Environ. Biosafety Res. 2 (2003) 247–261

DOI: 10.1051/ebr:2003015

# Enumerating lepidopteran species associated with maize as a first step in risk assessment in the USA

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**Pest management can have substantial impacts on non-target species both within and outside the units being managed. Assessment of these impacts is hampered by the lack of even the most basic checklist of the species present in most systems. The maize agroecosytem is of particular interest because of the large area covered and the intensity of widely varying forms of pest management. In this study a database of lepidopteran species that occur within the maize agroecosystem in the United States was compiled. The process was initiated by developing a list of plants present in maize using published sources and the first-hand knowledge of "weed" experts. This list of plant species associated with maize was then cross-listed with lepidopteran host feeding records using published sources. Finally, phenological profiles and conservation rankings were added. Although our list is not exhaustive, we found 132 plant species in 33 families associated with maize, and 229 lepidopteran species in 21 families that feed on these plants. The database of plants and lepidopteran species can be a starting point for assessment of risk to non-target Lepidoptera in maize from chemical control, biological control, and the use of transgenic *Bt* maize. The lepidopteran species associated with maize were found to be significantly less imperiled, as measured by their conservation rankings, than lepidopteran species as a whole in all habitats. This finding suggests that rare or endangered lepidopteran species are unlikely to be impacted by pest management in maize. Based on the likely lack of impact of pest management in maize on individual species, future studies should focus on potential impacts on the ecological services that lepidopteran species provide.**

**Keywords***: Bt* maize / transgenic / GMO / non-target species / risk assessment

## INTRODUCTION

Pest management and conservation are the two major endeavors involved with the management of insect populations. Although they are often considered separate or even in conflict with each other, these two disciplines are inextricably linked and interdependent. The goal of insect pest management is to maintain insect pest species below threshold densities. Pest management tactics interfere with the ability of insects to survive, reproduce or exploit resources, and the impacts of these tactics are very rarely confined to the target pest species. These relatively broad effects clearly impinge on a substantial proportion of insect habitats since, 70% of the land on earth is utilized for agriculture and forestry and presumably receives some level of pest management (Western, 1989). Two main goals of insect conservation are the preservation of rare insect species and of the ecological services that insect populations provide. Clearly, pest management practices can have important impacts on the conservation of insects and conversely, most managed systems could not function without the ecological services such as pollination, the biological control of pests, and decomposition of plant and animal tissue that

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insects provide. The first step towards a comprehensive insect management program that would provide adequate pest suppression, maintenance of ecological services, and minimal impact on rare species is a detailed assessment of which insect species are likely to exist in the managed system. Unfortunately, this baseline accounting of insect species is lacking for almost every managed system.

Here we describe a portion of the insect community associated with maize in the United States. The maize system is of particular interest because it outranks all other cultivated crops in the USA in terms of overall value, land area covered, and total pesticides used (U.S. Grains Council, 2002). Over 240 million metric tons of maize were produced in the USA in 2001, which was just over 41% of worldwide maize production (FAS-USDA, 2002). In the USA, maize is valued at $ 19 billion/year, it is grown on 32 million hectares, and over 100 million kilograms of pesticides are used annually (Economic Research Service-USDA, 2002; Padgitt et al., 2001). Pesticide usage consists primarily of insecticides that can directly impact non-target insects and herbicides that can impact insects indirectly by removing host plants. Considering the size of the maize system and the intensity of pest management applied to it, the potential for substantial impacts on nontarget insect species and services would appear to be high. Insects provide important ecological services in the maize system including contribution to the biological control of key pest insects and weeds.

The large area covered by maize production and the broad range of ecoregions encompassed would make an accounting of all insect species impractical for the scope of a single study. In this study we focus on species in the order Lepidoptera. The Lepidoptera were chosen because they include some of the major maize pests (*e.g.*, *Ostrinia nubilalis,* and *Heliocoverpa zea*) and this taxon also contains a substantial number of rare or endangered species. In addition, one of the few pest management tactics that is specific to an insect order, the use of transgenic maize expressing a gene encoding a *Bacillus thuringiensis* endotoxin (hereafter referred to as *Bt* maize), is specific to Lepidoptera. Since Lepidoptera are generally not predaceous or parasitic, they do not contribute to the suppression of pest insects. Although there are few data on the ecological roles of most Lepidoptera in maize, it has been documented across several systems that many lepidopteran species contribute to the biological control of important weed species (Julien and Griffiths, 1998), and they provide alternate prey for the natural enemies of important pests (Biddinger et al., 1994; Pavuk and Stinner, 1991). An accounting of Lepidoptera in maize will greatly facilitate the design of management plans that provide adequate pest suppression while maintaining ecological services and minimizing effects on rare species. The objective of this study is to provide a baseline list of the lepidopteran species that are likely to occur in and around maize in the continental USA.

## RESULTS

The survey of plants associated with maize identified 132 species in 33 families. The plant families accounting for the most species were Poaceae with 28 and Asteraceae with 20 (Appendix 1). Several plant families were represented by a single species. More than half the species (51.5%) were ranked as rare in maize, while 35.6% were ranked as common and 12.9% were ranked as abundant.

The survey of lepidopteran species that feed on plants associated with maize identified 229 species in 21 families (Appendix 2). The lepidoteran families accounting for the most species were Noctuidae with 84 and Hesperidae with 31. Several lepidopteran families were represented by a single species. Approximately one quarter of the lepidopteran species was identified as feeding on more than one plant species.

The distributions of global and national conservation status ranks for lepidopteran species identified as associated with maize were significantly different than the distributions of ranks for all lepidopteran species ranked in the NatureServe database ($P < 0.0001$; Figs. 1 and 2). Higher proportions of lepidopteran species associated with maize were assigned higher ranks (denoting a more secure status) compared to the proportions of all ranked lepidopteran species. Specifically, 87.4% of maize species were assigned a rank of G5 (globally secure) and 83.7% were assigned a rank of N5 (nationally secure), compared with 55.4% and 27.9%, respectively, for all the lepidopteran species ranked in the NatureServe database.

Only one maize-associated species, the mottled duskywing, *Erynnis martialis* (Lepidoptera: Hesperiidae), was assigned a rank below G4, denoting the species is at risk globally. It is important to note that although the karner blue butterfly, *Lycaeides melissa samuelis* (Lepidoptera: Lycaenidae), is ranked at G5, it is arguably more endangered than the mottled duskywing. Both species occur on host plants that are associated with maize but the largest stands of karner blue's primary host, wild lupine, grow in pine/oak savannahs that are rapidly disappearing due to fire suppression and development. Based on the rapid decline in its habitat the karner blue has been placed on the United States endangered species list. Both the karner blue and the monarch butterfly,

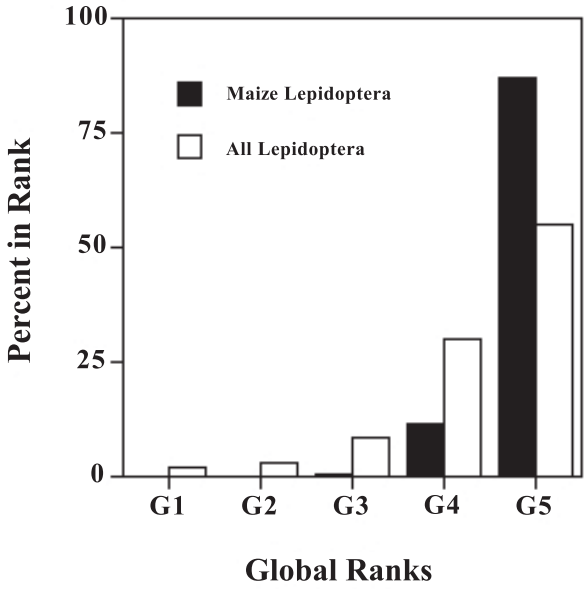


**Figure 1.** Frequency distribution for global conservation ranks of lepidopteran species. Black bars represent ranks of species associated with maize, and white bars represent species from all habitats combined.

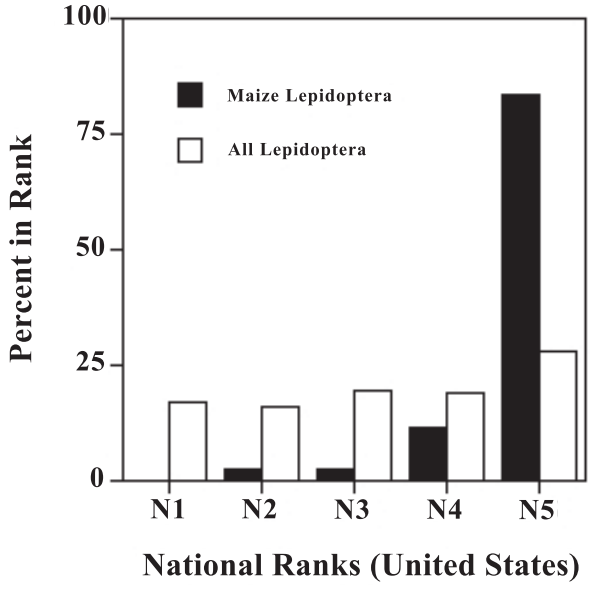


**Figure 2.** Frequency distribution for United States national conservation ranks of lepidopteran species. Black bars represent ranks of species associated with maize, and white bars represent species from all habitats combined.

*Danaus plexippus* (Lepidoptera: Nymphalidae), were assigned national ranks of N2 (nationally imperiled). The mottled duskywing and the southern scalloped sooty wing, *Staphylus mazans* (Lepidoptera: Hesperiidae), were assigned ranks of N3 (nationally vulnerable). As illustrated by these examples, national ranks are often lower than global ranks because they represent a subset of all the populations of a species. Thus a species could be imperiled in several individual countries yet globally secure. All other ranked species associated with maize were assigned ranks of N4 or N5 that denote apparent or demonstrable security nationally.

## DISCUSSION

The results of this survey show the unexpected complexity and diversity associated with the maize agroecosystem. Specifically they indicate clearly that there is a substantial number of lepidopteran species that feed on plants in and around fields of maize. This list of species can provide the basis for assessment of risk from a pest management tactic. Using this data set, species can be selected for more in-depth risk assessment based on their phenology and their security status. For example, univoltine species that go through their development in June could be given low priority for tactics applied in July and imperiled species with low security ranks could be given higher priority than those with higher security status ranks.

When considering either the list of species or their relative security potential, sources of bias should be considered. Lepidopteran checklists are probably likely to have a bias towards more common species, while the data on species security is more complete for less secure species that are usually rare. Groups such as the microlepidoptera that have not been well studied are almost certainly underrepresented in most sources. While each individual source may miss several rare species, by consulting a large number of sources we are confident that we have assembled sufficient data to firmly ground our conclusions.

Once a group of species is selected, risk assessment could proceed by gathering data on: (1) the relative importance of maize as a habitat for the host plant; (2) the relative importance of that plant for the herbivore species; and (3) the susceptibility of the species to impact from the management tactic being assessed. Further information may be available on the relative importance of maize as a habitat for the host plant. Because most non-crop plants in and around maize fields are considered weeds, the make-up of these plant communities is fairly well known. Unfortunately, what is not known for most of the plants associated with maize is the proportion of their total

distribution that falls within a distance that is likely to be affected by a given pest management tactic. An additional complicating factor is that the adoption of reduced tillage systems has increased the diversity of plants occurring in agricultural fields (Cardina et al., 1991).

It is possible to gauge the relative importance of a given set of host plants for a lepidopteran species by more in-depth scrutiny of the species life history. Specialist herbivores feeding on plants that grow exclusively near maize fields are much more likely to be affected by pest management in maize than herbivores that feed on plants growing in several habitats, in addition to maize. This type of niche analysis for a large number of species would not be trivial, so it is probably best reserved for those species that are identified as high priority in the initial screen.

By combining the relative importance of maize as a habitat for the host plant and the relative utilization of that host plant by the herbivore species, it is possible to estimate the importance of maize fields as a habitat for the lepidopteran species being examined. The data gathered will be equally applicable to any pest management tactic. Conversely, data on susceptibility will be almost completely specific to the tactic being assessed. There is a large amount of published data available on the susceptibility of many lepidopteran species to chemical applications and smaller amounts of data available on the *Bt* toxin that is incorporated into transgenic maize (Johnson et al., 1995; Peacock et al., 1998), and the egg parasitoid Trichogramma that is used as an augmentative biological control agent (Hoffmann et al., 1995; Orr et al., 2000). Unfortunately, an assessment of the susceptibility of all the lepidopteran species associated with maize is not available for any of the tactics. In general, most lepidopteran species are physiologically susceptible to the insecticides used to control lepidopteran pests in maize. However, susceptibility to chemical insecticides is dependent on relative size and feeding niche. Small larvae feeding on exposed leaves will be more susceptible than large larvae feeding in a protected area like the roots or stalk of a plant.

In contrast to insecticides, physiological susceptibility to the *Bt* toxin varies widely within lepidopteran families and even within genera (Johnson et al., 1995; Peacock et al., 1998). This extreme variability essentially makes it impossible to establish a phylogenetic pattern that could guide the risk assessment process. Thus, a full assessment of any lepidopteran species for which no data on susceptibility to *Bt* exists may require standardized toxicity testing.

Among the three main tactics the fewest data exist for susceptibility to Trichogramma wasps. The challenge in assessing risk for Trichogramma is that laboratory measures of physiological susceptibility (*e.g.* tests of oviposition in the eggs of a particular lepidopteran species) do not necessarily lead to accurate predictions of the level of non-target risk in the field. A current study, utilizing the database presented here, is assessing both the physiological and ecological susceptibility of a large group of lepidopteran species associated with maize to *Trichogramma ostriniae* (Wright et al., unpublished).

In addition to providing a list and biological information for more in-depth risk assessment, our review also uncovered an emergent property which applies generally to the complex of lepidopteran species that are associated with maize: only a very small proportion of the complex of lepidopteran species associated with maize are rare or endangered. In fact, this complex of species appears to have a lower proportion of rare or endangered species than the Lepidoptera as a whole. This is probably due to the large area covered by maize in a wide range of ecoregions and the fact that most of the plants associated with maize (*e.g.* weeds) are also adapted to thrive in other disturbed areas including other crops. In general, based on the prevalence of the maize habitat, any Lepidopteran that feeds on a plant associated with maize is probably not in immediate peril. The implication of this emergent property is that pest management tactics applied to maize are unlikely to affect an endangered or threatened lepidopteran species associated with non-maize plants that grow in and around maize fields.

The predicted lack of effects on endangered lepidopteran species does not mean that pest management tactics will not have negative impacts on the lepidopteran complex in maize as a whole. Many common lepidopteran species provide invaluable services such as the biological control of weeds (Julien and Griffiths, 1998), pollination (Buchmann and Nabhan, 1996), and alternate hosts for parasitoids of insect pests (Biddinger et al., 1994; Pavuk and Stinner, 1991). If pest management tactics depress lepidopteran densities, they may interfere with the provision of these services. If maize fields are serving as sources of the species providing these services in other systems, then even local depression of lepidopteran densities may cause disruption of the services on a regional basis. Thus, further assessment of the risk to the lepidopteran species associated with maize should focus on functional guilds as well as individual species.

## MATERIALS AND METHODS

The first step in any risk assessment is developing a list of species that might be affected by the pest management

tactics employed. Once a complete list is generated the relative level of risk can be estimated for each individual species. Our list is restricted to the top 17 maize producing states in the United States which are (in order of hectares planted to maize) IA, IL, NE, MN, IN, SD, WI, OH, KS, MO, MI, TX, PA, KY, CO, and NY. These 17 states account for over 90% of the maize planted in the United States (National Agricultural Statistics Service – USDA, 2000).

Since Lepidoptera are almost universally herbivorous, our first step in generating a list of lepidopteran species associated with maize was to determine which plant species were likely to be associated with this crop. The list of plant species in maize was generated through a combination of published data and personal knowledge (RGH) of plants in the maize system. The list is not intended to be exhaustive, but it does include most of the common and abundant plants, and illustrates the wide variety of plants associated with maize production. Each plant species was ranked as abundant, common, or rare by RGH.

The next step in our sequential approach was to determine which lepidopteran species feed on plants within the maize system. By cross-listing the plant species with the lepidopteran species that feed on these plants, an initial list of non-target herbivores was generated. All records of lepidopteran feeding on individual host plant species are based on published sources.

Once it had been determined which lepidopteran species feed on plant species in the maize system, the next step was to determine which of those herbivore species are feeding in the larval stage during the period when pest management tactics are likely to affect them. Since most pest management that would affect lepidopteran species in USA maize fields is undertaken in the summer months, we restricted our phenological profile to larval presence/absence in June, July and August. This phenological overlap with pest management tactics can serve as one measure of the potential severity of risk to individual species. The "effective" period is well known for most pest management tactics. To be affected by a given tactic, larvae must be present during or immediately after this period. Although exact phenological data are not available for many of the lepidopteran species identified, it is often possible to determine which of the summer months the larvae of most species are known to be active.

The final step in our protocol was the inclusion of a relative imperilment or security status ranking for all species currently ranked by NatureServe (2001). These ranks are calculated through consultation of both published sources and a network of taxon specific expertise (NatureServe, 2001). The conservation rank of a species known or assumed to exist within a jurisdiction is designated by a whole number from 1 to 5, preceded by G (Global) or N (National). The ranks have the following meaning: 1 = critically imperiled; 2 = imperiled; 3 = vulnerable to extirpation or extinction; 4 = apparently secure; and 5 = demonstrably widespread, abundant, and secure. G1, for example, indicates critical imperilment on a range-wide basis while N1 indicates critical imperilment within the United States. These rankings provide a measure of which potentially affected species should be of particular concern.

Global and national ranks for Lepidoptera identified in our study as being associated with maize were compared with ranks of all the lepidopteran species (across all habitats) from the NatureServe database (NatureServe, 2001). Species with a rank range were assigned the lower rank. For example, a species ranked as G3G4 were assigned a rank of G3 for this analysis. Comparisons were analyzed with the two-tailed Fisher's exact chi-square test, PROC FREQ (SAS Institute, 1996).

## ACKNOWLEDGEMENTS

The authors wish to thank Catherine Day, Megan Edlund, Melissa Jensen, Stephanie Johnson, Luisa Perez, and Diane Tran for their assistance with gathering and collating data for the database. We also wish to thank Robert Dirig for his helpful early comments on lepidopteran species and their host plants and Richard Hoebeke for his help with deciphering nomenclature. The manuscript was greatly improved by editorial input from Leslie Allee. Data on conservation ranks was provided with permission and assistance from NatureServe: Copyright© 2001 NatureServe, 1101 Wilson Boulevard, 15th Floor, Arlington, Virginia 22209, USA. All Rights Reserved.

Received October 8, 2002; accepted July 15, 2003.

**Appendix 1.**
Plants associated with maize that are potential hosts of lepidopteran species.

| Plant Number | Plant Common Name | Plant Scientific Name | Plant Family | Abundance | Weed Reference |
|---|---|---|---|---|---|
| 1 | Tumble piweed | *Amaranthus albus* | Amaranthaceae | Common | 1 |
| 2 | Sandhills amaranth | *Amaranthus arenicola* | Amaranthaceae | Rare | 1 |
| 3 | Prostrate pigweed | *Amaranthus graecizans* | Amaranthaceae | Rare | - |
| 4 | Palmer amaranth | *Amaranthus palmeri* | Amaranthaceae | Common | 1 |
| 5 | Red root pigweed | *Amaranthus retroflexus* | Amaranthaceae | Abundant | 2 |
| 6 | Common waterhemp | *Amaranthus rudis* | Amaranthaceae | Abundant | - |
| 7 | Spiny amaranth | *Amaranthus spinosus* | Amaranthaceae | Rare | - |
| 8 | Wild carrot | *Daucus carota* | Apiaceae | Rare | - |
| 9 | Hemp dogbane | *Apocynum cannabinum* | Apocynaceae | Common | 2 |
| 10 | Common milkweed | *Asclepias syriaca* | Asclepiadacea | Common | 2 |
| 11 | Honeyvine milkweed | *Cynanchum laeve* | Asclepiadacea | Common | - |
| 12 | Black swallow-wort | *Vincetoxicum nigrum* | Asclepiadacea | Common | - |
| 13 | Common ragweed | *Ambrosia artemisiifolia* | Asteraceae | Abundant | - |
| 14 | Lanceleaf ragweed | *Ambrosia bidentata* | Asteraceae | Rare | - |
| 15 | Western ragweed | *Ambrosia psilostachya* | Asteraceae | Rare | - |
| 16 | Giant ragweed | *Ambrosia trifida* | Asteraceae | Abundant | - |
| 17 | Common burdock | *Arctium minus* | Asteraceae | Rare | - |
| 18 | Musk thistle | *Carduus nutans* | Asteraceae | Rare | - |
| 19 | Tall thistle | *Cirsium altissimum* | Asteraceae | Rare | - |
| 20 | Canada thistle | *Cirsium arvense* | Asteraceae | Common | 2 |
| 21 | Bull thistle | *Cirsium vulgare* | Asteraceae | Rare | - |
| 22 | Horseweed | *Conyza canadensis* | Asteraceae | Common | - |
| 23 | Rough fleabane | *Erigeron strigosus* | Asteraceae | Rare | - |
| 24 | Small flower galinsoga | *Galinsoga parviflora* | Asteraceae | Rare | - |
| 25 | Common sunflower | *Helilanthus annuus* | Asteraceae | Abundant | 2 |
| 26 | Sawtooth sunflower | *Helilanthus grosseserratus* | Asteraceae | Rare | - |
| 27 | Jerusalem artichoke | *Helilanthus tuberosus* | Asteraceae | Common | - |
| 28 | Marsh elder | *Iva xanthifolia* | Asteraceae | Rare | 3 |
| 29 | Gray goldenrod | *Solidago nemoralis* | Asteraceae | Rare | - |
| 30 | Perennial sowthistle | *Sonchus arvensis* | Asteraceae | Rare | - |
| 31 | Dandelion | *Taraxacum officinale* | Asteraceae | Common | - |
| 32 | Common cocklebur | *Xanthium strumarium* | Asteraceae | Abundant | 2 |
| 33 | Trumpet creeper | *Campsis radicans* | Bignoniaceae | Rare | 2 |
| 34 | Yellow rocket | *Barbarea vulgaris* | Brassicaceae | Common | - |
| 35 | Indian mustard | *Brassica juncea* | Brassicaceae | Common | - |
| 36 | Wild mustard | *Brassica kaber* | Brassicaceae | Common | - |
| 37 | Black mustard | *Brassica nigra* | Brassicaceae | Rare | - |
| 38 | Shepherd's purse | *Capsella bursa-pastoris* | Brassicaceae | Common | - |
| 39 | Blue mustard | *Chorispora tenella* | Brassicaceae | Common | - |
| 40 | Field pepperweed | *Lepidium campestre* | Brassicaceae | Common | - |
| 41 | Tallhedge mustard | *Sisymbrium loeselii* | Brassicaceae | Common | - |
| 42 | Field pennycress | *Thlaspi arvense* | Brassicaceae | Common | - |
| 43 | Marijuana | *Cannabis sativa* | Cannabaceae | Common | - |
| 44 | Corn cockle | *Agrostemma githago* | Caryophyllaceae | Rare | - |
| 45 | Mouse-ear chickweed | *Cerastium vulgatum* | Caryophyllaceae | Rare | - |
| 46 | Bouncingbet | *Saponaria officinalis* | Caryophyllaceae | Rare | - |
| 47 | White cockle | *Silene alba* | Caryophyllaceae | Rare | - |
| 48 | Common chickweed | *Stellaria media* | Caryophyllaceae | Common | - |
| 49 | Spreading orach | *Atriplex subspicata* | Chenopodiaceae | Rare | - |
| 50 | Common lambsquarter | *Chenopodium album* | Chenopodiaceae | Abundant | 2, 4 |
| 51 | Mapleleaf goosefoot | *Chenopodium simplex* | Chenopodiaceae | Rare | - |
| 52 | Kochia | *Kochia scoparia* | Chenopodiaceae | Common | - |
| 53 | Rusian thistle | *Salsola iberi ca* | Chenopodiaceae | Common | 3 |
| 54 | Hedge bindweed | *Calystegia sepium* | Convolvulaceae | Common | - |
| 55 | Field bindweed | *Convolvulus arvensis* | Convolvulaceae | Common | - |
| 56 | Bindweeds | *Convolvulus spp.* | Convolvulaceae | Common | - |
| 57 | Ivyleaf morning glory | *Ipomoea hederacea* | Convolvulaceae | Common | - |
| 58 | Purple morning glory | *Ipomoea purpurea* | Convolvulaceae | Common | 1 |

**Appendix 1.**
*Continued.*

| Plant Number | Plant Common Name | Plant Scientific Name | Plant Family | Abundance | Weed Reference |
|---|---|---|---|---|---|
| 59 | Buffalo gourd | *Cucurbita foetidissima* | Cucurbitaceae | Rare | - |
| 60 | Wild cucumber | *Echinocystis lobata* | Cucurbitaceae | Common | - |
| 61 | Bur cucumber | *Sicyos angulatus* | Cucurbitaceae | Common | - |
| 62 | Yellow nutsedge | *Cyperus rotundus* | Cyperaceae | Abundant | 1 |
| 63 | Field horsetail | *Equisetum arvense* | Equisetaceae | Rare | - |
| 64 | Virginia copperleaf | *Acalypha virginica* | Euphorbiaceae | Rare | - |
| 65 | Toothed spurge | *Euphorbia dentata* | Euphorbiaceae | Common | 3 |
| 66 | Spotted spurge | *Euphorbia maculata* | Euphorbiaceae | Rare | - |
| 67 | Alfalfa | *Medicago sativa* | Fabaceae | Rare | |
| 68 | White clover | *Trifolium repens* | Fabaceae | Rare | |
| 69 | Carolina geranium | *Geranium carolinianum* | Geraniaceae | Rare | - |
| 70 | Wild onion | *Allium canadense* | Liliaceae | Rare | - |
| 71 | Wild garlic | *Allium vineale* | Liliaceae | Rare | - |
| 72 | Velvetleaf | *Abutilon theophrasti* | Malvaceae | Abundant | 2 |
| 73 | Venice mallow | *Hibiscus trionum* | Malvaceae | Common | 3 |
| 74 | Common mallow | *Malva neglecta* | Malvaceae | Rare | 3 |
| 75 | Prickly sida | *Sida spinosa* | Malvaceae | Common | - |
| 76 | Carpetweed | *Mollugo verticillata* | Molluniginaceae | Rare | - |
| 77 | Wild four-o'clock | *Mirabilis nyctaginea* | Nyctaginaceae | Rare | - |
| 78 | Evening primrose | *Oenothera biennis* | Onagraceae | Rare | - |
| 79 | Yellow woodsorrel | *Oxalis stricta* | Oxalidaceae | Rare | - |
| 80 | Common pokeweed | *Phytolacca americana* | Phytolaccaceae | Rare | - |
| 81 | Buckhorn plantain | *Plantago lanceolata* | Plantaginaceae | Rare | - |
| 82 | Quackgrass | *Agropyron repens* | Poaceae | Abundant | - |
| 83 | Wild oat | *Avena fatua* | Poaceae | Rare | 3 |
| 84 | Signalgrass | *Brachiaria platyphylla* | Poaceae | Rare | 1 |
| 85 | Japanese brome | *Bromus japonicus* | Poaceae | Rare | - |
| 86 | Cheatgrass | *Bromus secalinus* | Poaceae | Rare | - |
| 87 | Downy brome | *Bromus tectorum* | Poaceae | Rare | - |
| 88 | Longspine sandbur | *Cenchrus longispinus* | Poaceae | Common | 3 |
| 89 | Bermudagrass | *Cynodon dactylon* | Poaceae | Rare | 1 |
| 90 | Orchardgrass | *Dactylis glomerata* | Poaceae | Rare | - |
| 91 | Smooth crabgrass | *Digitaria ischaemum* | Poaceae | Common | 1 |
| 92 | Large crabgrass | *Digitaria sanguinalis* | Poaceae | Common | 1 |
| 93 | Barnyardgrass | *Echinochloa crus-galli* | Poaceae | Common | 3 |
| 94 | Goosegrass | *Eleusine indica* | Poaceae | Rare | - |
| 95 | Stinkgrass | *Eragrostris cilianensis* | Poaceae | Rare | 3 |
| 96 | Woolly cupgrass | *Eriochloa villosa* | Poaceae | Common | - |
| 97 | Tall fescue | *Festuca arundinacea* | Poaceae | Rare | - |
| 98 | Wirestem muhly | *Muhlenbergia frondosa* | Poaceae | Common | - |
| 99 | Witchgrass | *Panicum capillare* | Poaceae | Common | 3 |
| 100 | Fall panicum | *Panicum dichotomiflorum* | Poaceae | Abundant | - |
| 101 | Wild-proso millet | *Panicum miliaceum* | Poaceae | Rare | 3 |
| 102 | Texas panicum | *Panicum texanum* | Poaceae | Rare | 1 |
| 103 | Giant foxtail | *Setaria faberi* | Poaceae | Abundant | |
| 104 | Yellow foxtail | *Setaria glauca* | Poaceae | Abundant | 3 |
| 105 | Bristly foxtail | *Setaria verticillata* | Poaceae | Rare | - |
| 106 | Green foxtail | *Setaria viridis* | Poaceae | Abundant | 3 |
| 107 | Shattercane | *Sorghum bicolor* | Poaceae | Common | 3 |
| 108 | Johnsongrass | *Sorghum halepense* | Poaceae | Common | 2 |
| 109 | Corn | *Zea mays* | Poaceae | Abundant | |
| 110 | Alpine smartweed | *Polygenum viviparum* | Polygonaceae | Rare | |
| 111 | Swamp smartweed | *Polygonum coccineum* | Polygonaceae | Common | - |
| 112 | Wild buckwheat | *Polygonum convolvulus* | Polygonaceae | Rare | 3 |
| 113 | Pennsylvania smartweed | *Polygonum pennslyvanicum* | Polygonaceae | Abundant | 2 |
| 114 | Red sorrel | *Rumex acetosella* | Polygonaceae | Rare | - |
| 115 | Pale dock | *Rumex altissimus* | Polygonaceae | Rare | - |
| 116 | Curly dock | *Rumex crispus* | Polygonaceae | Rare | - |

**Appendix 1.**
*Continued.*

| Plant Number | Plant Common Name | Plant Scientific Name | Plant Family | Abundance | Weed Reference |
|---|---|---|---|---|---|
| 117 | Broadleaf dock | *Rumex obtusifolius* | Polygonaceae | Rare | - |
| 118 | Common purslane | *Portulaca oleracea* | Portulaceae | Rare | 3 |
| 119 | Rough cinquefoil | *Potentilla norvegica* | Rosaceae | Rare | - |
| 120 | Sulphur cinquefoil | *Potentilla recta* | Rosaceae | Rare | - |
| 121 | Wild blackberry | *Rubus allegheniensis* | Rosaceae | Rare | 4 |
| 122 | Catchweed bed straw | *Galium aparine* | Rubiaceae | Rare | - |
| 123 | Common mullein | *Verbascum thapsus* | Scrophulariaceae | Rare | - |
| 124 | Field speedwell | *Veronica agrestis* | Scrophulariaceae | Rare | - |
| 125 | Jimsonweed | *Datura stramonium* | Solanaceae | Common | |
| 126 | Clammy groundcherry | *Physalis heterophylla* | Solanaceae | Common | - |
| 127 | Virginia groundcherry | *Physalis virginiana* | Solanaceae | Common | - |
| 128 | Horse nettle | *Solanum carolinense* | Solanaceae | Common | 1 |
| 129 | Eastern blacknightshade | *Solanum ptycanthum* | Solanaceae | Abundant | - |
| 130 | Buffalo bur | *Solanum rostratum* | Solanaceae | Common | 2 |
| 131 | Hairy nightshade | *Solanum sarrachoides* | Solanaceae | Rare | 3 |
| 132 | Common cattail | *Typha latifolia* | Typhaceae | Rare | - |

Weed codes are from the following references: 1 = Webster and Cobble, 1997; 2 = Wax et al., 1981; 3 = Schweizer et al., 1998; and 4 = Glenn et al., 1997.

**Appendix 2.**
Lepidopteran species reported to feed as larva on plants that occur in and around maize fields.

| Family | Species | Common name | Jn | Jl | Ag | Host plant code[1] | Plant utilization reference[2] | Global rank | National rank |
|---|---|---|---|---|---|---|---|---|---|
| Aegeridae | *Albuna pyramidalis rubescens* | _ | _ | _ | _ | 78 | 2 | _ | _ |
| Agarastidae | *Euscirrhopterus gloveri* | _ | _ | _ | _ | 118 | 13 | _ | _ |
| Amatidae | *Ctenucha virginica* | virginia ctenucha | Y | Y | N | 93, 99 | 13 | _ | _ |
| Arctiidae | *Apantensis figurata* | _ | _ | _ | _ | 67 | 13 | _ | _ |
| Arctiidae | *Apantesis arge* | _ | _ | _ | _ | 81 | 13 | _ | _ |
| Arctiidae | *Apantesis ornata* | _ | _ | _ | _ | 50 | 13 | _ | _ |
| Arctiidae | *Apantesis parthenice* | _ | N | ? | Y | 50 | 13 | _ | _ |
| Arctiidae | *Arachnis picta* | painted arachnis | _ | _ | _ | 67 | 13 | _ | _ |
| Arctiidae | *Arctia caja* | great tiger moth | Y | Y | Y | 50 | 13 | G5 | _ |
| Arctiidae | *Estigmene acrea* | saltmarsh moth | Y | Y | Y | 7 | 13 | G5 | _ |
| Arctiidae | *Euchaetias egle* | milkweed tussock moth | Y | Y | Y | 11 | 10 | G5 | _ |
| Arctiidae | *Haploa lecontei* | Leconte's haploa | Y | Y | Y | 121 | 13 | G5 | _ |
| Arctiidae | *Holomelina aurantiaca* | _ | Y | Y | Y | 31, 50, 109 | 13 | G5 | _ |
| Arctiidae | *Hyphantria cunea* | fall webworm | Y | Y | Y | 67 | 14 | G5 | _ |
| Arctiidae | *Pyrrharctia isabella* | banded woolybear | Y | N | Y | 82, 25, 121 | 13 | _ | _ |
| Arctiidae | *Spilosoma vagans* | _ | _ | _ | _ | 50 | 13 | _ | _ |
| Arctiidae | *Spilosoma virginica* | yellow wolly bear moth | Y | N | Y | 16, 25, 50, 58, 67, 112, 121, 130 | 13 | G5 | N5 |
| Citheroniidae | *Anisota senatoria* | orangestriped oak-worm | Y | Y | Y | 121 | 13 | G5 | N5 |
| Geometridae | *Catopyrra coloraria* | _ | Y | Y | N | 121 | 3 | G4 | _ |
| Geometridae | *Cepphis decoloraria* | _ | Y | Y | Y | 121 | 3 | G5 | _ |

**Appendix 2.**
*Continued.*

| Family | Species | Common name | Jn | Jl | Ag | Host plant code[1] | Plant utilization reference[2] | Global rank | National rank |
|---|---|---|---|---|---|---|---|---|---|
| Geometridae | *Chlorochlamys chloroleucaria* | blackberry looper moth | Y | Y | Y | 121 | 13 | _ | _ |
| Geometridae | *Cingilia catenaria* | chainspotted geometer | N | N | N | 53 | 13 | _ | _ |
| Geometridae | *Dysstroma citrata* | dark marbled carpet | N | Y | Y | 121 | 13 | G5 | _ |
| Geometridae | *Hydria undulata* | scallop-shell moth | N | Y | N | 121 | 13 | _ | _ |
| Geometridae | *Phigalia titea* | the half-wing | N | N | N | 121 | 13 | _ | _ |
| Geometridae | *Scopula inductata* | soft-lined wave | Y | Y | Y | 16 | 13 | _ | _ |
| Geometridae | *Synchlora aerata* | wavy-lined emerald | Y | Y | Y | 121 | 13 | G5 | _ |
| Geometridae | *Xanthorhoe lacustrata* | toothed brown carpet | Y | Y | Y | 121 | 13 | _ | _ |
| Hesperiidae | *Amblyscirtes hegon* | pepper and salt skipper | Y | Y | Y | 107 | 13 | G5 | N5 |
| Hesperiidae | *Amblyscirtes nysa* | nysa roadside skipper | Y | Y | Y | 106 | 5 | G5 | N5 |
| Hesperiidae | *Amblyscirtes vialis* | roadside skipper | Y | Y | Y | 89 | 8 | G5 | N5 |
| Hesperiidae | *Atalopedes campestris* | satchem | Y | Y | Y | 89 | 8 | G5 | N5 |
| Hesperiidae | *Carterocephalus palaemon* | checked skipper butterfly | Y | Y | Y | 82, 92 | 13 | G5 | N5 |
| Hesperiidae | *Copaeodes minimus* | southern skipperling | Y | Y | Y | 89 | 17 | G5 | N5 |
| Hesperiidae | *Copaeodes minimus aurantiaca* | orange skipperling | Y | Y | Y | 92, 89 | 17,13 | G5 | |
| Hesperiidae | *Erinnyis funeralis* | funeral dusky wing | Y | Y | Y | 67 | 13 | G5 | N5 |
| Hesperiidae | *Erynnis lucilius* | columbine dusky wing | Y | Y | Y | 78, 50 | 17, 13 | G4 | N4 |
| Hesperiidae | *Erynnis martialis* | mottled duskywing | Y | Y | Y | 5, 6 | 13 | G3G4 | N3N4 |
| Hesperiidae | *Hesperia sassacus* | indian skipper | Y | Y | N | 92 | 5 | G5 | N5 |
| Hesperiidae | *Hylephila phyleus* | fiery skipper | Y | Y | Y | 89 | 9 | G5 | N5 |
| Hesperiidae | *Lerema accius* | clouded skipper | Y | Y | Y | 99, 109 | 11, 9 | G5 | N5 |
| Hesperiidae | *Lerodea eufala* | eufala skipper | Y | Y | Y | 108 | 5 | G5 | N5 |
| Hesperiidae | *Panoquina errans* | wandering skipper | N | Y | Y | 89 | 7 | _ | _ |
| Hesperiidae | *Pholisora catullus* | common sooty wing | Y | Y | Y | 3, 50, 5 | 6, 9, 5 | G5 | N5 |
| Hesperiidae | *Poanes melane* | umber skipper | Y | Y | Y | 89, 91 | 13 | G5 | N5 |
| Hesperiidae | *Polites mystic* | long dash | Y | Y | Y | 82 | 11 | G5 | N5 |
| Hesperiidae | *Polites sabuleti* | sandhill skipper | _ | _ | _ | 89 | 13 | G5 | N5 |
| Hesperiidae | *Polites themistocles* | tawny edged skipper | Y | Y | Y | 82 | 13 | G5 | N5 |
| Hesperiidae | *Polites vibex* | whirlabout | Y | Y | Y | 89 | 8 | G5 | N5 |
| Hesperiidae | *Pyrgus communis* | checkered skipper | Y | Y | Y | 50, 73 | 8, 11 | G5 | N5 |
| Hesperiidae | *Pyrgus syrichtus* | tropical checkered skipper | Y | Y | Y | 74 | 9 | G5 | _ |
| Hesperiidae | *Staphylus ceos* | golden-headed sooty-wing | Y | Y | Y | 51 | 7 | G5 | N4 |
| Hesperiidae | *Staphylus hayhurstii* | southern sooty wing | Y | Y | Y | 50 | 8 | G5 | N5 |
| Hesperiidae | *Staphylus mazans* | southern scalloped sooty wing | Y | Y | Y | 5 | 5 | G5 | N3N4 |
| Hesperiidae | *Thorybes bathyllus* | southern cloudy wing | N | N | N | 68 | 17 | G5 | N5 |
| Hesperiidae | *Thorybes pylades* | northern cloudy wing | Y | Y | Y | 67, 68 | 8, 13 | G5 | N5 |

**Appendix 2.**
*Continued.*

| Family | Species | Common name | Jn | Jl | Ag | Host plant code[1] | Plant utilization reference[2] | Global rank | National rank |
|---|---|---|---|---|---|---|---|---|---|
| Hesperiidae | *Urbanus simplicius* | plain longtail | _ | _ | _ | 89 | 7 | G5 | _ |
| Hesperiidae | *Wallengrenia otho* | _ | _ | _ | _ | 92 | 13 | G5 | _ |
| Hesperiidae | *Wallengrenia otho egeremet* | broken-dash | _ | _ | _ | 92 | 1 | G5 | N5 |
| Lasiocampidae | *Malacosoma californica* | western tent caterpillar | Y | Y | Y | 121 | 13 | _ | _ |
| Liparidae | *Nygmia phaeorrhoea* | brown-tail moth | ? | ? | ? | 121 | 13 | _ | _ |
| Liparidae | *Orgyia leucostigma* | _ | ? | ? | ? | 33, 50 | 13 | G5 | _ |
| Lycaenidae | *Brephidium exile* | western pigmy blue | Y | Y | Y | 50, 5 | 5, 9 | G5 | N5 |
| Lycaenidae | *Everes comyntas* | eastern tailed blue | Y | Y | Y | 68 | 5 | _ | _ |
| Lycaenidae | *Everes comyntas* | eastern tailed blue | Y | Y | Y | 67, 16 | 8, 13 | G5 | N5 |
| Lycaenidae | *Gaeides xanthoides* | great grey copper | Y | Y | Y | 116, 117 | 9 | _ | _ |
| Lycaenidae | *Hemiargus gyas* | _ | _ | _ | _ | 67 | 13 | _ | _ |
| Lycaenidae | *Leptotes marina* | marine blue | _ | _ | _ | 67 | 13 | G5 | N5 |
| Lycaenidae | *Lycaeides melissa* | orange-bordered blue | Y | Y | Y | 67 | 9 | G5 | N5 |
| Lycaenidae | *Lycaeides melissa samuelis* | karner blue | Y | Y | N | 67 | 12 | G5 | N2 |
| Lycaenidae | *Lycaena helloides* | purplish copper | Y | Y | Y | 114 | 17 | G5 | N5 |
| Lycaenidae | *Lycaena hyllus* | bronze copper | Y | Y | Y | 116 | 11 | G5 | N5 |
| Lycaenidae | *Lycaena phlaeas* | American copper | Y | Y | Y | 114, 116 | 11 | G5 | N5 |
| Lycaenidae | *Plebejus saepiolus* | greenish blue | Y | Y | Y | 115, 116 | 5 | G5 | N5 |
| Noctuidae | *Acronicta impressa* | _ | _ | _ | _ | 121 | 13 | _ | _ |
| Noctuidae | *Acronicta longa* | long-winged dagger moth | Y | Y | Y | 121 | 13 | _ | _ |
| Noctuidae | *Acronicta oblinita* | smeared dagger moth | Y | Y | Y | 121, 132 | 13 | G5 | N5 |
| Noctuidae | *Acronicta spingera* | nondescript dagger moth | Y | Y | Y | 121 | 13 | G4 | _ |
| Noctuidae | *Actebia fennica* | black army cutworm | N | Y | Y | 121, 123 | 13 | _ | _ |
| Noctuidae | *Agrotis gladiaria* | swordsman dart | N | N | ? | 121 | 13 | G5 | _ |
| Noctuidae | *Agrotis ipsilon* | black cutworm | Y | Y | Y | 37 | 13 | G5 | _ |
| Noctuidae | *Agrotis orthogonia* | pale western cutworm | _ | _ | _ | 20, 37, 50 | 13 | _ | _ |
| Noctuidae | *Agrotis vetusta* | old man dart | N | Y | Y | 123 | 13 | _ | _ |
| Noctuidae | *Anicla infecta* | green clover worm moth | Y | Y | Y | 92 | 13 | G5 | _ |
| Noctuidae | *Anomis erosa* | yellow scallop moth | N | N | Y | 72 | 13 | G5 | _ |
| Noctuidae | *Anticarsia gemmatilis* | velvetbean caterpillar | N | N | N | 67 | 13 | G5 | _ |
| Noctuidae | *Archanara oblonga* | oblong sedge borer moth | N | Y | Y | 132 | 13 | G5 | _ |
| Noctuidae | *Autographa californica* | alfalfa looper | _ | _ | _ | 67 | 13 | _ | _ |
| Noctuidae | *Autographa precationis* | common looper moth | Y | Y | Y | 50 | 13 | G5 | _ |
| Noctuidae | *Bellura densa* | _ | _ | _ | _ | 132 | 13 | _ | _ |
| Noctuidae | *Bellura obliqua* | _ | _ | _ | _ | 132 | 13 | _ | _ |
| Noctuidae | *Caenurgina erechtea* | forage looper | Y | Y | Y | 16, 67 | 13 | G5 | _ |
| Noctuidae | *Cercyonis latipes* | small mocis | Y | Y | Y | 92, 109 | 13 | _ | _ |

**Appendix 2.**
*Continued.*

| Family | Species | Common name | Jn | Jl | Ag | Host plant code[1] | Plant utilization reference[2] | Global rank | National rank |
|---|---|---|---|---|---|---|---|---|---|
| Noctuidae | *Copablepharon viridisparsum* | _ | _ | _ | _ | 37 | 13 | _ | _ |
| Noctuidae | *Crymodes devastator* | glassy cutworm moth | Y | Y | Y | 67 | 13 | _ | _ |
| Noctuidae | *Dargida procincta* | _ | _ | _ | _ | 82 | 13 | _ | _ |
| Noctuidae | *Erastria carneola* | _ | Y | Y | Y | 116 | 13 | _ | _ |
| Noctuidae | *Euxoa auxiliaris* | army cutworm | _ | _ | _ | 37 | 13 | _ | _ |
| Noctuidae | *Euxoa costata* | _ | _ | _ | _ | 53 | 13 | _ | _ |
| Noctuidae | *Euxoa divergens* | divergent dart | Y | Y | N | 67 | 13 | G4 | _ |
| Noctuidae | *Euxoa messoria* | reaper dart | N | N | Y | 25 | 16 | _ | _ |
| Noctuidae | *Euxoa pallipennis* | _ | _ | _ | _ | 53 | 13 | _ | _ |
| Noctuidae | *Euxoa pleuritica* | _ | ? | ? | ? | 118 | 3 | G4 | _ |
| Noctuidae | *Euxoa scandens* | white cutworm | Y | Y | N | 121 | 13 | G5 | _ |
| Noctuidae | *Euxoa tristicula* | _ | N | Y | N | 121 | 3 | G4 | _ |
| Noctuidae | *Feltia subterranea* | granulate cutworm | N | Y | Y | 31, 6 | 15, 13 | _ | _ |
| Noctuidae | *Heliothis obsoleta* | cotton boll-worm | ? | ? | Y | 32, 50, 58, 67, 73, 91, 107 | 13 | _ | _ |
| Noctuidae | *Heliothis phloxiphagus* | _ | _ | _ | _ | 67 | 13 | G5 | _ |
| Noctuidae | *Heliothis virescens* | tobacco budworm | Y | Y | Y | 67, 116 | 13 | G5 | _ |
| Noctuidae | *Hyppa xylinoides* | common hyppa | Y | Y | Y | 31, 50 | 13 | _ | _ |
| Noctuidae | *Lacinipolia lorea* | bridled arches | Y | Y | Y | 67 | 13 | _ | _ |
| Noctuidae | *Lacinipolia olivacea* | olive arches | y | Y | Y | 81 | 13 | _ | _ |
| Noctuidae | *Lacinipolia renigera* | bristly cutworm | Y | Y | Y | 67, 81 | 13 | G5 | _ |
| Noctuidae | *Leucania latiuscula* | _ | _ | _ | _ | 107, 109 | 13 | _ | _ |
| Noctuidae | *Leucania multilinea* | many-lined wainscot | Y | Y | Y | 107 | 13 | G5 | _ |
| Noctuidae | *Leucania pseudargyria guenee* | false wainscot | Y | Y | Y | 132 | 13 | G5 | _ |
| Noctuidae | *Leuconycta diphteroides* | green leuconycta | Y | Y | Y | 29 | 10 | G5 | _ |
| Noctuidae | *Luperina stipata* | _ | _ | _ | _ | 104 | 13 | G4 | _ |
| Noctuidae | *Mamestra configurata* | bertha armyworm | _ | _ | _ | 67 | 13 | _ | _ |
| Noctuidae | *Melanchra picta* | painted mamestra | _ | _ | _ | 8, 9, 67 | 13 | G4 | _ |
| Noctuidae | *Nola sorghiella* | _ | Y | Y | Y | 107 | 13 | _ | _ |
| Noctuidae | *Ogdoconta cinereola* | common pinkband | Y | Y | Y | 16, 13, 25 | 16, 3 | G5 | _ |
| Noctuidae | *Palthis angulais* | dark-spotted palthis | Y | Y | Y | 121 | 13 | G5 | _ |
| Noctuidae | *Papaiema nebris* | stalk borer | N | N | N | 123 | 13 | G5 | N5 |
| Noctuidae | *Papaipema arctivorens* | _ | _ | _ | _ | 20 | 13 | G5 | N5 |
| Noctuidae | *Papaipema arctivorens hampson* | _ | _ | _ | _ | 21 | 13 | _ | _ |
| Noctuidae | *Papaipema cataphracta* | burdock borer | N | N | N | 109, 121 | 13 | G5 | N5 |
| Noctuidae | *Papaipema nebris* | stalk borer | N | N | N | 13, 16, 20, 32, 50, 121 | 13 | G5 | N5 |
| Noctuidae | *Papaipema necopina* | _ | _ | _ | _ | 26 | 13 | G4 | N4 |
| Noctuidae | *Papaipema rutila* | _ | _ | _ | _ | 16 | 13 | G4 | N4 |
| Noctuidae | *Peridroma margaritosa* | pearly underwing | Y | Y | Y | 7, 81, 109, 118, 121, 125 | 13 | _ | _ |

**Appendix 2.**
*Continued.*

| Family | Species | Common name | Jn | Jl | Ag | Host plant code[1] | Plant utilization reference[2] | Global rank | National rank |
|---|---|---|---|---|---|---|---|---|---|
| Noctuidae | *Phosphila turbulenta* | turbulent phosphila | Y | Y | Y | 128 | 13 | G5 | _ |
| Noctuidae | *Plagiomimicus pityochromus* | black-barred brown | N | N | Y | 16 | 13 | _ | _ |
| Noctuidae | *Plathypena scabra* | green clover worm moth | Y | Y | ? | 67, 8, 16, 91 | 10, 13 | G5 | _ |
| Noctuidae | *Polia atlantica* | _ | _ | _ | _ | 67 | 13 | _ | _ |
| Noctuidae | *Polia grandis* | _ | Y | Y | Y | 50 | 13 | _ | _ |
| Noctuidae | *Polia legitima* | striped garden caterpillar | Y | Y | Y | 92, 121 | 13 | _ | _ |
| Noctuidae | *Protorthodes incincta* | _ | _ | _ | _ | 67 | 13 | _ | _ |
| Noctuidae | *Pseudaletia unipuncta* | white-speck | Y | Y | Y | 6, 16, 82, 89, 92, 101, 107 | 13 | G5 | N5 |
| Noctuidae | *Pseudorthordes irrorata* | _ | _ | _ | _ | 81 | 13 | _ | _ |
| Noctuidae | *Psychomorpha epimenis* | grapevine epimenis | Y | N | N | 33 | 13 | G5 | _ |
| Noctuidae | *Pyrrhia umbra* | bordered sallow | Y | Y | Y | 113, 121 | 13 | _ | _ |
| Noctuidae | *Schinia florida* | primrose moth | Y | Y | Y | 78 | 4 | _ | _ |
| Noctuidae | *Schinia marginata* | _ | _ | _ | _ | 13 | 13 | _ | _ |
| Noctuidae | *Schinia rivulosa* | _ | Y | Y | Y | 13 | 4 | G5 | _ |
| Noctuidae | *Schinia thoreaui* | Thoreau's flower moth | Y | Y | Y | 16 | 13 | _ | _ |
| Noctuidae | *Scotogramma trifolii* | clover cutworm | Y | Y | Y | 50, 118 | 13 | _ | _ |
| Noctuidae | *Simyra henrici* | Henry's marsh moth | Y | Y | Y | 132 | 13 | G5 | _ |
| Noctuidae | *Spodoptera dolichos* | _ | Y | N | Y | 125 | 3 | G5 | _ |
| Noctuidae | *Spodoptera eridania* | southern army worm | _ | _ | _ | 7, 91, 92 | 13 | G5 | _ |
| Noctuidae | *Spodoptera exigua* | beet army worm | _ | _ | _ | 5, 25, 50, 67 | 13 | G5 | _ |
| Noctuidae | *Spodoptera frugiperda* | fall army worm | N | Y | Y | 5, 32, 50, 56, 62, 67, 91, 92, 101, 102, 107 | 13 | G5 | _ |
| Noctuidae | *spodoptera ornithogalli* | cotton cutworm | _ | _ | _ | 5, 7, 22, 50, 58, 67, 81, 121, 125, 128 | 13 | G5 | _ |
| Noctuidae | *Spodoptera praefica* | western yellowstriped armyworm | _ | _ | _ | 50, 58, 67, 107, 121 | 13 | _ | _ |
| Noctuidae | *Stibadium spumosum* | frothy moth | N | N | Y | 25 | 3 | _ | _ |
| Noctuidae | *Tarachidia candefacta* | olive-shaded bird-dropping moth | Y | Y | Y | 13 | 13 | G5 | _ |
| Noctuidae | *Tarachidia erastriodes* | small bird-dropping moth | Y | Y | Y | 13 | 13 | G5 | _ |
| Noctuidae | *Trichoplusia ni* | cabagge looper | _ | _ | _ | 37, 50 | 13 | _ | _ |
| Notodontidae | *Datana ministra* | yellownecked caterpillar | Y | N | N | 121 | 13 | G5 | _ |
| Notodontidae | *Heterocampa guttivitta* | maple prominent | Y | Y | Y | 121 | 13 | G5 | _ |
| Notodontidae | *Schizura concinna* | red-humped caterpillar moth | Y | Y | Y | 121 | 13 | _ | _ |
| Notodontidae | *Schizura ipomoeae* | morning-glory prominent | Y | Y | Y | 56, 121 | 13 | G5 | _ |

**Appendix 2.**
*Continued.*

| Family | Species | Common name | Jn | Jl | Ag | Host plant code[1] | Plant utilization reference[2] | Global rank | National rank |
|---|---|---|---|---|---|---|---|---|---|
| Notodontidae | *Schizura unicornis* | unicorn caterpillar moth | Y | Y | Y | 121 | 13 | _ | _ |
| Nymphalidae | *Charidryas gorgone* | gorgone crescentspot | Y | Y | N | 16 | 9 | _ | _ |
| Nymphalidae | *Charidryas nycteis* | silvery checkerspot | _ | _ | _ | 22 | 13 | G5 | _ |
| Nymphalidae | *Chlosyne gorgone* | great plains checkerspot | Y | Y | Y | 25 | 11 | G5 | N5 |
| Nymphalidae | *Chlosyne lacinia* | bordered patch | Y | Y | Y | 25, 16 | 10, 7 | G5 | N5 |
| Nymphalidae | *Chlosyne lacinia adjutrix* | bordered patch | Y | Y | Y | 16 | 5 | _ | _ |
| Nymphalidae | *Chlosyne nycteis* | streamside checkerspot | Y | Y | Y | 25 | 11 | G5 | N5 |
| Nymphalidae | *Chlosyne palla* | northern checkerspot | Y | Y | Y | 23 | 7 | G5 | N5 |
| Nymphalidae | *Chlosyne whitneyi* | rockslide checkerspot | ? | Y | Y | 23 | 7 | G4G5 | N4 |
| Nymphalidae | *Cyllopsis gemma* | gemmed satyr | Y | Y | Y | 89 | 8 | G5 | N5 |
| Nymphalidae | *Danaus gilippus* | queen butterfly | N | Y | Y | 11 | 17 | G5 | N5 |
| Nymphalidae | *Danaus plexippus* | monarch butterfly | Y | Y | Y | 11 | 7 | G4 | N2N3 |
| Nymphalidae | *Euphydryas gillettii* | yellowstone checkerspot | Y | Y | Y | 124 | 7 | _ | _ |
| Nymphalidae | *Euphydryas phaeton* | the baltimore | Y | Y | Y | 132 | 13 | G4 | N4 |
| Nymphalidae | *Euptoieta claudia* | variegated frittilary | Y | Y | Y | 118 | 11 | G5 | N5 |
| Nymphalidae | *Junonia coenia* | common buckeye | Y | Y | Y | 81 | 7 | _ | _ |
| Nymphalidae | *Megisto rubricata* | red satyr | Y | Y | Y | 89 | 17 | G5 | N5 |
| Nymphalidae | *Nymphalis californica* | california tortoise shell | Y | Y | Y | 67 | 13 | G5 | N5 |
| Nymphalidae | *Nymphalis milberti* | Milbert's tortoise shell | N | Y | Y | 25 | 13 | G5 | N5 |
| Nymphalidae | *Occidryas taylori* | _ | _ | _ | _ | 81 | 13 | _ | _ |
| Nymphalidae | *Phyciodes pictus* | painted crescent | Y | Y | Y | 67, 55 | 13, 17 | G5 | _ |
| Nymphalidae | *Phyciodes tharos* | pearl crescent | Y | Y | Y | 23 | 7 | G5 | N5 |
| Nymphalidae | *Polygonia comma* | comma butterfly | _ | _ | _ | 13, 16 | 13 | G5 | N5 |
| Nymphalidae | *Polygonia gracilis* | graceful angle wing | _ | _ | _ | 16 | 13 | G5 | N5 |
| Nymphalidae | *Polygonia interrogationis* | question mark | _ | _ | _ | 13, 16 | 13 | G5 | N5 |
| Nymphalidae | *Proclossiana eunomia* | _ | _ | _ | _ | 110 | 5 | G5 | |
| Nymphalidae | *Proclossiana titania* | _ | _ | _ | _ | 110 | 17 | _ | _ |
| Nymphalidae | *Vanessa atalanta* | red admiral, alderman | Y | Y | Y | 13, 16 | 13 | G5 | N5 |
| Nymphalidae | *Vanessa cardui* | painted lady | Y | Y | Y | 18, 21, 20, 50, 74 | 16, 11 | G5 | N5 |
| Nymphalidae | *Vanessa virginiensis* | painted beauty | Y | Y | Y | 20 | 13 | G5 | N5 |
| Papilionidae | *Battus philenor* | pipevine swallowtail | Y | Y | Y | 112 | 11 | G5 | N5 |
| Papilionidae | *Papilio polyxenes* | black swallowtail | Y | Y | Y | 8 | 9 | G5 | N5 |
| Papilionidae | *Papilio zelicaon lucas* | anise swallowtail | Y | Y | N | 8 | 13 | G5 | N5 |
| Pieridae | *Anthocharis cethura* | desert orangetip | N | N | N | 36 | 13 | G4G5 | N4N5 |
| Pieridae | *Anthocharis midea* | falcate orangetip | N | N | N | 34 | 9 | G4G5 | N4N5 |
| Pieridae | *Anthocharis sara stella* | western orange tip | Y | Y | N | 37 | 13 | _ | _ |
| Pieridae | *Artogeia napi* | sharp-veined white | Y | Y | Y | 37 | 13 | G5 | _ |

**Appendix 2.**
*Continued.*

| Family | Species | Common name | Jn | Jl | Ag | Host plant code[1] | Plant utilization reference[2] | Global rank | National rank |
|---|---|---|---|---|---|---|---|---|---|
| Pieridae | *Colias alexandra* | queen alexandra's sulphur | Y | Y | Y | 68 | 17 | G5 | N5 |
| Pieridae | *Colias eurytheme* | alphalfa sulphur | Y | Y | Y | 67 | 13 | G5 | N5 |
| Pieridae | *Colias philodice* | clouded sulphur | Y | Y | ? | 68, 67 | 17, 5 | G5 | N5 |
| Pieridae | *Falcapoca midea* | falcate orangetip | _ | _ | _ | 34, 38 | 6 | _ | _ |
| Pieridae | *Nathalis iole* | dainty sulphur | Y | Y | Y | 48 | 6 | G5 | N5 |
| Pieridae | *Pieris rapae* | imported cabbageworm | Y | Y | Y | 37 | 13 | G5 | Ne |
| Pieridae | *Pontia beckerii* | sagebrush white | Y | N | Y | 37 | 9 | G5 | N5 |
| Pieridae | *Pontia occidentalis* | western white | Y | Y | Y | 37 | 7 | G5 | N5 |
| Pieridae | *Pontra protodice* | checkered white | Y | Y | Y | 22, 36, 38, 128 | 5, 13 | _ | _ |
| Pieridae | *Zerene cesonia* | southern dogface | Y | Y | Y | 67 | 8 | G5 | N5 |
| Saturniidae | *Automeris io* | io moth | Y | Y | Y | 121 | 13 | G5 | N5 |
| Saturniidae | *Hemileuca nevadensis stretch* | Nevada buck moth | N | N | N | 13 | 13 | G5 | N5 |
| Saturniidae | *Hyalphora cecropia* | emperor | Y | N | N | 121 | 3 | _ | _ |
| Satyridae | *Neonympha phocion* | _ | _ | _ | _ | 92 | 13 | _ | _ |
| Satyridaea | *Minois pegala* | blue-eyed grayling | _ | _ | _ | 83 | 13 | G5 | _ |
| Sphingidae | *Agrius cingulata* | pink-spotted hawk moth | Y | Y | Y | 125 | 13 | _ | _ |
| Sphingidae | *Ceratomia undulosa* | waved sphinx | Y | Y | Y | 33 | 13 | G5 | N5 |
| Sphingidae | *Erinnyis ello* | ello sphinx | N | Y | Y | 65 | 17 | G4G5 | N4 |
| Sphingidae | *Hemaris diffinis* | snowberry clearwing | Y | Y | Y | 9 | 17 | G4G5 | N5 |
| Sphingidae | *Hyles gallii* | dark-veined deilephila | _ | _ | _ | 118 | 13 | G5 | _ |
| Sphingidae | *Hyles lineata* | white-lined sphinx | Y | Y | Y | 118 | 13 | G5 | N5 |
| Sphingidae | *Manduca quinquemaculata* | five-spotted sphinx | Y | Y | Y | 125 | 13 | G5 | _ |
| Sphingidae | *Manduca rustica* | six-spotted sphinx | N | Y | Y | 25 | 13 | G5 | _ |
| Sphingidae | *Manduca sexta* | Carolina sphinx | Y | Y | Y | 125, 128 | 13 | G5 | _ |
| Sphingidae | *Paonias excaecata* | blind-eyed sphinx | Y | Y | Y | 121 | 13 | G5 | N5 |
| Sphingidae | *Paratrea plebeja* | plebian sphinx | Y | Y | Y | 33 | 17 | G5 | N5 |
| Sphingidae | *Proserpinus juanita* | green-banded day sphinx | Y | Y | Y | 78 | 10 | G4G5 | N4N5 |
| Thyatiridae | *Habrosyne scripta* | lettered habrosyne | Y | Y | Y | 121 | 3 | G5 | _ |
| Thyatiridae | *Haematopis grataria* | chickweed geometer | Y | Y | Y | 48 | 10 | _ | _ |
| Zanolidae | *Apatelodes torrefacta* | spotted apatelodes | Y | Y | Y | 121 | 13 | G5 | _ |

[1] Host plant codes from Appendix 1.
[2] Plant utilization codes are from the following references: 1 = Ebner, 1970; 2 = Engelhardt, 1946; 3 = Forbes, 1969; 4 = Hardwick, 1996; 5 = Howe, 1975; 6 = Klots, 1979; 7 = Opler, 1999; 8 = Opler and Krizek, 1984; 9 = Pyle, 1992; 10 = Richard and Heitzman, 1987; 11 = Scott, 1986; 12 = Shull, 1987; 13 = Tietz, 1972; 14 = Zhang, 1994; 15 = ipmwww.ncsu.edu/AG271/corn_sorghum/granulate_cutworm.htm; 16 = www.ext.nodak.edu/extpubs/plantsci/rowcrops/eb25w-6a.htm; 17 = http://www.npwrc.usgs.gov/resource/distr/lepid/BFLYUSA/bflyusa.htm.

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