MINNESOTA DEPARTMENT OF AGRICULTURE

Pollinator Report

Pollinator Bank, Habitat Protection, and Pesticide Special Review

Minnesota Department of Agriculture
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Pollinator Report to the Minnesota State Legislature: Pollinator Bank, Habitat Protection, and Pesticide Special Review

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Executive Summary

The Minnesota Department of Agriculture (MDA) developed this report in response to the 2013 Pollinator Legislation H.F. 976. in collaboration with Minnesota's Department of Transportation (MnDOT), Department of Natural Resources (DNR), Natural Resources Conservation Service (NRCS)-Minnesota, University of Minnesota (UMN), Minnesota Pollution Control Agency (MPCA), and Board of Water and Soil Resources (BWSR). The objectives of this report are to

(i) provide interpretations of the term 'pollinator bank' and propose feasibility, constraints, and uncertainties of the various interpretations;
(ii) delineate past, present, and future efforts by MDA, DNR, UMN, MPCA, BWSR and MnDOT to create and enhance insect (native and commercial) pollinator nesting and foraging habitat, as well as to establish and protect pollinator reserves or refuge areas by using Best Management Practices (BMPs);
(iii) discuss efforts and progress on developing BMPs to establish, enhance, protect, and restore pollinator habitat that will ultimately be incorporated into pesticide applicator and inspector training and;
(iv) outline the process and criteria of a special review of neonicotinoid insecticides, and provide a status update on the process, criteria, and progress of the special review of neonicotinoid pesticides registered by the Commissioner for use in this state currently and in the future.

While pollination can occur by approximately 200,000 pollinator species including insects, birds, bats, and other animals worldwide, this report focuses solely on insect pollinators. Insect pollinators, such as bees, flies, wasps, beetles, butterflies, moths, thrips, etc., are an important part of food production for humans and wildlife, and for plant reproduction in Minnesota and the world. Bees, however, are the most efficient and important pollinators of our food crops: In the United States, the estimated annual value of honey bee pollination for food production is approximately $15-18 billion while that of native bees is estimated at $3 billion.

Since 2007, the decline of honey bees (*Apis mellifera*) and the number of bee colonies has been ascribed to many interacting factors including pathogens and parasites, pesticides, poor nutrition due to loss of foraging habitat, and aging of beekeeper populations. It is likely that most of these same dangers, and some others such as loss of nesting habitat and climate change, threaten native bees and other insect pollinators in Minnesota. Although information is lacking on population levels of most other insect pollinator species, it is possible that they are also experiencing population declines.

Many state, federal, and non-profit programs already support pollinators by encouraging habitat. Historically, programs such as, Roadsides for Wildlife, Reinvest in Minnesota, the Minnesota Prairie Conservation Plan, and others had goals to create and enhance insect (native and commercial) pollinator nesting and foraging habitat, as well as to establish and protect pollinator reserves or refuge areas by using BMPs. However, even with all the current and historical programs to encourage pollinators described in this report, our understanding of their effectiveness and success is still largely unknown due in part to existing gaps in general knowledge about many pollinating insects and their habitat needs.

Currently, native plant community restoration and enhancement work performed by DNR, BWSR, and other state agencies is state-of-the-art; however, there is still no clear direction on procedures and species selection to address the decline in pollinator species. Therefore, DNR was directed to develop and implement new BMPs and habitat restoration guidelines for pollinator habitat on DNR lands. In

addition, MDA was directed to develop BMPs to protect pollinator habitat and train pesticide applicators and agricultural inspectors on how to effectively use these BMPs.

Assembly and development of pollinator BMPs by DNR and MDA is in progress. MDA has convened a Pollinator Habitat Advisory Work Group, held a stakeholder group meeting, and established three volunteer Pollinator BMP workgroups consisting of representative stakeholders and MDA, DNR, and MnDOT representatives. These workgroups will be meeting in early 2014 to begin BMP development in their respective areas: (1) Habitats Associated with Agricultural Land (e.g. near, adjacent to or in agricultural fields, such as grassed waterways and vegetative filter strips); (2) Habitats Associated with Gardens and Managed Landscapes (e.g. home/institutional gardens, parks, and parkways); and (3) Habitats Associated with Roadsides (e.g. rights-of-way and ditches).

However, challenges and constraints exist on establishing, enhancing, and managing foraging and refuge sites for all insect pollinators. Plant species for commercial honey bee foraging are not necessarily the same as those needed for the survival of native bees and other pollinating insects. Native pollinators, as a group, use a wider range of floral sources than honey bees and may also rely on these plants for nesting. The honey bees' traditional floral resources, for honey production, include a small variety of native and non-native flowering plant species including some that are now considered invasive by some agencies (e.g. yellow and white sweet clover). It is therefore, critical to find alternative native or non-native plant species that are not invasive that can, for example, be viable substitutes for sweet clover. In addition, some traditional honey bee foraging crops, like alfalfa, are becoming less abundant on the landscape as recent summer droughts and cold winters have reduced forage stands, and as land use changes may favor row crops or development.

It seems intuitive to introduce native flowering plants into existing landscapes as commercial honey bee habitat, because increasing abundance of native flowering plants in prairies, along roadsides, and as crop borders has been shown to be helpful to native pollinators. However, little is known or understood about global pollinator floral resource needs and about which native floral species have potential to provide commercial honey bees with good pollen and nectar for colony health and honey production.

In addition to foraging constraints, challenges exist when establishing or creating nesting sites for all insect pollinators, as nesting requirements for commercial honey bees are not the same as the habitat and nesting sites needed for survival of native bees and other pollinating insects. While honey bees are provided with nesting habitat by their beekeepers, native insect pollinators need to be able to find nesting or breeding habitat out in the wild. Depending on the species, native bees can require bare soil or cavities (vegetative and non-vegetative) to form their nests. Loss of habitat for native insect pollinators may be due to land use changes, local weather and climate changes, or other factors. More research is need since the habitat requirements of many native bees and other insect pollinators are unknown, making specific habitat recommendations a challenge.

Establishing and creating new pollinator habitat areas could potentially benefit some pollinators, but a more efficient solution may be to enhance acres of habitat that are already on the landscape. Examining ways these areas are currently managed and buffered is an important first step in order to maximize their effectiveness as pollinator reserves or refuges. Therefore, the proper implementation and use of existing BMPs (BWSR and others) and the new BMPs under development by DNR and MDA could increase the quality of pollinator habitat through changes in existing management practices such as mowing frequency, haying practices, reseeding mixtures, and pesticide spraying practices.

As requested by the legislature, MDA has outlined the process and criteria of a special review of neonicotinoid insecticides. Because MDA has already established the basic process and criteria to

conduct a variety of pesticide reviews, and because MDA has already reviewed several neonicotinoid concerns as part of its emerald ash borer insecticide review (including concerns about pollinator exposure), the Commissioner of Agriculture directed MDA staff to initiate a special review of neonicotinoid pesticides and insect pollinators. As such, this legislative report goes beyond outlining the process and criteria of a special review and includes a status update on the progress of the special review of neonicotinoid pesticides and insect pollinators.

Following this charge, MDA has begun working with the DNR and MPCA to develop a draft of the scope (the underlying criteria) to be used in conducting the special review. An in-depth, special review will be conducted to provide stakeholders and the MDA Commissioner with more information about Minnesota-specific pesticide products and issues. These reviews are not intended to be redundant of analyses and decisions reached by the U.S. Environmental Protection Agency (USEPA) during federal registration. Instead, these reviews result in a greater understanding of federal registration concerns and a variety of opportunities for action. Depending on the scope of the in-depth review, completion can take six months or more.

Addressing legislation, this report also proposed four interpretations of the term 'pollinator bank' providing an explanation of them as the Museum, Database, Genetic, and Ecological Interpretation and the feasibility, constraints, and uncertainties of each were discussed. Existing programs at state museums, zoos, and the University of Minnesota could be adapted for the Museum and Database interpretations, and made available online for public education. A pollen database, currently being assembled at the University of Minnesota, will be an essential tool towards increasing our awareness about bee diets. A germplasm repository of honey bee genes already exists in Washington State; therefore, creating an expensive genetic 'Pollinator Bank' in Minnesota is not necessary. The Ecological Interpretation was defined as establishing habitat areas and was the main focus of this report. Funding has been requested by UMN to hire a new interdisciplinary professor to coordinate statewide activities.

To help solve pollinator habitat issues, many state, federal, and non-profit agencies and academia are collaborating at the local, state, regional, national, and international levels to develop an understanding of pollinator populations, management, diseases, and predators, as well as the role of pesticides as stressors. MDA is committed to working collaboratively, with other interested parties, to find positive solutions that impact the health and well-being of our important insect pollinators, their habitat, and the agricultural production of our state.

Introduction

Seventy to eighty percent of all flowering plants rely on animal pollinators (insects and others) to reproduce. Pollination, the process of transferring pollen from a flower anther to a stigma for fertilization, can occur by an estimated 200,000 pollinator species worldwide, including insects, birds, bats, and other animals. Insects, such as bees, flies, wasps, beetles, butterflies, moths, thrips etc., are responsible for greater than 99% of the pollination process for plants not using wind or water as a means of pollen transfer. It is estimated that 35% of the volume of global food production comes from crops that to some extent depend on animal pollinators. Of all the animal pollinators, bees are the most efficient pollinators and are important for crop production.

The number of bee species worldwide is estimated at 20,000 species. In North America, there are more than 4,000 species of native bees, and in Minnesota, there are between 350-400 species of known native bees. These native bees are mostly unmanaged, but several species (e.g., one species of bumble bee, *Bombus impatiens*, orchard mason bees, and leafcutter bees) are managed for use in fruit crop, seed production, and greenhouse pollination. These diverse native bees, both wild and managed, contribute an estimated $3 billion to crop pollination in the U.S.

The majority of pollination for agricultural crops in the United States is done by the honey bee (*Apis mellifera*), a non-native bee species that is managed by humans. Honey bee colonies are managed for honey production and are moved around the country for pollination of our nation's almond, fruit, and vegetable crops. The annual value of pollination of food crops in the United States by honey bees is estimated at approximately $15-18 billion.

While beetles, butterflies, moths, wasps, thrips, and flies are some other insects known to pollinate flowers, the number and species of other insects that act as pollinators in the U.S. and in Minnesota is unknown. The pollination services offered by native bee and other insect pollinators also provide important food and habitat for other wildlife species.

This report will focus solely on habitat for insect pollinators. Habitat includes floral resources (nectar and pollen) used by pollinators for food, and nesting sites that some pollinators, such as native bees, use for rearing their young (spring and summer) and for hibernating (winter).

Many state and federal programs already support pollinators by creating suitable habitat. For example, Minnesota's Department of Transportation (MnDOT) and Department of Natural Resources (DNR) have worked for over 30 years promoting, restoring and enhancing habitat and native vegetation through programs such as the Prairie Passage Route, and Roadsides for Wildlife (RFW). The Roadsides for Wildlife program has provided funding to improve habitat on approximately 2,000 acres in Minnesota, by planting high quality, diverse seed mixes of native grass and wildflowers, and has created educational materials and outreach opportunities around the importance of pollinators and how roadsides can provide habitat. In addition, Minnesota DNR manages over 5 million acres of natural area land (State Forests, Wildlife Management Areas, Aquatic Management Areas, Scientific and Natural Areas, State Parks, State Trails, etc.) that benefit a variety of wildlife species. The Minnesota Board of Water and Soil Resources (BWSR) has been preserving and restoring pollinator habitat across Minnesota since 1987. BWSR's Reinvest In Minnesota (RIM) program has restored and protected approximately 250,000 acres. In addition, around 29,000 acres of habitat has been planted through soil and water conservation grants, and administration of the Wetland Conservation Act has helped protect Minnesota's 10.6 million acres of wetland. The U.S. Department of Agriculture (USDA) has many voluntary conservation incentive programs, funded through the Federal Farm Bill, that have some component focused on developing or improving wildlife habitat, including that for native pollinators. These include

the Wildlife Habitat Incentive Program (WHIP), Environmental Quality Incentives Program (EQIP), Conservation Reserve Program (CRP), Wetlands Reserve Program (WRP), Grassland Reserve Program (GRP), and Conservation Stewardship Program (CSP). The DNR also administers the Working Lands Initiative (WLI) and Native Prairie Bank (NPB) easement incentive programs. These USDA and DNR incentive programs are available to conservation-minded landowners who want to voluntarily create or enhance wildlife, including that for pollinators, on private agricultural and forest land and on tribal land.

Over the years, techniques for restoring and preserving habitat have greatly improved and evolved as knowledge and awareness have increased. Habitat managers now realize that species and structural diversity play an important role when managing for functional ecosystems. Successful habitat enhancement and restoration is strongly associated with appropriate selection of native species and seed sourcing. State and federal agencies are using this information to develop new guidelines and BMPs for establishing pollinator habitat.

This report will provide interpretations of the term 'pollinator bank' and propose feasibility, constraints, and uncertainties of the various interpretations. In addition, it will delineate past, present, and future efforts by the Minnesota Department of Agriculture (MDA), DNR, UMN, MPCA, BWSR, and MnDOT to create and enhance insect (native and commercial) pollinator nesting and foraging habitat, as well as to establish and protect pollinator reserves or refuge areas by using Best Management Practices (BMPs). Furthermore, it will discuss efforts and progress on developing BMPs to establish, enhance, protect, and restore pollinator habitat and outline the process, criteria, and status of a special review of neonicotinoid insecticides. Any additional material is beyond the scope of this report.

Background

Honey Bees

United States Department of Agriculture (USDA) Statistics indicate that there were just over 2.6 million managed colonies of honey bees in the U.S., in 2012. Over the last 50 years, honey bees have been faced with a number of stressors that impact their health and survivorship: they are confronted by a number of pests and diseases, there are fewer flowering plants available to meet their nutritional needs, and they encounter a wide variety of pesticides that can be toxic. In the 1980s, two parasitic mites were introduced into the United States. One mite, *Varroa destructor*, has caused very serious declines of honey bees (an average annual mortality of 15 to 20%) and is still a serious pest that is extremely difficult to control. Beginning in 2007, honey bee colonies began dying throughout the U.S. in unprecedented numbers. The term Colony Collapse Disorder (CCD) was used to describe these losses, because no single factor could account for the high bee mortality. Since 2007, the average mortality of honey bee colonies across the nation has been over 30% each year, raising concern over the long-term viability of the beekeeping industry. The general consensus among researchers was to attribute these extreme losses to the interaction between pathogens and parasites, pesticides, and poor nutrition due to lack of floral resources.

Honey bees produce honey in every state in the U.S., however, 2012 honey production in the upper Midwest states of North and South Dakota, Montana, Minnesota, Wisconsin, and Michigan were ranked by the USDA at 1st, 2nd, 5th, 6th, 8th, and 9th, respectively for pounds of honey produced. These six Midwest states produced 52% of the total U.S. honey for 2012. Other years have similar state production rankings. As additional value, most commercial beekeepers move their hives from these upper Midwest states during the winter months to pollinate crops in the western or southern states (e.g., approximately 1.6 million colonies are needed in California to pollinate almonds in February).

These upper Midwest states are important to beekeepers not only for the value of the honey production, but also for the positive effect that abundant floral resources can have on colony health. Honey bees require large foraging areas. A honey bee flies an average of 2.5 miles on each foraging trip from the hive, but, if necessary, it will fly more than 5 miles, one way, to reach flowers. It is estimated that honey bees visit approximately 2 million flowers to make 1 pound of honey, and that the hive requires 75-100 pounds of honey to survive the winter in Minnesota.

In Minnesota, habitat to protect and encourage colony survival of commercial honey bees during the summer months requires an abundance of available wild and cultivated forbs and flowering tree and shrub species for honey bee forage. The traditional floral resources and honey producing plants in Minnesota for honey bees include early blooming trees (willow, maple, oaks), dandelions, fruit trees and other flowering trees and shrubs, particularly American basswood and European lindens (*Tilia* spp.), clovers (*Trifolium* spp. and *Melilotus* spp.), alfalfa (*Medicago sativa*), many species of wild and garden flowers, and late blooming flowers like asters, goldenrod, and sunflowers. As clover plants in the genus *Melilotus* are listed as invasive plants by some agencies; it is critical to find alternative native or non-native, but non-invasive, floral sources that can be viable substitutes for sweet clover. While alfalfa and clover in pastures is a potential option, depending on management schemes, alfalfa and other clovers are traditionally cut in early bloom stages to optimize yield and forage quality, thus limiting the amount of time floral resources are available to foraging bees. In addition, USDA reported a 23% decline in acres of alfalfa and alfalfa mixtures harvested in Minnesota between 2010 and 2012. This decline was probably due to the extreme drought or cold conditions during these growing seasons. Even so, attention to the need for honey bee nutrition and forage habitat has only been in the spotlight since honey bees started dying in 2007.

It is not known which native floral species have potential to be good honey producing plants for commercial honey bees. Honey bees visit a number of native flowers, but native flowers are not planted in sufficient abundance or density anywhere in Minnesota and their use by honey bees has not been thoroughly studied. Ongoing research, at UMN funded by General Mills, is investigating whether a mixture of native wild flowering plants (including smooth penstemon, dotted mint, purple prairie clover, fragrant giant hyssop, mountain mint, and New England aster) are good candidates for honey production. While increasing abundance of native flowering plants in prairies, along roadsides, in field borders, or in other managed areas have been shown to be helpful to native pollinators it is unknown how these habitat management strategies affect commercial honey bee populations.

Native Bees

The abundance and diversity of native bees in Minnesota requires study. It is estimated that there are between 350-400 species, but surveys are needed to determine actual numbers and species. A few studies in the U.S. have shown that the native bee population, like the honey bee population, is in decline. Possible reasons for the declines of native bees include diseases, stresses from pesticide use, climate change, and habitat loss.

Minnesota is home to eighteen bumble bee species. Populations of several species have declined including the American (*Bombus pensylvanicus*), rusty patched (*B. affinis*), yellow-banded (*B. terricola*), and yellow (*B. fervidus*) bumble bees. Suspected reasons for these declines include habitat loss, diseases and pests, and pesticide exposure. For example, one species that has not been documented in the Minnesota for over 10 years is Ashton's bumble bee (*B. ashtoni*); this nest parasite specializes in parasitizing the nests of the rusty patched and yellow-banded bumble bees. For Ashton's bumble bee females to reproduce, they take over the nest of another species, whose workers then care for the offspring of new queen. The disappearance of Ashton's bumble bees corroborates the disappearance of their hosts.

As a group, native pollinators use a larger number of floral species compared to honey bees. Some native bees are generalists, visiting a wide range of flowering plants, including native and non-native species. Other native bees are specialists limiting their floral visits to a single plant species, genus or family on which they are dependent for survival.

Other Native Insect Pollinators

Little is known about the habitat requirements for flies, moths and many butterfly species that provide some pollination services. Although many native pollinators will visit a wide variety of plants, there are some native pollinators that require specific types of plants. It is well known that as caterpillars, monarch butterflies require milkweed plants for their food. The decline of monarch populations has been linked to the decline of the common milkweed plant from the Midwest landscape. Not all of these habitat relationships are documented but in general, encouraging plant diversity will help provide needed food sources and nesting sites for diverse insect pollinator populations.

The many other species of native pollinators in Minnesota face threats similar to bees. Although, information is lacking on population levels of most other pollinator species, it is reasonable to assume that they are also experiencing population declines. It is important that steps are taken to protect all of our pollinating insects by increasing pollinator habitat.

Pollinator Habitat

In order to survive, pollinators such as bees and other insects, require shelter and protection, nectar, pollen, and water. For a variety of reasons these resources may be scarcer in or near intensively-managed agricultural landscapes. Habitat loss may be due to land use changes, degradation of quality habitat with decreased pollinator forage species composition or other factors. The relative contribution of these factors has not been studied in Minnesota but would be valuable information for developing solutions to pollinator issues.

While honey bees are provided with nesting habitat by their beekeepers, native insect pollinators need to be able to find nesting or breeding habitat in the wild. Most native bees form their nests in soil and require areas of bare ground. Inclusion of bunch grasses in plantings helps to insure areas of bare ground. Different pollinator species prefer different soil types with some requiring sand for nesting. Other native bees require tunnels and other cavities for their nesting. Depending on the bee species, these cavities can be holes left in wood by beetles, hollow stems, or many other features. The nesting habitat requirements of some native bees and insect pollinators are well known, but many others have not been documented. Therefore, making specific recommendations for these species is challenging.

Legislative Actions in 2013

The decline of pollinator species and the resulting ecological and economic consequences were the subject of 2013 legislative discussions with several provisions included in the appropriation bill for Minnesota Department of Natural Resources (DNR), Department of Agriculture (MDA), Minnesota Pollution Control Agency (MPCA), and Board of Water and Soil Resources (BWSR). The statutory requirements and purpose for the Pollinator Report was outlined in the enabling legislation Minnesota Session Law 2013, Chapter 114 HF no. 976, Article 2, Sec. 67:

> "The commissioner of agriculture must develop the report in consultation with the commissioners of natural resources and the Pollution Control Agency, the Board of Water and Soil Resources, and representatives of the University of Minnesota. The report must include, but is not limited to, the following: (1) a proposal to establish a pollinator bank to preserve pollinator species diversity; (2) a proposal to efficiently and effectively create and enhance pollinator nesting and foraging habitat in this state including establishment of pollinator reserves or refuges; and (3) the process and criteria the commissioner of agriculture would use to perform a special review of neonicotinoid pesticides registered by the commissioner for use in this state currently and in the future."

Literary and Scientific Resources

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Proposal to Establish a 'Pollinator Bank'

The term 'pollinator bank' can be interpreted in a variety of ways. Four interpretations of the term 'pollinator bank' were created as a part of this collaborative Pollinator Report effort. Feasibility, challenges and constraints, as well as resource considerations for each interpretation are presented.

Museum Interpretation of 'Pollinator Bank'

If the 'Pollinator Bank' term is interpreted to mean existing insect museums or zoos, these facilities already contain insect specimens. These specimens are an irreplaceable bank of genetic data, historical locality information, and floral associations for these insects. For example, the University of Minnesota (UMN) Insect Museum holds thousands of pollinator specimens that could be considered a "pollinator bank." With this interpretation, a pollinator committee could be formed and funded that would work with the museum to determine project goals and curation needs (supplies, space, personnel). Without further assessment, this report would suggest databasing Minnesota specimens of all bees (Apoidea: Anthophila), some butterflies and moths, and select flies (especially Syrphidae). These data could be submitted to an aggregate site such as DiscoverLife (http://www.discoverlife.org/) , an interactive encyclopedia about the taxonomy, natural history, distribution, abundance, and ecology of species including those in the superfamily Apoidea. Information on site is made available online to the public via a mission "to assemble and share knowledge in order improve education, health, agriculture, economic development, and conservation throughout the world."

Database Interpretation of 'Pollinator Bank'

If captured specimen data is desired, information from the University of Minnesota can be combined with existing specimen data from museums in Minnesota, such as the Science Museum of Minnesota, and Southwest State University, and other museums to create a single database. The database itself would be the "pollinator bank" and it would draw information from UMN's largest holding of pollinator specimens, and these other state museums to form this single database. These data could also be submitted to an aggregate site (such as mentioned above) and made available online to researchers and the public. This interpretation differs from the first in that it focuses more on capturing specimen data and less on preserving genetic material.

Another database for pollinators could be a reference database of bee-collected pollens. This database would basically be a library of pollens collected for permanent storage from bee-preferred flower species. A pollen database would provide invaluable information on the flowering plants, shrubs and trees that all bees (honey bees and native bees) use as food plants in particular areas. One of the challenges of providing habitat for pollinators is our lack of understanding of bee diets. A pollen library is an essential tool for studying bee diets. A pollen reference database is currently being constructed at the UMN for bee-collected pollens in the Prairie Pothole Region of ND and from Le Sueur and Princeton, MN. See Appendix 1 for a listing of these and other UMN pollinator related activities.

Genetic Interpretation of 'Pollinator Bank'

The Minnesota Zoo developed its own interpretation of a Pollinator Bank, when it established the Prairie Butterfly Conservation Program in 2012, aimed at averting the extinction of native prairie butterflies. The Minnesota Zoo conducts conservation research programs as an insurance backup for selected endangered species to preserve genetic integrity of the species. With extinction in mind, the zoo's efforts provide "insurance breeding populations" for species that are disappearing. This approach is not generally practical for the vast majority of native bee species that have behavioral or ecological requirements that would make captive breeding impractical.

Another interpretation could mean establishing some sort of honey bee germplasm repository. In fact, researchers at Washington State University (S. Sheppard) have started the first repository (bank) for honey bee germplasm (sperm). Honey bee sperm samples collected from stocks throughout the U.S. and from other subspecies of honey bees collected in Europe are stored in liquid nitrogen. All collected samples are quarantined first to prevent viruses or other pathogens from spreading. Sperm is utilized for research purposes only via controlled matings using instrumental (artificial) insemination. This is a national bank, and since honey bees comprise only one species (*Apis mellifera*) that are distributed worldwide, it would not be cost effective to establish another germplasm repository here in Minnesota. Furthermore, as there is no available technology to artificially inseminate native bee pollinators, a germplasm (sperm bank) repository for these species is impractical.

Ecological Interpretation of 'Pollinator Bank'

An 'Ecological Bank,' means establishing areas of habitat that provide floral resources and protection. Under this ecological interpretation of a pollinator bank, land under control of the Minnesota Department of Natural Resources (DNR) and other public and privately owned land, would be considered an ecological bank of resources that support all insect pollinators. In addition, some areas could be designated "pollinator parks" for public education, awareness, and tourism. Focusing on this ecological interpretation, the next section of this report will describe past, present, and future efforts and best management practices used by state and federal agencies to create and enhance insect pollinator (honey bee and native pollinator) nesting and foraging habitat, as well as to establish and protect pollinator reserves or refuge areas, using Best Management Practices (BMPs).

Native insect pollinators (bees, some butterflies and moths, and select flies) are in need of foraging habitat, which primarily consists of floral resources that are protected from pesticides. For wild, native bees, habitat refers to both floral foraging resources and their preferred nesting sites in undisturbed ground, hollow stems, or other cavities. Floral foraging resources include forbs, flowering shrubs, and flowering trees that provide pollen and/or nectar for insect pollinators.

Commercial honey bees have historically preferred and produced the best and largest quantities of honey for hive health by foraging from the following native and non-native plants: clover (*Melilotus* and *Trifolium* spps.), alfalfa (*Medicago* spp.), buckwheat (*Fagopyrum esculentum*), sunflower (*Helianthus* spp.) or other flowers in the aster family, American basswood (*Tilia americana*), and wildflowers. It is not known how much honey bees collect from native flowers, or whether native plants and managed areas will be helpful to commercial honey bees.

Challenges and Constraints

Honey bee needs: Honey bees need to produce large amounts of honey for colony survival. More research is needed to determine whether native and restored prairies or managed areas with native plants and wildflowers will benefit non-native honey bees. Our knowledge about pollinator floral resource needs is limited, and it is necessary to understand which native floral species have potential to be good honey producing plants for honey bees. White and yellow sweet clover (*Melilotus* spp.) have been the main honey producing floral sources for over 100 years in Minnesota, but they currently are considered by many agencies to be invasive. It is critical to find alternative floral sources that can be viable substitutes for sweet clover in order to sustain the large beekeeping industry in Minnesota, particularly the commercial beekeepers that depend on honey production for their livelihood.

Native bee needs: Most native bees are unmanaged. While several species are managed for pollination of fruit, seed, and greenhouse crops, most native bees live in the wild. More knowledge exists about commercial honey bees than native bees, and therefore, additional work is needed to learn about native bee populations. Firstly, the diversity and abundances of native bee species that live in Minnesota is an

approximation at best. A survey to compile a new statewide species list is needed. All recent bee surveys have had limited geographic scope. The last statewide species list was compiled in 1919 and it missed at least 80% of the Minnesota species. In addition to documenting species presence and abundance, documentation of life histories, nesting preferences and biology, nutrition requirements, and floral/diet breadth would help to construct appropriate management practices for native bees.

Butterfly and Moth Needs: Butterflies and moths visit flowers for nectar and incidentally transfer pollen. Since they do not actively collect pollen as bees do, butterflies and moths are not as effective at pollinating plants. The extent of their role as plant pollinators is largely unknown. While research from the Monarch Lab at the UMN (See Appendix 1), showed a terrible year for monarch populations in 2013, little is known about the status and habitat needs of other butterflies and moths. Butterflies tend to be attracted to brightly colored flowers. Moths, which are mostly active at night, are attracted by plants that have pale and sweet smelling flowers. Moths, which are abundant, have the potential to be significant pollinators. A survey of butterflies and moths in Minnesota would be helpful in assessing distributions and host plant preferences to support butterflies and moths. Studies documenting their role as pollinators would help us to properly evaluate their contribution to pollination in Minnesota.

While the importance of butterflies and moths as pollinators is unknown, concern for their conservation is not really related to their pollination services. For example, the United States Fish and Wildlife Service (USFWS) is currently taking comments on a proposal to list two rare butterfly species, the Dakota Skipper and the Poweshiek Skipperling, as Threatened or Endangered, respectively. DNR is seeking guidance from the USFWS on management of land identified as Critical Habitat for these species. This guidance is expected to also benefit pollinators in general, as well as these rare species. The Monarch Joint Venture is a partnership of thirteen federal and state agencies, non-governmental organizations, and academic programs working to facilitate a united conservation, education, and research effort across the U.S. promoting habitat conservation for monarch migration that benefits other pollinator insects as well (See Appendix 1).

Other Insect Pollinators: Besides bees, butterflies and moths, there are wasps, flies, beetles, thrips, and other insects that contribute to pollination of plants in Minnesota. A specific survey is not recommended for these insect groups as most of these flower-visiting insects would be captured during surveys at flowers for bees. However, additional resources and expertise would be needed for identification of these specimens. As with butterflies and moths, studies documenting their role as pollinators would help properly evaluate their contribution to pollination in Minnesota.

Resource Considerations for 'Pollinator Bank' Establishment

The University of Minnesota, Department of Entomology, is requesting funding from the Legislative-Citizen Commission on Minnesota Resources (LCCMR), UMN or other state agencies or legislature to hire a new interdisciplinary UMN faculty member to help coordinate statewide pollinator bank activities related to three of the pollinator bank interpretations. The new professor's activities will include but are not limited to:

1. Directing the museum database interpretation effort, by hiring technician(s) or post-doctoral researcher(s), and/or coordinating with the DNR and other agencies to do the identification, curation, and databasing of Minnesota's pollinator specimens.

2. Coordinating a statewide, on-line database interpretation effort, by hiring technician(s) or post-doctoral researcher(s), and/or collaborating with DNR, the Science Museum, State Universities and others.

3. Leading the ecological interpretation effort by collaborating with UMN, DNR, Minnesota Department of Transportation (MnDOT), Natural Resources Conservation Service (NRCS), the Board of Water and Soil Resources (BWSR), The Nature Conservancy (TNC), and the Minnesota Department of Agriculture (MDA) to coordinate, help consolidate and accelerate the many pollinator efforts that are ongoing and planned, including those concerned with managed bee populations in the state (UMN and Beekeeping Associations), surveying and compiling the state's first database of wild pollinators (DNR), acquiring land and easements for pollinators (Pheasants Forever), reconstructing habitats and corridors for pollinator nesting and foraging (TNC), enhancing rural farmland management (NRCS, MDA, UMN), and educating and learning from the many stakeholders in this system.

Proposal Regarding Pollinator Habitat

Many state, federal, and non-profit agencies already work towards improving native pollinator habitat. This section of the report will delineate past, present, and future efforts by the Minnesota Department of Agriculture (MDA), Department of Natural Resources (DNR), University of Minnesota (UMN), Minnesota Pollution Control Agency (MPCA), United States Department of Agriculture(USDA) through the Natural Resources Conservation Service (NRCS) and Farm Service Agency (FSA) Minnesota offices, Board of Water and Soil Resources (BWSR), and the Minnesota Department of Transportation (MnDOT) to create and enhance insect pollinator nesting and foraging habitat, as well as to establish and protect pollinator reserves or refuge areas, using Best Management Practices (BMPs). Even with all the ongoing current and historical efforts to enhance and encourage pollinators described in this section, our understanding of their effectiveness and success is still largely unknown due in part to existing gaps in general knowledge about many pollinating insects and their habitat needs.

Creation and Enhancement of Nesting and Foraging Sites

MDA, DNR and MnDOT have long histories of championing the use of native vegetation on roadsides, which created and enhanced nesting and foraging habitats for native pollinators. Some concern has been expressed relative to vehicle mortality of insects; however, research suggests that the benefits from roadside habitat outweigh the hazards.

Beginning in 1998 after legislation was passed to incorporate Integrated Pest Management (IPM) strategies on all state-owned lands, MDA began training county agricultural inspectors, township supervisors and city weed inspectors responsible for enforcement of the state's Noxious Weed Law, on the importance of targeting management to specific noxious weeds and invasive plants in order to preserve native and beneficial plant species important for pollinators and the ecology of the state. MDA's Standard Operating Procedure for Noxious Weed Enforcement emphasizes that when noxious weeds are present, targeting management to those specific plants is critical to preserving the habitats that have been invaded thus ensuring greater biodiversity. Over the past several decades, several county agricultural inspectors have become leaders statewide and throughout the Midwest in championing the idea of developing robust weed programs that seek to control problematic species and preserve beneficial plants that promote greater biodiversity.

In 1984, DNR offered a program called Roadsides for Wildlife (RFW). The Roadsides for Wildlife program has since provided funding to improve habitat on approximately 2,000 acres, in Minnesota, by planting high quality, diverse seed mixes of native grass and wildflowers. In addition, the RFW program uses educational and outreach materials such as posters, flyers, brochures, signs, and radio and television spots to illustrate the importance of pollinators and how roadsides can provide habitat. The Minnesota Prairie Conservation Plan (See Appendix 2) also places strong emphasis on grassland habitat and how these corridors connect across the Minnesota landscape. Currently, this Prairie Plan is a joint effort of state, federal, and non-profit agencies working to increase a network of corridors. This plan, along with other efforts to restore habitat complexes and corridors can help guide efforts to restore pollinator reserves or refuges. In 1983, MnDOT became involved in the Lt. Governor-appointed wildflower task force. By 1990, MnDOT had designated six wildflower routes featuring roadside prairie remnants. Around the same time, the practice of planting roadsides using native wildflower seed mixes began. These roadside plantings acted as food sources for pollinators in a landscape dominated by agriculture or urban sprawl.

In addition to roadsides, many opportunities exist to improve pollinator nesting and foraging habitat on acres already present within the Minnesota landscape such as ditches, railroad and utility rights-of-way, parks, designated state, federal, and non-profit wildlife areas, conservation lands, private lands in

conservation programs, hayfields, and pastures. State and Federal agencies and private landowners could implement minor management practices to significantly increase the quality of pollinator habitat. Economic incentives, site assessments, and buffer zones between habitat sites and highly managed or agricultural land would need to be considered.

BWSR targets conservation efforts at private lands that comprise about 75% of Minnesota's landscape. Key habitat features (clean water, pollen, nectar and nesting sites) are being protected and restored through BWSR programs that provide wetland protection, conservation easements, and soil and water grants. BWSR's Reinvest In Minnesota (RIM) program has restored around 230,000 acres, and protected around 20,000 acres of natural areas. Approximately 29,000 acres of habitat has been planted through soil and water conservation grants, and administration of the Wetland Conservation Act has helped protect Minnesota's 10.6 million acres of wetland. Many wetlands are part of important habitat corridors and provide essential pollen and nectar sources, clean water, and nesting sites. Appendix 3 includes a draft (Nov.18, 2013) copy of BWSR's Pollinator Plan. The BWSR Native Vegetation Establishment and Enhancement Guidelines contain several pollinator resources that can also act as "stand alone" documents including a pollinator habitat fact sheet, project installation and maintenance guidance, seed mix recommendations, and a summary of state and federal programs that can be used for establishing pollinator habitat. The Minnesota Wetland Restoration Guide developed by BWSR also provides detailed information on restoring and maintaining wetlands and upland buffers. Inter-seeding guidelines have been developed to direct efforts to increase project floral diversity. BWSR's "What's Working" webpage also summarized effective methods of restoring diverse plantings.

In 2011, the Natural Resources Conservation Service (NRCS)-Minnesota along with the Xerces Society, published Biology Jobsheets #16 and 17, *Native Habitat Development for Pollinators* and *Pollinator Habitat Management* and an online Pollinator Habitat Assessment Form and Guide (See Appendix 4, 5, and 6). These sheets provide landowners with tools allowing them to assess, restore, conserve, and manage native plant communities to benefit pollinators and other associated wildlife species.

BWSR's soil and water conservation grants promote projects and conservation practices that include planting trees and grasses, restoring prairie and wetlands, constructing windbreaks, shelterbelts, grassed waterways, contour buffer strips, filter strips, and riparian buffers, as well as planting critical areas and cover crops. All of these practices provide food and nesting sites and supply clean water sources for pollinators in agricultural landscapes. DNR suggests that ideally a variety of cut and uncut areas would be beneficial to pollinators. For example, modifying roadside mowing to once per year in late autumn, when pollinators are not in flight, could encourage longer blooming periods for pollen and nectar collection. The least amount of impact on pollinator and grassland bird habitat would occur if mowing was scheduled every three to five years rotating the location of mowing annually.

Conservation plantings that focus on planting trees and shrubs such as windbreaks, shelterbelts, riparian buffers, wooded wetlands, and shoreline stabilization projects play an important role in providing habitat for bees that require woody plants for nesting. A wide range of conservation plantings that involve prairie plantings (including RIM program) provide habitat for ground nesting bees. Dry prairies and savannas may provide the best habitat for ground nesting bees, as these bees often require areas of open soil with sparse vegetation that will not flood.

Many of the above programs focus on native plants to enhance native insect pollinators. However, it is not well understood whether honey bees will benefit from native plants as forage habitat. Ongoing research, funded by General Mills, is underway to investigate whether native plantings provide sufficient floral resources for honeybees.

Establishment of Reserves or Refuges

Pollinator reserves and refuges can fit easily into Minnesota's agricultural landscape. While "establishing" or "creating" new pollinator habitat would certainly be beneficial, there are many opportunities to enhance acres of habitat that are already on the landscape in the form of roadsides, ditches, railroad and utility rights-of-way, parks, designated state, federal, and non-profit wildlife areas, conservation lands, private lands in conservation programs, hayfields, and pastures. Examining the way these areas are currently managed and buffered is an important first step in order to maximize their effectiveness as pollinator reserves or refuges. Agencies and landowners could dramatically increase the quality of pollinator habitat through a variety of changes in existing management practices such as mowing frequency, haying practices, reseeding mixtures, and spraying practices.

In the past 26 years, BWSR's RIM Program and soil conservation grants have played an important role in establishing habitat in agricultural landscapes by restoring approximately 230,000 acres of marginal farmland (or preventing CRP conversion to agriculture). Over the past ten years MnDOT has planted over 5,000 acres with native seed. DNR manages 5.74 million acres of state land primarily as Native Plant Communities thereby maximizing native species diversity. DNR is currently drafting BMPs and Restoration Guidelines as mandated by the 2013 legislature to optimize management for pollinators on state owned lands.

Over the years, techniques utilized by DNR have greatly improved and evolved as knowledge and awareness has increased. Habitat managers now realize that species and structural diversity play an important role when managing for functional ecosystems. Successful habitat enhancement and restoration is strongly associated with appropriate selection of native species and seed sourcing.

In addition to paying attention to species selection, landscape level site considerations are important. Habitat complexes and corridors provide natural passageways for pollinators, as well as nesting and forage sites, and sources of clean water. These corridors should be protected and buffered in both rural and urban areas. It is ideal to have nesting and forage resources in the same habitat patch, but some pollinators are able to adapt to landscapes in which nesting and forage resources are separated. However, it is important that these two key habitat components are not too far apart. Considering the landscape context in which the native plant community restoration exists will help managers optimize the location of pollinator habitat enhancements.

Working with the Minnesota Crop Improvement Association, MnDOT lead the effort to create a system of "source identified" seed certification, which emphasizes the use of local ecotype native seed. MnDOT's requirements for native seed and seed mixes have been an important influence on the native seed industry in Minnesota. MnDOT recently led the project to create a site specific design manual for native seed mixes. This work involved close collaboration with native seed producers and ecological restoration practitioners around Minnesota and resulted in a guide to help in the creation of native seed mixes that are suited to local site conditions.

In 2009, MnDOT, BWSR and DNR partnered on the development of 24 new state seed mixes with a focus on providing high floral diversity. Several mixes feature 3 to 6 times as many forb species as previous native mixes. Many of these mixes are more regional or specialized and are designed to meet the needs of BWSR's mitigation programs. Since these mixes are used by multiple agencies, local government units and consultants, they will have widespread impact.

In addition to state efforts, USDA has incentive and easement programs to seed set-aside acres with native plant species. For example, Practice CP42 "Establishment of Native Pollinator Habitat" within the CRP program, administered by the USDA Farm Service Agency, and the Pollinator Enhancement

within the Conservation Stewardship Program (CSP), administered by NRCS, are specific to native pollinator habitat establishment. Since these pollinator initiatives are relatively new (< 5 years), USDA feels they still need time to evaluate and learn from these seeded acres. MnDOT partners with the NRCS in incentivizing landowners to plant living snow fences next to highways. Recent modifications to MnDOT's cost share structure now include an increased payment to landowners who choose to include seed mixes that will benefit pollinators in their living snow fence planting. In addition to helping pollinators, the increased abundance of native forbs in these plantings allows the stand of grasses to stay upright under heavier snow loads, thus improving its ability to catch and hold snow.

MnDOT is increasing the use of prescribed fire for roadside vegetation management and now has four trained and equipped fire crews around the state. These crews will focus on managing roadsides with native vegetation, which will improve pollinator habitat and reduce the need for herbicide application.

Wetlands often get less attention, but there are diverse functions and features associated with wetland plant communities that are important as part of the habitat bank for native pollinators. With wetland protection in mind, the MPCA suggests three potential efforts to enhance wetland habitats:

1. Increase the efforts to reduce and eliminate invasive plant species. In addition to foreign invaders, the list of invasive species should include native North American plants that have expanded or have the potential to expand their range into Minnesota.
2. Consider the assessment, maintenance, and restoration of wetland ditches (roadside, agricultural, etc.) to include a greater diversity of plant species considered beneficial to native pollinators.
3. Develop and maintain wetland corridors throughout the state that serve as conduits for native plant and animal species and reduce the potential of species and populations to become isolated or stranded.

MnDOT will also increase its focus on early detection and rapid response (EDRR) invasive plant species control to prevent large-scale infestations of species that can harm native biodiversity. Preventing early infestations from becoming established will reduce large scale problems, protect existing pollinator habitat, and reduce herbicide use in the long term. BWSR coordinates the Cooperative Weed Management Area Program where twenty five partnerships across covering thirty-six counties Minnesota are focused on the control of invasive plant species with the goals of protecting natural areas and conservation lands, ultimately protecting floral diversity for pollinators.

Challenges and Constraints

More research is needed to determine whether native and restored prairies or managed areas with native plants and wildflowers will benefit non-native honey bees. There are large knowledge gaps about species of Minnesota pollinators. Additional invertebrate inventories are still needed and some species may need to be considered 'at-risk'.

Many roadsides contain native flowering plants that bloom in mid to late summer. Revising roadside mowing practices (as suggested on page 18), would require a modification of the roadside mowing law (M.S. 160.232). Subsequently, any change in the law would need education and enforcement efforts to be successfully implemented.

Another concern is that many roadside habitats are long and narrow. This linear shape can provide corridors of connectivity, but they are very susceptible to edge effect from management activities on adjacent land. Chemical drift, when pesticides are applied to adjacent fields, can negatively impact pollinator habitat. Likewise, roadside mowing, if done too frequently or at the wrong time, can also negatively impact pollinators.

We do not know what size buffer zones will be effective and what size of land reserves are needed to be attractive to native pollinators and/or commercial honey bees. Larger blocks of pollinator habitat such as pastures and conservation lands can mitigate these effects.

Providing habitat for both nesting and foraging may influence the plant species in a seed mix. Techniques to manage mixed forage species may pose a challenge in some instances.

DNR and transportation agencies could work to incorporate native wildflowers into roadside right-of-ways. Budget support of the Roadside for Wildlife Program has been reduced, but in light of increased attention around the plight of pollinators, renewed multi-agency support of the program would directly contribute to pollinator reserves and refuges across the state.

Cost share funding and per acre amounts could be evaluated and revised since they are likely to be inadequate to optimize pollinator habitat restoration success. Additional funding is needed for the establishment of floral rich plantings that are a few acres in size and located in areas of high quality pollinator habitat that is buffered from pesticide use. According to DNR, the actual estimated cost of restoring quality diverse native wildflowers can be as high as $1,000 per acre, especially if extensive site preparation is needed. Current cost share levels are usually in the $200-$400 range.

Resource Considerations

The University of Minnesota, Department of Entomology, is requesting funding from the Legislative-Citizen Commission on Minnesota Resources (LCCMR), UMN, or other agencies in support of hiring a new professor to help coordinate statewide surveys and research on pollinator habitat.

Since wetlands often get less attention yet have diverse functions and features, an important component to consider is the associated wetland plant communities as part of the habitat bank for native pollinators.

Education and Training

Improving pollinator habitat relies in part on successful education and training programs. Pollinator education will be developed in cooperation with MDA, UMN, and Subject Matter Experts. This information will be incorporated into training manuals and recertification requirements for pesticide applicators, as well as county agricultural inspectors. For example, training on native plant identification could promote behavior to assure effective and economical control of invasive plant species; while ultimately, a site that contains non-target native species would be protected.

In addition, MDA is currently updating its training materials and Standard Operating Procedure for County Agricultural Inspectors enforcing the Noxious Weed Law to highlight the importance of pollinator habitat for crop production and many other ecological benefits. County Agricultural Inspectors have incorporated into their annual summer short-course an emphasis on identifying target and non-target plants (i.e., native and other beneficial species) to ensure that noxious weed enforcement and management is more efficient statewide.

BWSR has been conducting five to ten presentations and workshops each year, for local government units and resource professionals, focused on native vegetation identification and restoration. In coming years, BWSR programs will focus greater attention on the topic of pollinator habitat. The LCCMR funded "Restoring Minnesota" website and on-line courses were developed through a partnership between the UMN and state agencies to educate professionals about restoration planning, installation, and management methods. In the spring of 2014, BWSR plans to start a "hands-on" training program with opportunities to be involved in the installation and management of a wide range of project types including pollinator habitat plantings. Workshops, presentations, and individual project assistance will be used to promote and guide pollinator projects. Informational and educational resources about

obtaining native plants and seeds for pollinator habitat, promoting the importance of bees, and illustrating how pollinator habitat can be incorporated into rural and urban settings is under development.

Literary and Scientific Resources

Noordijk, J. Delille, K. Schaffers, A.P., and Sýkora K. 2009. Optimizing grassland management for flower-visiting insects in roadside verges. Biological Conservation. 142(10):2097-2103. http://dx.doi.org/10.1016/j.biocon.2009.04.009

Wojcik, V.A. and Buchmann S. 2012. Pollinator conservation and management of electrical transmission and roadside rights-of-way: A review. J. Pollination Ecology. 7(3):16-26.

BMPs for the Creation and Enhancement of Pollinator Habitat

Best Management Practices (BMPs) are broadly defined as "economically sound, voluntary practices or series of production options" that when used prevent or minimize environmental impacts and encourage the efficient use of pesticides as part of an Integrated Pest Management (IPM) program. The previous section mentioned existing efforts to create and enhance pollinator nesting and foraging habitat and establish reserves and refuge. Many state and federal agencies already participating in these efforts have existing or are developing BMPs or similar resources (e.g. guidelines, factsheets, jobsheets, etc.) to create, manage, and establish habitat.

Existing BMPs

Many opportunities exist to improve pollinator habitat on acres already present within the Minnesota landscape existing as roadsides, ditches, railroad and utility rights-of-way, parks, designated State and Federal wildlife areas, conservation lands, private lands in conservation programs, hayfields, and pastures. State and federal agencies could make adjustments, some which might be minor, to current management practices on government land, or they could assist landowners with implementing changes to management practices on private lands, that could significantly increase the quality of pollinator habitat.

Minnesota Board of Water and Soil Resources (BWSR) have existing program policies that require the use of native 'pollinator-friendly' plants for projects. The BWSR Native Vegetation Establishment and Enhancement Guidelines were developed to assist resource professionals and landowners make decisions about planting and maintaining state funded restoration and BMP projects. The BWSR Native Vegetation Establishment and Enhancement Guidelines contain several pollinator resources that can act as "stand alone" documents including a pollinator habitat fact sheet, project installation and maintenance guide, seed mix recommendations, and a summary of state and federal programs that can be used for establishing pollinator habitat. The Minnesota Wetland Restoration Guide developed by BWSR also provides detailed information on restoring and maintaining wetlands and upland buffers; inter-seeding guidelines have been developed to guide efforts to increase project floral diversity. BWSR's "What's Working" webpage also summarized effective methods of restoring diverse plantings.

NRCS conservation practice standards, similar to BMPs, contain information on why and where a particular practice should be used to address soil, water, air, plant, animal, and human and economic resource concerns. Conservation practice standards set forth the minimum quality criteria that must be met during the application of that practice in order for it to achieve its intended purpose(s). State conservation practice standards and supplemental support documents are available through the NRCS Field Office Technical Guide (FOTG). NRCS has developed two job sheets that summarize recommendations for native plant selection, establishment techniques and management of native pollinator habitat in Minnesota (See Appendix 4, and 5).

Development of New BMPs

While native plant community restoration and enhancement work performed by the Minnesota Department of Natural Resources (DNR) is state-of-the-art, there is no clear direction on procedures and species selection to address the alarming decline in pollinator species. Thus, DNR was directed to develop and implement Best Management Practices (BMPs) and habitat restoration guidelines for pollinator habitat enhancement on DNR lands in Minnesota. Further, prairie restorations on state lands or with state funds must include an appropriate diversity of native species to provide pollinator habitat through the growing season.

Minnesota Session Law 2013, Chapter 114 HF no. 976, Article 4

Sec. 12. **[84.973] POLLINATOR HABITAT PROGRAM.**
(a) The commissioner shall develop best management practices and habitat restoration guidelines for pollinator habitat enhancement. Best management practices and guidelines developed under this section must be used for all habitat enhancement or restoration of lands under the commissioner's control.
(b) Prairie restorations conducted on state lands or with state funds must include an appropriate diversity of native species selected to provide habitat for pollinators throughout the growing season.

Furthermore, the legislature appropriated pesticide regulatory funds to develop BMPs that protect pollinators and incorporate these BMPs practices into pesticide applicator and inspector training.

Minnesota Session Law 2013, Chapter 114 HF no. 976, Article 1

Sec. 3. **DEPARTMENT OF AGRICULTURE**
Subd. 2 **Protection Services**...Notwithstanding Minnesota Statutes, section 18B.05, $150,000 the first year and $150,000 the second year are from the pesticide regulatory account in the agricultural fund to: develop and use best management practices that protect pollinators by providing habitat necessary for their survival and reproduction; incorporate these practices into pesticide applicator and county agricultural inspector training; and increase public awareness of the importance of pollinators and pollinator habitat. The commissioner may transfer a portion of this appropriation to the Board of Regents of the University of Minnesota to design habitat and measure and report the outcomes achieved under this paragraph. This is a onetime appropriation.

The MDA initially convened a Pollinator Habitat Advisory Work Group composed of members from the MDA, DNR, Minnesota Department of Transportation (MnDOT), BWSR, University of Minnesota (UMN), Natural Resources Conservation Service (NRCS), and Minnesota Pollution Control Agency (MPCA). This advisory working group has met four times since July 24, 2013 to discuss the roles and resources each organization could draw upon to address the above legislation. In addition, the advisory group has devised an initial three-pronged approach to BMP development. This approach proposes BMPs to help expand and protect pollinator habitats associated with gardens and managed landscapes (e.g. homes/institutional gardens, landscapes, parks, etc.); roadsides (e.g. County/Township rights-of-way and ditches); and agricultural land (e.g. near, in, or adjacent to agricultural fields).

In order for BMP development to be successful and provide a common vision, the next step in developing effective BMPs for pollinator habitat protection depends on input from a larger and more diverse group of stakeholder experts. An invitation letter and e-mail was sent to 66 interested stakeholders, to join a larger stakeholder group and provide input regarding the development of BMPs for pollinator habitat protection. Stakeholders such as commodity crop organizations, city/county/township officials, environmental nonprofit organizations, horticultural associations, beekeepers/honey producers, organic producers, golf course superintendents, soil and water conservations districts, and other interested groups and individuals were contacted to attend MDA's first Pollinator Stakeholder meeting on November 14th, 2013. Thirty-eight stakeholders attended and participated in the meeting. Additional stakeholder meetings will be held as deemed necessary.

The stakeholders in attendance at the November 14th meeting, as well as others, who were suggested after the meeting, were asked to volunteer on one of three Pollinator BMP Workgroups: (1) Habitats Associated with Agricultural Land (e.g. near, in or adjacent to agricultural fields, such as grassed waterways and vegetative filter strips); (2) Habitats Associated with Gardens and Managed Landscapes (e.g. home/institutional gardens, parks, and parkways); and (3) Habitats Associated with Roadsides (e.g.

rights-of-way and ditches). Each workgroup consists of ten to twelve stakeholders and at least two MDA representatives. These workgroups will be meeting in 2014 to begin BMP development in their respective areas.

The Minnesota Department of Natural Resources (DNR) is developing best management practices for activities on state lands that are designed to enhance pollinator habitat. In locations where it is not critical to preserve the integrity of native plant species, such as land within or around a farm, roadsides, and other private and state lands, including urban landscapes, (i.e., the majority of land use in Minnesota), Best Management Practices will be established for enhancing pollinator habitat, using non-invasive plant species, that would have particular benefit for managed honey bees and native bees. These BMPs could be used by any agency or private landowners to improve grasslands, roadsides, and private lands across Minnesota. In locations where it is critical to preserve the integrity of native plant species, such as in prairies and restored prairie sites, DNR is establishing Best Management Practices and Restoration Guidelines for Native Plant Communities for enhancing insect pollinator habitat on lands controlled by the DNR and for prairie restorations conducted with state funds.

These BMPs, being designed for implementation by DNR, could be evaluated for use by any agency or private landowner to improve grasslands, roadsides, and private lands across Minnesota. The DNR will partner with any entity to help identify areas with existing prairie plants and develop plans to address management needs while minimizing impacts to their value as pollinator reserves and refuges.

Many opportunities exist to improve pollinator habitat on acres present within the Minnesota landscape existing as roadsides, ditches, railroad and utility rights-of-way, parks, designated State and Federal wildlife areas, conservation lands, private lands in conservation programs, hayfields, and pastures. State and Federal agencies and private landowners could implement minor management practices to significantly increase the quality of pollinator habitat. Additionally, BMPs could target restoration of key habitat complexes and corridors to provide pollinator reserves and refuges to maximize habit and plant community benefits. Interagency collaboration has begun to evaluate existing BMPs and create additional BMPs.

Education and Training

To increase the awareness of and successful implementation of these BMPs, new education and training programs will be created, and existing training will be updated to include this new information. Pollinator-specific education will be developed by will be developed in cooperation with MDA, UMN, and Subject Matter Experts. This information will be incorporated into training manuals and recertification requirements for pesticide applicators, as well as county agricultural inspectors. MDA is currently updating its training materials and Standard Operating Procedure for County Agricultural Inspectors enforcing the Noxious Weed Law to highlight the importance of pollinator habitat for crop production and many other ecological benefits. Training on native plant identification could promote behavior to assure effective and economical control of invasive plant species; while ultimately, a site that contains non-target native species would be protected.

In consultation with the Xerces Society, NRCS has two job sheets and an online Pollinator Habitat Assessment tool (See Appendix 4, 5, and 6) to aid landowners and resource managers establish and manage pollinator habitat. The University of Minnesota Bee Lab has also produced fact sheets about native bee diversity and nesting habits as well as plants preferred by bees in Minnesota.

Challenges and Constraints

Some challenges in developing BMPs center around the fact that there is insufficient knowledge about pollinators and habitat needs. Not all bee species require the same pollen and nectar source. Honey bees often prefer and produce the best and largest quantities of honey for hive health and commercial sale from non-native plants some of which are considered invasive by some agencies. It is not known how much honey bees collect from native flowers, or whether native plants and managed areas will be helpful to commercial honey bees. Native bees rely on both native and many non-native plant species for food sources. Some native bees require particular plants and these special needs have not all been documented. In addition, the specific nesting requirements of many bees are unknown. Other insect pollinators may also have specific habitat needs, such as specific host plants for caterpillars of moths and butterflies.

The impact of climate change and local factors such as weather, climate, seed availability, natural variability, cost, etc. affect success of management efforts and could impact pollinator populations. It is important that landscapes are designed and managed to provide resilient pollinator habitat.

Incentive payments will probably be needed to implement BMPs. In addition, implementation in some instances may need to be written into federal farm policy.

An important effort could be to encourage farmers to grow more flowering cover crops to support pollinators on agricultural lands. One option is to encourage the use of cover crops that include clovers (*Trifolium* spp., not *Melilotus* spp.*),* alfalfa, buckwheat, canola and oilseed crops such as pennycress, and camelina. The use of a cover crop is an exciting emerging practice in conventional agricultural systems. Large opportunities exist but significant research remains to determine the best methods for incorporating cover crops into conventional crop rotations and getting them established in the shorter Minnesota growing season. The MDA encourages research on the use of cover crops not only to encourage pollinator habitat, but for the many other synergistic benefits and ecosystem services they provide such as improving soil structure, building organic matter content, retaining or redistributing nutrients like nitrogen in the soil, preventing wind and water erosion, increasing biodiversity, reducing soil compaction, and suppressing weeds and pressure from other pests.

Resource Considerations

More research is needed to:

1. Identify important Minnesota pollinator species,
2. determine best native plant species for pollinators, and to fill large gaps about the nutrition content of native plants for pollinators,
3. understand the key causes of quality pollinator habitat loss,
4. identify key conservation areas of the state for targeted species and species complexes in regards to habitat needs and targeted protection of existing key habitat complexes and corridors that can provide pollinator reserves and refuges,
5. provide more detailed recommendations about how to select pollinator habitat on a site scale to address pesticide concerns and maximize food, water, and nesting resources,
6. provide guidance on how to maintain the long-term resiliency of pollinator habitat and,
7. promote the installation of more projects that provide multiple functions (biofuels, carbon sequestration, conservation grazing, water quality etc.) while incorporating native flowers.

Increased outreach to the general public, producers, landowners, etc. and training of pesticide applicators and county agricultural inspectors would be helpful. For example, including native plant identification would assure more targeted and effective control of invasive plant species and at the same

time minimize impacts to non-target native plant species. Education and training will be a crucial part of implementation of any BMPs.

The ultimate goal and desired outcome of the legislature appropriated pesticide regulatory funds for protection services is for the creation and enhancement of pollinator habitat. These outcomes are addressed primarily through creation of BMPs and education and outreach efforts encouraging their use.

The BMP project will be evaluated using performance measures related to the effort put towards selected programs, projects, or activities. The MDA is committed to achieving cost effective results with its legislative appropriation and will report BMP results widely in a meaningful and easily understood format. To accomplish this MDA will gather data (qualitative, quantitative, and perhaps narrative) for potential measurable program inputs, outputs and outcomes to address the questions: *what actions have we taken and what differences do our pollinator BMP programs, projects, and activities make?*

Roadside vegetation will need to be managed to provide continual benefits to pollinators. This effort will impose additional costs on road authorities. In addition, funding will be needed so that seed mixes can be continually assessed and modified to contain important species for pollinators.

Special Review of Neonicotinoid Insecticides

Background

The Minnesota Department of Agriculture (MDA) is the lead state agency for pesticide environmental and regulatory functions in Minnesota under the Pesticide Control Law (M.S. 18B). One of those functions is state-level registration of pesticide products approved by the U.S. Environmental Protection Agency (USEPA). In 2006, and in response to a Minnesota Legislative Auditor's report, the MDA initiated an effort to broaden state-level review of pesticide registrations by routinely learning more about new registrations and conducting expanded review to better understand Minnesota-specific registration issues. The scope of these special registration reviews varies depending on the potential education, outreach, and enforcement needs identified by the MDA and its collaborators.

The MDA's first formal review in response to the Auditor's recommendations was for the corn herbicide atrazine, a multi-agency review comprised of five agency-specific technical assessments addressing human health, the environment, costs and benefits, water quality monitoring and product labels. Subsequent in-depth reviews have addressed insecticide active ingredients used to control emerald ash borer, which included a review of several neonicotinoids and potential pollinator impacts, and a special review of insecticide issues related to bed bug control. All of these in-depth reviews led MDA and its collaborators and stakeholder groups to a greater understanding of the risks-benefits of pesticide product use. These reviews also generated various voluntary and enforcement-related educational and outreach materials related to human health and environmental protection.

In addition to the in-depth reviews, the MDA also reviews new active ingredients recently approved by USEPA as well as currently registered pesticides that have significant new uses or have undergone a major label change. In the process of completing these shorter reviews, the MDA explored a variety of human health and ecological risk issues, and assessed laboratory analytical concerns for tracking potential misuse and non-target impacts. To complete these shorter reviews, information on projected pesticide use and efficacy is gathered from University Extension, user groups and others. Reviews may also include communication with USEPA or the registrant to request more information about identified concerns.

The concern over the use of neonicotinoid insecticides in relation to insect pollinators led the legislature to request that the MDA report on the process and criteria to be used in a review of neonicotinoid use in Minnesota currently and in the future.

Process

Because the basic process and criteria the MDA uses to conduct a variety of pesticide reviews has already been established, and because MDA has already reviewed several neonicotinoid concerns as part of its emerald ash borer insecticide review (including concerns about pollinator exposure), the Commissioner of Agriculture directed MDA staff to initiate a special review of neonicotinoid pesticides and insect pollinators. This report, therefore, is a status update on the process, criteria and progress of the special review of neonicotinoid pesticides registered by the Commissioner for use in this state currently and in the future.

An in-depth, special review is conducted to provide stakeholders and the MDA Commissioner with more information about Minnesota-specific pesticide products and issues. As such, these reviews are not intended to be redundant of analyses and decisions reached by the USEPA during federal registration. Rather, these reviews result in a greater understanding of federal registration concerns and a variety of opportunities for action. Outcomes can include clarification of label provisions designed to

protect the environment, enforcement-related education, applicator guidance and social network tools developed to enhance product stewardship, and other measures designed to minimize the impacts of pesticide use on human health and the environment. Depending on the scope of the in-depth review, completion can take six months or more.

The MDA has a history of reviewing Minnesota-specific MDA enforcement and other data related to pesticide use and insect pollinators, including endangered pollinator species (Karner blue butterfly) or candidate species (Dakota skipper butterfly). As noted above, the MDA's special review of insecticide active ingredients used to control emerald ash borer included a review of several neonicotinoids and potential pollinator impacts. As an outgrowth of that review, the MDA has been collecting and reviewing a significant amount of information and peer-reviewed research related to neonicotinoids and pollinators.

Commissioner Directs Special Registration Review: In late 2013, the MDA Commissioner directed a Special Registration Review of Neonicotinoid Insecticides (See Appendix 7). As a first step, the MDA has begun working with the DNR and MPCA to develop a draft of the scope (the underlying criteria) to be used in conducting the review. In early 2014, MDA will collaborate with BWSR and the University of Minnesota to further refine the draft scope.

Following public comment, the MDA and collaborators will modify the review scope as appropriate, and then complete the review. Once complete, the review's findings will be made available for public comment. At the close of the comment period, the MDA Commissioner will issue a determination on the review's findings and opportunities for action.

Criteria

The criteria used to conduct the review reflect its scope. As with previous in-depth special reviews of pesticides, the scope of the neonicotinoid review will include an overview of federal and state pesticide programs, and roles and responsibilities related to the registration and use of neonicotinoids in Minnesota.

Additionally, the scope will include: examples of neonicotinoid product use, sales and restrictive actions taken by USEPA, states and other political entities; potential or known pollinator risks and impacts from neonicotinoid applications and movement in the environment based on registration studies as well as studies reported in scientific literature; and risks and benefits of neonicotinoid use in agricultural/nursery production and landscape settings visited by pollinators. Each criterion will be explored in relation to Minnesota-specific concerns and opportunities for action. Preliminary information regarding the scoped criteria is presented below.

Neonicotinoid Background, Chemistry and Mode of Action: Neonicotinoids have a structure and mode of action similar to nicotine, a naturally occurring plant alkaloid compound. They are potent broad-spectrum insecticides possessing contact, stomach, and systemic activity. Their action causes excitation of the nerves and eventual paralysis, which can lead to death depending on the dose and exposure duration. Because they are effective at very low concentrations and bind at a specific site, they are less toxic to birds and mammals and are not cross-resistant to previously or still available classes of insecticides including carbamates, organophosphates and synthetic pyrethroids.

The review will provide an overview of the various neonicotinoid insecticides commercially available since the introduction of imidacloprid in 1991.

Federal and State Neonicotinoid Registration: Both federal and state laws govern the registration and use of neonicotinoid insecticides in Minnesota. Most neonicotinoid insecticide regulatory activities in Minnesota rely on guidance developed at the federal level by the USEPA.

Neonicotinoids are registered globally in more than 120 countries. In the United States, six neonicotinoid insecticides are registered for controlling agricultural insects.

Because all neonicotinoid insecticides were registered after 1984, they were not subject to specific reregistration requirements outlined in the federal Food Quality Protection Act. However, by law, and for products registered or reregistered after 1984, the USEPA must complete a registration review of pesticide active ingredients within 15 years of the registration or reregistration to determine whether registration requirements under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) are still being met. This process includes a determination that there are no unreasonable risks to human health, workers, or the environment when products are used as directed on product labels.

The review will summarize USEPA existing neonicotinoid registration review activity including reviews of all major neonicotinoids under accelerated review and scheduled for completion between 2016 and 2018. The review will describe how the MDA monitors USEPA registration schedules for future neonicotinoid products, and incorporates related information into new product reviews prior to Minnesota registration.

Federal ecological risk assessment of pesticides on pollinators – In conjunction with the individual neonicotinoid active ingredient reviews, USEPA has been working across international borders to revise pollinator toxicity testing for pesticides and degradates of toxicological concern. The current testing paradigm relies on a 3-tiered assessment using honey bees as a surrogate organism for all pollinators. The review will include a summary of significant USEPA and international activity focused on revising pollinator toxicity testing.

New USEPA labeling requirements on neonicotinoid pesticides to improve protection for bees and pollinators – The USEPA has acknowledged some uncertainties with initial registration of neonicotinoid insecticides regarding their potential environmental fate and effects, particularly as they relate to pollinators. In August 2013, the USEPA revised neonicotinoid labels with new advisory and regulatory language (application restrictions) to further protect bees by prohibiting the use of some neonicotinoid insecticide products where bees or their food sources are present. The review will summarize USEPA label revisions, as well as revisions made by other entities including those in other U.S. states, Canada, and the European Union.

Neonicotinoid Use and Sales: Neonicotinoids are water soluble and are readily absorbed by plants via either their roots or leaves. They are then transported throughout the tissues of the plant. This provides many advantages in pest control, for they protect all parts of the plant; for example, they are effective against boring insects and root-feeding insects, both of which cannot be easily controlled using foliar sprays of non-systemic compounds. Additionally, they are effective at very low concentrations sufficient to protect all parts of the plant for several months following planting. For this reason neonicotinoids (primarily imidacloprid, clothianidin and thiamethoxam) are predominantly used as seed treatments to protect a broad variety of crops such as corn, soybean, oilseed rape, sunflower, cereals, sugar beets, potatoes, etc. at per acre concentrations that are relatively lower than other conventional application methods. In addition, they can be used as foliar sprays on row, horticultural, vegetable, turf, or ornamental crops. They are also used for the treatment of pastures and grasslands, domestic animal pests, and for domestic use against cockroaches and ants. They can be applied as a soil drench or in irrigation water to treat perennial crops such as vines, and they can be injected into tree roots or stems,

or sprayed onto tree bark to protect trees against invasive pests (for example emerald ash borer), where a single application can provide protection for several months or years.

The review will assemble use and sales data on the 487 neonicotinoid products sold in Minnesota as tracked by MDA's pesticide sales database. Additional release of neonicotinoids into the environment occurs with seed-treatment of Minnesota crops like corn, soybean, sugar beets and sunflower. Seeds treated outside of state boundaries are distributed for sale and use differently than most pesticide products. Because of this difference, pesticide use associated with seeds treated outside of Minnesota's borders, the review must be estimated. Therefore, the review will include an estimate of the additional mass of neonicotinoids released to Minnesota's environment from neonicotinoid treated seeds.

Risks of Neonicotinoid Use: Although neonicotinoids in general – and seed treatments in particular – have important benefits, they also pose certain risks. The widespread adoption of systemic neonicotinoids for prophylactic insect control has been blamed for initiating a paradigm that moves away from integrated pest management (IPM). Prophylactic use of neonicotinoids may lead to resurgence of the target pest, replacement by secondary pests, adverse impacts on natural enemies and pollinators, development of pest resistance, and increased costs. The review will, therefore, summarize these risks, as well as information on neonicotinoid persistence in soil, leaching in soil and potential to contaminate water resources.

Risks to insect pollinators -The specific risk to pollinators will be the focus of the review, and will include a summary of research into neonicotinoid risks to a variety of pollinator species in crop production and garden/landscape settings, and the related risks of biodiversity maintenance and ecological balance in natural ecosystems. The review will include an overview of potential direct effects of neonicotinoid use on insect pollinators, as well as the effects of residue accumulation in pollen, nectar, guttation drops, or other pollinator exposure pathways associated with treated plants.

Risks to other non-target organisms – The review will also briefly summarize the risks of neonicotinoids to non-target organisms other than insect pollinators in terrestrial and aquatic environments.

Neonicotinoid Applications and Movement in the Environment: The potential for adverse environmental impacts from neonicotinoid insecticides is under constant evaluation and research by the USEPA, industry, University researchers, the MDA, and other organizations. The method and timing of insecticide applications, proximity to sensitive aquatic resources (streams, rivers etc.) and terrestrial habitat (e.g. honey bee hives and plants that are attractive to pollinators), and soil type at the site of application are a few of the variables that have the potential to influence the environmental fate and potential ecological effects from neonicotinoid insecticide use.

The review will include an assessment of the partitioning, fate and transport of neonicotinoid insecticides in the environment based on a variety of use patterns and scenarios, including an overview of relevant MDA water quality monitoring data.

Benefits of Neonicotinoid Use: Currently, neonicotinoid insecticides are the most widely used class of insecticides in the world and comprise about 25% of the global agrochemical market. Neonicotinoid insecticides have some distinct advantages over other classes of insecticides. They provide very effective control of piercing and sucking insects that have developed resistance to other classes of insecticides including organophosphates, carbamates, pyrethroids, and chlorinated hydrocarbons. The review will include the unique nature of neonicotinoids as systemic insecticides (including their use as targeted seed treatments in crop production), their role in managing insecticide resistance and the spread of insect-transmitted viruses in various crops, as well as benefits associated with household, lawn and garden, and animal health use.

Resources

1. Office of the Legislative Auditor, "Pesticide Regulation," March 2006
2. MDA Atrazine Special Registration Review, http://www.mda.state.mn.us/chemicals/pesticides/atrazine/atrazinereview.aspx
3. MDA Emerald Ash Borer Insecticide Review, http://www.mda.state.mn.us/chemicals/pesticides/eabinsecticidereview.aspx
4. MDA Bed Bug Control Insecticide Special Registration Review, http://www.mda.state.mn.us/chemicals/pesticides/regs/pestprodreg/bedbugs.aspx
5. MDA Pesticide Special Registration Reviews, http://www.mda.state.mn.us/chemicals/pesticides/regs/~/media/Files/chemicals/reviews/psrrsummary.ashx
6. MDA New Active Ingredient and New Use Special Registration Reviews, http://www.mda.state.mn.us/chemicals/pesticides/regs/newreviews.aspx
7. EPA Pollinator Protection: EPA Actions to Protect Pollinators, http://www.epa.gov/opp00001/ecosystem/pollinator/risk-mgmt.html
8. MDA Pesticide Use in Minnesota http://www.mda.state.mn.us/chemicals/pesticides/pesticideuse.aspx

Other Activities

The U.S. Environmental Protection Agency (USEPA) and the U.S. Department of Agriculture (USDA)-- comprising its Agricultural Resource Service (ARS), Natural Resources Conservation Service (NRCS), U.S. Forest Service (FS), Farm Service Agency (FSA), and the National Institute of Food and Agriculture (NIFA) agencies-- together with their regional and state-level offices and collaborators, are engaged in many areas of pollinator protection activity.

It will be important for Minnesota state agencies and institutions to be aware of, participate in and coordinate with ongoing federal activities. In the area of pesticides, for example, USEPA has already changed several neonicotinoid insecticide labels to better protect pollinators from exposure, and is developing new data requirements from registrants on pollinator impacts from pesticide residues in plant tissue, pollen, nectar, and guttation drops.

Additionally, federal agencies and academia are collaborating nationally and internationally to develop a global understanding of pollinator populations, management, diseases and predators, as well as the role of pesticides as stressors. There are also federal efforts to develop pollinator protection BMPs for use during crop production, and USEPA is accelerating its review of neonicotinoid pesticides.

As such, it is important that state agencies and institutions explore what is possible at the state and local level to help resolve the complex set of issues that pollinators face, while acknowledging the extensive federal resources dedicated to generating information that may be important for Minnesota to consider in the future.

Conclusions

While on a global scale, pollination occurs by up to 200,000 different animal species, this report focused solely on insect pollinators, as an important part of food production for humans and wildlife, and for plant reproduction in Minnesota. Concern exists over the decline of honey bees and bee colony numbers, which has been attributed to many interacting factors including pathogens and parasites, pesticides, poor nutrition, and aging of beekeeper populations. The number and decline of native bees and other insect pollinators in Minnesota has also been a concern, but it is not well documented or understood. Unlike the honey bee, the habitat requirements of many native bees and other insect pollinators is also unknown, making habitat recommendations a challenge.

The decline of pollinator species (honey bees, native bees, and other insect pollinators) and the resulting ecological and economic consequences were the impetus for the 2013 Pollinator Legislation H.F. 976 which directed the Minnesota Department of Agriculture (MDA) to write this report in collaboration with Minnesota's Department of Transportation (MnDOT) and Department of Natural Resources (DNR), Natural Resources Conservation Service (NRCS)-Minnesota, University of Minnesota (UMN), Minnesota Pollution Control Agency (MPCA), and Board of Water and Soil Resources (BWSR).

Addressing legislation, this report proposed four interpretations of the term 'pollinator bank' providing an explanation of them as the Museum, Database, Genetic, and Ecological Interpretation and it discussed the feasibility, constraints, and uncertainties of each. Insect specimens already exist at state museums, zoos, and the University of Minnesota which are or could be adapted for the Museum and Database interpretations. Museum or Database Pollinator information could be made available online for public education. One challenge to pollinator habitat creation has been the lack of knowledge about bee diets. A pollen database, currently being assembled at the University of Minnesota, will be an essential tool for studying bee diets. A germplasm repository of honey bee genes was established in Washington State; therefore, no need exists for creating an expensive genetic 'Pollinator Bank' in Minnesota. The Ecological Interpretation was defined as establishing habitat areas and was the main focus of this report. Funding has been requested by UMN to hire a new interdisciplinary professor to coordinate statewide activities.

Many state, federal, and non-profit agencies have long histories and already work towards improving native pollinator habitat. Efforts by programs such as, Roadsides for Wildlife, Reinvest in Minnesota, the Minnesota Prairie Conservation Plan, and others with a goal to create and enhance insect (native and commercial) pollinator nesting and foraging habitat, as well as to establish and protect pollinator reserves or refuge areas by using Best Management Practices (BMPs) were discussed. Challenges and constraints to continue these efforts were listed and included but were not limited to developing and funding research to address missing information and knowledge about pollinator species identification, numbers, habitat needs, and the impact on their populations by the size and shape of current habitat corridors, management practices, climate change, etc. For example, knowledge about pollinator floral resource needs is limited. It is not understood, which native floral species have potential to be good honey producing plants for honey bees and which provide the best floral resources and nesting sites to the diverse and largely unknown populations of native bees or other insect pollinators that live in Minnesota.

While "establishing" or "creating" new pollinator habitat would certainly be beneficial, there are many opportunities to enhance acres of habitat that are already on the landscape. Examining ways these areas are currently managed and buffered is an important first step in order to maximize their effectiveness as pollinator reserves or refuges. Therefore, the proper implementation and use of existing BMPs (BWSR)

and new BMPs under development by MN DNR and MDA could dramatically increase the quality of pollinator habitat through minor changes in existing management practices.

Progress on developing new BMPs as directed by 2013 Pollinator Legislation H.F. 976 is underway. MDA has convened a Pollinator Habitat Advisory Work Group, held a stakeholder group meeting, and established three volunteer Pollinator BMP workgroups consisting of 10 to 12 representative stakeholders and at least two MDA representatives. These workgroups will be meeting in 2014 to begin BMP development in their respective areas: (1) Habitats Associated with Agricultural Land (e.g. near, adjacent to or in agricultural fields, such as grassed waterways and vegetative filter strips); (2) Habitats Associated with Gardens and Managed Landscapes (e.g. home/institutional gardens, parks, and parkways); and (3) Habitats Associated with Roadsides (e.g. rights-of-way and ditches). These BMPs will ultimately be incorporated into pesticide applicator and inspector training.

As requested by the legislature, as a result of concern over the use of neonicotinoid insecticides in relation to insect pollinators, MDA outlined the process and criteria of a special review of neonicotinoid insecticides, and provided a status update on the process, criteria, and progress of the special review of neonicotinoid pesticides registered by the Commissioner for use in this state currently and in the future.

Because MDA has already established the basic process and criteria to conduct a variety of pesticide reviews, and because MDA has already reviewed several neonicotinoid concerns as part of its emerald ash borer insecticide review (including concerns about pollinator exposure), the Commissioner of Agriculture directed MDA staff to initiate a special review of neonicotinoid pesticides and insect pollinators.

MDA has begun working with the DNR and MPCA to develop a draft of the scope (the underlying criteria) to be used in conducting the review. In early 2014, MDA will collaborate with BWSR and the University of Minnesota to further refine the draft scope.

This pollinator report effort revealed a key reoccurring concern as the large knowledge and data gaps regarding insect pollinators in general, including but not limited to their habitat needs, numbers, abundance, and diversity of insect pollinator species in Minnesota. For example, while increasing abundance of native flowering plants in prairies, along roadsides, as crop borders, or in other managed areas have been shown to be helpful to native pollinators it is unknown how these habitat management strategies affect commercial honey bee populations. Current and future efforts will continue to educate and train the general public, producers, pesticide applicators, county agricultural inspectors, and government and industry representatives on what knowledge is available and what is lacking.

It is important to realize that different insect pollinating species (honey bees, native bees, and other insect pollinators) cannot be treated the same in terms of habitat needs or in terms of existing knowledge. To help solve pollinator habitat issues, many state, federal, and non-profit agencies and academia are collaborating at the local, state, regional , national, and international levels to develop an understanding of pollinator populations, management, diseases, and predators, as well as the role of pesticides as stressors. There are also federal efforts to develop pollinator protection BMPs for use during crop production, and USEPA is accelerating its review of neonicotinoid pesticides.

With this in mind, it is important that MDA and other state agencies and institutions explore what is possible at the state and local level to help resolve the complex set of issues that pollinators face, while acknowledging the extensive federal resources dedicated to generating information that may be important for Minnesota to consider in the future. Working together we can have a positive impact on

the health and well-being of our important insect pollinators, their habitat, and the agricultural production of our state.

Appendices- Partner Activities and Reports

Appendix 1: University of Minnesota Pollinator Research and Extension Activities

I. **Dr. Marla Spivak, Distinguished McKnight University Professor, University of Minnesota, Department of Entomology:** Our goal is to promote the health of bee pollinators. Our primary research focus is on honey bees, ranging from basic studies on mechanisms of social behaviors to applied studies on bee breeding and management. We also study the abundance and diversity of native bee pollinators. We work as a team to provide the richest learning environment for students at all levels and from all backgrounds.

Honey Bee Hygienic Behavior and Bee Breeding

Our primary and long-term goal (**M. Spivak and G. Reuter**) is to help honey bees and beekeepers reduce the amount of antibiotics and pesticides used in beehives to control diseases and parasitic mites. We have been breeding bees for resistance to these maladies since 1993 with the aim of "getting bees back on their own six feet" to end their reliance on chemical treatments for survival. A reduction in the use of antibiotics and pesticides will reduce operating costs for beekeepers, while ensuring healthy, strong colonies for honey production and pollination, and the purity of honey, wax and other marketable bee products. Hygienic behavior of honey bees is the main mechanism of resistance to the devastating bacterial disease, American foulbrood (*Paenibacillus larvae* subsp. *Larvae*), and the fungal disease, chalkbrood (*Ascosphaera apis*). Hygienic bees detect and remove infected brood from the nest before the pathogen becomes infectious. In 1993, we began by breeding a line of honey bees for hygienic behavior with the goal of testing if the behavior is also an effective mechanism of resistance to the parasitic mite, *Varroa destructor*. Extensive field trials at the University and in collaboration with commercial beekeepers have shown that bees bred for hygienic behavior do detect and remove mite-infested worker brood, and colonies bred for the behavior have reduced mite loads compared to unselected control colonies. Although our "MN Hygienic" line of bees is sold throughout the U.S., our current emphasis is helping beekeepers and bee breeders select for this and other resistance traits from among their own lines of bees. We are working closely with three **Minnesota beekeepers** to certify that their stocks are hygienic. Read about it: The future of the MN Hygienic stock of bees is in good hands!. We are also working one-on-one with members of the **California Bee Breeders Association** to help them select for disease and mite-resistance from among their tried-and-true stocks. Our aim is to promote genetic diversity, resilience and healthy bees, and we feel that working directly with queen breeders is the best way to accomplish our goal.

Propolis

1. A series of new research projects on propolis, a complex mixture of resins that honey bees collect from some trees, such as poplar and birch in temperate regions was initiated (M. Simone-Finstrom, 2010), and funded by NSF IOS-0717530. Bees collect the propolis on their hind legs and deposit it in the nest as a form of cement to seal cracks and to line the nest entrance and cavity. Propolis is widely known for its diverse antimicrobial properties and its value as a human medicine. Few studies have investigated the antimicrobial benefits of propolis to bees. This research focused on the evolutionary benefits of resin collection to honey bees, and the proximate mechanisms that regulate resin collection at the individual and colony-level. We have determined that propolis in the hive allows adult bees to invest less in individual immune function due to its ability to reduce overall bacterial loads in colonies. In this way propolis may reduce stress that bees are exposed to and may increase colony health. Other studies have shown

that resin foragers are more sensitive to tactile information than other forager types, which may indicate that tactile cues are relevant in the initiation of resin foraging behavior. We have also recently documented that propolis use by honey bees may be a unique example of self-medication, since resin collection increases after challenge with a fungal parasite.

2. Continuing research on the benefits of propolis to bees' immune system, R. Borba, (PhD student) is taking this study back to Brazil, to study propolis in African-derived honey bees. This race of bees appears to be more resistant to diseases and parasites compared to the European-derived honey bees in North America. Is propolis part of their defense? This work will determine the relative effect of propolis on the immune system of African-derived bee colonies. This comparative study will shed light on ways we can improve the health of our European bees in the U.S. It will also examining "propolis trap" configurations that encourage bees to naturally deposit propolis within commercial beekeeping hives and the seasonal effects of propolis to European-derived bee health after a contiguous layer of propolis is deposited surrounding the nest area. The role of resin in European-derived bee social immunity after infection with the bacterial pathogen Paenibacillus larvae subsp. larvae, which causes American foulbrood disease will also be studied. (Funded by NSF-IOS-0717530 / NAPPC / NCR-SARE / California Beekeepers Association).

3. The chemical components of plant resins from different botanical origins, and identification of those components that are responsible for the biological activity against bee- and human-related bacteria is being studied (M. Wilson, PhD student, Co-advised by J. Cohen, Plant Biological Sciences, funded by College of Agriculture, Food and Natural Resource Sciences. This research is focused on (1) using metabolic fingerprinting analysis to identify the plant sources of resin collected by foragers, (2) screening botanically diverse propolis samples for growth inhibition of Paenibacillus larvae (a honey bee brood pathogen), and (3) using bioassay-guided separation to isolate active compounds in inhibitory propolis samples.

Pathogens and Cell Line

The first continuous cell line derived from honey bee embryonic tissues was developed (**M. Goblirsch,** PhD student). Ongoing work utilizes this research tool to better understand some of the challenges that honey bees are confronted with. An *in vitro* system derived from honey bee cells will be beneficial for (1) determining how factors such as intracellular pathogens or toxicological agents interact with host cells to negatively affect bee health; (2) developing diagnostic assays and screening novel therapeutics against emerging bee diseases such as viruses; (3) assessing pesticide toxicity, using wells of a culture plate as experimental units instead of entire honey bee colonies; and (4) uncovering regulatory networks and functional evaluation of the honey bee genome through RNA interference (RNAi) gene silencing technology. Importantly, cell culture material is available for distribution to other researchers to foster collaborations and expansion of our understanding of honey bee biology and pathology.

Landscapes effects on Honey Bee Health and Native Bee Diversity

This collaborative project with J. Pettis, USDA-ARS Bee Lab, Beltsville, MD, and N. Euliss, USGS, Jamestown, ND examines the influence of mid-continent land-use trends on floral diversity and pollen availability to sustain bee health, diversity and ecosystem (funded by USDA-NIFA 2010-65615-20631). **M. Smart** (PhD student) is studying how varying agricultural and native landscapes, during the summer in North Dakota, affect honey bee nutritional physiology and immunology, and how these measures change through the winter when commercial honey bee colonies are moved to California for pollination. This work will help our understanding the flow of nutrients, particularly protein, in honey bee colonies and the relationships between landscape nutritional quality/availability and disease – and how this is manifested at the colony and individual bee levels. **E. Evans** (PhD student) is examining the impact of agricultural intensity and other landscape factors on native bee abundance and diversity in North

Dakota. The two main factors determining the value of different landscapes to bees are the presence of potential nesting sites and the presence of nutritional resources (pollen and nectar from flowering plants). The results from this research will be added to a model (EcoServ) that has been developed by researchers at the USGS for forecasting change in ecosystem services under alternate land-use and climate futures. This model can be used to predict landscapes that can best support native bee population.

Improving honey bee and wild bee nutrition in urban landscapes (Bee Lawn)

M.S. student, Ian Lane (funded by MN Environmental and Natural Resources Trust Fund) is studying how commercial turfgrasses and flowering plants can be combined to create foraging patches for bees in home lawns. As flowering resources are removed from the landscape by human development, new tools are needed to ensure the health of managed and wild bees. Turfgrass represents a significant portion of cultivated land in the United States (40 million acres), and is classically devoid of flowers. Investigating new ways of managing and planting turf lawns with flowering plants holds the potential to greatly improve the foraging resources available to bees in highly developed areas.

Other Native Bees: Orchard mason bees and Leafcutter bees

A survey of native bees was conducted at Itasca State Park, MN (**J. Gardner,** M.S. student) and results were compared with a 75-year-old museum collection. As widespread interest in bees by both the public and science is relatively recent, looking at museum collections is currently the only way to make long-term comparisons between bee species and associated declines. This work studied the family Megachilidae (mason and leafcutter bees) and found evidence for some possible declines since 1938, even in a protected area like Itasca State Park. Future work will involve looking at the other four bee families from this state park.

Effects of Neonicotinyl Pesticides on Honey Bees and Bumblebees

Sub-lethal effects of neonicotinyl insecticides on honey bee and bumble bee queens and colony development is being examined (**J. Wu,** PhD student, Department of Entomology, UMN) and funded by an EPA star fellowship. This research is focusing on queen honey bee and bumble bee behavior, specifically egg-laying rate and mobility. It also examines the sub-lethal effects of exposure on colony development including brood production, worker foraging rates, and worker hygienic behavior or the ability to detect and remove diseased and or mite-infested brood.

Tech-Transfer Teams: Helping Commercial Beekeepers

The University of Minnesota heads the Midwest Tech-Transfer Team (**K. Lee**, PhD Student) a part of the Bee Informed Partnership (beeinformed.org). Tech-Transfer Teams are modeled after crop consultants of the agriculture industry. Tech-Teams help beekeepers monitor diseases and pests, and test potential breeder colonies for disease resistance. Objectives are to quantify the success of the selection progress in hygienic behavior by commercial honey bee breeders, and to examine colony losses in commercial operations using an epidemiological model.

Bee Squad

Inspired by Dr. Marla Spivak at the University of Minnesota Bee Lab, the Bee Squad helps beekeepers and the community in the Twin Cities area foster healthy bee populations and pollinator landscapes through education and hands-on mentorship. The Bee Squad, led by **B. Masterman,** is committed to bringing back a bee friendly world by educating, training, and assisting people engaged in helping bees thrive. By promoting awareness about the critical contribution of pollinators to nutritious foods and a green environment, the Bee Squad helps people make choices that are good for the bees and ultimately good for us all.

II. **Dr. Karen Oberhauser, Associate Professor, University of Minnesota, Department of Ecology, Evolution, and Behavior:** works on Monarch butterflies addressing their reproductive ecology. She developed inquiry-based curriculum aimed at engaging students and teachers (Monarchs in the Classroom) as well as a nationwide Citizen Science project (Monarch Larva Monitoring Project). More information on her work can be found at:
http://www.cbs.umn.edu/eeb/contacts/karen-s-oberhauser

The Monarch Joint Venture (MJV) is a partnership of thirteen federal and state agencies, non-governmental organizations, and academic programs supporting monarch conservation as a flagship for conservation. More information and resources can be found at:
http://www.monarchjointventure.org/

III. **Dr. Vera Krischik**, **Associate Professor, University of Minnesota, Department of Entomology:** Her research interests center around increasing the use of Integrated Pest Management (IPM) tactics. Research interests can be viewed at:
http://www.entomology.umn.edu/People/GradFaculty/Krischik/ . Other research efforts include studying the effects of neonictonoid pesticides on bees and other beneficial insects. A link to this research and extension programs can be seen at:
http://www.entomology.umn.edu/cues/pollinators/index.html

Appendices Continued- Partner Activities and Reports

2. DNR - Final Draft January 29, 2013--Implementation of the Minnesota Prairie Conservation Plan *2013-2017*.
   http://www.mda.state.mn.us/~/media/Files/news/govrelations/pollinators/dnrprairieconsplan.ashx

3. BSWR- January 10, 2014—Draft BSWR Pollinator Plan. (To view appendix report click on link) http://www.mda.state.mn.us/~/media/Files/news/govrelations/pollinators/bwsrpollinatorplan.ashx

4. NRCS-Minnesota—USDA Native Native Habitat development for Pollinators (327) Biology Jobsheet #16 (2011).
   http://www.mda.state.mn.us/~/media/Files/news/govrelations/pollinators/nrcsjobsheet16.ashx

5. NRCS-Minnesota—USDA Pollinator Habitat Management Biology Jobsheet #17 (4/11).
   http://www.mda.state.mn.us/~/media/Files/news/govrelations/pollinators/nrcsjobsheet17.ashx

6. The Xerces Society for Invertebrate Conservation, Native Bee Conservation Pollinator Habitat Assessment Form and Guide, June 2013, funded in part by USDA-NRCS- MN. Available at:
   http://www.xerces.org/wp-content/uploads/2009/11/PollinatorHabitatAssessment.pdf

7. Minnesota Department of Agriculture: Commissioners Office Memorandum directing staff to initiate a special review of neonicotinoid pesticides and insect pollinators dated November 5, 2013.
   http://www.mda.state.mn.us/~/media/Files/news/govrelations/pollinators/neonicmemo11-5-2013.ashx