PROJECT DESCRIPTION

Description Outline

Introduction

We propose to develop a citizen science program using ladybugs to illustrate concepts including invasive species, biodiversity, and conservation through activities that connect culture 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 recently 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). Our project will extend citizen science in the following areas:

- The opportunity to participate in ongoing and important scientific research by taking part in a national survey of threatened rare ladybug species
- Specific focus on 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. 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

Why target Native American and Rural Youth?

Our primary intended audience is 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. Initially, our geographic focus is upstate New York and South Dakota with subsequent expansion to similar areas nationwide. Both NY and SD have high populations (~14,000 persons in each state) of NA people, comprised of at least 14 different tribes or cultural groups, living in relatively defined rural areas, reservations, or nations. Many of these tribes 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 in each focus area. In NY and SD, respectively, 18% (~200,000) and 22% (~30,000) of all rural children live in poverty. We will concentrate on children across NY and SD 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). A subset within rural farming communities, and a priority of our project outreach in NY and SD, 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 Ladybug project. 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 had a ladybug booth at the SD State fair in September 2006. We drew 55 people in 2 hours (8 - 10 a.m., heavy rain that morning) and had lots of questions from visitors, indicating that ladybugs were a popular topic.

Using citizen science to bridge the digital divide. Some readers of our proposal have 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. We are working with existing programs to provide the necessary hardware (e.g. digital cameras, computers so that all interested parties will be able to participate. See our supplemental documentation for more on bridging the digital divide.

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). Given their potential to control pest species, many programs have tried to supplement extant populations or introduce new species. Ladybugs have been the subject of many scientific studies and from these studies we know that ladybug species vary greatly in their ability to suppress pest populations (reviewed in Hodek and Honek 1996) and their response to changing environmental conditions (Iperti 1999; Bazzocchi et al. 2004). 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 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 would be a major discovery. In fact, the first discovery of our fledgling program has already been made. Laurel (age 11) and Jonathon Penhale (age 10) 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.

It seems likely that the program we propose will find more rare ladybugs. However, our citizen science program will be 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 (see table 1). 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 harness the power of citizen science to save these species before it is too late.

How will 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. The program we propose will provide a framework for citizen scientists 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.

Several studies and books describe and address the disconnect between the experience of children living in communities with little exposure to informal or formal science and knowledge/comfort/familiarity with the scientific process. For youth in these communities, science is often regarded as foreign, unfamiliar, somewhat scary, and perhaps suspect because scientists generally use their minds to work with ideas rather than use their bodies to work with things. Indeed this discomfort is the personal experience of about a third of our team and advisory board, having grown up in rural, blue collar, farming, and or Native American communities. One of the most important attributes contributing to Native American children's success is the ability to manage both Native American and non-Native American worlds (Cleary and Peacock 1998).

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 and retention participant through partnerships and training. In order to employ a "train-the-trainer" strategy for maximizing the reach of our project, we have formed partnerships with broad-based organizations: statewide (NY State 4H, SD State 4H, Migrant Worker Children's Education Program), region-wide (ONC BOCES CROP after school and summer programs, Cayuga Nature Center), and community-wide (Seneca Nation Department of Education Summer Programs, Seneca Nation Early Childhood Learning Centers After School Program, Onondaga Nation After School Program. (Please see additional partners and letters in Supplementary Documents.) In both NY and SD, we are starting to conduct orientations and trainings for 4H youth development educators from every county at their scheduled annual statewide meetings. The 4H youth development educators will then, in turn, train individual leaders of 4H youth groups, after-school programs and nature centers in various communities within their home county. In NY, we will also train the 15-20 undergraduate and graduate student interns through the interdisciplinary service-learning course, 'Naturalist Outreach Practicum'. These "ladybug spotters" will lead programs in migrant children's summer programs across the state and they will share the information with other youth leaders in the program. Through our partnership with Cayuga Nature Center, we will publicize the ladybug project to other nature centers in each state through their web site, newsletters, and annual meeting. Region wide train-the-trainer workshops for nature center youth leaders region wide will be publicized by and held at Cayuga Nature Center. Participation within our regional and community partner groups will be facilitated through training 4H leaders, after school and nature center staff, and others. To recruit participants we will offer trainings and demonstrate the project through established annual meetings, fairs, professional organizations, and communication vehicles such as newsletters and websites within each partner group. We will use a regional approach focused on target communities with participation generated in a type of "circuit rider" model. Graduate students will conduct educational/sampling programs and demonstrations for participating groups and be on call to make short trips to verify particularly important finds. Each graduate student would visit and sample with a minimum number groups each year. All training workshops and materials for youth leaders will include: background information and literature, demonstrations of activities and cultural template, field and technical training videos, plus follow-up video conferences, and web-support. By developing a base of trained volunteers and integrating culturally sensitive outreach training into curriculum at Cornell and other institutions we will be able to provide personal interaction with participants far beyond the funding cycle of this grant.

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. In conjunction with our full-time education/outreach specialist, Lori Quigley (a Native American member of our advisory board) will coordinate contact with organizations such as: National Presidential Advisory Council on Indian Education, Native American Indian Education Association of New York, Native Language Network **(**more examples in supplemental documentation).

In addition to contacting organizations we will contact media outlets directly. While the proposal is pending, we will work with Blaine Friedlander of the CORNELL NEWS SERVICE to raise awareness of our program at a national level through publicizing the recent discovery of the nine-spotted ladybug in national news articles (ex. NY Times Science section, NPR radio). He will describe how citizens can look for lost ladybugs by participating in our ladybug survey, that we are applying for funding to expand the project into an informal science project for children, and provide our web information. Working together, our full-time outreach development specialist and collaborators like Friedlander and Quigley will constitute an effective public relations team.

In our first year of funding we will contact regional South Dakota Conservation Digest; Insect Spotlight section of Farm Forum (a multi-state publication in the northern Plains), NY Conservationist. In the second phase of the project, after the website is operating, we will spark national participation with 10 new web, and 10 new national print outlets such as Natural History, Scientific American, National Wildlife, Wildlife Conservation. As members of the Entomological Society of America we will present our project with literature, a booth, and workshops at annual meetings; publish in the national newsletter.

Estimate of Participation. We estimate that ~9,688 individual children will be directly reached by our ladybug project during the three active years of the award: 2,500 in 2008, 3,125 in 2009, and 4,063 in 2010. This estimate is based on the following: From the estimates of our partners (listed below) we know ~2,500 children will participate in the project's first year in 2008. Probably ~75% will continue as partners and use the project for all three years (subtotal ~6,250). In addition, we assume we will recruit by our active outreach program (described below) and by word of mouth at least half as many additional new partners serving ~1,250 children in 2009 and ~75% will continue as partners in 2010 (subtotal ~8,438). Finally, we will recruit more new partners serving ~1,250 new children in 2010 (~9,688 total). Long range, we plan to stay in touch with established partners in NY and SD, keep the website up and continue our efforts in other states. Therefore we estimate the ladybug project will have become a standard and be used yearly by at least 25% of all our partners serving ~1,000 children a year. So five years following the grant period a total of 5,000 additional individual children will be directly reached by the project. It is worth noting that combined the Cornell and Discover Life sites have had over 2500 visitors in the last three months with almost no recruitment effort.

Facilitating retention. After initial participation, our goal is to retain youth leaders and to foster continued participation by individual children. To encourage youth leaders to continue using our ladybug project as part of their program year after year we will stay in touch through email, video conferences, offer support, updates, new materials, use of kits and materials with agreement to use project for another 5 years. We will acknowledge every child'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 will 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 database. We envision the following system of levels for progression and advancement: Citizen Scientist 1, Bronze 100, Silver 250, Gold 500, Platinum 1000. Participation points would be accrued according to the following scale: 1 For each ladybug image, 5 additional points for single surveys with more than 20 identifiable ladybug images, 5 additional points for above with at least 80% collected ladybugs identified, 10 for each rare ladybug identified, 25 for each very rare ladybug identified. This scheme is still in the conceptualization phase but it illustrates our goal of allowing advancement while minimizing competitive interactions.

What concepts will we teach?

Our program will cover broad concepts of biodiversity, and conservation. Within these broad concepts we are 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. Modules will have specific instructions on implementation of each learning activity. Materials will detail educational standards for science and process covered.

To increase relevance and provide bridges to the science within the Ladybug project we will 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. Care will be taken to make sure content is appropriate and respectful of community needs, permission and approval will be sought from elders, tribal authorities, and other entities. Activities will be 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; connected to the sharing of Native American stories, it potentially opens a very large storeroom. The Iroquois Indian Museum and Nature Park, in Howes Cave, NY has an educational program called Iroquois Environments, they are creating curricula about Iroquois art and culture that engages students in mathematical and scientific understandings. A staff member, Mike Tarbell, is assisting us in finding stories about ladybugs, the traditional Iroquois 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.

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 (reviewed by Miller, Cleary and Peacock 1998, Klug and Whitfield 2003). Quigley (2002) reports "Rhodes (1994) reviewed several approaches to learning and noted that teachers acting as facilitators and coaches, encouraging active Native learning, have been most effective" and "In a survey of student learning styles (Wilson, 1997), 23 of 28 Native students scored highest in the "Active Experimentation" style." We will provide opportunities to take part in real science and make concrete connections between the child's community and science. This includes gathering, and having children gather from their families, stories about insects, crops, and food in their culture. We will offer grad students and others as mentors and examples of people doing science. We will also offer very concrete direct examples of how to be a scientist or citizen scientist and how science is part of everyday life in each culture.

Another issue that came to light during conversations with youth leaders was the importance of language, especially NA languages that are being revived. Some NA youth programs are conducted entirely in a Native language other than English and will require a translator to work with our program. Other programs have a bilingual approach and will appreciate materials with key terms and names in both languages. To explore, understand, and fill language needs we will draw on the expertise and experience of advisory board members and partners such as Lori Quigley and Mary Jo Dudley (see CV/letter supplemental). We are working to identify individuals in local communities to assist in translation and further develop dynamic project materials that are responsive to culture and language in each community. Adding a language aspect to the project enhances interest, sustainability, extends use of our project as a whole, and increases participation of underserved audiences in STEM.

How will we develop our program?

Project Design. The youth program materials, survey methods, website, database, media, and exhibit are being designed by staff and consultants in collaboration with participating informal education community partners and the Advisory Board and developed through pilot and field testing in the community. In addition to individual conversations, this committed and enthusiastic Advisory Board has already met twice as a group to advise on audience, impacts, recruitment, and evaluation. Based on front-end research and planning we have a solid estimate for completion of each stage of the project. Please see the Timeline in supplemental documents for a projection of progress on each deliverable for each of the four years of the grant.

Our participatory citizen science experiment will be based on the successful citizen science projects, focused on birds, developed at the Cornell Lab of Ornithology (CLO). Using this model avoids reinventing the wheel and allows us to adapt, improve, and add technology and innovations for use in entomology. Rick Bonney, from CLO and the principal investigator for several citizen science projects, is on the Advisory Board and will play a key role in knowledge transfer about the model.

The project education and outreach specialist will coordinate the design of the educational modules and outreach activities (described above). When funded, we intend to fill this position with someone from one or more of our target communities, two strong candidates are already interested in the position, (see supplemental documents for biographies).

To develop educational modules we will draw on several existing ladybug curricula (Ross 1997, Echols 1999, Dias Ward & Dias 2004, Loewen 2004), biodiversity, conservation, and nature education resources (Caduto, M. and J. Bruchac 1988, 1994, Cornell 1998, Burnett 1999, NBII 2006), and children's books about ladybugs (Godkin 1998, Allen 2003) to create a program that meets our impact goals, prepares participants for the ladybug survey, and stands alone as an educational resource. The activities in each module will be organized to connect science and culture by incorporating stories, literature, language, music, dance, food and art, from printed materials (ex. Powers 1917, Hitchcock 1963, Capinera 1993, Cherry 2002) and through community partnerships. These efforts are ongoing and will vary with each community, for example: Dr. Lori Quigley and the Seneca Language Project is working with us incorporating language/culture into a full educational curriculum that we will implement at six afterschool and summer programs as part of her sabbatic project in 2007-08. Dr. Milford Muskett is gathering stories related to biodiversity and foodwebs through his ongoing research on stories and story telling in Native communities nationwide. We are locating a translator to work with the Akwesasne Freedom School after-school and summer immersion program to develop and conduct all activities in the Mohawk language. After our pilot-run at the Onondaga Nation we incorporated the Onondaga word for ladybug and several traditional foods. We are working with program educators to incorporate more words and stories. The interns at the Migrant Worker's Children's summer program will conduct most of the project in Spanish. The materials developed through these collaborations will also be placed on the web for others to use. The website will also provide a template for other children to tailor and create project materials using resources and information from their community.

The online citizen science participation facets of this project will be developed and hosted by the web based global biodiversity group Discoverlife, headquartered at the University of Georgia, under the lead of John Pickering. This group has a great deal of experience designing websites, online reporting tools, and databases, they currently maintain global databases utilized both by scientists and the public worldwide. Population biologist James Nichols will review the format of the data to be stored in the database to ensure usability for statistical modeling.

How will participants participate?

Users will learn about ladybugs, invasive species, biodiversity, and conservation through activities that connect culture and science. The educational program will encompass a package of educational materials and activities that can be used by adult mentors in youth programs or directly by youth as a self-directed learning experience. In many cases participation will be facilitated by our volunteer Ladybug Spotter Guides who will be trained as part of the Ladybug program through an outreach practicum. The outreach training practicum will be developed within advisory board member and Cornell K-12 outreach specialist Linda Rayor's highly successful interdisciplinary service-learning course, 'Naturalist Outreach Practicum'. It will be available to be offered by any adult learning, youth services, or extension group. It will be a program that multiplies its impact as students move on into other areas.

Activities will include working with the ladybug database to generate and test hypotheses. For example, using tools provided on the website students could ask if native or introduced ladybug species are more common in their state or region. They might also compare the complex of ladybugs they or others found to other regions or other time periods in their own region. Users will be able to generate "posters" of the most common ladybugs in their region.

Although these materials will be 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 evaluate what participants learn?

The major intended educational impacts of the ladybug project are:

1. For children, their families and community to feel more comfortable and familiar with doing science. By creating concrete connections between the children's cultural community and science, children will also realize they already do science.
2. For children to directly experience authentic science, with opportunities for meaningful achievement and mastery, through active participation in a national survey of ladybugs.

3. For children to increase their understanding of the importance of preservation through biodiversity and conservation through these activities.

Objectives to assess these educational impacts:

1. Children will show increased comfort and familiarity with science as measured in interviews, drawing the world, and stories before and after participation in the project.
2. Children will gain understanding of the scientific process through active experience in an enjoyable comfortable setting. Measures will be increased abilities in activities that develop inquiry skills: asking questions, planning and conducting investigations, using tools such as hand lenses, digital cameras, and the interactive computer website, organizing and forming hypotheses with their results, communicating their results and considering the results of others.
4. Children will show increased understanding of ecological functions, biodiversity, and invasive species.

We will measure the impacts of our educational program on biodiversity and conservation by using a pre- and post-assessment process of surveys and activities. Internal evaluation will be built into each educational program and web based audience interaction. First, as participants initially encounter our program materials, we will assess the student's basic knowledge of and attitudes toward biodiversity and conservation. In addition to how well they can define these concepts, we will assess the participant's knowledge and attitudes toward scientific method. Then we will assess both areas (biodiversity and scientific method) again after completion of the program modules and again after participation in the ladybug survey. We will measure their application of knowledge from the program modules to activities in our ladybug survey and in their planning to present the material to others. More importantly, we will measure the level of enjoyment and comfort in direct experience of science. We plan to use evaluation scales that are adapted from other citizen science projects, such as those used by the Cornell Laboratory of Ornithology. Most of the evaluation will be done with surveys that can be distributed by local leaders. The graduate students will be trained in interviewing, to gather some more qualitative data and the external evaluator will visit selected sites. When we compare the pre-assessment to the post-assessment we expect to see an increase in understanding of importance, terms related to, and knowledge of biodiversity, conservation, and scientific inquiry. High levels of enjoyment and an increase in comfort level will be another measure of our success. As lifelong learners this will predispose citizens to feel comfortable with other experiences of science and to be aware of and value scientific issues and knowledge.

Children's core knowledge and attitudes will be assessed in several ways: at the beginning of the program we'll ask the children to draw the world outside, we'll also ask some children to dictate a story about a bug outside. Then after completing some project modules and participating in the ladybug survey we will ask children to draw the world and or tell a bug story again. Then we will compare the before and after pictures for differences in complexity and evidence of concepts and information from our program. As a control we will also do these assessments over the same time period with a similar group of children that do not participate in the ladybug project. More specifics on the evaluation plan are included in Supplemental Documents.

A summative evaluation will be carried out by the professional evaluator during the entire fourth year of the project. The evaluator, Dr. Bruce Lewenstein, is Director of Seavoss Associates, a science communications consulting firm with experience evaluating NSF funded informal science education projects such as NestWatch, Classroom FeederWatch, The Birdhouse Network, and Project PigeonWatch through the Cornell Laboratory of Ornithology. Results of evaluations will be published on informalscience.org, our own Ladybug Survey website, and in forms for the public, science educators, and professionals in fields related to the project, for example the American Entomologist, and the Conservationist magazine.

How will this project benefit education and biology?

Our contribution to ISE will be to show a citizen science project designed, implemented, and evaluated to maximize both scientific and educational outcomes. This project will build and expand on the successful Citizen Science model of the Cornell Lab of Ornithology. We will show how the Citizen Science model can be adapted to a new taxonomic group with an emphasis on gathering high-quality data. Since we aim to reach Native American, rural, farming, and low-income populations, we will explore how the model can be tailored to fit a different underserved audience. The hands-on activities including the use of digital cameras and the large-scale open access electronic identification system, will 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 will be one of the first Citizen Science projects to generate a unique new database that will be used by scientists. The online national ladybug survey is a new offering and the high-quality interactive website will provide 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.

PROJECT DELIVERABLES: The primary deliverables from this project will be a citizen science program including 1), a website that provides (a) a self-contained but fully integrated educational program on biodiversity and conservation, and (b) a portal to participation in a survey of ladybugs and interaction with a ladybug database, 2) a dedicated corps of trained volunteers that will visit interested groups and work with them to make full use of the educational resources and participate in the survey, and 3) one of the largest, most accurate biological databases ever developed which will be fully accessible to both specialists and nonspecialist citizens.

Media Deliverables. We intend to incorporate the latest advances in media deliverables by making a series of short features available as traditional audio and also video podcasts. Since the audience for this new media is growing but still a relatively narrow segment of our intended audience we will make these same features available as downloadable or streaming video clips from our website. Initially, we will produce (and star) in these features ourselves but as the project progresses we intend to facilitate the dissemination of short video clips of participants sharing details of their own ladybug collecting or other science-related experiences. Working with resources available at Cornell (e.g. CyberTower or Education TV) we will produce several features targeted primarily at youth and several targeted for either youth or adult mentors of youth.

Research Deliverables: Our primary opportunity for development of dissemination of data on applied educational research will be utilizing data gathered throughout the project and especially in the fourth year. Our evaluation consultant, Seavoss Associates, always seeks to design evaluations that will contribute to broader knowledge about the informal science learning process (in addition to project assessment). Dr. Bruce Lewenstein, director of Seavoss, has published widely on topics relating to public science education. We expect that evaluations of this project will lead to peer-reviewed publications on the knowledge, attitudes, and behaviors of project participants.

It is important to note that the data gathered by nonspecialists in this project will allow us to publish answers to biological questions that could not be addressed without their participation (see supplemental documents for letters from several prominent biologists attesting to the importance of this data). Possibly the greatest impediment to the utilization of data collected in citizen science programs is a lack of confidence in the data collected. A pertinent example is Canada's Spot the Ladybug program in which over 32,000 individual observations were submitted, nearly equal to all published studies on ladybugs. Unfortunately, this rich ladybug data set is not utilized by scientists because of concerns over identification errors by non-specialists. One study suggested that misidentification errors (a wrong species ID) by non-specialist "citizen scientists" could run as high as 40% (Marshall 2000). Compounding this high error rate is the fact that observations cannot be revisited. Once reported incorrectly they represent a permanent and irreversible error in the data set.

To address these issues we are proposing a new citizen science model in which every data point will be permanently linked to a digital image of the ladybug to which it pertains. To be officially entered into the database identifications will be made not by citizen scientists but by trained specialists (and later partly by an automated ID system). This novel protocol will reduce errors in identification to a negligible level and it will create a virtual collection in which every data point will be vouchered.

Virtual vouchering will allow an interested party to examine identifications of individual data points. By assessing a number of points within the database it will be possible to estimate an overall error rate. This represents an advance not only over current citizen science models but over essentially all published research in entomology in which only a small subsample of observations are represented by physical vouchers (e.g. pinned specimens).

In addition to creating one of the most accurate and reliable biological databases ever developed, virtual vouchering will also allow subsequent reclassification of the data. For example, future studies may determine that a given ladybug species should actually be considered a complex of two or more species and that there are important ecological differences between the species. With our virtual vouchers we would most likely be able to reclassify our data and reanalyze it with the new classification. This is possible in very few (if any) other existing large biological data sets. For this reason we believe our ladybug database could set a new "gold standard" for the quality and reliability of biological data.

If we are as successful as we hope to be in recruiting participants, identification of images could quickly become a rate-limiting step in our program. To address this challenge we are proposing to develop an automated identification system. This part of the project brings participants in contact with cutting edge and highly innovative image analysis for species identification developed by Joseph Ellington and Jeffery Drake, NMSU. This automatic system will operate seamlessly through our website and provide vetting and expert species identification feedback of the ladybugs observed.

Input to the imaging system will be the color digital photos taken by citizen scientists. Once submitted via the web the system will use pattern recognition protocols to determine the species that each image represents. This will involve an iterative process of determining optimal configuration/parameters for field imaging of ladybugs, and developing and implementing image processing and pattern classification algorithms. Pre-defined spectral and morphological features will be extracted from each sample for input to the pattern classification algorithm. This mechanism leverages the proven vision system (image processing, image analysis, and pattern classification) techniques developed for an automated insect identification and sorting system. These successful systems have been with insect groups whose characteristics are ostensibly more complex than those used to separate ladybugs. In ladybugs most species can be separated by fairly simple spot patterns on the hardened wings (elytra).

Several attributes make this system uniquely suitable for citizen science. First, classification results should be available in real-time, providing instant feedback to the users. This will greatly facilitate utilization of sampled data in a single event. Equally important, classification accuracy-to the species level-is expected to ultimately exceed 95%.

Web Deliverables: Our goal is to have an independent and autonomous web-based program completed during year 3. More technical detail and a full list of features are available in supplemental documents. The web site will have five basic components: 1) educational activities and general information, 2) project participation and data submission, 3) automated identification system, 4) interactive ladybug database, and 5) support for youth-produced research reports and the Ladybug Webzine. Components 1, 4 and 5 will be usable as stand-alone educational units. In essence all educational activities regarding biodiversity and the interactive ladybug database and report creation tools will be freely available to anyone regardless of their participation in the project. For those who choose to participate, text, diagrams and video clips (see media deliverables) will guide them in ladybug sampling, image creation, and data submission. Submitted images will be sent electronically to the automated identification system (see description in supplemental documentation) and images identified automatically or manually will be entered into the interactive database.

All aspects of the website creation and design are being handled by the experts at Discover Life one of the largest and fastest growing biological data and education organizations in the world. The beginning stages of the Ladybug website are underway at http://instruct1.cit.cornell.edu/courses/icb344/Lost_Ladybugs.htm**.**
While our site will be specifically tailored to this project, Discover Life already has online interactive databases that link data and images and can handle vast datasets (see link to Cornell site). The computing aspect of the project is entirely web-based and designed for use by children with minimal adult assistance. The technical uploading of images through the website from a digital camera requires no special hardware or software. Once specimen images are uploaded, they will be classified to genus and species by the automated system. If the automated system cannot classify a specimen, the specimen is queued for a human expert (project staff) to perform the classification using a web interface to view the image of the specimen and the metadata associated with it. Only successfully identified images of ladybugs will be entered into the database and become available for viewing (thus eliminating the potential for unwanted images).

The specimen and expedition data entered into the online database by participants will be available to other participants, scientists, and the general public. The database will be a virtual entomology collection which can be searched and browsed and from which data can be downloaded. The web application providing access to the database will be specifically designed to facilitate indexing by Google and other search engines, effectively making all specimens and their metadata available from any web browser. Data will be formatted to allow it to be integrated seamlessly with other Discover Life data and other databases.

The web site will also provide presentations of data that have more relevance and meaning to participants. For example, the site will give recognition to the participants with the most expeditions, most specimens, most observers, and most diverse specimen collection. The site will also provide a running total of the number of participants, number of specimens, and number of species held in the database. Dynamically created maps will show locations of participants and locations of specimens for each type of species. Participants will be able to generate species diversity reports for their collections and compare them to that of other participants. The general public will be able to generate species diversity reports for state, county, and multi-state regions. User-friendly tools will facilitate the creation of pie charts and other simple graphs.

The web site will encourage participants to go beyond comparing data gathered by other participants by creating a sense of community and facilitating peer-to-peer communication and learning. Discussion forums will allow participants to interact and compare methods and notes online. It will also provide a forum to compile research reports, contribute to a ladybug "webzine," and share cultural and language information, including legends and stories, about ladybugs, insects, crop plants, and foods.

Youth and Community Program Deliverables. While the web will be main venue or dissemination mechanism we will employ, our project is, at its core, a youth and community program. In years 1 and 2 this program will be developed and delivered primarily through live interactions with specialists in New York and South Dakota. In year 3 the focus will shift to a national primarily web-based program developed based on experiences in the first two years. The keystone of our program is the opportunity for non-specialists to participate in a major experiment that 1) cannot be completed without their input, and 2) the results of which may allow us to save several ecologically important species before its too late. Participation will consist of 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. Especially for youth in our target audience, who may never have considered science accessible, participating in an important scientific endeavor should be a thought provoking and perhaps even a life-changing experience.

What makes our team qualified to complete this project?

Lead PI John Losey teaches a course in insect conservation biology and has published several papers on the decline of native ladybeetles. Team members Leslie Allee, Louis Hesler and Michael Cantangui have all been involved with ladybeetle surveys, outreach, and research on the role of ladybugs as predators. John Pickering has vast experience designing and maintaining web interfaces and databases for citizen science survey data. Combining our expertise and partnering with organizations including cooperative extension, 4H, and representatives from our target audience we can develop an effective and innovative program.

The PI and the project leader will work together to ensure that the timeline is followed closely projects are completed when needed. The core project team senior staff will meet weekly in Ithaca. Graduate students will also meet with senior staff advisors. In addition, the PI 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. Names and affiliations of our project team are presented in supplemental documentation.