Conservation Assessment for Fitch's Elephanthopper (Fitchiella robertsoni (Fitch))

USDA Forest Service, Eastern Region

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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This Conservation Assessment was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a Conservation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.

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EXECUTIVE SUMMARY

Fitch's elephanthopper (*Fitchiella robertsoni* Fitch) is a very small, grayish and black-mottled insect associated with high quality, native grassland remnants in the eastern United States. It is considered rare and intensely local range-wide, with approximately 12 populations known in the world prior to 2000. This highly distinctive, flightless planthopper typically produces two broods per year, although southern populations (such as those in southern Mississippi and Florida) may be present year-round. *Fitchiella robertsoni* is extremely rare and most records are based on one or a few individuals. Suppression of wildfires and conversion to agricultural production in the past 200 years has greatly reduced the amount and distribution of suitable habitat for this and many other species. Most records for this planthopper date from 50-100 years ago, and come from areas that are now completely urbanized, converted to agricultural production or have undergone succession to woodlands and forests following local wildfire suppression. The adults of *Fitchiella robertsoni* are sedentary and are never found outside of high quality barrens remnants. The few, fragments of suitable habitat that remain are often small and isolated from one another. Numerous invasive species (both plant and animal) appear to pose imminent threats to the survival of many populations of this rare insect. They are also sensitive to dormant season fires, but possibly less so than some other grassland leafhoppers and planthoppers. Therefore, a concentrated effort to identify populations prior to the initiation of burn management is warranted to avoid accidental extermination. The protection, restoration and expansion of known populations will be needed to ensure the long-term survival of Fitch's elephanthopper across its range.

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 Boone Creek, Cloverlick and Harding Flats Barrens Special Areas, where I eventually discovered healthy populations of *Fitchiella robertsoni*. Ron Panzer (Northeastern Illinois University) provided valuable information regarding the current known distribution and biology of Fitch's elephanthopper in Illinois. Richard Henderson and Scott Sauer (Wisconsin DNR) were also very helpful in providing information from their exhaustive surveys of the insects occurring on Wisconsin prairies. Dr. Luciana Musetti (The Ohio State University) provided valuable information on some previously unknown specimens of *Fitchiella robertsoni* housed in the Charles Triplehorn Insect Collection at OSU. Finally, I would like to thank K. G. A. (Andy) Hamilton at Agriculture Canada in Ottawa, Ontario. Dr. Hamilton is a world authority on the Homoptera and Cicadellidae. He provided information on *Fitchiella robertsoni* habitat in Canada and records housed in the Canadian National Insect Collection.

NOMENCLATURE AND TAXONOMY

Fitch's elephanthopper (*Fitchiella robertsoni*) was first described by Asa Fitch in 1856 as *Naso robertsoni*. VanDuzee (1917) found that the name *Naso* was pre-occupied and proposed the name *Fitchiella* as its replacement. Lawson synthesized the genus in 1933, with seven species, five of which he described as new from the American West. In 1941, Kathleen Doering re-described *Fitchiella robertsoni* and related species in her thorough treatment of the planthopper family Issidae.

DESCRIPTION OF SPECIES

DESCRIPTION OF ADULT STAGE

Fitch's elephanthopper typically measures 3-5 mm (0.2 inches) in length and is named for the large, black margined process or "nose" that occupies much of the face (Figure 1). The forewings (also called "elytra") are extremely shortened, barely covering the first three abdominal segments. The wings and body are light grayish to olive brown in color, with patches of blackish and brown forming a mottled pattern. The wing veins are also margined in dark brown. The hindwings are absent. The legs are light tan, dark brown and grey.

Fitchiella robertsoni can only be confused with one other *Fitchiella* species, *F. fitchii* (see Doering, 1941). However, the latter species is either peach or a darker brown and larger, typically six to eight millimeters in length. The nasal process is also shorter and less bulbous. *Fitchiella fitchii* is known from only a handful of sites in the central Great Plains, where it can be locally common (Doering, 1941). All other *Fitchiella* species are black or blackish and occur in the American Southwest. It is somewhat ironic that, given its rarity, this is one of the most commonly figured insects in North America. Since their seminal work "an Introduction to the Study of Insects" was first published in 1964, Borror, DeLong and Triplehorn have figured *Fitchiella robertsoni* as the signature species for the family Issidae (figure 212L on page 307 in the 1976 edition).

DESCRIPTION OF IMMATURE STAGES

Nothing is known about the life history of this species. Given behaviors observed in related species, it is assumed that the eggs of *Fitchiella robertsoni* are inserted into tissues of their foodplant(s). The eggs then hatch into nymphs, probably rather soon (one to two weeks). The young nymphs of plant hoppers feed by sucking fluids from tissue in the veins on the leaves and stems of the foodplant(s). As they grow, the nymphs become more similar to adults in size and development of the nasal process and genitalia. All stages lack well-developed forewings and the hindwings are absent.

LIFE HISTORY

REPRODUCTION

All Homoptera are hemimetabolous, meaning they pass through a gradual metamorphosis in which each stage resembles a small adult. In winged species, the wings are at first minute and subsequently grow larger, with the adult stage being reached following the final moult (skin shedding event). However, with *Fitchiella*, the wings remain as small pads, incapable of flight. *Fitchiella robertsoni* adults appear in late summer (mid-August through September). They feed, mate and (it is assumed) females lay eggs over a protracted period of several weeks to a few months or more. Eggs are laid either in plant tissues or on the ground near foodplant(s). In the Hoosier National Forest, many adults apparently overwinter and are observed again in the early spring, presumably feeding and continuing to reproduce. Therefore, the adult brood period can last up to nine months. In the Hoosier NF, adults tend to disappear in sweep net samples by late June.

ECOLOGY

Fitchiella robertsoni is extremely rare and was historically known from a few scattered sites in the eastern United States. Given its rarity, little has been published about the ecology of this species. Little is known about the primary food plant(s) of *Fitchiella robertsoni*. In discussions with Ron Panzer, he states that his collections on "goathill prairies" in west-central Illinois were in close association with French grass (*Orbexilum onobrychis*). In the Hoosier National Forest, *Fitchiella robertsoni* is found in dry barrens on hilltops and upper slopes where *Orbexilum pedunculatum, Desmodium* spp., *Lespedeza, Tephrosia virginiana,* and native grasses are common. Vegetation in the Hoosier NF habitats is typically moderate to tall in height (1-2 meters: ~3-6 feet) and dominated by perennial grasses and forbs in the plant families Asteraceae and Fabaceae.

As in other Issidae, the species presumably feeds by sucking fluids from the phloem tubes in leaf veins of their foodplant(s). The Mississippi habitat was dry, blackjack oak (*Quercus marilandica*) barrens on the Atlantic Coastal Plain, while the Wisconsin habitats are predominantly dry hill prairies in the unglaciated "Driftless Region" in the SW part of the state. Hamilton (2005, pers. comm.) states that the Ontario habitat is sand dunes on Alvar along the southern Great Lakes, where the species is found in a northern, barrens-like habitat in the back dunes, with a mixture of brush and herbaceous species. He associates *Fitchiella robertsoni* with *Aristida* grasses, although these grasses are rare or absent from the Indiana and Illinois habitats.

DISPERSAL/MIGRATION

Given its specific habitat requirements and limted vagility, *Fitchiella robertsoni* rarely (if ever) leaves the native grasslands where it is found. The adults are rather sedentary, typically moving carefully among plants, oftentimes crawling through vegetation. The females lay numerous small

eggs and probably disperse over a fairly small area during the course of their lives (~400 square feet). This elephanthopper is not known to migrate, lacks wings and is flightless.

OBLIGATE ASSOCIATIONS

The obligate habitat for Fitch's elephanthopper is high quality, dry native barrens containing an abundance of relatively short buchgrasses, and a variety of forbs such as scurfy peas (*Orbexilum* and *Pediomelum* spp.). In the Hoosier National Forest, *Fitchiella robertsoni* is associated with *Orbexilum pedunculatum* and a rich mixture of native plants in dry barrens remnants on limestone dominated by little bluestem and Indiangrass (Bess, 2004). This elephanthopper was always collected near or in stands of *Orbexilum*, and adults are superficially identical to its dried seedpods. Fitch's elephanthopper also shares its habitat with a number of regionally and globally imperiled insect, plant and vertebrate species (see Bess, 1990-2004; Panzer et al., 1995).

HABITAT

Fitchiella robertsoni occurs in a few, closely related grassland types, including dry gravel hill prairie, sand dunes on limestone bedrock alvar and oak-pine barrens. Dozier (1932) reported sweeping eight adults and several nymphs of *F. robertsoni* from coarse grasses in a blackjack oak (*Quercus marilandica*) and shortleaf pine (*Pinus resinosa*?) woodland in southern Mississippi. Andy Hamilton of Agriculture Canada has found this species with a number of other prairie endemic Homoptera on sand dunes at an alvar (limestone bedrock grassland) site along southern Lake Huron in Ontario, Canada (Hamilton, 1998).

Osborn (1938) reported that the Ohio record came from Adams County and was collected by Knull in 1934. Adams County occurs in the extreme southeastern part of the state, along the Ohio River. The County is known to contain numerous barrens sites, many of which have large open, grass-dominated areas often called "prairies". Panzer collected several adults from gravel hill prairies along the Illinois River in west-central Illinois. Here, the vegetation was dominated by short to medium height bunchgrasses like side oats gramma (*Bouteloua curtipendula*), little bluestem (*Schizachyrium scoparium*) and prairie dropseed (*Sporobolus heterolepis*). It also occurs on Dolomite bluff prairie along the Mississippi River, as in SW Wisconsin. In Indiana, this species is found primarily in high quality, blackjack-post oak barrens on thin clay soils over limestone and sandstone bedrock along the Ohio River.

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

In the Hoosier National Forest (HNF) of extreme southern Indiana, *Fitchiella robertsoni* is found on unglaciated limestone barrens along the Ohio River (see Figure 2). The habitat occupied by this leafhopper in the Hoosier NF is considered exemplary for high quality remnants in the Ohio River Valley and is as described below. On the Hoosier, populations of Fitch's elephanthopper are associated with *Orbexilum pedunculatum*. This plant is local in the Hoosier National Forest, found primarily in isolated colonies occurring on small roadside prairies, powerline rights-of-

way and scattered throughout high quality, fire-maintained barrens. In high quality barrens remnants, *Orbexilum pedunculatum* occurs on toe slopes or decomposing rock outcrops and in areas having thicker soils on the tops of ridges. Most of the roadside populations of this plant are small, highly isolated and do not support populations of Fitch's elephanthopper.

SITE SPECIFIC

Hoosier NF: Boone Creek Special Area

Boone Creek SA is a formerly fire suppressed barrens complex that has recently undergone intensive fire management, with very positive results. Here, *Orbexilum peduncultaum* is found in scattered patches in the more open barrens, especially on the upper portions of south and southwest facing slopes and along the roadside on the north boundary of the Special Area. The canopy is near 100 percent throughout much of the SA, but recent fire management has eliminated much of the subcanopy woody growth, especially on upper slopes. Removal of detritus and competing woody plants has allowed the herbaceous layer to flourish. In many areas there is a fairly thick cover of sedges, grasses and forbs. Characteristic sedges include *Carex albicans, C. cephalophora, C. complanata, C. frankii, C. glaucodea* and *C. granularis*. Warm season grasses dominated in open areas and along roadsides, with big bluestem, little bluestem and Indiangrass being most frequent. In more shaded areas, wood oats (*Chasmanthium latifolium*), poverty oatgrass and rye grasses (*Elymus* spp.) typically dominated the graminoid component..

In the more diverse portions of the Special Area, characteristic forbs include agave (*Agave virginica*), pussytoes (*Antennaria plantaginifolia*), smooth blue aster, butterfly weed, pale Indian plantain (*Cacalia atriplicifolia*), bluebells (*Campanula americana*), New Jersey tea (*Ceanothus americanus*), tall tickseed (*Coreopsis tripteris*), partridge pea (*Cassia fasciculata*), sticktights (*Desmodium* spp.), purple coneflower (*Echinacea purpurea*), rattlesnake master, flowering spurge, woodland sunflower (*Helianthus divaricatus*), bush clovers, blazingstars (*L. aspera, L. spicata, L. squarrosa*), puccoon, bergamot (*Monarda fistulosa*), prairie phlox (*Phlox glaberrima*), downy phlox, narrow-leaved mountainmint (*Pycnanthemum tenuifolium*), gray coneflower (*Ratibida pinnata*), wild roses (*Rosa carolina* and *R. setigera*), prairie dock, three-leaved rosinweed (*Silphium trifoliatum*), American columbo (*Swertia caroliniensis*), goat's rue and tall ironweed (*Vernonia altissima*). There is approximately 40 acres of high quality *Fitchiella robertsoni* habitat at Boone Creek, with another 100 to 200 acres of fair to marginal habitat.

Hoosier NF: Clover Lick Special Area

The Clover Lick Special Area is a ca. 1,300 acre complex of open and closed canopy oak and oak-pine barrens. This entire site was formerly open barrens and prairie, with old, widely spaced blackjack oaks, post oaks and hard pines in the canopy layer. Historically, a farm was developed here and part of the site was planted for soft pine timber production. Along with these activities came fire suppression, further degrading the barrens. Currently, much of the site is closed in

with young oaks, maples (*Acer* spp.) and hickories (*Carya* spp.). However, recent restoration activities (including removal of the pine plantation) have opened approximately 200 acres of "prairie-like" barrens. *Sorghastrum* grows profusely in these open, grassy barrens and in the 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 Indiangrass.

In occupied *Fitchiella robertsoni* habitat, the herbaceous vegetation is dominated by warm season bunchgrasses like bushy bluestem (*Andropogon glomerata*), broomsedge (*A. virginica*), little bluestem and Indiangrass. Big bluestem is more local in distribution. Additional common grasses include poverty oatgrass and panic grasses (particularly *Panicum anceps* and species in 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, the latter a co-dominant throughout much of the higher quality habitat.

Characteristic forbs include; wild onion (*Allium canadense*), smooth blue aster (*Aster laevis*), swamp aster (*Aster puniceus*), white wild indigo (*Baptisia leucantha*), blue hearts (*Buchnera americana*), 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*), cream gentian (*Gentiana alba*), downy sunflower (*Helianthus mollis*), rough blazingstar (*Liatris aspera*), scaly blazingstar (*Liatris squarrosa*), marsh blazingstar (*Liatris spicata*), bushclovers (*Lespedeza* spp.), bergamot (*Monarda fistulosa*), marsh phlox (*Phlox glaberrima*), obedient plant (*Physostegia virginiana*), Indiangrass (*Sorghastrum*), mountainmint (*Pycnanthemum pycnanthemoides, P. virginianum*), black-eyed Susan (*Rudbeckia hirta*), wild petunia (*Ruellia humilis*), rose gentian (*Sabatia angularis*), three-leaved rosinweed (*Silphium trifolium*), prairie dock, 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 dry oak woodland or barrens, 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, especially on fire suppressed remnants. 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 are generally inhospitable to both *Orbexilum* and Fitch's elephanthopper. This site contains roughly 100 acres of high quality habitat for *Fitchiella robertsoni*, with an additional 200-300 acres of fair to marginal habitat.

Hoosier NF: Harding Flats Special Area

Harding Flats Barrens is another large barrens complex Special Area in the Hoosier NF. Here, *Orbexilum* is found in localized colonies occurring in roadside prairies and more open barrens, especially on the upper portions of south and southwest facing slopes. In some areas that have received recent fire management, this plant can be very common in the shrub-herbaceous layers. The canopy cover by trees is near 100 percent throughout much of the SA, but recent fire management has eliminated much of the subcanopy and shrub growth in some areas. This has allowed the herbaceous layer to flourish in a diverse assemblage of sedges (e.g. *Carex albicans, C. cephalophora, C. complanata, C. frankii, C. glaucodea* and *C. granularis*), grasses (such as big bluestem, wood reed, poverty oatgrass, rye grasses, Indiangrass, little bluestem) and forbs.

Characteristic forbs include agave (*Agave virginica*), pussytoes (*Antennaria plantaginifolia*), smooth blue aster, butterfly weed, pale Indian plantain (*Cacalia atriplicifolia*), bluebells (*Campanula americana*), New Jersey tea (*Ceanothus americanus*), tall tickseed (*Coreopsis tripteris*), partridge pea (*Cassia fasciculata*), sticktights (*Desmodium* spp.), purple coneflower (*Echinacea purpurea*), rattlesnake master, flowering spurge, woodland sunflower (*Helianthus divaricatus*), bush clovers, blazingstars (*L. aspera, L. spicata, L. squarrosa*), puccoon, bergamot (*Monarda fistulosa*), Sampson's snakeweed (*Orbexilum pedunculatum*), prairie phlox (*Phlox glaberrima*), downy phlox, narrow-leaved mountainmint (*Pycnanthemum tenuifolium*), gray coneflower (*Ratibida pinnata*), wild roses (*Rosa carolina* and *R. setigera*), prairie dock, three-leaved rosinweed (*Silphium trifoliatum*), American columbo (*Swertia caroliniensis*), goat's rue and tall ironweed (*Vernonia altissima*). There is approximately 20 acres of known, high quality *Fitchiella robertsoni* habitat at Harding Flats, with another 60 to 100 acres of fair to marginal habitat.

DISTRIBUTION AND ABUNDANCE

RANGE-WIDE DISTRIBUTION

Although *Fitchiella robertsoni* has a fairly broad range in eastern North America, it is known from very few sites and is considered extremely rare and local wherever found (Bess, 2004; Doering, 1941; Dozier, 1934; Hamilton, 1999; Osborn, 1938; Panzer, 2005). Currently, a total of 20 known populations have been recorded from eleven states (see Figure 2). Many of the known records consist of a single specimen and few observers have noted more than a few individuals on a given survey. Osborn (1938) reported a single record from extreme southern Ohio. Dozier (1934) collected several individuals at a single site in southern Mississippi and listed nine additional states from which the species was historically known (AR, FL, IN, KS, MD, MN, MS, NY, OH, OK, TX, WI). Additional records come from specimens housed in the Charles Triplehorn Insect Collection at Ohio State University (Columbus, OH) and at the University of Minnesota Insect Collection (Minneapolis-St. Paul, MN).

STATE AND NATIONAL FOREST DISTRIBUTION

The following state-level distribution information for Fitch's elephanthopper is gathered from a number of sources, including Bess (2004), Haarstadt (2002), Hamilton (1999 and 2005, pers. comm.), (Osborn, 1938) and Panzer (2005, pers. comm.). In discussions with Andy Hamilton, he stated that Fitch's specimens came from "the west" and that the species is not actually known from New York. This leaves nine original states, including Dozier's record from MS. From these nine states, fewer than 25 specimens were known prior to 1998.

Since 1998, Bess and Panzer have identified (at least) six additional populations of this species from hill prairie and barrens remnants in central Illinois and southern Indiana (see Figure 2; Bess, 2004; Panzer et al., 1995 and 2005 pers. comm.). Dr. John Haarstadt has found three new populations in east-central Minnesota (Haarstadt, 2002). Exhaustive surveys for prairie associated insects in Wisconsin found this species in only a few sites (Sauer, 2005 pers. comm.). Illinois, Indiana, Minnesota and Wisconsin have the only known extant populations in the U. S., with approximately three each. Floridas has four historic populations, at least some of which are probably still active.

National Forest information is provided for the Hoosier National Forest in Indiana. This is the only places where *Fitchiella robertsoni* is currently known to occur in relatively large numbers (indicating robust populations). When known, county-level comparisons with National Forest boundaries were also made for each additional state occupied by the leafhopper. Known or potential occurrences for military installations and other federal landholdings have been included when relevant.

Arkansas

A single occurrence is known from the state. The exact location of this collection is unknown. Potential habitat for this species occurs throughout much of Arkansas, including the Quachita National Forest. However, recent collecting efforts have not found this species (Bess, 1997, 1998, 1999).

Illinois

There are three known populations in the southern part of the state (Panzer 2005, pers. comm.). There are no known National Forest occurrences. Suitable habitat for this species likely occurs in the Shawnee National Forest, but no surveys have been undertaken to date. Populations are known from just to the south, over the Ohio River, in Kentucky. *Fitchiella robertsoni* is currently known from three fire-maintained prairie preserves in the state of Illinois, all along the Illinois and Mississippi Rivers.

Indiana

Fitchiella robertsoni is known from four populations in the state, one historic and three current. The current populations all occur in the Hoosier NF in the extreme southern tip of the state (see Figure 2).

Florida
Dozier records two individuals collected by J. C. Drake at Gainsville on July 28, 1918. Dr. Lucianna Mussetti provided specimen information from the Charles Triplehorn Insect Collection at The Ohio State University. This important collection contains most of the specimens from the monumental works of both Herbert Osborn and Dwight DeLong. Dr. Musetti found nine additional Florida specimens from:

- Sebring, FL on May 16, 1939 by D. J. & J. N. Knull (7),
- St. Petersburg, FL on March 11, 1921 by H. Osborn (1), and
- Miami, FL., on April14-21 collector unknown (1)

These areas are now heavily developed and the current status of these elephanthopper populations is questionable. However, potentially suitable habitat may still occur in the state, including the Ocala and Appalachicola National Forests.

Kansas
Dozier reported this species from Kansas. The exact location of this record is unknown, although it likely comes from a localized habitat type, possibly hill prairie along the Missouri River. No National Forests occur in Kansas.

Maryland
A single record exists for the state (see Dozier, 1926). Its current status is unknown. Only limited leafhopper and planthopper sampling has been undertaken in Maryland, so additional populations of this species are possible.

Minnesota
Dr. John Haarstad (University of Minnesota) has recorded this rare species from three sites in east central Minnesota, near the Mississippi River (see Cedar Creek, 2002). These are among the few known extant colonies of this species in the World.

Ohio
Osborn recorded this species from a single specimen collected by J. N. Knull in Adams County in 1934. No other records are known for the state. There is still much potential habitat for this species in Adams County and possibly surrounding regions, including the Scioto National Forest.

Oklahoma
A single record is known from the state, exact location unknown. There are likely additional, undiscovered, populations in the Crosstimbers and Osage Hills regions.

Texas
Known from a single ancient record (Dozier, 1926). There is additional potential habitat for this species in the Davey Crockett National Forest and other part of east and coastal Texas. Little Homoptera collecting has been undertaken in the state since the early part of the 20th century.

Wisconsin
Fitchiella robertsoni has recently been recorded from four sites in Wisconsin (Sauer, 2005 pers. comm.). All are associated with the Mississippi River drainage. Three are in the southwest corner of the state on Dolomite Hill Prairie and one is in the northwest corner of state, near the Minnesota occurrence.

RANGE WIDE STATUS

Despite its extreme rarity and distinctive appearance, *Fitchiella robertsoni* is still an unknown organism (from a conservation perspective) in most of the states from which it has been recorded. The lack of specimens of this easily collected species in nearly all major insect collections attests to its historic rarity. There is strong evidence to conclude that Fitch's elephanthopper is imperiled rangewide. This is especially true with regards to its preferred habitats; high quality barrens and hill prairie remnants. The following information was gathered (in part) from the NatureServe Website in November of 2005. NatureServe has not yet provided this species with a Global Rank. Global and National ranks in ( ) are herein proposed for *Fitchiella robertsoni*.

Global Status: GNR (G2G3)
Global Status Last Reviewed: - (November, 2005)
Global Status Last Changed: GNR
Rounded Global Status: GNR (G2)
National Status: GNR (N2)
Status and Ranking by: NatureServe (J. A. Bess)

STATE-LEVEL STATUS (S-RANKS)

The NatureServe Website contains no information on this species other than a few state ranks (NatureServe, 2005). Despite its historic rarity, Fitch's elephanthopper is considered an imperiled species only in Indiana (S1S2). Florida, Kansas, Maryland, Oklahoma and Texas have this species unrecorded and unranked. The Illinois and Wisconsin DNR have this elephanthopper listed on their websites as "a Species of Greatest Conservation Concern" (ILDNR, 2005; WIDNR, 2005). *Fitchiella robertsoni* is listed as a State Threatened species in Indiana (INDNR, 2005).

STATUS OF HABITAT IN WESTERN RANGE

The NatureServe site provides little 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 *Fitchiella robertsoni* habitat at Clover Lick 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). One of the oak 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 Muldraugh Hills of west-central Kentucky, where superficially identical habitats occur in Meade, Hardin and Bullitt Counties and are similarly imperiled (G1G3; NatureServe, 2005). 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)

The Minnesota populations are located in the Cedar Creek Natural History Area (CCNHA). This site is a 5400-acre research preserve owned by the University of Minnesota (see Haarstad, 2002). CCNHA is located on the Anoka/Isanti County boundary, roughly 30 miles north of the Minneapolis-St. Paul metropolitan region in east-central Minnesota. The Research Area lies on sandy outwash plain near the Mississippi River. The Research Area is divided into four subeaqual parts: wooded uplands, abandoned fields, lowland wooded swamps, and open marshes. The upland habitats were historically dry prairies and barrens on fine, highly erodible, outwash sands. Lowlands often have a muck-peat substrate atop sand and support(ed) marsh, wet prairie and fen habitats. These peaty depressions were formed in ice-block basins following the last Wisconsin glacial retreat. *Fitchiella* was found only in a few of the old fields that had reverted to a prairie-like condition.

POPULATION BIOLOGY AND VIABILITY

Prior to European settlement of the continent, *Fitchiella robertsoni* apparently occurred on native grasslands across eastern North America. Fire suppression, and the rapid transformation of the Nation's barrens and hill prairies to pasture and intensive row crop agriculture, followed the westward expansion of European colonials in the mid-1800's. Concurrently, this led to a rapid reduction in habitat acreage for *Fitchiella robertsoni* and other grassland species. Today, this planthopper exists as a small collection of isolated populations varying greatly in size. It is quite possible that some historic populations may no longer be extant. Recent insect surveys in Arkansas and Kentucky failed to find this species, despite exhaustive sampling efforts (Bess, 1990-2001). Conversely, Arkansas, the Carolinas, Missouri, Iowa, Kansas, Oklahoma and Texas all contain fairly extensive amounts of potential habitat for this species but are poorly sampled for Homoptera.

POTENTIAL THREATS

The preferred habitats of Fitch's elephanthopper are prairies, savannas or barrens that were historically maintained 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, available habitat for this species has been greatly reduced through fire suppression, overgrazing, the conversion of grasslands to row crop agriculture, residential development/urban sprawl and other human activities.

Remaining suitable habitat for *Fitchiella robertsoni* typically occurs as small (10 acres or less), highly isolated grasslands, separated from one another on the landscape by vast expanses of agricultural lands, urban/suburban sprawl and other man-made habitats. In addition, the environmental forces that once created and regulated these grasslands (e.g. fire, bison herds, prairie dog towns) are no longer functioning. Invasive, non-native plants have also colonized these degraded habitats and are currently invading many remnant natural areas. Fitch's elephanthopper is also susceptible to depredation by a variety of insect predators and parasites. Because of its overwintering characteristics, this leafhopper is highly susceptible to immolation during dormant season fires and small, isolated populations are easily eradicated when fire consumes their habitat completely. Real and potential threats to this species and its habitat are outlined below.

ROW CROP AGRICULTURE

The conversion of much of the Great Plains and central Midwest to large scale, row crop agricultural production following World War II coincided with a precipitous loss of wet prairie, fen and sedge meadow habitat (see Hutchinson, 1996). Up until this time, most U.S. farms were small and diverse, geared towards self-sustenance and supplying small local economies. Often, wetter parts of the land were placed under pasture or ignored and fencerows were common. Marginal areas of farmland often contained a diverse assemblage of prairie plants, associated insects and other organisms. 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 were 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 allowed many formerly unfarmable acres to be tilled, especially in the drier prairies and barrens of the Midwest and Great Plains.

FIRE SUPPRESSION

The suppression of wildfires following European colonization is among the more profound changes to the North American environment in the past 5,000 years (see Heinselman, 1981; Nuzzo, 1996). Fire is known to regulate vegetation structure, which has a reciprocal influence on fire frequency (Anderson et al., 1970; Anderson and Brown, 1986; Anderson et al., 1999; Auclair, et al., 1973; Bancroft, 1977; Cohen et al., 1984; Daubenmire, 1968; Duever, et al., 1986; Forman, 1979; Glasser, 1985; Henderson and Long, 1984; Kozlowski and Ahlgrens, 1974; Schwaegman and Anderson, 1984; Tester, 1989; Wade, et al., 1980; Weaver, 1954; Weaver and Fitzpatrick, 1934; Wells and Boyce, 1953; Wright and Bailey, 1982). In the absence of fire, many formerly open, grass-dominated plant communities have quickly succeeded to shrublands and closed canopy forests.

It has been well documented that many North American grass 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; Kirby, et al., 1988; Komarek, 1971: Lotan, 1981; Loveless, 1959; Penfound, 1952; Schwegman and Anderson, 1984; Thompson, 1959; Weaver and Alderson, 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 (Allan and Anderson, 1955; Anderson and Brown, 1986; Britton, et al., 1980; Daubenmire, 1968; Dorney and Dorney, 1989; Grimm, 1984; Henderson and Long, 1984; Kozlowski and Ahlgren, 1974; Kline, 1984; Lotan et al., 1981; Miller, 1963; Schwartz and Heim, 1996; Schwaegman and Anderson, 1984; Tester, 1989; Tester and Marshall, 1962; Uhler, 1944; White, 1983; Wright and Bailey, 1982).

Fire also reduces canopy cover of woody species and removes accumulated detritus (Gresham, C. A. 1985; Linde, 1969; Linduska, 1960; Miller, 1963; 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 (Allan and Anderson, 1955; Auclair, et al. 1973; Cohen, 1974; Dorney and Dorney, 1981; Lorimer, 1985; Smith and Kadlec, 1985; Thor and Nichols, 1973; U.S. Fish and Wildlife Service, 1964). Burning also releases nutrients, although their availability is often limited temporally (Bancroft, 1977; Bayley and Odum, 1976; Faulkner and de la Cruz, 1982)

FIRE MANAGEMENT

In the case of *Fitchiella robertsoni*, fire can cause direct mortality of its overwintering stages (adults and poss. eggs in S. Indiana), given their location in the previous year's detritus on the soil surface. However, from observations made at the Boone Creek site in the Hoosier National Forest (Perry Co., IN), adults or eggs can either survive spring burns or the nymphs/adults move into habitat from nearby refugia rapidly. In June of 2003, a few adults were collected from barrens at this site burned earlier that spring (March). The nearest unburned refugium occurred over 500 yards away across a 30 foot-wide dirt road from the burn unit. If the adults did come from nearby refugia, this movement apparently happened quickly, especially given their lack of wings. However, adults were collected some distance from the unit boundary (>200 yards) and it is suspected that at least some of them originated in the burned unit. If eggs are the overwintering stage, they may be placed under the soil surface, further aiding their ability to survive fire.

Somewhat conversely to the hopper, *Orbexilum* (=*Psoralea*) *tenuiflora* and native warm season grasses all tend to respond favorably to burn management through an increase in above-ground biomass, number of flowering heads and increased seed production (Dokken and Hulbert, 1978; Hulbert, 1969, 1981; Towne and Knapp, 1999). Therefore, although fire is essential to the long-term survival of *Fitchiella robertsoni* habitat, some precautions are necessary to ensure that the entire population of the elephanthopper (or its food plant) is not contained in a single burn unit. In much of its range, *Fitchiella robertsoni* is probably double brooded and the second generation of adults is typically larger than the earlier one. These adults can move into adjacent, recently burned

habitat, allowing them to more rapidly colonize newly managed habitat than more northern populations.

GRAZING AND MOWING

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 elephanthopper (in many instances) may be greatly facilitated by the fact scurfy peas are avoided by domesticated grazing animals.

Extensive livestock grazing reduces the cover of native grasses and forbs on which the adult elephanthopper depends for food, resting places and cover. 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 southern barrens inhabited by *Fitchiella robertsoni*, 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., 1970; 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 the cool-season grasses native to northwestern Europe. 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 organisms 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 wet-mesic pasture "enhancement" or "restoration" include redtop (*Agrostis alba*), smooth brome (*Bromus inermis*), fescue (*Festuca elatior* and others), reed canary grass (*Phalaris arundinacea*) and Kentucky bluegrass (*Poa pratensis*). On less saturated soils, legumes such as clovers (*Melilotus* and *Trifolium* spp.), alfalfa (*Medicago sativa*) or black medic (*Medicago lupulina*) are often placed in the grass mix to provide nitrogen fixation in the soil and fodder for livestock. On drier sites (especially in sand), grasses such as smooth or Hungarian brome (*Bromus inermis*), crested wheatgrass *(Agropyron cristatum*), bluegrasses and greasegrass (*Tridens flava*) are often planted as pasture enhancers. Clovers and alfalfa are often included in the pasture mix. In Florida, subtropical pasture mixes are used, including both native and non-native grasses such as bahiagrass (*Paspalum notatum*: non-native) and St. Augustine grass (*Stenotaphrum secundatum*: native).

These methods have become indoctrinated into our system of land reclamation and persist to this day. By producing large amounts of seed that germinate under cool temperatures, these European 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 activities may eliminate potential habitat for Fitch's elephanthopper, particularly along fencerows and roadsides.

Only in the past 20 years have native species been actively marketed as viable alternatives for use in erosion control, bank stabilization and pasture or range enhancement. Recent research has found that, despite their widespread use, non-native pastures often harbor large populations of pest insect species (typically 10 times those found on adjacent native pastures), with many of them also being non-native (Bess, et al., 2004). The inclusion of alfala and sweet clovers in the pasture greatly increases the abundance of non-native pest species. Native grass and forb species provide much better sustainable forage over the course of the growing season and support fewer agricultural pest insects.

COMPETITION FROM INTRODUCED SPECIES

In addition to the pasture species mentioned above, a number of other introduced plants threaten the quality and long-term survival of habitat for Fitch's elephanthopper. It is estimated that the U. S. government spends 138 billion dollars each year in damage from introduced species and their control efforts (BASF, 2005). In the Great Plains, these include downy brome (*Bromus tectorum*), musk thistle (*Carduus nutans*), spotted knapweed (*Centaurea maculatum* and others), Canada thistle (*Cirsium arvense*), leafy spurge (*Euphorbia esula*), St. Johnswort (*Hypericum perforatum*), whitetop (*Lepidium draba*) and many others (see McKnight, 1993; Miller, 2003; Swearingen, 2004).

In barrens and hill prairies, autumn olive (*Eleagnus umbellatus*), Japanese honeysuckle (*Lonicera japonica*), bush honeysuckle (*Lonicera mackii* and *S. tartarica*), white mulberry (*Morus alba*), glossy buckthorn (*Rhamnus cathartica*), black locust (*Robinia pseudoaccacia*) and multiflora rose (*Rosa multiflora*) are frequent invaders on fire suppressed native grassland remnants. Many native trees and shrubs such as junipers (*Juniperus* spp.), Osage orange (*Maclura pomifera*), 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, Japanese honeysuckle, bush honeysuckles and glossy buckthorn 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 and open areas. Black locust and osage orange have been widely planted for ewindbreaks and erosion control. They are now a common (and often dominant) component of many former natural areas. Many of these species can become so abundant as to exclude nearly all other flora from the ground and shrub layers. They are especially abundant in woodlands and barrens 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). Multiple year, intensive control programs must be implemented to effectively eliminate these species even on the smallest natural areas.

DISEASE OR PREDATION

A number of insectivorous animals feed on leafhoppers, planthoppers and elephanthoppers (Perkins, 1905; Waloff, 1980). These include; dragonflies (Odonata), robber flies (order Diptera: family Asilidae), bullet-head flies (Diptera: family Pipunculidae), twisted-wing parasites (order Strepsiptera), spiders (numerous families) and a variety of parasitic wasps (primarily families Dryinidae, Mymaridae and Trichogrammatidae). The effect of these depredations can be devestating on small, isolated populations of their hosts. Mymaridae and Trichogrammatidae lay their eggs inside the eggs of other insects. Typically these single wasp eggs immediately divide into dozens or hundreds of clones, each of which then develop into a larva and adult. The leafhopper egg is always killed in the process. Bullet-head flies typically catch leafhoppers in the air or resting on plant spems and lay their eggs directly on them. The hatching larvae burrow

into the leafhopper's skin and feeds on the internal organs. Typically, the leafhopper dies when the fully developed larva pupates and emerges as an adult.

Twisted-wing parasites go one step further, causing infected leafhoppers to undergo physical changes in which the genitalia do not fully develop, thus rendering these individuals sterile. In Montana, 25 percent or more of various leafhopper species were infected with Dryinid wasp parasites (Bess, unpub. data). Although these particular parasites do not typically kill their hosts until late in life, they must certainly have a negative effect on their development and likely reduce fecundity. Dryinid wasp females will typically sting numerous leafhoppers, feed on hemolymph (bodily fluids) that exude from the wound and then do not lay an egg. These stung leafhoppers rarely recover (see Guglielmino and Olmi, 1997; Perkins, 1905; Waloff, 1980). A number of diseases can also affect Fitch's elephanthopper and its relatives, but

INSECT PEST CONTROL EFFORTS

Numerous species of leafhoppers are known vectors of plant diseases, causing millions or billions of dollars in crop losses and reduced yields around the world. Therefore, a large part of the annual insect control effort in this country is aimed at eliminating these insects. Although *Fitchiella robertsoni* and related species are not known to be vectors of any plant diseases, they can be negatively impacted by control efforts aimed at pest species.

A number of insect pest species can also occur in wooded areas adjacent to *Fitchiella robertsoni* habitat, particularly in barrens. These include the gypsy moth (*Lymantria dispar*), emerald ash borer beetle, pine shoot tip moth and many others. Control efforts aimed at these species have potential to negatively affect *Fitchiella robertsoni* populations in the event of direct contact during broadcast spraying of insecticides or drift of these pesticides from adjacent control areas. For example, attempts to eradicate the gypsy moth in the middle of the 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 and their predators) 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 insect 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 et al., 1995). Like the earlier pesticides, Dimilin kills insects (and most other Arthropods) indiscriminately across all orders (see Uniroyal Corp., 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; 1988a-b; 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 et al., 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).

Gypsy moth outbreaks tend to occur in oak-dominated forests, woodlands and barrens. Throughout the eastern two-thirds of its range, *Fitchiella robertsoni* occurs in scattered areas of Indiangrass dominated prairie set in a matrix of oak-pine barrens and woodlands. Unfortunately for Fitch's elephanthopper, the gypsy moth currently occurs throughout much of its range. Therefore, the potential for co-occurrence is high. Fortunately for the leafhopper, a biocontrol agent, *Bacillus thuringiensis kurstaki* or *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). This bacterium does not appear to harm leafhoppers, although it indiscriminately kills all Lepidoptera and members of several other insect orders. The spraying of *Btk* 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 and Miller, 1995; Wagner et al., 1996; Whaley, 1998).

These control efforts not only indiscriminately kill countless insects, but also have long-lasting effects on the habitats that are sprayed. For example, the loss of Lepidoptera caterpillars from spraying is known to negatively affect fecundity and body weight in the nesting birds, bats and small mammals that feed on them (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.

In the case of Homoptera, researchers (e.g. Bethke, et al., 2001) are constantly testing the use of several kinds of insecticides and different application methods for the control of leafhopper and planthopper pests. To minimize negative effects on non-target species, applied entomologists have endeavoured to find or design new control methods that more closely target the pest species. Researchers are continuously assessing a variety of predatory and parasitic species for this purpose. All of the above-mentioned parasitic insect groups are potential biocontrol agents for pest leafhopper species. Therefore, buildups in local populations of these parasites in agricultural lands would certainly have potential for negatively affecting populations of *Fitchiella robertsoni* in adjacent habitats. Research is also underway to promote the use of insect pathogens such as *Hirsutella* sp., a fungus that is known to affect leafhoppers in the southeastern United States. All of these control methods have great potential to negatively affect *Fitchiella robertsoni* through increased mortality from parasitism and disease, when applied in adjacent or occupied habitats.

OVER-UTILIZATION

Fitch's elephanthopper's secretive habits and small size make it difficult to collect on a large scale. There is currently no market for rare elephanthoppers and little chance that it will be over-

utilized. However, activities that reduce standing crop of scurfy peas and native grasses on occupied sites should be seen as detrimental to the leafhopper. These activities include heavy grazing, ATV or horse traffic, heavy foot traffic, mowing, salt runoff, excessive fire, tree plantings in prairie or barrens, etc.

RESIDENTIAL DEVELOPMENT

Residential development can negatively affect habitat for *Fitchiella robertsoni* 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).

In the Midwest, high-end and exclusive residential developments are often located in remnants of barrens or savannas in rural areas adjacent to large Metropolitan areas like Chicago, Illinois or Louisville, Kentucky. Hundreds of subdivisions have been developed on the Valparaiso Moraine around Chicago and southern Lake Michigan, in an area that likely contained *Fitchiella robertsoni*. However, all areas of potential habitat were destroyed prior to thorough surveys for this species. 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 the leafhopper and its foodplants. Fire suppression is also a key factor in the development and maintenance of these human-made habitats.

INADEQUACY OF EXISTING REGULATORY MECHANISMS

The lack of any long-standing Federal program to protect, manage and restore the nation's grasslands has led to the degradation or elimination 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 entities such as *Fitchiella robertsoni*. 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 the Nation's natural resources. Many organisms are endangered simply because their habitats are becoming increasingly fragmented and degraded by unchecked human activity. This is especially true for those requiring Midwestern barrens, hill prairie or Atlantic Coastal Plain grasslands. Federally mandated efforts to restore our Nation's grasslands (some of which are already underway), particularly barrens and hill prairies, would not only protect thousands of species from impending doom, but also provide our human population with expanded opportunities for jobs, hunting, fishing, gathering of natural products, education, research, observation and enlightenment.

SUMMARY OF LAND OWNERSHIP & EXISTING HABITAT PROTECTION

The U. S. Forest Service owns occupied *Fitchiella robertsoni* habitat in Indiana and possibly other states (e.g. AR, FL, IL, TX). Additional U. S. landholdings with occupied or potential habitat for the species are also known (e.g. Department of Defense). State and privately managed lands (e.g. Wildlife Refuges, Nature Preserves, Conservation Areas, etc.) are also known to contain occupied or potential habitat for this species. State-level efforts at the conservation, restoration and management of high quality grassland and wetland remnants continue to protect populations of this and other rare species.

Federal congressional efforts have included grassland and wetland protection and restoration as important platforms in the most recent 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 Forest continues to acquire, protect and manage barrens remanants for the conservation and enhancement of native biodiversity. The states of Illinois and Wisconsin are actively managing several known populations of this species on Nature Preserves under their stewardship. Minnesota and Wisconsin are also actively inventorying and managing native grassland remnants containing occupied and potential habitat for this species.

SUMMARY OF EXISTING MANAGEMENT ACTIVITIES AND RECOMMENDATIONS

CURRENT MANAGEMENT ACTIVITIES

Little or no management is currently being directed at *Fitchiella robertsoni* habitat based solely on the species' presence or absence. However, the leafhopper's preferred habitats happen to include globally imperiled plant communities; gravel hill prairie and oak-pine barrens. Therefore, its habitat has received management in some areas, given ongoing efforts to protect and restore these rare plant communities. Programs to manually remove exotic and native invasive plants (as mentioned in previous sections) have benefited this species, by opening the canopy and reducing competition with its larval food plant and adult nectar sources.

RECOMMENDATIONS

In most areas, grassland restoration and management has depended on prescribed fire as a primary tool. Given that *Orbexilum pedunculatum* and native grasses respond favorably to fire, *Fitchiella robertsoni* is found more commonly in fire maintained areas than in those that have been fire suppressed. This is true elsewhere in its range and many historic sites are currently overgrown with shrubs because of fire suppression and other alterations of the environment. However, this leafhopper is extremely sensitive to eradication during dormant season burns because the eggs overwinter in the previous years' detritus, which is highly combustable.

Therefore, on occupied sites, efforts must be undertaken to delineate the boundaries of known population prior to a prescribed burn, and to divide the population between burn units (at least two on large (>100 acre sites) and four on small (<100 acres) sites). By ensuring that at least half of the population remains unburned during a given prescription, individuals will survive to re-populate the newly restored habitat. In the case of sites having two burn units, at least two growing seasons should pass before the adjacent unit is burned. On sites containing four or more units, a given, occupied burn unit should receive fire on a three year or greater rotation (depending on site characteristics and burn prescription). That is, two full growing seasons between burns. In a single year, no more than 25 percent of occupied *Fitchiella robertsoni* habitat should be burned on small sites.

PAST AND CURRENT CONSERVATION ACTIVITIES

Fitch's elephanthopper has always been reported as rare and local (see Whitcomb and Hicks, 1988), though not usually from a conservation standpoint. Conservation of this species has typically been an incidental by-product of efforts to protect and restore remnants of our native grasslands. Only recently have researchers begun to suggest that *Fitchiella robertsoni* is 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, this species is considered Threatened in Indiana (INDNR 2005). In Illinois and Wisconsin, it is proposed as a "Species of Greatest Conservation Concern" (ILDNR, 2005; WIDNR, 2005). Other states from where this species is historically known should undertake surveys for this and other rare insect species.

On an individual level, Dr. Ronald Panzer (Northeastern Illinois University) has gone to great lengths to educate local and regional land managers about the juducious use of fire in restoring and maintaining native grasslands. Dr. Panzer and his associates have conducted thousands of hours of research on the prairies of the Chicago region, assessing the effects of fire on the resident insect populations. His conclusion is that fire is an essential part of managing native grasslands and that, when used wisely, does not negatively affect fire sensitive insect species (i.e. those that overwinter aboveground). This is the current author's determination as well. As a rule of thumb, if no more than twenty-five percent of a fire sensitive insect's habitat is burned in any one season, then that species should have no trouble re-colonizing the newly managed habitat. For sites with *Fitchiella robertsoni* and having abundant and evenly distributed Indiangrass, managers could even burn as much as fifty percent of the occupied habitat in a given year. However, on small sites (1 acre or less), the more conservative numer (25) is recommended.

RESEARCH AND MONITORING

Currently, little research is being conducted regarding Fitch's elephanthopper except for general surveys (see Bess, 1996, 2001, 2004; Panzer et al., 1995) and some fire studies (Panzer and Schwartz, 1998). Much is still unknown about this species, particularly regarding its ability to move between areas of suitable habitat. It is recommended that (whenever feasible) restoration projects involving native grasslands track the effects of restoration techniques on fire-sensitive,

globally imperiled species (such as *Fitchiella robertsoni*) when they are present or known to occur nearby. As with many things, the ability of regional land managers to undertake such studies is limited by funding and availability of expertise. To this end, long-term monitoring of the insect fauna occurring in grassland restorations would address the fundamental question of whether such projects actually provide habitat for rare and imperiled organisms or are merely glorified "flower gardens". In many instances, rare insects are the only significant, non-plant taxa, left on small nature preserves. Once available, such information would allow land managers to measure the effectiveness of a variety of techniques, ultimately leading to more effective restoration of these ecosystems and protection of the rare species they contain.

The food plant of this elephanthopper is an attractive species and would make a valuable landscaping plant. Its foliage, flowers and seeds provide food for a variety of wildlife. Native grasses also produce seeds that are food for a variety of songbirds, small mammals and insects. They provide nesting and resting habitat for numerous birds and small mammals. The preferred habitats of Fitch's elephanthopper are also visually attractive, features which make them excellent candidates for raising public awareness of (and funding for) grassland protection, restoration and creation.

EXISTING SURVEYS, MONITORING, AND RESEARCH

Many of the historic sites for this species have not been visited in over 80 years. Verification of all occurrences 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 *Fitchiella robertsoni*, despite its rarity. However, recent surveys for rare insects on the Hoosier National Forest uncovered new populations (Bess, 2004). Additional surveys have been conducted for this and other rare grassland insect species throughout the Midwest (Bess, 1990-2005). Dr. Ronald Panzer (Northeastern Illinois University) has also been periodically monitoring this elephanthopper at known sites in Illinois. Dr. Panzer has conducted numerous fire effects studies on leafhoppers and planthoppers, in addition to exhaustive surveys of the grassland insect fauna occurring in the greater Chicago region (Panzer, 1998; Panzer et al., 1995).

SURVEY PROTOCOL

Surveys should initially be focused around known historic populations of Fitch's elephanthopper. As a rule of thumb, surveys should concentrate on prairie and barrens remnants with large populations of scurfy peas. Timing of surveys should occur when the adults are present, as these are the easiest life stages to locate and obtain accurate identification and counts. Adults should be searched for with sweep nets, but are cryptically colored, fairly sedentary and sometimes difficult to locate. Vegetation in this species' habitat is typically moderate to short, making sweeping less difficult than for species like *Flexamia reflexa.* The net should be swung back and forth rapidly in a 180 degree arc, through the vegetation at waist height to near ground level, while walking at a moderate pace. The open face of the net bag should be perpendicular to the direction of the sweeper at all times. Sweep net sampling should occur on warm to hot, humid

days, either between 10:00 am and noon or 4:00 pm and dusk. The entire sweep sample may be placed into a ziploc bag and immediately frozen, or individual specimens aspirated out of the net into a vial. This last technique is best left to experienced individuals.

Specimens of suspected adults must be kept with precise information regarding location, date and time of collection. Given the similarity of this to more common species, a specimen from any new locality must be collected as a voucher. These should be placed dry into a vial and frozen. They can be stored frozen or dried and attached with a small drop of glue to a small paper point through which an insect pin is drawn. Locality and collecting information must be affixed to the pin immediately. Adults can also be kept in the original container and kept frozen or dried. If drying, remove lid to avoid mold growth. In the case of entire sweep samples, the leafhoppers must be removed from the detritus and placed into a vial following the procedures outlined above. At the very least, collected adults must be kept 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.

Any collected specimens should be forwarded to an expert on the group for verification (see list at end of this Conservation Assessment).

MONITORING PROTOCOL

To conduct long-term monitoring programs, a permanent monitoring transect will need to be developed (see Bess et al., 2004). Monitoring programs will naturally vary from site to site and depend greatly on the resources available to conduct such programs. At a minimum, a long-term monitoring program for *Fitchiella robertsoni* should involve the designation of 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 dense concentrations of Indiangrass. 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 100-200 sweeps with a 15 inch diameter, muslin sweep net can be taken while walking at a moderate pace. Sweeps should be taken as close to ground level as possible, and extend in a 180 degree arc in front of the surveyor. The net must be held with the face perpendicular to the direction of walking at all times, with care being taken to not spill the net's contents or allow them to escape between sweeps. Each back and forth movement is two sweeps. All the planthoppers/elephanthoppers collected in a 100 or 200-sweep sample should be sorted from the detritus, counted, preserved and identified. Potential *Fitchiella robertsoni* specimens should then be segregated and counted.

Information on the habitat characteristics should also be recorded, such as frequency and cover of Indiangrass, degree of canopy closure, amount of exposed soil, dominant vegetation, soil

moisture, etc. 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 in late August or September, when the summer brood of adults is present. This will give more accurate adult population estimates for the next flight season. These surveys provide a wealth of data for use in tracking long-term trends in population size, phenology, distribution and resource utilization.

RESEARCH PRIORITIES

To date, no research has been conducted regarding the impacts of potential dispersal barriers such as cultivated fields, roads, thick brush, forest tracts, highways or waterways on this species. My personal experience shows that this elephanthopperhopper is fairly sedentary, but adults are able to move into areas of recently managed habitat. They are probably capable of moving at least a couple hundred yards in the course of their adult lives, especially in tracts of contiguous habitat. Determining the maximum distance that individuals will move between remnants and the proper size, composition and location of dispersal corridors necessary for continued survival are key areas of future research on this and other rare insect species. Although Panzer and associates (1995, 1998) have conducted research on fire effects and recolonization rates, much additional research on this species is needed. Further research should address at least some of the following:

1. Optimal canopy cover,
2. Minimum patch size of habitat and food plants,
3. Maximum adult travel distance between patches,
4. Percent cover and frequency of Indiangrass necessary for long-term survival,
5. Optimal density of associated vegetation (especially adult nectar sources),
6. Fire effects and optimal fire regime,
7. Effectiveness of prairie restorations as habitat for rare leafhoppers,
8. Effects of invasive plants (and efforts to control them) on Indiangrass, the leafhopper and associated vegetation, and
9. Effects of silvicultural activities such as pine plantations, pesticide application, harvesting, etc on the leafhopper, its food plants and habitat(s).

Additional Areas of Potential *Fitchiella robertsoni* Research

Additional areas of research center on developing optimal habitat restoration procedures and re-introduction methodology for the leafhopper. It is also quite probable that there are undetected populations of *Fitchiella robertsoni* in the central and southeastern 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 *Fitchiella robertsoni*

Historically, this leafhopper 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 leafhopper once shared its habitat include the original Human Beings, American Bison, Greater Prairie Chicken,

Henslow's sparrow and Peregrine Falcon. In addition to these somewhat more charismatic megafuana, a large number of rare insects are also known to occur with *Fitchiella robertsoni* (Bess, 2004; Blocker and Reed, 1976; Panzer et al., 1998). These include the albarufan dagger moth (*Acronycta albarufa*: G3), Van Duzee's Shovelheaded Leafhopper (*Attenuipyga vanduzeei*: G1), Bell's roadside skipper (*Amblyscirtes belli*: G3), swamp metalmark butterfly (*Calephelis mutica*: G3), the hill prairie relict moth (*Dichagyris reliqua*: G1G2), Beer's blazingstar borer moth (*Papaipema beeriana*; G2G3); Kansas prairie leafhopper (*Prairiana kansana*), jaguar flower moth (*Schinia jaguarina*; G4) and regal fritillary (*Speyeria idalia*: G2 and candidate for listing as a Federally Endangered Species).

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APPENDIX

LIST OF CONTACTS

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REVIEW REQUESTS

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FIGURES

Figure 1. ***Fitchiella robertsoni*** **adult, two views (greatly magnified).**

2002 John Haardstadt

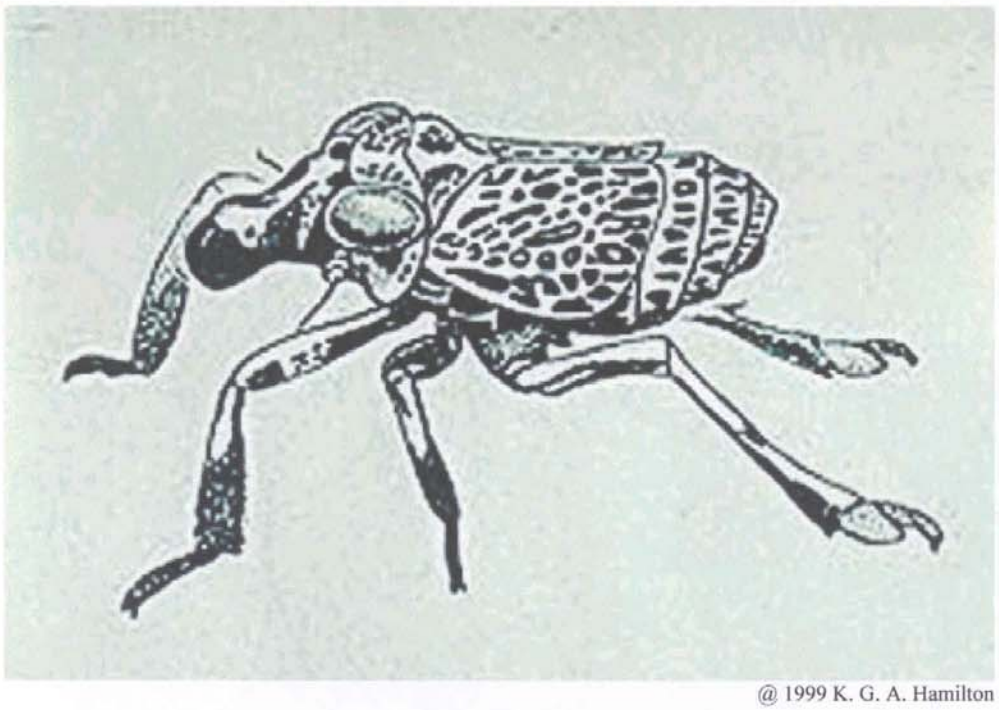

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Figure 2. Known Distribution of Fitch's elephanthopper (*Fitchiella robertsoni* (Fitch)) in the Eastern United States.

● = Known Occurrence of *F. robertsoni*

✳ = Approximated State Occurrence