	G5
	Empidonax traillii	Willow flycatcher				S5B	G5
	Eremophila alpestris	Horned lark					G5
	Gallinago delicata	Wilson's snipe		CR		S3B,S3N	G5
	Icteria virens	Yellow-breasted chat				S5B	G5
	Melanerpes erythrocephalus	Red-headed woodpecker				S4B,S4N	G5
	Phasianus colchicus	Ring-necked pheasant					G5
	Scolopax minor	American woodcock				S5B	G5
	Sialia sialis	Eastern Bluebird					G5
	Spiza americana	Dickcissel		PT	PE	S2B	G5
	Spizella pallida	Clay-colored sparrow					
	Sturnella magna	Eastern meadowlark				S5B,S4N	G5
	Toxostoma rufum	Brown thrasher				S4B	G5
	Tyto alba	Barn owl		CR		S3B,S3N	G5
	Vermivora chrysoptera	Golden-winged warbler				S4B	G4
	Vermivora pinus	Blue-winged warbler				S4B	G5

Herps						
	Crotalus horridus	Timber rattlesnake	CA	PC	S3S4	G4
	Heterodon platirhinos	Eastern hognose snake			S3S4	G5
	Clemmys guttata	Spotted turtle			S3	G5
	Clemmys insculpata	Wood turtle			S3S4	G4
Invertebrates						
	Callophrys irus	Frosted elfin			S1S2	G3
	Celithemis eponina	Halloween pennate			S2S3	G5
	Euphydryas phaeton	Baltimore Checkerspot			S2S4	G4
	Hemileuca maia	Barrens buckmoth			S1S2	G5
	Hesperia leonardus	Leonard's skipper	PS		S3S4	G4
	Hesperia sassacus	Indian Skipper			S3S4	G5
	Lagoa crispata	Black-waved flannel moth			S1	G5
	Speyeria aphrodite	Aphrodite Fritillary			S3S4	G5

*Historical

Fort Indiantown Gap National Guard Training Center (22 miles east of Harrisburg, Pennsylvania) is categorized as a top priority natural area in both Lebanon and Dauphin Counties by the Pennsylvania Natural Heritage Program (TNC 2003 and TNC 2005; Table 1). FIG is home to a mosaic of vegetation types. One of these types is warm-season grasslands, an ecosystem that has seen a severe decline, especially in the northeast United States. This installation provides documented breeding habitat to many grassland species on the PA Wildlife Action Plan (WAP; Table 2) priority species list including the largest eastern population of the regal fritillary butterfly (*Speyeria idalia*); a Pennsylvania Invertebrate of Immediate Conservation Concern and a Pennsylvania Responsibility Species (PGC and PFBC 2005).

Table 2. Grassland-associated WAP Priority Species documented to occur at FIG:

Northern Harrier	Golden-Winged Warbler	Eastern Box Turtle*
Barn Owl	Blue-Winged Warbler	Spotted Turtle*
Common Nighthawk	Yellow Breasted Chat	Eastern Hognose Snake*
Whip-poor-will	Prairie Warbler	Smooth Green Snake*
Solitary Sandpiper	Grasshopper Sparrow	E. Timber Rattlesnake*
American Woodcock	Bobolink	Eastern Ribbon Snake*
Red-Headed Woodpecker	Dickcissel	Regal Fritillary Butterfly**
Brown Thrasher	Eastern Meadowlark	
N. Bobwhite Quail (hist.)	Upland Sandpiper (hist.)	Fowler's Toad (hybrids)*

*=PFBC responsibility, **=Orphan taxa

Red = immediate concern, Orange = high concern, Black = maintenance concern

Figure 1. Female (two rows of white spots on hind wings) Regal Fritillary Resting on Native Little Bluestem Grass.

Figure 2. Male Regal Fritillary (one row of white spots, one row of orange spots) Resting on Butterfly Milkweed.

Ecology of Native Grasslands at Fort Indiantown Gap

On 10 April 1931, Governor Gifford Pinchot ("Father of Conservation") authorized the creation of the Fort Indiantown Gap (FIG) National Guard Training Center. Land was purchased from local farmers and military training started in the early 1930's. In 1941 the land was leased to the Federal Government and the building of a runway, 1,800 buildings, and 20+ ranges. Fort Indiantown Gap is divided into 2 distinct areas: Cantonment (south of forests on Blue Mountain; offices, barracks, air field, and warehouses) and Corridor (toe of Blue Mountain to the south face of Second Mountain). In fact, many areas in the Cantonment have a surprising amount or grassland habitat (e.g. the runway is surrounded by native grass in a mowed lawn setting). The less developed portion of FIG (Range Road Complex and Corridor) has scattered buildings surrounded by mature forests, scrubland, savanna, and grasslands. The amount of grassland at FIG is due to the continuation of infrequent and moderate disturbance from training in a manner very similar to Depression-era farming. Based on historical photos, institutional knowledge, and field observation existing grasslands at FIG were created in the following manner:

- Removal of topsoil in the construction of ranges to create berms,
- Removal of topsoil from uncontrolled military vehicle maneuvers (1931-1990's; FIG Natural Resources Office was established in 1997),
- Range fires from ordnance (artillery shells, tracers, flares, and cigarettes),
- Controlled fire to reduce fuel loads (1941-1997),
- Prescribed fire to reduce fuel loads, improve training areas, and grassland maintenance (2000-present).

Regals occupy approximately 220 acres of high quality grassland/old-field habitat within four general areas at FIG. Other areas on the base harbor regals but at much lower densities (<5 individuals) which are not considered stable populations. All of these areas were ranges at one time or another. In 1998 FIG set aside 219 acres of training area for Regal Research Areas (RRAs) to study the butterfly, determine life history requirements, and to conduct experiments (PANG 2002). RRAs are considered protected from the confounding effects on vegetation by mechanized training. This habitat is managed through soil disturbance, prescribed fire, and by planting native species to increase diversity. Other land stewardship includes mowing, applying selective herbicide, and manually removing woody species. A comprehensive multi-year management plan utilizing disturbance is necessary to maintain habitat quality for the regal over the long term.

Based on available data of regal habitat at Fort Indiantown Gap 1/3 of the vegetative cover should be little bluestem and broom-sedge, 1/3 other grasses (both native and introduced), 1/3 forb, shrub, and small tree cover. Bare ground should between 5-15% coverage to allow for the germination of violets, native grass, and nectar plants. A preliminary assessment is that at least 5,000-10,000 violets per acre and 100 primary nectar plants per acre (blooming) are required for regal fritillary.

Figure 3. Grassland Habitat at Range 23 Fort Indiantown Gap Containing Regals.

Herbicide, mechanical removal of vegetation, soil scarification, and prescribed fire are the preferred methods of habitat manipulation (Latham et al. 2007). Fort Indiantown Gap uses manual removal, prescribed fire, mechanical removal, and low-volume herbicide application (in decreasing acreage) to maintain regal habitat and associated adjacent areas. Fort Indiantown Gap uses prescribed fire, mechanical removal, and broadcast herbicide application (in decreasing acreage) to restore or reclaim grassland outside of regal research areas (RRA). FIG utilizes ecological adaptive management (assess current and desired habitat conditions, design, implement, monitor, evaluate, and adjust management techniques in a circular feedback process (Landres *et al.* 1999 and Wilhere 2002). This concept is not new; most managers, scientists, and wildlife biologists are aware of adaptive management.

The 2 key components of adaptive management are 1) land management is effectively set out as an experiment, and 2) a direct feedback loop exists between science and management (Halbert 1993). Essentially, adaptive management is the incorporation of the scientific method (experiments) into a management framework (policy decisions). This differentiates adaptive management from traditional trial-and-error or learn-as-you-go management (Hilborn 1992, Halbert 1993, and Aldridge *et al*. 2004).

When determining herbicide treatments, the target species determines the primary chemical used while limiting control of non-target vegetation (desirable). There are non-selective and selective herbicides, and application can be a low-volume or a high-volume application. Integrated Pest Management strives to use herbicide only when cost or ecologically effective and herbicide use is on the conservative side in order to limit potential environmental side effects. When applying herbicide following all applicable laws and regulations, secondary effects often determine how

effective the treatment is. Applicators have to cognizant of weather (drought stress limits effectiveness), water quality (herbicide binds to suspended clays), season (some herbicides work better in growing season or carbohydrate transport periods), and possible chemical antagonism effects of mixed herbicide use. Often management areas have to be retreated in subsequent years as not all undesirable vegetation will be controlled and germination of seeds will continue within the seedbank. Using herbicide to control invasives is not a once-and-done effort and follow-up treatment is required to eradicate invasives from natural areas.

Expectations

The objectives of the project are to establish native warm-season grassland habitat to benefit a multitude of species including, but not limited to, the regal fritillary, and to establish a long-term sustainable breeding populations of regal fritillaries outside of Department of Defense managed lands.

Short-term Goals and Objectives

1. Restore and establish a minimum of 40 acres of native warm-season grassland (dominated by little bluestem and broom-sedge) ecosystem at each major location proposed for repatriation.
2. Enhance existing grasslands and grassland restoration projects already underway.
   a. Create a viewable wildlife location for native warm-season grass and regal establishment close to main use areas and public involvement.
   b. Choose locations based on connectivity and genetic circulation.
   c. Create signage for interpretation to inform the public of management techniques and to decrease possible negative reactions toward disturbance in larger areas of restoration.
3. Restore native plants including milkweeds, thistles, and violets to local habitat.
4. Repatriate restored sites with regal fritillary butterflies from stock originally obtained from Fort Indiantown Gap.
   a. Release captive-reared regal fritillaries in all stages of the life cycle.
   b. Repatriate gravid females using techniques developed in Iowa (Debinski and Drobney 2000, Shepherd and Debinski 2005).

Long-term Goals

1. Establish a functioning and self-sustaining native grassland ecosystem historically found in the area using local eco-type seed sources.
2. Utilize an adaptive management approach to fine-tune techniques of Eastern grassland restoration.
3. Increase local diversity and populations of native animal species including grassland endemic birds, arthropods, herps, and mammals.
4. Connect initial repatriation sites to form a self-sustaining metapopulation of regal fritillaries outside Fort Indiantown Gap to increase the likelihood of species survival and return the species to its original range.
   a. Augment other native warm-season grass projects started by partner agencies in the past 20 years.
   b. Reclaim old field succession along the former railroad beds and pipeline rights of ways.
   c. Rehabilitate coal tailing barren communities where possible, if possible.
5. Enhance populations of known or suspected rare, threatened, and endangered plants and

animals currently found in or believed to occur in partner locations that would otherwise be threatened by succession and woody encroachment.

6. Establish species of grassland specialists known to occur elsewhere in the region.
7. Enhance watchable wildlife opportunities by promoting open habitats.
8. Educate the public on statewide native grassland scarcity and the regal fritillary.
9. Increase visitation and visitor appreciation of the park and its resources.

Long-term Vision

Grassland habitat will not be the dominant land cover for an entire site or property, but the habitat is expected to cover enough land to ensure the establishment and maintenance of native specialists. Native warm-season grasslands that become established would preferably have enough connectivity to allow populations to have the genetic exchange they need to remain stable. A self-sustaining regal fritillary population would be ideal, although an occasionally maintained population would be acceptable, mirroring activities taking place with other rare and endangered fritillaries in other parts of the country (M.J. Andersen pers. comm.).

Grasslands would be dominated by little bluestem (*Schizachyrium scoparium*) or other native warm-season grasses (medium height grass < 4' tall) found to be suitable to regal fritillary use, with communities of native thistle (*Cirsium spp.*), milkweeds (*Asclepias spp.*), and violets (*Viola spp.)* at levels similar to Fort Indiantown Gap. Wetlands or areas with wet soil would present wet meadow habitat niche opportunities and support additional populations of regal fritillary nectar sources.

Basic Treatments

Three main methods of vegetation treatment can/will be used at the site level: 1.) chemical through traditional herbicide, 2.) mechanical through machinery and hand labor to manipulate material, and 3.) combustible through the use of prescribed fire. Mechanical and proper chemical treatments have received the endorsement of all parties involved in the project. Fire has been the most effective technique used at FIG but still needs further discussion to gain the approval of the Bureau of State Parks and probably will not be available at the national parks due to archaeological sensitivity. All three methods will be prescribed in the event that all three are or become available. Prescriptions will be broken out by species and community type.

Fire is the most helpful method in establishing and maintaining native warm-season grasslands. Mowing and herbicide do not address soil conditions or light requirements like fire. Fire breaks down plant detritus including thatch, releases soil nutrients, creates interstitial space (bare soil) and increases sunlight soil exposure (removes thatch and mulch) which warms the soil. This allows plant species crucial to the regal fritillary, such as the violets, to emerge, propagate, and grow with vigor. Fire does take public education to avoid negative public opinion. Proper smoke management and early notification can not be stressed enough. Burned areas do green up quickly once the growing season begins and the effects are often welcomed by public users. Only the application method usually draws concern.

Mowing and brushcutting are extremely helpful in removing woody plant material from the site. Possibly the cheapest methods of maintenance, mowing and brushcutting can remove height for chemical treatment and can reduce plant vigor by stressing nutritional reserves through regrowth.

It is recommended to remove the cut vegetative material when mowing is used as a management technique. Otherwise, thick litter/mulch builds up, which tends to speed the rate at which grasses competitively suppress other plants and advance toward grass monoculture (Bascompte and Rodríguez 2000) and limits the germination of violets or key native nectar plants.

Mowing is not ecologically equivalent to burning or grazing, in part because it fails to remove thatch/mulch, create areas of bare soil, which are a requirement for some wildlife species and as sites for seed germination and colonization for less-competitive plant species. Patches of bare soil commonly develop in prescribed fire "hot spots" and in places where grazers congregate or wallow (Latham and Thorne 2007).

The key advantage to mowing is that it can be done by a single individual in a short time span with little training investment. The cutting can take place in almost any season as well as in inclement weather, which limit fire and chemical control. In terms of managing landscapes, Cech and Tudor (2005) noted that routine "prettification" of yards, parks, and roadsides has led to the decline of grassland butterflies. They suggested avoiding growing season mowing and indiscriminate herbicide use although some management at the proper time of the year is needed to maintain the habitat.

Chemical control produces the strongest public reaction following treatment. Depending on the chemical used, dying plant material and large brown spots can be seen on the landscape for weeks or months following treatment. Chemical is also the most expensive treatment method (except for removal of high-density and large diameter woody material) due to the inherent price of the material and the equipment used for its application. Chemical is the only method that virtually assures individual plant mortality. Mowing and fire can often take several regimes to remove individuals from the landscape, and neither prevents species regrowth and recolonization. In order to have success, the applicator must have a well researched plan for timing and chemical concentrations, background training for certification, and the proper environmental conditions for application.

Undesired Species and Community Prescriptions

Rates given are for prime conditions (e.g. mid-growing season in fair weather). Drought or periods of little rain or late-season (near-dormancy) conditions may require additional chemical, though the rate must still fit limits defined on the product label.

Herbaceous:

Goldenrods – Goldenrods (*Solidago spp.*) while native this group of plants are invasive and show high dominance rates in open areas. The density of the species in some areas allows very little room and resources available to other herbaceous and graminoid species.

> Chemical – Treatments of triclopyr 61.6% (Garlon 4, Tahoe 4E) have been effective at Fort Indiantown Gap at removing broadleaf perennials at concentrations near 1-4 qts. per acre (label recommended rate). Applications for broadleaf weeds involve suspending the triclopyr in water using a surfactant at 0.3% of the mixture with constant agitation (Garlon 4 2007). Most treatments can be used as a broadcast since goldenrod is so pure in the stands.

Alternatively, where goldenrods are so dense that complete control of the area will not impair the restoration, glyphosate (Accord XRT, Roundup) can be used at a rate of 1.5 to 4 quarts/acre (not to exceed 8 qts. per acre per year) in a water solution with a surfactant. Subsequent disturbance, whether planting, seeding, disking, or removing brush should wait at least 1 week for the chemical to run its course and damage the roots (Accord XRT 2006).

Sulfometuron methyl 50% (Landmark XP) at 4.5 oz. per acre with surfactant for control during the growing season is another option, but labels prevent use in recreation areas. Landmark has soil residency and can be used as a pre-emergent. Apply in the fall at a rate of 1.5 oz./acre within 6 weeks of soil freezing or in spring 6 weeks after the soil thaws. Check with a product label before applying. Replanting should not begin for at least 3 months after spring application for some species, 6 months after for others (DuPont Landmark XP 2005).

In areas that desired species should be saved, the herbicide could possibly be applied to the stem and leaves without controlling other shorter species. Wick application is the best method to do this, possibly mounted on the front of a piece of equipment and set at a height to hit mid-stem. Similar applications are used by brown brush monitors (combination brush cutter and herbicide applicator) that apply the herbicide to cut stubble through wipes at the rear of a brush-cutting machine.

Mechanical – Mowing and disking will likely be necessary to keep seed stock down and break up the existing vegetation. For the first year, pulvi-mulching or heavier soil disturbance could be used where no native warm-season grass exists.

Fire – Unless under ideal weather and curing conditions fire will not usually pass through a dense stand of goldenrod in the Northeast. The basal leaves and stems usually remain green throughout the season and do not provide dry fine fuels to support consumption. Additionally, goldenrod tends to come back more aggressively the first year after fire in places where it is not dominant. Goldenrod dominance after a fire is enhanced by a large root mass, clonal growth and quite possibly seed ecology. The seed source is held out of the fire on the long stem and becomes the first available seed for colonization on bare soil. Warm-season grasses generally overtake the goldenrod after the initial year following fire, but they first have to be established prior to Rx fire. Further research needs to be conducted at FIG to determine beneficial prescriptions involving growing season mowing, herbicide, and fire.

Crown-vetch – Crown-vetch (*Coronilla varia*) has the ability to overtake herbaceous fields otherwise dominated by goldenrods or grasses. Other invasives become a major component of these crown-vetch patches when the species are aggressive enough to break through the crown-vetch shading.

Mechanical – With crown-vetch, the foliar material and meristems at or below ground level can be shaded by the overgrowth of other individuals above. For this reason, top cover must be removed before chemical treatment can begin. The best approach is a spot mowing immediately preceding the chemical application. A traditional mower will do the job, but flail mowers should be avoided as their flails can become entangled or simply

move reproductive material from location to location. Mowing alone rarely holds back crown-vetch as the species is adaptable to blade heights and treatment times. Still, when full scale chemical treatment can not be completed, mowing can be performed whenever the species blooms.

Chemical – A broadleaf application will remove the targets while leaving the grasses to repopulate newly created openings. A triclopyr 44.4% (Garlon 3A) application of 3% performs this well. Spot treatments with 3% of triclopyr and adjuvant per gallon of water can be used to treat crown-vetch in other places where it is a lesser component of the community.

Alternatively, use clopyralid (Transline; legume and composite selective) applied at 2/3 to 1 1/3 pints per acre, not to exceed 1 1/3 total pints per acre in a given year. Clopyralid requires constant agitation to keep the herbicide in suspension and should be applied with a surfactant to increase absorption through the foliage. The herbicide will reside in uncut grasses and other vegetation litter, so cuttings should be worked into the soil or burned to promote herbicidal decomposition. Cuttings are not to be baled for other uses. Clopyralid can not be used in the presence of desirable seedling grasses, although established grasses will survive the treatment. The herbicide has increased effectiveness against legumes, making it an aggressive treatment for crown-vetch, but is also effective against all thistles. Thus it should be used with caution after the establishment of regal fritillary nectar species.

In areas where crown-vetch forms a monoculture, glyphosate can be used at rates mentioned for *Solidago*. If applied properly, the glyphosate will reduce the amount existing herbaceous material from the area of application.

Fire – Fire treatment will remove living and dead material for future spraying. This can be done where warm-season grasses are present to stimulate their spring growth to overtake some of the crown-vetch and thistle community. Fire causes plants to use up carbohydrate reserves and reduces the amount of green growth thereby increasing the effectiveness of herbicide. Also, in high hummocks where mowing is difficult, fire can lower the vegetative stratification to make spraying possible. As early colonizers, fire without follow-up chemical treatment will only serve to spread the species into new vacant landscapes.

Mile-a-minute – Mile-a-minute (*Persicaria perfoliata*) is an annual vine armed with small barbs and highly edible (for wildlife) berries. The species displays some of the most rapid growth in the plant kingdom, and seeds within the fruit can germinate above 30% following 8 years in the soil bank (Gerlach Okay 1999). The species produces fruit in at least two cycles, the earliest in July and the latest in September. The vine itself is weak and one of the first species to succumb to early frosts, making it extremely vulnerable to herbicides. Still, the vine uses brush as a refuge, making elimination nearly impossible without large disturbances to the landscape. Typically, the species will linger in brush until growth reaches a large amount of sunlight, when the species explodes into growth and fruit. The vine is also extremely successful at reproduction, germinating well from self-pollination so that one individual can possibly create a large population given time and proper conditions.

Mechanical – Vines do not often root from anywhere other than the basal meristem, and thus mechanical removal can inhibit the growth and fruiting of a population. The vine has been successfully removed by hand in a number of northern colonies, but very few of these locations have completed the removal of the species from the site. The vine is very weak and prone to breaking before the basal roots can be removed. Any vegetative material left rooted will quickly regrow and flower in timing with the season. Vegetative material removed will also expose new seedstock to the light requirements necessary to germinate.

Mechanical treatment is mainly thus a means to reach the plant for chemical treatment. Plants are typically found in edge and brush areas where individuals can be difficult to locate and even more difficult to reach with a foliar herbicide. The best means to rid the area of the species is to strip away that brush or other structural component the species needs to ladder and shade its seedling stage, and then spray out the foliage in May or June. By the beginning of July the fruits will already have progressed too far for effective treatment on some plants.

Chemical – As stated, the best time to target the species is in May or June when plants are large enough to be identified, but before the first flowering and fruiting period begins. Fruits can develop rapidly and one berry is technically enough to perpetuate the colony. Leaves can be sprayed with any broadleaf chemical typically at the lowest labeled rate as the vine has very little root structure and rapidly transports the chemical throughout. Spraying has to occur more than once a year to effectively treat all growth as the species tends to demonstrate a delayed pattern of germination, flowering, and fruiting that can recur throughout the growing season. The species ends growth as the weather turns colder in September.

Spot treatment at a 1% solution of triclopyr 44.4% (Garlon 3A) effectively treats individuals. A broadcast rate of three-quarters of a pound of active ingredient per acre should be effective. Similarly, triclopyr 61.6% (Garlon 4, Tahoe 4E), imazapic (Plateau), glyphosate (Accord, Roundup), or other broad leaf herbicides will work at their lowest label rates. DMVA has experimented with applications of pre-emergent herbicides, but the delayed germination rates seem to tolerate and avoid effectiveness of these harsher chemicals. Additionally, the pre-emergents often create a large bare area that can be further colonized by invasive species and look unattractive to park visitors. Interpretive materials have been created for DCNR to explain habitat management techniques. At this time, DMVA does not recommend that these pre-emergents be used, but DCNR land managemnt swing crews may want to make use of the active ingredients in situations when return intervals are widely spaced. Imazapic or sulfometuron methyl (Landmark) is used at FIG for these applications, again at their lowest labeled rate per acre.

Fire – Fire does generate a favorable control effect on mile-a-minute. Fire generally releases the species by eliminating competing vegetation, allowing light to reach the base of ladder species, and nutrifying the soil. Additionally, mile-a-minute is well adapted to low-intensity surface fires by residing in the soil and aggressively growing and shading regrowth from competing perennial species. In areas of dense colonization, fire generally only consumes the base of the dead vines if consuming any plant material at all. The material is too loose to present continuous fuel loads up high where berries have the

greatest potential for dispersal, and the species can shade and hold in moisture to extinguish ground-running flames.

Sericea lespedeza – Sericea lespedeza (*Lespedeza cuneata*) has a history of establishment in agricultural and remnant agricultural settings and establishes easily in grasslands. The exotic plant is a prolific seed source and blooms and seeds at the very end of the field season (September to October) after the peak of its vegetative growth. Stands can quickly outcompete nectar species and grasslands, forming dense monocultural thickets.

Mechanical – Flowers and seed set occurs anywhere and nearly everywhere along the stem that leaves can emerge, making mowing ineffective by adjusting to seed set at lower heights. The lateness of the season helps to ensure that the seed will make contact with the soil, as many other species have already senesced. Soil disturbance appears to enable colonization and should be avoided.

Chemical – Triclopyr (61.6%, Garlon 4 or Tahoe 4E; 60.5% Remedy Ultra) can be used from peak foliage up to or through the flowering stage (KSU 2009, Remedy Ultra) when applied at 1-2 pts. per acre in at least 20 gallons of water. Water must be agitated at a rate sufficient to suspend the chemical mixture and allow even distribution of the herbicide, and surfactant should be used according to label to act as an emulsifier.

Fire – Like other lespedezas including the native bushclovers, sericea is well adapted to fire. The species takes quick advantage of bare ground and sets seed into the fall fire season. The plant itself produces very little litter due to reduced leaves and nearly no laddering fuels other than the stem so that fire does not travel well into the fruiting portion of the stem. Fire is not recommended for control.

Graminoid:

Fescue – Agronomic fescue grasses (*Festuca spp*.) are a cool-season genus, and treatment may be possible during native warm-season grasses' dormancy period. This species aggressively occupy habitat space that can prevent growth of native warm-season grassland species, but are relatively weak competitors when those natives become established.

Mechanical – Cool-season grasses like fescues are often well adapted to mowing and other mechanical controls through means such as vegetative growth, low growing height, and early and late fruiting periods. Mechanical means usually help to maintain the species, rather than convert them. In areas where fescues form a complete sod, tilling or disking may be necessary to create room for native grasses. Those natives will need further means of establishment before the fescue heals its carpet.

Fire – Cool-season grasses are very poorly adapted to fire. Fire is often the primary means of control in climates where growing season fires can occur, but can be problematic in the Northeast when facing a well-formed sod. As more desired species begin to colonize an area, providing the fuel necessary to complete a burn, fire can become an effective management tool for removing the rest of the fescue.

Chemical – Following a mowing treatment, grass should be allowed to regrow to regain

leaf surface. At this time, before any flowering or seeding structures appear, repeated applications of glyphosate (Roundup) will steal nutrients from the roots and remove the species. Alternatively, glyphosate can be applied in the fall as the grass takes material into its roots to support overwintering. Another option is to apply glyphosate in late fall or early spring when only cold-season grass is actively photosynthetic and desirable vegetation is dormant.

Sethoxydim (Poast) applied at 1.5 pints per acre will selectively control most grasses (including warm season) while leaving broad-leaved plants. All access must be controlled to the application area for 12 hours post-application. The chemical may take up to 3 weeks to create symptoms (Poast 2005).

Imazapic (Plateau) at 2-12 ounces per acre controls cool-season grasses in the presence of established warm-season grasses. Surfactant should be used with the imazapic to enhance control. Any native grass plantings should be given time to root and establish before application, but imazapic can then take the place of a glyphosate or sethoxydim.

Japanese stiltgrass – Japanese stiltgrass (*Microstegium vimineum*) is an annual grass that establishes mainly through seeding and produces very shallow and fine roots. T he grass tolerates high amounts of shading and often out-competes other species on heavily compacted soils where it spreads quickly with heavy coverage. The main mechanisms that favor stiltgrass establishment are quick growth and high-volume seed production. All treatments should therefore take effect before seed set to have a positive outcome.

Chemical – Treatment effects can be isolated through the use of imazapic (Plateau), which targets cool-season grasses but does not affect many broadleaf species. Imazapic should be applied at rates of 2-8 ounces per acre (depending on the maturity of the plants, roughly equivocal to seasonality). Imazapic should only be used where a standard buffer exists between the treatment zone and any standing or surface waters are present.

As an alternative, sethoxydim (Poast) may work at a rate of 1-1.5 pints per acre to control the annual grass without harming broadleaf species, although clear label prescriptions are not given for the species. Glyphosate (Accord, Roundup), picloram (Tordon) or another non-selective herbicide may be used when treating a monoculture.

Mechanical – The grasses do not reproduce through rhizomes, so ground disturbance may be useful in removing the species before seed masts develop. This method will also bring existing seed mass to the surface, however, and will require repeated treatments. Alternatively, the grass can be mowed just before flowering to the lowest height made possible by the landscape. Since the species are annual, either of these processes in repetition will eventually exhaust the seedstock, removing the species. A solely mechanical method, however, will take lots of time and will not exhaust the original offsite source of the colonization. Mechanical methods should be used when delays in chemical treatments can not be avoided.

Fire – Fire is not a useful tool for stiltgrass, and may promote the species (Howard 2005). Some anecdotal studies show that fire opens up habitat for seed already dispersed in the

seed bed, thus creating more biomass to produce more seed the following year.

Shrub:

Olive – Autumn-olive (*Elaeagnus umbellata*) and the less common Russian olive (*Elaeagnus angustifolia*)are keystone species in that it forms its own vegetative community through shading and possible organic toxins (allelopathy) released into the soil. Species observed cohabitating with olive at partner sites include rough avens (*Geum laciniatum*), garlic mustard (*Alliaria petiolata*), *Rubus* species, poison ivy (*Toxicodendron radicans*), multiflora rose (*Rosa multiflora*), and honeysuckles (*Lonicera spp.* and *Symphoricarpos spp.*). Even in places where grassland is not the target community, replacement of autumn-olive shrubs with native food sources will encourage healthier habitat.

Chemical – Initially, treatment consists of either basal bark herbicide or a cut and stump herbicide method. In either situation, triclopyr 61.6% (Garlon 4, Tahoe 4E) in basal oil is recommended at a rate of 5 gallons per acre at 20-30%. Basal treatments should be performed when applicators can apply the herbicide to all 360 degrees of surface of the stems. Herbicide should be sprayed from the ground to 12-15 inches. When the species forms thickets that prevent full application, brush should first be mechanically removed before spraying the cut stumps with a broadcast application. For small thickets, point applications may be used. Treatments can be performed year-round except for those times when snow will not allow treatment to reach all the way to the ground surface (Garlon 4 2007).

During the growing season, especially after the first mechanical removal has been performed, foliar treatments can be used to kill the plants through their leaf material. Triclopyr 44.4% (Garlon 3A) can be used at a rate of 1-3% or 1 to 3 gallons per acre with surfactant. Triclopyr 61.6% (Garlon 4, Tahoe 4E) can also be applied as a foliar spot application with a surfactant in water with constant agitation at a solution of up to 5% (not to exceed 8 qts. per acre per year).

Mechanical – Mechanical treatment should be followed up with chemical treatment whenever possible, as the root network is well established and the first resprouts will make retreatment difficult. Treatment can be performed by hand when vegetation cover is light, but heavy cases will require a large brush grinding device such as a Fecon, a Brown Bear, or a Tiger mower. In all cases, treatment should attempt to grind the slash and stump down into the soil (below the root collar) to prevent stump sprouting, disturb roots, and bury the wood mulch/slash (to a depth of 3-6 inches) that would otherwise smother germinating seeds. In some places where soils have been removed, this may not be feasible due to high rock content in the remaining soil. In most places, however, topsoil exists to a depth that the equipment will withstand. Adding organic matter ties up nitrogen through decomposition and gives native grasses a competitive edge. This effect is sometimes referred to as reverse fertilization.

Fire – Fire treatment is not recommended for olive (Munger 2003) due to vigorous regrowth. From personal observations, fire does not carry well through monocultures due to low amounts of litter on the floor, shade-captured moisture, and few available ladder fuels. It is a mixed-value tool when olive leaves room for more combustible species.

Honeysuckles – Not all honeysuckles are exotic, i.e. native coralberry (*Symphoricarpos orbiculatus*) or common elderberry, (*Sambucus canadensis*), but some can overgrow grasslands once established. Bush honeysuckles (*Lonicera spp.*; Tartarian, Amur, Morrow's) are extremely invasive and provide support for laddering species such as Asiatic bittersweet (*Celastrus orbiculatus*), mile-a-minute (*Persicaria perfoliata*), and Japanese honeysuckle (*Lonicera japonica*; vine). Multiple species of invasive exotic honeysuckle shrubs can be found within the state. Each acts in similar manner, can be difficult to distinguish from one another, and therefore is treated in the same manner. The species often require foliar contact herbicide to achieve removal, but timing can be crucial as to which herbicide prescription will succeed.

Mechanical – Surface cutting to remove the stem and leaves must be followed by a stump treatment such as glyphosate at a 20-50% concentration. Cutting and stump painting can be accomplished from the late summer through the dormant season (Nyboer 1992). Otherwise, mechanical treatments alone must destroy the root collar if the manager is to have any hope of destroying the plant and preventing regrowth. Even then, resprouting is likely to occur. Multiple mechanical treatments would be necessary to exhaust root nutrient supplies.

Chemical – Spot treatments of 1 to 1.5% glyphosate in water (Accord, Roundup) can control shrubs when applied to the foliage. The label recommends a rate of 3-6 pints per acre for broadcast treatment. The best time for treatment is immediately after blooming in June, but applications can occur between the end of the blooming period to the beginning of the color change in fall. All foliage must be sprayed or shoots will survive the treatment (Nyboer 1992, Love and Anderson in press). Treatment must not exceed 8 quarts per acre (Accord 2006).

Foliar spot treatments with triclopyr (Garlon 3A) can be effective in the spring (50-60%), but lose their effectiveness in the fall. For best effectiveness, imazapyr (Arsenal) should be tank mixed with the triclopyr at a rate of 3% triclopyr and 1/8% Arsenal. This mixture can be applied any time of the year that living foliage is present without reducing effectiveness too greatly (Rathfon and Ruble 2007). Both triclopyr and imazapyr will only affect broadleaved species, making this the preferred treatment for selective applications in grass.

Herbicide can be applied directly to dormant stems through basal bark application. Triclopyr (Garlon 4, Tahoe 4E) can be applied at a rate of 20% in basal oil to the stems during the dormant period for effectiveness of about 40% (Rathfon and Ruble 2007).

Fire – Fire can effectively treat honeysuckle, but multiple fires will be necessary to complete the treatment. Spring fires are the most beneficial, as they can conduct through the leaf litter with some heat and the plants are the most vulnerable as they start to break dormancy. Fire must be repeated as often as it can be sustained in areas where these species are dominant until the species is repelled. The seeds of these species tend to favor trips through their hosts' digestive systems and do not respond well to fire.

Multiflora Rose – Invasive, exotic rose (*Rosa multiflora*) are major competitors found in locations where typical treatment cannot reach them or fails to impair them. Multiflora rose prefers to stay on the outer edge just beyond jurisdictional wetlands, as well as in swales and

other hydrological sites that fail to become fully functional such as shaded areas and slope drainages. The species can also survive mowing, growing and fruiting beneath blade height for years once root mass has been established. Exotic roses often are infected with rose rosette disease, a potentially lethal threat that impairs invasive roses much more frequently or obviously than native roses.

Mechanical – Rose is often amongst the first species to green in the spring, making dormant brush control difficult but mechanical harassment easier. Three to six mowings per season for two to four consecutive seasons are necessary to kill plants through defoliation (Loux et al. 2005, Szafoni 1990). Resprouting can occur from root fragments, so grubbing does not necessarily enhance the effectiveness of the treatment.

Chemical – Foliar treatment of rose is difficult as most of its biomass is stored in the stem with small, divided leaflets able to absorb chemical but not in the quantity to kill the plant in one year of application. Rose rosette disease also deforms the leaf, making most of the plant leafless when infected. Foliar control can be tricky and depends on timing and the product used.

Triclopyr (Garlon 4, Tahoe 4E) is effective in basal oil as a dormant season basal bark treatment at a 20% solution. Again, the dormant season in rose is considerably shorter than some other species, with Pennsylvania dormancy sometimes breaking in February (Childs 1992).

Fire – Fire can effectively treat rose, although multiple fires are necessary for control. Spring fires are the most beneficial, as they can conduct through the leaf litter with some heat and the plants are the most vulnerable as they start to break dormancy. Fire must be repeated as often as it can be sustained in areas where these species are dominant until the species is repelled. The seeds of these species tend to favor trips through their hosts' digestive systems and do not respond well to fire.

Blackberries and dewberries – Blackberries and dewberries (*Rubus spp*.) are a dominant species in patches scattered through brushy areas. Species are capable of surviving most treatments meant to encourage grassland habitat. Once established, blackberries (upright taller plants) can provide shelter for other growing invasive woody material, while dewberries (sprawling low vines) can out-compete some smaller forbs including violets for resources.

Chemical – Foliar treatments work well for all of the species, given their thin stems. Dewberries hide under too much vegetation for much herbicide application, but blackberries definitely can be targeted. Triclopyr 44% (Garlon 3A) tank mixed at a rate of 1-2 gallons per acre will work when applied to photosynthesizing leaves.

Mechanical – Mowing from time to time will reduce blackberry growth and limit seed dispersal. Mowing can be done annually at the end of May during grassland establishment. Dewberries will also loose fruiting bodies through mowing. Even if the dewberries do get to flower and fruit, reducing their height makes the fruit less visible to would-be vectors. When left uncontrolled, dewberries will climb other vegetation for some stratified advantage.

Fire – Spring burns retard *Rubus* species for 1-2 years. Plants that have burned produce wilted leaves and rust blights during this time frame. In some climates and with some species, especially those further south, fire managers cite *Rubus* as a genus that responds well to fire, but FIG observations have shown that it is an acceptable treatment for the early timeframe. Fire may be the only way to open areas where dewberry coverage is heavy.

Desirable Species

The regal fritillary depends on vegetation at two distinctive times in its life cycle. First, the larva has requirements of violets for food and native bunch grasses for shelter. These are typically arrow-leaved violet (*Viola sagittata*) and little bluestem grass in Pennsylvania. Other field-growing violets are used by the species elsewhere in the US. Second, adult regals depend on nectar-providing wildflowers to gain the energy for flight and life-cycle requirements. These needs are primarily filled by field thistle (*Cirsium discolor*), pasture thistle (*C. pumilum*), butterflyweed (*Asclepias tuberosa*), swamp milkweed (*A. incarnata*), and common milkweed (*A. syriaca*). Other candidate nectar preferences include swamp thistle (*Cirsium muticum*), bergamot (*Monarda fistulosa*), and blazing stars (*Liatris spp.*). Swamp thistle is commercially available (generally of unknown eco-type), unlike other native thistles. During lab rearing, regals have eaten any members of the violet family offered to them including garden pansy (*Viola tricolor*). In the wild, they have proven to be much more selective. These species are targets for the restoration's success. Fort Indiantown Gap staff collected the seed of the above nectar plants and is in the process of locating PA-ecotype blazing-star (*Liatris spp*.) since they do not occur at FIG but are found in Lancaster, Lebanon, Chester, and Butler counties (Rhoads and Block 2007).

The main methods of installment for these species are planting and seeding. Planting will be done from plugs in patches within the fields to avoid mortality if non-selective or soil active herbicides are used to remove invasive and undesirable vegetation. Seed and plugs will come from local ecotype sources including collections taken at Fort Indiantown Gap and within the partner sites themselves. Once established, these species thrive on regular cycles of disturbance such as fire, mowing, herbicide, and light disking. All of the species are well adapted to colonize grasslands and can survive short-duration low-intensity disturbance on a continual basis. Heavy tilling of soil should be avoided as this will negatively affect native grass (disturbs roots).

Seeding little bluestem can be done in the spring (March-May, prime in mid-April) or as a dormant season treatment in winter (Miller and Dickerson 1999, MDC 2000, DeLong and Brittingham 2002). The advantages to winter planting are fewer time constraints during the dormant season, natural stratification and preparation for germination, and the available establishment time before the start of the herbicide season for competing vegetation. Prime spring planting times generally conflict with prescribed fire, active foliar herbicide applications, and invasive species treatments.

At sites that deal with exotic thistle issues, including Canada thistle, bull thistle, and nodding thistle, field identification is important for native thistle conservation. Bull thistle has a narrow opening at the top of the flowerhead, stout spines along the stem, and stout white spines on the flowerhead. Field thistle can be identified by white fuzz on the backs of the leaves (the specific epithet *discolor* is Latin meaning two different colors), a narrowing head with long, slender

yellowish spines, well cut (lobed) lower leaves, and an absence of spines growing down the stem. Field thistle is tall and blooms in late July - September, remaining as one of the last flowering species in the field. Pasture thistle is short with a large head, well-armed leaves but a spine-free stem, and blooms in June and early July. Swamp thistle blooms in September and October has a darker green appearance, a sticky head with soft spines that resembles field thistle, purple seeds, and grows in much more wet places than other thistle species.

Seed and Plug Stock

Wildflower seed is collected annually at Fort Indiantown Gap and from plantings at partner sites in summer and fall. This seed stock is ultimately too little to broadcast at the repatriation sites, but plugs will be grown through subcontract nurseries through the winter. Currently DMVA ordered over 20,000 plants to be grown by 3 different native plant nurseries. Once DMVA stockpiles enough native seed, this seed may be planted with a no-till drill or hand planted in a manner similar to techniques used by the PA Game Commission at Middle Creek Wildlife Management Area and surrounding State Game Lands (SGL's). Volunteers collect native seed, clean native seed, and hand plant meadows (<10 acres) at Middle Creek SGL 46, Furnace Hills SGL 156, and Mount Gretna SGL 145. This program has been ongoing for the past 10 years under the direction of Jim Binder, Middle Creek manager and Scott Bills SGL's 156 and 145 manager. This program started with non-PA ecotype seed and has matured into a PA-ecotype effort from locally collected seed. Middle Creek keeps track of where non-PA-ecotype seed has been planted and where PA-ecotype has been planted. Volunteers collect seed for propagation meadows and use this seed in subsequent plantings. This technique may be used at partner sites in order to increase the amount of local ecotype seed as the volunteer program matures. However, small patches of fields may be augmented with nectar plants while the remaining area develops native grass coverage. Natural seed dispersal will fill in native grass dominated areas and provide partners with sources of local ecotype seed for future restoration efforts (Brown pers. comm.). In restoring natural areas it is preferred to use a local seed source as much as possible in order to conserve genetic integrity and improve the chance of a successful restoration (DCNR 2005a). Seed conservation zones have been developed and it appears that using broad physiographic provinces are preferred for transfer of seed among natural areas (Peters 1998 and DCNR 2005b).

FIG-ecotype native little bluestem seed and Centre County-ecotype upland bentgrass (*Agrostis perennans*; native cold season grass) is readily available from Ernst Conservation Seeds Company through a 10-year license agreement with FIG. Ernst Seed also has committed 15 acres to growing FIG-ecotype bergamot (*Monarda fistulosa*; collected 2003) and has purple love grass (*Agrostis spectabilis*; native warm season grass; collected in 2007) in the pipeline for propagation. Seed collected at FIG will be available for limited distribution at the repatriation sites. FIG will use some of the seed collected to start propagation plots similar to the native plant program at PGC landholdings in Southeastern and Central PA. Seed from either source can be obtained for the project as soon as the fields are ready for planting.

Equipment

DMVA Wildlife has the following equipment available for use. Some pieces of equipment are in high-demand at FIG and may not truly be available, despite their inclusion on this list.

58-hp 4 X 4 tractor (highly difficult to transport)
1 500 cc ATV and 2 UTVs
6' flail mower deck, 8' rotary blade mower deck, walk behind brush cutter 15 HP
Various brush-cutters, chainsaws, augers, and handheld equipment and assorted hand tools
Stationary water pumps, ATV, and truck slip-on units
Herbicide tanks and sprayers (boom, boomless, wand; truck & tractor-mounted and backpack)
4' chain and spike harrow, 4' ATV disc, 6' tractor disc, 8' tractor disc
8' pulvi-mulcher (highly difficult to transport)
4' ATV drop and 2-ton rotary tractor (highly difficult to transport) pulled lime spreaders
Pick-up trucks and trailers
8' No-till Truax drill (highly difficult to transport)
Vicon, PS403DM pendulum spreader (PTO rotary spreader that can spread fluffy grass seed)
Fecon-head FTX Bull Hog 87-HP skid loader (high demand, difficult to transport)
6' wide pull-behind native seed collector and brush-cutter (hand-held) mounted seed collector
250 gallon skid mounted and 500 gallon towed hydroseeders
Irrigation and watering equipment
Other equipment may be available, but has not been identified at this time.

General Timeline

<u>Winter</u>
Clean native seed and grow out seed stock at commercial vendors/greenhosues
Basal bark treatments for shrubs and trees
Seedbed preparation – disking and planting when soil is thawed

<u>Spring</u>
Plant grass and nectar plant seed (if available)
Rx fire treatment
Pre-emergent herbicide treatments
Foliar herbicide treatments, especially invasives

<u>Summer</u>
Mowing and brush cutting with equipment
Continue herbicide application
Plant plugs as they become available from nurseries
Monitoring

<u>Fall</u>
Seeding, planting plugs
Herbicide usually spot treatment
Fire treatment
Collect and clean native seed

Conclusion

The restoration, rehabilitation, and management of Eastern warm-season grasslands are attainable goals prior to regal fritillary repatriation. For the regal, a number of specific requirements for violet and nectar plants must be met to sustain a repatriated population. These requirements include a properly timed and intensive land management program. The use of native materials and typical land management methods will turn back succession and create prairie-like conditions. The Army has been doing this work for decades, and until recently without an ecological objective in mind. The key is low- to mid severity and high-frequency (3-5 years) disturbance which nets a stable population of annuals and perennial plants suited to low growth, high yield, and dense cover. Benefits that can be reaped include high visitor use, high biodiversity, colorful aesthetics, rare species conservation, and durable, resilient training habitat.

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