PROJECT DESCRIPTION

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Introduction

Broad implementation of the Lost Ladybug Project will capitalize on the momentum and initial success of the citizen science website, materials, and program we have built in the last four years. The Lost Ladybug Project was developed with NSF ISE award 0741738, titled: Have you spotted me?: Learning Lessons Looking for Ladybugs and funded at $1.9 million, from May 2008 to April 2012.

The Lost Ladybug Project is a citizen science program that uses ladybugs to illustrate concepts including biodiversity, invasive species, and conservation through activities that connect education and science. Citizen science encompasses a set of projects that range from engagement of the public in professionally directed research to participatory action research focused on local environmental problems. As a tool for increasing both science knowledge and scientific literacy, citizen science has gained acceptance as a method for answering important, large-scale scientific questions (Bhattacharjee 2005) while helping participants learn science content and gain understanding of the scientific process (Bonney 2004).

However, many citizen science programs are limited in scope and, though excellent educational tools, have not yet resulted in data advancing the field of biology. Our project extends the scope of citizen science in the following areas:

- The opportunity to participate in ongoing and important scientific research by taking part in a national survey to find threatened rare ladybug species.
- Assessable and engaging for people of a wide range of ages and backgrounds.
- Specific focused outreach to an audience (Native American and rural youth) that have few opportunities to participate in research but possess unique connections to the land.
- Integrating the scientific understanding of biodiversity gained through participation in the survey and other activities with a cultural appreciation through myth, language, art, and story-telling.
- Facilitating hands-on interaction with charismatic animals in a way that is not possible with vertebrates.
- Combining the most basic natural history observations (e.g. finding ladybugs) with cutting edge technology (e.g. open online database with interactive mapping and graphics features, automated ladybug identification) to allow a seamless mechanism for citizens to utilize and contribute to a massive but accessible database.

- Linkage of every data point to a digital image ensures data accuracy by allowing each data point to be examined by anyone for identification errors and reclassified should species categorizations change after collection.

Project Rationale

Why focus on ladybugs?

Coccinellids, known as ladybugs, ladybeetles, or ladybird beetles are one of the most common and easily recognizable invertebrate components of almost every terrestrial ecosystem in the U.S. and Canada (Gordon 1985). Species in this family are so ubiquitous and yet so sensitive to environmental conditions that they have been proposed as indicator species (Iperti 1999). In addition to their ubiquity, the bright coloration and gentle nature of this group makes them a favorite wild creature of adults and youth alike. They are often seen as a symbol of healthy, friendly nature and their likeness is incorporated into toys and games. Unlike most charismatic vertebrate species, ladybugs, like honeybees, are revered for their industriousness and their important ecological role as well as their beauty.

This respect is well-deserved as ladybugs contribute to the control of many pest insect species (reviewed in Hodek and Honek 1996). However, studies have shown that species vary widely in their ability to suppress pests and thus, long-term regional shifts in species composition may have important implications for the functioning of this complex and its response to environmental changes.

Over the past twenty years several native ladybug species that were once very common have become extremely rare (Harmon et al. 2006). During this same time several species of ladybugs from other places have greatly increased both their numbers and range (Harmon et al. 2006). This has happened very quickly and we don't know how this shift happened, what impact it will have (e.g. will the exotic species be able to control pests as well as our familiar native ones always have) and how we can prevent more native species from becoming so rare.

These rapid ongoing changes in the North American complex of ladybug species are clearly a cause for concern. As applied scientists we need data on the current status and future trends in the ladybug complex so we can most effectively utilize ladybug populations so that they continue to suppress pests and to prevent the extinction of native species. These shifts in the ladybug complex also afford us a rare opportunity to address some major issues in basic ecology regarding the distribution and abundance of rare species and pattern of invasion and spread of invasive species (Strayer et al. 2006). Thus, both from a basic and an applied perspective it is vital that we obtain more data on the distribution and abundance of ladybugs over time.

Why use citizen science?

While we have attempted to make a case for ladybugs being an excellent focal group for fostering education and for their ecological and economic importance it may be less clear why non-specialist citizens are needed to help us gather data on this group. The dilemma for scientists seeking data on rare ladybugs or any rare species is that it is difficult to collect or observe enough individuals to accurately characterize the distribution of species. Intuitively it is clear that with each additional ladybug observation our potential for observing a rare species increases but it is also possible to quantitatively define how much additional observations will "help". Using an equation based on the Poisson distribution (Clopper and Pearson 1934) we can see that with one set of 25 observations (the average number of observations per "hunt") we can be 95% confident that we would find any ladybug that accounts for more than 12% of all ladybugs in the observed area (see Table 1 in supplemental documentation). With 100 observations in an area we would also find ladybugs that make up only 3% of the ladybug complex. The most intensive "conventional science" surveys conducted by ladybug specialists make just over 1000 observations and most are a few 100 (Harmon et al. 2006). Conventional surveys will never be able to make substantially more observations because of the limited number of specialist observers. This means that conventional surveys are highly unlikely to ever find ladybug species that are below half of one percent of the total. At this level many rare species will "fly below the radar" of conventional surveys. In a recent review of 36 conventional ladybug surveys only 53 species

were reported which accounts for just over 10% of the 500 species known to exist in the U.S. (Harmon et al. 2006). An even moderately successful citizen science program that recruited 400 participants could accrue 10,000 ladybug observations and thus could find ladybug species that made up only 0.03% of the total complex or 3 per 10,000.

Clearly finding a rare ladybug species is a major discovery. The first discovery of the Lost Ladybug program was made by Laurel (age 11) and Jonathon Penhale (age 10). They discovered a rare nine-spotted ladybug near their home in Arlington, Virginia in October 2006 after hearing of our program through a family friend who attended one of our presentations. This represented the first individual of this species collected in the eastern U.S. in over 14 years and one of only seven individuals collected in the U.S. since the year 2000 (Losey et al. 2007). Each rare ladybug observation marks a definite time, place, and habitat where that species existence is confirmed. As a group these rare sightings represent a valuable data set and each individual rare ladybug observed can be the impetus for specialists to visit the area and make more in-depth observations.

The success of the project has grown since our first discovery, the Lost Ladybug Project has already produced more "finds" of rare ladybugs than all the traditional surveys conducted in the last 20 years! However, our citizen science program is more than just a “fishing expedition”. The same equations that allow us to predict how rare of a ladybug we are likely to find can also allow us to make important inferences about species that are never found. For example, if a rare ladybug species is not among 100 observations we can be 95% sure that it makes up less than 3% of the ladybug complex. The more observations that are made without finding a given rare species allows us to accurately lower our estimate of that species density. In this way, *every ladybug observed, whether common or rare, provides us with vital information*. Even if we never observe a given rare ladybug species, having an accurate estimate of its density in different areas will allow us to determine if they if enough individuals exist to constitute a minimum viable population (Shaffer 1981) or if they are in imminent danger of extinction. This in turn will answer basic questions and facilitate the conservation of these species. Conventional science will never be able to obtain the data we need so it is imperative that we continue to harness the power of citizen science to save these species before it is too late.

Our Original Audience - Why target Native American and Rural Youth?

Our original primary intended audience has been children 5-11 years old from rural and suburban locations with an emphasis on including children from Native American (NA), rural, farming, or disadvantaged communities. We chose these groups because they are generally under-represented in science and can be at a disadvantage in access to information, experience, mentors, and careers in science. Across the country there are more than 564 tribal groups, most have separate native languages and all have distinct cultural traditions. An important priority of our project outreach is to include informal education programs specifically run by the nations and tribes themselves. In NY and SD, respectively, 18% (~200,000) and 22% (~30,000) of all rural children live in poverty, with 21% (~2.7 million) nationwide. We will concentrate on children in rural communities where the percentage who qualify for free lunch is above average (>15% in NY and >25% in SD), and their families’ median household income is below average (<$42,722 in NY and <$34,832 in SD) (USDA ERS 2003, NCES 2004). Most rural children speak English but have a variety of cultural traditions. A subset within rural farming communities, and a priority of our project outreach, are children of migrant farm workers. Nationally, of the ~825,000 children (13,500 in NY) who qualify for Migrant Education Programs, such as after school and summer, >50% of participants are 5-12 years old. The majority of migrant children live in poverty, are Hispanic, speak Spanish and English, and ~25% have limited English proficiency (Strang 1993, Henderson 1994).

We selected an elementary school age (5-11) target audience because we want to contact children as early as possible with the concepts and empowering experiences of the Lost Ladybug Project. First graders know how learning works, they can ask questions about organisms and follow steps in an inquiry process to find explanations. Young children can use tools to measure, sweep nets and pictoral keys to identify organisms, and operate cameras and computers with some assistance. In our pilot projects first

graders enjoyed the activities and were able to participate in an effective way. Indeed, we found that ladybug survey data generated by first graders approximates results from older children and adults and can be used as reliable data. By about 5th grade, children can conduct full inquiries, ask questions about patterns in ecosystems, and recognize the relationship between explanation and evidence. They can use cameras and computers independently to process data. Often older children are interested in being formal or informal mentors for younger children to get involved. We have entered into a variety of collaborations to facilitate use of our materials and participation in the project. An increasing number of groups and individuals from across the country access our materials and participate in the project solely through our website.

Using citizen science to bridge the digital divide. Some readers of our original proposal questioned the wisdom of developing a program that will use the web as a vehicle to deliver a citizen science project to a target audience of Native American and low-income rural youth. To date we have found most communities to be well equipped or to have reasonable access to the web. When needed we negotiate with existing programs and help to provide the necessary hardware (e.g. digital cameras, computers), internet access, and expertise so that all interested parties are able to participate.

What are the Lost Ladybug Project achievements (educational and biological) so far, from the initial launch and smaller scale period? How is the Lost Ladybug Project effective for informal science learning?

Educational Achievements – Our deliverables

Our successful citizen science program has reached over 80,000 people through the internet, over 15,000 have participated in activities of the project, and over 3,500 people have submitted ladybug images. Over 10,000 images of ladybugs have already been submitted to the Lost Ladybug database by citizen scientists from every state. Interest and participation in the project continues to grow, in the last year website visits increased by 519% and 74% of visits were from new visitors. Much of the effort over the past three years of the Lost Ladybug Project (LLP) has been directed towards developing and tailoring a website that provides a) a self-contained but integrated educational program on biodiversity and conservation, b) a fully functional portal to independent participation in a survey of ladybugs and interaction with a ladybug database, and c) one of the largest, most accurate, accessible biological databases ever developed. The successful framework of the website based project we have established is not only enthusiastically used by youth and youth educators but also by a large audience of adults.

The rebuilding and expansion of the Lost Ladybug website, along with development of the online database, and the linking of these two large systems required hundreds of [combined LLP staff and programmer] hours of brainstorming, formulating, and trouble-shooting. It was necessary to connect each submitted photograph to a database that would delineate all the relevant scientific data we could ascribe to each observation while monitoring the demographic information we needed in order to best understand our audience and the effectiveness of our multiple outreach efforts. At the same time, we intended to design a website that would be both visually and intellectually appealing to a very broad audience. We wanted young people to be able to find their way to pictures and educational tools, adults to find content that would invite returning interest, educators to find useful materials that would give confidence and facilitate use of the LLP as part of their curriculum, and science professionals to see that the LLP could offer valuable information and opportunities for them as well.

Foremost in our plans was creation of a data and photograph submission process that would be as headache-free as possible for LLP participants. Effort was made to limit the number of required fields on the submission form, provide pull-down menus wherever possible, and phrase questions very clearly. We maximized the technical capability of the submission format to accept the widest possible range of photo sizes, while stating the form's mechanical limitations both on the form and in friendly error messages. The format also allows for participants to submit multiple photos at a time and quickly and smoothly transition between sets of photographs from different locations, dates, or conditions with only minimal editing to their original data. They do not need to re-enter the information they have already set down within a given session. The public website interface and the database are linked so that ladybug spotters

can see their photographs become part of the LLP and so that, from the website, people will be able to access the Lost Ladybug Data in order to create charts maps and lists that will allow them possibilities for posing their own research questions and in other ways become more involved in the LLP. Both large systems are structured to allow for vast expansion as the project grows. The Lost Ladybug website is fully functional as a means for people to find the project, learn how to participate and complete the submission process. Website visitors easily find out how the project began and how to participate. They find tips for ladybug searching and photography, as well as LLP generated news articles and links to media about the project. In a section of the website called "Ladybug Learning" people can find a Lost Ladybug comic/coloring book, a Lost Ladybug song, and a wide array of downloadable pdfs for information and distribution: brochures, bookmarks, posters, etc. The website and the materials offered for download at no charge constitutes a complete self-contained online resource that informal science educators can use independently for outreach and programming and to independently establish a Lost Ladybug project. There also, educators can find more than 14 supplementary (in addition to participating by finding and photographing ladybugs) learning activities. These can be accessed either individually or in prepared sets of curriculum for either grades K-2 or 3-6. The Lost Ladybug curriculum is formatted as a NYS 4-H SET Science Toolkit (http://www.lostladybug.org/lesson_plans.php) and meets New York State learning standards in 12 areas (See Supplemental Documents.)

Currently, the Lost Ladybug Project website offers visitors easy access to viewing over 10,000 ladybug images with confirmed species identifications, along with "collection" date, location and habitat information, all able to be sorted (in alphabetical order) by location and spotter name and able to be filtered (excluding other categories) by location, spotter name, genus/species, and date. Visitors can also view a data summary page listing LLP findings by Species and State. From each blue-linked ladybug species name on this alphabetical list, website visitors can go to a "Ladybug Bio" for that species (see Supplemental). Each Ladybug Bio contains a taxonomic index, a description of how to identify the species and historical context (e.g. when the species was introduced to North America), several representative images that are linked to the original LLP submissions from which they have come, and set of relevant website links. One of these links leads to a display of all of the photos of that species currently in the LLP database. While a website visitor can find this information by filtering the "Contributor's Page" and see, for example, where a particular species has been found, the display of all photos is the best way for people to perceive the amount of morphological variation for a species and whether perhaps their own specimen belongs to that species. Other links lead to live maps where each species has been found by LLP contributors, and historical distribution maps of each species' range up to 1985 (Gordon, 1985). We also include any available photographs we can offer of immature forms of the species, and any relevant publications about the species. In the "Data & Mapping" section of the website we also display live maps of the findings of all three of the suddenly rare native species, as well as the most notorious of the introduced species, *Harmonia axyridis*. Clicking on any of our live maps allows the viewer to zoom in and directly clicking on the symbols brings the page to the photographic record of the submission.

Newly added to the LLP, and the first of our online data manipulation tools, is our Pie Chart Maker!! This engaging graphics tools allows participants to draw from up to date LLP data and pose original research questions by selecting among literally hundreds of options of data subsets to analyze (pies) and hundreds of options for analysis (pie slices). Pie chart images can be saved to other file formats so that they can be arranged for comparison. Examples of most of the LLP web pages mentioned above can be found in Supplemental Documents.

Educational Achievements – Our participants

Each year we seek to strengthen the educational value of the project and improve implementation. This past year 2010 we incorporated results and recommendations from the 2009 formative evaluation (see Executive Summary in Supplemental Documents) into our work and refinements of the program. Our intended impacts to increase participants' science knowledge, skills, and attitudes through the practice of real field science had positive learning outcomes. Children recalled a great deal of information about

ladybugs and ecological issues more than a year after participation and maintained awareness of ladybugs in the world, seeking to identify species they encountered. The outdoor hands-on experience and the support and interactions with leaders were important factors in their learning. We are very pleased that our project provided entry points for experience and learning to children of a range of abilities. However, children still tended to retain a perception of "science" as an indoor activity not related to their enjoyment and interest in the Lost Ladybug Project and nature! Adults learned a great deal of information about ladybug species, behavior, and ecology. More importantly, adults gained skills and understanding of the process of science.

One of the most substantial findings from the 2009 evaluation was that participants most valued and were most motivated by the feeling of contributing to real, important scientific research. To support this, we provided clear communication with past participants about the scientific results from their data via our website and a first annual program newsletter (http://www.lostladybug.org/newsletter2010-975.php). This newsletter reported to participants some of the key scientific results coming out of their data and what our science staff was doing in response to this data. Visitor feedback on the usability of the website submission pages also guided a number of changes to make the forms and process more user-friendly. With refinements such as these added, the program has continued on its course of recruiting and supporting participants' remote engagement in the program.

A significant number of adult participants, who submitted photos to the website, returned and also participated in our online surveys in 2009 and in 2010. The response was high (39% and 38%), quite positive, and extremely valuable. A solid portion of survey respondents said their strongest motivation for participating in the program was the desire to contribute to a real scientific study and indicated that the ease of engaging with the LLP facilitated broad interaction and a feeling of authentic contribution. We were also happy to learn that people are really having fun out there doing just what the program needs for them to do! We will use the survey responses to best shape the future of the LLP in terms of where we can streamline and what people would most like for us to offer on the website as it continues to develop.

Participant survey respondents were nearly two-thirds female but were relatively evenly distributed across other demographic variables. Participants were split roughly in thirds, with about one-third having a Bachelor's degree, one-third having less than a Bachelor's degree, and one-third having an advanced degree (Master's or higher). Overall, the majority lived in either rural or suburban areas. Further, respondents to the survey, like program participants overall, came from many states in the U.S., as well as some from Canada. In total, respondents reported being from 39 different states, with the most common states (reported by 10 or more respondents) being: New York, Florida, California, Rhode Island, and Virginia.

As noted, we have had an unexpected reach to adults who participate on their own, without a child or group; over half of respondents participated in this way. This was in stark contrast to the original design that anticipated families would be the primary participants. The next most common way of participating was with children from their family followed by few respondents from group-facilitated modes. It should be noted that individuals identified as organized youth group leaders were not the target audience for this survey; they were asked to participate in a separate study. Thus, it is not surprising that few respondents reported participating as part of a youth group. Although the program was unexpectedly reaching a large number of adult participants, the data did show that child participants tended to be in the targeted age ranges of five to twelve years old, as was originally envisioned.

A key area of interest is to understand the motivations of self-directed participants – what led them to participate initially, what they enjoyed, and what might lead them to continue participation in future years. The results showed that the most powerful motivation for participation and what was enjoyed most was the desire to contribute to a scientific study or conservation, with 70% or more of respondents indicating strong agreement. The next most common motivational factor was participants' pre-existing content-based interest, in nature-related topics or insects/ladybugs. Interest in learning more about ladybugs and that the project seemed easy to do were also moderately strong motivators.

Interest in photography and socially-based motivations were not strong motivators for the vast majority of participants, receiving neutral or negative mean ratings. However, many of these items had

high standard deviations and slightly bimodal distributions, indicating that while they were not motivating for most, they were highly motivating for a minority of participants.

Nearly all respondents indicated that they would likely participate again next year. Due to the potential for bias in those who responded to the survey, this percentage is likely higher than it would be for the full population of past participants.

Following the 2009 evaluation, the Lost Ladybug program staff identified several key communication points that were important to respondents – primarily messages confirming that submissions were received and identified. For the 2010 evaluation study, nearly three-quarters saw their submission posted on the website, and a smaller, but substantial, proportion of respondents reported more in-depth communication such as having their questions answered by staff or ongoing conversation with staff. Participants reported high levels of satisfaction with the communication they received.

The Lost Ladybug website is the primary tool for participants to gain information on participation. However, about a quarter cited print media and web based social networks as their source of information, confirming our perception that media coverage of the project has been widespread and effective. Indeed in the last 14 months the LLP has been reported in over 700 media outlets!

Biological Achievements

OVERVIEW OF SCIENTIFIC CONTRIBUTION BY LOST LADYBUG PROJECT PARTICIPANTS. Over 10,000 Ladybug photographs have been submitted from all states including the District of Columbia and Puerto Rico, 6 Canadian provinces, and 3 Mexican estados. This includes 106 different species of ladybugs. Each ladybug can be viewed on our website and the database is available to scientists and lay people alike, in several formats, for a variety of analyses, both on and off the website. The database is used by scientists to support taxonomic work , call for more testing for new introductions of exotic ladybugs and other predators, and inform related ecological and agricultural studies. (See examples and letters from researchers in Supplemental Documents.)

DOCUMENTATION OF RARE LADYBUG SPECIES. Since the spring of 2008, LLP spotters have found more of the once common and now suddenly rare ladybug species than have been found in any other survey in decades. Through May 2010, confirmed sightings include; *Coccinella novemnotata* [ninespotted] (44), *Coccinella transversoguttata* [transverse] (53), and *Adalia bipunctata* [twospotted] (95). While we by no means consider the search to be finished or the current locations where these ladybugs have been found to be the last viable spaces for these native species, we are excited to begin looking for patterns and have enough ladybugs in our colonies to start controlled lab experiments to decipher the causes for their disappearances.

RANGE AND NICHE MODELING. The submitted images of the rare native nine-spotted ladybug (C9) and the relatively common introduced seven-spotted ladybug (C7) are helping us to determine where C9 still exists (its range) and what conditions exist in those areas (its niche). The submissions of C7 provide a measure of sampling intensity that can tell us where the rare C9 has *not* been found in spite of sampling. Using the density of C7 (map 2 in supplemental) we can apply advanced modeling techniques to get a better sense of the current range of C9 (compare maps 3 and 4 in supplemental). We are now incorporating all other submitted species to further clarify C9's estimated range. Now that we have at least a preliminary picture of the range of C9 we are working with Cornell collaborators to try to understand its niche. C9 and *C. transversoguttata* have so far been found mostly in the high dry west (e.g. Colorado, South Dakota and the panhandle of Nebraska). In contrast, *A. bipunctata* has maintained a broader distribution. Niche modeling predicts the likelihood of finding a species based on the climate characteristics of where that species has already been found. These niche models can guide future sampling efforts and eventually they can guide conservation efforts.

CONFIRMATION OF SHIFTS IN LADYBUG SPECIES COMPOSITION. The LLP now possesses one of the largest and most geographically widespread ladybug databases in existence and can confirm the relatively recent shift for ladybugs in North America to at least half introduced foreign species (currently 56%). This is dominated by a single species, *Harmonia axyridis* (61% of the introduced species). These

numbers are in sharp contrast to the pre 1985 composition which was less than 5% foreign species (Harmon et al. 2006).

DOCUMENTATION OF RANGE SHIFTS. Spotters with the LPP have found species of ladybugs in areas where they were not previously recorded. A prime example is the first documentation of *Harmonia* in Arizona (Fothergill et al. 2010). We are continuing to monitor range shifts of individual species and shifts in species composition is changing in various regions.

QUANTIFICATION OF "SHRINKING" LADYBUGS. LLP research has determined that the nine-spotted ladybugs (C9) collected in 2009 were significantly smaller than their offspring reared in the laboratory with constant access to pea aphids. Field collected specimens were also significantly smaller than specimens from the Cornell University Insect Collection (collected between 1909 and 1972) and C7's from both the laboratory and the field. LLP research demonstrated that C9 ladybugs that were fed fewer aphids as larvae grew into significantly smaller adults and that these smaller individual insects had survival and fewer offspring. These results are consistent with the hypothesis that introduced species, particularly the seven-spotted ladybugs may be outcompeting with the C9 for food and that this may be contributing to C9 decline.

LADYBUGS WITH THE WRONG NUMBER OF SPOTS. Among the images of C7 submitted to the LLP are several that show two extra "ghost spots" making them appear more like C9 ladybugs. In addition, one submitted image has the characteristics of a C9 (e.g. white across the neck shield, black line between the wing covers) except that it has only seven spots. These findings have been accepted for publication in the Proceedings of the Entomological Society of Washington. Furthermore, true C9 and C7 ladybugs were observed mating in a vial just after collection in 2009. These pieces of evidence have prompted LLP research into the possibility that the closely related C9 and C7 ladybugs may be interbreeding.

Why broaden the implementation of the Lost Ladybug Project? Why expand our audience?

The primary deliverables from this project will be the broader implementation of the Lost Ladybug Project. Much of the effort over the past three years of the Lost Ladybug Project has been directed towards developing and tailoring a website that provides a) a self-contained but integrated educational program on biodiversity and conservation, b) a fully functional portal to participation in a survey of ladybugs and interaction with a ladybug database, and c) one of the largest, most accurate, accessible biological databases ever developed. Our evaluation results and numbers of participants show that we have built an effective project that engages the public and makes STEM learning approachable. For this new project we are proposing to build on the successful framework we have established by greatly broadening the implementation of the Lost Ladybug Project. We propose to broaden and deepen participation by expanding the geographic, audience age, cultures, and learning settings of the current Lost Ladybug Project.

Geographic. We initially developed the project in New York and South Dakota, but once we launched our full web site and received national publicity predominantly from several articles written by Mary Esch, an AP reporter and writer on the environment, participation quickly spread to people across North America. We want to continue to capitalize on this national recognition and participation in order to broaden and deepen our audience base. Now that we have a strong working project and framework we think it is important to focus particularly in the many states containing underserved populations where participation and partnerships in the Lost Ladybug Project are still low, mostly states with fewer than 25 ladybug photos submitted. These states are also predominantly those with eligibility to compete for funding through the Experimental Program to Stimulate Competitive Research (EPSCoR): AR, GA, KY, LA, ME, MS, ND, NH, NV, OK, SC, WV, WY. Eligible states receive less than or equal to 0.75% of the total NSF research support budget for the last three years. Lost Ladybug Project CoPI, Dr. Leslie Allee, participated in the EPSCoR 2010 NSF Education Outreach Conference and began networking and establishing relationships to lay the groundwork for broadening implementation of the LLP with attending states.

Audience Age. As described above, early evaluations of participants revealed a strong but unanticipated audience of adults surveying ladybugs without children. The original Lost Ladybug Project focused on impacting youth audiences in New York and South Dakota, who engaged in the program through facilitation by group leaders in out-of-school environments, such as 4-H Clubs. As the project was implemented, an unanticipated audience of adults emerged, who participated in a self-directed Lost Ladybug program experience, using online resources. As formative evaluation took place, it became clear that these two different models of program delivery and audiences had different needs for long-term sustainability and to be scaled up to achieve sustained, national participation. As we broaden implementation geographically and add an adult component, we will maintain a focus on our original underserved and underrepresented target audience of Native American, migrant, and rural youth.

Cultures. The Lost Ladybug Project fits well with cultural base of our rural focal audience that incorporates more outdoor activity then urban cultures. Our project resonates particularly well with the cultural/spiritual orientation of many Native American tribal nations that place a high value on interaction with and respect for nature. Based on this good fit we will expand our recruitment and retention efforts to these audiences. Specific groups such as boy and girl scouts have been successful contributors and have demonstrated a similar culture of respect for nature and science so we are seeking more direct collaboration with them through are new "kids to farms" program.

Learning Settings. Most of our participants are self- directed adults, families, and children in afterschool and other groups. Our small but successful forays into museum, botanical garden, zoo, and nature center audiences show potential.

Project Design

How do we recruit and retain participants?

Harnessing the excitement of the search for rare creatures: Bigfoot in your backyard.

Most children and many adults dream of being the intrepid explorer who finally produces convincing evidence of Bigfoot or some other rare species' existence. Unfortunately, the search for rare species called "cryptobiology" has been almost exclusively the realm of trained scientists. Very few non-specialists have had the opportunity to experience the thrill of searching for a truly rare creature because few private citizens have the means and equipment to penetrate the dense northwestern forests to look for Bigfoot or the swamps of Arkansas to search for the Ivory Billed Woodpecker. Even if they could reach and explore the potential habitat search techniques are often complex enough that they require extensive training. The good news is that ladybugs are one group of animals that include rare species that may (and recently have!) turn up in someone's back yard. LLP participants have now found the main three rare and declining ladybug species in a number of different states. In addition, they have also found species that have always been rare. One reason we propose to expand the Lost Ladybug Project is it provides a framework for citizen scientists of all ages to search effectively for these ladybugs in their own yards and communities. Through our project everyone will have the opportunity to join the exciting search for rare species and make a tangible contribution to the conservation of these beautiful and useful creatures.

In our pilot projects, children responded with the most enthusiasm and attention when we said "now we need your help to find these missing ladybugs" and "we need you to be scientists". Although specific in nature, our ladybug project addresses the broad human *need to make a difference, to belong, to matter, and to achieve*, four themes of positive youth development. While these themes are universal across cultural groups, we draw specifically from the research and experiences of the Circle of Courage model developed in SD that "integrates Native American philosophies of child-rearing, the heritage of early pioneers in education and youth work, and contemporary resilience research" (Brendtro et al. 2002). These themes have since been incorporated into many successful programs for youth developed by Cooperative Extension, 4H, and others. Throughout the ladybug project we plan to provide opportunities for: *generosity* (participation contributes to the well-being of the community and the environment, reinforces caring, thoughtfulness, and responsibility), *belonging* (group investigations, ties to family and community through story telling, arts, and food, part of a larger group of scientists and community through website), *independence and power* (genuine participation in a real scientific investigation, as

partners they ask their own questions, gather and submit their own data), and *mastery* (hands-on activities to learn specific skills, experiential learning activities that facilitate understanding of broad concepts, discovery activities that generate excitement and fun). Specific correlations to National Science Standards are discussed in the supplemental documentation.

Building bridges between science and culture: One of our strategies for attracting and engaging our target audiences to participate in STEM is to build bridges between familiar culture and science. For example to learn about and understand the relationship between ladybugs, pest insects, and food plants we are developing activities that involve gathering and telling legends and stories; learning and sharing words from different languages; observing drawing, coloring, and modeling. Familiar arts activities help to build observational skills and create an introduction to science activities.

In a review of how constructivist methodology and cultural factors are aligned with current knowledge of Native American learning Quigley (2002) writes: "Reyhner (1992) proposes that Native American students learn better when methodologies for instruction focus on homes, communities and cultural values. Gilliland (1999) includes the successes of culturally relevant educational programs that recognize and incorporate students' backgrounds, experiences, and interests. Researchers (Tharp, 1989, Goldenberg & Gallimore, 1989) concluded that cultural differences reflected in the classroom are associated with greater child motivation, participation, enjoyment and school achievement. Bowman (1989) suggests a conceptual framework for early childhood settings that is appropriate for diverse cultures including use of familiar language, reinforcement of family values, and address of differences between home and school culture. Programs that recognize and encompass a child's family and background have significant effect on children's reported self esteem (Nissani, 1990). When learners don't see the association between schoolwork and outside life, their motivation and subsequent learning may be affected (Purcell-Gates, 1994)."

Children do science all the time through their natural inquisitiveness about the world. The "problem" is rural poor and Native youth may perceive themselves as so far removed from the process of science that it has no relevance or reality for them. We're proposing a program that can help them to embrace science by demonstrating the importance of this grand "experiment". Without hyperbole the simple message is "if we don't have a stable complex of predators, pests will take over and we will all starve". We scientists need their help because the scope of the problem is too large for us to tackle on our own. Science doesn't need to be expensive, complicated or high tech. High tech can help but they can do legitimate important science in their own back yards with just theirs hands, eyes, and a notebook. The value of these simple observations can be greatly enhanced by documenting them with digital images and sharing them via the web.

Recruitment through direct outreach. In addition to our work through partner organizations, we will also publicize the project and recruit additional participants directly. This will be a two-tiered approach 1) broad based groups for volume, and 2) smaller specific groups to reach segments of our target audience. Through visuals, written materials, a traveling "mini-exhibit" containing posters and activities, website, podcasts and demonstrations we will show the ease of using our website to participate in the Ladybug project.

Participants are recruited through partnerships with organizations that serve children, the environment, and education. In addition we recruit directly through outreach at conferences and community events, youth educator training, radio and television spots, interviews and articles in national, regional, and local newspapers, magazines, and children's publications and websites (e.g. Ranger Rick, American Girl, Time for Kids, Weekly Reader), and direction to our website occurs through blogs and links on other related websites. We use a wide variety of Lost Ladybug Project informational materials (all available to download cost free from our website) including a brochure, bookmarks, a coloring book, posters, identification guide, children's activity guides in the 4H SET format, and our own ladybug song!

Facilitating retention. After initial participation, our goal is to retain youth education leaders and to foster continued participation by individual children and adults. To encourage youth leaders and individuals to continue using our ladybug project as part of their program year after year we plan to stay in touch through email, an electronic newsletter, video conferences, offer support, updates, new materials,

use of kits and materials. We acknowledge everyone's data submission and recognize all participants even if none of the submitted images are identifiable. To foster continuing participation and demonstrated mastery of this field of science we provide additional acknowledgement and encouragement to participants who accrue multiple submissions of images that are identified and entered along with corresponding collection data into our website.

What concepts do we teach?

Our program covers broad concepts of biodiversity, and conservation. Within these broad concepts we continue to creating activities and educational materials to cover more specific topics including: ladybug identification, drawing your favorite ladybug; ladybug and insect lore, myth, story, and song; basic biology and lifecycle; importance of ladybugs as predators; why some species are declining, invasive species, understanding species richness, evenness and diversity; and which species are common (and which are rare) in your area – using our unique database.

To increase relevance and provide bridges to the science within the Ladybug project we create culturally inclusive program activities in collaboration with children, families, community members and educators. Our goal is to provide support and a template to incorporate cultural stories, language, dance, art, and food in a way that is affirming and acceptable to the community. Activities are designed to appeal to the different ways children learn, to their multiple intelligences (Gardner 1983, 1991). For example, children can gather from their families or make up a story about insects, crops, and food in their community. The story of the origin of the name Lady beetle or Ladybug is a nice link to the role of biodiversity and the recognized importance to food webs. In Haudenosaunee communities connections are made to traditional food plants like corn, beans, squash, and strawberries that ladybugs are active on, and the culturally important maple tree where ladybugs often hibernate under dry leaves. Haudenosaunee Environmental program staff, teachers, and youth leaders, and now Lost Ladybug staff often begin a community ladybug project activity by referring to the Thanksgiving Address. This is a central cultural component recited daily and as an opening to all important events, the address describes in great detail the shared duty to live in balance and harmony with each other and all living things. Interactive learning and specific skill development are crucial to science learning, and some literature suggests they may be even more important for our target audiences. The Lost Ladybug Project provides opportunities to take part in real science and make concrete connections between a person's community and science.

How do participants participate?

Users learn about ladybugs, invasive species, biodiversity, and conservation through activities that connect culture and science. Although these materials are designed to be independent, for most "citizen scientists" participation will culminate in the survey of a defined area for ladybugs followed by taking digital images of specimens they collect and uploading these images onto the web for species identification and inclusion in a national database.

How will we broaden and develop the program?

Specifically, we propose to expand on our successful outreach and implement: 1) a geographically broad recruitment program aimed at specific organizations, 2) more explicit connections with museums and nature centers, 3) continued outreach to NA, Migrant, Rural Youth; and build new initiatives with 4) greater recruitment and retention of adult participants, and 5) a Spanish version of our website and educational materials. Below we outline our strategies within each of our five initiatives:

1) *a geographically broad recruitment program aimed at specific organizations*

A. Kids To Farms: Organic Farms and 4H, Girl/Boy Scout pairings for each state. Forging connections between youth groups (4-H, Girl Scouts, Boy Scouts) and local farms for multifaceted learning experiences as young people explore the farms, learn more about their communities and food systems, and become citizen scientists inspired by questions related to conservation and biodiversity. We have already begun to identify specific organic farms and local youth organizations (see

supplemental documents). We are focusing on organic farms because there is less danger of exposure to harmful chemicals and many organic farms have an educational component.

B. Families to Parks: Mixed age groups in state and national parks

Establishing programs for participation in the Lost Ladybug Project (LLP) in parks. These programs could range from ladybug "blitzes" led by park staff and/or LLP staff to dedicated computer kiosks for submitting images to simple posting of information about the LLP. We have made some early forays in this direction and have been met with great interest and some successful programs (see the West Virginia "blitz" in the supplemental documents).

C. National 4H set tool kit: Building on our current collaboration with 4H

We envision 4H groups participating in three modes: 1) structure for conducting survey or leading a blitz in the SET Tool Kit Mode, 2) as all or part of a mapping and GPS project like IRIS, or 3) as a State Fair Project to educate and alert people of their state to the existence of the project. We will continue to network (including post on the national list serve) and present at national and state 4H conferences to inform youth educators about the project and our online tool kit. We have enjoyed great support from the 4H (see supplemental documents) and we are in an excellent position to use our current network to expand our 4H collaborations.

D. The No Child Left Inside Act: Using new national legislation as a catalyst

The No Child Left Inside Act (S-866) would direct support through states for "activities to improve and support environmental education" and specifically for "developing or disseminating innovations or model programs". Sponsor of the bill, Senator Jack Reed of Rhode Island, has issued a press release naming the LLP as an example program and noting "this project is a great way to let kids have fun and learn about nature at the same time" (see supplemental documents). Working with Senator Reed's staff we will provide each senator's office with a summary and guide to the LLP and how it relates to this piece of legislation. As the bill progresses with are prepared to work with sponsors to further the shared goals of this legislation and the LLP.

2) *more explicit connections with museums; community and botanical gardens; nature centers*

We will develop explicit connections with museums, botanical and community gardens, zoos, and nature centers with the goal of collaborating to create a Lost Ladybug Project in some form within the institution. In most connections we will supply materials and expertise and with our input the contact person will build a project appropriate to their needs. For example, for the Natural History Museum of LA County and the San Diego Botanical Gardens, a key staff person consulted with us and then built their own ongoing LL Project with a web connection to our website and a yearly LL Day, respectively. The Rochester Museum of Play, NY and the Cable Museum, WI have ladybug hunts outside during the summer. The American Museum of Natural History hosted our project team as we made a presentation open to the public. We will pursue and facilitate a variety of levels of participation at institutions across the US.

3) *expansion of our current outreach to Native American communities across the continent*

We will network and build relationships through contacts with new tribes as they express interest.
In addition to word of mouth and introductions we will: a) place articles in major publications read across the NA community such as News from Indian Country, as well as in smaller tribal and community publications and radio stations, b) contact and visit tribal environmental protection programs, c) contact and visit tribal youth organizations and larger organizations that serve tribal youth such as Boys and Girls clubs, and d) contact and visit tribal community garden projects. See letters and articles in Supplementary Documents for examples of our current working relationships.

4) *greater recruitment and retention of adult participants*

Creating a forum for adult continuing education and participation in a project that gives added meaning and motivation to healthy activities such as photography, nature observation, and hiking. Although our initial efforts were geared toward youth over half our participants were adults not associated with youth

(see supplemental documents) and certain press coverage was geared specifically to adults (e.g. and article in the AARP magazine online). While we expect all our broadening initiatives (1-5) will result in increased adult participation we plan to specifically increase adult recruitment and retention including the following programs:

A. new content on our website including: ladybug biographies, tips on ways to interact with the data, expanded options for interacting with the data such as dynamic mapping and graphics such as pie charts.

B. expanding our web based exposure: placing information and interacting on pages and sites such as social networking, environmental, nature, and bug guide;

C. utilizing new modes of electronic communication such as Facebook (we have established an LLP page) and Twitter

D. Develop applications for iPhone and Android systems, continue and expand expand our collaboration with phone-based biological observation projects (e.g. NOAH

E. Outreach to Master Gardeners, garden clubs, adult environmental and agricultural groups

F. Expansion of print publication in forums targeted to adults: Examples inclide NYS Conservationist, Birds and Blooms, Better Homes and Gardens, Family Circle, Organic Gardening, Field and Stream, Hoard's Dairyman

5) *Spanish version of our website and educational materials*

A Spanish version of even a portion of our site will greatly enhance our ability to recruit and retain participants from Mexico and from among the nearly 30 million citizens of the US that speak primarily Spanish (2000 Census) in addition to the migrant workers who may not be counted in the census. We will take the following steps we to get Spanish features designed, software written, tested and implemented before Spanish pages are integrated into the existing website:

A. Basic translation and second party proof reading of existing text-driven pages.
B. A template system that allows a mirrored Spanish page including items such as menus and slide show captions to be created every time we add to or expand the web site.
C. Software, testing, and implementation for interactive data pages for participants to view and work with the database, to operate in Spanish.
D. Software, testing, and implementation for the photograph data upload page and system to operate and integrate into the existing database.

How will we evaluate program effectiveness and how broadly we've been able to implement the project?

The Institute for Learning Innovation (ILI), a non-profit research and evaluation group dedicated to understanding, fostering, and promoting lifelong learning, will conduct independent, external evaluation of the achievement of intended impacts through the broader implementation of the *Lost Ladybug Project*. ILI will collaborate with Cornell to conduct front-end and formative evaluation to understand audience needs and help shape program design in Years 1 and 2. Summative evaluation, conducted, analyzed, and disseminated in Years 3 and 4, will address achievement of targeted impacts and expand upon what was learned in the initial project, addressing the following evaluation questions:

For Youth Participants: As the *Lost Ladybug Project* network expands, using new outreach, are STEM learning impacts for youth maintained or strengthened, compared to the original project? In what ways, if any, are experiences or learning different for STEM-underrepresented youth? What influence on youth learning is had by the degree of training and support the youth's educator received from program staff?

For Out-of-School Educators: What aspects of the expanded *Lost Ladybug Project* network most effectively provide resources, support, and skill-building for educators? What influence is had on teacher experience and effectiveness by formal program training?

For Adults: Do enhanced online resources and outreach for adults expand the depth and breadth of learning by adult participants? In what ways, if any, are the experiences, motivations, or learning

outcomes different for Spanish-speaking participants?

Additionally, evaluators will work with program staff to help incorporate systems for tracking and recording data about the breadth and depth of individual and group participation within the program's infrastructure for recruitment and data submission. This will allow for reliable and detailed reporting on the program's audience reach, including measurement of: number of participants (total and within each model of delivery), number of submissions per participant/group, geographic distribution, demographic characteristics, and level of repeat participation. See Supplemental Documentation for the specific details of our Intended Impacts for each audience, Front-End, Formative, and Summative Evaluation plans.

How will broadening the implementation of this project benefit informal science education and biology?

An upcoming workshop and online learning network organized by AMNH, Audubon, and Cornell Lab of Ornithology and funded by NSF identifies some key issues for advancing conservation through public participation in science research (PPSR): "Identifying factors to increase PPSR's contribution to biodiversity conservation through generating and communicating scientifically valid data; Reaching and involving audiences and disciplines not currently represented in PPSR; Understanding motivations and multiple benefits to engage people in PPSR for conservation outcomes."

From our evaluations we plan to produce a set of guidelines, recommendations, best practices for scaling up a citizen science project to a national level. Our evaluations will identify motivations and multiple benefits to participants that will aid in the design of future projects. This information will also help identify ways to increase the public's ability to contribute to biodiversity conservation through generating scientifically valid data.

From our evaluations we plan to increase and share knowledge about reaching and involving Native American, rural, and migrant audiences, not currently represented in citizen science based STEM learning. We will generate specific examples of programs tailored to fit each distinct audience.

Our involvement with the No Child Left Inside Act raises awareness of ISE, may serve to raise the standards and expectations for access to high quality of environmental and science education and ultimately should increase support and funding for new programs.

The LLP offers the opportunity for hands-on interaction with charismatic animals in a way that is not possible with vertebrates. The simple but unique spot pattern of each species allows for the use of an automated identification system that facilitates building a usable database with much greater size and accuracy than any previously assembled by a citizen science program. This combination of hands-on simplicity and accessible data creates learning opportunities unlike any others currently available. Broad implementation of the successful Lost Ladybug Project will make these opportunities available to larger audience and wider variety of people.

Our contribution to ISE will continue in showing a citizen science project designed, implemented, and evaluated to maximize both scientific and educational outcomes. This project builds and expands on the successful Citizen Science model of the Cornell Lab of Ornithology. We have shown how the Citizen Science model can be adapted to a new taxonomic group with an emphasis on gathering high-quality data.

The hands-on activities including the use of digital cameras and the large-scale open access electronic identification system, facilitate opportunities for comparing data between known collections and participants. These applications enhance and extend Citizen Science in a new way and address a major problem in collecting data. This project is one of the first Citizen Science projects to generate a unique new database that is being used by scientists. The online national ladybug survey is a new offering and the high-quality interactive website provides an innovative use of technology for informal educators to engage citizens. Our use of digital imagery and interactive technology, for the collection of usable data is one of our strong strategic impacts. This stands alone as an added deliverable interactive tool that participants in informal education and scientists can use.

To a great extent we have achieved our initial goals of creating a fully functioning online program that attracts participants and engages them in a broad range of scientific inquiry, from examining tiny creatures in backyards to understanding how thousands of small observations add up to give valuable

information. We have successfully set the stage for both extending the reach of the Lost Ladybug Project and deepening the potential for participant involvement. Many contributors have already expressed feeling "part of" the Lost Ladybug Project. As more adults become interested and as the children we already know grow older, we want to give them more to do and learn and share. We now have the audience and the database to make that possible.

One extremely important advance in the ways that people can use the Lost Ladybug website will involve interactive mapping. Right now we offer up to date maps of individual species and of the entire LLP collection. Using the same Global Mapper mapping program that allows viewers to click right down to the photograph of each ladybug, people will soon be able to pose their own research questions and view them in map form. For example, people may want to map ladybug species of their own particular interest or map certain species across certain habitats. Another important advance in LLP outreach will be achieved with a parallel version of the website in Spanish. This will ease inclusion of Spanish-speaking participants and greatly facilitate the incorporation of the LLP in bi-lingual informal education settings.

Our Summary Page will become a core of ladybug species information. Where now each species name becomes a blue link to that species' "Ladybug Bio" where visitors can access further links to maps and photographs, in the future the links to the "Ladybug Bio", the LLP map, and the collection so all photos of that species will appear immediately next to the species name. This will facilitate participant research by reducing the number of steps to the information they seek.

Another important expansion of the LLP will be our further involvement in social media. Our Facebook page is only in its infant stage, not yet even linked to our website homepage! As use of this venue accelerates, and as we join Twitter and finalize our mobile phone applications we will be supporting the development of a community of Lost Ladybug enthusiasts, photographers, and learners for whom the message that someone cares about what they know.

Management

What makes our team qualified to complete this project?

Lead PI John Losey teaches a course in insect conservation biology, has published papers on the decline of native ladybeetles and leads research on this question and the role of ladybugs as predators. Co-PI Leslie Allee oversees the daily operations of the project, uses ladybeetle surveys to train youth educators, leads outreach efforts to underserved communities. Rebecca Smyth oversees maintaining web interfaces, content, and databases, identification of Coccinellids for citizen science survey data. All team members lead project outreach activities, give workshops for youth educators, collaborate on development of the website and educational materials and give presentations to promote awareness of the project. An Outreach Assistant, recruited from target audience communities, will assist with communications with participants in our national outreach effort. NEXT Interactives, LLC will continue to assist with innovations and maintenance for our website, www.lostladybug.org. Evaluation will be conducted by Jessica Sickler, Institute for Learning Innovation (ILI), an Edgewater, Maryland based 501(c)(3) not-for-profit research and development organization. Evaluation will be directed by Jessica Sickler, a Senior Research Associate at ILI whose work has focused on the learning and development of children in formal and informal learning environments. Sickler directed formative and summative evaluation for the initial development and launch of the Lost Ladybug Project.

The PI and the project leader will work together to ensure that the timeline (see Supplemental Documentation) is followed closely and projects are completed when needed. The core project team senior staff will meet weekly in Ithaca. Graduate and undergraduate students will also meet with senior staff advisors. In addition, the PI and CoPI will hold monthly phone meetings with the external evaluator. Finally, the advisory board will meet once each year to review progress and offer input. Advisory board members also will consult regularly by phone and email.