Conservation Assessment for The Jaguar Flower Moth (Schinia jaguarina Guenee)

USDA Forest Service, Eastern Region

September 16, 2005

James Bess
OTIS Enterprises
13501 south 750 west
Wanatah, Indiana 46390

This document is undergoing peer review, comments welcome

This Conservation Assessment was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a Conservation Assessment for the Eastern Region of the Forest Service. It does not represent a management decision by the U.S. Forest Service. Though the best scientific information available was used and subject experts were consulted in preparation of this document, it is expected that new information will arise. In the spirit of continuous learning and adaptive management, if you have information that will assist in conserving the subject taxon, please contact the Eastern Region of the Forest Service - Threatened and Endangered Species Program at 310 Wisconsin Avenue, Suite 580 Milwaukee, Wisconsin 53203.

TABLE OF CONTENTS

EXECUTIVE SUMMARY 1
ACKNOWLEDGEMENTS 1
NOMENCLATURE AND TAXONOMY 1
DESCRIPTION OF SPECIES 2
description of adult stage 2
description of immature stages 2
lIFE HISTORY 2
Reproduction 2
Ecology 3
Dispersal/Migration 3
Obligate Associations 4
HABITAT 4
Range-wide 4
Atlantic Coastal Plain 4
Ohio Valley 5
Great Plains 5
Desert Southwest 6
National Forests: Hoosier NF (Perry Co., IN) 6
Site Specific 6
Hoosier NF: Cloverlick Barrens Special Area 6
DISTRIBUTION AND ABUNDANCE 7
Range-wide Distribution 7
State and National Forest Distribution 8
RANGE WIDE STATUS 11
POPULATION BIOLOGY AND VIABILITY 11
POTENTIAL THREATS 12
Present or Threatened Risks to Habitat 12
Row Crop Agriculture 12
Fire Suppression 13
Grazing 14
Pasture Development 14
Competition from Introduced Species 15
Disease or Predation 16
Gypsy Moth Outbreaks and Control Efforts 16
Over utilization 18
Residential Development 18
Inadequacy of Existing Regulatory Mechanisms 18
SUMMARY OF LAND OWNERSHIP & EXISTING HABITAT PROTECTION 19
SUMMARY OF EXISTING MANAGEMENT ACTIVITIES 19
PAST AND CURRENT CONSERVATION ACTIVITIES 20
RESEARCH AND MONITORING 20
Existing Surveys, Monitoring, and Research 20
Survey Protocol 20

Monitoring Protocol 21
Research Priorities 21
Additional Areas of Potential Jaguar Flower Moth Research 22
Other Rare Species Associated with the Jaguar Flower Moth 22
REFERENCES 22
APPENDIX 32
LIST OF CONTACTS 32
Information Requests 32
Review Requests 32

LIST OF FIGURES

Figure 1. Known Distribution of the Jaguar Flower Moth (*Schinia jaguarina*) and its Foodplants in the Eastern United States.

Figure 2. Sample Field Form for Conducting *Schinia jaguarina* Surveys.

EXECUTIVE SUMMARY

The Jaguar Flower Moth (*Schinia jaguarina* Guenee) is a medium-sized, brightly colored moth associated with high quality native grassland remnants in the Great Plains, Upper Midwest and southern Atlantic Coastal Plain. It is considered rare and local throughout much of its range; always found in close association with its primary larval food plants, scurfy peas (*Psoralea* spp.). This moth typically produces one brood per year, with the adults appearing in early summer. The Jaguar Flower Moth is rarely common (except on a very local level) and most records consist of one or a few individuals. The destruction of the nation's grasslands over the past 200 years has greatly reduced suitable habitat for this and many other species. The few high quality fragments that remain are often small and highly isolated from one another. Therefore, a concentrated, region-wide effort to protect and restore habitat for this species will be needed to ensure its long-term survival. It is recommended that restoration projects (particularly those involving native grasslands) track the effects of restoration techniques on globally imperiled species such as the Jaguar Flower Moth, when present. Much is still unknown about this species, particularly regarding its range of habitat requirements. Grassland restoration projects would be a rich source of pertinent information to address these fundamental questions. Once available, this information would also allow land managers to measure a variety of restoration techniques, ultimately leading to more effective restoration of these ecosystems.

ACKNOWLEDGEMENTS

I would first like to thank Steve Olson, Kelle Reynolds and Kirk Larson (US Forest Service) for initiating this project and providing valuable support throughout. Steve Olson (US Forest Service) provided information on the vegetation of the Hoosier National Forest and introduced me to Cloverlick Barrens, where I eventually discovered a very large (and new to the state) population of *Schinia jaguarina*. Ron Panzer (Northeastern Illinois University) provided information on the Jaguar Flower Moth in Illinois. Mike Homoya (IN DNR: Division of Nature Preserves) provided valuable insight on the distribution of *Orbexilum pedunculatum* in southern Indiana.

NOMENCLATURE AND TAXONOMY

The genus *Schinia* was first designated by Hubner in 1818 and based on the type species *Schinia trifascia* (Hardwick, 1996). The Jaguar Flower Moth (*Schinia jaguarina*) was first described as *Anthoecia jaguarina* by Guenee in 1852 and later placed in *Schinia*.

DESCRIPTION OF SPECIES

DESCRIPTION OF ADULT STAGE

The Jaguar Flower Moth typically measures 22-28 mm (0.8-1.25 inches) in wingspan. The forewings are tan to dark olive in color, with a lighter colored "hourglass-shaped" band traversing the entire median of the forewing (see Covell, 1984; Hardwick, 1996; USGS, 2005b). The hindwings are yellow to orange yellow, with an outer border of large black spots, typically forming a thick, irregular black border. A separate black spot typically occupies the center of the hindwing. Occasional pale individuals (ab. *demaculata* Strand) have a washed out appearance and lack the black markings on the hindwing. Below, the ground color is pale tan, with the ordinary lines marked in darker brown, often with a pinkish or reddish cast.

This species is similar in pattern to the much more common *Schinia lynx and S. obscurata*, but *S. jaguarina* is typically twice their size. The forewing of *S. jaguarina* is almost always some shade of olive-brown or olive-tan, while the other two species are more yellowish brown or tan. Both *Schinia lynx* and *S. obscurata* occur in a number of habitats, particularly old fields and disturbed areas containing their foodplants, various species of *Aster, Coniza* and *Erigeron*. *Schinia jaguarina* is almost never found in such habitats, being closely associated with the larval food plants (scurfy peas) on remnant native grasslands.

DESCRIPTION OF IMMATURE STAGES

Eggs of *Schinia jaguarina* are strongly dimpled, greenish yellow and spherical, typically placed inside the corolla cup of Scurfy pea flowers. After a few days, the developing larva becomes visible through the eggs shell (chorion). Eggs hatch within three to four days. The young larvae are greenish, highly mobile and bore into the developing seed pods, where they feed. Many larvae remain completely within a developing pod during their 1st and 2nd instars. From the third through final instars, the larvae are bright green with longitudinal white stripes and a series of black spots on each body segment. The head is a dull mustard yellow color. The larvae also increase greatly in size at this time and begin to feed externally on the developing seed pods. The larvae reach maturity in five instars, with the larval brood period lasting a little over two weeks in captivity (Hardwick, 1996).

LIFE HISTORY

REPRODUCTION

Like all other Lepidoptera, the Jaguar Flower Moth goes through four distinct developmental stages: egg, larva, pupa and adult. A single brood is produced in a typical year. The first brood of adults appears in early summer (late June-July, depending on latitude), arising from pupae that overwinter in earthen cells deep underground (see Hardwick, 1996). The adults mate, lay eggs and the larvae feed on developing seed pods and flowers of their food plants. The larvae are full grown by late August and then burrow underground, where they may estivate for some time prior to pupation.

ECOLOGY

The larval food plant of *Schinia jaguarina* in the Hoosier National Forest is the Scurfy pea known as Sampson's snakeroot (*Orbexilum* (*=Psoralea) pedunculata*), a species of barrens, dry prairies and glades (Britton and Brown, 1913; Deam, 1940; Gleason and Cronquist, 1991). The plant species formerly placed in the genus *Psoralea* have now been subdivided into several genera, with *Psoralea pudunculata* (*=psoralioides*) now in the genus *Orbexilum* (see PLANTS Database, 2005). The Jaguar Flower Moth is also associated with other native scurfy peas (species now in the genera *Hoita, Orbexilum, Pediomelum* and *Psoralidium*) in parts of its range. In California, populations of this moth must be associated with specie of *Hoita*, the only native scurfy peas.

In the Great Plains, several species of "breadroot" scurfy peas (genus *Pediomelum*) also serve as hosts for this moth. On the Atlantic Coastal Plain from Florida to New Jersey, it is associated with species of *Orbexilum* (e.g. *O. lupinellum, O. pedunculatum, O. virgatum*) and *Pediomelum canescens*. In Illinois, it is associated with *Orbexilum onobrychis* and (apparently) *Psoralidium tenuiflorum* (R. Panzer, 2005 pers. comm.). Hardwick (1996) reared the species from *Orbexilum rhombifolium* in Texas. In the Southwest and western Great Plains, species of *Orbexilum* and *Pediomelum* are the predominate hosts. California, Nevada and other far western populations are undoubtedly associated with scurfy peas in the genus *Hoita* (and a few species of *Pediomelum*) the only local representatives. Figure 1 shows the current distribution of this moth and several species of scurfy pea in the United States.

The Jaguar Flower Moth is always associated with large populations of scurfy peas. Vegetation in these habitats is typically short to moderate in height (0.3-1 meters: 1-3 feet) and consists largely of grasses and forbs dominated by the plant families Asteraceae and Fabaceae. The adults are rapid fliers, often darting among plants and interacting with one another and other insects (J. Bess, pers. obs.). Mating occurs on the food plant and adults often rest on the foliage and flowers when not flying (J. Bess, pers. obs.). The adults probably feed on nectar from a number of plant species.

There is one adult brood per season; early in the South (May-June) and later in the Midwest and Northern Great Plains (late June and July). The adult brood period lasts approximately two weeks, during which they mate and females lay eggs on the larval food plant. The eggs hatch in a week and the young larvae feed on the developing seed pods of the food plant. They feed at first by boring directly into developing fruit, with subsequent instars feeding externally on the maturing seed pods. The larvae are always found on scurfy peas. In the extreme southern part of the species' range, records from mid-August through early September are indicativbe of at least a partial second brood. It is unknown if this brood actually produces viable offspring that survive to pupation prior to the onset of winter.

DISPERSAL/MIGRATION

Despite its broad geographic range, *Schinia jaguarina* is generally regarded as rare and highly local in occurrence. Given its specific foodplant requirements, the Jaguar Flower Moth rarely (if ever) leaves the native grasslands where scurfy peas abound. Although adults are strong fliers and can likely travel relatively long distances (1-5 miles) when necessary, the fragmented nature

of the species' habitat means that typical dispersal distances are probably on the order of a few hundred yards. However, populations are likely capable of dispersing over large areas of contiguous suitable habitat, particularly along railroad lines passing through pasturelands in the Great Plains vegetated with native praire under moderate grazing regimes. To date, no research has been conducted regarding the impacts of potential dispersal barriers such as cultivated fields, roads, thick brush or waterways on this species. The Jaguar Flower Moth is not known to migrate.

OBLIGATE ASSOCIATIONS

The obligate habitat for the Jaguar Flower Moth is high quality, dry to mesic native grasslands containing an abundance of scurfy peas, particularly species in the genera *Orbexilum*, *Pediomelum* and *Hoita*. In the barrens of the Hoosier National Forest, *Schinia jaguarina* is associated with *Orbexilum pedunculatum* var. *psoralioides* in mesic prairie and barrens on limestone (Bess, 2004a). This moth rarely (if ever) occurs far from stands of the larval food plant(s), although adults may venture into adjacent habitats to feed on nectar from flowers. The Jaguar Flower Moth also shares its habitat with a number of regionally and globally imperiled insect, plant and vertebrate species (see Bess, 2004; Hall, 1999).

HABITAT

RANGE-WIDE

Across its range, *Schinia jaguarina* occurs in four somewhat geographically isolated regions (see Figure 1). In each region it is found in structurally similar native grassland habitat types. These grassland types vary by region and include;

Atlantic Coastal Plain

- Prairies and barrens on aeolian sand deposits and ancient marine desposits where the larval food plants (*Orbexilum* and *Pediomelum* spp.) are common.

Members of the genera *Orbexilum* and *Pediomelum* on the Atlantic Coastal Plain are primarily associated with remnants of pine and pine oak savannas occurring across a wide variety of soils derived from bedrock, sand and sandy clay. Today these once vast plant communities have been reduced to a series of highly isolated and often tiny remnants. Historically, these plant communities were created and perpetuated by frequent fires, which created many open, "prairie-like" areas. In recently burned savannas, the understory was sparse in terms of woody species but rich in herbaceous plants, particularly grasses. Wiregrass (*Arisitida spicata*) was a primary component of these communities from Texas to Maryland. Shrubs and young pines quickly invade recently burned savanna, quickly transforming grass-dominated communities into forest if left unburned for several years or more. The two species of *Pediomelum* native in the southeast are *P. canescens* and *P. subacaule*. Currently, *Schinia jaguarina* is known from only a few, widely scattered, sites within this once vast complex of native ecosystems.

Ohio Valley

- Unglaciated limestone barrens and associated prairies where the larval food plant (*Orbexilum pedunculatum*) is common.

The Ohio Valley habitat for the Jaguar Flower Moth is characterized by a sparse or absent canopy (<35 percent tree cover), with a rich herbaceous layer dominated by grasses and forbs. These habitats differ from those to the east on the Atlantic Coast in that they are associated with rocky habitats on clay or sandy clay soils known as barrens. However, the open character of the woody component and domination by fire-adapted herbaceous species make these habitats very similar structurally. In some south-facing valleys, along old alluvial plains, fairly deep soils have been deposited, on which a plant community closely resembling mesic tallgrass prairie has developed (as described in Weaver, 1954 and Weaver and Fitzpatrick, 1934). These grasslands are very similar to the "Kentucky Mesic Tallgrass Prairie" and the "Unglaciated Mesic Tallgrass Prairie" Ecological Associations described on the NatureServe Website (NatureServe 2005). The Kentucky Tallgrass Prairie association is considered Globally Imperiled (G1G2). *Schinia jaguarina* is currently known from only a single location within the Greater Ohio Valley subregion.

Great Plains

- Native short to mid-grass prairie where the larval food plants (*Orbexilum* and *Pediomelum* spp.) are common.

The Great Plains habitats for *Schinia jaguarina* include remnant short, mid-grass and mixed grass prairie types, typically on dry sites, often on sand or loess deposits and rock outcrops, particularly limestone (see Weaver and Albertson, 1956). The moth is found only where scurfy peas (e.g. *Orbexilum, Pediomelum*) are common and these remnant, native grasslands maintain the bulk of the populations for this species. Weaver and Fitzpatrick (1934) picture ideal habitat for the Jaguar Flower Moth in figure 37 of their classic work "The Prairie". Grasses and herbaceous forbs dominate and include little bluestem, Junegrass (*Kohleria cristata*), big bluestem, sand bluestem (*Andropogon hallii*), gramma grasses (*Bouteloua* spp.), buffalograss (*Buchloe dactyloides*), wheatgrasses (*Elymus =Agropyron* spp.) and ricegrasses (*Oryzopsis* spp.). Percent vegetative cover, plant species composition and relative abundance varies greatly with latitude, soil composition, aspect and grazing regime.

Forbs are dominated by perennial Asteraceae and Fabaceae and can include leadplant (*Amorpha canescens*), anemones (*Anemone* spp.), low daisy (*Erigeron pumilus*), downy sunflower (*Helianthus mollis*), prairie sunflower (*Helianthus occidentalis*), desert sunflower (*H. petiolaris*), stiff sunflower (*H. rigidus*), hairy golden aster (*Heterotheca villosa*), sand lily (*Leucocrinum montanum*), mentzelia (*Mentzelia nuda*), prairie evening primrose (*Oenothera albicaulis*), scarlet globemallow (*Sphaeralcea coccinea*) and scurfy peas. As with the grasses, forb species composition varies greatly over the broad area covered in these grassland types.

Desert Southwest

- Montane desert grasslands and shrublands where the larval food plants (*Hoita*, *Orbexilum* and *Pediomelum* spp.) are common.

As with the Great Plains, these montane desert grasslands vary greatly in species composition with latitude and altitude. I am including in this category the southern California record and the historic record from southern Oregon, both of which are/were associated with grasslands similar to those discussed here. Perennial bunchgrasses are typically the dominant plant form, although cacti, succulents and shrubs are often a significant portion of the flora (see Brown, 1994; Dick-Peddie, 1993; McClaran and Van Devender, 1995). The grasses are almost solely warm season, C_4 species adapted to warm, dry habitats with abundant sunshine and low precipitation. They include several species of *Bouteloua*, *Elymus*, *Eragrostis*, *Muhlenbergia* and *Sporobolus*. Forbs are dominated by drought tolerant Asteraceae and Fabaceae. At higher elevations and latitudes, these grasslands grade into shortgrass prairie, pine-juniper-oak scrub or woodland.

NATIONAL FORESTS: HOOSIER NF (PERRY CO., IN)

In the Hoosier National Forest (HNF) of Indiana, the habitat for *Schinia jaguarina* is considered exemplary for high quality remnants in the Ohio River Valley and is as described previously. The Hoosier National Forest populations of the Jaguar Flower Moth are associated with *Orbexilum pedunculatum*. This plant is very local in the Hoosier National Forest, occurring primarily in isolated colonies near the Ohio River (see Deam, 1940), where it typically occurs on dry rocky slopes in fire-maintained barrens. It can also occur along poorly maintained roadsides through barrens remnants and even in some open, disturbed natural communities, such as former pine plantations. Most of these roadside and old field populations are small, highly isolated and do not support populations of the Jaguar Flower Moth.

SITE SPECIFIC

Hoosier NF: Cloverlick Barrens Special Area

The only known occurrence for *Schinia jaguarina* within the HNF is the Cloverlick Barrens Special Area, a ca. 1,300 acre complex of open and closed canopy oak and oak-pine barrens. This site contains roughly 200 acres of habitat for the butterfly, with a diverse flora as given below. Much of the occupied Jaguar Flower Moth habitat at Cloverlick Barrens was formerly open oak barrens and prairie, with old, widely-spaced blackjack and post oaks occupying the canopy layer. *Orbexilum pedunculatum* grows in profusion in open, grassy barrens and on the edges of more mesic prairie along the floodplain of Cloverlick Creek. These barrens and grasslands have been managed with manual cutting of brush and prescribed fire, resulting in a high quality dry-mesic grassland complex, with the more mesic end dominated by big bluestem and Indian grass. Approximately 200 acres of potential habitat for this species occurs at the Cloverlick Barrens Special Area.

The herbaceous vegetation is dominated by warm season, bunchgrasses like big bluestem (*Andropogon gerardi*), bushy bluestem (*Andropogon glomerata*), broomsedge (*A. virginica*), silver plumegrass (*Erianthus*), little bluestem (*Schizachyrium scoparium*) and Indian grass (*Sorghastrum nutans*). Additional common grasses include wood oats (*Chasmanthium*

latifolium), rye grasses (*Elymus hystrix, E. virginicus*) and panic grasses (particularly *Panicum anceps* and species of the subgenus *Dichanthemium*). Sedges are also common and often locally dominant, including *Carex albicans, C. cephalophora, C. complanata, C. glaucodea* and *C. rosea*. The nodding bulrush (*Scirpus pendulus*) and nutsedge (*Scleria oligantha*) are also common, especially in seepy areas.

Characteristic forbs include; wild onion (*Allium canadense*), smooth blue aster (*Aster laevis*), swamp aster (*Aster puniceus*), white wild indigo (*Baptisia leucantha*), indian plantain (*Cacalia atriplicifolia*), tall thistle (*Cirsium altissimum*), Carolina thistle (*C. carolinianum*), tall tickseed (*Coreopsis tripteris*), fuzzy sticktight (*Desmodium canescens*), shootingstar (*Dodecatheon media*), rattlesnake master (*Eryngium yuccifolium*), flowering spurge (*Euphorbia corollata*), downy sunflower (*Helianthus mollis*), rough blazingstar (*Liatris aspera*), scaly blazingstar (*Liatris squarrosa*), marsh blazingstar (*Liatris spicata*), bergamot (*Monarda fistulosa*), marsh phlox (*Phlox glaberrima*), obedient plant (*Physostegia virginiana*), Scurfy pea (*Orbexilum pedunculatum*), mountainmint (*Pycnanthemum pycnanthemoides, P. virginianum*), black-eyed Susan (*Rudbeckia hirta*), wild petunia (*Ruellia humilis*), rose gentian (*Sabatia angularis*), three-leaved rosinweed (*Silphium trifolium*), stiff goldenrod (*Solidago rigida*), goats rue (*Tephrosia virginiana*), meadowsweet (*Thalictrum* sp.), spiderwort (*Tradescantia virginiana*) and early wingstem (*Verbesina helianthoides*).

The community surrounding the grass and forb dominated openings is typically oak woodland, dominated by post oak (*Quercus stellata*), blackjack oak (*Q. marilandica*), white oak (*Q. alba*) and black oak (*Q. velutina*). Tuliptree (*Liriodendron tulipifera*), black gum (*Nyssa sylvatica*), sycamore (*Platanus occidentalis*) and red elm (*Ulmus rubra*) are also common. Shrubs are diverse and can quickly dominate sites that are not periodically burned. Common shrubs include paw paw (*Asimina triloba*), redbud (*Cercis canadensis*), flowering dogwood (*Cornus florida*), hazelnut (*Corylus americana*), huckleberry (*Gaylusaccia baccata*), witch hazel (*Hamamelis virginiana*), Carolina buckthorn (*Rhamnus caroliniana*), raspberries (*Rubus alleghaniensis, R. occidentalis*), coralberry (*Symphoricarpos*), sassafras (*Sassafras albidum*), blueberries (*Vaccinium* spp.) and possum haw (*Viburnum rufidulum*). Closed canopy oak woodland and forest is inhospitable to both *Orbexilum* and the Jaguar Flower Moth.

DISTRIBUTION AND ABUNDANCE

RANGE-WIDE DISTRIBUTION

The Jaguar Flower Moth has a rather broad (although very patchy) range across North America, occurring from California to North Carolina and Alberta south to at least Mexico City (see Figure 1). Most known records are from the mixedgrass prairies of the western Great Plains (Montana south to Colorado, Nebraska, New Mexico and Texas). Very few records exist for populations east of the 94th meridian. Throughout its range, this moth is considered uncommon or rare and always local in occurrence. Many records for the Jaguar Flower Moth consist of a single individual or specimen and observers rarely note more than a few individuals on a given survey. Several historic occurrences are no longer extant, having been destroyed or altered significantly through fire suppression, agricultural production, residential development and other human uses.

STATE AND NATIONAL FOREST DISTRIBUTION

The following state-level distribution information for the Jaguar Flower Moth is gathered from Bess (2004), Covell (1984), Forbes (1954), Hardwick (1996), The Lepidopterists Society Newsletter, NatureServe and several other websites (see References). National Forest Information is provided for the Hoosier National Forest in Indiana. When known, county-level comparisons with National Forest boundaries were also made for each additional state occupied by the moth. Known or potential occurrences for military installations and other federal landholdings have been included when found to be relevant.

Arkansas

No known National Forest occurrences. However, the Ozark and Ouachita National Forests may contain habitat suitable for the species.

Arizona

Historic records for *Schinia jaguarina* from Arizona all come from in or near National Forests, including the Coconino, Prescott and Tonto. All sites are in montane grasslands and oak and oak-pine scrubland and savannas.

California

Only known record is historic and from the extreme southwest (San Diego). Suitable habitat for this species may occur in the nearby Cleveland and San Bernadino National Forests.

Colorado

Numerous records from most counties in eastern half of the state. Suitable habitat may occur in the nearby Pike, Roosevelt and San Isabel National Forests.

Florida

Only a few scattered records are known from the central part of state. Suitable habitat may occur in the nearby Ocala National Forest. Foodplants are locally distributed in the northern half of the state.

Georgia

A few scattered historic populations are known from the Coastal Plain and Piedmont regions where they are associated with dry grasslands in oak or oak-pine barrens. No National Forests occur in these areas. The foodplants for this species are very local, with records scattered throughout the state.

Illinois

There are no known National Forest occurrences. There is potential habitat in the Shawnee National Forest, but no surveys for this species have been conducted. Only known occurrences are from the central and northern parts of the state (R. Panzer, 2005 pers. comm.), where there are no National Forests.

Indiana
The single known population is contained within the boundaries of the Hoosier National Forest. The Harrison-Crawford State Forest is immediately adjacent to the Hoosier NF and contains superficially suitable habitat for this species.

Iowa
The Iowa populations occur in the extreme eastern and western parts of the state, where it is associated with midgrass prairies on loess deposits along major rivers. No National Forests occur in these areas.

Kansas
Records occur for nearly all counties in the western two-thirds of the state where the species is associated with mixed to shortgrass prairies. No National Forests occur in these areas.

Maryland
This is a species of concern in the state of Maryland. No National Forests in Maryland, although some National Seashore and National Wildlife Refuge properties may contain (or have contained) suitable habitat for the species. However, *Orbexilum pedunculatum psoralioides* is listed as extirpated in the state of Maryland (Maryland DNR, 2003).

Minnesota
Scattered populations occur on dry to mesic native prairie remnants across the southern two-thirds of the state. No National Forests occur in these areas.

Missouri
Scattered populations occur on dry to mesic native prairie and glade remnants across the state. Suitable habitat for this species may occur in the Mark Twain National Forest.

Montana
Numerous populations scattered across the eastern two-thirds of the state in short and mixed grass prairie remnants. Not currently known from the intermontane region. May occur in suitable habitat in the Custer, Gallatin and Lewis and Clark National Forests.

Nebraska
Few populations scattered across the state, probably an artifact of limited collecting by Lepidopterists. Weaver (1965) reported scurfy peas as integral components of several prairie types in Nebraska, so this species is probably more widespread than records indicate. The species should be searched for in suitable habitat on the McKelvie and Nebraska National Forests.

Nevada
One county record from the extreme northwest corner of the state; near or on the Sheldon National Wildlife Refuge. Suitable habitat probably occurs on the Humboldt-Toiyabe National Forest. Scurfy peas in the genera *Hoita, Pediomelum* and *Psoralidium* occur on dry grassland, scrubland and woodland remnants throughout much of Nevada.

New Jersey
Historic records for this species from New Jersey are taken from Forbes (1954). Exact location unknown but likely from dunes along the coast or in the pine barrens region. The known foodplants for this species are uncommon or rare and very local in New Jersey. Suitable habitat may occur in the greater Pinelands National Reserve.

New Mexico
Only recently recorded in New Mexico (2000), now known from a few counties in the northern and southwestern parts of the state. Known populations associated with dry prairie and pine savanna habitats near the Carson, Gila and Santa Fe National Forests.

North Carolina
Known from only a few scattered populations in high quality, sand hills pine savanna on the Coastal Plain. The Croatan National Forest may contain suitable habitat for this species.

North Dakota
Only three county records in the southeastern and central parts of the state. No National Forests in North Dakota. The species may be more widespread, especially in the western part of the state.

Oklahoma
Oklahoma contains numerous populations of *Schinia jaguarina*, and the species should be expected statewide. Suitable habitat may occur in the Ouachita National Forest.

Oregon
The single historic record for this species is from the south central part of the state and suitable habitat may occur in the Fremont, Rougue River or Umpqua National Forests.

South Carolina
The exact locations of historic records for this species from the state have not been verified, although it is expected to occur in habitat(s) similar to those in North Carolina. The Francis Martin National Forest may contain suitable habitat for this species.

South Dakota
The single record from the extreme eastern portion of the state is likely a result of limited collecting by Lepidopterists. The species should be expected in suitable high quality native grasslands statewide. The Black Hills National Forest may contain suitable habitat for this species.

Texas
Numerous records for this species indicate a statewide distribution, with a concentration of records around the more heavily collected eastern half. Suitable habitat for this species may occur in the Davey Crockett National Forest and populations are known from the immediate vicinity.

Wisconsin
Scattered populations occur on dry to mesic native prairie remnants across the southern two-thirds of the state. No National Forests occur in these areas.

Wyoming
Numerous county records from short and mixed grass prairie remnants in the eastern half of the state. The Bighorn and Medicine Bow National Forests may contain suitable habitat for this species, as may the Thunder Bay National Grassland.

RANGE WIDE STATUS

Schinia jaguarina is considered imperiled by only a few states in the eastern half of its range and none in the western (NatureServe, 2005). However, without a concerted effort to protect and restore habitat for this species, it is in immediate danger of extirpation throughout much of its eastern range. Even in its supposed stronghold (the Great Plains) there seems to be insufficient information to conclude that the Jaguar Flower Moth is demonstrably secure. This is especially true with regards to its preferred habitats; high quality dry prairie, barrens and savanna having an abundance of scurfy peas. The following information was gathered (in part) from the NatureServe.org Website in August of 2005.

Global Status: G4
Global Status Last Reviewed: 07Jul2004
Global Status Last Changed: 07Jul2004
Rounded Global Status: G4
Status and Ranking by: D. F. Schweitzer

State-level Status (S-Ranks)
The Jaguar Flower Moth is an element in Indiana (**S1**) and North Carolina (**S1S3**). It is listed as a State Endangered Species in Indiana (INDNR 2005) and State Rare in North Carolina (NC Heritage Program, 2004). In Illinois, it is proposed as a species of concern (Panzer, 2005 pers. comm.) but is not tracked as an element in other states. *Schinia jaguarina* needs a re-assessment of its rarity, especially in the eastern half of its range. There is a huge gap in distribution between the Great Plains populations of this moth and those in the East. It is quite possible that, as with the Regal Fritillary (*Speyeria idalia*), this species should be treated as two separate metapopulations; one east and one west of the 94th Meridian (roughly Texas north to Minnesota). The review should discuss the isolation of extant populations, patchy distribution of host plants and limited availability of potential habitat.

POPULATION BIOLOGY AND VIABILITY

Prior to European settlement of the continent, *Schinia jaguarina* and it food plants enjoyed an expansive distribution, occurring from coast to coast and western Canada south to Mexico City. The rapid transformation of the Great Plains from native pasture to intensive row crop agriculture following World War II led to the rapid reduction in habitat acreage for this and other grassland species. Today, the Jaguar Flower Moth exists as a collection of isolated

subpopulations varying greatly in size. In some parts of the western portion of its range, there is sufficient inter-connected habitat to allow the formation of "regional metapopulations".

In the East, the bulk of the remaining populations occur on small, isolated grasslands surrounded by closed canopy forests, row crops, old fields and other large-scale human developments. These man-made habitats are essentially hostile to the moth and are probably an impediment to its dispersal. Fortunately, populations of this moth occur on state or federally owned forests or national grasslands, affording them some degree of protection from human development. Populations on Federal and State Forests are also subject to logging and other human uses, although currently not at the pace of past centuries. In the east, this species is probably imperiled in all states from which it is recorded, although it is being tracked as an element in only a few.

POTENTIAL THREATS

PRESENT OR THREATENED RISKS TO HABITAT

Most, if not all, of the Jaguar Flower Moth's habitats were once extensive prairies, savannas or barrens which were mantained by periodic fire (Anderson et al., 1999; Delcourt and Delcourt, 1997; Dorney and Dorney, 1984; Grimm, 1984; Henderson and Long, 1984; Higgins, 1986; Komarek, 1971, 1985; Lynch, 1941; Nuzzo, 1986; Tester, 1989, White, 1983). Currently however, the amount of available Jaguar Flower Moth habitat has been greatly reduced through fire suppression, overgrazing, conversion to row crop agriculture, road construction and other human activities. Once extensive, unbroken grasslands have been reduced to scattered fragments in a sea of row crops, fire suppressed woodlands and non-native pasture species. Those fragments of native grassland that do remain are often highly isolated from one another on the landscape and the environmental forces that once created and regulated them are no longer functioning.

Row Crop Agriculture

The conversion of much of the Great Plains and central Midwest to large scale row crop agriculture following World War II led to a precipitous loss of habitat for the Jaguar Flower Moth (and many other species). Up until this time, most U.S. farms were small and diverse, geared towards self-sustenance and supplying small local economies. Often, drier or rocky parts of the land were placed under pasture or ignored and fencerows were common. These marginal areas of relatively native habitat often contained a diverse assemblage of prairie plants, associated insects and other animals.

These conditions were rapidly changed with the development of hybrid seeds, insecticides, herbicides and the entrance of the U.S. into the global food economy. Fencerows and pastures have been knocked out to make way for large-scale machinery to till and plant vast stretches of corn, rice, cotton and bean monocultures. Center-pivot irrigation has allowed many formerly untillable acres to be farmed, especially in the drier short grass and mid-grass prairie regions of the western Great Plains and Desert Southwest.

Fire Suppression

The suppression of wildfires has been among the more profound changes to the North American environment in the past 1,000 years (see Heinselman, 1981; Nuzzo, 1996). Fire is known to regulate vegetation structure, which has a reciprocal influence on fire frequency (Anderson and Owensby, 1920; Anderson and Brown, 1986; Anderson et al., 1999; Daubenmire, 1968; Glasser, 1985; Henderson and Long, 1984; Kozlowski and Ahlgrens, 1974; Schwaegman and Anderson, 1984; Tester, 1989; Weaver, 1954; Weaver and Fitzpatrick, 1934). Many formerly open, grass-dominated plant communities have quickly succeeded to shrublands and closed canopy forests in the absence of fire. This is especially true in the Midwest, where we have lost nearly 99 percent of our former native grasslands.

It has been well documented that many North American grass and herbaceous forb dominated plant communities burned with relative frequency in the past (Bayley and Odum, 1976; Bancroft, 1977; Cohen, 1974; Cohen, et al. 1984; Cypert, 1961; Duever, et al. 1986; Forman, 1979; Foster and Glaser, 1986; Garren, 1943; Glasser, 1985; Henderson and Long, 1984; Higgins, 1986; Komarek, 1971: Lotan, 1981; Loveless, 1959; Penfound, 1952; Schwegman and Anderson, 1984; Thompson, 1959; Weaver and Anderson, 1956; Wells, 1931, 1942). Many of the plants occurring in these communities are also “fire-dependent”, meaning they require periodic fire for their long-term survival (Anderson et al., 1970; Arend and Scholtz, 1969; Daubenmire, 1968; Hulbert, 1969, 1981; Knapp and Seastadt, 1986; Peet et al., 1975; Thor and Nichols, 1973; Tilman, 1987; Weaver, 1954; Weaver and Fitzpatrick, 1934; Whitford and Whitford, 1978; Wright and Bailey, 1982).

In degraded remnants of these habitat-types, prescribed burning relaxes competition from invading, non-fire adapted plants, allowing fire-adapted species to proliferate and expand into newly opened areas (Anderson and Brown, 1986; Brown et al., 2000; Daubenmire, 1968; Dorney and Dorney, 1989; Grimm, 1984; Henderson, 1982; Henderson and Long, 1984; Kline, 1984; Lotan et al., 1981; Schwegman and Anderson, 1984; Tester, 1989; White, 1983; Wright and Bailey, 1982). Fire also reduces canopy cover of woody species and removes accumulated detritus (Van Lear and Johnson, 1983; Witford and Whitford, 1978). This allows more sunlight to reach the soil surface, resulting in increased photosynthetic productivity in the herbaceous flora (Dorney and Dorney, 1981; Lorimer, 1985; Thor and Nichols, 1973). Burning also releases nutrients, although their availability is often limited temporally (Bancroft, 1977; Bayley and Odum, 1976)

Frequent fires typically favor species that require grass, sedge and herb dominated vegetation as habitat for feeding, resting, mating, breeding or other activities. The reduction in woody cover and detritus accumulation further improves habitat for some species, while removing or limiting habitat for others. In the case of the Jaguar Flower Moth, fire does not cause direct mortality of overwintering stages, given their location deep in the soil. Their food plants, scurfy peas, (in general) respond favorably to burn management (USGS, 2005). Therefore fire has been (and must continue to be) an essential part of habitat creation and maintenance for the Jaguar Flower Moth butterfly.

Grazing

Domesticated cattle, sheep and horses do not eat scurfy peas, and their foliage (containing known photo-reactive alakloids) is suspected of being toxic (USDA Forest Service, 2005). However, the starchy roots of several species were widely used by the Plains Indians as staple food sources (Cowen, 1991; Spessard, 1988; USDA Forest Service, 1937). Studies in North Dakota (NDSU, 2005) have found that *Psoralea* (=*Orbexilum*) *esculenta* showed a positive response to light or no grazing, while *P. argophylla* showed a positive response to moderate grazing. In Montana, scurfy peas are considered increasers in response to light or moderate grazing pressure (Montana State University, 2002). The survival of this moth (in many instances) may be greatly facilitated by the fact that scurfy peas are avoided by domesticated grazing animals.

Extensive livestock grazing reduces the cover of native grasses and forbs on which the adult Jaguar Flower Moth depends for resting places and nectar sources. Repeated heavy grazing degrades native plant communities, disturbs and compacts the soil and can kill the original flora, providing germination sites for invasive weeds, shrubs and young trees (Tester and Marshall, 1962). It can also lead to rapid soil erosion, especially on hilly and/or rocky sites. Particularly in the Ohio Valley grasslands inhabited by *Schinia jaguarina*, the thin underlying soils are easily disturbed and overgrazing often leads to destruction of the vegetation and widespread erosion of topsoil. For example, in Perry County, Indiana, it is reported that all upland soils have been stripped of their original A and B soil horizons through severe erosion (USDA Soil Conservation Service, 1969). These factors have combined to make many sites formerly suitable for this species currently unfit as habitat. However, well-managed, rotational, grazing would probably have only limited (if any) negative effects on this species in large (>100 acre) pastures.

Pasture Development

Intimately associated with grazing is the development and maintenance of sustainable pastures. In prehistoric times (and locally in our recent history) pastures have been developed, maintained and enhanced through the use of fire (Allan and Anderson, 1955; Anderson, 1996; Britton, et al., 1980; Anderson et al., 1979; Cohen, 1974; Heinselman, 1981; Henderson and Long, 1984; Komareck, 1971; Lynch, 1941; Miller, 1963; Nuzzo, 1986; Uhler, 1944; Sipple, 1978, 1979; USFWS, 1964; Wells, 1931, 1942). Fire removes the accumulated duff, kills seedlings and saplings of woody species and provides germination sites for the seeds of fire adapted grassland plants (see Anderson et al., 1970, 1984; Daubenmire, 1968; Dorney and Dorney, 1989; Grimm, 1984; Henderson and Long, 1984; Knapp and Seastedt, 1986; Packard, 1988; Peet et al., 1975; Schwaegman and Anderson, 1984; Tester, 1989; Thor and Nichols, 1973; Tilman, 1987; White, 1983; Whitford and Whitford, 1978; Wright and Bailey, 1982). Prehistoric Native Americans were typically concerned with providing feeding grounds for game animals and the production of native plant crops (Anderson et al., 1999; Delcourt and Delcourt, 1997). European immigrants initially used fire to clear brush and enhance the growth of grasses and other plants that provided forage for their domesticated livestock. Unfortunately, excessive numbers of animals were often placed on grasslands with marginal amounts of available forage, leading to the destruction of the native vegetation and erosion of topsoil.

In the early 1800's, when America experienced its first great wave of westward expansion by Europeans, most formal training on the subject of pasturage was based in Europe. Therefore, nearly all American pasture development, enhancement or maintenance projects at that time

were based on experience with cool-season grasses. Many overgrazed pastures formerly dominated by warm-season native grasses were subsequently replanted with cool-season, Eurasian grasses. These grasses were thought to be superior because they remained green throughout much of the growing season. Extensive pasture replanting and "enhancement" efforts further limited and fragmented the amount of available habitat for insects dependent on native grasslands. This isolation of often small populations can lead to inbreeding and extinction (see Wilson and MacArthur, 1967).

Species typically used in dry pasture "enhancement" or "restoration" include crested wheatgrass (*Agropyron cristatum*), smooth brome (*Bromus inermis*) and bluegrasses (*Poa compressa* and *P. pratensis*). Clovers (*Medicago, Melilotus* and *Trifolium* spp.) are often placed in the grass mix to provide nitrogen fixation in the soil and fodder for livestock. These methods became indoctrinated into our system of land reclamation and persist to this day. Recent research has found that, despite its widespread use, crested wheatgrass pastures often harbor large populations of pest insect species, many of them non-native (Bess, et al., 2002). The inclusion of alfala and sweetclovers in the pasture greatly increases the abundance of non-native pest species. Crested wheatgrass dominated pastures also provide only limited early and late season forage and are considered unpalatable by stock during much of the growing season. This plant also inhibits the growth of other C_3 grasses and the fixation of carbon in the soil (Christian and Wilson, 1999). Native wheatgrass species provide much better sustainable forage over the course of the growing season.

By producing large amounts of seed that germinate under cool temperatures, these grasses and clovers can quickly dominate areas of exposed soil and move into adjacent native habitats. They compete with native species for resources and can exclude many of them from sites where they were formerly common, especially following disturbance of the original vegetation. Farmers and ranchers often spray herbicides to remove unwanted broadleaf species (such as scurfy peas) from grass pastures. These factors eliminate potential habitat for the Jaguar Flower Moth, particularly along fencerows, ditches and roadsides. Only in recent times (past 20 years) have native species been marketed as alternatives for use in erosion control, bank stabilization and pasture/range enhancement.

Competition from Introduced Species

In addition to the pasture species mentioned above, a number of other introduced plants threaten the quality and survival of Jaguar Flower Moth habitat (see McKnight, 1993; Miller, 2003; Swearingen, 2004). In the west, these include downy brome (*Bromus tectorum*), musk thistle (*Carduus nutans*), spotted knapweed (*Centaurea maculatum*), Canada thistle (*Cirsium arvense*), leafy spurge (*Euphorbia esula*), St. Johnswort (*Hypericum perforatum*), whitetop (*Lepidium draba*) and many others.

In the Midwest, non-native pasture species such as smooth brome and fescue often dominate what were once native grasslands. Sweet clovers (*Melilotus*) and perennial clovers (*Trifolium* spp.) are also frequently planted in pastures and occur as weeds across much of North America, often to the exclusion of the native flora. Japanese honeysuckle (*Lonicera japonica*), bush honeysuckle (*Lonicera mackii* and *L. tartarica*), glossy buckthorn (*Rhamnus cathartica*) and multiflora rose (*Rosa multiflora*) are frequent invaders on fire suppressed native grassland

remnants. Many native trees and shrubs such as junipers (*Juniperus* spp.), oaks (*Quercus* spp.), pines (*Pinus* spp.), cherries (*Prunus* spp.), sumacs (*Rhus* spp.) and snowberry (*Symphoricarpos*) can also overtake fire suppressed or otherwise disturbed grasslands.

Autumn olive (*Eleagnus umbellatus*), Japanese honeysuckle (*Lonicera japonica*), bush honeysuckles (*Lonicera mackii* and *L. tartarica*) and glossy buckthorn (*Rhamnus cathartica*) have long been used for landscape and wildlife plantings. These shrubs produce large numbers of berries, which are readily eaten by birds and redistributed across our woodlands. They are now a common (often dominant) component of the understory in our woodlands and forests. Both *Lonicera* and *Rhamnus* species can become so abundant as to exclude nearly all other flora from the ground and shrub layers. They are especially abundant in woodlands that have experienced a history of grazing that reduced the native vegetative cover and can move into formerly open, grass dominated areas with great speed. Some, such as Japanese honeysuckle, can be controlled with fire management. All can be controlled with manual cutting and herbicide application, although re-infestations are often inevitable (Luken et al., 1997).

Disease or Predation

The use of *Bacillus thuringiensis kurstaki* (B_{tk}) for control of the introduced gypsy moth (*Lymantria dispar*) has potential for negatively affecting populations of the Jaguar Flower Moth. Although the larvae are present later in the growing season than the gypsy moth, the increased presence of the pathogen in the local environment (resulting from both the initial spray efforts and decomposing gypsy moth larval cadavers) could lead to an increase in mortality in the *Schinia* larvae. They would also be susceptible to drift of B_{tk} onto scurfy peas growing in areas adjacent to where gypsy moths are present. Potential effects from the gypsy moth and its control efforts are dealt with in the following section.

Gypsy Moth Outbreaks and Control Efforts

Since its introduction into New England in the early 1800's, the Eurasian gypsy moth (*Lymantria dispar*) has posed a direct and indirect threat to native Lepidoptera, including the Jaguar Flower Moth. For many years, the gypsy moth had few predators or parasites in North America, and its populations soared to outbreak proportions throughout the Northeast. It then rapidly spread west and now inhabits much of the Upper Midwest (see Schweitzer 2004b for a review). The larvae feed primarily on oaks (*Quercus* spp.) and defoliated countless acres of oak and mixed hardwood forest, woodland and barrens. This includes sites that contain or are adjacent to Jaguar Flower Moth habitat.

Attempts to eradicate the gypsy moth in the mid 20th century involved the use of broad scale organophosphate insecticides such as DDT and Carbaryl. These spraying campaigns covered over 12 million acres in the northern and central Appalachians and affected a wide array of organisms, insects and non-insects alike (Schweitzer, 2004b). Chemicals such as DDT also accumulate in successive trophic levels as they pass through an ecosystem. Organisms at the top of food chains (such as insectivores) develop ever-increasing levels of toxins, causing death and/or reduced fecundity. Given the widespread, catastrophic effects of DDT and Carbaryl spraying, these pesticides have been banned in the United States.

In 1976, the growth inhibitor Diflurobenzuron (trade name Dimilin or Vigilante) was registered to control pest insects, while eliminating the indiscriminate poisoning of other organisms (see Schweitzer, 2004). Diflurobenzuron inhibits the formation of chitin, a protein that is the principal component of most arthropod exoskeletons. It only affects young insects, killing them when they go through their next moult ("skin shedding event"). Many fungi also contain chitin in their cell walls, and may also be affected (Dubey, 1995). Like the earlier pesticides, Dimilin kills insects (and most other Arthropods) indiscriminately across all orders (see Uniroyal, 1983).

The chemical also has a long-lasting residual effect by becoming bound to leaves (particularly conifers) and remaining active even after leaf fall (Martinat et al., 1987; Mutanen et al., 1988; Whimmer et al., 1993). Both aquatic leaf shredders and terrestrial detritivores that feed on these fallen leaves are highly susceptible to this chemical (Bradt and Williams, 1998). Widespread mortality has been documented in the field and laboratory, in both aquatic and terrestrial ecosystems (Bradt and Williams, 1990; Butler et al., 1997; Dubey, 1995; Hansen and Garten, 1982; Lih et al., 1995; Martinat et al., 1987, 1988a-b; 1993; McCasland et al., 1998; Mutanen, et al., 1988; Reardon, 1995; Swift et al., 1988).

Bacillus thuringiensis kurstaki (*Btk*) is a relatively new threat to forest Lepidoptera, introduced in the fight to control Gypsy moth outbreaks in the early 1970's. *Btk* is a naturally occurring soil pathogen that is stated to affect only Lepidoptera larvae, causing high rates of mortality in exposed individuals across many families (Peacock et al., 1998). The bacterium attacks the lining of the gut wall, interrupting the uptake of nutrients by the affected caterpillar, causing starvation and death. *Btk* spraying for both gypsy moth and spruce budworm control is known to have long-lasting, deleterious effects on resident populations of non-target Lepidoptera (Boettner et al., 2000; Butler et al., 1995, 1997; Cooper et al., 1990; Hall et al., 1999; Herms et al., 1997; Johnson, et al., 1995; Krieg and Langenbruch, 1981; Miller, 1990; Morris, 1969; Schweitzer, 2000, 2004b; Severns, 2002; Wagner, 1995; Wagner et al., 1996; Whaley, 1998).

Gypsy moth outbreaks tend to occur in oak-dominated forests, woodlands and barrens. The larvae of this moth also feed readily on a number of other species occurring in forests of which oaks are a component. Unfortunately for the Jaguar Flower Moth, the gypsy moth currently occurs throughout the northeastern portion of its range. Oak barrens, woodlands and forests also typically adjoin prairies and related plant communities. Therefore, the potential for co-occurrence is high. Should the gypsy moth begin moving south or west, there is also potential for additional co-occurrence of it and the Jaguar Flower Moth. Therefore, large scale spraying efforts within the range of the Jaguar Flower Moth will likely have deleterious effects on its long-term survival. Btk is currently the preferred control agent for outbreaks of the gypsy moth and in Wisconsin alone, more than 250,000 acres were sprayed in 2004 (see USDA, 2004a). However, there is no evidence to suggest that B_{tk} (in any way) has limited the spread of the gypsy moth.

These control efforts not only indiscriminately kill countless insects, but also have long-lasting effects on the habitats that are sprayed. The loss of caterpillars from spraying is known to negatively affect fecundity and body weight in nesting birds, bats and small mammals (Bellocq et al., 1992; Cooper et al., 1990; Holmes, 1998; Sample, 1991; Sample et al., 1993a-b, 1996; Seidel and Whitmore, 1995; Whitmore et al., 1993a-b; Williams, 2000). This effect is typically

carried over through at least a second year, mimicking the reduction in observed Lepidoptera larvae during the season of application. Given that gypsy moth larvae develop earlier than the Jaguar Flower Moth, mortality from direct spraying of B_{tk} is unlikely. However, there is great potential for an increased, residual presence of Btk in recently sprayed areas, which could certainly have a negative effect on the resident Lepidoptera community, including *Schinia jaguarina*.

Over utilization

The Jaguar Flower Moth's small size and secretive habits make it relatively difficult to collect on a large scale. However, flower moths are colorful and the species' general rarity has made it a prize among collectors since its original description. In certain areas (i.e. western Great Plains), this species can be locally common in high quality grassland complexes. However, in the eastern part of the moth's range, populations are small, localized and susceptible to localized extinction caused by catastrophic events such as shrub invasion, outbreaks of disease or overcollecting.

Residential Development

Residential Development can negatively affect habitat for *Schinia jaguarina* in a variety of ways. The clearing of sites for houses and associated roadways eliminates habitat and divides what remains into highly isolated islands, separated by paved streets, parking lots, lawns and other habitats inhospitable to the butterfly. Lawn development and maintenance eliminates the native flora, and drift of herbicides and insecticides has a cumulative effect in deteriorating what remains in adjacent natural areas. Fertilizer and pesticide runoff can also contaminate adjacent natural areas, enter streams and rivers and can degrade local and regional water quality (Medina, 1990). On the Atlantic Coast and in the Upper Midwest, high-end and exclusive residential developments are often located in remnants of savannas overlooking coastal or hilltop grasslands. Infrastructure to maintain and service these developments includes roadways, ditches and utility rights-of-way, whose construction often has extremely deleterious effects on occupied and potential habitat for *Schinia jaguarina*.

Inadequacy of Existing Regulatory Mechanisms

The lack of any long-standing national program to protect and restore the nation's grasslands has led to the degradation of millions of acres of former native pasturage. In addition, the current, species-based approach to federal laws regarding the protection of imperiled organisms does not currently afford legal protection to the Jaguar Flower Moth. This is despite the fact that its global rarity would make it a candidate for listing as a federally threatened species. A system for environmental protection and restoration based on the conservation of ecological associations or plant communities would be more appropriate for protecting many of the Nation's natural resources. Many organisms are endangered simply because their habitats are becoming increasingly fragmented and degraded by human activity. This is especially true for those requiring fens, wet-mesic prairie or southern barrens. Federally mandated efforts to restore our Nation's wetlands (some of which are already underway), savannas and barrens would not only protect hundreds of species from impending peril, but also provide our human population with expanded opportunities for jobs, hunting, fishing, gathering of forest products, education, research, observation and enlightenment.

SUMMARY OF LAND OWNERSHIP & EXISTING HABITAT PROTECTION

The U. S. Forest Service owns occupied Jaguar Flower Moth habitat in Indiana and probably several other states, especially in the West. Additional U. S. landholdings with potential for suitable habitat occur throughout the species' range. Additional state and privately managed lands (Wildlife Refuges, Nature Preserves, Conservation Areas, etc.) are known or suspected to contain populations of this species. State-level efforts at the protection, restoration and management of high quality grassland remnants continue to protect populations of this and other rare species. This is especially true of sites containing known food plants of the Jaguar Flower Moth.

Recent congressional efforts have included grassland restoration and protection as key platforms in the recently passed National Farm Bills. Iowa and Indiana have been key players in this effort to restore some of our native grasslands and wetlands. The state of Iowa is also undertaking an ambitious project to create or restore grassland all along Interstate 80 and other major highways. In Indiana, the Hoosier National Foprest continues to protect and manage barrens remanants for the protection and enhancement of native biodiversity. The State of Illinois is actively managing two of the only known populations of this species, which occur on State-owned Nature Preserves. In North Carolina, State and other groups have protected Sand Hills and Coastal Plain Savanna remnants containing populations of this species and continue on-going management of these sites. Minnesota and Wisconsin are also actively inventorying and managing native grasslanbd remnants containing potential habitat for this species.

SUMMARY OF EXISTING MANAGEMENT ACTIVITIES

Little or no management is currently being directed at the Jaguar Flower Moth's habitat based solely on the species' presence or absence. However, the moth's preferred habitats happen to include globally imperiled plant communities; short and mixed-grass prairie, Midwestern dry prairie, oak-pine barrens or savanna and Coastal Plain savanna along the Atlantic seaboard. Therefore, *Schinia jaguarina* habitat has received some management, given ongoing efforts to protect and restore the Nation's remaining prairies and oak-pine barrens.

In most areas, grassland restoration and management has depended on prescribed fire as a primary tool. The Cloverlick Barrens site on the Hoosier National Forest has undergone prescribed fire management on several occasions in the past 20 years. The efforts at Cloverlick has created a substantial amount of habitat for this species and it was found scattered throughout roughly 200 acres of the 1,300 acre site. Given that other scurfy peas respond favorably to fire, *Orbexilum pedunculatum* likely does also and it is found more commonly in fire maintained areas than in those that have been fire suppressed. Pupae hibernating in the ground are completely protected from fire, allowing for rapid colonization of recently restored habitat. Efforts to manually remove exotic and native invasive plants (as mentioned in previous sections) have also benefited this species, by opening the canopy and reducing competition with its larval food plant and adult nectar sources.

PAST AND CURRENT CONSERVATION ACTIVITIES

The Jaguar Flower Moth has always been reported as rather rare and local, though not usually from a conservation standpoint. Only recently have researchers begun to suggest that the species is indeed imperiled and that efforts should be undertaken to identify known and active populations, and begin to assess their health and needs for continued survival. Currently, the Jaguar Flower Moth is considered critically imperiled (S1) in only two states, Indiana and North Carolina (S1S3). All other states have it listed as unranked. Conservation of this species has typically been an incidental by-product of efforts to protect and restore remnants of our native grassland flora.

RESEARCH AND MONITORING

Currently, little research is being conducted regarding the Jaguar Flower Moth (see IMLS, 2005). The larval food plants are attractive species and highly valuable for butterfly and hummingbird gardens. They also produce seeds that are food for a variety of songbirds, particularly goldfinches. The Jaguar Flower Moth and its preferred habitats are also visually attractive, features which would make them excellent candidates for raising public awareness of (and funding for) fen and wet-mesic prairie restoration.

EXISTING SURVEYS, MONITORING, AND RESEARCH

Many of the historic sites for this species have not been visited in over 20 years, some in nearly 100. Verification of all occurrences east of the 94th Meridian (roughly east Texas to eastern South Dakota) and accompanying population estimates should be an early priority for research on this species. At the present time, little to no monitoring or survey work is being focused on this species, despite its relative rarity. However, recent surveys for rare insects on the Hoosier National Forest uncovered a population of *Schinia jaguarina* new to the state (Bess, 2004). Dr. Ronald Panzer (Northeastern Illinois University) has been monitoring this species at the few known sites in Illinois. Stephen Hall (North Carolina Heritage Program) has conducted surveys of Coastal Plain natural areas and provided recommendations for management and future monitoring as relates to this and associated rare species.

SURVEY PROTOCOL

Surveys should initially be focused on known historic populations of the Jaguar Flower Moth. As a rule of thumb, surveys should be focused on dry to mesic prairie remnants with large populations of scurfy peas. Timing of surveys should occur when the adults are present, as these are the easiest to identify. Larvae may also be searched for on *Psoralea* plants, but are cryptically colored and more difficult to locate. Photographs of suspected adults and larvae should be taken and kept with precise information regarding location, date and time. Given the similarity of this to other more common species, a specimen from any new locality should be collected as a voucher. In an emergency situation, collected adults can be pinched firmly on the thorax and placed in a glassine envelope or similar protective sleeve. If a killing jar is at your disposal, this may be used instead. Adults can also be placed live into glassine envelopes and frozen, but this is best left to professionals.

Collected adults should be either kept in a glassine envelope or pinned and affixed with a label bearing the following information:

1. State, County or Parish, Town, Range, Section and Quarter Section (or nearest reference point) of origin;
2. Date of Collection
3. Name of Collector
4. Type of habitat and any associated plants.

MONITORING PROTOCOL

To conduct long-term monitoring programs, a permanent monitoring transect will need to be developed (see Pollard, 1977). Monitoring programs will naturally vary from site to site and depend greatly on the amount of resources available to conduct such programs. At a minimum, a long-term monitoring program for *Schinia jaguarina* should have at least one permanent monitoring transect per occupied site. Monitoring transects should pass through all representative habitats within a site or management unit, with emphasis placed on areas with scurfy peas. Canopy closure should vary along the transect as much as is representative of the site being surveyed.

The monitoring transect should be of a length that can be covered by one or two observers in one to two hours, while walking at a moderate pace. All Jaguar Flower Moths observed within 30 feet of the transect line should be counted and their sex and flight condition (freshly emerged, slightly worn, badly worn) noted. Information on behavior should also be recorded, such as nectaring, ovipositing, mating, resting, etc. Standardized survey forms can easily be developed and a sample is attached as Figure 2. At a minimum; transect name, location, date, time, temperature and cloud cover should be noted on each survey form. Information on plant phenology, species in bloom, canopy cover, invasive species, predation, etc. is also useful. Surveys should be conducted every day with suitable weather conditions for the duration of the flight period. These surveys provide a wealth of data for use in tracking long-term trends in population size, phenology, distribution and resource utilization.

RESEARCH PRIORITIES

Further research is needed regarding the exact habitat requirements of the Jaguar Flower Moth, such as:

1. Optimal canopy cover,
2. Minimum patch size of habitat and food plants,
3. Percent cover and frequency of scurfy peas necessary for long-term survival,
4. Optimal density of associated vegetation (especially adult nectar sources),
5. Fire effects and optimal fire regime,
6. Effects of invasive plants (and efforts to control them) on Scurfy pea, nectar sources and the moth, and
7. Effects of silvicultural activities such as pine plantations, pesticide application, harvesting, etc on the moth, its food plants and habitat(s).

Additional Areas of Potential Jaguar Flower Moth Research

Additional areas of research center on developing optimal habitat restoration procedures for dry grasslands and re-introduction methodology for the moth. The maximum distance between remnants and location of dispersal corridors necessary for metapopulation establishment and survival would also be a key area of future research on this species. It is also quite probable that there are undetected populations of *Schinia jaguarina* in the central and eastern United States. Regional and state level efforts are needed to survey for (and protect) this and many other rare insect species.

Other Rare Species Associated with the Jaguar Flower Moth

Historically, the Jaguar Flower Moth shared its habitat with an impressive collection of species, many of which are now globally imperiled through loss of habitat and, in some cases, active extermination programs. Imperiled vertebrate species with which the flower moth once shared its habitat include the original Human Beings, American Bison, Black Footed Ferret, Greater Prairie Chicken, Prairie Falcon and Sage Grouse.

In addition to these more charismatic megafuana, a large number of rare insects are also known to occur with *Schinia jaguarina* (Bess, 2004; Hall, 1999). These include the Albarufan Dagger Moth (*Acronycta albarufa*), Bell's Roadside Skipper (*Amblyscirtes belli*: G3), Swamp Metalmark Butterfly (*Calephelis mutica*: G3), Great Plains Mole Cricket (*Gryllotalpa major*: G2), Dakota Skipper (*Hesperia dakotae*: G2 and candidate for federal listing), American Burying Beetle (*Nicrophorus americanus*: G1G2 and federally endangered), Powesheik Skipper (*Oarisma powesheik*: G2), Rattlesnake Master Borer Moth (*Papaipema eryngii*: G1) and Regal Fritillary (*Speyeria idalia*: G2).

REFERENCES

Anderson, D. 1996. The vegetation of Ohio: Two centuries of change. Draft. Ohio Biological Survey.

Anderson, K., E. Smith, and C. Owensby. 1970. Burning bluestem range. *Journal of Range Management* 23:81-92.

Anderson, R., T. Fralish and J. Baskin. 1999. Savannas, Barrens and Rock Outcrop Plant Communities of North America. Cambridge University Press, London, UK. 470 pages.

Anderson, R. and L. Brown. 1986. Stability and instability in plant communities following fire. *American Journal of Botany* 73:364-368.

Arend, J. L. and H. F. Scholz. 1969. Oak forests of the Lake States and their management. *USDA Forest Service, North Central Forest Experiment Station Research Paper NC-31. 36pp.*

Bess, J. 2004. A final report on insect surveys at three barrens special areas. Unpublished Report to the Hoosier National Forest, US Forest Service, USDA. 40 pages, 3 maps, 3 tables(74).

Bess, J. 1990. A Report on the Insect Fauna of Kentucky Remnant Grasslands. *Unpublished Report to the Kentucky Chapter of The Nature Conservancy.*

Blatchley, W. 1920. The Orthoptera of northeastern North America. The Nature Publishing Company. 784 pp.

Boettner, G., J. Elkington, and C. Boettner. 2000. Effects of a biological control introduction on three nontarget native species of saturniid moths. *Conservation Biology 14(6):1798-1806.*

Bradt, P. and J. Williams. 1990. Response of Hydropsychidae (Insecta: Trichoptera) larvae to diflubenzuron. *Journal Pennsylvania Academy Science 64:19-22.*

Britton, N. and A. Brown. 1913. An Illustrated Flora of the Northern United States, Canada and the British Possessions. Charles Scribner's Sons. New York.

Brown, D. 1994. Editor: Biotic Communities Southwestern United States and Northwestern Mexico. University of Utah Press. Salt Lake City, UT.

.Brown, J., K. Smith and J. Kapler, eds. 2000. Wildland Fire in Ecosystems: Effects of Fire on Flora. General Technical Report RMRS-GTR-42-vol. 2 Ogden, Utah. USDA Forest Service, Rocky Mountain Research Station. 257 pages.

Butler, L., C. Zivkovich, and B. Sample. 1995. Richness and abundance of arthropods in the oak canopy of West Virginia's Eastern Ridge and Valley Section during a study of impact of Bacillus thuringiensis with emphasis on macrolepidoptera larvae. *West Virginia University Experiment Station Bulletin 711. 19pp.*

Butler, L., G. Chrislip, V. Kondo, and E. Townsend. 1997. Impact of diflubenzuron on nontarget canopy arthropods in closed deciduous watersheds in a central Appalachian forest. *Journal Economic Entomology 90.*

Campbell, J. 2001. Native vegetation types of Appalachian Kentucky. Unpublished report to The Nature Conservancy, Lexington, KY. 210 pp.

Christian, J.M. and S.D. Wilson. 1999. Long-term ecosystem impacts of an introduced grass in the northern Great Plains. *Ecology 80(7):2397-2407.*

Clark, D. 2004. Dallas Butterflies Website: http://www.dallasbutterflies.com/Butterflies/html/belli.html.

Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.

Cooper, R., K. Dodge, D. Thurber, R. Whitmore, and H. Smith. 1993. Response of ground-level wildlife food plants to canopy defoliation by the gypsy moth. *Proceedings Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 1993:268-275.*

Cooper, R., K. Dodge, P. Martinat, S. Donahoe, and R. Whitmore. 1990. Effect of diflubenzuron application on eastern deciduous forest birds. *Journal of Wildlife Management 54:486-493.*

Covell, C. 1999. An Annotated Checklist of the Butterflies and Moths (Lepidoptera) of Kentucky. *Kentucky State Nature Preserves Commission Scientific and Technical series no. 6.*

Cowen, R. 1991. The sacred turnip. *Science News. 139(20): 316-317.*

Daubenmire, T. 1968. Ecology of fire in grasslands. *Advances in Ecological Research* 5:209-266.

Deam, C. 1940. Flora of Indiana. Blackburn Press. Caldwell, New Jersey.

Delcourt, H., and P. Delcourt. 1997. Pre-Columbian Native American use of fire on southern Appalachian landscapes. Conservation Biology 11(4):1010-1014.

DeSelm, H., and N. Murdock. 1993. Grass-dominated communities. Pages 87-141 in: W. H. Martin, S. G. Boyce, and A. C. Echternacht, editors. Biodiversity of the southeastern United States: Upland terrestrial communities. John Wiley and Sons, New York.

Dick-Peddie, W. 1993. New Mexico Vegetation: Past, Present and Future; with contributions by W. Moir and R. Spellenberg. University of New Mexico Press. Albuquerque, NM

Dorney, C. and J. Dorney. 1989. An unusual oak savanna in northeastern Wisconsin: The effect of Indian-caused fire. *American Midland Naturalist* 122:103-113.

Dubey, T., 1995. Aquatic fungi. In R.C. Reardon (coordinator). Effects of Diflubenzuron on non-target organisms in broadleaf forested watersheds in the Northeast. USDA Forest Service.FHM-NC-05-95, 174 pp.

Dubey, T.; Stephenson, S. L.; Edwards, P. J. 1995. Dimilin effects on leaf-decomposing aquatic fungi on the Fernow Experimental Forest, West Virginia. In: Gottschalk, Kurt W.; Fosbroke, Sandra L.C., eds. 1995.Proceedings, 10th central hardwood forest conference 1995, March 5-8 Morgantown, WV. *General Technical Report NE-197. Radnor, PA: U.S. Department of Agriculture, ForestService, Northeastern Forest Experiment Station: 421-429.*

Eyre, F., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 pp.

Fairbrothers, D. and J. Gray. 1972. *Microstegium vimineum* (Trin.) A. Camus (Gramineae) in the United States. *Bulletin of the Torrey Botanical Club 99:97-100.*

Forman, R., editor 1979. Pine Barrens: ecosystem and landscape. Academic Press, New York. 601 pp.

Garren, K. 1943. Effects of fire on vegetation of the southeastern United States. *Bot. Rev. 9:617-654.*

Garrett, H., W.J. Rietveld, and R.F. Fisher, eds. 2000. North American Agroforestry: An Integrated Science and Practice. American Society of Agronomy, Madison, Wisconsin.

Gleason, H. and A. Cronquist, 1991. Manual of the vascular plants of the northeastern United states and Canada, 2nd Ed. New York Botanical Garden, New York.

Gordon, A. and S.M. Newman, eds. 1997. Temperate Agroforestry Systems. CAB International, Oxon, UK

Grimm, E. 1984. Fire and factors controlling the Big Woods vegetation of Minnesota in the mid-nineteenth century. *Ecological Monographs* 54:291-311.

Hajek, A., L. Butler, J. Liebherr, and M. Wheeler. 2000. Risk of infection by the fungal pathogen Entomophaga maimaiga among Lepidoptera on the forest floor. *Environmental Entomology 29(3):645-650.*

Hajek, A., L. Butler, S. Walsh, J. Perry, J. Silver, F. Hain, T. O'Dell, and D. Smitley. 1996. Host range of the gypsy moth (Lepidoptera: Lymantriidae) pathogen Entomophaga maimaiga(Zygometes: Entomophthorales) in the field versus laboratory. *Environmental Entomology 25:709-721.*

Hajek, A., L. Butler, and M. Wheeler. 1995. Laboratory bioassays testing the host range of the gypsy moth fungal pathogen Entomophaga maimaiga. *Biological Control 5:530-544.*

Hall, S. P. 1999. Inventory of lepidoptera of the Albemarle-Pamlico peninsular region of North Carolina, including Pettigrew, Goose Creek, and Jockey's Ridge State Parks and Nag's Head Woods Ecological Preserve. North Carolina Department of Environment and Natural Resources, Natural Heritage Program, Raleigh, NC.

Hall, S, J. Sullivan, and D. Schweitzer, 1999. Assessment of risk to non-target macromoths after Btk application to Asian gypsy moth in the Cape Fear region of North Carolina. USDA Forest Service, Morgantown West Virginia, FHTET-98-16, 95pp.

Hansen, S. and R. Garton. 1982. The effects of diflubenzuron on a complex laboratory stream community. *Archives of Environmental Contamination and Toxicology 11:1-10*.

Hanson, H. 1939. Fire in land use and management. *American Midland Naturalist 21:415-434.*

Hardwick, D. 1996. A Monograph to the North American Heliothentinae. Self Published. 281 pages.

Heinselman, M. 1981. Fire intensity and frequency as factors in the distribution and structure of northern ecosystems. Pages 7-57 in H. A. Mooney, T. M. Bonnicksen, N. L. Christensen, J. E. Lotan, and W. A. Reiners, tech. coords. Proceedings of the conference: fire regimes and ecosystem properties. 11-15 December. 1978, Honolulu, HI. *U. S. Forest Service General Technical Report WO-26.*

Heitzman, J. and J. Heitzman. 1987. Butterflies and Moths of Missouri. Missouri Department of Conservation Publication. 385 pages.

Henderson, N. R. and J. N. Long. 1984. A comparison of stand structure and fire history in two black oak woodlands in northwest Indiana. *Botanical Gazette* 145:22-228.

Herms, C.P., D.G. McCullough, L.S. Bauer, R.A. Haack, D.L. Miller, and N.R. Dubois. 1997. Susceptibility of the endangered Karner blue butterfly (Lepidoptera: Lycaenidae) to Bacillus thuringiensisvar. kurstaki used for gypsy moth suppression in Michigan. *Great Lakes Entomologist 30:125-141*.

Higgins, K F. 1986. Interpretation and compendium of historical fire accounts in the Northern Great Plains. *U.S. Fish Wildlife Service, Resource Publication 161. 39 pp.*

Hofstetter, R. H. 1974. The effect of fire on the pineland and sawgrass communities of southern Florida. Pages 201-212 in P. J. Gleason, ed. Environments of south Florida: present and past. *Miami Geological Society Memoirs 2.*

Holmes, S.B. 1998. Reproduction and nest behaviour of Tennessee warblers Vermivora peregrina in forests treated with Lepidoptera-specific insecticides. *Journal of Applied Ecology 35:185-194.*

Hough, R. 1907. Handbook of the Trees of the Northern States and Canada. The MacMillan Company, New York.

Hulbert, L. 1969. Fire and litter effects in undisturbed bluestem prairie in Kansas. *Ecology 50: 874-877.*

Hulbert, L. 1981. Causes of fire effects in tall grass prairie. *Ecology 69:46-58.*

Hunt, D. M. and Robert E. Zaremba. 1992. The northeastward spread of *Microstegium vimineum* (Poaceae) into New York and adjacent states. *Rhodora 94:167- 170.*

Hutchinson. 1996. Monitoring Changes in Landscapes from Satellite Imagery. Eros Data Center, U. S. Geologic Survey, Sioux Falls, SD. http:/biology.usgs.gov/s+t/noframe/m3229.htm

Illinois Plant Information Network. 2004. Gallery of Illinois Plants. Illinois Natuural History Survey, Champaign-Urbana, IL. http://www.inhs.uiuc.edu/cwe/illinois_plants/PlantsofIllinois.html

IMLS. 2005. National Institute of Museum and Library Services: 2005 Grant Recipients. http://www.imls.gov/results.asp?keyword=&inst=&city=&state=0&year=9&program=1001&description=on&sort=year

Johnson, K.S., J.M. Scriber, J.K. Nitao, and D.R. Smitley. 1995. Toxicity of Bacillus thuringiensis var. kustaki to three nontarget Lepidoptera in field studies. *Environmental Entomology 24:288-297.*

Kline, V. 1984. Wisconsin oak forests from an ecological and historical perspective, pp. 3-7. In: J. E. Johnson (ed.), Proc. Challenges in oak management and utilization. *Cooperative Extension Services, University of Wisconsin, Madison.*

Knapp, A. K. and T. R. Seastedt. 1986. Detritus accumulation limits productivity of tall grass prairie. *Bioscience 36:662-668.*

Komarek, E. 1985. Wildlife and fire research: past, present, and future. Pages 1-7 in J. E. Lotan and J. K Brown, compilers. Fire's effects on wildlife habitat--symposium proceedings. Missoula, Montana, 21 March 1984. *U.S. Forest Service General Technical Report INT-186.*

Komarek, E. V. 1971. Effects of fire on wildlife and range habitats. Pages 46-52 in U.S. Forest Service Prescribed burning symposium proceedings. Southeastern Forest Experiment Station, Asheville, N.C.

Kozlowski, T. T., and C. E. Ahlgren, editors. 1974. Fire and ecosystems. Academic Press, New York. 542 pp.

Krieg, A. and G.A. Langenbruch. 1981. Susceptibility of arthropod species to Bacillus thuringiensis. pp. 837-896 In H.D. Burges (ed.), Microbial control of pests and plant diseases. Academic Press, New York.

Kuchler, A. 1964. Potential Natural Vegetation of the Counterminous United States: a Map and Manual. American Geographical Society Special Publication 36. Princeton Polychrome Press, Princeton, NJ. 116 pages.

LaFleur, A. 1996. Invasive plant information sheet: Japanese stilt grass. The Nature Conservancy, Connecticut Chapter Connecticut, Hartford, CT.

Lih, M. P., F. M. Stephen, K. G. Smith, L. R. Nagy, G. W. Wallis, and L. C. Thompson. 1995. Effects of a gypsy moth eradication program on nontarget forest canopy insects and their bird predators. *Proceedings Annual Gypsy Moth Review*. Portland, OR. Oct. 30-Nov. 2, 1994.

Linduska, J. 1960. Fire for bigger game crops. *Sports Afield 143(1): 30-31, 88-90.*

Lotan, J. E., M. E. Alexander, S. F. Arno, R.E. French, O. G. Langdon, R. M. Loomis, R. A. Norum, R. C. Rothermel, W. C. Schmidt, and J. Van Wagtendonk. 1981. Effects of fire on flora: a state-of-knowledge review. *U.S. Forest Service General Technical Report WO-16. 71 pp.*

Luken, J.O., L.M. Kuddes, and T.C. Tholemeier. 1997. Response of understory species to gap formation and soil disturbance in Lonicera maackii thickets. *Restoration Ecology 5:229-235.*

Luken, J.O., and M. Shea. 2000. Repeated Prescribed Burning at Dinsmore Woods State Nature Preserve (Kentucky, USA): Responses of the Understory Community. *Natural Areas Journal. 20(2): 150-158*

Lynch, J. J. 1941. The place of burning in management of the Gulf coast wildlife refuges. *Journal of Wildlife Management 5:451-457.*

Martinat, P. J., V. Christman, R. J. Cooper, K. M. Dodge, R. C. Whitmore, G. Booth, and G. Seidel. 1987. Environmental fate of Dimilin 25-W in a central Appalachian forest. Bull. *Environmental Contaminants and Toxicology 39:142-149.*

Martinat, P.J., C.C. Coffman, K.M. Dodge, R.J. Cooper, and R.C. Whitmore. 1988. Effect of Dimilin 25-W on the canopy arthropod community in a central Appalachian forest. *Journal of Economic Entomology 81:261-267.*

Martinat, P. J., C. C. Coffman, K. M. Dodge, R. J. Cooper, and R. C. Whitmore. 1988. Effect of Diflubenzuron on the canopy arthropod community in a central Appalachian forest. *Journal Economic Entomology 81:261-267.*

Martinat, P.J., D.T. Jennings, and R.C. Whitmore. 1993. Effects of diflubenzuron on the litter spider and orthopteroid community in a central Appalachian forest infested with gypsy moth (Lepidoptera: Lymantriidae). *Environmental Entomology 22:1003-1008.*

McCasland, C. S., R. J. Cooper, and D. A. Barnum. 1998. Implications for the use of Diflubenzuron to reduce arthropod populations inhabiting evaporation ponds of the San Joaquin Valley, California. *Bulletin of Environmental Contamination and Toxicology 60:702-708.*

McClaran, M. and Van Devender, T. 1995. The Desert Grassland. University of Arizona Press. Tucson, AZ.

McNight, B. N. (ed.). 1993. Biological Pollution: The Control and Impact of Invasive Exotic Species. Indiana Academy of Science, Indianapolis.

Midwestern Ecology Working Group of NatureServe. No date. International Ecological Classification Standard: International Vegetation Classification. Terrestrial Vegetation. NatureServe, Minneapolis, MN.

Miller, H. 1963. Use of fire in wildlife management. *Proceedings Annual Tall Timbers Fire Ecology Conference 2:19-30.*

Miller, J. 2003. Nonnative invasive plants of southern forests: a field guide for identification and control. USDA Forest Service, Southern Research Station. General Technical Report SRS-62. Asheville, NC. 93 pages.

Miller, J. 1990. Field assessment of the effects of a microbial pest control agent on non-target Lepidoptera. *American Entomologist 36:135-139.*

Miller, J. 1990. Effects of a microbial insecticide, Bacillus thuringiensis kurstaki, on nontarget Lepidoptera in a spruce budworm-infested forest. *Journal of Research on the Lepidoptera 29(4):267-276.*

MNNHP [Minnesota Natural Heritage Program]. 1993. Minnesota's native vegetation: A key to natural communities. Version 1.5. Minnesota Department of Natural Resources, Natural Heritage Program, St. Paul, MN. 110 pp.

Montana State University, 2002. MSU Extension Services: 250 Plants for Range Contests in Montana. http://www.montana.edu/wwwpb/pubs/mt8402ag.html.

Morris, O. 1969. Susceptibility of several forest insects of British Columbia to commercially produced Bacillus thuringiensis. II. Laboratory and field pathogenicity tests. *Journal of Invertebrate Pathology 13:285-295.*

Mutanen, R., H. Siltanen, V. Kuukka, E. Annila, and M. Varama. 1988. Residues of diflubenzuron and two of its metabolites in a forest ecosystem after control of the pine looper moth Bupalus pinarius L. *Pesticide Science 23(2):131-140.*

NatureServe Explorer: An online encyclopedia of life (web application). 2005. Version 1.6. Arlington, Virginia. http://www.natureserve.org/explorer.

Nelson, P. 1985. The terrestrial natural communities of Missouri. Missouri Natural Areas Committee, Jefferson City. 197 pp. Revised edition, 1987.

NDSU, 2005. North Dakota State University Central Grasslands Research Extension Center. http://www.ag.ndsu.nodak.edu/streeter/2001report/Grazing_intensity_Plant%20Comm.htm#Table9

Nuzzo, V. 1986. Extent and status of Midwestern oak savanna: presettlement and 1985. *Natural Areas Journal 6:6-36*.

Opler, J. 2004. Moths of North America: The Jaguar Flower Moth (Schinia jaguarina).

Packard, S. 1988. Chronicals of restoration: restoration and rediscovery of the tall grass savanna. *Restoration and Management Notes* 6:13-20.

Peacock, J., D. Schweitzer, J. Carter, and N. Dubois. 1998. Laboratory assessment of the effects of Bacillus thuringiensis on native Lepidoptera. *Environmental Entomology 27(2):450-457*.

Peet, M., T. Anderson, and M. Adams. 1975. Effects of fire on big bluestem production. *American Midland Naturalist 94:15-26.*

Pollard, E. 1977. A method for assessing changes in the abundance of butterflies. *Biological Conservation. 12:115-134.*

Poole, R. 1988. Lepidopterorum Catalogus (New Series): Fascicle 118 Noctuidae Parts 1-3. E. J. Brill, Flora and Fauna Publications. 1,314 pages. New York.

Reardon, R. and A. Hajek. 1998. The gypsy moth fungus Entomophaga maimaiga in North America. USDA Forest Service Forest Health Technology Enterprise Team, FHTET-97-11. 22 pp.

Reardon, R., J. Podgwaite, and R. Zerillo. 1996. Gypchek- The Gypsy Moth Nuclear Polyhedrosis Virus Product. *USDA Forest Service, Forest Health Technology Enterprise Team, FHTET-96-10. 31 pp.*

Reardon, R., 1995 (coordinator). Effects of Diflubenzuron on non-target organisms in broadleaf forested watersheds in the Northeast. *USDA Forest Service.FHM-NC-05-95, 174 pp.*

Redman, Donnell E. 1995. Distribution and habitat types for Nepal Microstegium [*Microstegium vimineum* (Trin.) Camus] in Maryland and the District of Columbia. Castanea 60(3): 270-275.

Riemenschneider, V., T. Cordell and B. Allison, 1995. Impact of white-tailed deer on plant cover and biomass in Potato Creek State Park, St. Joseph County, Indiana. Unpublished report.

Sample, B. 1991. Effects of Dimilin on food of the endangered Virginia big-eared bat. Ph.D. Dissertation, West Virginia University, Morgantown, W.Va. 201pp.

Sample, B., R. Cooper, and R. Whitmore. 1993a. Dietary shifts among songbirds from a diflubenzuron-treated forest. *Condor 95:616-624*.

Sample, B., L. Butler, and R. Whitmore. 1993b. Effects of an operational application of Dimilin on nontarget insects. *The Canadian Entomologist 125:173-179.*

Sample, B., L. Butler, C. Zivkovich, R. Whitmore, and R. Reardon. 1996. Effects of Bacillus thuringiensis and defoliation by the gypsy moth on native arthropods in West Virginia. *Canadian Entomologist 128:573-592.*

Schwaegman, J. and T. Anderson. 1984. Effects of eleven years of fire exclusion on the vegetation of a southern Illinois barren remnant, pp. 146-148. In: *Proceedings of the Ninth North American Prairie Conference.*

Schwartz, M. and J. Heim. 1996. Effects of a prescribed fire on degraded forest vegetation. *Natural Areas Journal. 16:184-191*.

Schweitzer, D. 2004a. Schinia jaguarina Species Account: Nature Serve Explorer. Version 1.6. Arlington, Virginia. http://www.natureserve.org/explorer.

Schweitzer, D. 2004b. Gypsy Moth (Lymantria dispar): Impacts and Options for Biodiversity-Oriented Land Managers. 59 pp. Nature Serve Explorer. Arlington, Virginia. http://www.natureserve.org/explorer.

Schweitzer, D. 2000. Impacts of the 1999 Gypsy Moth Eradication Project at Highlands, North Carolina: Characterization of the moth fauna in the project area, and a preliminary assessment of the impacts from the 1999 treatments. Unpublished consultant's report sent to Jeff Witcosky, USDA Forest Service, Asheville, NC, 22 pp.

Seidel, G. and R. Whitmore. 1995. Effects of Dimilin application on white-footed mouse populations in a central Appalachian Forest. *Environmental Toxicology and Chemistry 14:793-795.*

Severns, P. 2002. Evidence for the negative effects of BT (Bacillus thuringiensis var. kurstaki) on a non-target butterfly community in western Oregon, USA. *Journal of the Lepidopterists' Society 56(3): 166-170.*

Southeastern Ecology Working Group of NatureServe. No date. International Ecological Classification Standard: International Vegetation Classification. Terrestrial Vegetation. NatureServe, Durham, NC.

Spessard, L. 1988. Seed-germination studies of Psoralea esculenta Pursh (Indian turnip) and Psoralea argophylla Pursh (silver scurfpea). *Transactions of the Nebraska Academy of Sciences. 16: 123-126.*

Stamps, W. and M. Linit. 1997. Plant diversity and arthropod communities: Implications for temperate agroforestry. *Agroforestry Systems. 39(1): 73-89(17).*

Swearingen, J. 2004. WeedUS: Database of Invasive Plants of Natural Areas in the U.S. Plant Conservation Alliance. http://www.nps.gov/plants/alien

Swift, M.C., R.A. Smucker, and K.W. Cummins. 1988. Effects of Dimilin on freshwater litter decomposition. *Environmental Toxicology and Chemistry 7:161-166.*

Tester, J. 1989. Effects of fire frequency on oak savanna in east-central Minnesota. *Bulletin of the Torrey Botanical Club 116:134-144.*

Tester, J., and W. Marshall. 1962. Minnesota prairie management techniques and their wildlife implications. *North American Wildlife Natural Resources Conference 27:267-287.*

Thomas, M. and D. Schumann. 1993. Income Opportunities in Special Forest Products: Self-Help Suggestions for Rural Entrepreneurs (Agriculture Information Bulletin AIB-666). USDA Forest Service, Washington, DC. http://www.fpl.fs.fed.us/documnts/usda/agib666/agib666.htm

Thor, E. and G. Nichols. 1973. Some effects of fires on litter, soil, and hardwood regeneration. In: Proceedings in the Tall Timbers Fire Ecology Conference. 13:317-329.

Tilman, D. 1987. Secondary succession and the pattern of plant dominance along an experimental nitrogen gradient. *Ecological Monographs* 57:198-214.

Uniroyal Corporation. 1983. Product profile for experimental use of Dimilin 25 W., 6 pp. plus inserted Material Safety Data Sheet. Distributed by Uniroyal.

USDA, NRCS. 2004. The PLANTS Database, Version 3.5. National Plant Data Center, Baton Rouge, LA. http://plants.usda.gov

USDA Forest Service. 2005. Fire Effects Information System [Online]. www.fs.fed.us/database/feis/plants/forb/psohyp/all.html.

USDA Forest Service. 2004a. Biological evaluation for the gypsy moth "slow the spread" project 2004 on the Washburn, Great Divide and Medford/Park Falls Ranger Districts,

Chequamegon-Nicolet National Forest, Wisconsin. www.fs.fed.us/r9/cnnf/natres/eis/04_gypsy_moth/04gm_BE.pdf

USDA Forest Service. 2004b. Forest Stewardship Program Website. Washington, D.C. http://www.fs.fed.us/spf/coop/programs/loa/fsp.shtml

USDA Forest Service. 2004. Chatahootchee-Oconee National Forest, Land and Resource Management Plan, Appendix E: General Recommendations for Rare Communities, Management Prescription 9F. http://www.fs.fed.us/conf/200401-plan/5-PA_E.pdf

USDA Forest Service. 1937. Range plant handbook. Washington, DC. 532 p.

USDA Soil Conservation Service. 1969. Soil Survey, Perry County, Indiana. 70 pages, 70 maps, 1 folding chart.

USGS, 2005a. US Geologic Survey: Northern Prairie Wildlife Research Center Website. Effects of Fire in the Northern Great Plains: General Observations of Fire Effects on Certain Plant Species. http://www.npwrc.usgs.gov/resource/habitat/fire/genobser.htm.

USGS, 2005a. US Geologic Survey: Northern Prairie Wildlife Research Center: Moths of North America Website.

Van Lear, D. and V. Johnson. 1983. Effects of prescribed burning in the southern Appalachian and upper Piedmont forests: a review. Clemson University, Clemson, SC. *College of Forestry and Recreation Resources, Department of Forestry, Forest Bulletin 36. 8 pp.*

Wade, D., J. Ewel, and R. Hofstetter. 1980. Fire in south Florida ecosystems. *U.S. Forest Service General Technical Report SE-17. 125 pp.*

Wagner, D.L., J.W. Peacock, J.L. Carter, and S.E. Talley. 1996. Field assessment of Bacillus thuringiensis on nontarget Lepidoptera. *Environmental Entomology 25(6):1444-1454.*

Wagner, D. and J. Miller. 1995. Must butterflies die for gypsy moths' sins? *American Butterflies 3(3):19-23.*

Weaver, J. 1965. The Natural Vegetation of Nebraska. Johnson Publishing Company, Lincoln, Nebraska.

Weaver, J. 1954. North American Prairie. Johnson Publishing Company, Lincoln, Nebraska.

Weaver, J. and T. Fitzpatrick. 1934. The Prairie. *Ecological Monographs 4: 109-295.*

Webb, D., H. DeSelm, and W. Dennis. 1997. Studies of prairie barrens of northwestern Alabama. *Castanea 62:173-184.*

Wells, B. 1942. Ecological problems of the southeastern United States coastal plain. *Botanical Review 8:533-561.*

Wells, B. 1931. The vegetation and habitat factors of the coarse sands of the North Carolina coastal plain: an ecological study. *Ecological Monographs 1: 465-520.*

Whaley, W., J. Anhold, B. Schaalje. 1998. Canyon drift and dispersion of Bacillus thuringiensis and its effects on select non-target Lepidopterans in Utah. *Environmental Entomology 27(3): 539-548.*

White, A. 1983. The effects of thirteen years of annual burning on a *Quercus ellipsoidalis* community in Minnesota. *Ecology* 64:1081-1085.

White, J., and M. Madany. 1978. Classification of natural communities in Illinois. Pages 311-405 in: Natural Areas Inventory technical report: Volume I, survey methods and results. Illinois Natural Areas Inventory, Urbana, IL.

Whitford, P. and P. Whitford. 1978. Effects of trees on ground cover in old-field succession. *American Midland Naturalist* 99:435-443.

Whitmore, R., R. Cooper, and B. Sample. 1993a. Bird fat reductions in forests treated with Dimilin. *Environmental Toxicology and Chemistry. 12:2059-2064.*

Whitmore, R., B. Sample, and R. Cooper. 1993b. Bird fat levels as a measure of effect in forests treated with diflubenzuron. *Environmental Toxicology and Chemistry 12:2059-2064.*

Williams, A. 2000. The effects of gypsy moth treatment applications of Bacillus thuringiensis on Worm-eating Warblers in Virginia. MS Thesis, University of Georgia, Department of Forest Resources, Athens, GA.

Wilson, E. and R. MacArthur. 1967. The Theory of Island Biogeography. Princeton, University Press: Princeton, NJ.

Wimmer, M., R. Smith, D. Wellings, S. Toney, D. Faber, J. Miracle, J. Carnes, and A. Rutherford. 1993. Persistence of diflubenzuron on Appalachian forest leaves after aerial application of Dimilin. *Journal of Agricultural and Food Chemistry 41:2184-2190.*

Wright, H. and A. Bailey. 1982. Fire Ecology. John Wiley and Sons, New York.

APPENDIX

LIST OF CONTACTS

INFORMATION REQUESTS

Kirk Larson, Hoosier National Forest, Bedford, Indiana office. Phone: (812) 277-3596
e-mail: kwlarson@fs.fed.us

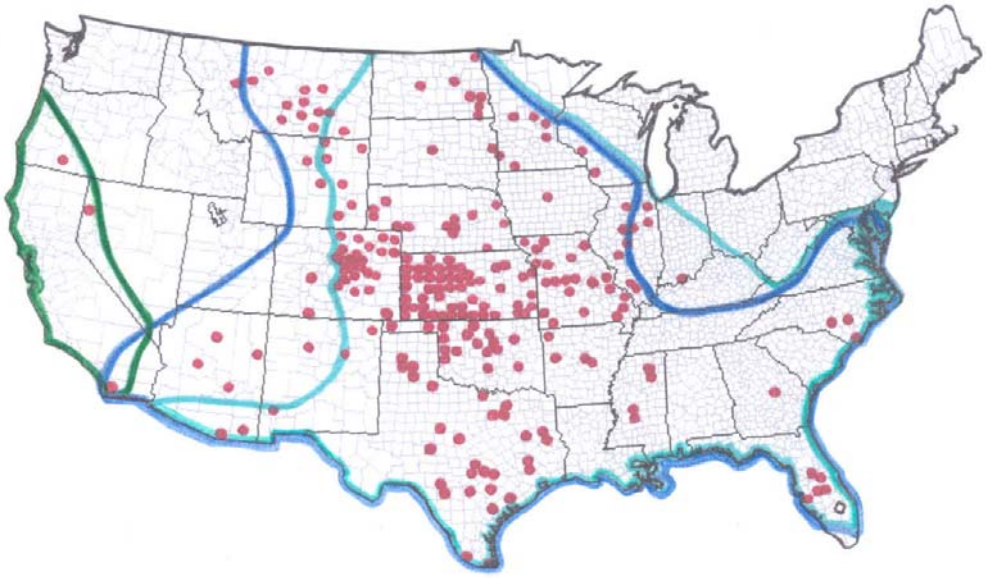
James Bess, OTIS Enterprises, Wanatah, IN 46390. Phone (219) 733-2947. E-mail: jabess@netnitco.net.

REVIEW REQUESTS

Kirk Larson, Hoosier National Forest, Bedford, Indiana office. Phone: (812) 277-3596
e-mail: kwlarson@fs.fed.us

FIGURES

Figure 1. Known Distribution of the Jaguar Flower Moth (*Schinia jaguarina*) and its Foodplants in the United States.



MAP LEGEND

- = *Known Schinia jaguarina* occurrences
- = distribution of *Orbexilum* spp.
- = distribution of *Pediomelum* spp.
- = distribution of *Hoita* spp.

Figure 2. Sample Field Form for Conducting *Schinia jaguarina* Surveys.

Transect:
Date:
Observer(s):
Survey Number:
Page of

Begin Time:
End Time:
Temperature:
Wind:
Cloud Cover:

Species	Time	Number Observed	Sex	Condition	Behavior	Plant Associations