Conservation Assessment for the unexpected tiger moth (Cycnia inopinatus (Edwards))

USDA Forest Service, Eastern Region
December 23, 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This Conservation Assessment was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a Conservation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

LIST OF FIGURES

EXECUTIVE SUMMARY

The unexpected tiger moth (*Cycnia inopinatus*) is a small, pale gray moth occurring in barrens and associated dry grasslands. It is considered uncommon to rare and local throughout its range, usually being found in close association with the larval food plants, milkweeds (*Asclepias tuberosa*, *A. verticillata* and other *Asclepias* species). This moth typically produces two broods per year, with the adults appearing in spring and late summer. It is never common (except on a very local level) and most states contain only one or a few populations. During the westward expansion of Europeans following the American Revolution, vast acreage of dry grassland and barrens were cleared for agricultural production. Native grasslands were also heavily pastured, with erosion and topsoil loss being widespread. During this time, the unexpected tiger moth lost a considerable amount of habitat. Given the current degraded status of the oak barrens and dry grassland ecosystems, this species' remaining habitat is fragmented and occurrences are often widely separated. The moth also overwinters aboveground in a cocoon in the leaflitter, making it fire-sensitive. Therefore efforts must be made to secure unburned refugia containing known tigermoth and milkweed populations when undertaking prescribed fire management on occupied sites. Ongoing efforts to protect and restore remnants of these ecosystems will hopefully provide additional habitat for this species. Whenever feasible, current and future restoration projects should track the effects of their efforts on potentially sensitive species such as the unexpected tiger moth. This would provide land managers with useful information for measuring the effectiveness of various restoration techniques in enhancing and maintaining habitat.

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 the Cloverlick Special Area, where I eventually discovered a healthy population of *Cycnia inopinatus*. Kelle Reynolds was instrumental in obtaining funding for much of my Conservation Assessment work. Kirk Larson supplied valuable logistic and botanical assistance.

NOMENCLATURE AND TAXONOMY

The genus *Cycnia* was first designated by Hubner in 1818. The unexpected tiger moth (*Cycnia inopinatus*) was described by Henry Edwards in 1882 as "*Euchaetes inopinatus*" (Papilio 2:13). Stretch named the species *Euchaetes nivalis* in 1906, now a synonym. This moth was for long confused with the species originally named "*Ammalo eglenensis*" by Clemens in 1860, and was often called as "*Euchaetes eglenensis*" in confusion with a more southern species now known as *Pygarctia eglenensis* (Clemens).

DESCRIPTION OF SPECIES

DESCRIPTION OF ADULT STAGE

Our native *Cycnia* are quite similar in appearance; being whitish gray with pale, yellow-orange on the edge of the leading edge of the forewings and thorax. *Cycnia inopinatus* is superficially identical to *Cycnia oregonensis* and *C. tenera*, two much more common species. This moth typically measures 25-40 mm (1.0 - 1.5 inches) in wingspan and is shown in Figure 1 and in Covell (1988).

DESCRIPTION OF IMMATURE STAGES

Eggs of *Cycnia inopinatus* are chalk white and spherical. They are placed on *Asclepias* stems and/or leaves, singly or in small groups. Upon hatching, the young larvae progressively develop a thick series of hair tufts along its body. At maturity, the hair tufts are gray and the insect's skin is bright orange, providing effective warning coloration. The hairs form a shield over the entire body. This species is presumably poisonous given the toxic alkaloids contained in milkweeds. When disturbed, the larvae roll up into a ball and fall from the foodplant. Upon hitting the ground, they move quickly out of sight and are difficult to locate, despite their bright skin coloration.

LIFE HISTORY

REPRODUCTION

Like all other Lepidoptera, the unexpected tiger moth goes through four distinct developmental stages: egg, larva, pupa and adult. Two or three broods are produced each year. The adults emerge from their cocoons in the early spring and begin laying eggs shortly thereafter. The larvae then feed from mid-spring on and pupate by mid-summer. The pupae mature fairly quickly and a second brood of adults appears in August. These adults lay eggs which then mature into larvae that pupate by early fall (October in NW Indiana). The pupae overwinter in thin cocoons in the surface leaflitter, which emerge the following spring.

ECOLOGY

Cycnia inopinatus is typically found in high quality, coastal scrub, dry barrens and similar native grasslands, typically on sand and associated with the Atlantic Coastal Plain or Great Lakes drainage. In Indiana, this moth is always associated with large populations of milkweeds (primarily *Asclepias tuberosa, A. verticillata*; sometimes *A. hirtella* and *A. viridiflora*), the larval food plants. They do not typically eat the common *Asclepias syriaca*, possibly because of alkaloid content in the foliage. Throughout most of the species' range, there are two adult broods per season, in spring and again in late summer. In peninsular Florida there may be three broods scattered throughout the year. The adult brood periods lasts roughly two to three weeks each, during which they mate and females lay eggs. The adults have rudimentary mouthparts and likely do not feed. The larvae feed on milkweed and overwinter as pupae in loose brown cocoons located in the duff of fallen *Asclepias* leaves.

DISPERSAL/MIGRATION

Given its specific foodplant requirements, the unexpected tiger moth does not typically travel far from colonies of milkweeds. Maximum individual dispersal distances are probably on the order of a few hundred yards to a half-mile, and the species is generally regarded as being rare and highly local in occurrence. However, populations are likely capable of dispersing over large areas of contiguous suitable habitat, particularly along linear corridors such as railroad prairie remnants. *Cycnia inopinatus* is not known to migrate.

OBLIGATE ASSOCIATIONS

The obligate habitat for the unexpected tiger moth is a mixture of high quality barrens and dry grassland containing an abundance of the primary arval foodplants, *Asclepias tuberosa* and *A. verticillata*. The larvae also feed on other native *Asclepias* like *A. amplexicaulis, A. hirtella, A. viridis* and *A. viridiflora*. The moth rarely (if ever) occurs far from stands of these milkweeds.

HABITAT

Cycnia inopinatus occurs in three fairly distinct ecosystems;

1. Dry, often sandy, prairie in the eastern Great Plains and Upper Midwest;
2. Clay-soil barrens and dry prairies on limestone and Cretaceous gravels in the Interior Uplands; and
3. Coastal sand scrub, barrens and savanna on the Atlantic Coastal Plain.

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

In the Hoosier National Forest (HNF) of Indiana, the high quality habitat for *Cycnia inopinatus* at Cloverlick Special Area is typical of that for the species throughout much of the central parts of its range. At the known population in Perry County, the overstory is dominated by oaks (*Quercus alba*, *Q. stellata* and *Q. marilandica*) and several other species, including red maple (*Acer rubrum*), hickories (*Carya*), ash (*Fraxinus*) and tulip tree (*Liriodendron tulipifera*). Beech (*Fagus grandiflora*), persimmon (*Diospyros*), black gum (*Nyssa sylvatica*), hop hornbeam (*Ostrya virginiana*), red elm (*Ulmus rubra*), and other species may be locally important. The shrub layer includes saplings of canopy species, plus paw paw (*Asimina triloba*), redbud (*Cercis canadensis*), flowering dogwood (*Cornus florida*), hazelnut (*Corylus americana*), huckleberry (*Gaylusaccia baccata*), witch hazel (*Hamamelis virginiana*), spicebush (*Lindera benzoin*), Carolina buckthorn (*Rhamnus caroliniana*), raspberries (*Rubus alleghaniensis, R. occidentalis*), coralberry, sassafras (*Sassafras albidum*) and blueberries (*Vaccinium* spp.).

Characteristic herbaceous species include Virginia snakeroot (*Aristolochia serpentaria*), Indian plantain (*Cacalia atriplicifolia*), bellflower (*Campanula americana*), poison hemlock (*Cicuta maculata*), Carolina thistle (*Cirsium carolinianum*), tall tickseed (*Coreopsis tripteris*), wild oregano (*Cunila origanoides*), numerous sticktights (*Desmodium canescens, D. glutinosum, D. nudiflorum, D. paniculatum, D. rotundifolium*), coneflowers, bonesets (*Eupatorium* spp.), woodland sunflowers (*Helianthus divaricatus* and *H. hirsutus*), dwarf crested iris (*Iris cristata*), blazingstars (*Liatris aspera, L. spicata* and *L. squarrosa*). wild bergamot (*Monarda fistulosa*), scurfy pea (*Psoralea psoralioides*), Jacob's ladder (*Polemonium reptans*), cup plant (*Polymnia uvedalia*), mountain mint (*Pycnanthemum tenuifolium*), rattlesnake master, black-eyed Susan, wild petunia (*Ruellia humilis*), skullcaps (*Scutellaria elliptica, S. leonardii*), goldenrods (*Solidago glauca, S. caesia, S. ulmifolia*), American columbo (*Swertia caroliniensis*), Virginia spiderwort (*Tradescantia viriginiana*), ironweed (*Vernonia altissima*) and wingstem (*Verbesina* spp.).

As elsewhere in the moth's range, grasses, sedges and rushes are important components of the herbaceous layer in areas of occupied habitat. These include wood reed (*Cinna arundinacea*), bottlebrush grass (*Elymus hystrix*), Virginia wild rye (*Elymus virginicus*), panic grasses (*Panicum anceps, P. boscii, P. dichotomum, P. laxiflorum*), sedges (*Carex albicans, C. cephalophora, C. complanata, C. glaucodea, C. rosea*), rushes (*Juncus* spp.), nodding bulrush (*Scirpus pendulus*) and nut rush (*Scleria oligantha*).

SITE SPECIFIC

Hoosier NF: Cloverlick Special Area

The only known occurrence for *Cycnia inopinatus* within the HNF is the Cloverlick Special Area, a ca. 1,300 acre complex of open and closed canopy oak and oak-pine barrens. This site contains several hundred acres of habitat for the moth, with a diverse flora as listed above. Much of the occupied unexpected tiger moth habitat at Cloverlick was formerly open oak barrens, with old, widely-spaced white, black, blackjack and post oaks occupying the canopy layer. Currently, young (15-25 yr old) oak, ash, tulip tree and red maple saplings dominate much of the former barrens, forming a closed-canopy forest. *Asclepias tuberosa* grows locally on the edges of the closed canopy, especially on open, grassy slopes. *Asclepias verticillata* is more local, but widespread across the Hoosier. In the central portion of the barrens complex, open grassland dominated by little bluestem and Indian grass intermingles with the wooded barrens. Recent fire management and mechanical brush removal has opened much of the fire suppressed barrens and encouraged a diverse array of wildflowers and grasses. This is especially true along the ecotone between these two community types, with a corresponding richness in butterflies and moths. Several hundred to a few thousand acres of superficially similar habitat occurs on adjacent Forest Service and private lands.

DISTRIBUTION AND ABUNDANCE

RANGE-WIDE DISTRIBUTION

Historically, this moth was reported as occurring primarily on the Atlantic Coastal Plain, where it was considered rare and local. Most of the Ohio Valley and Upper Midwest records are recent and primarily associated with high quality barrens remnants (see Bess, 1996, 1999, 2000, 2004, 2005; Covell, 1999; Metzler et al., 2005). Currently, this moth is considered uncommon to rare and always local in occurrence (see Covell, 1988). Many occurrences for this species are represented by a single individual (see Covell, 1999). The NatureServe Website provides very little information regarding the distribution of this species.

STATE AND NATIONAL FOREST DISTRIBUTION

The following, state-level distribution information for the unexpected tiger moth is gathered from Metzler et al., 2005 and additional sources (Bess, 1999, 2000, 2001, 2004, 2005; Covell, 1988, 1999; the NatureServe Website, 2005). Known populations are plotted in Figure 1. This species is reported along the Atlantic Coastal Plain from New Jersey and New York, south to Florida and west to Texas and Minnesota.

RANGE WIDE STATUS

Cycnia inopinatus is considered uncommon to imperiled in most or all parts of its range (Schweitzer, 2002). While it does not appear to be in immediate danger of extirpation range-wide, there seems to be insufficient information to conclude that it is demonstrably secure. This is especially true with regards to its preferred habitats (i.e. fire maintained oak barrens and dry-mesic grassland), which are globally imperiled. The following information was taken directly from the NatureServe.org Website in 2005 (see NatureServe, 2005).

Global Status: G4 (G2G3)
Global Status Last Reviewed: 16Dec2002
Global Status Last Changed: 31May2002
Rounded Global Status: G4 (G3)
National Status: NNR

Reasons: No reasons are given for the G4 rank for this species. The NatureServe Website also provides only rudimentary distribution information. Metzler and associates (2005) provide a dot map showing 86 known populations of this species. Their study of the Lepidoptera associated with prairie remnants culled data from both private collections and institutional collections and is provides one of the most complete distribution assessments known for many prairie associated species. I know of another 10 or so populations not figured in their study, bringing the total number of known element occurrences to around 100. This suggests that this moth is quite rare, despite having a very distinctive, readily visible larva and being attracted to lights. Therefore, a more proper G-rank such as G2G3 is fitting.

Status (S-Rank) in the Following States:
Alabama (SNR), Arkansas (SNR), Connecticut (SNR), Florida (SNR), Georgia (SNR), Indiana (S2S3), Illinois (SNR), Iowa (SNR), Kansas (SNR), Kentucky (SNR), Louisiana (SNR), Massachusetts (S1S2), Michigan (SNR), Missouri (SNR), Nebraska (SNR), New Jersey (SNR), North Carolina (SU), Ohio (S1), Oklahoma (SNR), Pennsylvania (SNR), South Carolina (SNR), Virginia (S1S3), Wisconsin (SNR).

The status ranks in many of these states should be much more reflective of the known range of this species and the distribution and quality of potential habitats and foodplants. Unfortunately, most states lack the appropriate personnel to make assessments of rare insects and provide recommendations for listing. No state has more than 14 Element Occurrences (WI) for this species, according to Metzler, et. al., (2005). Wisconsin has been heavily sampled for moths and butterflies by several competent Lepidopterists, so such a low number of occurrences would imply that this species is rare and of S2S3 status in Wisconsin. Most other states have only one to five Element Occurrences and would have to give this species either an S1, S1S2 or S1S3 ranking.

STATUS OF HABITAT IN THE OHIO VALLEY REGION

The NatureServe site provides no information on the range, habitat requirements or biology of this species. Therefore, some basic observations I have made over the years are included here. It should be noted that the *Cycnia inopinatus* habitat at Cloverlick SA (and probably elsewhere in the southern district of the Hoosier NF) is located on the Mitchell Karst Plain. This area was prehistorically covered in open oak woodland, barrens and dry-mesic prairie (see NatureServe, 2005). This complex of woodland and grassland spread east through the Bluegrass region of Kentucky to southern Ohio (Adams County). Interestingly, although adequate habitat occurs in the state, this species is unreported from Tennessee.

One of the oak woodland/barrens types in this complex is known to occur only on the Mitchell Plain of southern Indiana and again in Adams County, Ohio. This community type is considered globally significant and imperiled (G1; see NatureServe, 2005; Homoya, 1994). The Mitchell Plain passes inexorably into the the Muldraugh Hills of west-central Kentucky and superficially identical habitats also occur in Meade, Hardin and Bullitt Counties and are similarly imperiled (G1G3; NatureServe, 2005). These include the "Kentucky-Tennessee Big Barrens (CEGL007805: G2G3)," "Kentucky Mesic Tallgrass Prairie (CEGL004677: G1G2)," "Western Highland Rim Prairie and Barrens (CES202.352)", "Eastern Highland Rim Prairie and Barrens" (CES202.354), "Pennyroyal Karst Plain Prairie and Barrens (CES202.355)" and "Southern Ridge and Valley Patch Prairie (CES202.453)" form a series of similar plant communities in the eastern Interior Highlands and adjacent Ridge and Valley regions. This vegetation was the predominant landcover type throughout much of southern Indiana and west-central Kentucky and Tennessee in the early 1800s, and probably originated from burning by Native Americans. The barrens and prairies of Adams County, OH; Perry County, IN and Hardin County, KY are known to contain some of the richest assemblages of rare insects in North America (see Bess, 1990, 1996, 2000, 2004; Metzler et al., 2004)

POPULATION BIOLOGY AND VIABILITY

The unexpected tiger moth occurs in a series of plant communities that were once widespread across the eastern United States. It is a species of dry barrens and associated grasslands characterized (in their primordial state) by an open canopy dominated by widely spaced oaks. These communities are always characterized by mature or over-mature canopy trees, with a rich herbaceous layer. Most (if not all) of these habitats were fire-maintained in the past, with pockets of protected forest and woodland along streams that only occasionally received fire. The larval foodplant, *Asclepias*, is also widespread across eastern North America. Therefore, prior to the westward expansion of Europeans across eastern North America, the unexpected tiger moth was probably locally common wherever *Asclepias* occurred in the region delineated in Figure 1.

However, pressures from grazing by domesticated animals and deforestation began to reduce acreage of suitable habitat for the unexpected tiger moth and many other species of flora and fauna. The suppression of wildfires has also been among the more profound changes to the North American environment in the past 5,000 years. Many open, grasslands and barrens communities quickly succeeded to brushland or closed canopy forests of young softwoods and hardwoods. Others were invaded by non-native plant species that quickly excluded native species from the flora. As a result, habitat suitable for *Cycnia inopinatus* has become fragmented, often with large expanses of plowed fields, roads, cities and other barriers to dispersal, separating the remnants and isolating populations of the moth.

POTENTIAL THREATS

PRESENT OR THREATENED RISKS TO HABITAT

Human activity over the past 200 years has resulted in a shift in the distribution of the plant communities on which the unexpected tiger moth depends. Suppression of wildfires has resulted in the rapid succession of these barrens and savannas to closed canopy forest. Extensive livestock grazing has reduced the cover of native roses that this moth depends on and repeated, heavy grazing greatly degrades native plant communities. The thin soils underlying this vegetation are easily disturbed and overgrazing often leads to the widespread erosion of topsoil. Many overgrazed pastures have been subsequently replanted with Eurasian, cool-season grasses, further limiting and fragmenting the amount of available habitat for insects dependent on native grasses and grasslands. This isolation of often small populations can lead to inbreeding and extinction (see Wilson and MacArthur, 1967). Because the species is fire-sensitive, these now isolated populations are susceptible to extirpation from fire management activities, should an entire population be contained within a given burn unit.

Grazing

Given the poisonous nature of milkweed foliage, they are not browsed by deer. Domesticated cattle and horses also avoid *Asclepias* and do not pose a threat to the moth by consuming and/or trampling larval food sources, eggs, larvae and/or pupae. Well-managed, rotational, grazing would probably have only limited negative effects on this species. Unfortunately, excessive stocking rates (which are often the norm) lead to the compaction and erosion of soils, destruction of foodplant and altering of plant community structure. Swine, goats and sheep eat nearly all green matter and often severely compact and erode soils in areas where they are stocked. These factors have combined to make many sites formerly suitable for this species currently unfit as habitat.

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. 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. European immigrants used fire to clear brush and enhance the growth of grasses and other plants that provided forage for their domesticated, European livestock. Unfortunately, excessive numbers of animals were often placed on grasslands with marginal amounts of available forage, leading to the destruction of the 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 involved the seeding of cool-season, non-native grasses. Preferred species in upland pastures include smooth brome (*Bromus inermis*), fescue (*Festuca arundinacea* and *F. elatior*), orchardgrass (*Dactylis glomerata*) and the bluegrasses (*Poa compressa* and *P. pratensis*). These methods became indoctrinated into our system of land reclamation and these grasses persist to this day as recommended cover species. Clovers (*Medicago, Melilotus* and *Trifolium* spp.) are often placed in the grass mix to provide nitrogen fixation in the soil and fodder for livestock. 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. 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. Finally, milkweeds are recognized as noxius weeds by livestock producers and typically eradicated from pastures.

Competition from Introduced Species

In addition to the pasture species mentioned above, a number of other introduced plants threaten the quality and survival of unexpected tiger moth habitat (see McKnight, 1993). These include garlic mustard (*Alliaria petiolata*), Japanese honeysuckle (*Lonicera japonica*), bush honeysuckles (*Lonicera mackii* and *L. tartarica*), Japanese stilt grass (*Microstegium vimineum*) and glossy buckthorn (*Rhamnus cathartica*). Each of these will be dealt with separately in the following sections.

Black Locust

In the northwest portion of the unexpected tiger moth's range, black locust was frequently planted as a wind-break and for erosion control in the 1950's. Unlike in the areas where this tree is native (SE U. S.), in the sands of the Upper Midwest, this tree is very aggressive and forms numerous root suckers, in addition to prodigious quantities of seed. When a single individual is cut, it may send up more than 100 new sprouts from the lateral roots. These grow quickly and can attain heights of two meters (~6 feet) in two years. This species is best controlled through late summer or dormant season cutting and treatment of cut stumps with Glyphosate or Triclopyr. Mature trees can also be girdled at chest height and the cut band painted with herbicide. Repeated treatments are inevitable and this species can be quite difficult to control and eradicate.

Garlic Mustard

Non-native garlic mustard is a severe threat to the long-term survival of many wooded plant communities. This plant is highly adaptable and survives under a broad range of moisture, light and soil conditions (Anderson and Kelley, 1995; Anderson et al., 1996; Brunelle, 1996; Byers and Quinn, 1998; Cruden et al., 1996; Dhillion and Anderson, 1999; Nuzzo, 1993; Roberts and Bodrell, 1983). Garlic mustard overgrows native herbaceous plants, often excluding them from the flora (see Brothers and Springarn, 1992; Luken and Shea, 2000; Luken et al., 1997; McCarthy, 1997; Nuzzo, 1999). Although it is fond of disturbed situations, garlic mustard can invade relatively pristine plant communities, especially along paths, roadsides and utility rights-of-way (Brothers and Springarn, 1992; Brunell, 1996; Luken et al., 1997; Luken and Shea, 2000; Nuzzo, 1999).

Japanese and Bush Honeysuckles

Non-native honeysuckles have long been used for landscape and wildlife plantings. They grow rapidly, flower prodigiously and produce large numbers of berries, which are readily eaten by birds and redistributed across our woodlands and forests. The seeds germinate and seedlings grow in shade or light. They are now a common (often dominant) component of the understory in our woodlands and forests. Both *Lonicera japonica* and *L. mackii* 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. All can be controlled with manual cutting and herbicide application, although re-infestations are often inevitable (Luken et al., 1997).

Japanese Stilt Grass

Like garlic mustard, Japanese stilt grass poses a serious threat to habitat for *Cycnia inopinatus* throughout much of the moth's range (Barden, 1987, 1991; Fairbrothers and Gray, 1972; Hunt and Zaremba, 1992; LaFleur, 1996). This fairly recent introduction moves into natural areas quickly along roadsides, paths and waterways. In the south, where many small streamlets dry up or cease flowing during the summer months, this grass can establish itself quickly on newly exposed soil in the streambed. The species forms numerous clones over the growing season, each of which flowers in late summer. Once established, this grass typically forms a solid monoculture along roadsides and pathways. Rain events wash plants and seed down roadways and paths into drains and streams, quickly distributing fresh propagules over a large area. Japanese stilt grass is best controlled with a combination of mowing prior to seed set, with follow up mowing and herbicide application as needed.

Glossy Buckthorn, Autumn Olive and Multiflora Rose

The threat, mode of dispersal and methods of control for these species are the same as the honeysuckles mentioned previously. Both are aggressive invaders that need repeated management effort to completely eradicate from even small sites. These species are especially troublesome because they will more readily invade open grasslands than honeysuckles.

Over utilization

The unexpected tiger moth is somewhat of concern to moth enthusiasts, although comparatively few people pursue it for the purpose of collecting specimens. Its habitat selection and secretive habits make it relatively difficult to collect on a large scale, although it can be locally common, especially in the northwestern part of its range. However, rarely are more than a half dozen individuals observed at any one time.

Disease or Predation

A number of insectivorous animals feed on moth larvae and pupae, particularly birds, mice, voles, squirrels and chipmunks. Numerous insects attack moth larvae, such as wasps (Hymeonptera: Vespidae), stink bugs (Hemiptera: Pentatomidae), ants (Hymenoptera: Formicidae) and spiders (Araneidae). The dense hair and presence of poisonous alkaloids from the milkweed protect larvae of *Cycnia inopinatus* from most insectivores. However, parasitic wasps and flies can bypass these defenses and lay eggs or young larvae on the caterpillars.

Microbial pathogens also affect *Cycnia inopinatus* and related species, one of which is the soil born bacteria, *Bacillus thuringiensis kurstaki* (*Btk*). For the past 30 years, this bacterium has been developed on a massive scale to control a number of agricultural insect pests. The use of B_{tk} for control of the introduced gypsy moth (*Lymantria dispar*) has potential for negatively affecting populations of the milkweed borer. The larvae are present throughout the growing season increasing their susceptibility to the pathogen in the local environment (resulting from both the initial spray efforts and decomposing gypsy moth larval cadavers). This could lead to an increase in mortality in the *Cycnia* larvae. They would also be susceptible to drift of B_{tk} onto milkweed 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 unexpected tiger moth. For many years, the gypsy moth had few predators or parasites here, and its populations soared to outbreak proportions throughout the Northeast (see Schweitzer 2004 for a review). The larvae feed primarily on oaks (*Quercus* spp.) and defoliated countless acres of oak and mixed hardwood forest, including habitat for *Cycnia inopinatus*. These defoliation events result in the direct mortality of many other insect species that feed on oak, and change the character of the forest, allowing light to reach the ground flora for a prolonged period of time in early summer. On sites where trees are already stressed by edaphic conditions, repeated defoliation can lead to tree mortality. The leaves that remain or re-sprout have characteristic differing from those on trees that did not experience defoliation (Feeny, 1970; Schultz and Baldwin, 1982; Schweitzer, 1979). The effects of canopy defoliation on the herbaceous flora are discussed by Cooper et al. (1993).

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, 2004). Chemicals such as DDT also accumulate in successive trophic levels as they pass through an ecosystem. Organisms at the tops of food chains (such as insectivores) accumulate 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 (*Btk*) is a relatively new threat to the butterfly, 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., 1990; Herms et al., 1997; Johnson, et al., 1995; Krieg and Langenbruch, 1981; Miller, 1990; Morris, 1969; Schweitzer, 2000, 2004a-b; 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 unexpected tiger 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. Because of this, large scale spraying efforts within the range of *Cycnia inopinatus* could 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 *Btk* (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 at the same time of year as the unexpected tiger moth, spraying of *Btk* or other pesticides in occupied habitat could certainly have a negative effect on the resident butterfly population.

Residential Development

Residential Development can negatively affect habitat for *Cycnia inopinatus* 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, including milkweed, 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). In the Northeast and Upper Midwest, high-end and exclusive residential developments are often located in remnants of woodland and barrens.

Inadequacy of Existing Regulatory Mechanisms

The current, species-based approach to federal laws regarding the protection of imperiled organisms does not currently afford legal protection to the unexpected tiger moth. An ecosystem or plant community based approach would be more adequate for the protection of organisms whose habitats are becoming increasingly fragmented and degraded by human activity. This is especially true for those requiring southern barrens and savannas, where there are no federally protected insect species. Federally mandated efforts to restore our Nation's woodlands, barrens and grasslands would not only protect hundreds of species from impending peril, but provide the human population with expanded opportunities for hunting, fishing, gathering of forest products, development of medicines, education, research, observation and enlightenment.

SUMMARY OF LAND OWNERSHIP & EXISTING HABITAT PROTECTION

The U. S. Forest Service owns occupied unexpected tiger moth habitat in Indiana. Additional Federal lands may also harbor populations of this species. State and Private Nature Preserves hold additional potential or occupied habitat in a number of states.

SUMMARY OF EXISTING MANAGEMENT ACTIVITIES

Little or no management is currently being directed at unexpected tiger moth habitat based solely on the species' presence or absence. However, the moth's preferred habitat happens to be the juncture of two highly imperiled plant communities, oak barrens and woodland. Therefore, *Cycnia inopinatus* habitat has received management in many areas, given ongoing efforts to protect and restore the Nation's remaining prairies and oak barrens.

In most areas management has taken the form of prescribed fire. The Cloverlick site has recently undergone prescribed fire management. The efforts at Cloverlick have created a substantial amount of habitat for this species and it was found scattered throughout the open and lightly wooded portions of the 1,300 acre site. *Cycnia inopinatus* overwinters as a tough, silken cocoon at the base of *Asclepias* stems or nearby in the surface detritus. Pupae/cocoons hibernating in this dried vegetation would surely be consumed in a fire. Therefore, this species is considered fire-sensitive, although it is possible that at least some *Asclepias* may escape fire in a given burn.

In sites where it is known to occur, unburned refugia containing *Asclepias tuberosa, A. verticillata* or related species should be left to provide stock for re-colonizing the newly restored areas.

Efforts to manually remove exotic invasive plants (as mentioned in previous sections) have also benefited this species, by reducing competition with its larval food plant and adult nectar sources. This is especially true with regards to glossy buckthorn, multiflora rose and non-native honeysuckles.

PAST AND CURRENT CONSERVATION ACTIVITIES

The unexpected tiger moth has always been reported as 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. It is also becoming apparent that we need to assess the health and long-term viability of these populations. Currently, the unexpected tiger moth is considered critically imperiled (S1S2) in Indiana and Virginia (S1S3). However, it is listed as probably of historic occurrence in New York. All other states have it listed as secure or unranked.

RESEARCH AND MONITORING

Currently, little or no research is being conducted regarding the unexpected tiger moth. *Asclepias* has attractive foliage and flowers and several species are already cultivated, with innumerable cultivar's developed over many years of breeding. Finally, the habitats occupied by this moth and its foodplant are aesthetically pleasing to the human eye. These attributes could make restoration of occupied and potential *Cycnia inopinatus* habitat more attractive to land managers and the general public.

EXISTING SURVEYS, MONITORING, AND RESEARCH

At the present time, 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 previously unknown Indiana populations of *Cycnia inopinatus* (Bess, 2004).

SURVEY PROTOCOL

Surveys for the unexpected tiger moth should initially be focused on known populations of *Asclepias tuberosa, A. verticillata* or similar species. Timing of surveys should occur when the larvae are present, as these are the easiest to locate and identify. Best timing for surveys is mid-July. Look for feeding signs on the leaves and the distinctive larvae. Adults can be surveyed for with ultraviolet lights, but this is a less reliable method of sampling. Given the extreme similarity of adults of this species to other Arctiidae, vocuher specimens should be collected from any new population. The larvae of *Cycnia inopinatus* is unmistakable and the two species' larvae are very dissimilar. Larvae can be photographed and easily identified to species. Collected adults can be placed live into a glass or plastic jar and frozen. If a killing jar is at your disposal, this may be used instead. Collected adults should be either kept in a freezer or pinned and affixed with a label bearing the following information:

1. State, County, Town, Range, Section and quarter section (or nearest reference point) of origin;
2. Date of Collection
3. Name of Collector
4. Type of habitat

The specimen can then be forwarded to an expert on the group for verification. A list of potential identification experts for *Cycnia* specimens is given in Appendix A.

MONITORING PROTOCOL

To conduct long-term monitoring programs, a long-term 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 *Cycnia inopinatus* should involve the designation of at least one permanent, monitoring transect. Monitoring transects should be placed in patches of *Asclepias* and occur when larvae are roughly half-grown (mid-July).

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 *Asclepias* observed within 30 feet of the transect line should be counted and searched for larvae. Standardized survey forms can easily be developed for such surveys. At a minimum; transect name, location, date and time should be noted on each survey form. If more than one transect is being used, each should be identified individually. Information on plant phenology, species blooming, canopy cover, invasive species, predation, etc. is also useful. Surveys should be conducted when larvae are at their peak of growth (July or September). These surveys can provide a wealth of data for use in tracking long-term population shifts in size, phenology, distribution and resource utilization.

RESEARCH PRIORITIES

Further research is needed regarding the exact habitat requirements of this species, such as:

1. Optimal canopy cover,
2. Minimum habitat patch size requirements,
3. Optimal density and distribution of *Asclepias*,
4. Long-term fire effects and optimal fire regime,
5. Effects of invasive plants (and efforts to control them) on milkweed, nectar sources and the moth,
6. Effects of silvicultural activities such as pine plantations, pesticide application, harvesting, etc.

It is also quite probable that there are additional, undetected populations of this species in the central United States. Statewide efforts are needed to survey for this and other rare species.

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.*

Bellocq, M.I., J.F. Bendell, and B.L. Cadogan. 1992. Effects of Bacillus thuringiensis on Sorex cinereus (masked shrew) populations, diet, and prey selection in a jack pine plantation in northern Ontario. *Canadian Journal of Zoology 70:505-510.*

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.

Britton, C., J. Cornely, and F. Sneva. 1980. Burning, haying, grazing, and non-use of flood meadow vegetation. Oregon Agricultural Experiment Station. Special Report no. 586:7-9.

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.

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.*

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.

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.*

Faulkner, S., and A. de la Cruz. 1982. Nutrient mobilization following winter fires in an irregularly flooded marsh. *Journal of Environmental Quality 11:129-133.*

Forbes, W. 1954. The Lepidoptera of New York and Neighboring States: Part III Noctuidae.

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.

Glasser, J. 1985. Successional trends on tree islands in the Okefenokee Swamp as determined by interspecific association analysis. Am. Midl. Nat. 113:287-293.

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

Gresham, C. 1985. Clearcutting not enough for early establishment of desirable species in Santee River swamp. Southern Journal of Applied Forestry 9:52-54.

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.*

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.*

Hessel, S.A. 1954. A guide to collecting the plant-boring larvae of the genus Cycnia (Noctuidae). Lepidoptera News 8:57-63.

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.*

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.*

Homoya, M. 1994. Indiana barrens: Classification and description. *Castanea 59(3):204-213.*

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

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.*

Kelsall, J. P., E. S. Telfer, and T. D. Wright. 1977. The effects of fire on the ecology of the boreal forest, with particular reference to the Canadian North: a review and selected bibliography. *Canadian Wildlife Service Occasional Papers no. 32. 58 pp.*

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.*

Lorimer, C. 1977. The presettlement forest and natural disturbance cycle of northeastern Maine. *Ecology* 58:*139-148.*

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*.

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

Medina, A. (1990). Possible effects of residential development on streamflow, riparian communities, and fisheries on small mountain streams in central Arizona. *Forest Ecology and Management 33/34: 351-361.*

Metzler, E., J. Shuey, L. Ferge, R. Henderson and P. Goldstein. 2005. Contributions to the Understanding of Tallgrass Prairie-Dependent Butterflies and Moths (Lepidoptera) and their Biogeography in the United States. 143 pages. Ohio Biological Survey, Inc. Columbus, OH.

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. Search Results for Cycnia beeriana (dated May 01, 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.
Nuzzo, V. 1986. Extent and status of Midwestern oak savanna: presettlement and 1985. *Natural Areas Journal 6:6-36*.
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.*
Penfound, W. 1952. Southern swamps and marshes. *Botanical Review 18:413-446.*
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., 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.*

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.

Rings, R., E. Metzler, F. Arnold and D. Harris. 1992. The Owlet Moths of Ohio (Order Lepidoptera: Family Noctuidae). *Ohio Biological Survey IX (2) New Series. 219 pages.*

Rowe, J. , and G. Scotter. 1973. Fire in the boreal forest. *Quaternary Research (NY) 3:441 164.*

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. 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.*

Smith, J. 1889. Revision of the genus Hydroecia. *Transactions of the American Entomological Society 26: 1-48, 2pls*

Slaughter, C., R. Barney, and G. Hansen, editors 1971. Fire in the northern environment-a symposium. *U.S. Forest Service, Pacific Northwest Forest Range Experiment Station, Portland, OR. 275 pp.*

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

Thompson, D. 1959. Biological investigation of the Upper Fox River. *Wisconsin Conservation Department Special Wildlife Report 2. 41 pp.*

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.

Uhler, F. 1944. Control of undesirable plants in waterfowl habitats. *Transactions of the North American Wildlife Conference 9:295-303.*

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.*

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.*

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

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

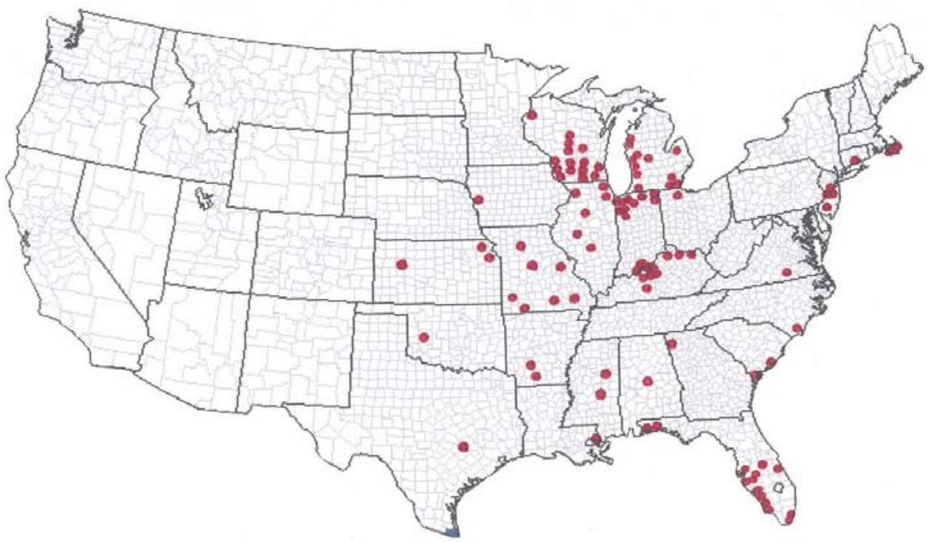
Kirk Larson, Hoosier National Forest, Bedford, Indiana office. Phone: (812) 277-3596
e-mail: kwlarson@fs.fed.us

FIGURES

Figure 1. Adult of the Unexpected Tiger Moth (*Cycnia inopinatus* (Edwards)).

Figure 2. Larva of the Unexpected Tiger Moth (*Cycnia inopinatus*(Edwards)).

Figure 3. Known Distribution of the Unexpected Tiger Moth (*Cycnia inopinatus*) in eastern North America.



● = Known Occurrence of *Cycnia inopinatus* ✳ = Approximated State Occurrence