United States Department of Agriculture

USDA Honey Bee Forage and Nutrition Summit

October 20-21, 2014

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Disclaimer:

This is a report presenting the proceedings of a stakeholder conference organized and conducted by members of the USDA Forage and Nutrition Summit Conference Steering Committee on October 20-21, 2014 in Alexandria, VA. The views expressed in this report are those of the presenters and participants and do not necessarily represent the policies or positions of the U.S. Department of Agriculture (USDA), the Environmental Protection Agency (EPA), or the United States Government (USG).

Conference Overview

The goal of the conference was to enable administrators from the U.S. Department of Agriculture (USDA) and the Environmental Protection Agency (EPA) to receive input from scientists, State governments, non-governmental organizations, industry, and beekeepers on the state of current research as well as to obtain recommendations of future goals to better understand bee nutrition, nutrition's effects on bee immunity, behavior, lifespan and health, and to increase access of bees to nutritious forage on public and private lands across the United States.

Invited Speakers

- Opening Remarks/Welcome
    - Catherine Woteki, Under Secretary for USDA Research, Education, and Economics mission area, and USDA Chief Scientist
- Overview of Habitat Losses in the US
    - Zac Browning, former President and current Legislative Advisor of the American Beekeeping Federation
- Nutrition and Honey Bee Health: Current Research and Future Directions
    - Gloria DeGrandi-Hoffman, USDA-ARS Research Leader, Carl Hayden Bee Research Center, Tucson, AZ
- Honey bee nutritional stress: interactions between individual physiology, disease, and landscape
    - Amy Toth, Iowa State University
- Nutritional stress, abnormal behavioral development and honey bee health
    - Miguel Corona, USDA-ARS, Beltsville MD
- Factors important for honey bee health and the specific effect of antibiotics
    - Tugrul Giray, University of Puerto Rico
- Bee nutrition: from genes to landscapes

    - Christina M. Grozinger, Pennsylvania State University
- Development and implementation of floral resources to support honey bees and native bee populations in perennial fruit crop systems –
    - Rufus Isaacs, Michigan State University
- Predictive models of optimal placement of habitat enhancement within agricultural and other landscapes
    - Neal Williams, UC Davis
- How the agricultural landscape is used by pollinators and how their abundance and diversity in field crop systems can be improved
    - Matthew O'Neal, Iowa State University
- Honey bee pollen utilization in agricultural lands: implications for colony health and survival
    - Matthew Smart, University of Minnesota
- The interface of insect conservation and crop production
    - Jonathan Lundgren, ARS, South Dakota
- Building Honey Bee Forage Habitat - Challenges, solutions and creating a successful regional model
    - Christi Heintz, Project Apis m
- Improving Forage Conditions for Honey Bees on USDA Conservation Lands
    - Clint Otto, Northern Prairie Wildlife Research Center
- Conservation Reserve Program
    - Mike Schmidt, USDA-FSA
- Environmental Quality Incentives Program
    - Terrell Erickson, Mark Rose, John Englert, USDA-NRCS
- Providing Access to Honey Bees on Federally Managed Lands – Opportunities and Challenges – Panel Session
    - Carol Spurrier, Bureau of Land Management,
    - Cindy Hall, Fish and Wildlife Service
    - Larry Stritch, Forest Service
    - Carol DiSalvo, National Park Service

- Alternative Management of Rights-of Way - Case Study in Missouri
    - Ed Spevak, St. Louis Zoo, Stacy Armstrong, MO Department of Transportation and Brian Holderness, Ameren Missouri
- Pollinator habitat management on rights-of-way
    - Victoria Wojcik, Pollinator Partnership
- Challenges and Opportunities in providing beekeeper access to Trust Lands
    - Darla Guenzler, CA Council of Land Trusts
- Competition between honey bees and native bees for floral resources
    - Jim Cane, USDA-ARS, Logan, Utah
- Approaches to integrated weed management that reduces reliance on herbicide use in agricultural systems and rights-of way
    - David Mortensen, Penn State University

Executive Summary

The 2013 “Report on the National Stakeholders Conference on Honey Bee Health” (http://www.usda.gov/documents/ReportHoneyBeeHealth.pdf) highlighted nutrition and improved access by bees to nutritious forage as primary factors affecting the health of honey bee (*Apis mellifera*) populations. However, the document noted that a more in-depth understanding of the nutritional value of pollen sources and the factors affecting nutrient acquisition is needed to provide more accurate assessments of the nutritional benefits of different pollen sources and artificial diets. At the request of a coalition of stakeholder organizations and individuals, the Forage and Nutrition Summit was convened by the USDA on October 20-21, 2014, at the Sheraton Suites Old Town, Alexandria, Virginia. Approximately 150 invitees participated in the Summit, with beekeepers, agricultural commodity and retail groups, scientists, the crop protection industry, highway and transportation representatives, utility companies and Federal and State agencies represented. The two-day meeting featured research presentations from private, Federal and university scientists, and included concurrent work group sessions to solicit input on key priorities for future research, extension and outreach on four selected focal areas:

- Nutrition research;
- Forage research and implementation;
- Federal programmatic efforts to establish forage plantings; and,
- Accessibility of Federally-managed lands, rights-of-way (ROW) and land-trusts to honey bees.

The primary goal of the summit was to serve as a means for the USDA to receive input from stakeholders and bee researchers to inform future actions to promote health of managed honey bees through an improved understanding of bee nutrition and its interactions with other factors affecting bee health, and to improve and increase access of bees to nutritious and safe forage plantings in the United States. The meeting had four objectives: 1) synthesize the current state of knowledge regarding nutrition

research; 2) identify priority topics for research, education and outreach, 3) identify means to encourage and facilitate the planting of nutritious bee forage on public and private lands, and 4) improve and increase beekeeper access to forage plantings.

Highlights of Research Overviews

Invited research presentations identified several key knowledge gaps in understanding the impacts of nutrition and forage on bee health:

Nutrition Research Gaps

- Nutritional needs of individual bees and whole colonies change as bees age and/or engage in different colony tasks; a thorough understanding of nutritional needs of colonies throughout the annual colony cycle is fundamental to development of optimal forage seed mixes used by land managers and for supplemental feeds for use by beekeepers during periods when flowering plants are not available.
- Additional research is needed to understand the overlap between stress-response and nutritional pathways at the molecular level and to determine how nutrition may affect bee resistance to numerous stressors (*e.g.*, pests, diseases, pesticides) that may in turn impact colony function.
- An improved understanding is needed of the effects that nutritional stress has on bee behavioral and physiological development.
- Additional research is needed in how honey bee gut microbiota affects nutrition.

Forage Research Gaps

- A greater understanding of the factors affecting optimal design of bee forage plantings is needed, including: floral abundance/diversity, quality of plant pollen and nectar, distance between colony and resources, size of plantings, timing of bloom, effects of soil quality on quality of floral resources and costs associated with forage establishment and maintenance.

- Studies are needed on the effects of forage plantings within annual crop-dominated prairie farmland on limiting loss of nutrients and subsequent effects on water quality.
- Studies are needed to address whether honey bees adversely affect native bees via competition for limited nectar and pollen resources when allowed to forage on public and private lands; this question needs to be addressed before some landowners and Federal agencies focused on conservation will allow beekeeper access.

Modeling

- Develop decision tools to optimize forage selection, guide establishment efforts, and increase efficacy of these efforts, thereby ensuring that investments in habitat enhancement for pollinators can have the greatest benefit for both bees and for agriculture
- Develop a greater understanding of land use and landscape-wide honey bee foraging patterns as indicators of honey bee health and survival.

Social Science Research

- Identify opportunities and barriers for adoption of forage plantings within cropping systems and the potential for crop enhancements from increased bee and other beneficial arthropod abundance.
- Identify opportunities and barriers for adoption of forage plantings along utility corridors, transportation rights-of-way and land trusts.
- Identify best methods to communicate and promote landowner and/or land manager adoption of forage plantings on public and private lands.

Highlights of Work Group Sessions

Nutrition Work Group

- Research is needed to address knowledge gaps in basic nutritional requirements of honey bees at the individual and colony levels and to determine how nutrients are obtained from pollen to better inform efforts in formulating honey bee dietary supplements.
    - Short-term: 1) identify the minimum amount of pollen required to improve the nutritional value of supplements; 2) develop biomarkers to detect signs of nutritional stress; 3) identify key plant species to be used in forage seed mixes; 4) identify highly nutritious pollen sources by region of the U.S; and, 5) identify which plants complement each other to maximize nutritional value and seasonal availability.
    - Intermediate-term: 1) identify sources of nutritious pollen to add to supplements; 2) determine best methods to administer supplemental protein diets; 3) create region-specific seed blends that include plants with highly nutritious pollen; and, 4) determine the number of colonies that can be sustained per acre of forage plantings.
    - Long-term: establish forage plantings in and near to commercially important crops to provide nutritional resources before and during periods when bees are used to provide commercial pollination services.
- Research is needed to identify how nutritional stress influences colony immune responses to Varroa mites (*Varroa destructor*) and other arthropod pests, disease pathogens and pesticides.
- The role microbial communities play in bee digestion, immunity and individual health requires research that includes the effects of plant sources, geographic location and beekeeping practices on microbial composition and diversity in bees and their food stores.

Forage Work Group

- *Short-Term Priorities*:
  - Sweet clover (*Melilotus officinalis*) has historically supported honey bee health in many areas of the U.S., and according to beekeepers is critically needed by bees for both nutrition and honey production. The work group emphasized the need for Federal and State partners to review policies identifying sweet clover as an invasive weed species and to take emergency measures to allow beekeepers access to sweet clover forage while research is conducted on alternative plants.
    - Immediate-term: stop or delay mowing and herbicide spraying of sweet clover along rights-of-way and utility corridors.
    - Short to Intermediate-term: identify areas suitable for sweet clover forage habitat where invasive potential is minimized.
    - Intermediate-term: conduct research to determine management methods to mitigate the invasive potential of sweet clover.
  - Determine the size, location and plant composition of forage plantings to support healthy development of honey bee colonies.
  - Review existing policies related to honey bee access on Federal and State lands.
    - Assess the consistency of policies across and within agencies (*e.g.*, regional consistency of policy application).
    - Review the scientific evidence serving as the basis of those policies.
- *Intermediate-Term Priorities*:
  - Assess crop systems that integrate bee forage to also address multiple types of ecosystem services (*e.g.*, soil and water quality, plus pollinator resources).
  - Evaluate forage mixes (on a region-specific basis) that provide resources addressing hive functions (*e.g.,* honey production vs. colony maintenance) and their associated costs.

- *Long-Term Priorities*:
  - Develop temporally dynamic multi-scale models of forage needs, availability and any potential threat/risk (land use/type) that are scalable from a local landscape level to State and regional levels.
  - Determine strategies and feasibility for integration of oil seed crops with high nutritive value for honey bees into commercial production systems. Oil seed crops may offer value as cash and/or cover crops.
  - Investigate competition between native bees and honey bees, with temporal and application-relevant spatial scales, to inform land use policies.

USDA Conservation Programs Work Group

- *Outreach:*
  - Group members identified a lack of transparency in what outreach and program information is available to beekeepers and crop producers.
  - Federal agencies need to develop and provide information and outreach products that are tailored to local agronomic conditions, and are targeted to four main stakeholder groups (*i.e*., seed producers, beekeepers, crop producers, and land owners), each group having distinct objectives.
  - USDA needs to improve delivery of current outreach materials and increase the volume of targeted education materials about conservation programs.
  - Beekeepers recommended increased use of their networks to communicate with land owners to provide targeted information on pollinator friendly land practices.
- *Technical Assistance:*
  - Improve the flow of technical assistance to stakeholders utilizing existing networks, emphasizing use of low-transaction cost interactions.
  - Share information and data resources more transparently and regularly with stakeholders (*e.g.,* locations of underutilized forage sites with potentially high value for pollinator health).

- Develop tools that address multiple objectives and information needs, recognizing that different stakeholders have different priorities/objectives (*e.g.,* cost minimization/profit maximization (land owners), conservation maximization (conservation groups), and optimization of pollinator health (beekeepers)).

- *Communication:*
  - New communications tools need to be developed for outreach to landowners which do not rely solely on USDA field offices and events.

- *Challenges to Improving Conservation Programs:*
  - Current program requirements are considered rigid and may not support best practices given the individual characteristics of specific parcels of land.
  - Communication between the seed industry and those who are charged with determining seed mixes needs to be improved.
  - Legumes, which are especially nutritious for pollinators, are underrepresented in available seed mixes.
  - Several beekeeper-preferred pollinator forage options (*e.g*., clover) appear on noxious weeds lists.

Providing Access to Honey Bees on Federally Managed Lands, Rights-Of Way and Land-Trusts Work Group

- Communication with land managers needs to focus on the importance of supporting honey bee health.
- Stakeholders expressed a need for managers of Federal lands to assess policy across and within agencies to achieve regional consistency of policy application.
- Beekeepers expressed a willingness to provide input to Federal/State/private landowners regarding site-specific criteria needed to produce good habitat for honey bees.

- Public and private land managers need to communicate policies, rules/restrictions/permit processes regarding beekeeper site access, and prepare general agreements or contracts with beekeeper(s) with specific protocols on use of these land.
- It was recommended that a national extension specialist position be established to serve as a single point of contact for information regarding issues of liability, fees, lease time periods, and best management practices (BMPs) for both landowners and beekeepers.

Research needs:

- Studies to explore competition between honey bees placed in a landscape for time-limited periods and native bees established in that habitat.
- Optimal honey bee colony stocking rates for different landscapes should be investigated.
- Determine suitable methods to both develop and sustain honey bee habitat in a variety of landscapes (*e.g.*, weed control).

Prioritized Research Themes Across Work Groups

- Investigate the potential effects of competition between native bees and honey bees when honey bees are placed in a landscape for time-limited periods.
- Investigate knowledge gaps in basic nutritional requirements of honey bees at the individual and colony level.
- Identify means to improve nutritional quality and timing of supplemental diets.
- Investigate the size, location, and plant composition of forage plantings to support healthy development of honey bee colonies.
- Quantify multiple ecosystem services from cropping systems that integrate bee forage habitat.

Stakeholder Policy Themes Across Work Groups

- Conduct a review and communicate policies related to honey bee access on Federal and State lands across and within agencies to achieve regional consistency of policy application.
- Develop region-specific seed blends that include plants with highly nutritious pollen specific to honey bees
- Establish forage plantings in and near to commercially important crops that bloom before and during commercial pollination periods.
- Federal and State partners should review the science behind policies listing plants as invasive species that are known to provide high quality bee forage.

Summary of Presentations (in order as presented at Summit)

Dr. Catherine Woteki, USDA Chief Scientist and Under Secretary for Research, Education and Economics opened the Summit with a welcoming speech to an audience of approximately 150 persons representing over 70 Federal, State, commodity, retail, professional, agrichemical and non-profit organizations (Appendix 1). Dr. Woteki was followed by Mr. Zac Browning, a fourth generation commercial beekeeper from Jamestown, North Dakota, and past president and current legislative committee member of the American Beekeeping Federation.

Mr. Browning provided an overview of the challenges faced by commercial beekeepers regarding declines in honey bee foraging habitat across the U.S. over the past decade, reporting a loss of 13 million acres of Conservation Reserve Program (CRP) lands over the past five years (from 37 million acres in 2007 to 24 million acres in 2014). According to Mr. Browning, North Dakota lost over 50 percent of its CRP lands between 2005 and 2013. Much of the displaced CRP lands were planted to corn and soybean crops. Beekeepers associate this loss of CRP lands with higher supplemental feed costs, decreased honey production, higher winter mortality rates and fewer hives available to fulfill pollination service contracts. Mr. Browning suggested new approaches in providing additional nutritional and safe honey bee forage, including alternative management of roadsides, easements, rights-of-way, public lands, as well as development and implementation of sustainable agricultural practices and changes to conservation programming that involves beekeeper input.

Eleven research presentations from researchers representing the USDA Agricultural Research Service (ARS), eight universities and Project Apis m followed, addressing current research in honey bee nutrition and forage planting (abstracts and pdf versions of presentations are found in **Appendices 2** and **3**).

Nutrition Presentations

Dr. Gloria DeGrandi-Hoffman, USDA-ARS, Tucson, Arizona, provided an overview of current research investigating honey bee nutrition, emphasizing the far-reaching effects of nutrition on all aspects of bee biology and the dynamic, changing nature of nutritional requirements as a bee ages or their role in different colony tasks change. Dr. DeGrandi-Hoffman also pointed out that nutritional needs of whole colonies are dynamic, changing throughout the annual colony cycle. She reported that natural pollen has higher concentrations of protein and several amino acids not provided through current protein supplements, and that greater queen and colony loss, as well as higher disease incidence, is associated with reliance on protein supplements over natural pollen. These findings indicate that pollen-based diets could improve colony health and reduce losses. However, in the absence of high quality floral resources, commercial migratory beekeepers must provide their colonies with protein and carbohydrate supplements. Information provided through this research is also important to the discussion surrounding the benefits of planting bee forage indicating that the benefits of natural forage may outweigh the costs of establishment for ensuring hive availability to meet pollination demands.

Dr. Amy Toth, Departments of Ecology, Evolution, and Organismal Biology and Entomology at Iowa State University reported on the cascade of detrimental effects and interactions with other stressors that results from poor nutrition, demonstrating that pollen-deprived bees or bees fed on diets of low pollen diversity are more likely to succumb to viral infections. By contrast, bees fed a diverse mix of high-quality pollen are better able to withstand the effects of disease infection. However, Dr. Toth's work indicates that the presence of pesticides in pollen can diminish the value of the pollens in providing disease resistance. Dr. Toth also called for more studies that tie together the interactions between specific landscape type, forage quantity/quality, and nutritional health.

Dr. Miguel Corona, USDA-ARS, Bee Research Laboratory, Beltsville, Maryland, presented research indicating that nutritional stress due to habitat loss is an important underlying factor associated with colony losses. Dr. Corona explained the use of molecular markers of behavior and nutrition, and how they allow the precise identification of the bee's behavioral and nutritional state for disease diagnoses. He stressed that pollen from different plants differ in protein and lipid quantity and quality (content of essential amino acids and fatty acids), and that bees eating pollen from a variety of diverse plants are likely to be healthier. Dr. Corona reported that pollen deprivation induced accelerated behavioral development (*i.e*., transition from nurse bee duties within the hive to foraging duties outside the hive) with direct impacts on bee immune function and disease susceptibility. Dr. Corona also showed that supplemental feeding with lipids and amino acids restored normal behavioral development in pollen-deprived colonies. Among his suggestions for improving bee nutrition were increased diversity of agricultural landscapes and dietary supplementation with specific amino acids.

Dr. Tugrul Giray, Department of Biology, University of Puerto Rico reported on a model predicting that temperature increases associated with climate change may adversely impact colonies by reducing bee activity and subsequent foraging abilities, resulting in reduced honey yields. Dr. Giray also correlated higher colony losses with: 1) increased number of colonies within a bee yard; 2) migratory beekeeping (losses higher than stationary beekeepers); 3) particular cropping systems (*e.g*., sunflowers and cotton); and, 4) increased varroa mite load. He closed by proposing development of an approach that combines statistics and ecological knowledge with direct colony measurements (sentinels + matrix model) to assist in identifying critical factors affecting honey bee health.

Dr. Christina M. Grozinger, Department of Entomology, Center for Pollinator Research, Pennsylvania State University reported on the importance of nutrition in overcoming the impacts of multiple stressors (pathogens, parasites, and pesticides) on honey bee workers at the genomic level. She showed that parasitization with the

intestinal parasite Nosema (*Nosema apis*, *N. ceranae*) and chronic sublethal exposure to certain pesticides both modulated expression of metabolic and nutrition-related pathways, suggesting that nutritional parameters can mitigate the impacts of these stressors. Dr. Grozinger presented data showing that intake of high quality pollen improves honey bee resistance to exposure to the insecticide chlorpyrifos. She also discussed research examining factors associated with colony overwintering success, reporting that colony weight (primarily food stores and adult bees) is positively associated with colony overwintering survival, and that there is substantial variation in this regard between apiaries that can be tied to varying landscape effects. These effects include soil quality, distance of forage resources from colonies, and bloom timing in addition to floral abundance and diversity.

Forage Presentations

Dr. Rufus Isaacs, Michigan State University, is the principal investigator in a USDA National Institute of Food and Agriculture (NIFA) funded project investigating Integrated Crop Pollination. This project looks at combining the use of different pollinator species, habitat augmentation and certain management practices to provide reliable and economical pollination of crops. He spoke to the importance of diversifying both annual and perennial crop lands through the use of cover crops, adjacent forage plantings, crop rotation, planting of trees, shrubs and wildflowers, as well as inclusion of grasslands and rangelands to benefit both crop production and pollinators. He presented data showing that the costs associated with establishment of a 2-acre wildflower planting adjacent to a 10-acre blueberry field could be recovered within four years by increasing blueberry yield approximately twenty-three percent over that period. He also emphasized that native bee and honey bee populations respond differentially to forage mixes, but that all bee species can benefit from seed mixes tailored to specific landscapes. Dr. Isaacs prioritized the development and adoption of protocols for establishment and maintenance of forage plantings.

Dr. Neal Williams, University of California at Davis, spoke to the importance of developing a formalized decision framework and models that address costs and benefits in designing bee forage habitat that meet specifically stated goals. He presented a decision tool that optimized selected sets of plant species to best achieve stated objectives within a selected landscape. Model parameters include: habitat placement, pollinator-preferred plant selection that is regionally relevant and that provides continual bloom, habitat size, species of pollinator present, and cost effectiveness. Similar to Dr. Isaacs' work, Dr. Williams showed gains in yield and monetary benefit using habitats of different sizes and placement relative to crop fields. Dr. Williams' cost-benefit analysis revealed that although multiple habitat options may enhance pollinators and crop yields, the benefit they provide may not always exceed the costs of implementation, and that a range of objectives across many landscape and farm contexts must be considered.

Dr. Matthew O'Neal, Iowa State University, provided an overview of his research in which he surveyed the community of pollinators that visit and forage in Iowa field crops, identifying 44 species of bees in corn and 36 species in soybean. Overall, solitary native bees were more common than social bees; honey bees represented less than 1% of the bees captured in both crop systems. Up to 38% of the bees collected from soybean fields were carrying soybean pollen and 50% of those in cornfields had corn pollen. Dr. O'Neal also reported on investigations into establishment of buffer strips attractive to bees (composed of plant species recommended for prairie restoration) that are intended to increase biodiversity and enhance the delivery of insect-derived ecosystem services in corn and soybean. More beneficial insects (including bees) were collected in buffers composed of plant species recommended for prairie restoration. His team is exploring how reconstructing prairie in annual crop-dominated landscapes can contribute to several ecosystem services, including limiting the loss of nutrients and sediment from farmland that degrades water quality, while harboring more beneficial insects (including bees) than adjacent cropland. Dr. O'Neal encouraged the use of these measures to increase bee forage and to consider additional objectives in

improving ecosystem services, particularly in agricultural landscapes that are not dominated by crops that require bee pollination.

Matthew Smart, University of Minnesota, presented his doctoral research that measured the extent to which agricultural land use in proximity to apiaries directly affected annual survival of commercial honey bee colonies in the Great Plains region during summer and winter, and subsequent effects for colony availability for California almond pollination the following spring. The upper-Midwestern region of the U.S. historically hosts approximately 1 million commercially-managed honey bee colonies annually, but steep declines in acreage of alfalfa, canola, sunflower and CRP lands across the Great Plains region over the last decade have affected honey bee health and survival. This research involved sampling and assessing 144 colonies in six apiaries every six weeks from 2010-2012 for hive honey production and pollen storage (cataloguing plant family and genus). He concluded that land use exerts a significant influence on colony survival, and that bees are largely reliant on mixtures of pollen collected from available CRP lands, pastures, haylands, ditches and grasslands.

Dr. Jonathan Lundgren, USDA ARS, South Dakota, presented research showing that reduced plant diversity within croplands is positively correlated with increased honeybee nutritional stress. Dr Lundgren presented evidence that diversifying crop rotations by planting fields with bee-friendly crops, use of flowering cover crops during fallow periods, use of conservation strips, avoidance of mowing, haying, or spraying field margins, and planting smaller fields with more crop species are sound agronomic solutions to improve bee health. He appealed for efforts to coordinate regional set asides (*i.e*., taking parcels of land out of agricultural production) across crop landscapes to achieve maximum benefits of forage enhancement. Similar to other speakers, Dr. Lundgren also pointed to the positive effects that diversification of agroecosystems can provide for multiple animal species and overall ecosystem services, such as improved water and soil quality.

Ms. Christi Heintz, Executive Director for Project Apis m (PAM), a non-profit 501(c)(5) organization which funds and directs research to enhance the health and vitality of honey bee colonies while improving crop production, reported on research investigating the establishment of forage plantings before and after almond bloom to sustain the approximate 1.6 million bee colonies annually needed for almond pollination. Private and public land owners and land managers in California and the Great Plains states were recruited to grow diverse floral resources for honey bees to help build colonies and increase honey production. Ms. Heintz discussed the importance of identifying cost-effective seed mixes that address seasonally adjusted regional needs in providing nutritious pollen and nectar for bees while also providing economic and ecological benefits to landowners. In California, PAM focused on establishing mustards for before bloom forage (cost effective for large-scale plantings) and clovers and vetch for the after-bloom time period. The California fall seed mix included canola, braco white mustard, nemfix mustard and daikon radish. PAM produces planting guides for landowners and confirms and communicates the benefits of cover cropping to landowners. Traditional media, field days, and electronic and social media avenues were used; follow-up surveys and site visits were conducted as communication tools by PAM. In all cases, however, personal direct communication was the most effective means for obtaining landowner involvement.

Federal Conservation Program Presentations

Four talks addressing Federal programmatic efforts in establishing forage plantings were presented in the afternoon plenary session on Day 1 of the Summit. Dr. Clint Otto, a Research Ecologist with the U.S. Geological Survey (USGS) Northern Prairie Wildlife Research Center, provided data emphasizing the changing North Dakota landscape where more land is planted with narrow spectrum of crops and fewer areas dedicated to CRP. He reported on research investigating which plant species honey bees forage on, when they forage, time periods when the landscape doesn't provide nutritional bee forage, and what kinds of pollen bees collect from different landscape

types. This information will be used to inform and evaluate seed mixes for USDA conservation programs.

Mr. Mike Schmidt, Deputy Administrator for Farm Programs within the USDA ***Farm Service Agency (FSA), presented on conservation and disaster assistance programs. Mr. Schmidt provided information regarding the*** Emergency Assistance for Livestock, Honeybees and Farm-Raised Fish Program (ELAP) and the CRP, providing updates on policy, funding levels, current enrollment, cost-sharing requirements, incentives and sign-up information for the CRP honey bee initiative available in five states (MI, MN, ND, SD, and WI). Mr. Schmidt also reported on six projects monitoring the effectiveness of CRP. These projects assess pollinator plantings covering eleven states (CO, IA, MI, MN, MT, NE, ND, SD, TX, WA, and WI).

Dr. Terrell Erickson (Director of Ecological Sciences), Mr. Mark Rose (Director Financial Assistance Programs Division), and Mr. John Englert (Plant Materials Technical and Program Specialist) all of whom are within the USDA Natural Resource Conservation Service (NRCS), presented a report on the NRCS Environmental Quality Incentives Program (EQIP). Efforts in improving honey bee health are currently being focused in five North Central states (MI, MN, ND, SD, and WI). The presentation included a review of primary vegetative and management conservation practices and seeding and planting recommendations. A discussion on inclusion of yellow sweet clover in NRCS seed mixes ensued, with explanations that though highly desired by beekeepers as a honey bee forage item, yellow clover is not allowed in three states (MI, WI, and MN), it is not recommended by NRCS in North Dakota, and it is not allowed in South Dakota on native prairie; in other areas, a maximum of 10 percent yellow clover in seed mixes is recommended on previously tilled land. Financial assistance to producers was reviewed and preliminary data were presented on enrollment in the 2014 EQIP honey bee pollinator effort.

Speakers representing the FSA and NRCS fielded questions from stakeholders regarding conservation programs following their presentations. Several stakeholders

expressed concerns with seed mix selection, particularly with respect to the exclusion of sweet clovers. Questions and responses are provided below.

- American Honey Producers Association: why is yellow sweet clover on the unapproved list? The plant is easy to control, cheap to plant, and a good source for bees. Is USDA Animal and Plant Health Inspection Service (APHIS) involved in listing of sweet clovers as invasive weeds, if not, why not? (NRCS response: States and counties evaluate plant lists in making decisions regarding what plants to include on approved list; they leave the decisions up to the state technical specialists).
- There are conflicts in programs/policies that discourage honey bee forage planting. For example, there are situations where haying or thistles are not allowed. Schmidt (FSA response): Existing statutes limit some of the flexibility allowed.
- Are monitoring/testing programs in place to evaluate efficacy of planting mixtures? USGS response: after our pilot program is finished, we will set benchmarks/metrics to evaluate success of these programs. USDA and USGS need to work together to set the benchmarks.
- Agencies need a more nuanced approach to herbicide use (*e.g.*, thistle management, in particular); generally these agencies use broadcast sprays which remove non-target species. It was noted that in South Dakota, yellow sweet clover can be managed.

Federally Managed Lands Panel

(see abstracts, **Appendix 2** for agency statements)

A panel session on providing access to honey bees on Federally Managed Lands followed, with representatives of four Federal agencies providing information and responding to audience questions on agency missions and policies related to honey bee access. The Bureau of Land Management (BLM) was represented by Rangeland

Ecologist, Carol Spurrier, Fish and Wildlife Service (FWS) was represented by National Integrated Pest Management Coordinator, Cindy Hall, the National Park Service (NPS) was represented by the Integrated Pest Management (IPM) Coordinator, Carol DiSalvo, and U.S. Forest Service was represented by National Botanist, Larry Stritch. Dr. Hall addressed questions regarding the extent to which honey bees preferentially pollinate invasive plant species that FWS must control and/or eradicate in order to maintain native habitats and the extent of competition between native bees and honey bees on refuges and what are the consequences of that competition for native bees. A sampling of questions from stakeholders are provided below.

- Question to BLM from a beekeeper who used to have bees on BLM but stated that permits are no longer allowed (response to a request to re-instate permitting). BLM Response: request may have been handled differently if made in person rather than in writing.
- There is a lack of continuity in Federal agency policies from state to state. Can directives come from national headquarters to provide such continuity?
- CA beekeepers: BLM properties have allowed bees in California in past, but heavy rains regularly washed out roads and BLM allowed beekeepers to repair roads to insure access. This is no longer allowed. Can this be re-evaluated? Response: it is unclear how stipulations get put into permits; therefore, guidelines are currently being developed.

Rights-of-Way (ROW) and Land Trusts Presentations

Five speakers addressed topics on providing access to honey bees on ROW and land trusts (Abstracts, **Appendix 2**).

Dr. Ed Spevak (St. Louis Zoo), Stacy Armstrong (Missouri Department of Transportation), and Brian Holderness (Ameren Missouri) provided a case study in Missouri on an on-going project on alternative management of ROW. Project goals

include: increase habitat for pollinators, beautify roadsides, increase breeding habitat for monarch butterflies, increase pollination services and habitat for beneficial insects in agricultural crops, and decrease mowing budget of Missouri Department of Transportation (DOT) toward reducing state expenditures. Dr. Spevak discussed conflicts between idealism and realism in achieving some goals, such as the need to mow for aesthetic and safety reasons versus the desire to simply quit mowing to provide more flowering plants. This was contrasted to the needs of each partner in the project to address different goals and requirements for land use versus the idealism of planting forage for the common good. He noted the learning curve encountered in understanding that site preparation and habitat restoration costs vary greatly from site to site. Speakers noted the need for education and outreach related to alternative roadside management and public perceptions of “weediness”. Additional considerations include long-term maintenance/management, selective management of woody and invasive species (spread into crop fields), Federal and State rules affecting utility corridors, erosion and sediment control, conflicting land-use needs and costs.

Dr. Victoria Wojcik, Pollinator Partnership (P2) presented current P2 projects on pollinator habitat management on utility ROWs. Dr. Wojcik noted that there are over 500,000 linear miles of transmission corridors and over 4 million miles of roadside across the U.S. that intersect with forest, agricultural, and urban lands. P2 promotes Integrated Vegetation Management (IVM) for creating diverse habitat, with low-growing herbaceous habitat to benefit native bees and honey bees. Honey bees in this landscape were variously associated with a mix of native and non-native plant species, some of which were weeds. By comparison, P2 reports that mowed areas result in plant material that does not provide high quality pollinator habitat, particularly for ground-nesting bees (IVM had a 94% increase in species richness and 198% increase in abundance). P2 is also investigating incorporating honey bee forage in areas where ROW are being actively reclaimed within California almond landscapes and will be investigating how seeding honey bee forage can be integrated into grower compensation models. Seeding and installing habitat onto ROWs can be complicated by cost and access issues, but in some areas a balance may be possible.

Dr. Darla Guenzler, California Council of Land Trusts, stated that California land trusts hold nearly two million acres of open space and are uniquely positioned to host honey bees. Issues related to bringing bees on land trust properties include avoiding private benefit contracts (charitable status), articulating the impacts on property, and establishing professional, operational arrangements with responsible beekeepers. Considerations here include liability concerns, access fees and on-site requirements (*e.g.,* road access, security and water). A major challenge for land trusts is found in articulating the impacts, if any, that allowing honey bees on trust lands may have on native pollinators, an issue that is contentious, but lacking in scientific investigation.

Dr. Jim Cane, USDA-ARS, Logan, Utah, was asked to address the question of whether managed honey bees competitively exploit nectar and pollen resources to the detriment of native bees. Dr. Cane reported that no single answer can be offered, that competition is a function of bees' abundance and bloom, which can be variable in space and time with episodic shortfalls in forage. He compared the question to livestock grazing on rangelands, stating that stocking density is everything. Overstocking will detract from native bee reproduction, so the answer lies in finding the proper stocking rates of honey bees for the particular site.

Dr. David A. Mortensen, Pennsylvania State University, reported on, "*Approaches to Integrated Weed Management that Reduces Reliance on Herbicide Use in Agricultural Systems and Rights-of Way*." He spoke to conserving floral diversity and abundance across the landscape as an alternative to establishing new forage plantings, and discussed network analysis as a helpful quantitative tool for elucidating pollinator networks and for assembling plant mixes likely to provide the pollination service needed by recipient pollinated crops. Dr. Mortensen proffered an ecologically informed approach to achieving enhanced pollinator provisioning. This included site assessment to determine the provisioning potential of an existing planting, identification of the supplementation mix to complement existing vegetation for that location (region), and an implementation plan that is compatible with the management goals of the site and

which addresses what aggressive, invasive plant species are present. Dr. Mortensen stressed that undesired vegetation should be suppressed prior to supplementation, and that the choice of a native grass mix makes it possible to use selective broadleaf herbicides to suppress unwanted broadleaf invasive plants, followed one to several years after grass establishment with the desired pollinator mix seeded into the native grass. He also asserted that maintenance of the planting and of the site broadly must be carefully considered at the planning stage.

USDA Conservation Programs Panel

Day 2 of the Summit started with a one-hour panel session entitled, "*Stakeholder Perspectives on USDA Conservation Programs and Honey Bee Forage*." Panelists each made introductory comments, followed by 30 minutes of questions/comments from the audience, and panelists' responses. Panel members included:

- *Clint Otto*, Research Ecologist, U.S. Geological Survey
- *Mace Vaughan*, Co-Director, The Xerces Society for Invertebrate Conservation
- *Vicky Wojcik*, Research Director, Pollinator Partnership
- *Tim Tucker*, American Beekeepers Federation
- *Randy Verhoek*, American Honey Producers Association

Comment – Question and Response Highlights

- Beekeepers are at the tipping point – How many have gone out of business? Any numbers? Response – no numbers are currently available.
- USDA programs can benefit honeybees. Do you feel that the beekeeping industry has had enough input into programs? Tucker response: there have been a lot of efforts; EQIP program results have yet to be seen.

- Is seed planted in these programs going on “clean” ground? Pasture improvement provides return (individual effort). For Federal programs it is likely that you won’t see results of efforts for several more years. The beekeeping industry is at crisis point and is not sustainable. Verhoek: the beekeeping industry does not feel that beekeepers have had input; however, he has seen signs of improvement in the last few weeks so they are hopeful.
- With NRCS programs it is hard to see how decisions are made because some are made at Federal level and others, more locally. There is a lack of transparency and it is not clear to public how decisions are made and at what level.
- What is the incentive for growers to change behaviors, especially for those crops that are not dependent on bees for pollination services? Vaughan response: need to bundle pollinator initiatives within other conservation programs (*i.e.*, offer as a package). Wojcik: pollinators are not the hook at the local level; CRP lands are not permanent conservation landscapes, they are working landscapes. One option may be to consider a CRP with pollinator benefit (honeybee CRP). Verhoek: need to tag the efforts onto pheasant/duck programs.
- Iowa is not part of NRCS five-state program and does not have a large commercial bee keeping industry, making it a challenge in taking practices for honey bees onto the landscape.
- Question to beekeepers: Do you hear about layering ecosystems services? Is this a distraction? Is there a fit for you? Response: no – need to work with other groups to address habitat to help pollinators. In the near future there will be a meeting with the American Association of Pest Control Officials (AAPCO) to work on coordination of efforts (*e.g.*, AAPCO is overseeing the development of State-based pollinator protection programs).
- Alfalfa/sweet clover seed mixes enable beekeepers to make honey to support colony health. Englert (NRCS): A prescribed seed mix at a national level will not work as there are too many local differences in climate, soils, *etc*. At national level, NRCS has compiled a draft list of potential plant species for consideration by scientists/land managers at the local level. Yellow sweet clover was rejected by 4

of the 5 states (SD allows for clover, but not on prairie land). The concern has been for the potential invasiveness of sweet clover. In 2014, NRCS mostly promoted the planting of cover crops, rather than pollinator attractive species from list.

Work Group Reports

The aim of the Summit was to engage scientists, stakeholders, policy-makers and regulatory personnel in a balanced dialogue to deliver practical input to inform future actions, and to enable collaborative endeavors toward improving honey bee health. Towards that aim, Summit participants were divided into work groups on Day 2 of the Summit to facilitate directed discussions seeking individual input from participants on one of four assigned focus areas (below). Charge questions were developed in advance of the Summit by group facilitators, working in collaboration with the speakers who presented talks on Day 1 of the Summit in each of the four topic areas (**Appendix 3**). Work groups met over a five-hour period, after which time one or members of each group reported results of those discussions at a reconvened general plenary session. The four topic areas included:

I. Nutrition Research and Implementation: facilitated by Robyn Rose, USDA-APHIS, Gloria DeGrandi-Hoffman USDA-ARS and Jeff Pettis, USDA-ARS

II. Forage Research and Implementation: facilitated by Thomas Moriarty, USEPA and David Epstein, USDA Office of Pest Management Policy (OPMP)

III. USDA Conservation Programs: facilitated by Skip Hyberg, USDA-FSA and Lisa Bertelson, USDA-NRCS

IV. Providing Access to Honey Bees on Rights-of-Way and Land Trusts and Federally Managed Lands: facilitated by Mary Purcell-Miramontes, USDA-NIFA and Larry Stritch, USDA Forest Service (FS)

Nutrition Work Group

The discussion began with the question: “What knowledge gaps are there to understanding basic nutritional requirements of honey bees at the individual and colony level?” The group agreed that those gaps are considerable, and this makes it difficult to formulate supplemental diets to feed colonies when flowering plants are not available. However, a starting point might be to determine a baseline defining a ‘healthy bee’, in order to determine what might be needed to achieve this in a diet supplement. The baselines should be specific for larvae, adults and colony populations throughout the year. Information required for establishing the baselines as identified by the group are: determining bees’ nutritional needs at different times of year, and at different geographical locations, climates and levels of stress.

The discussion continued with the current knowledge of amino acid, lipid, and micronutrient needs and their availability in pollen. The group agreed that more research is needed to identify pollen sources with high nutritional value, and that these pollen sources could serve as key plant species to add in forage seed mixes. Cataloging major pollen plants by geographic regions and by nutritional values was also suggested. The University of Delaware has a reference library with about 600 pollens identified to the phylogenetic Family level. The USGS in Jamestown, North Dakota, also has a regional collection of pollen types used by bees. The group agreed that better methods to identify and catalog pollen are needed and a comprehensive U.S. pollen database is also needed. Additionally, information on what plants complement each other to get the most complete nutrition is needed as is a standard for developing nutritious floral/pollen mixes.

The second question addressed by the group was: “What are your thoughts on developing protein supplement diets for bees as substitutes for bee forage?” The group agreed that information is lacking on the best methods to administer supplemental protein diets. Since weak colonies don’t get enough nutrition from the dry formulation

and evidence indicates that pollen substitutes placed in the hive may lead to small hive beetle infestations, a liquid, syrup or other delivery method should be considered. How pollen is broken down in the hive also needs to be investigated. The group discussed developing a basic supplement with micronutrients added based on different regional needs. The supplement should also be targeted to support a particular purpose or need of the colony, such as brood or honey production.

The group then addressed the question of knowledge gaps in the development of protein supplements and amino acid and micronutrient additives. The best ways to evaluate protein supplements for nutritional quality also need further study. Beekeepers shared that, in the past, supplements worked well and increased colony populations; however, that is no longer the case. Possible explanations were lack of pollen throughout the year, pesticide contamination in colonies interfering with absorption and digestion (particularly fungicides and systemic insecticides), and mites and disease causing greater levels of stress. The group concluded that if we have a better understanding of the nutrients that bees need and how these nutrients are obtained from pollen, we could assess the feasibility of duplicating the nutrients in pollen in an artificial diet.

The group discussed the economics and cost of a diet that would be a complete substitute for pollen. The beekeepers shared that they purchase very large amounts of protein supplements to feed to their colonies throughout the year and that it is a major expense. In some areas of the U.S., protein supplements encourage the growth of small hive beetles in colonies. The consensus of the group was that adding pollen to protein supplements improves consumption and colony growth greatly, and could be an immediate solution to improving supplements that are already available. The minimum percentage of pollen required to improve protein supplements is a researchable question that needs to be addressed. The pollen might need to be irradiated to prevent disease; however, irradiation may harm beneficial microbes in pollen and/or reduce the nutritional value of the pollen. More information is also needed on the contribution of nectar and its sugars and how they may blend with pollen in supplements. This may

include an evaluation of how much high fructose corn syrup is used and the benefits of moving to cane or beet sugar especially for overwintering.

Following the discussion on protein supplements and the nutritional needs of colonies, the group discussed the need for biomarkers that could be used in the field to identify nutritional stress. A break in brood (*i.e*., developing bee eggs, larvae, and pupae) production and rearing or a less than solid brood pattern normally indicates that bees are eating the eggs and larvae due to nutritional stress. However, beekeepers stated that by the time those symptoms occur, the colony is in poor condition and it might be too late to save the bees. Beekeepers would like simpler diagnostic tools that would diagnose malnutrition at an early stage so that colonies could be saved. The beekeepers identified the times of greatest nutritional stress to be late summer through the fall, but regional differences occur based on cycles of natural forage and flowering in agriculture crops.

The group then discussed the third question: “What role does nutrition play in allowing individuals or colonies to defend against parasites and disease?” The discussion began with the impact of Varroa on colony health. Nutritionally stressed bees have low tolerance for Varroa mites, and colonies can be lost to disease or reduced adult lifespan due to parasitism. How nutritional stress might influence disease levels in the colony (especially foulbrood, chalkbrood, and Nosema) also was discussed relative to mechanisms where pollen feeding might stimulate immunity. For example, Nosema levels have been reported to increase when protein supplements are used, but bees are better able to tolerate this pathogen when there is good nutrition. Small hive beetle populations also can increase when protein supplements are fed to colonies, so alternative applications should be considered such as feeding smaller patties with less sugar. The group discussed that pollen may have some constituent, perhaps bacteria, which stimulates immunity, but isn’t contained in current supplements. A better understanding of the relationship between feeding on nectar and pollen and immunity is greatly needed. Whether protein supplement diets have the same effects on immune response and disease prevention also was identified as an area requiring further study.

Consideration should also be given to how the presence of propolis (*i.e*., plant resins collected by bees) helps the immune system.

Finally, the role of symbiotic microbes in the bee and their food stores was discussed relative to question 4: “How might natural forage, protein supplements, environmental contaminants, and colony management affect individual and colony level microbial communities?” A core microbiome has been identified, but the role that the microbial communities have in digestion, immunity and individual health is not known. The effects that plant sources, geographic location, and beekeeping practices (*e.g*., antibiotics, feeding protein and carbohydrate supplements, and exposure to pesticides and fungicides) have on the composition and diversity of microbial communities in bees and their food stores also was discussed and identified as areas requiring further study. Determining how long after antibiotic feeding does it take for the core gut microbiome to reestablish, and whether there are management practices beekeepers could use to encourage the reestablishment were also identified as areas requiring study.

The group discussion identified short, intermediate and long-term research priorities. A high priority from the group is identifying the nutritional needs of colonies throughout the year, and how those needs are met by the pollen and nectar that bees collect. This will require an integrated effort among laboratories and researchers. A short-term priority for improving protein supplements is identifying the minimum amount of pollen required to improve the nutritional value of the supplement. This should be done based on time of year and nutritional needs of the colony, which is an intermediate priority. Identifying sources of clean, nutritious pollen to add to the supplements also is an intermediate priority. Again, developing biomarkers to identify nutritional stress was a short-term priority identified by the group. These biomarkers may vary with time of year and/or longitude. Ultimately, best management practices must be developed for using protein supplements to optimize their effectiveness in alleviating/mitigating nutritional stress in colonies.

Another short-term priority is identifying highly nutritious sources of pollen by region of the U.S. An intermediate goal is to create region-specific seed blends that include the plants with highly nutritious pollen. Methods need to be developed to disseminate information on regional plants that supply highly nutritious pollen. This was identified as a short-term priority. The number of colonies that can be sustained per acre of the plantings needs to be determined and is an intermediate priority. The long-term goal is to have these plantings available to bees especially during periods after they are used for crop pollination or immediately before so that strong colonies can be introduced.

Information on the honey bee microbiome is limited at this time, and was identified as an area requiring further study. Research on the relationships between bees and their symbiotic microbes is needed to obtain a complete picture of the nutritional needs of colonies and how they are met to achieve optimum health. The effects that beekeeping practices (*e.g.*, applications of antibiotics, miticides and sublethal exposure to pesticides and fungicides) might have on the microbial community bees require for digestion and nutrient acquisition also needs to be addressed.

The group was unanimous that if bees have adequate, diverse forage plants throughout the year, they would be healthier. Because forage areas can be limited, there is a need to identify what plants are most nutritious to bees and plant more of them.

Forage Work Group

The work group started with a discussion around the question, "how much forage is needed to support a healthy colony," noting that the answer must incorporate both temporal and spatial components. Some cited anecdotal information that an average size colony needs 1 acre of flowers. However, such an estimate may not take into account differential floral density across an acre, weather and plant quality and diversity.

The work group also discussed that the amount and type of forage needed varies throughout the season depending on whether the goal is to produce a honey crop, to support colony growth and development or to provide supplemental forage while providing pollination services.

A discussion on sweet clover ensued, with beekeepers noting that they have historically looked to clover forage as a proven and reliable plant by which to quickly build bee colonies and produce abundant honey. Sweet clover is a favorable food source for bees, is highly attractive, and blooms at a time of year when other nectar sources are scarce. It also provides other ecosystem services, such as naturally fixing nitrogen to build soil quality. The problem is that some states have programs targeting removal of sweet clover in roadside/ditch management, and do not allow for inclusion of sweet clover in seed mixes used in Federal Conservation programs due to classifications of clover as an invasive weed. Some group members argued that this may be true in some landscape types, but that the decisions surrounding sweet clover designation as an invasive weed is more anecdotal than research-based science. The group reached consensus that due to the importance of sweet clover as an acknowledged nutritious plant and the current emergency situation that commercial migratory beekeepers face with maintaining colony health and strength, that state and Federal partners identify where they can either stop or delay mowing and herbicide spraying of sweet clover along rights-of-way and utility corridors. Meanwhile research should be conducted to determine clover management methods that allow for growing of clover, while mitigating its invasive potential.

The group acknowledged that there are good examples of the invasive nature of sweet clover, such as a clover infestation in the Badlands of South Dakota. There may also be additional implications to increased clover forage that need to be considered. For example, not mowing weeds may create a traffic safety concern, or may potentially increase habitat for disease vectors. Other important forage plants (*e.g.*, Chinese tallow, knotweed, and yellow star thistle) are also considered invasive. State weed management plans and practices should be examined to consider all pollinators,

perhaps permitting for selective removal or selective treatment, which would allow some forage resources to remain.

In the short term, land managers should identify alternatives to mowing or applying herbicides to plant species valued as high-quality bee forage, thereby providing an immediate forage source for honey bees and native bees alike. Deliberate plantings and the possibility of managing sweet clover like a crop and to keep it contained, could maximize the benefits and availability of sweet clover but minimize its invasive characteristic. There was also consideration whether clover (or other species) could be integrated into cropping systems and if research incentives are needed to evaluate this option.

Another conversation ensued around the topic of habitat management, where it was emphasized that the focus should be on management of the whole ecosystem and not just providing bee forage. Long-term planning needs to consider season-long forage for pollinators and ecosystem services addressing a range of issues, including soil and water quality.

The work group discussed the possibility of developing a tool to map and identify current forage plantings, locations for potential forage development, adjacent crop land/type and potential for supporting honey bee colonies. Some of this information is currently available, and some would need to be researched and compiled. Members of the group noted that mapping with geographic information system (GIS) data could be developed to assist in not only locating forage but in assessing size and carrying capacity of forage resources to determine appropriate stocking rates to maintain healthy colonies of bees. Modeling and GIS could also be useful in assessing the need and timing for supplemental feeding of migratory colonies. A map tool could include data layers with crop phenology (*i.e*., what, when and where of agricultural crops) with the potential to provide information on associated pesticide usage, to better determine a landscape's potential for promoting colony health and growth. Members discussed that USGS and USDA have mapped the country into parcels, and that it may be reasonable

to start at this level and proceed to layer-on additional data such as political boundaries, soil type, forage quality, forage availability, political boundaries, crop locations, hive locations, *etc*.

The work group identified "clean" forage (*i.e*., free from pesticide contamination) as a key principle in providing high-quality and nutritious bee forage. The work group discussed the idea of hive registry with respect to knowing where clean forage may be located relative to the placement of colonies. With respect to mapping resources and "clean" forage, it was noted that information toward preventing inadvertent pesticide exposure can be viewed two ways, *i.e*., informing pesticide applicators about bee yard location and informing beekeepers about crop field locations.

Forage quality is an important variable to include in development of a modeling tool, with values assessing pesticide exposure in addition to plant diversity, soil and water. The group suggested that we set a baseline with what is currently available. Maps or tool development assessing forage availability/quantity/quality would need to be up-to-date and dynamic to reflect real-time changes in land use based on policies and landowner decisions (*e.g*., crop land conversion to corn).

Establishment of honey bee forage "reservoirs," not adjacent to crop production and of sufficient size to provide clean forage for bees between pollination contacts, was discussed. Such an approach may require measures to incentivize the use of Federal, State or private land to be managed in a honey bee-friendly manner. There remains a need to determine what can be done in the major cropland landscapes to provide bee forage without conflicting with the needs of crop production and pest management. Utilizing cropland in a new way that is honey bee friendly needs to represent an increase in profit (to the farmer/land manager), or at least be cost-neutral.

In the short term a simple conceptual model could be created with input from beekeepers on the places where immediate "rest stops" would be needed most. The more sophisticated model, discussed previously by the group, incorporating

quantitative, multi-layer GIS information, would be a longer-term goal. It was noted that the lands of Tribal Nations should also be considered. There are current efforts underway with certain Tribal Nations in Arizona about using their territory as a staging area prior to the contract pollination in California almonds.

Regarding access to Federal lands, a discussion ensued around the question of competition between honey bees and native bees for floral resources and whether such competition leads to disease transmission. Some federal agencies are denying beekeepers access to Federally-managed lands based on concerns that the honey bee adversely affects native bee communities. According to group members, the scientific literature upon which to base these claims is minimal and open to interpretation. There is some research on *Bombus*, suggesting reproductive success declined when utilizing shared forage sources with honey bees, but further research is needed.

Some group members argued that land-use policies regarding beekeeper access are inconsistently applied within and across Federal agencies, and that some policies are based on anecdotal information, not sound science and should be updated to reflect the objectives of President Obama's memorandum on creating a Federal strategy to promote the health of honey bees and other pollinators (https://www.whitehouse.gov/the-press-office/2014/06/20/presidential-memorandum-creating-federal-strategy-promote-health-honey-b). Access to Federal lands, such as BLM lands may be possible, based upon the fact that the grazing industry works with BLM, and since bees are now being considered as livestock, perhaps the beekeeping industry could approach BLM and other land managers in a similar manner.

Certain cover crops are considered good forage for bees, but they are often not commercially popular, *e.g*., pot marigold (calendula) or starflower (borage). These crops are widely grown in Europe and are used in cosmetic products. A group member noted that cosmetic companies (*e.g*., Aveda), have to look outside the U.S. for these commodities. Group members spoke to engaging with large retailers, to begin discussion and develop support for production of these crops in the U.S.

The group then discussed the need to evaluate existing seed mixes for value specific to honey bees, and that this evaluation should be both regional and national in scale. There is a need to address whether or not the plant species in currently available NRCS mixes, are in the appropriate ratios to provide good nutrition to both honey bees and native bees. Such analysis should be reflected in seed mixes from the USDA plant materials centers. Testing of these seed mixes could be accomplished on NRCS test plots as well as state and county lands, if available. Seed mix costs must also be considered.

IPM practices could be reviewed and possibly modified to reflect the current understanding of honey bee health and be more supportive of pollinators in general. Land managers could be presented with a menu of these land management options, some of which may already exist (*e.g.,* delaying alfalfa harvest), but others can be developed.

USDA Conservation Programs Work Group

During the USDA Conservation Programs Working Group sessions, participants were asked to discuss several charge questions on topics ranging from outreach, technical assistance, communication, and financial assistance. The collected responses were synthesized and presented alongside ‘take-aways’ and ‘action items’ to be presented at the closing session of the Summit.

Contributors to the Federal Conservation program discussion included individuals representing a diverse cross-section of interests including the Federal Government, conservation groups, beekeepers, seed producers, legal counsel, and academics spanning multiple fields of expertise. In general, those gathered for the working group were united in an objective to determine ways to improve the quantity and quality of forage available to pollinators through enhancements to Federal conservation programs. Further, there was consensus that stakeholders need to capitalize on the

momentum provided by the President's memorandum to source additional support for programs and to make modifications that would improve their efficacy.

Outreach: Several themes emerged during discussions of conservation program outreach efforts. The group identified a lack of transparency in terms of what outreach and program information is available to beekeepers and crop producers/land managers. It is not clear to potential participants and conservation program supporters what type of products are available and to which groups. Offerings tend to be geographically focused and not easily accessible to distant stakeholder groups. Complicating problems created by a lack of information on current program offerings is a dearth of publically-available data on program participation and land management practices. Participants noted the need for increased information sharing, especially in the Northern Plains. It was suggested that various organizations, including the Federal government, coordinate to make existing information products more widely available, in part so that current offerings can serve as a template for other stakeholder groups.

A second theme to emerge from the discussions was the need to provide different information and outreach products to the four main stakeholder groups: seed producers, beekeepers, crop producers and land owners. Each of these groups has distinct needs and objectives and requires targeted information to make informed decisions. For example, seed producers requested improved information on what mixes might be recommended by NRCS so that they may link that to production decisions. Demand for native seed can be dramatically affected by program changes, and it can be difficult to find additional seed supplies on short notice. Native seed production requires a minimum of 1 year and often 2 to 3 years. With improved lead time, the seed industry may be better poised to increase the seed supply in support of Federal Conservation programs. Similarly, beekeepers would like information on what forage land is, or will be, available, and to have access on parcel-level information on prospective planting and geographic characteristics. Beekeepers would also like to have access to the contact information for landowners. However, they recognize the landowner privacy is protected by statute (Section 1619 of the Farm Bill). Landowners are likely to need

information on the private financial benefits of pro-pollinator land practices and the public benefits that may also result from program participation.

Tailoring outreach and enrollment information to local agronomic conditions emerged as sub-theme. Outreach material targeted at land owners is thought to be most effective when local conditions are taken into account, and when it is recognized that economic incentives are at the forefront of adoption decisions. Materials that tailor the economic message and focus on the private benefits to the land owner are felt to be most effective. It is recognized that social benefits, including a variety of ecosystem services and indirect production enhancements, are also likely to stem from enhancement of conservation practices. However, the monetized social benefits are not available at present. Benefits to the land stemming from planting of pollinator-friendly seed mixes include nitrogen fixing, reduced soil erosion and compaction, and increased soil moisture.

A third outreach theme is the need to improve information delivery alongside the previous themes of increasing the transparency of current offerings, and increasing the volume of targeted conservation program education materials. It was noted that the number of wildlife biologists serving at NRCS field offices available to coordinate the diversity of pollinator-related conservation program materials has declined. This has been offset to some extent by increases in the number of non-NRCS liaison staff; these individuals are knowledgeable advocates who leverage the efforts of other groups. These conservation partnerships help increase the rate of conservation practice adoption. The typical outreach model is to train NRCS staff at one location and create trainers who can then educate others, thus creating a ripple effect. This practice has not been effectively integrated with respect to pollinator-related conservation programs. Efforts to develop trainers are likely to focus on areas where the greatest benefit is expected, such as states where there are a number of bee yards, significant acreage of specialty crops, and/or significant acres of historic forage grounds.

In addition to leveraging the expertise and personnel at NRCS field offices, beekeepers in attendance recommended increased use of their networks to communicate with land owners. Beekeepers communicate regularly with crop producers that use their pollination services. These interactions create an opportunity to provide targeted information on pro-pollinator land practices. Discussions could be enhanced through the development of a “tool kit” and training for demonstrating to growers/land managers the value of bees/pollinators to their operations. For example, the California State Beekeepers Association has developed information for their members to share with crop producers. NRCS also has a tool kit designed to be used when working with landowners. The basic information contained in these “kits” is likely to be generalizable to other regions and could serve as a template for customizable tool kit development. It is recognized that land owners/mangers will have variable levels of information on pollinator health issues. Tool kits should be customizable not only geographically but also based on perceived level of baseline information.

Linkages between commodity groups and their land owner/manager members are thought to be an underutilized network. It is noted that many landowners/land managers will not visit a NRCS office, but many do participate in commodity organizations and meetings. Use of targeted delivery of conservation information is thought to be more effective than more passive means and more effective than the “hit or miss” delivery that takes place at extension field days.

Technical Assistance: Discussions of outreach and technical assistance were largely intertwined, however, whereas outreach discussion was focused on current problem areas and bottlenecks, discussions of technical assistance were organized around objectives and recommendations for providing stakeholder support. The overarching goals for improving technical assistance are as follows: improve the flow of technical assistance to stakeholders; increase the availability of applicable and accurate information; build awareness of multiple stakeholder objectives; integrate monitoring and research; reduce the costs of communication between stakeholders; and, leverage existing resources.

The first objective (*i.e*., to improve the flow of technical assistance to stakeholders) builds on suggestions from the outreach discussion to utilize existing networks and make the most of low-transaction cost interactions. For example, in the case of land owners, information on conservation practices and programs that are applicable to the individual could be provided at industry/commodity group events and/or during routine interactions with beekeepers.

The second objective underscores need to share information and data resources more transparently and more regularly with stakeholders. Examples of the type of information needed by stakeholders were provided in the outreach discussion and are detailed in the previous section. It was emphasized that all stakeholders are time-constrained; therefore, access to timely, relevant information and easily customizable tool kits will aid interest groups in targeting their efforts. It was also noted that the need for information on conservation practices is growing as pollinator forage land is decreasing. Beekeepers in the group felt that many of their constituents may have already “sniffed out” the best sites for locating hives in the U.S.; however, improved reporting of land use that helps to reveal underutilized current and/or future forage sites of potentially high value to pollinator health, would be especially useful.

The third recommendation is to develop tools that are reflective of multiple objectives and information needs. A sampling of objectives across stakeholder groups may include: cost minimization/profit maximization (land owners), conservation maximization (conservation groups), and optimization of pollinator health (beekeepers). These objectives do not always align and can put stakeholders at odds.

To improve Federal technical assistance, participants urged action where there is the greatest potential impact on honey bee health. These areas are typically in the Upper Midwest where there is the greatest concentration of mixed floral resources that provide continuous forage to pollinators. This area is also where there is already a concentration of CRP-enrolled land. Areas of California that are visited by many

pollinators (*e.g.*, Almond production zones) are also high value targets for enhanced education and training about pro-pollinator land management practices.

An important acknowledgement is that there is a hard cap on the number of acres of land that can be enrolled in CRP programs (24 million acres), expansion is not likely in the medium- to long-term and not possible in the short-term. It was reported that while there have been additional funds made available for pollinator-related conservation programs on enrolled lands, these funds are also limited. There are no guarantees of additional funding in the long term. Further, there are multiple CRP objectives and not all relate to pollinators; program objectives may also change over time. The message is that lasting support for pollinator-related conservation practices will have to come through involvement of the private sector and most likely will. If land owners are able to see a personal, financial benefit, they are more likely to adopt new practices. Demonstrating these types of benefits to land owners/land managers is likely to require a personalized approach and will be aided by the development of customizable conservation advocacy tools.

Communication: Current USDA conservation programs could be more effective in supporting pollinator health if communication across stakeholder groups and to and from Federal facilitators is improved. The quality and quantity of information currently available has supported high levels of participation in Federal programs. However, increased adoption of conservation practices, outside the scope of Federal programs, could be supported through improved communication methods. Most communication materials are targeted at land owners and most delivery methods rely on busy land owners/managers getting to an NRCS office to gather materials or participate in an extension field day. The use of traditional mechanisms for communicating to landowners and producers misses many of whom are targeted. New communications tools to reach landowners not using USDA field offices and events need to be developed.

While a personalized approach to communicating the benefits of conservation practices was preferred, there was recognition that there are not enough agents or beekeepers to conduct a wide-reaching promotion campaign. In addition, most beekeepers and agents do not have public relations training and are themselves busy. Reducing the costs of getting conservation messages to the end user, as well as telling the conservation story, needs to be at the forefront of a redesign of current communication methods and media. Additional consideration and recommended best practices include the following items.

- Use credible and less sensational data/evidence to support claims related to the benefits of adopting conservation practices.
- Keep stakeholder objectives in mind and recognize that it is legitimate for a land owner/manager to be concerned about their bottom line first.
- Work to form information-sharing networks between stakeholders with similar interests and share media and/or tool kit resources (preferably electronically).
- Utilize a mixed-media message where possible, and provide a diversity of information resources to suit preferred education methods.
- Use trusted networks such as local Extension or e(X)tension, local cooperatives, *etc*. to provide a forum for sharing information about the needs for adopting conservation practices and methods.
- Promote conservation on its own merits and tailor the message to the audience, keeping in mind variables levels of education about bee health challenges and conservation methods.
- Where appropriate, use personal appeals and share beekeepers' stories, but avoid sounding like a broken record; keep the focus on the downstream benefits while being clear on costs.
- Develop case studies of successful beekeeper/landowner partnerships and/or stories from land owners'/managers' perspectives on what it is like to participate in conservation programs, to adopt new practices, and what differences are observed in different use scenarios.

Financial Assistance: Working group participants were asked to provide feedback on whether program incentives were adequate and timely and whether current resources were adequately allocated. Representatives from USDA-FSA noted that the EQIP program utilized its full budget allocation, exhausting available funds for newly-enrolled land. It was noted that there were more interested participants than funds, an indication of the popularity of the program and the adequacy of the financial incentives to participate.

Some funding decisions are outside of a specific agency's control, and funds may be available on a one time or limited basis. This challenges investment in areas of interest such as the planting of pollinator-friendly forage. To mitigate the effects of limited budgets and time, Federal agencies have focused new programs on locations where there is the biggest perceived "bang for the buck" and these are generally in the Upper Midwest. With feedback from stakeholders, investment in specific areas may shift; this is in keeping with the theme of adaptive Federal program management.

Revising programs so that they provide the greatest benefit, subject to budgetary constraints, is impacted by what is perceived to be a top-down approach to program creation. Facilitation happens on the State level and good ideas or program improvements may be left out because of limited access to decision makers. Most funds are likely to be sourced at the Federal level and dispersed to States; State-government sourced funding for conservation programs is thought to be limited. It was noted that media interest and a critical mass of land owner/manager participation in conservation programs increase the likelihood that additional financial resources will be diverted to fund pollinator-related programs. The Presidential memo on improving pollinator health provides an opportunity to capitalize on the created momentum to source additional support for conservation programs.

Challenges to Improving Conservation Programs: The general objective of working group participants was to discuss means of improving the quantity and quality

of forage available to support pollinator health in the U.S. land owners/managers were not represented in the working group session, however, some noted that there is a societal obligation to increase pollinator access to nutritious forage as doing so may support improvements to the larger agro-ecosystem. Acknowledging this, attention can be focused on how to move forward and what obstacles are in the path towards meeting the stated objective.

Programs:

- There is a hard cap on the number of acres that can be enrolled in CRP programs and limited funding to support USDA conservation initiatives.
- While mid-contract management does provide an opportunity to give advice on improved management techniques, the group felt that a significant proportion of CRP-enrolled land is minimally-managed. Planting this land with more pollinator-friendly mixes could increase management requirements.
- When States get an acreage allocation under a new CRP initiative and do not use it (*e.g.*, CRP Practice CP33) acres are unavailable for states that could enroll more acres than they had been allocated.
- It takes time to reallocate acres across States to where there is demand and need.
- Current specialty crop research funds exclude inclusion of legumes, as they are considered forage.
- Current program requirements are rigid and may not support best practices given the individual characteristics of specific parcels of land.

Seed Mixes:

- Mismatches between prescribed seed mixes and optimal seed applications were identified. This problem was thought to be made worse by a lack of communication between the seed industry and those who are charged with determining seed mixes. Low supply of certain prescribed seeds has the potential to increase prices. Currently, seed mixes are distributed by weight.

Legumes, which are especially nutritious for pollinators, have large seeds and are underrepresented in the seed mixes. Packaging seed mixes by cover per area such as live seed per square foot may reduce related problems.

- Several preferred pollinator forage options, such as clover, appear on noxious weeds lists.
- A limited number and diversity of forb species are used in conservation program plantings.

Communication and Technical Assistance:

- There is limited coordination between stakeholder groups with similar objectives.
- It may be difficult for the public and land owners to envision a pollinator-friendly habitat and to experience a pollinator-focused landscape.

Take-Aways and Next Steps

Implementation of Federal conservation practices is an adaptive management process and should be recognized as such. Program implementation and improvement generally takes time but can be expedited by engaging stakeholder groups. In the case of pollinator-related forage development programs, stakeholders include beekeepers, land owners/managers, seed suppliers, as well as various interest groups. In addition to contributing to dialogues on Federal programs, these groups are also encouraged to be proactive in supporting their individual objectives/priorities and taking steps to enhance their networking, aggregation of information resources, and coordination of activities, where appropriate.

Next Steps and Recommendations

Ongoing:

- More frequent and transparent stakeholder discussions at the Federal and local-level to aid in improving the process of adaptation and program creation
- Regular evaluation of the efficacy of Federal programs and their progress towards program objectives and revision of program practices where appropriate.

Involve stakeholders in program development discussions and reviews of program progress.

- Support beekeepers and conservation organizations in their efforts to promote conservation practices on private lands via collaborative efforts with landowner/land managers. This can be done by making applicable research more widely available, making searchable directories of State plant specialists and wildlife personnel publicly available, and providing case studies of successful beekeeper/landowner partnerships.

Short term:

- Look to acres that are enrolled in forage programs as a first place to enhance landscapes to provide pollinator-friendly forage.
- Increase the proportion of legumes in seed mixes and measure mixes by live seeds per square foot as opposed to weight.
- Conduct a review of available conservation practice information and consider creating a searchable database that enhances access to resources from diverse groups.
- Invite seed industry representatives to participate in discussions regarding seed mix recommendations and share information on seed availability and cost.
- Create a searchable database of NRCS personnel including plant materials specialists and wildlife biologists.
- Use resources gathered from private organizations (*e.g*., California Beekeepers Alliance) and public sources (*e.g*., NRCS), to assist beekeepers in developing tool kits that can be customized with pertinent conservation practice and cost/benefit information for landowners/land managers in their networks.
- Encourage beekeepers and conservation practice proponents to bring their message and personal stories to land owners/managers at low-cost of attendance events (*e.g*., commodity group annual meetings, co-op meetings, *etc*.).
- Plant pollinator gardens with beehives via USDA county service centers/field offices/research facilities as demonstration sites.

Medium to Long term:

- Consider developing a demonstration plot to showcase a landscape that is planted to continuously provide forage options for native and honey bee pollinators.
- Streamline the process of cross-State acreage allocation to allow for the more enrollments to be available in areas of greater demand.
- Support the gathering of empirical evidence to assist States in making scientifically-based decisions regarding the inclusion of clover on noxious weeds lists.
- Focus efforts on expanding conservation practices on non-CRP enrolled lands and communicating the personal and public benefits of employing conservation practices.
- Expand the use of mid-contract management of CRP lands to improve nutritional quality of cover crops for honey bees and pollinators.
- Support expanded research into novel conservation practices and the impacts of monoculture planting systems on pollinator forage.

Summary

Federal Conservation programs are working to support improved honey bee nutrition by increasing available forage. Recent program enhancements have further assisted to increase pollinator access to floral resources and to educate land owners and the public about the benefits of conservation practices. Federal programs management should be viewed as an adaptive process and can be improved through many means including: solicitation of input from stakeholders, especially seed distributors; improved outreach methods which acknowledge heterogeneity in lands and land owners; and. improvement in information access for stakeholders.

Federal programs are one component of a multi-faceted strategy to increase the adoption of conservation practices on agricultural land. While this session focused on

Federal conservation programs, many of the suggested improvements are transferrable to efforts to promote conservation by non-Federal stakeholder groups. Federal action has the potential to catalyze the efforts of private groups while the same groups have the potential to enhance the efficacy of Federal programs. The mutual benefits of coordination are recognized and serve as a point of departure for both groups to capitalize on the momentum created by the Presidential memo and the urgency of the pollinator health situation.

Providing Access to Honey Bees on Rights-of Way, Land Trusts, and Federally Managed Lands Work Group

This work group contained a good cross section of land managers from the private, Government and public sector, university researchers, energy, transportation, utility companies, non-profit organizations, the beekeeping industry and crop commodity groups which utilize honey bees for pollination. In addition, Federal administrators that have responsibilities to conduct research and regulate activities affecting pollinator were participants in the group. This discussion centered on the theme of identifying major obstacles that need to be overcome to increase access of honey bees to ROW, land trusts, and Federally Managed Lands. The group agreed on three over-arching needs or challenges in which to frame the discussion: 1) articulate to the public and to land managers why bee health is a major concern to food security, the global economy and the environment; 2) identify potential ROW, land trusts and Federal lands that could be accessible to beekeepers; and, 3) develop protocols for specific best management practices for specific sites and which are compatible with land management goals and objectives. Towards the conclusion, a few group members introduced suggested research needs that would be critical to ensuring effective foraging sites for managed honey bees; however, there was insufficient time to fully vet these research needs.

1) Why is honey bee health an important concern?

To help land managers and the public better understand why bee health is important and thus well positioned to support research and policies that protect honey bees, several compelling reasons were identified. First, the abundance and affordability of the food supply is at stake because it is predicted that widespread food shortages will occur as the world population grows to over 9 billion people by 2050. In addition, at least one third of crop species depend on the pollination services of honey bees. Second, the decline of honey bees has been targeted as a major initiative by the President in his 2014 memorandum "*Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators*." Third, one of the possible reasons why bees are in decline is that, in general, there is a lack of understanding about where food comes from and the role of bees in pollinator-dependent fruits, vegetables and nut crops and in maintaining viable crop yields. In addition, honey bees provide essential ecosystem services that are important for maintaining biodiversity and habitat for plants as natural resources. As a result, this group felt that the public hasn't sufficiently voiced their concerns to policy makers and legislators to adequately support activities that promote pollinator health.

2) How is available land for honey bee access best delineated?

Land managers must first articulate their policies, rules/restrictions/permit processes regarding bee foraging, site access (*e.g.*, specifics on entering/gate/timing), use of liquid versus dry smoke used to manage bees in drought-ridden areas to reduce fire hazards and potential manipulation to enhance sites for hive locations, and to conserve native species as well. Second, land managers must prepare a general agreement or contract with beekeeper(s) with specific protocols on use of their land. A "code of conduct" can be drawn up which would include liability insurance for both the beekeeper and the land manager/owner. Other items included developing agreements on the fees involved, the length of the use of the land (*i.e.*, lease on the land). Lastly, it

was recommended that a national extension specialist position be created to be the single point of contact for this information to be more accessible.

3) Protocols for Best Management Practices

To facilitate good working relationships, the work group agreed on several best practices that beekeepers should follow.

- Develop protocols to maintain “clean bees” (*e.g.*, bees that are healthy, with low incidence of diseases and pests).
- Maintain clean hive equipment prevent the transfer or spread of invasive weeds to land properties.
- Hives should be inspected to meet established standards by State Departments of agriculture.

In turn, the group agreed upon the following BMPs that land managers should follow to preserve and protect pollinators:

- Consult with beekeepers to determine most suitable seeds or plants that meet nutritional needs of bees.
- Determine suitable methods to prepare the ground that will restore and sustain ideal habitat for honey bees (*e.g.*, weed control).
- Develop an IPM plan to manage invasive plants without harming bees (*e.g.*, mowing weeds; using herbicides with a long residual life that may adversely affect the plants intended for pollinators).
- A widely accessible database of seed materials should be developed. Whether this is done by the government, a non-profit organization or some combination needs to be addressed.
- Understand differences in needs for different geographic regions and cultural values (*e.g.*, Tribal lands).
- Increase awareness that weeds may be native plants as well as exotic species.

Appendix 1. Summit Attendees

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Appendix 2. Speaker Presentation Abstracts

Overview of habitat losses in US

Zac Browning, American Beekeeping Federation

70 percent of the crops we rely on for our human diet and pollinated, mainly by honey bees. Bee decline has amplified our focus on what is required to sustain this critical balance. Modern agriculture systems that rely on bees are very productive in terms of yield per acre, but that efficiency has come at a cost. That cost is plant diversity and accessible clean forage within the farming environment. Bees need abundant pesticide free forage to sustain healthy populations that are required for pollinating crops. Without good nutrition, from clean abundant forage, bees are weak and more susceptible to many of the stressors known to weaken hives, including pests, disease, and even pesticide poisoning. Hives that are able to access good forage tend to be more healthy and robust and are more likely to survive periods of dearth and the movement to and from different pollinating jobs. Unfortunately, we are losing suitable honey bee habitat at alarming rates. Pressure from high commodity prices has converted millions of acres of traditional bee pasture into crop production in just the last few years. Furthermore, modern farming practices use herbicide on such a wide scale, that few areas are left that could support any natural forage. Not surprisingly, over the past decade both honey crops and bee health nationwide have suffered significant declines.

Nutrition and honey bee health: Current research and future directions

Gloria DeGrandi-Hoffman, USDA-ARS, Tucson, AZ

Nutrition is the fundamental link between organisms and their environment. The ability to acquire and metabolize nutrients affects all aspects of an individual's physiology. Nutrition also is the fuel that drives population growth and survival. In honey bees, colony growth and survival are driven by the availability of flowering plants. Honey bees meet all their nutritional requirements by collecting pollen and nectar. Bees nutritional requirements change as they age or with their engagement in different colony tasks.

For example, worker bees that care for brood require more protein than those that forage and need a diet high in carbohydrates. Similarly, the nutritional needs of colonies are probably dynamic and change throughout the yearly colony cycle. Though bees need pollen and nectar to survive, there are periods when flowering plants are not available. At these times, beekeepers provide their colonies with protein and carbohydrate supplements as a substitute for pollen and nectar. Whether these substitutes, particularly protein supplements, provide the nutrients bees need to sustain the health of colonies was investigated during the overwintering period prior to almond bloom. More colonies are used for almond pollination than for any other agricultural crop. Bees are brought to California in the fall and overwinter there until February when almonds bloom. During this period, bees are actively foraging but flowering plants are unavailable. During this time, colonies are largely fed sugar syrup and protein supplements. Recently, there has been growing interest in planting forage for bees to provide pollen and nectar prior to almond bloom. Whether the benefits of planting bee forage outweigh the costs are not known. To address this question, we compared the health of colonies either foraging on a fall mustard called rapini (*Brassica rapa)* or fed commercially available protein supplements. The study began in November and ended in February just prior to almond bloom. We found that rapini pollen has higher concentrations of protein and several amino acids than the protein supplements. Bees more readily digested rapini pollen and obtained more protein from it than the protein supplements. Though there were differences in protein availability and acquisition between rapini pollen and protein supplements, this did not translate into differences in colony size at the end of the study. However, colony and queen survival through the winter was twice as high in those foraging on rapini. These differences might have been at least partially due to levels of Nosema and virus that were higher in colonies fed protein supplements compared with foraging on rapini. Our results indicate that colonies foraging on rapini prior to almond bloom have greater queen and colony survival and lower disease titers than those fed the protein supplements we tested. Though colony sizes did not increase from their starting populations, having pollen available could improve colony health and reduce losses thus increasing hive availability for almond pollination.

Honey bee nutritional stress: interactions between individual physiology, disease, and landscape

Dr. Amy Toth, Departments of Ecology, Evolution, and Organismal Biology and Entomology at Iowa State University

Proper nutrition is a fundamental aspect of any organism's physiology, with implications for immunity, behavior, lifespan, and health. In honey bees, low or imbalanced nourishment has the potential for a cascade of detrimental effects and interactions with other stressors that may impact colony function and disease incidence. I will present work investigating the interactions between nutritional stress and viral infection in honey bees. By experimentally challenging bees with several common honey bee viruses that are present at low levels in healthy colonies, we demonstrate that bees under pollen deprivation or fed on diets of low pollen diversity are more likely to succumb to viral infections. In contrast, feeding on a high quality pollen diet (either polyfloral or highly nutritious single-source pollen) can mitigate the effects of viral infection. The effects of high quality pollen, however, are sensitive to the presence of even moderate, sub-lethal doses of pesticides-- only a diet of high quality pollen with sufficiently low levels of pesticides provide protection against viral infection. Finally, I will present preliminary data that aims to tie together our findings on diet and nutritional physiology with the environmental drivers of nutritional stress: floral resources and landscape diversity.

Nutritional stress, abnormal behavioral development and honey bee health

Dr. Miguel Corona, USDA-ARS, Bee Research Laboratory, Beltsville, MD

Colony losses can be predicted by measuring the extent of open land relative to developed land area, suggesting that nutritional stress due to habitat loss is an important underlying factor associated to colony losses. Habitat loss is associated with reduced plant biodiversity and the quantity and quality of the pollen, the main source of proteins and lipids for honeybees. We tested the effects of pollen deprivation at colony

level to gain insight into the mechanisms connecting nutrition, behavioral development and honey bee health. For this purpose, we determined the expression of molecular markers of behavior, expression of immune genes and virus load. Our results showed that pollen deprivation induced accelerated behavioral development and that the behavioral state has a major effect on the expression of immune genes and virus load. Foragers were found to have higher expression of immune genes and virus load compared with nurses. In another set of experiments, we showed that lipids and amino acids supplementation restored normal behavioral development in pollen-deprived colonies. Overall, our results reveal that nutritional stress induced abnormal behavioral development, decreased immune function and higher susceptibility to diseases and support the proposal that nutritional stress is an important contributing factor associated with colony losses.

Factors important for honey bee health and the specific effect of antibiotics

Tugrul Giray, Department of Biology, University of Puerto Rico

For over a decade the colony numbers of the managed pollinator, the honey bee *Apis mellifera*, has been on the decline, yet pollinator problem was not well publicized until the Colony Collapse Disorder (CCD) further diminished the honey bee population in the United States. In addition to honey bees, bumble bees and other pollinators are also on the decline, perhaps due to combined effects of pesticide use and habitat destruction by *Homo sapiens.* My thesis in this talk is that there could be a common denominator to the problems both honey bees and other pollinators face (Huang and Giray 2012[1]). Therefore, taking advantage of tractable honey bee as a model we can learn more about impact of environment where pollinators live, and feed on pollinator health. I will discuss multiple factors identified in honey bee health crisis, focusing on two case studies I am involved with, Turkey and Puerto Rico (Giray *et al*. 2010[2], Delgado *et al*.

[1] Huang, Z.Y., Giray, T. 2012. Factors affecting pollinators and pollination. ***Psyche***, 2012:302409 3 pages, doi:10.1155/2012/302409.

[2] Giray, T., Kence, M., Oskay, D., Doke, M.A., Kence, A. 2010. Scientific note: colony losses survey in Turkey and causes of bee deaths ***Apidologie*** 41 (2010): 451-453. DOI: 10.1051/apido/2009077.

2012[3]). I will present methods we have used in addressing pollinator health and the important factors in both of these cases, extending from use of historical data, climate data, geographical information, and survey data (*e.g*., Rivera-Marchand *et al*. 2008[4], 2012[5], Giray *et al*. 2010[6], Delgado *et al*. 2012[7]). We also have begun studying impact of landscape differences on behavior, such as orientation and mating (Galindo-Cardona *et al*. 2012[8]). Once important factors are identified, these need to be linked directly, at physiological level to pollinator health and behavior. Our research exemplifies how genetics of the pollinator, honey bee, influences health and behavior (Galindo-Cardona *et al*. 2013[9], Kence *et al*. 2014[10]). We also present one potential factor, either as a contaminant, or due to deliberate use, antibiotics influence gut microbiota and also behavior of the forager honey bee. Lastly we speculate on how microbiota and nutrition effects could be linked, and how a future project on real-time monitoring of pollinators and landscape data could be an important tool for managing factors influencing pollinator health and behavior.

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[3] Delgado, D.L., Perez, M.E., Galindo-Cardona, A., Giray, T., Restrepo, C. 2012. Forecasting the influence of climate change on agroecosystem services: Impacts on honey yields in a small-island developing state. ***Psyche***, 2012:951215 10 pages, doi:10.1155/2012/951215.

[4] Rivera-Marchand, B., Guzman-Novoa, E., Giray, T. 2008. The cost of defense in social insects: insights from the honey bee. ***Entomologia Experimentalis et Applicata***, 129: 1-10. DOI: 10.1111/j.1570 7458.2008.00747.x

[5] Rivera-Marchand, B., Oskay, D., Giray, T. 2012. Gentle Africanized bees on an oceanic island. ***Evolutionary Applications*.** http://onlinelibrary.wiley.com/doi/10.1111/j.1752-4571.2012.00252.x/full

[6] *Ibid* Giray *et al*. 2010.

[7] *Ibid* Delgada *et al*. 2012.

[8] Galindo-Cardona, A., Moreno-Jackson, R., Rivera-Rivera, C., Huertas-Dones, C., Caicedo-Quiroga, L. Giray, T. 2012. Where are the Drone Congregation Areas of the honeybee *Apis mellifera*? ***Journal of Insect Science***, 12:122.

[9] Galindo-Cardona, A., Acevedo, J.P., Rivera-Marchand, B., Giray, T. 2013. Genetic structure of the gentle Africanized honey bee population (gAHB) in Puerto Rico. ***BMC Genetics*** 14 (1): 1-12.

[10] Kence, M., Oskay, D., Giray, T., Kence, A. 2013. Honey bee colonies of different races show variation in defenses against the varroa mite in a 'common garden'. ***Entomologia Experimentalis et Applicata*** 149 (1): 36-43.

Bee nutrition: from genes to landscapes

Christina M. Grozinger, Department of Entomology, Center for Pollinator Research, Pennsylvania State University

Populations of honey bees and other pollinators are in decline globally due to the effects of multiple biotic and abiotic stressors. We have examined the impacts of several of these stressors (pathogens, parasites, and pesticides) on honey bee workers at the genomic level to determine if they perturb common or distinct pathways, and if these pathways are related to particular physiological functions or social behaviors. Parasitization with Nosema and chronic sublethal pesticide exposure both modulate expression of metabolic and nutrition-related pathways, suggesting that nutritional parameters can mitigate the impact of these stressors. Additional testing demonstrated that diet can significantly influence individual bees' sensitivity to pesticides. Furthermore, we have demonstrated that the nutritional quality of floral resources is influenced by environmental conditions, and, in turn, influences foraging preferences of bees. Overall, our results demonstrate that the nutritional quality of floral resources is modulated by multiple factors, bees use nutritional cues while foraging, and high quality nutrition improves bees' resistance to multiple stressors.

Development and implementation of floral resources to support honey bees and native bee populations in perennial fruit crop systems

Rufus Isaacs, MI State University

Michigan contains diverse agricultural landscapes that include many pollinator-dependent crops, so there is great interest in honey bee health as well as maintaining diverse wild bee populations. Investment in pollinator-supportive plantings has been substantial over the last decade and it continues to increase through Government-funded programs aimed at supporting wild bees and, more recently, honey bees. Within this context, I will describe a series of research projects to evaluate native plants as bee forage and to determine the response of bee communities to large-scale plantings. The ability of such plantings to also boost crop yield will be discussed using data from a

recent study in blueberry farms, coupled with an overview of a project currently examining forage plantings across the US. The opportunities and barriers for adoption of forage plantings within perennial fruit crop systems will be discussed.

Predictive models of optimal placement of habitat enhancement within agricultural and other landscapes

Neal Williams, UC Davis

Lack of abundant and diverse pollen and nectar resources throughout the flight season and at critical times of bees' life cycles have exacerbated ongoing challenges facing honey bees and wild bee species alike. Researchers, conservation practitioners, beekeepers and growers across the country have begun planting pollinator habitat in an effort to enhance available resources. Pollinator plantings in agricultural lands offer additional benefits if they can also enhance crop pollination by bolstering bee populations. A set of questions common to those engaged in such efforts are: What species should I plant? Where should I locate the planting to achieve greatest benefits? How much area should I plant? Does the planting provide a net economic benefit (essentially is it cost effective to plant it in the first place)? The answers to these questions involve complex decisions accounting for costs and benefits of different choices. A formalized decision framework and associated models can be an extremely useful tool to guide answering these questions. This approach allows us to clearly define goals and constraints, while forcing us to confront associated costs.

To address the question of plant selection, I present a decision tool that uses an optimization approach to select sets of plant species to best achieve stated objectives. Diversity and identity of plants for the objective, "maximize bee diversity for the fewest plants," are compared to those for the objective, "support key crop pollinators". I also explore the impact on plant selection of using a balanced decision involving both objectives.

To address the question of habitat placement, habitat size and cost effectiveness, I model different options for planting pollinator habitat to bolster bee populations and enhance pollination and yield of watermelon. I use a spatially explicit model that

predicts bee community abundance throughout a landscape and empirical data on the relationship of bee abundance and diversity to crop pollination. I estimate the marginal gains in yield and monetary benefit of habitats of different sizes and placement relative to a target watermelon field. I also consider how crop field size and landscape context (high versus low proportion of existing pollinator habitat) affect the relative benefit versus cost of pollinator habitats and ultimately the decision to plant or not. The cost benefit analysis reveals that although multiple habitat options may enhance pollinators and yield, the benefit they provide may not always exceed the costs of implementation. Such decision-analysis approaches are very flexible and can incorporate a range of objectives across many landscape and farm contexts. Habitat enhancements for bees are a critical part of sustainable future for pollinators, but are complex and costly. Such tools to aid decisions can help guide efforts and increase efficiency and efficacy of these efforts, so that investments in habitat enhancement for pollinators can have the greatest benefit for bees and for agriculture.

How the agricultural landscape is used by pollinators and how their abundance and diversity in field crop systems can be improved

Matthew O'Neal, Iowa State University

The Iowa landscape is dominated by two crops (corn and soybean) that do not require insect pollination, which likely contributes to a limited knowledge of how these crops are used by bees. These crops produce pollen and nectar which can be a forage source for diverse community of bees, including honey bees. My research team surveyed the community of pollinators that visit and forage on corn and soybean. Furthermore, we explored conservation approaches for increasing the diversity and abundance of pollinators within Iowa. Overall, we identified at least 44 species of bees in corn and 36 species in soybean. The most abundant species in both crops were *Agapostemon virescens* F. and *Dialictus* species (Hymenoptera: Halictidae: Lasioglossum), and *Melissodes bimaculata* Lepeletier (Hymenoptera: Apidae). Overall, solitary native bees were more common than social bees; honey bees (*Apis mellifera*) represented less than 1 percent of the bees captured but found in both crops. To determine if these pollinators

were foraging on corn or soybean, we searched for visible pollen loads on the most abundant bee species collected that had visible pollen loads. Up to 38 percent of the bees with visible pollen loads collected from soybean fields were carrying soybean pollen and 50 percent of those in cornfields had corn pollen. Native plants attractive to bees may improve the value of buffer strips by increasing biodiversity and enhancing the delivery of insect-derived ecosystem services. In a two-year field experiment, we measured the response of insect communities across nine buffers that varied in plant diversity. We constructed buffers with plants commonly found in buffers in Iowa (typically a single species) and those recommended for prairie reconstruction (including those recommended by MSU; http://nativeplants.msu.edu/). More beneficial insects (including bees) were collected in a buffers composed of species recommended for prairie restoration than individual and crop species. Taking this a step further, a multi-disciplinary team of scientist at Iowa is exploring how reconstructing prairie in annual crop-dominated landscapes can contribute to several ecosystem services. This project, called STRIPS (Science-based Trials of Rowcrops Integrated with Prairie Strips; http://www.nrem.iastate.edu/research/STRIPS/), was designed to limit the loss of nutrients from farmland that degrade water quality (i.e. the anoxic zone in the Gulf of Mexico). Treatments include catchments entirely in row crops under a no-till, corn-soybean rotation, catchments with 10 percent of the land in prairie located at the base, and catchments with 10 percent or 20 percent of the land in multiple contour strips of prairie. Prairie strips reduced the amount of sediment and nutrient loss in runoff from watersheds. In addition, these prairies strips harbor more beneficial insects (including bees) than the adjacent cropland. Our results suggest that prairie strips, in addition to providing soil and water quality benefits, increase the populations of beneficial insects. Going forward, the STRIPS project suggests that efforts to improve forage for bees should partner with other activities that seek to improve other ecosystem services (like improved water quality). This is especially true in agricultural landscapes that are not dominated by crops that require bee pollination.

Honey bee pollen utilization in agricultural lands: implications for colony health and survival

Matthew Smart, University of Minnesota

The upper-Midwestern region of the U.S. has historically acted as an unofficial “bee refuge” for a large number of honey bee colonies throughout the growing season. This region hosts approximately 1 million managed, commercial honey bee colonies every year, representing approximately 40 percent of the total U.S. managed, commercial pool of honey bee colonies. Colonies transported to this region for the summer by migratory beekeepers have done very well historically due, in large part, to an abundance of nectar and pollen-producing flowers present throughout the growing season. Critical regional blooms include: perennial and biennial clovers and alfalfa (blooming Mid-July through September), canola (blooming early June), wildflowers (both native and non-native, including weeds), sunflower (blooming late July through August), and, more broadly, contributions from certain land use types such as livestock-grazed pastures, and more recently, CRP lands.

Steep declines in acreage of the above types of land use (alfalfa, canola, sunflower, CRP) have occurred across the Great Plains region over the last decade; while concurrent acreage planted in nonbee-utilized crops such as corn and soybeans has sharply increased. The expansion and increasing intensity of corn and soybeans in particular, brought on by historically high commodity prices, are alarming given the large proportion of beekeepers aggregating in the region each summer that go on to service various other sectors of the beekeeping/pollination industries.

With the recent and widespread changes in land use in North Dakota, coupled with high colony losses and need for more colonies to pollinate almonds in California in February-March, attention has turned to how the landscape surrounding honey bee colonies may mediate their health and survival. Surprisingly, land use as an indicator of honey bee health and survival, and landscape-wide honey bee foraging patterns have been considered only in a few studies. This study tested the degree to which land use

around apiaries directly affects annual survival of commercial honey bee colonies in those landscapes during summer, and over the winter for California almond pollination.

The interface of insect conservation and crop production

Jonathan Lundgren, ARS, South Dakota

The simplification of agroecosystems resulting from high crop prices has had numerous unintended consequences, including reduced bee forage for honeybees and other pollinators. There are numerous ways that producers can reverse this simplification in their own operations. Within cropland, diversifying crop rotations by planting fields with bee-friendly crops, using flowering cover crops during fallow periods, planting smaller fields of more crop species are all agronomically sound and economically viable solutions to diversify farmland. Outside of crop fields, field margins can be planted to bee-friendly conservation strips, and practices such as mowing, haying, or spraying field margins should be avoided. Within a landscape, the amount of cropland is positively correlated with honeybee nutritional stress, and efforts that coordinate regional set asides across a landscape will be necessary for maximum benefits of forage enhancement to be realized. It is also important to realize that diversifying agroecosystems will have important, positive effects on other ecosystem services that should be considered when evaluating the benefits of these conservation efforts.

Building Honey Bee Forage Habitat – Challenges, Solutions and Creating a Successful Regional Model

Christi Heintz, Project Apis m.

Project Apis m's direct involvement in honey bee forage and habitat began in 2009 with the initiation of a major Best Management Practices (BMP) project that included nutrition as one of six original key elements of the BMP effort. Then, in 2010, the California State Beekeepers Association specifically request Project Apis m. (PAm) develop before and after almond bloom forage to help maintain bee health during these times of dearth. In North America, honey bees pollinate 95 different fruits, nuts, vegetable crops and most herbs and spices, but California witnesses the largest

pollination event in the world each February. With unsustainable over-wintering losses of honey bees, beekeepers communicated to PAm the need to build honey bee forage near almond-producing areas to sustain colonies for this very early blooming crop. The goal to improve nutrition sources was met by several major challenges, one of which was funding for a project of such magnitude. Government and corporate grants were sought and won, partnerships were formed with corporations and non-profit organizations, Government agencies, crop consultants and crop producers…engaging them to plant seeds for bees. Private and public land owners and land managers were recruited to grow diverse food resources for honey bees while also helping their own enterprises. California's Central Valley was the initial focus for pollination needs, which has since expanded to the prairies of the Midwest to help build colonies and increased honey production. Facing the additional challenges of weather, precipitation (too little in the West; too much in the Midwest), costs and supply of seed and water, and engaging landowners for the acreage without providing to them a direct economic return, PAm focused on developing plant species, cultivating friendships in strategic places for resource assistance, and enlisting cooperation from existing groups and suppliers. PAm confirmed and communicated the real-time benefits of cover cropping to landowners. Traditional media, field days, and electronic and social media avenues were used and follow-up surveys and site visits conducted. In all cases, however, personal communication was the most effective means for obtaining landowner involvement. The PAm forage project has become a successful regional model, the impact of which results in improved bee nutrition, mitigation of honey bee pests and diseases, better colony health and strength, the provision of more bees for pollination services and improved crop productivity and yield.

USDA Conservation Programs

Dr. Clint Otto, Research Ecologist, USGS Northern Prairie Wildlife Research Center

Habitat loss and forage reduction pose significant risk to domesticated honey bees and native pollinators. Pollinator habitat loss is of primary concern in the Great Plains where native prairie and conservation grasslands are being converted to agriculture at alarming rates. We are developing research to address how forage conditions can be improved for honey bees and native pollinators on USDA conservation lands throughout the northern Great Plains and Upper Midwest. We are applying wildlife ecology principles and novel techniques to address research hypotheses related to pollinator forage and land-use effects on pollinator populations. In 2014, we initiated pilot research with FSA and NRCS to develop techniques for monitoring honey bee forage preferences and evaluating how USDA conservation lands contribute to honey bee colony health and productivity at a landscape scale. This research led to the development of genetic sequencing techniques for determining what plants honey bees prefer for pollen forage. This technique will allow honey bee foraging data to be collected quickly and easily across landscapes. We will apply this, and other techniques, to honey bee research being developed across North Dakota, South Dakota, Minnesota, Wisconsin, and Michigan in 2015. Information gathered from this study will be used to evaluate seed mix options for USDA conservation programs. Our research results will be published on the US Geological Survey's Pollinator Library website - an online repository of pollinator forage preference information - so that research findings can be effectively distributed to natural resource managers and policy makers.

Mike Schmidt, Deputy Administrator for Farm Programs, Farm Service Agency

FSA serves all farmers, ranchers, and agricultural partners through its administering of commodity, farm loan, conservation and disaster assistance programs. Two FSA programs that directly benefit beekeepers and honey producers are the Emergency Assistance for Livestock, Honeybees and Farm-Raised Fish Program (ELAP) and the

CRP. ELAP provides up to $20 million each fiscal year for emergency relief to producers of livestock, honey bees, and farm-raised fish. ELAP covers losses from disaster such as adverse weather or other conditions not adequately covered by any other disaster program. ELAP provides assistance for the loss of honeybee colonies, in excess of normal mortality, due to CCD or other natural causes. It covers damage to honeybee hives and honeybee feed that was purchased or produced for eligible honeybees, including additional feed purchased above normal quantities to sustain honeybees until such time that additional feed becomes available, due to drought or other natural causes. The 24 million acre CRP pays a yearly rental payment in exchange for farmers removing environmentally sensitive land from agricultural production and planting species that will improve environmental quality. Since 1986 the CRP has provided millions of acres of vital habitat for honey bees and other pollinators. With millions acres of legume-rich forage or diverse wildflower plantings, CRP lands offer a safe haven for honeybees and other pollinators—supplying large-scale sources of pollen and nectar that keep bee colonies healthy, and playing a part in generating millions of dollars' worth of honey every year. These same CRP lands offer tremendous benefits to native bumble bees and other pollinators that require diverse wildflowers, shrubs, and safe nesting sites. Analysis by USGS and ARS is demonstrating that CRP in North Dakota is providing habitat that enhances productivity and honey bee health. In June, USDA announced $8 million in CRP incentives initially targeted in Michigan, Minnesota, North Dakota, South Dakota and Wisconsin for farmers and ranchers who establish new habitats or improve existing habitats for to support honey bee populations. More than half of the commercially managed honey bees are in these five states during the summer.

Environmental Quality Incentives Program

Terrell Erickson, Mark Rose, John Englert, USDA/NRCS

No abstract provided

Providing Access to Honey Bees on Federally Managed Lands

Carol Spurrier, Rangeland Ecologist

BLM operates a small apiary permit program on public lands and issues those permits under the authority granted in the Federal Lands Policy and Management Act.

L. Peter Boice, Department of Defense

The Department of Defense has no specific policy on access by beekeepers to military lands. DoD Instruction 4715.03, *Natural Resources Conservation Program,* states that military installation "Integrated Natural Resource Management Plans (INRMPs) shall describe areas and conditions appropriate for public access." The INRMPs, which must be approved by the installation commander, as well as by the U.S. Fish and Wildlife Service and the state fish and wildlife agency, must explicitly identify and assess all proposed actions prior to implementation. All such actions must also meet all required safety and security requirements.

Cindy Hall, National Coordinator, Integrated Pest Management Program, USFWS

The U.S. Fish and Wildlife Service (Service) understands the important role of honey bees in agriculture, the significant problems facing honey bees, and the impacts to beekeepers who strive to supply honey bees to support agriculture.

Decisions on beekeeping activities on National Wildlife Refuge System lands are made similar to decisions on other proposed uses of a refuge. Refuge use decisions are based on authorizing legislation for the National Wildlife Refuge System (Refuge System). The National Wildlife Refuge System Administration Act of 1966, as amended (16 U.S.C. 668dd-668ee) authorizes the Service to establish policies for managing refuges and to govern refuge uses.

The Refuge Administration Act prohibits uses that are not compatible with the purpose(s) of an individual refuge and the Refuge System mission. The Service uses the following policies to guide the decision process for uses allowed on refuges: Comprehensive Conservation Planning Process (602 FW 3), Step-Down

Management Planning Policy (602 FW 4), Appropriate Refuge Uses (603 FW 1), Compatible Uses (603 FW 2), and Biological Integrity, Diversity, and Environmental Health (601 FW3). (The policies can be found at: http://www.fws.gov/policy/manuals/part.cfm?series=600&seriestitle=LAND USEAND MANAGEMENT SERIES).

All potential uses, including beekeeping activities, are reviewed under these policies. A refuge mission often includes the conservation of native species and their habitats. Determining if a proposed use is an Appropriate Use and conducting the Compatibility Analysis of a proposed use, such as beekeeping, is the responsibility of a refuge manager in concurrence with leadership. If a proposed use is determined to be compatible with a Refuge mission, goals, and objectives, the proposed use would be authorized by a Special Use Permit issued by the Refuge. Commercial uses, as all potential uses of a refuge, are reviewed to determine if it is a Refuge management economic activity, if it directly supports a priority general public use of a Refuge, or if it is specifically authorized by statute. Priority uses for the NWRS are wildlife-dependent recreational use involving hunting, fishing, wildlife observation and photography, or environmental education and interpretation.

Larry Stritch, Ph.D., National Botanist, US Forest Service, Washington, DC
Our national policy direction per the Forest Service 2722.14 – Apiary states:

"This designation covers both the production of honey and the storage of hives. For both uses, comply with State and local ordinances governing beehives. Base the fees on the specific type of use."

USDA Forest Service Special Use Permits

A Special Use Authorization is a permit that grants rights or privileges of occupancy and use subject to specified terms and conditions on National Forest land. These permits use to authorize a broad range of activities.

Please contact any Ranger District Office for information about any special use permits.

More Information

Various groups and individuals regularly approach the Forest Service with requests to use national forest lands for an array of diverse activities. The Forest Service must always weigh whether the proposed use is compatible with the values that make the national forest an irreplaceable forest – including plants, animals, beauty, clean air and water, recreation opportunities, and forest products.

Applicants for special-use permits should note that the permitting process is time-consuming, may require multi-step National Forest Management Act analysis and National Environmental Policy Act (NEPA) documentation, and ultimately may not be approved. The Forest Service will evaluate special-use applicants to see if they are in the public interest.

At a minimum, these proposals should: be consistent with Forest Plan management area objectives, standards, and desired future conditions; be consistent with other applicable Federal, State, and local statutes and regulations; and not be undertaken on national forest land if they can be reasonably accommodated on private land.

For Temporary Special Use Permit (Events), Easements and Land Uses, special use permits are required. Most permits require at least 90 days to be processed and must be acquired from the appropriate Ranger Station.

How do I apply?

Contact the district office in the area where you wish to have your activity. You must complete an application providing (1) the applicant's name and mailing address; (2) if the applicant is an organization, the name of an individual authorized to receive notice of the decision on the application; (3) a description of the activity; (4) the location and description of the NFS lands and facilities you would like to use; (5) the estimated number of participants and spectators; (6) the starting and ending date and time of the activity; and (7) the name of the person or persons 21 years of age or older who will sign the permit on behalf of the applicant. The application must be received by the local ranger district office at least 72 hours in advance of your activity.

How long will it take to get a permit?

All applications for noncommercial group uses will be deemed granted unless denied within 48 hours of receipt. If your application is granted, a permit will be issued prior to the start of your activity.

What will the Forest Service consider in evaluating my application?

Applications will be granted if they meet the following eight evaluation criteria (for details on the eight criteria, particularly on criteria 5 and 6, review the Code of Federal Regulations at 36 C.F.R. 251.54 (h)(1)):

1. Authorization of the activity is not prohibited by rules or orders that apply to the national forests or by Federal, State, or local law related to the content of activity.
2. Authorization of the activity is consistent or can be made consistent with standards and guidelines in the forest plan that apply to the area where the activity will take place.
3. The activity does not materially impact the characteristics or functions of environmentally sensitive resources or lands.
4. The activity will not delay, halt, or prevent administrative use of an area by the Forest Service or other scheduled or existing activities on NFS lands.

5. The activity does not violate state and local public health laws and regulations applicable to the site proposed for the activity.
6. The activity will not pose a substantial danger to public safety.
7. The activity does not involve military or paramilitary training or exercises by private organizations or individuals, unless such training or exercises are federally funded.
8. A person (or persons) 21 years of age or older has been designated to sign and do sign a permit on behalf of the applicant.

Carol DiSalvo, IPM Coordinator, National Park Service

The National Park Service (NPS), created in 1916 by the NPS Organic Act (16 U.S.C. 1—4), is mandated to protect and preserve unimpaired the resources and values of the national park system while providing for their public use and enjoyment. The National Park System General Authorities Act (16 U.S.C. 1a-1 *et seq.*), directs the NPS to prohibit activities and refrain from management actions that would cause derogation of the values and purposes for which the parks have been established. With respect to NPS management, as stated in NPS *Management Policies* (2006), chapter 4, the NPS "recognizes that natural processes and species are evolving, and the Service will allow this evolution to continue—minimally influenced by human actions." Section 4.4.4.1 of *Management Policies* prohibits the NPS from introducing nonnative species unless it is supporting a specific management goal in accordance with the park's mandate.

Accordingly, grazing is sometimes allowed where needed to maintain the cultural scene or support park operations. The hypothetical use of park resources by honey bees would conflict with NPS management objectives, however. The bees would compete with native species for resources, and risk introducing disease or other pest species to native species. As for parties other than the NPS introducing honey bees, Title 36 of the Code of Federal Regulations, in particular section 2.1(a)(2), expressly prohibits the introduction of "wildlife, fish or plants, including their reproductive bodies, into a park area ecosystem."

Managing Roadsides and Utility Corridors for Pollinators – Missouri Case Study

Ed Spevak, Saint Louis Zoo, Stacy Armstrong, MO Department of Transportation and Brian Holderness, Ameren Missouri

Habitat loss and reduction in floral resources have been identified as a cause for the loss of and possible reduction in health of native bees, honey bees and other pollinators. Identifying areas that could accommodate pollinator resources are vital to turn the tide. ROWs along roadsides and within electrical transmission corridors are potential sites for hundreds of thousands of acres of pollinator habitat improvements that would benefit not only bees and other pollinators but other wildlife as well. Some states have long established programs for roadside plantings, *e.g*., Iowa and Minnesota. In Missouri, beyond selected programs and projects in various areas, no coordinated efforts have been undertaken to create a holistic management for these large parcels of land for pollinator and wildlife habitat improvement. A recent initiative has begun in Missouri looking at roadsides and utility corridors for pollinators.

Discussions between Missouri Department of Transportation (MoDOT), the Saint Louis Zoo's WildCare Institute Center for Native Pollinator Conservation and the Xerces Society for Invertebrate Conservation regarding the development of pollinator roadsides within Missouri along MoDOT managed highways and roads began in 2010. The goals of the initial discussions were two-fold, plant roadside easements with native forbs and grasses beneficial to pollinators and reduce mowing regimes and schedules along roadsides to help reduce MoDOT budget expenses. Discussions continued but due to lack of start-up funds further progress towards planting remained unachieved. In 2013, a possible private foundation was identified for funding the initial start-up of the project. Discussions began anew and also included the Missouri Department of Agriculture. A third goal was added, where possible plantings would occur on roadsides along or near agricultural crops that would benefit from enhanced pollination services and bio-control from beneficial insects. Funding for the first pollinator roadside project was acquired in 2014.

In addition to the pollinator roadside the Saint Louis Zoo has initiated preliminary discussions and a project with Missouri utility company Ameren Missouri to create pollinator friendly corridors under electric transmission lines. Ameren Missouri has historically performed habitat restoration under sections of ROWs using conventional grass seed mixes but has recently been experimenting with a low maintenance, sustainable vegetation cover using a limited palette of native forbes and grasses. The goal of this new initiative is to enhance plant diversity in these areas and where possible to recreate wildlife habitat within these ROWs.

This presentation will discuss these emerging Missouri programs from the perspective of the various stakeholders and how to bring each of the players to the table and attempt to satisfy each's, sometimes conflicting agendas. Costs, efforts, timing and possible educational opportunities to further the programs will also be discussed.

Pollinator Habitat Management on Utility Rights-of-way

Victoria Wojcik, Pollinator Partnership

Landscapes along utility corridors, both electric and gas transmission, are managed heavily to maintain safe and clear access. In many cases, as in overhead transmission wires, this management is federally mandated. The magnitude of utility corridors and their intersections with various landscapes makes them ideal candidates for pollinator habitat development, and potential areas where pollinator services can be promoted. There are over 500,000 linear miles of transmission corridors across the United States that intersect with forest, agricultural, and urban lands. A review of research into utility and roadside management shows that many pollinators can be supported on ROW; however, information is still geographically limited. Integrated Vegetation Management (IVM) has been primarily responsible for creating diverse habitat. Low-growing herbaceous habitat benefits native bees and honey bees. Depending on the local composition of plants, these areas might also provide for wildflower honey production. Much of this work is from the East; I will present some data on IVM and pollinator communities from California were IVM was shown to correlate with two-fold increases in

pollinator abundance and richness in the landscape. Honey bees in this landscape were variously associated with a mix of native and non-native plant species, some of which were weeds. This signals the need to consider a range of management activities when aiming to promote honey bee plants and maintain an appropriate local landscape. Additional targeted work on honey bee forage development is occurring in California through partnerships with the utility industry. We are investigating installing honey bee forage in areas where rights-of-way are being actively reclaimed within almond landscapes and will be investigating how seeding honey bee forage can be integrated into grower compensation models. Seeding and installing habitat onto rights-of-ways can be complicated by cost and access issues, but in some areas a balance may be possible.

Challenges and Opportunities in providing beekeeper access to Trust Lands

Darla Guenzler, CA Council of Land Trusts

The State of California and honeybees have a strong mutual relationship-there is no place on earth where more queens are reared or replacement hives reconstituted. Millions of bees are brought into California every year to pollinate the many crops grown in our state and honeybees are a keystone indicator species of environmental health. They have, unfortunately, experienced rapid and devastating population decline in the past several years.

California land trusts hold nearly two million acres of open space and are uniquely positioned to host honeybees. In response to the honeybee crisis, the California Council of Land Trusts (CCLT) began making the case for framing honeybees and honeybee forage as a conservation goal. CCLT is working with land trusts and beekeepers to bring bees to land trust land. We have tackled a range of issues related to bringing bees on land trust properties that include avoiding private benefit contracts, articulating the impacts, if any, on native pollinators and professional, operational arrangements with responsible beekeepers. Beyond land trust land, CCLT will be

exploring the legal, financial, and cultural challenges of opening state and local public lands for honeybee forage.

Competition between honey bees and native bees for floral resources

Jim Cane, USDA-ARS, Logan, Utah

Do managed honeybees competitively exploit nectar and pollen resources from wildlands to the detriment of native bees? The question has no one answer, it being a function of hive densities and unknowable native bee abundances and floral standing crops. All vary spatiotemporally. Nesting sites may limit our cavity-nesters, but > ¾ of our bees are ground-nesting, a plentiful resource in nature. Food is therefore the concern. Being mostly solitary and univoltine, our native bees are foraging adults for just 3-4 weeks annually. This year's adults were last year's progeny, so bee abundance lags current bloom, the asynchrony leaving unused pollen/nectar in some sites, seasons and years. Solitary bees must daily collect pollen and nectar from their floral host(s) in proportions needed for their provision (33 percent pollen for *Megachile rotundata*); without storage, they can't compensate for imbalances, so pollen in particular can become limiting. How much do honeybees take? By weight, six 15-mg honey bee pollen pellets equal one 90-mg provision of an average-sized bee, *M. rotundata*. Each colony reportedly collects 25 kg of pellets annually, or after crop pollination in Utah, about 750,000 loads, or what would feed 130,000 solitary bee progeny. A 40-hive apiary on wildlands would withdraw the pollen of ~5 million wild bee provisions across about 4 mi^2. As an alternative, large CRP acreages withdrawn from grain crops host few native bees, but planted to legumes, provide a resource bonanza that we are showing can be used to multiply *M. rotundata*, but can feed honey bees too.

Approaches to integrated weed management that reduces reliance on herbicide use in agricultural systems and rights-of way

David A. Mortensen, Melanie Kammerer, Arthur Gover, and Katy Barlow

Department of Plant Sciences and the Ecology IGDP, The Pennsylvania State University

Roadway, pipe, and transmission line rights of way cover tens of millions of hectares and that area is growing rapidly as infrastructure supporting natural gas development expands. While the greater proportion of land in roadway rights of way is immediately adjacent to agricultural land, increased pollinator provisioning on all rights of way would benefit agriculture as well as bee pollinated plants in wildlands. The recent expanded interest in counteracting Colony Collapse has resulted in many studies and reviews identifying plant species and strategies of planting these species in mixture to achieve temporally consistent bee provisioning throughout the growing season. Network analysis has been a particularly helpful quantitative tool for elucidating pollinator networks and for assembling plant mixes likely to provide the pollination service needed by recipient pollinated crops. An ecologically informed approach to achieving enhanced pollinator provisioning should include the following steps. First, assess the site to determine the provisioning potential of the existing planting. Here deliberate steps should be taken to limit mowing and herbicide use in order to conserve existing plant communities. Second, identify the supplementation mix that will complement the existing vegetation bearing in mind the pollination service needed in the region. Native, persistent yet non-invasive species should be selected for supplementation. Third, the implementation plan must be compatible with the management goals of the site and should address the reality that aggressive, invasive plant species are present. In such cases, a staged process of establishment should be implemented. A particularly effective strategy aims to first suppress the existing undesirable vegetation, then seed with a native grass mix. The grass mix makes it possible to use selective broadleaf herbicides to suppress unwanted broadleaf invasives. One to several years after grass establishment, the desirable pollinator mix is seeded into the native grass. Finally, maintenance of the planting and of the site broadly must be carefully considered at the planning stage. The opportunity to enhance pollinator services along rights of way exists. Given the large land area in rights of way, the foraging corridors they represent and the proximity of that land to recipient crops, the benefits of enhancing pollination services along rights of way could be quite large.

Appendix 3. Work Group Questions

Nutrition Research and Implementation

1. What knowledge gaps are there to understanding basic nutritional requirements at the individual and colony level?
    - Do nutritional requirements differ due to geographical location or climate?

2. What are your thoughts on developing protein supplement diets for bees as substitutes for bee forage?
    - What are the knowledge gaps or challenges in the development of supplements?
    - How should they be formulated?
    - What are the limitations in formulating the diets?
    - Do we know enough about the nutritional needs of colonies to formulate these diets?
    - What markers should be used to evaluate the diets?
    - Can we develop BMP for use of the diets; should they differ with time of year?

3. What role does nutrition play in allowing individuals or colonies to defend against parasites and disease?

4. How might natural forage, protein supplements, environmental contaminants, and colony management affect individual and colony level microbial communities?
    - How might these effects influence colony nutrition?
    - How might these effects influence susceptibility to diseases?

Forage Research & Implementation

1. What research gaps are limiting greater adoption of forage plantings by landowners?

2. How do we determine plant species that are of greatest importance to honeybees and other bees for their nutrition and/or population support?

3. How much forage does a colony need?

4. What are the best ways to measure bee response/health/preference to various forage planting schemes? - Generalizable and standardized across regions?

5. What are the nuts and bolts of increasing forage from a producer perspective? What plant species or level of plant diversity is needed? How much area needs to be planted? When do these plants need to be available? What are the economics of taking land out of production to feed bees and how can farmers be compensated for this?

USDA Conservation Programs

1. How can USDA conservation programs be more effective in enhancing honey bee nutrition and forage? What are the barriers to implementation?

2. Outreach – Identifying and reaching landowners, developing partnerships, and utilizing stakeholder networks.

3. Technical Assistance – Developing conservation plans, using appropriate practices and plantings for varying landscapes, and assuring staffing resources are available.

4. Communications– Having the relevant information available, in an accessible format, and linked to USDA Staff, State agencies, Technical Assistance Providers, Landowners and Managers, Bee Keepers, and other Stakeholders.

5. Financial Assistance – Are program incentives adequate and timely? Are current resources effectively allocated?

Providing Access to Honey Bees on Rights-of-Way and Land Trusts and Federally Managed Lands

1. Native bees vs. honey bees- What does the data show regarding risks of endangering native bees by placement of honey bees on private/public lands? What kinds of studies are still needed?

2. Invasive plant species: What protocols need to be developed to minimize impacts of invasive plant species on ROW or land trusts that retain forage for bees?

3. How will agreements and trust between land managers and beekeeper be best established?

4. What kinds of tools need to be in place to make promote adoption of policies for forage for honey bees?

5. What are the main obstacles that need to be overcome?