1. SCOPE AND APPLICABILITY/JUSTIFICATION

Native bees are the primary or sole pollinators of many of our forest trees, including American Holly (*Ilex opaca*), Tuliptree (*Liriodendron tulipifera*), Sourgum (*Nyssa sylvatica*), and various maples (*Acer* spp.) and willows (*Salix* spp.), as well as a multitude of understory trees, shrubs, and herbaceous plants, including Flowering Dogwood (*Cornus florida*), Spicebush (*Lindera benzoin*), many juneberries (*Amelanchier* spp.), numerous ericaceous shrubs, and most of the vernal flowers. In the absence of their pollinators, bee-pollinated trees, shrubs, and herbaceous plants would be gradually replaced by other species, resulting in radical shifts in forest composition.

There is good reason to be concerned about such pollinator losses. Recent years have seen dramatic declines of managed and feral honeybee populations in North America, and there is evidence of widespread declines in native bee populations as well in both North America and Europe (e.g., Allen-Wardell et al. 1998; Kearns et al. 1998; Biesmeijer et al. 2006; National Research Council 2006), making the proposed work particularly timely. Native bees and honeybees are significant pollinators in both natural and agricultural ecosystems. While modern agriculture relies heavily on the services of honeybees, however, native habitats are thought to be pollinated largely by native bees. Consequently, native bee declines could have an even greater impact on natural ecosystems than on the honeybee-dependent agricultural systems.

To investigate whether forests in urban areas retain populations of native bees, we propose to sample bees along urban-to-rural woodland gradients. These will be replicated across five metropolitan areas in the eastern United States, a region with a bee fauna of more than 800 species. Factors associated with high and low populations of native bees will be investigated using on-site photographs, GIS, and other data sources to characterize the landscape matrix surrounding sampled sites, as well as the particular sites themselves. We will identify tree species composition, surrounding landscape, and other site characteristics associated with higher or lower overall bee species richness, as well as with the presence or absence of particular bee species and guilds.

Our analysis of the relationship between site and landscape characteristics and the composition of associated bee communities will allow both assessment of the impact of urbanization on forest ecosystems as well as the development of specific management and acquisition recommendations that favor forests with a healthy pollinator component. This project will also yield a standardized survey protocol and public database that will create the baseline for long-term monitoring of urban forests and their native bee communities.

Results of this study will be useful to managers in municipalities, civic associations, watersheds, and parks within the urban/suburban matrix who must make land use decisions that affect what trees are planted, what types of secondary trees are included, and which properties are expanded and which are least critical and thus most appropriate for development. Foresters, ecologists and other biologists interested in forest ecology, landscape ecology, and pollinator conservation will also use this information in studying landscape fragmentation and the retention of ecologically functional and diverse communities within urban landscapes. We hope to facilitate

the widespread use of native bee surveys as one important indicator of the functional health of forests, particularly in areas significantly impacted by humans.

The critical importance for both natural and agricultural ecosystems of large-scale baseline research and long-term monitoring of pollinators has recently been emphasized by the National Research Council (National Research Council 2006) and others.

2. LITERATURE REVIEW

Insect diversity--including bee diversity--in some urban habitats such as garden and parks can be quite high (e.g., Frankie and Ehler 1978 and references therein; Frankie et al. 2005). Only a few studies, however, have actually compared bee communities in areas with differing degrees of urbanization. Cane et al. (2006) studied the composition of desert bee communities associated with *Larrea tridentata* (Zygophyllaceae) in patches of different sizes and ages in Tucson, Arizona, and the surrounding area. They found that the sensitivity of different bee species to anthropogenic habitat fragmentation--a key component of urbanization—was heterogeneous and was best predicted by the nesting habits and diet breadth of particular species. McFrederick and LeBuhn (2006) studied bumblebee communities in 18 urban parks and two nearby "wild" parks around San Francisco, California. They found that local bumblebee abundance was correlated with features of the surrounding habitat matrix, emphasizing the importance of the surrounding area in any ecological habitat analysis. The importance of the surrounding landscape on local bee diversity and abundance has previously been explored by Steffan-Dewenter et al. (2002).

Two studies have looked directly at the impact of anthropogenic landscape changes on forest bee diversity. Winfree et al. (2007) studied the impact of human disturbance on bee communities in a forested landscape in southern New Jersey. They found that the species richness of local bee communities tended to decrease with an increasing proportion of forest in the surrounding landscape, although a subset of species were associated with more extensive forests. Romey et al. (2007) found, similarly, that at least in the short-term, moderate logging increased bee diversity and abundance in a northern hardwood forest in New York. These two studies suggest that the conservation of many, although not all, native bee species may be compatible with moderate levels of human disturbance of the landscape.

These studies were necessarily confined to relatively geographically narrow and ecologically homogeneous areas. In contrast, we propose to address the question of how bee communities respond to urbanization on a far larger scale, replicating our urban, suburban, and rural sampling across five different metropolitan regions and several ecoregions in the eastern United States. This sampling design allows much stronger and more broadly applicable inferences about the impacts of urbanization and makes it posssible to examine whether the impact of urbanization is geographically or ecologically heterogeneous, as well as to ask other important questions that cannot be addressed well in a narrower study. For example, analyses of vascular plants and some other taxa have indicated that although species diversity in urban areas is often high, urbanization may result in homogenization such that urbanized areas are more similar in community composition than are similarly separated more natural areas, with a loss in urban areas of many distinctive elements and a disproportionate representation of exotic species (McKinney 2006). If we found such a pattern for bee communities in urban forests, this could

have important implications for the diversity of the forests being pollinated by the altered bee communities. The very broad sampling we propose is possible only because of our novel use of volunteer bee samplers (see below) and a simple standardized sampling protocol.

3. ORGANIZATION/METHODOLOGY

To compare bee diversity associated with different degrees of urbanization, we will run multiple transects through a set of five eastern cities and into outlying suburban and rural areas (although we are not yet certain which metro areas we will focus on, likely candidates are Boston, New York, Baltimore-DC, Atlanta, and Nashville). We will define "urban", "suburban", and "rural" sites based on human population and housing density in the surrounding matrix. Within each of these three site categories, we will use GIS and other map sources to randomly allocate sampling to accessible woodland habitats with forests greater than 40 years of age (including equal numbers of upland and riparian sites).

At each sampling locality, bees will be sampled twice, once at the time when deciduous oaks are first leafing out and once two to three weeks later (native bee diversity in woodlands tends to be greatest in the early spring, with populations disappearing almost entirely soon after complete leaf-out and cessation of woody and herbaceous bloom, so we will focus our efforts on this period). Bees are sampled by placing out transects of small flower-colored plastic bowls, or "bee bowls", filled with soapy water; bees are attracted to the bowls and drown (e.g., Leong and Thorp 1999; Campbell and Hanula 2007). As noted above, most sampling will be carried out by volunteers. Although every sampling method has advantages and disadvantages, bee bowl sampling provides a remarkably efficient and consistent technique for sampling bees that is nearly independent of user skill or experience, an advantage that is particularly beneficial given our reliance on volunteerss. Sampled bees will be shipped to us for identification and databasing.

For each of the five metropolitan areas, we will run 30 rural, 30 suburban, and 30 urban 15-bowl transects (one transect per site) twice each spring for three years (Fig. 1). Each volunteer will run six transects (= 90 bowls) twice each season, so we will need 15 volunteers for each of the five metropolitan areas. Based on extensive experience (>17,000 bowls, S. Droege pers. comm.), we expect an average of ~0.5 bees per bowl, yielding an expected total for all of our sites across three years of ~20,000 bees. Sampling each site six times across three years will greatly reduce the potential problem of "random" temporal variability and will significantly increase our sample sizes and statistical power. Our collaborator, Sam Droege (Patuxent Wildlife Research Center), has used volunteer bee samplers for smaller projects for several years and has found recruiting volunteers through nature centers, natural history societies, and government (city, state and federal) biologists to be unproblematic and the quality of their work to be high. We anticipate no serious difficulties in these areas; nevertheless, along with collaborating on project design and identifying bees, a major responsibility of the Project Coordinator we will hire will be recruiting volunteers, providing them with the minimal training necessary, monitoring their work, and troubleshooting any problems (see #7, below).

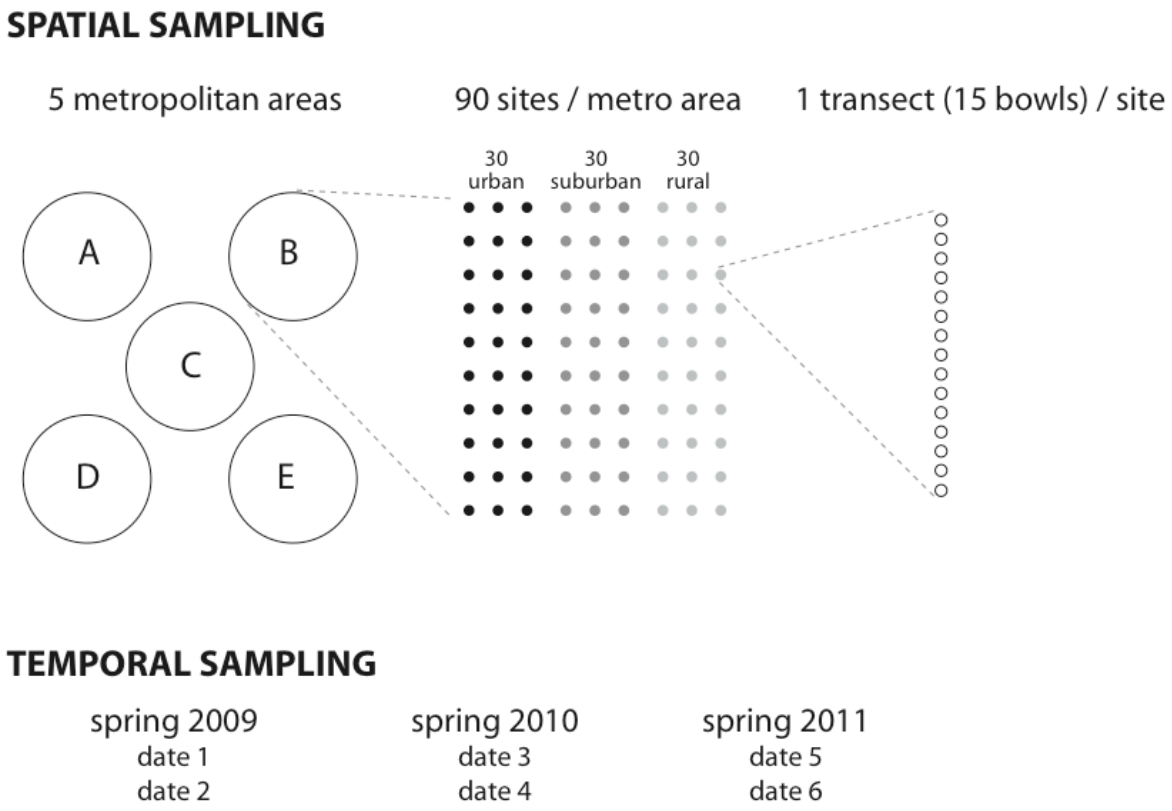

Fig. 1. Sampling scheme.

4. PRODUCT

We will produce an analysis of (a) the impact of urbanization on forest bee communities in the eastern United States and (b) landscape and site variables associated with high or low bee diversity and the presence or absence of particular species or ecological guilds. Based on our results, we will develop basic recommendations regarding managing urban, suburban, and rural forests to maintain the healthy bee communities on which they depend.

5. NATIONAL DISTRIBUTION OF FINDINGS

We will make our results freely available, distributing our findings online, in technical journals, and in reports to land managers: (a) We will develop a web site to describe our study and communicate with volunteers and potential end-users of our data (e.g., foresters, ecologists, pollination biologists). We will present a summary of our work (and a link to our web site) on TreeLink (a major web portal for urban and community forestry) and on web sites such as those of the USDA Forest Service Urban and Community Forestry Program, the National Association of State Foresters and the North American Pollinator Protection Campaign. (2) We will publish

our results in appropriate peer-reviewed professional journals. (3) We will deliver a summary of our findings to key individuals such as foresters responsible for forests included in our study and all the state coordinators for urban forestry in the eastern United States.

6. PROJECT EVALUATION

To evaluate our success in achieving our goals for this project, we will take several approaches: (a) We will monitor traffic on our web site to assess our success at reaching potentially interested individuals. (b) We will tally our publications in peer-reviewed technical journals and monitor how frequently they are cited. (c) We will assess whether we have been successful in generating coverage about our project in local newspapers and other popular media outlets to reach the general public. (d) We will ask potential end-users visiting our web site or receiving hard copy reports to tell us whether or not they believe our findings could affect their own management decisions in the next five years.

7. EXPERIENCE/PERSONNEL/ADEQUACY OF RESOURCE

(1) Most sampling will be carried out by volunteers. Until we have the necessary resources to carry out this project and are able to finalize the geographic details of our study, it is not possible to provide great detail about our volunteers. However, we have letters of commitment (see attached) from several groups who have well established pools of volunteers within the New York City area (Liz Johnson), the Baltimore-DC area (Sam Droege), and the Boston and Atlanta areas (John Pickering). Additional volunteers will be recruited through both personal contacts and through museums, universities, nature centers, supporters of local and regional parks, relevant listserves (e.g., the bee monitoring listserve run by Sam Droege), and other sources. Because the sampling protocol developed by Droege and colleagues is simple to follow and requires neither technical expertise nor a large time commitment (for this project, ~25 hours/year/volunteer), recruiting sufficient numbers of qualified volunteers for bee sampling has never been a problem and we anticipate no difficulties recruiting the volunteers required for this project (15 for each of the five metro regions).

(2) To assist with study design, bee identifications, and data analysis, and to coordinate sampling and processing of bees, we will hire a Project Coordinator. We have already identified an excellent highly qualified candidate for this position.

(3) We will support a graduate student for two field seasons to serve as Southeastern Field Coordinator. This individual will assist with recruitment and coordination of volunteers in the southeastern U.S., as well as undertake some supplementary sampling. This position will be important given that the Project Coordinator and collaborator Sam Droege will both be based in the DC metro area.

(4) Sam Droege of the USGS Patuxent Wildlife Research Center (PWRC) will be an invaluable collaborator. He is a leading expert on the sampling and identification of the bees of eastern North America and will be actively involved in this project (see letter of support). Droege and the Project Coordinator will collaborate in designing the detailed sampling protocol for this project and analyzing data and Droege will oversee all bee identifications. If needed,

statisticians with special expertise in population and community sampling design and analysis are readily available at PWRC for consultation. Droege's lab is accustomed to efficiently processing and databasing large numbers of bee specimens using barcoded labels and other streamlining techniques and the specimen volume generated by this project will be readily managed. Droege has many years of experience developing and coordinating long-term population monitoring programs relying heavily on volunteers, including the very successful Breeding Bird Survey (see Price et al. 1995) and FrogWatch.

(5) John Pickering (Polistes Foundation) is an expert on web design and online database development and management and will lend his expertise to helping with data management, communicating with volunteers, and making the results of our research available on the Polistes Foundation web site.

The expenses associated with collecting bees are minimal (see budget) and resources for identifying eastern bees (e.g., microscopes, online keys developed mainly by Sam Droege at http://www.discoverlife.org/20/q, etc.) are available in Droege's lab and elsewhere.

8. BUDGET AND FUNDING

Organization: Polistes Foundation
Project Title: Native bees in urban forests
Total Cost: $230,650.00

Line Item	Federal Funds Requested	Non-federal Match		Total	Source of Matching Funds
		Cash	In-kind		
Personnel	$100,000.00*	$0.00	$112,500.00**	$212,500.00	75 volunteers
Bee sampling kits***	$3,000.00	$0.00	$0.00	$3,000.00	
Web/data services	$0.00	$0.00	$10,000.00	$10,000.00	Polistes Foundation
Indirect costs (5%)	$5,150.00	$0.00	$0.00	$5,150.00	
Totals:	$108,150.00	$0.00	$122,500	$230,650	
		Total Match = $122,500			

Budget Comments & Footnotes

*(1 Project Coordinator)($30,000/year)(3 years)
+ (1 Southeastern Field Coordinator)($5,000/year)(2 years) = $100,000

**(75 volunteer bee samplers)($20/hour)(25 hours/volunteer/year)(3 years) = $112,500

***(100 sampling kits)($30/kit) = $3,000

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SCHEDULE OF WORK (Fall 2008-Fall 2011)

Fall-Winter 2008: Detailed planning of sampling scheme and remote preliminary characterization of sites, recruitment and preparation of sampling volunteers, preparation of sampling kits, processing of any permit requests that may be necessary for particular sites, design and establishment of project web site.

Spring 2009: First season of data collection

Summer-Winter 2009: Processing of bees and site data from first season, preliminary data compilation (shared on project web site), assessment of any changes necessary for subsequent seasons.

Spring 2010: Second season of data collection.

Summer-Winter 2010: Processing of bees from second season, preliminary cumulative data compilation (shared on project web site).

Spring 2011: Third season of data collection.

Summer-Fall 2011: Processing of bees from third season, completion of data compilation and analysis, preparation of report for web site and distribution, preparation of manuscripts for submission to appropriate peer-reviewed technical journals, possibly preparation of popular (non-technical) articles if appropriate outlets are identified.

polistes

Polistes Foundation, Inc.
133 Washington Street
Belmont, MA 02478

23 January 2008

National Urban and Community Forestry Advisory Council
Sidney Yates Building (1-Central)
201 14th Street SW, MS-1151
Washington, DC 20250-1151

Dear National Urban and Community Forestry Advisory Council,

I am writing regarding our proposal "Native Bees in Urban Forests" that we have submitted to the NUCFAC 2008 Challenge Cost-Share grant program.

Because this project will rely heavily on volunteers, I wish to clarify how we will recruit and organize volunteers. Field work will take place in five metropolitan areas. Although we have not made a final determination of which metro areas we will focus on, our likely choices are Boston, New York, Baltimore/DC, Atlanta, and Nashville.

The Polistes Foundation, which is the legal umbrella of Discover Life (http://www.discoverlife.org), is based in the Boston area and has excellent contacts with local naturalists and organizations. For example, our board of advisors includes Peter Alden and Edward O. Wilson, both well known local naturalists. We also have excellent contacts for recruiting volunteers in the Atlanta region. I am on the Ecology faculty at the University of Georgia. Our partners include the Georgia State Botanical Garden, local nature-oriented outreach organizations, and schools.

Our collaborator on this grant, bee expert Sam Droege at the Patuxent Wildlife Research Center, is in touch with an active network of volunteers in the Baltimore-DC region. Liz Johnson, manager of the Metropolitan Biodiversity Program at the American Museum of Natural History in New York, is actively engaged with local New York City area naturalists, such as John Ascher, who would be eager to volunteer some time for a project such as the one we are proposing. We have enclosed letters from Droege and Johnson expressing their willingness to help recruit volunteers for our project.

Given that we will require only 15 volunteers per metro area, that each volunteer must dedicate only ~25 hours per year to this project, and that volunteers need have no special expertise to participate, we anticipate no difficulty recruiting the necessary volunteers through our many contacts. Droege has used volunteers extensively for bee sampling projects. Volunteer preparation is minimal and need not be done in person. Recruiting and coordinating volunteers will be one responsibility of the Project Coordinator we will hire. For additional assistance recruiting and coordinating volunteers in the southeastern U.S, as well as to supplement sampling in this region, we will support a graduate student for two field seasons.

We will use our website, Discover Life, to help coordinate the volunteers and manage the collection and sharing of information. Discover Life has a set of on-line tools to help in this endeavor. It currently averages over 150,000 users per month and has served over 210 million pages and images since inception in 1998.

We believe our proposal to undertake a large-scale examination of the impact of urbanization on the bee pollinator communities of urban forests is exciting and timely. Thank you for your consideration of our proposal.

Sincerely,

John Pickering
President, Polistes Foundation

United States Department of the Interior
USGS Patuxent Wildlife Research Center
12100 Beech Forest Road
Laurel, Maryland 20708-4039
(301)-497-5503 • fax (301)-497-5505

23 January 2008

National Urban and Community Forestry Advisory Council
1400 Independence Avenue, S.W.
Mailstop 1151
Washington, DC 20250-1151

Dear Reviewers:

I am writing this letter in support of the Polistes Foundation's proposal to investigate native bees within urban forest lands. This project fits well within my Lab's work to monitor the nation's native bee populations. We have a great deal of concern regarding the status of these primary insect pollinators of trees and herbaceous plants. This work within the urban environment will provide a context for other systems less under stress. My hope is that we will find that native bee species do occur in many of these urban forests and that will provide evidence for their abilities to populate even small woodlands.

While not mentioned in the project proposal, I would also suspect that we may find a number of new introduced species of bees. Recently a number of Asian and European bee species have been detected in Eastern North America…all within urban areas. As in any group of introduced species, these are all potential competitors and vectors of diseases in a system we know little about.

Due to a shortage of investigators able to correctly identify bee specimens we have developed online guides to bee identification that are both up-to-date in their taxonomy and superior to the very old literature on the subject (http://www.discoverlife.org/20/q?search=Apoidea). We have been holding bee identification workshops every 3 months for the past year and slots fill up within hours each time. As part of this project I will oversee and validate all the specimen identifications. Additionally, all specimens will be individually numbered and posted to mapping programs available at the above web site after their quality is checked.

Finally, we will coordinate with the project to recruit volunteers within both Baltimore and Washington. We are situated between the 2 cities and have developed a pool of volunteers and interested biologists who have collected bees for us in the past and are eager to embark on additional projects. As an active and long-term member of the several state natural history societies I see no problem in recruiting sufficient personnel to collect the necessary samples.

Cordially,

Sam Droege
Head of the USGS Native Bee Inventory and Monitoring Laboratory

AMERICAN MUSEUM of NATURAL HISTORY

January 24, 2008

Dear National Urban and Community Forestry Advisory Council Members:

I am please to write this letter in support of the proposal "Bees in Urban Forests" being submitted by the Polistes Foundation. The Center for Biodiversity and Conservation at the American Museum of Natural History is very committed to the conservation of urban biodiversity, particularly of forests. We have been active members of the Metropolitan Forest Ecosystem Council, an organization that promotes research and management of urban forests in the New York region and have worked closely with the Central Park Conservancy to study the forest leaf litter invertebrate community as part of the Conservancy's ongoing woodland restoration work.

Most recently, we are collaborating with the New York City Department of Parks & Recreation's Greenbelt Native Plant Center to better understand our urban bee fauna as it relates to native plants. Successful forest restoration of both trees and the understory shrub and herb layers depends in part on a healthy pollinator community. This past summer we initiated a citizen science project, "The Great Pollinator Project," to help us gather data for this research.

We are enthusiastic about the "Bees in Urban Forests" proposal. As described, it will add critical information to our understanding of urban forests and the forest community components necessary for successful restoration and management of these ecosystems. We have worked closely with Sam Droege over the past year in regard to our own citizen science project and have every confidence in the success of the "Bees in Urban Forests" project given his involvement. We are also committed to assisting with volunteer recruitment and other logistics for the New York City portion of the research. We have a dedicated core of volunteers from our own work as well as an engaged New York City Parks ranger staff to draw upon so should have no trouble finding good volunteers to participate in the "Bees in Urban Forests" Project.

If you need additional information, please contact me at 212-769-5047.

Sincerely,

Elizabeth Johnson

Elizabeth Johnson
Manager, Metropolitan Biodiversity Program

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