PROJECT SUMMARY

Title: Management Of The Asian Tiger Mosquito Among Socioeconomically Diverse Urban Neighborhoods Through Community-Based Education And Involvement

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This is a Joint Research-Extension project to advance management of the invasive Asian tiger mosquito among urban environments with diverse socioeconomic and cultural backgrounds. The Asian tiger is a common human-biting mosquito in urban areas and important in West Nile transmission. Abatement efforts by public agencies are ineffective because it breeds in obscure water-containers spread across private-access land. This project will conduct: (1) research to identify mosquito exposure and evaluate education materials and ‘citizen science’ strategies; and (2) extension with stakeholders to develop and implement management interventions appropriate for different socioeconomic and cultural contexts. This approach will reduce numbers of containers and adult mosquitoes by promoting lasting behavior change. It will reduce the use of temporary and ineffective adulticides. Mosquito populations and knowledge, attitudes, and practices of residents in Washington, DC and Baltimore, MD will be compared between education-intervention and non-intervention settings using entomological and social surveys in a Before-After-Control-Intervention design. Focus groups and interviews will evaluate individual materials and strategies and inform development of improved methods. Materials, workshops, and publications will disseminate knowledge to audiences to broaden the implementation of successful methods. This project addresses the priorities of the NEIPM’s Community/Public Health IPM working group, which include using diverse media to educate the public on implementing IPM in their homes and landscapes, and developing creative tools for measuring the impact of public education related to IPM practices in residential settings on changes in awareness and behaviors of target audiences. We request $84,253 for research and $39,921 for extension in this 3-year project.

(i) Problem, Background and Justification

Problem: The Asian tiger mosquito, *Aedes albopictus,* is an important pest and serious public health threat in the Northeast and greater Eastern US[1-6]. This species is thought to be one of the fastest spreading animals worldwide[7]. It has been identified among 100 of the "World's Worst" invaders by establishing in more than 40 countries since 1979[2, 7]. *Aedes albopictus* established in the continental US in the mid-1980s through used tires that were imported from Japan into Texas[8]. Since then it has spread to more than 30 US states and is continuing to expand its range. *Aedes albopictus* has established in CT, DE, MA, MD, NJ, NY, PA, WV and the District of Columbia (DC)[9]. Climate change is likely to increase its expansion northward and facilitate colonization of RI, NH, VT, and ME. *Aedes albopictus* was first detected in RI in 2010[10]. Female *Ae. albopictus* readily bite humans and have adapted to breed in a vast array of receptacles that hold water in backyards, including birdbaths, flowerpots, gutters, pipes, cans and tires[5, 11-12].

Aedes albopictus is capable of transmitting almost all the viruses for which it has been experimentally tested[1, 13-14]. At least 11 viruses that affect human health have been isolated from specimens in the field[14]. *Aedes albopictus* is a likely bridge vector of West Nile virus (WNv)[15], and the recent emergence of WNv in the US triggered the largest mosquito-borne meningoencephalitis in the Western Hemisphere[16]. *Aedes albopictus* has been implicated as the principal vector in numerous outbreaks of dengue virus and chikungunya around the world[1, 14, 17-21]. The 2001-02 outbreak of dengue in Hawaii, with 95 infections, illustrates the potential for *Ae. albopictus* to circulate dengue virus that originated from imported cases[22]. In 2010, 355 dengue cases were imported into the US, including 86 in the Northeast[23]. A 2007 chikungunya epidemic in Italy involved a new strain of chikungunya that has enhanced replication in *Ae. albopictus,* likely through a single point mutation[24]. The rapid emergence of this new chikungunya strain indicates the potential for *Ae. albopictus* to shape the evolution of vector-virus systems and suggests that a similar event could occur for arboviruses that threaten Americans[13-14].

Conventional mosquito abatement methods used by public agencies do not control *Ae. albopictus.* Conventional methods were originally designed to combat malaria vectors and nuisance mosquitoes that breed in defined water bodies (e.g., wetlands and ponds) and are active during dawn and dusk. Programs that use ultra-low volume fogging to kill adults generally apply materials in the evening when air temperature limits evaporation. Because *Ae. albopictus* are most active during the daytime, these pesticides are ineffective. Larvicides (e.g., *Bacillus thuringiensis (Bti)* or methoprene) are effective when applied to breeding habitats but treatment of containers is impractical because they are too numerous and often obscure. Truck-mounted applications do not reach all target containers such as those under decks, in roof gutters, or in down pipes. The only effective control of *Ae. albopictus* is to remove and drain water-holding containers. But public agencies do not have the resources or the legal authority to do this over large areas.

Background: Funding for mosquito surveillance and control in the US has been stagnant over the last 10 years and is increasingly under threat of severe cuts[25-26]. Many cities cannot afford extensive spraying or source reduction programs. Baltimore City, for example, has no consistent mosquito monitoring or control program. In Washington DC, adult fogging only occurs when a mosquito or human tests positive for WNv[27]. The control area is usually limited to 3-5 blocks and spraying extends for only a few days to provide temporary relief from biting adults. Complaints by residents of nuisance mosquitoes do not warrant control by most mosquito control programs. Washington DC and Baltimore represent many urban communities across the US that are underserved for mosquito control, and likely represent increasingly widespread situations under future fiscal conditions. It is clear that residents must bear an increasingly substantial responsibility for source reduction and practice behaviors to reduce mosquito biting.

The World Health Organization considers community-based source reduction and personal protection (e.g., use repellent, covering clothing, avoid areas/times of day) from biting as the cornerstone strategies for combating diseases vectored by container-breeding urban mosquitoes[28]. Numerous large-scale community intervention programs have been undertaken in areas of high dengue and yellow fever transmission overseas[29-31]. However, programs are rarely evaluated for their effectiveness in actually influencing public behavior and reducing mosquito populations[32]. Few control programs quantitatively compare intervention and non-intervention settings; thus they cannot make sound conclusions on the effectiveness of community involvement in *Aedes* control[32]. Even fewer studies extend more than 12 months after the intervention, making an assessment of the sustainability of interventions over multiple seasons impossible.

Few studies have compared North American's knowledge, attitudes, and practices surrounding WNv and mosquitoes [33-38]. Even fewer studies have tested whether public knowledge or perceptions are related to actual exposure to mosquitoes. The results of one study in upstate New York showed residents with increased concern about WNv had fewer containers in their yards and practiced greater personal protection[39]. This result suggests that appropriate education can alter residents' behavior but no assessment of how residents gained education or changed behaviors was made in the study. Another study sampled adult *Ae. albopictus* populations in two neighboring areas in Alexandria, VA. Both areas received education leaflets promoting source reduction but only one area received visits by control professionals who demonstrated source reduction part-way through the season[40]. *Aedes albopictus* declined in the intervention block after these visits and remained lower than in the control block throughout the season. These findings suggest that the specific format of education outreach can alter behaviors and ultimately lower exposure to biting *Ae. albopictus*.

Pest control agencies in the Northeast and greater US have undertaken a blinding array of diverse approaches to educate public of mosquito-prevention behaviors, especially in the years immediately after WNv emergence[12, 40-45]. The CDC made education materials ("Fight the Bite") freely available on the web[46]. Local programs have utilized a wide range of mass media, such as TV, radio, and newspapers, and distributed various promotional items (e.g., cups, t-shirts, stationary)[41, 45, 47]. In some communities, control professionals conduct door-to-door visits[12, 40], hold facility open-days, organize field trips, attend local community events, and develop and disseminate school curricula[41-43]. Despite the cost to support these activities, few agencies have evaluated their effectiveness in influencing public behavior or reducing populations of *Ae. albopictus*[40, 44, 47]. Many strategies also are simply unreported[48]. Some studies are described in trade magazines or at professional meetings[12, 40-44, 47], which are valuable ways to share findings to professionals but can neglect other stakeholders such as community groups.

It is clear that we need to better understand *how* and *why* certain education strategies lead to lasting changes in behavior and others do not. The cornerstone of all environmental sustainability is lasting behavior change. Many studies indicate that enhanced knowledge alone may not impact behaviors[49-52]. More recent approaches have suggested that community-based social marketing is a useful framework to change behaviors. In this framework, promoters identify the activity to be promoted and the barriers to this activity and then design strategies to overcome these barriers[50]. Psychology literature also give us clues as to what tools may be used to change behaviors. These include regular prompts, gaining commitments from participants, developing community norms, and direct personal contact[50]. In regards to source reduction, for example, residents may know that mosquitoes breed in standing water but they may be unaware of all the potential breeding sites in their yard. They may need to be shown where site are and told how often to drain them. The effectiveness of psychology tools in changing human behavior also is affected by the socioeconomic and cultural context. For example, the types of containers in yards may vary with income level (garden receptacles vs. trash). Language of education materials is critical and even the cultural identity of community educators may be important. Thus, any community-based education strategy needs to consider the socioeconomic environment.

While many of the individual parameters of our proposed study have been considered, no studies have integrated the education and socioeconomic into a comprehensive and quantitative effort to develop and evaluate community-based management of *Ae. albopictus* among residents with different socioeconomic and cultural backgrounds. Our study will consider if exposure to *Ae. albopictus* can be explained by socioeconomic and cultural background, and explore how specific educational interventions can reduce such exposure using a stepwise approach (**Fig. 1**).

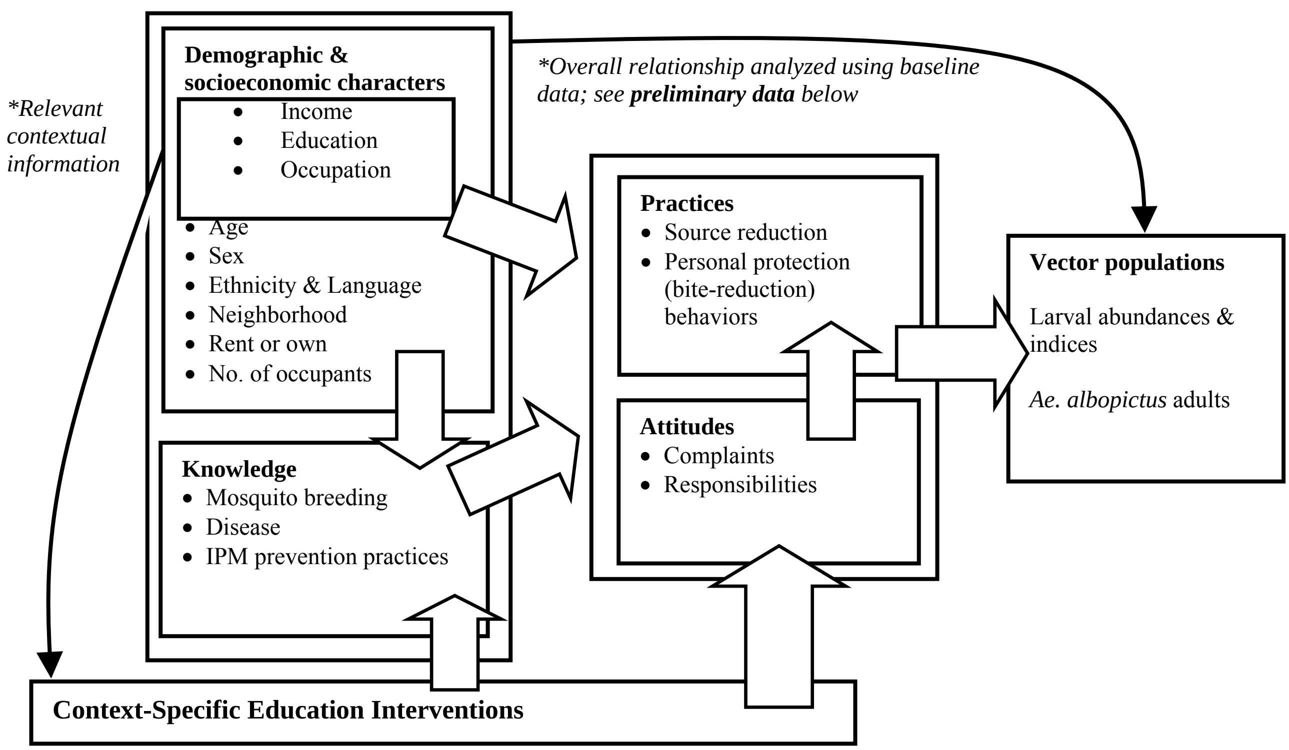

Fig. 1. Diagram of the relationships between socioeconomic status and other demographic characteristics, mosquito knowledge, practices, attitudes, and *Ae. albopictus* populations.

We will improve education strategies by addressing specific barriers to knowledge, attitudes, and prevention practices within the socioeconomic and cultural context and using psychology tools described above to make lasting changes to human behaviors. Our project will build on existing mosquito and social data obtained in 2010 [see **preliminary data**] and existing collaborations with on-the-ground researchers, mosquito-control agencies, and community-groups in Washington DC and Baltimore City [see **letters of support**]. The study proposed here requires considerable multidisciplinary expertise to conduct the mosquito surveys, administer questionnaires, coordinate focus groups and interviews, and develop education materials. By integrating the project in this proposal with these prior studies and existing expertise, we utilize an excellent opportunity for Integrated Pest Management (IPM) strategies to be implemented in historically underserved cities of Washington DC and Baltimore City.

Aedes albopictus is the most common nuisance mosquito in Washington DC and Baltimore, as well as urban areas across in the US[6]. Both cities have high percentages of people living below the poverty line and crime rates well above national averages[53-54]. Amid these serious social and economic issues, poorer residents may receive less mosquito-related education or actively practice mosquito prevention. This is especially problematic as the Baltimore-DC region is at a high risk of imported cases of exotic diseases by being a hub for global travel and trade. Both cities also have high rates of HIV infection in comparison with national averages[55]. Immunocompromised individuals, including those living with AIDS, often exhibit greater vulnerability to vector-borne pathogens than healthy individuals[55]. Developing community-involved mosquito control is particularly important in Baltimore. Baltimore's population has declined 3.0% between 2000 and 2006 and the city has an estimated 17,558 vacant lots[56] that may be sources of adult *Ae. albopictus* to neighbors. Further, Baltimore has no organized or consistent mosquito surveillance or control program due to budget constraints[57]. Washington DC differs from Baltimore in that its population grew by 3.5% between 2000 and 2006, and has fewer vacant lots (3,546)[56]. However, neighborhoods in Washington DC vary considerably in their socioeconomic status[53]. DC has also historically been underrepresented in regional mosquito control activities[27]. In Washington DC, we will evaluate the efficacy of education materials that are mailed to individual households. Our intervention builds on existing outreach by the DC-Department of Health (DC-DOH) (see **letter of support**). In Baltimore, we will both evaluate the efficacy of improved education materials and start a program by which community members will be trained to conduct much of the outreach and monitoring within their own neighborhoods. Given that most agencies simply do not have the resources to create, implement, and evaluate public outreach strategies[40], we think this type of intervention will be effective and of increasing importance throughout the US.

Justification: Most mosquito control programs fail to control *Ae. albopictus,* which readily breeds in urban neighborhoods and is an important vector of WNv transmission to humans. Diminishing municipal budgets mean that residents and property owners increasingly have to accept responsibility to prevent breeding and biting of *Ae. albopictus*. However, despite the perception of wide-spread understanding among US residents, few mosquito control programs have successfully empowered communities to effectively manage this pest. Many residents are unaware of certain microhabitats in their own yards or do not know how to prevent mosquito proliferation and biting[39]. The greatest need for community involvement in mosquito management is in low socioeconomic status urban neighborhoods, where city budgets are limited, and the landscape consists of a patchwork of developed landuses with limited access for municipal control. The focal cities in this project, Washington DC and Baltimore, define our nation's capital region and receive numerous travelers, immigrants and global trade, making it a high risk area for the emergence of mosquito-borne diseases. These cities also house some of our poorest and most vulnerable residents. Washington DC has an underfunded mosquito control program relative to neighboring jurisdictions and Baltimore has no current mosquito control program; thus this project would fill an immediate niche [see **letters of support**]. This project will provide a significant benefit to public agencies in the Northeast and greater eastern US by evaluating and developing strategies to enhance control of *Ae. albopictus.*

Although the focus of this study is towards *Ae. albopictus,* rigorous evaluations of educational materials and strategies can be used anywhere in the country to inform IPM strategies against numerous pest species. More specific information on container-breeding mosquitoes will be valuable to manage other species in the Northeast, *Culex* sp., the invasive *Aedes japonicus* (Asian bush mosquito), and *Aedes triseriatus* are also abundant container species that are important vectors of disease. Further, basic information on education media will be of benefit to any IPM outreach focused on any pest. Without this project, Washington DC, Baltimore and cities throughout the Northeast and the greater US will continue to direct money toward unproven education strategies and fail to sustainably control *Ae. albopictus* and other container-breeding species. The development of community-based education and involvement will promote lasting behavioral changes that are more cost-effective than the status quo.

This study addresses several documented *stakeholder-identified priorities*:

- Community IPM Working Group: (1) Use diverse media to educate the public on implementing IPM in their homes, lawns, and landscapes; and (2) Develop creative tools for measuring the impact of public education related to IPM practices in residential settings on changes in awareness and behaviors of target audience.
- NEREAP-IPM: Urban pest issues including insects and rodents.
- Pest Management Alternatives Program: Develop IPM tactics for critical or emerging pests of regional or national magnitude.

(ii) Objectives and Anticipated Impacts

The overall goal of this project is to advance community-based *Ae. albopictus* management through two main objectives:

Objective 1 (Research): Evaluate the efficacy of community-based education and 'citizen scientist' involvement to control *Ae. albopictus* in urban communities that vary in cultural and socioeconomic background. To achieve this objective we will address three research goals:

(1) Quantify *Ae. albopictus* exposure in individual households/yards and area-wide neighborhood blocks. We will test the hypothesis that residents of varying socioeconomic and cultural backgrounds are exposed to different baseline levels of *Ae. albopictus.* We will also evaluate seasonal variation of *Ae. albopictus* population abundances at each of these scales;

(2) Test the hypothesis that socioeconomic and culture status affects knowledge of *Ae. albopictus* ecology, mosquito-borne disease, and mosquito-breeding and mosquito-bite prevention practices. We will also evaluate whether 'correct' knowledge and perceptions correspond to the use of practices that prevent mosquito breeding and biting; and

(3) Test the hypothesis that improved community education and citizen scientist involvement will improve neighborhood engagement with control practices and ultimately reduce exposure to *Ae. albopictus.*

Objective 2 (Extension): Improve public knowledge of *Ae. albopictus* and promote lasting behavioral changes to minimize its threat among urban communities that vary in cultural and socioeconomic background. To achieve this objective we will pursue 4 extension goals:

(1) Establish a Washington DC-Baltimore City IPM Steering Committee to help project personnel better integrate research methods and findings into extension programs;

(2) Develop and implement improved extension programs with local community groups and agencies to create citizen scientists that drive community-based IPM;

(3) Work with on-the-ground efforts and partners in the Northeast region and greater US to disseminate findings from this project and seed community-involvement strategies in other cities; and

(4) Build high-school and undergraduate student knowledge and awareness of IPM strategies through internships, opportunities to collect data and discuss results with mentoring scientists, and the development of innovative coursework.

Impacts: *Safeguarding human health and the environment*. This proposal will produce knowledge and materials (education items, protocols, strategies) to empower urban communities to practice source reduction and behaviors to prevent adult biting. Outputs from this proposal will promote lasting behavioral change among urban communities and will have a considerable impact on human and environmental health. *Aedes albopictus* is the most important mosquito pest in the Northeast. Container-breeding mosquitoes are substantial pests throughout the US. Nearly 80% of Americans live in urban areas and nearly 60% in cities over 200,000[53]. The development of community programs to reduce sources of *Ae. albopictus* will eliminate dependence on broad-spectrum adulticides such as malathion and synthetic pyrethroids for *Ae. albopictus* control and allow their use only in severe instances of pest or public health need. Overall the outputs of our project will reduce human and other non-target exposure to toxic agents.

Economic benefits. Educating communities to practice source reduction will reduce the number of complaints to mosquito control agencies and result in fewer spraying events. This has significant economic benefits for public agencies and individual residents. For example, as part of a cost share program with county and state agencies, residents pay $20 for four minutes of adult fogging in Queen's Anne County, MD[58]. Some local and state governments currently use a significant part of their public health budget to educate residents about pests but most often do so without ever evaluating the efficacy of their methods and media. Improving education methods and media through quantitative evaluation of efficacy and focus group interviews across socioeconomic classes will help better target funds for education. Overall, minimizing risks from mosquito-borne disease outbreaks, such as WNv, has substantial economic benefits. Outbreaks of WNv have been estimated to cost $20.1-42.3 M[59-60]. Although difficult to measure precisely, days off work and lost productivity due to mild WNv are not accounted for but likely to be substantial.

Implementation of IPM. The proposed study will evaluate and improve a number of individual education media and two overall IPM strategies (mailings vs. community-involvement). We will disseminate these materials and strategies to various stakeholders, which is an explicit goal of this study: **(1)** We will deliver improved materials to 240 and 180 households (approx. 720 and 540 residents) in Washington DC and Baltimore, respectively, within the 3-year duration of the study. These same materials will be made available to appropriate agencies and partners for broader dissemination across both cities, the Northeast, and greater US. **(2)** As part of developing community-involvement we will directly train 6-12 citizen scientists in Baltimore to monitor and control mosquitoes and educate fellow residents. These citizen scientists will be encouraged to participate with our agency partners to share methods and train new citizen scientists in other communities. **(3)** We will conduct a workshop at an International IPM conference (approx. 30 professionals) and make available reports of our findings and protocols to all mosquito-control agencies and IPM professionals in the US via printed booklets and the web so that community-involvement strategies can be implemented beyond the scope of this study. **(4)** All aspects of this study will be integrated into two existing university classes, each consisting of 30 students per year, to promote the adoption of IPM strategies in the future generation of scientists. **(5)** By establishing a DC-Baltimore IPM Steering Committee, we will help the growth of IPM in this historically underserved region and enhance collaboration of existing expertise.

(iii) Approach and Procedures

Our overall approach is to build on 'pre-intervention' data collected in Washington DC in 2010 (described below) by administering an education intervention at the scale of individual households (i.e., mailed materials) and repeating sampling of the same households to collect 'post-intervention' data. Using focus groups and interviews, we will then improve these education materials and include them in an intervention study at the scale of whole neighborhood blocks in Baltimore City that also involves implementing a citizen scientist program.

Collection of baseline data in Summer 2010: In the Summer 2010, we administered a knowledge, attitudes, and practices (KAP) questionnaire (Protocol #2009-429) and surveyed of all mosquito-breeding habitats in 240 households in Washington DC. Forty households were randomly selected in each of six neighborhoods that varied in house type and socioeconomic and cultural background. We selected neighborhoods from geo-demographic clusters defined by the PRIZM model developed by Claritas Inc (now owned by Nielsen Systems) (http://www.claritas.com/MyBestSegments/Default.jsp) to capture the range within Washington DC. The PRIZM model is based on US census data and is a widely used customer segmentation system for marketing in the US. We chose neighborhoods of each house type that represented high, medium, and low socioeconomic status' found in DC (**Table 1**).

Table 1. Key demographic characteristics of study neighborhoods in Washington DC in which baseline mosquito and KAP survey data was collected in 2010. *denotes income and education data from our KAP surveys of individual households. #denotes data collected from 1999 US census. Note that ethnicity and language data will be collected from individual households in 2011.

Neighborhood	House type	Most common household income ($)*	Most common education class*	% African American	% Spanish speaking
Shepherd's P., DC	Stand alone	>120,001	Grad. degree	40.1	4.6
Silver Spring, MD	Stand alone	45,001-120,000	Coll. degree	72.2	7.8
Deanwood, DC	Stand alone	<45,000	High S. or less	97.8	11.1
Georgetown, DC	Row	>120,000	Grad. degree	4.0	8.9
Petworth, DC	Row	45,001-120,000	Coll. degree	80.6	11.6
Trinidad, DC	Row	<45,000	High S. or less	78.0	10.2

Ten households in each neighborhood were surveyed in four 2-week periods from late May to late August (10 houses x 4 periods x 6 neighborhoods = 240 total). Teams of 2 researchers visited each household and administered the questionnaire before gaining permission to survey for mosquitoes on the property. The KAP questionnaire consisted of 14 questions on the knowledge, attitudes, and perceptions of mosquitoes and 9 questions on demographic background (**Fig. 1**). Knowledge of mosquitoes was measured by asking questions on mosquito ecology, common infected animals, disease symptoms, and source reduction and personal protection. Attitudes and perceptions were measured by asking questions about the importance of mosquito-vectored diseases, seriousness of pest mosquitoes, responsibility for mosquito control, and if current agency control is sufficient. Questions were open ended, derived from existing questionaires[39, 61], and tested on subjects before the survey.

Mosquito surveys consisted of inspecting every water-holding container in each yard. We used a specially constructed pump on an extendable handle to extract water from difficult-to-reach locations. Data on a range of physical, chemical and biological parameters of each container were also collected, including size, volume, shade, and a range of water chemistry parameters (including total dissolved solids, pH, Nitrate, Ammonia, Phosphate [using Hach test-strips]). Container water was homogenized and up to 1-L sampled from each container. Total mosquito numbers were calculated for each container. Overall mosquito numbers have been compiled so far and we present one key finding here. We analyzed relationships between demographic variables (**Fig. 1**) and total numbers of water-holding containers and mosquitoes per household using general linear models (GLMs) to examine if socioeconomic and cultural background was related to source reduction and larval mosquito populations. In univariate tests, education, income, occupation, sex, neighborhood, ownership status (rent/own) and numbers of occupants ($P<0.10$), but not ethnicity ($P>0.250$), were related to numbers of containers and total mosquitoes per yard ($\alpha=0.10$), and were included in multivariate analyses with sample period and all two-way interactions. Initial multivariate models showed no significant interactions and these were removed. Least significant variables were then removed from models in a backward stepwise procedure until models lost significant fit compared to the previous model. This procedure also controlled for collinearity between predictor variables. In the final models, there was a significant effect of education on both numbers of containers ($F_{3, 150}=2.94$, $P<0.036$) and total mosquitoes ($F_{3, 150}=3.65$, $P<0.013$), with higher education households having fewer

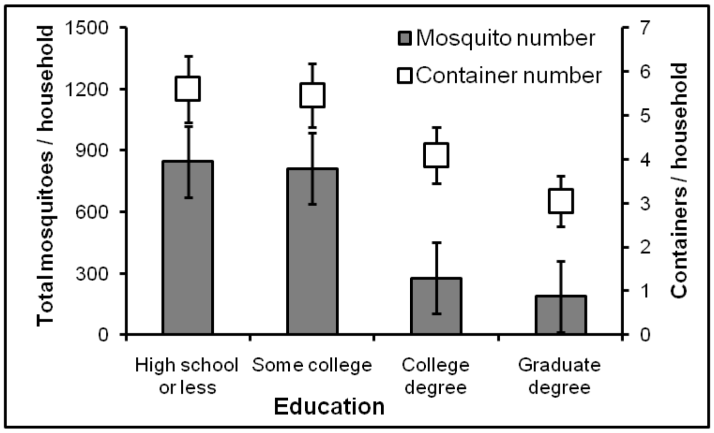

Fig. 2. Least squares means of numbers of larval mosquitoes and water-holding containers found per household by highest education level during door-to-door visits in six neighborhoods in Washington DC in 2010.

<u>containers and mosquitoes (**Fig. 2**). All other variables were not significant in multivariate models (*P*>0.350).</u>

There are a number of tentative conclusions we can make from these initial analyses: **(1)** Higher education households have lower exposure to mosquitoes presumably because they appear to practice better source reduction. Indeed, numbers of mosquitoes and numbers of container habitats among households is positively correlated (Spearman rank: r_{240}=0.464, *P*<0.0001). **(2)** Since education level is clearly important to mosquito exposure, mosquito-related education inventions, and their effectiveness, are likely to impact attitudes and mosquito-prevention practices. **(3)** Other demographic variables are also clearly related to source reduction and mosquito numbers but likely interrelated. **(4)** Multi-season data, investigating relationships between individual demographic variables, and investigating the relationships between knowledge, attitudes, and practices in intervention and non-intervention settings will likely yield interesting and important results. Speciation of larval specimens will be completed by the end of 2010 and the data re-analyzed to determine if preliminary trends are consistent among individual mosquito species, including *Ae. albopictus*. To explore these relationships we will use Chi-square tests, binary logistic, ordinal regressions, and other multivariate procedures (Multi-dimensional scaling, cluster analysis, PCA), in addition in GLM.

Timetable & Management: Research-extension coordination will be the responsibility of the PDs in collaboration with the DC-Baltimore Steering Committee.

				Complete by quarter											
Stage	**Objective**	**Goal**	**Tasks**	**2011**				**2012**				**2013**			
1	1	1	Baseline data collection in DC	Completed in 2010											
2	2	1	Establish Steering Committee	■		■		■		■		■		■	
3	1	1,2,3	Mail initial education materials in DC	■											
		1,2,3	Post-intervention data collection		■	■			■	■					
5	1	4	Focus groups in DC			■	■			■	■				
6	2	2	Research analysis and Improve materials				■	■			■	■			
7	1	1	Baseline data collection in BC		■	■									
8	1 2	1,2,3 2	Implement community-scientist program in BC (including trainings)					■	■	■			■	■	
9	2	3	Focus groups & Interviews in BC								■	■			
10	2	4	Disseminate Knowledge						■	■				■	■

<u>Stage 2: Steering Committee.</u> We will establish a DC-Baltimore City Steering Committee consisting of all the PDs and representatives from various community stakeholders, including but not limited to local IPM extension researchers, residents, and local mosquito control agencies.

Residents outside the study areas will be recruited to avoid confounding our research activities. This Committee will undertake half-yearly meetings to identify broad strategies to help implement our project and better integrate research outputs into extension programs and disseminate our findings. Meetings will be held via conference call and chaired by PD Leisnham. Additional correspondence will circulate via email with PD Leisnham keeping records. We do not expect all members to be available for all meetings but to create a network of IPM stakeholders that can share ideas to advance mosquito control in the DC-BC area. Collaborators Mary Kay Malinoski, a member of the Community IPM Working Group, and Vicky Carrasco, Chair of the Latinos and Planning Division of American Planning Association will be influential in supporting our efforts and maintain this Committee (see **support letters**).

Stages 3 & 4: Washington DC Intervention. We will conduct a Before, After, Control, Intervention (BACI) study to test the effect of a standard education campaign on household knowledge, attitudes, and mosquito-prevention practices. The observational units will be the 240 households visited in 2010. Data collected in 2010 will serve as baseline or 'before' data in this proposal. Our intervention will involve mailing educational materials (intervention) in English or Spanish to half of all the households in each neighborhood during Spring 2011, before the mosquito summer breeding season. The other half of all households will receive no intervention (control). Education materials will consist of items commonly used in prior education campaigns: educational leaflet, 12"-ruler, 200-leaf notepad, fridge magnet, and 12-month calendar that we expect will vary in their permanence (**Fig. 2**). During 2011 and 2012 summers, we will re-visit all households at approximately the same time of year as surveyed in 2010. A new KAP questionnaire will be created based on the 2010 questionnaire to allow comparisons of intervention vs. non-intervention settings. Some questions may be deleted or added dependant on the advice of the DC-BC steering committee. If residents are not present when we visit, we will return twice during a 48-hr period. Based on the success of this strategy in 2010, we are confident that we will be able to re-survey almost all households in both seasons. In 2010, personnel avoided informing residents of prevention practices or showing them collections from their backyards to minimize influencing future behaviors. BACI designs are the most powerful study design available to evaluate changes in mosquito and KAP indices due to a public health intervention but have been rarely used in *Aedes* control programs in the US or overseas[32]. By already developing trust with residents and sampling households in 2010, we have an excellent opportunity to undertake this powerful test of education materials. We also expect residents to complete any unanswered demographic questions with repeat visits.

Using GLM within the BACI design, we will test for differences in mosquito and KAP indices between Control (i.e., no education materials) vs. Intervention (i.e., education materials) treatments and between the Before (2010) and After years (2011, 2012). Logistic and ordinal regressions will be used to test the effect of educational interventions on questionnaire scores. Analyses will follow a stepwise approach (**Fig. 1**) to analyze relationships between socioeconomic status and other demographic variables, knowledge, practice, and mosquito populations. Residents will also be asked questions about the effectiveness of education materials and different media to help guide focus groups in Stage 5 of our project.

Stage 5: Focus Groups in DC. In Summer and Fall 2011, researchers will recruit residents from intervention households in each Washington DC neighborhood for participation in focus groups designed to gauge the effectiveness of each of the educational items in the intervention and other prototype designs. Separate focus groups will be held for each neighborhood in order to determine whether the distinct cultural and socioeconomic characteristics of these communities shape responses to educational interventions. To randomize recruitment, letters of invitation will be sent to randomly selected households from the intervention group in each neighborhood until 10 residents have agreed to participate. In addition to discussing the effectiveness and appropriateness of educational materials, focus groups will discuss whether residents encountered difficulties in implementing source reduction activities prescribed by the educational materials. Residents will also be asked to evaluate and discuss different mass media as tools for mosquito education showing current examples in the Northeast and greater US, including by not limited to agency web-pages (e.g., DC-DOH, Fairfax Co.), Twitter, Facebook (Community IPM page), and TV, newspaper, and radio segments. Residents will also be asked whether they require additional support from other community institutions or stakeholders such as health and housing code enforcers, city public works departments, or landlords. Focus group proceedings will be recorded digitally and transcribed and the feedback used to redesign educational messages and materials.

Because of the wide variety of educational materials we plan to test, it would be impractical to test for the effects of individual materials via a BACI design. Focus groups are an efficient means of seeking feedback on social marketing campaigns but have been rarely used in mosquito IPM. The interpersonal setting of a focus group that involves several members of the same community helps elicit comments and insights that are less likely to emerge in individual interviews or surveys. Transcripts from focus groups and interviews will be analyzed for content to identify the most effective educational messages and materials; and to identify mosquito control activities and procedures that residents found difficult to complete.

Stage 6: Develop improved education materials. Results from KAP surveys and focus groups in 2011 will be used to inform the revision of education materials. Improved materials will be distributed to intervention households in Baltimore in Stage 7 & 8. Concurrently, various mass media (TV, radio, newspaper, webpages) will be developed but will not be made available until after the Summer of Year 3 to avoid 'polluting' treatments in the Baltimore control groups. Improvements made to educational materials will be dependent on focus group results, but possible improvements might include messages more sharply focused on disease risks and vulnerabilities, clearer directions for source reduction activities, and references to other stakeholders that can help support source reduction.

Stage 7 & 8: Implement 'citizen scientist' program in Baltimore. Six neighborhoods (defined at the scale of a city block) in Baltimore will be selected for study; 3 each from high and low socioeconomic status neighborhoods. All six neighborhoods will be selected from within the Watershed 263 boundaries in west and southwest Baltimore to minimize spatial differences between blocks. These neighborhoods generally have a residential block structure that includes up to 20-30 row homes attached around a common green or open space, although individual yards may be defined in some cases. We aim to take advantage of this clustering to test treatments at the scale of the full city block using a clustered BACI design, which is the most powerful design for area-wide intervention studies[62]. In each year of the study, 5 households in each neighborhood block will be surveyed each week over 6 weeks in July and August so that all

30 houses in each block are visited once. Resident participation will be recruited to maximize coverage within the block (at least 10 households). In 2011, baseline or pre-treatment mosquito and behavior data will be collected by teams of researchers who will administer KAP surveys and sample for mosquito breeding habitat and larvae as described in DC-based protocol.

In Winter 2011-2012, PDs Hagar and LaDeau and Parks and People Foundation (PPF) will organize community workshops to train and engage interested citizen scientists from these neighborhood blocks to identify potential breeding habitats and mosquito larvae and disseminate information to fellow residents. Especially engaged and competent catalysts (~1 or 2 per neighborhood) will be recruited to be 'citizen scientists' and will be trained to implement further sampling for larvae and potential breeding habitats and assist researchers with adult surveillance using BG-Sentinel traps™ (see below). In late Spring, 2012, all households in one replicate block per socioeconomic status (~60 households, total) will receive the 'improved' education materials developed after outcomes of the DC-based Focus Groups. A third replicate block of each socioeconomic status (~60 households, total) will have regular visits from citizen scientists. Visits by citizen scientists will demonstrate to residents how to find and empty real or potential breeding habitats and practice mosquito-bite prevention practices. They may be any interested residents from the broader neighborhood but will not be residents from either of the other two blocks. The frequency of visits by citizen scientists will be determined after discussion with the researchers. Their ability to maintain continued dissemination and sampling will be one evaluation criterion for success of the program. One replicate block per socioeconomic status will serve as the control and receive no interventions. In 2013, we will repeat sampling and encourage the continuation of citizen scientist participation. We will compare mosquito and KAP indices between before and after intervention treatments and between intervention and control treatments using BACI design in a GLM framework.

Adult abundance. Larval mosquito control programs are ineffective if they do reduce adult mosquitoes. Adult abundance will be measured in Baltimore neighborhoods with BG-Sentinel™ mosquito traps during all three years of the project. The neighborhood level replication in Baltimore allows area-wide comparisons of *Ae. albopictus* that individual household surveys in DC do not. BG-Sentinel trap uses lures specially designed to attract *Ae. albopictus* adults and studies have shown it to be highly effective and superior to other traps at sampling *Ae. albopictus* adults[63]. Traps will be placed in four randomly selected backyards in each neighborhood during August when *Ae. albopictus* is at its peak abundance. Adult mosquitoes will be collected, indentified, enumerated, and mean abundance calculated by dividing the total number of *Ae. albopictus* by the number of traps. This procedure will be repeated at 72 hr intervals for 2 weeks. Statistical differences between before and after and between control and intervention treatments will be tested. Leisnham and LaDeau labs will supply traps.

Stage 9: Focus Groups and Interviews in Baltimore. In Summer and Fall of 2012 (the first post-intervention year in the Baltimore study), researchers will convene a focus group representing each neighborhood involved in the community-based intervention, according to the same recruitment procedures used in DC. The focus groups will be used to gauge the effectiveness of various educational materials, community-based activities, and the need for additional support for other stakeholders. Results and feedback from these focus groups will be compared with those from DC in order to assess the benefit of community-based approaches for delivering educational messages and providing support for residents to undertake source reduction and bite-prevention behaviors. In 2013, researchers will conduct in-depth interviews with each community scientist to determine challenges and successes with motivating and educating fellow residents. Citizen scientists will also be asked whether they require additional support from other community institutions or stakeholders such as health and housing code enforcers, city public works departments, or landlords. Interviews will be recorded digitally and transcribed and the feedback used to redesign educational messages, materials, and procedures for community-based programs. Parks and People Foundation will lead efforts to disseminate community results and needs to appropriate Baltimore agencies and involve stakeholders, as applicable.

Stage 10: Dissemination of Protocols and Results. All materials and protocols will be assembled into a booklet that will be sent to all stakeholders in the Northeast. Concurrently, all the materials will also be posted on the University of Maryland IPM-Extension and eXtension websites (http://www.extension.org/), along with supplementary information learned to educate stakeholders in other parts of the US where mosquitoes are pests. Advice for appropriate dissemination to on-the-ground stakeholders in the greater Northeast and US will be guided by the DC-Baltimore Steering Committee. In addition to presenting research results, PD Leisnham intends to organize a workshop in community-based pest control at the International IPM Conference in Memphis, TN in Year 2, as a way to help professional development. We envisage costs will be covered by participants; thus we request for none in this proposal. By the end of Year 3 the PDs expect to have 2 publications submitted to peer-reviewed science journals.

Building Student Knowledge and Awareness of IPM strategies. Undergraduate interns will have the opportunity to conduct small research projects under the direct supervision of the co-PDs. There will be two main sources of undergraduates in this project: **(1)** The multidisciplinary Gemstone Program at UMCP (www.gemstone.umd.edu/about/index.html); **(2)** two internships in The Department of Environmental Science and Technology at the University of Maryland College Park funded from this project. These sources will collect a diverse pool of motivated students capable of collecting data relevant to the research of this project. The Gemstone program explores the interdependence of science and technology with society, thus it aligns well with the thrust of this project. In addition, pre-college students will also be encouraged to participate. Students from Montgomery Blair High School Magnet Program will be given the opportunity to volunteer to help on the project. PD Leisnham successfully advised a Montgomery Blair High student in 2010 data collection on a small part of the overall project (see **letter of support**). PD LaDeau has shared mosquito data with the Education Department of the Baltimore Ecosystem Study to support curriculum development for high school and middle school students. BES Education team will continue to work with LaDeau to involve local students in place-based mosquito ecology and control/bite protection strategies (see **letter of support**).

All aspects of this project will be integrated into courses taught at UMCP and UMBC, including, for example, ENST/MEES 436: Emerging Environmental Threats and ENST689: Invasion Ecology in the Department of Environmental Science and Technology, UMCP and 429/629: Seminar in Environmental Health and 400/600: Field Course in Environmental Justice in the Department of Geography and Environmental Systems, UMBC. The main assessment of ENST689 is a small research practicum and students will be given the opportunity to integrate their practicum into the data collection and management of this project, under the direct supervision of the PDs.

(iv) Evaluation Plans

Objective 1 (Research): We will evaluate the efficacy of community-based education and 'citizen scientist' involvement to manage *Ae. albopictus* in urban residential environments that vary with socioeconomic status. We will evaluate our success primarily by comparing numbers of potential breeding containers and larval and adult mosquito abundances in intervention vs. non-intervention settings. More specifically, we will use standard BACI methods to statistically compare the change in abundance associated with the education mailings, the community involvement interventions, and the control groups, blocking each group of replicates according to socio-economic category. We will initially (after Year 1) be able to quantify the strength of the relationship (if any) between socioeconomic ranking and *Ae. albopictus* exposure within and between our study neighborhoods. In Years 2 and 3 we will be able to also evaluate the sustainability of a one-year intervention (of mailed education material and community involvement). Finally**,** we will use focus groups and interviews to evaluate the efficacy of individual education materials and citizen scientist strategies and better understand any interesting or unexpected findings from the KAP survey.

Objective 2 (Extension): Intervention success, focus groups and interviews will be used to evaluate education materials and strategies. Reduced numbers of breeding habitats, larval mosquitoes and adult mosquitoes in each season following intervention (as compared with similar data from control sites) will be indicative of successful intervention strategies. Chemical and Cost analyses: This project is expected to reduce the use of chemicals and economic costs associated with the control of *Ae. albopictus*. Elimination of breeding habitats will suppress the larval population and will substantially reduce the adult population. Increased knowledge and source reduction practices by residents will lead to fewer visits, reduced surveillance, and less application of adulticides by agency professionals. For most agencies to justify the application of pesticides, mosquito populations must meet or exceed a minimum adult density (usually after public complaints initiate additional adult surveillance in an area)[64]. For example, in Maryland, the minimum light trap (BG-Sentinel Traps™ for *Ae. albopictus*) collection to warrant ground spraying is 12 female mosquitoes per night[64]. By comparing intervention vs. non-intervention settings in Baltimore, we can estimate reductions in costs related to misused surveillance, numbers of adulticiding events, and education interventions for various agencies. Our goal will be to reduce total costs for a particular area by 50%. We will collaborate with the DC-DOH and MD-Ag for this cost analysis [see **letters of support**]. Performance Indicators for this project are outlined in the Logic Model below.

(v) Key Personnel

PD Leisnham will coordinate the entire project and direct the Washington DC intervention study; PDs LaDeau and Hager will coordinate the intervention study in Baltimore, and with Parks and People Foundation Staff, organize community involvement in Baltimore neighborhoods. PD Biehler will organize Focus Groups and Interviews with public from both cities and help develop the questionnaire that will evaluate the effectiveness of education interventions.

Focus Area: **Community IPM**; Impact Area: **Washington DC and Baltimore City, Northeast region, greater US**

Roadmap Goal: **Reduce exposure of urban residents to the Asian tiger mosquito & other pest mosquitoes through community-based education and involvement**

		Impacts		
Inputs	Audience Activities	Short Term (Knowledge Change)	Intermediate Term (Behavior Change)	Long Term (Condition Change)
• People time and skills • Existing mosquito and KAP survey data • Interagency Cooperation • Collaborations with DC-DOH, MDAg, Georgetown Uni. • In-kind resources, including infrastructure, supplies, material development, information delivery, and support • Existing student IPM internships • Volunteers	**Audience** • Public • Mosquito control professionals • Government agencies • Scientific & Extension communities **Activities** • Creation of DC-BC Steering Committee • Print/Electronic materials • Household visits, including collection of biophysical data and administration of KAP questionnaires • Focus groups & Interviews • Training sessions of citizen scientists • Conference workshops & presentations • Peer-reviewed publications & reports • Summary Report/Workbook • Develop web-page material • Non-formal trade magazines	**Indicators** • Increase public awareness of invasive mosquito ecology and disease risks in urban backyards and other habitats. • Increase public awareness of low-risks to the environment and human health and economic benefits of IPM measures: source reduction and bite-prevention. • Increase general public understanding of IPM/IMM. • Increase public awareness of increased safety of targeted DEET use. • Increase citizen scientist understanding of effective strategies to motivate fellow residents **Measures** • Measured improvements of public knowledge of mosquito ecology, diseases, and prevention practices from KAP data using Before-After-Control-Intervention (BACI) designs and focus groups and interviews • Measured increased knowledge gain and attitudinal change with improved vs. standard education materials (KAP and focus group data) • Increased year-to-year access rates of web-material	**Indicators** • Reduced numbers of potential mosquito breeding habitats in yards and neighborhoods • Increased use of source reduction activities among public • Increased personal protection practices by public • Increased discussion of mosquito ecology, disease risk, and prevention practices among residents (especially in Baltimore). • Active citizen scientist program, including use of Twitter & Facebook **Measures** • Measured reductions of surface area and volume of potential mosquito breeding habitat using BACI (source reduction; mosquito survey data) • Measured increase in numbers of residents practicing bite-prevention practices (KAP data) • Measured reductions in numbers of residents limiting their outdoor social activities (KAP data) • Measured reduction in complaints (KAP & Agency data) • Measured adoption of education materials and involvement strategies by control agencies • Measured within-year & year-to-year increase in activity of citizen scientists (e.g., visits, use of web-media to educate fellow residents)	**Reduced exposure of public to *Ae. albopictus* & other pest mosquitoes at all socioeconomic levels** • Decreased abundance of mosquito larvae in yards, neighborhoods. • Decreased abundance of biting adults in yards & neighborhoods. • Reduced disease risk associated with mosquito transmission • Reduced nuisance complaints • Improved education strategies and materials **Measures** • Measured reduction of larval and adult mosquito indices & abundances at the household and/or neighborhood block scales • Estimated reduction in adulticides use from reduced • Estimated 50% reduction in costs to public agencies because of projected fewer visits, reduced surveillance and application of adulticides by mosquito professionals. • Measured year-to-year increase in citizen-science recruitment of additional residents.

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(b) Project title: Management of the Asian tiger mosquito in socioeconomically diverse urban neighborhoods through community-based education and involvement

(c) Project type: Joint Research-Extension Community IPM project

(**d) Project summary:** This project advances community-based management of the Asian tiger mosquito, *Ae. albopictus,* in urban neighborhoods with diverse socioeconomic and cultural backgrounds. *Aedes albopictus* is the most common human-biting mosquito in urban areas and is important in West Nile transmission. Abatement efforts by public agencies are ineffective because this species breeds in obscure water-containers spread across private-access land. This project will conduct: (1) research to identify mosquito exposure and evaluate education materials and 'citizen science' management strategies; and (2) extension with stakeholders to develop and implement mosquito management strategies appropriate for different socioeconomic and cultural contexts. This Integrate Pest Management (IPM) approach will reduce numbers of containers and adult mosquitoes by promoting lasting behavior change. It will reduce the use of temporary and ineffective adulticides by control programs. Mosquito populations and knowledge, attitudes, and practices of householders in Washington DC and Baltimore City, MD will be compared between intervention and non-intervention settings using entomological and human surveys in a powerful BACI (Before-After-Control-Intervention) design. Focus groups and interviews will evaluate individual materials and strategies. Evaluations will inform the development of improved education materials and strategies targeted for specific socioeconomic and cultural contexts. Workshops, materials, and publications will disseminate knowledge to Northeastern, national and international audiences to foster broader implementation of our community-based management strategies. This project addresses the priorities of the NEIPM's Community IPM working group, which include using diverse media to educate the public on implementing IPM in their homes, lawns, and landscapes, and developing creative tools for measuring the impact of public education related to IPM practices in residential settings on changes in awareness and behaviors of target audiences.

Problem: *Aedes albopictus* is an important pest and serious public health threat in the Northeast and greater Eastern US. This species is one of the fastest invading animals worldwide and has adapted to breed in a vast array of water-holding receptacles in urban environments, including birdbaths, flowerpots, guttering, pipes, cans and other trash. *Aedes albopictus* established in the continental US in the mid-1980s. Since then it has spread to more than 30 US states and is continuing to expand its range. *Aedes albopictus* has established in CT, DE, MA, MD, NJ, NY, PA, WV and the District of Columbia (DC). Climate change is likely to increase its expansion northward and facilitate the colonization of RI, NH, VT, and ME. *Aedes albopictus* was first detected in RI in 2010. Female *Ae. albopictus* readily inflict painful bites, induces dermatological and allergic manifestations, and negatively affects the quality of life and wellbeing of Americans. *Aedes albopictus* is naturally infected with serious human pathogens, including West Nile virus (WNv), dengue virus, and chikungunya virus. The 2001-02 outbreak of dengue in Hawaii, with 95 infections, illustrates the potential for *Ae. albopictus* to circulate dengue virus that originated from imported cases. In 2010, 355 dengue cases were imported into the US, including 86 in the Northeast. Conventional mosquito abatement methods used by public agencies do not control *Ae. albopictus.* The application of ultra-low volume pesticides to kill adults applies materials in the evening. Because *Ae. albopictus* are most active during the daytime these pesticides are ineffective. Larvicides are effective when applied to breeding habitats but treatment of containers is impractical because they are too numerous. Truck-mounted applications do not reach all target containers. The only effective control of *Aedes* is to remove and drain water-holding containers. But public agencies do not have the resources or the legal authority to do this over large areas.

Background: Funding for mosquito control is stagnant and increasingly under threat of severe budget cuts. Most US cities cannot afford source reduction programs or routine spraying. Complaints by residents of nuisance mosquitoes do not warrant control by most control programs. Residents must bear an increasingly substantial responsibility for source reduction and practice personal protection (i.e., use repellent, wear covering clothing, avoid certain areas). Community education and intervention programs to control urban container-breeding mosquitoes have been undertaken in the US and overseas, but few are evaluated for their effectiveness in influencing public behavior, reducing breeding habitats, and minimizing exposure to mosquito populations. Most interventions go unreported or poorly designed. We need to better understand *if, how* and *why* certain education strategies lead to lasting changes in behavior and others do not. Psychology literature gives us clues to as to what tools may be used to change behaviors. These include regular prompts, gaining commitments from participants, developing community norms, and direct personal contact. The effectiveness of these tools is highly affected by the socioeconomic and cultural context. No studies in the US have rigorously considered the socioeconomic and cultural context in community-based mosquito control. Our study will test if public exposure to *Ae. albopictus* can be explained by socioeconomic and cultural context, and explore how education interventions can reduce such exposure among these different contexts.

Justification: Most mosquito control programs fail to control *Ae. albopictus.* Diminishing agency budgets mean that residents have to accept responsibility of managing this pest. Despite the perception of wide-spread understanding among Americans, few mosquito control programs have successfully empowered communities to effectively reduce its breeding and practice personal protection. Many residents are simply unaware of certain breeding sites in their own yards and the effort needed to minimize *Ae. albopictus* exposure. The cities being studied in this project, Washington DC and Baltimore, MD, constitute a hub for international travel and trade making it a high-risk area for imported mosquito-borne diseases. These cities also house some of our poorest and most vulnerable residents to disease and bites. Characteristic of many US cities, Washington DC has a limited mosquito control program. Baltimore has no mosquito control program. Thus, this project would fill an immediate niche in underserved populations. This study addresses several documented stakeholder-identified priorities, including: (1) Community IPM Working Group: Use diverse media to educate the public on implementing IPM in their homes, lawns, and landscapes; and develop creative tools for measuring the impact of public education related to IPM practices in residential settings on changes in awareness and behaviors of target audience; (2) NEREAP-IPM: Urban pest issues including insects and rodents; (3) Pest Management Alternatives Program: Develop IPM tactics for critical or emerging pests of regional or national magnitude.

Objectives: Obj. 1. Research - Evaluate the efficacy of community-based education and 'citizen scientist' involvement to control *Ae. albopictus* in urban residential environments that vary with socioeconomic status. To achieve this objective, we will disseminate education materials to selected households in Washington DC and establish neighborhood-scale community-based education and involvement programs in Baltimore City, MD. Mosquito populations (larvae and adult) and the knowledge, attitudes, and prevention practices (KAP) of households will be compared between intervention and non-intervention settings by re-surveying households over multiple seasons in a powerful BACI (Before-After-Control-Intervention) design. Follow-up focus groups and interviews will evaluate individual materials and strategies in detail. **Obj. 2. Extension -** Improve public knowledge of *Ae. albopictus* and promote lasting behavioral changes to minimize its threat among urban communities that vary in cultural and socioeconomic background. To achieve this objective we will use information from KAP surveys, focus groups, and interviews to improve community education materials and involvement strategies appropriate for variable socioeconomic and cultural contexts to be re-evaluated. We will partner with various stakeholders to help implement this IPM strategy on local and broader scales (see **Main Impacts**).

Main Impacts: *Safeguarding human health and the environment*. *Aedes albopictus* is the most important mosquito pest in the Northeast and greater Eastern US, but outputs of this project can also be used anywhere in the country to reduce urban container-breeding mosquitoes. According to the US Census Nearly 80% of Americans live in urban areas and nearly 60% in cities over 200,000. Low-income urban communities, which constitute 3.3M people in the Northeast, have underserved IPM programs. The development of socioeconomic and culturally appropriate education programs to reduce sources of *Ae. albopictus* and other urban mosquito pests will restrict the use of broad-spectrum adulticides for urban mosquito control to only severe circumstances. The outputs of our project will reduce human and other non-target exposure to toxic agents. *Economic benefits.* Educating communities to practice source reduction and personal protection will reduce the number of complaints to mosquito control agencies, and result in less reactionary monitoring and spraying events that cost money. Tailoring improved intervention strategies for different socioeconomic and cultural contexts will better use public funds. Outbreaks of WNv in the US have been estimated to have cost $20.1-42.3 M. Although difficult to quantify, lost workdays and productivity due to mild WNv, usually misdiagnosed as "flu" or "summer cold", are estimated to be substantial. *Implementation of IPM.* The proposed study will evaluate and improve a number of individual education media and strategies. We will disseminate improved materials to 240 and 180 households (~720 and 540 residents) in Washington DC and Baltimore, respectively. As part of developing community-involvement, we will train 6-12 citizen scientists to monitor and control mosquitoes and educate fellow residents. We will conduct a workshop at the International IPM conference in 2012 (~30 professionals) and make available reports of our findings and protocols to all mosquito-control agencies and IPM professionals in the US through print and web-based materials so that our strategies can be implemented beyond the scope of our study sites. All aspects of this study will be integrated into two existing university classes each consisting of ~30 students/year to promote the adoption of IPM strategies in future generations of professionals. By establishing a DC-Baltimore Steering Committee, we will also help the growth of IPM in this historically underserved region, enhance collaboration of existing expertise, and facilitate new partnerships relevant to IPM. Specific impacts are detailed in the logic model below.

Focus Area: **Community IPM**; Impact Area: **Washington DC and Baltimore City, Northeast region, greater US**

Roadmap Goal: **Reduce exposure of urban residents to the Asian tiger mosquito & other pest mosquitoes through community-based education and involvement**

		Impacts		
Inputs	Audience Activities	Short Term (Knowledge Change)	Intermediate Term (Behavior Change)	Long Term (Condition Change)
• People time and skills • Existing mosquito and KAP survey data • Interagency Cooperation • Collaborations with DC-DOH, MDAg, Georgetown Uni. • In-kind resources, including infrastructure, supplies, material development, information delivery, and support • Existing student IPM internships • Volunteers	**Audience** • Public • Mosquito control professionals • Government agencies • Scientific & Extension communities **Activities** • Creation of DC-BC Steering Committee • Print/Electronic materials • Household visits, including collection of biophysical data and administration of KAP questionnaires • Focus groups & Interviews • Training sessions of citizen scientists • Conference workshops & presentations • Peer-reviewed publications & reports • Summary Report/Workbook • Develop web-page material • Non-formal trade magazines	**Indicators** • Increase public awareness of invasive mosquito ecology and disease risks in urban backyards and other habitats. • Increase public awareness of low-risks to the environment and human health and economic benefits of IPM measures: source reduction and bite-prevention. • Increase general public understanding of IPM/IMM. • Increase public awareness of increased safety of targeted DEET use. • Increase citizen scientist understanding of effective strategies to motivate fellow residents **Measures** • Measured improvements of public knowledge of mosquito ecology, diseases, and prevention practices from KAP data using Before-After-Control-Intervention (BACI) designs and focus groups and interviews • Measured increased knowledge gain and attitudinal change with improved vs. standard education materials (KAP and focus group data) • Increased year-to-year access rates of web-material	**Indicators** • Reduced numbers of potential mosquito breeding habitats in yards and neighborhoods • Increased use of source reduction activities among public • Increased personal protection practices by public • Increased discussion of mosquito ecology, disease risk, and prevention practices among residents (especially in Baltimore). • Active citizen scientist program, including use of Twitter & Facebook **Measures** • Measured reductions of surface area and volume of potential mosquito breeding habitat using BACI (source reduction; mosquito survey data) • Measured increase in numbers of residents practicing bite-prevention practices (KAP data) • Measured reductions in numbers of residents limiting their outdoor social activities (KAP data) • Measured reduction in complaints (KAP & Agency data) • Measured adoption of education materials and involvement strategies by control agencies • Measured within-year & year-to-year increase in activity of citizen scientists (e.g., visits, use of web-media to educate fellow residents)	**Reduced exposure of public to *Ae. albopictus* & other pest mosquitoes at all socioeconomic levels** • Decreased abundance of mosquito larvae in yards, neighborhoods. • Decreased abundance of biting adults in yards & neighborhoods. • Reduced disease risk associated with mosquito transmission • Reduced nuisance complaints • Improved education strategies and materials **Measures** • Measured reduction of larval and adult mosquito indices & abundances at the household and/or neighborhood block scales • Estimated reduction in adulticides use from reduced • Estimated 50% reduction in costs to public agencies because of projected fewer visits, reduced surveillance and application of adulticides by mosquito professionals. • Measured year-to-year increase in citizen-science recruitment of additional residents.