OMB Number: 4040-0001
Expiration Date: 06/30/2011

**APPLICATION FOR FEDERAL ASSISTANCE**
# SF 424 (R&R)

**3. DATE RECEIVED BY STATE:** | **State Application Identifier:** AZ

**1. * TYPE OF SUBMISSION**
☐ Pre-application ☐ Application ☒ Changed/Corrected Application

**4. a. Federal Identifier:** AI101224
**b. Agency Routing Identifier:**

**2. DATE SUBMITTED:** 03/10/2013
**Applicant Identifier:** 10013

**5. APPLICANT INFORMATION**
*** Organizational DUNS:** 806345617
* Legal Name: Arizona Board of Regents, University of Arizona
Department: Public Health
Division: UNIVERSITY OF ARIZONA
* Street1: P.O. Box 210158
Street2:
* City: Tucson
County / Parish: Pima
* State: AZ: Arizona
Province:
* Country: USA: UNITED STATES
* ZIP / Postal Code: 85721-0158

Person to be contacted on matters involving this application
Prefix:
* First Name: Sherry
Middle Name: L
* Last Name: Esham
Suffix:
* Phone Number: 520-626-6000
Fax Number: 520-626-4130
Email: sponsor@email.arizona.edu

**6. * EMPLOYER IDENTIFICATION** *(EIN) or (TIN):* 1742652689A1

**7. * TYPE OF APPLICANT:** H: Public/State Controlled Institution of Higher Education
Other (Specify):
**Small Business Organization Type** ☐ Women Owned ☐ Socially and Economically Disadvantaged

**8. * TYPE OF APPLICATION:**
☐ New ☒ Resubmission
☐ Renewal ☐ Continuation ☐ Revision
If Revision, mark appropriate box(es).
☐ A. Increase Award ☐ B. Decrease Award ☐ C. Increase Duration ☐ D. Decrease Duration
☐ E. Other (specify):

* Is this application being submitted to other agencies? Yes ☐ No ☒ What other Agencies?

**9. * NAME OF FEDERAL AGENCY:** National Institutes of Health

**10. CATALOG OF FEDERAL DOMESTIC ASSISTANCE NUMBER:**
TITLE: Mentored Research Scientist Development Award (Parent K01)

**11. * DESCRIPTIVE TITLE OF APPLICANT'S PROJECT:**
Simulation Modeling of Public Health Interventions on Dengue Vector Abundance: Current and Future Estimations.

**12. PROPOSED PROJECT:**
* Start Date: 12/01/2013
* Ending Date: 11/30/2018

*** 13. CONGRESSIONAL DISTRICT OF APPLICANT:** AZ-003

**14. PROJECT DIRECTOR/PRINCIPAL INVESTIGATOR CONTACT INFORMATION**
Prefix:
* First Name: Heidi
Middle Name: E
* Last Name: Brown
Suffix:
Position/Title: Assistant Professor
* Organization Name: Arizona Board of Regents, University of Arizona
Department: Public Health
Division: UNIVERSITY OF ARIZONA
* Street1: EPIDEMIOLOGY AND BIOSTATISTICS
Street2: PO Box 210202
* City: TUCSON
County / Parish:
* State: AZ: Arizona
Province:
* Country: USA: UNITED STATES
* ZIP / Postal Code: 85724-5163
* Phone Number: 520-626-2262
Fax Number:
* Email: heidibrown@email.arizona.edu

**15. ESTIMATED PROJECT FUNDING**

| | |
|---|---|
| a. Total Federal Funds Requested | 604,800.06 |
| b. Total Non-Federal Funds | 0.00 |
| c. Total Federal & Non-Federal Funds | 604,800.06 |
| d. Estimated Program Income | 0.00 |

**16. * IS APPLICATION SUBJECT TO REVIEW BY STATE EXECUTIVE ORDER 12372 PROCESS?**

a. YES ☐ THIS PREAPPLICATION/APPLICATION WAS MADE AVAILABLE TO THE STATE EXECUTIVE ORDER 12372 PROCESS FOR REVIEW ON:

DATE:

b. NO ☒ PROGRAM IS NOT COVERED BY E.O. 12372; OR

☐ PROGRAM HAS NOT BEEN SELECTED BY STATE FOR REVIEW

**17. By signing this application, I certify (1) to the statements contained in the list of certifications* and (2) that the statements herein are true, complete and accurate to the best of my knowledge. I also provide the required assurances * and agree to comply with any resulting terms if I accept an award. I am aware that any false, fictitious. or fraudulent statements or claims may subject me to criminal, civil, or administrative penalities. (U.S. Code, Title 18, Section 1001)**

☒ *** I agree**

**** The list of certifications and assurances, or an Internet site where you may obtain this list, is contained in the announcement or agency specific instructions.***

**18. SFLLL or other Explanatory Documentation**

Add Attachment | Delete Attachment | View Attachment

**19. Authorized Representative**

Prefix: * First Name: Leslie Middle Name: P.

* Last Name: Tolbert Suffix:

* Position/Title: Senior Vice President for Research

* Organization: Arizona Board of Regents, University of Arizona

Department: Arizona Board of Regents, Uni Division:

* Street1: P.O. Box 210158

Street2:

* City: Tucson County / Parish: Pima

* State: AZ: Arizona Province:

* Country: USA: UNITED STATES * ZIP / Postal Code: 85721-0158

* Phone Number: 520-626-6000 Fax Number: 520-626-4130

* Email: sponsor@email.arizona.edu

*** Signature of Authorized Representative**: Leslie P. Tolbert

*** Date Signed**: 03/10/2013

**20. Pre-application** Add Attachment | Delete Attachment | View Attachment

# 424 R&R and PHS-398 Specific Table Of Contents

OMB Number: 4040-0010
Expiration Date: 08/31/2011

# Project/Performance Site Location(s)

**Project/Performance Site Primary Location** ☐ I am submitting an application as an individual, and not on behalf of a company, state, local or tribal government, academia, or other type of organization.

Organization Name: Arizona Board of Regents, University of Arizona

DUNS Number: 8063456170000

* Street1: P.O. Box 210158

Street2:

* City: Tucson County: Pima

* State: AZ: Arizona

Province:

* Country: USA: UNITED STATES

* ZIP / Postal Code: 85721-0158 * Project/ Performance Site Congressional District: AZ-003

**Project/Performance Site Location** 1 ☐ I am submitting an application as an individual, and not on behalf of a company, state, local or tribal government, academia, or other type of organization.

Organization Name:

DUNS Number:

* Street1:

Street2:

* City: County:

* State:

Province:

* Country: USA: UNITED STATES

* ZIP / Postal Code: * Project/ Performance Site Congressional District:

**Additional Location(s)** Add Attachment Delete Attachment View Attachment

# RESEARCH & RELATED Other Project Information

1. * Are Human Subjects Involved? ☐ Yes ☒ No

1.a If YES to Human Subjects

Is the Project Exempt from Federal regulations? ☐ Yes ☐ No

If yes, check appropriate exemption number. ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

If no, is the IRB review Pending? ☐ Yes ☐ No

IRB Approval Date:

Human Subject Assurance Number:

2. * Are Vertebrate Animals Used? ☐ Yes ☒ No

2.a. If YES to Vertebrate Animals

Is the IACUC review Pending? ☐ Yes ☐ No

IACUC Approval Date:

Animal Welfare Assurance Number

3. * Is proprietary/privileged information included in the application? ☐ Yes ☒ No

4.a. * Does this project have an actual or potential impact on the environment? ☐ Yes ☒ No

4.b. If yes, please explain:

4.c. If this project has an actual or potential impact on the environment, has an exemption been authorized or an environmental assessment (EA) or environmental impact statement (EIS) been performed? ☐ Yes ☐ No

4.d. If yes, please explain:

5. * Is the research performance site designated, or eligible to be designated, as a historic place? ☐ Yes ☒ No

5.a. If yes, please explain:

6. * Does this project involve activities outside of the United States or partnerships with international collaborators? ☐ Yes ☒ No

6.a. If yes, identify countries:

6.b. Optional Explanation:

**7. * Project Summary/Abstract** ProjectSummary.pdf Add Attachment | Delete Attachment | View Attachment

**8. * Project Narrative** ProjectNarative.pdf Add Attachment | Delete Attachment | View Attachment

**9. Bibliography & References Cited** Bibliography.pdf Add Attachment | Delete Attachment | View Attachment

**10. Facilities & Other Resources** Add Attachment | Delete Attachment | View Attachment

**11. Equipment** Add Attachment | Delete Attachment | View Attachment

**12. Other Attachments** Add Attachments | Delete Attachments | View Attachments ☐

## PROJECT SUMMARY

Dengue is the most important arthropod-borne viral disease with over 50 million human cases annually. No vaccine or specific medical treatment is available. Limiting exposure to infected mosquitoes is the only public health strategy to reduce dengue. A novel exposure reduction strategy is being tested by the CDC: a trap that attracts gravid females but prevents escape after egg laying. Since only those which imbibe an infectious blood meal are infectious to humans, this trap removes the most dangerous mosquitoes.

The goal of this proposal is to develop a model to test how manipulating oviposition sites influences *Aedes aegypti* flight range and abundance. The proposed work has both an empirical experimentation facet - **testing the effect of oviposition site density on vector flight range** and a modeling component – develop a mathematical model to examine **effect of epidemiologic interventions on dengue vector population dynamics.**

The data gleaned from the proposed flight range experiments provide insight into how dengue moves through a population and will be used in the modeling component. The experiments will be conducted at Biosphere-2, providing a unique outreach opportunity. Biosphere-2 was constructed as a microcosm for human space colonization but has been converted to ecosystem scale experimentation. Because of its history, it is a tourist destination and guests interact with the scientist they meet.

Since human data are rarely collected at the right level (serology and exposure location), the modeling component involves simulating mosquito population dynamics. It is parameterized using *Aedes aegypti* life tables and optimized with the CDC's gravid trap data. When completed, it can be used to test the impact of source reduction versus gravid removal trapping and identify the number of gravid traps necessary to have a significant effect on dengue vectors.

Dengue continues to be a significant disease internationally and increasingly in the United States. The findings from both the experimentation and modeling components connote important advancements in dengue prevention. For me, this mentored career development award provides additional training in modeling epidemiological data and experience in public health promotion strategies. Dengue, like many of the vector-borne diseases is a complex system. Progress toward its reduction requires the interdisciplinary approach and variety of expertise as described in this proposal.

## PROJECT NARRATIVE

Two and a half billion people around the world are at risk from the mosquito-borne viral disease, dengue. Reducing risk by eliminating the mosquitoes that carry the virus is the only way to prevent disease. I propose to model a novel intervention strategy being tested by the Centers for Disease Control and Prevention in Puerto Rico. By modeling this public health intervention its effectiveness can be model compared to other strategies, in other locations, and under alternative climate scenarios.

**BIBLIOGRAPHY**

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OMB Number: 4040-0001
Expiration Date: 06/30/2011

# RESEARCH & RELATED Senior/Key Person Profile (Expanded)

**PROFILE - Project Director/Principal Investigator**

Prefix: | * First Name: Heidi | Middle Name: E
* Last Name: Brown | Suffix:
Position/Title: Assistant Professor | Department: Public Health
Organization Name: Arizona Board of Regents, University of Arizona | Division: UNIVERSITY OF ARIZONA
* Street1: EPIDEMIOLOGY AND BIOSTATISTICS
Street2: PO Box 210202
* City: TUCSON | County/ Parish:
* State: AZ: Arizona | Province:
* Country: USA: UNITED STATES | * Zip / Postal Code: 85724-5163
* Phone Number: 520-626-2262 | Fax Number:
* E-Mail: heidibrown@email.arizona.edu

Credential, e.g., agency login: HEIDIBROWN

*** Project Role:** PD/PI | **Other Project Role Category:**

**Degree Type:** Doctor of Science
**Degree Year:** 2007

***Attach Biographical Sketch** Biosketch_Brown.pdf [Add Attachment] [Delete Attachment] [View Attachment]
**Attach Current & Pending Support** [Add Attachment] [Delete Attachment] [View Attachment]

**PROFILE - Senior/Key Person 1**

Prefix: | * First Name: Joceline | Middle Name: C
* Last Name: Lega | Suffix:
Position/Title: Professor | Department: Public Health
Organization Name: Arizona Board of Regents, University of Arizona | Division: UNIVERSITY OF ARIZONA
* Street1: MATHEMATICS
Street2: PO Box 210077
* City: TUCSON | County/ Parish:
* State: AZ: Arizona | Province:
* Country: USA: UNITED STATES | * Zip / Postal Code: 85721-0089
* Phone Number: 520-621-4350 | Fax Number:
* E-Mail: lega@math.arizona.edu

Credential, e.g., agency login:

*** Project Role:** Other (Specify) | **Other Project Role Category:** Mentor

**Degree Type:** Doctor of Science
**Degree Year:** 1980

***Attach Biographical Sketch** 5b_Biosketch_Lega.pdf [Add Attachment] [Delete Attachment] [View Attachment]
**Attach Current & Pending Support** [Add Attachment] [Delete Attachment] [View Attachment]

# RESEARCH & RELATED Senior/Key Person Profile (Expanded)

**PROFILE - Senior/Key Person 2**

Prefix: | * First Name: Roberto | Middle Name:

* Last Name: Barrera | Suffix:

Position/Title: Chief | Department: Public Health

Organization Name: Arizona Board of Regents, University of Arizona | Division: UNIVERSITY OF ARIZONA

* Street1: 1324 Calle Canada

Street2:

* City: San Juan | County/ Parish: USA: United States

* State: PR: Puerto Rico | Province:

* Country: USA: UNITED STATES | * Zip / Postal Code: 00920-3860

* Phone Number: 787-706-2399 | Fax Number:

* E-Mail: amz9@cdc.gov

Credential, e.g., agency login:

*** Project Role:** Other (Specify) | **Other Project Role Category:** Co-Mentor

**Degree Type:** Doctor of Science

**Degree Year:** 1988

***Attach Biographical Sketch** 5b_Biosketch_Barrera.pdf | Add Attachment | Delete Attachment | View Attachment

**Attach Current & Pending Support** | Add Attachment | Delete Attachment | View Attachment

**PROFILE - Senior/Key Person 3**

Prefix: | * First Name: Andrew | Middle Name: C

* Last Name: Comrie | Suffix:

Position/Title: Professor | Department: Public Health

Organization Name: Arizona Board of Regents, University of Arizona | Division: UNIVERSITY OF ARIZONA

* Street1: OFFICE OF ACADEMIC AFFAIRS

Street2:

* City: TUCSON | County/ Parish:

* State: AZ: Arizona | Province:

* Country: USA: UNITED STATES | * Zip / Postal Code: 85721-0066

* Phone Number: 520-621-3512 | Fax Number:

* E-Mail: comrie@email.arizona.edu

Credential, e.g., agency login:

*** Project Role:** Other (Specify) | **Other Project Role Category:** Co-Mentor

**Degree Type:** Doctor of Science

**Degree Year:** 1992

***Attach Biographical Sketch** 5b_Biosketch_Comrie_15Oct12.p | Add Attachment | Delete Attachment | View Attachment

**Attach Current & Pending Support** | Add Attachment | Delete Attachment | View Attachment

# RESEARCH & RELATED Senior/Key Person Profile (Expanded)

**PROFILE - Senior/Key Person 4**

| | | | | | |
|---|---|---|---|---|---|
| Prefix: | | * First Name: | Lynn | Middle Name: | B |
| * Last Name: | Gerald | | | Suffix: | |
| Position/Title: | Associate Dean For Research | | | Department: | Public Health |
| Organization Name: | Arizona Board of Regents, University of Arizona | | | Division: | UNIVERSITY OF ARIZONA |
| * Street1: | PUBLIC HEALTH ADMINISTRATION | | | | |
| Street2: | 245209 | | | | |
| * City: | TUCSON | | | County/ Parish: | |
| * State: | AZ: Arizona | | | Province: | |
| * Country: | USA: UNITED STATES | | | * Zip / Postal Code: | 85724-5163 |
| * Phone Number: | 520-626-3243 | | | Fax Number: | |
| * E-Mail: | lgerald@email.arizona.edu | | | | |

Credential, e.g., agency login: geraldl

*** Project Role:** Other (Specify) **Other Project Role Category:** Collaborator

**Degree Type:** Doctor of Science

**Degree Year:** 1997

| | | | | |
|---|---|---|---|---|
| ***Attach Biographical Sketch** | 5b_Biosketch_LBG.pdf | Add Attachment | Delete Attachment | View Attachment |
| **Attach Current & Pending Support** | | Add Attachment | Delete Attachment | View Attachment |

## BIOGRAPHICAL SKETCH

Provide the following information for the key personnel and other significant contributors in the order listed on Form Page 2.
Follow this format for each person. **DO NOT EXCEED FOUR PAGES.**

| NAME | POSITION TITLE |
|---|---|
| Heidi Brown<br>HEIDIBROWN | Assistant Professor |

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training.)*

| INSTITUTION AND LOCATION | DEGREE *(if applicable)* | YEAR(s) | FIELD OF STUDY |
|---|---|---|---|
| Virginia Polytechnic Institute & State University, Blacksburg, VA | B.S. | 1995 | Psychology |
| George Washington University, Washington, DC | M.P.H. | 1999 | International Health Promotion |
| Yale University, New Haven, CT | M.Phil. | 2006 | Epidemiology of Microbial Diseases |
| Yale University, New Haven, CT | Ph. D. | 2007 | Epidemiology of Microbial Diseases |

### A. Personal Statement

Since beginning my Ph.D. studies I have been involved in the spatial and temporal distribution of disease vectors. As an epidemiologist I study the complex interactions in an ecosystem that result in increased risk of disease. My experience includes entomologic risk maps for mosquito-, tick-, flea-, and midge-borne diseases. Melding field, laboratory and modeling work, I utilize remotely sensed imagery and meteorological data to model the distribution and abundance of vectors. These models are then related to host distribution and disease outcomes to inform public health practice. My current work involves dynamic modeling of West Nile virus vectors across the United States. I use these simulation models to investigate the association between mosquito abundance and disease incidence in humans. In addition to regularly incorporating spatial and temporal data into my research, I have taught GIS both one-on-one and in the classroom. The current application brings together experts on spatial analyses, statistics and disease to develop a statistically sound and biologically plausible implementable method to address spatial uncertainty in public health data.

### B. Positions and Honors

**Positions and Employment**

1995 – 1996 Senior Laboratory Technician, Georgetown University, Washington, DC, USA
1996 – 1998 Research Assistant, Georgetown University Medical Center, Washington, DC, USA
2000 – 2003 Research Associate, Institute for Defense Analyses, Alexandria, VA, USA
2004 – 2007 Teaching Assistant – Master's level courses, Yale University, New Haven, CT, USA
2007 – 2008 Post-doctoral Research Assistant, Dept of Zoology, Oxford University, Oxford, UK
2008 – 2010 Fellow, Bacterial Diseases Branch, CDC-DVBID, Ft Collins, CO, USA
2010 – 2013 Post-doctoral Associate, Dept of Geography and Dev., University of Arizona, Tucson, AZ, USA
2013 – Assistant Professor, Division of Epidemiology, University of Arizona, Tucson, AZ, USA

**Other Experience and Professional Memberships**

2003- American Society of Tropical Medicine and Hygiene
2003- Society for Vector Ecology

**Honors**

Student Presentation Award, Society for Vector Ecology 37th Annual Conference, Anchorage AK, 2006.
"Predicting mosquito species distribution using satellite imagery." ($200 honorarium and conference registration remission)

McDougal Fellow for Academic and Student Life- Community Service, Career Services and Coordinating Fellow, Yale University 2004 – 2007 ($4000 annual)
US Delegate to the NATO Bio Medical Advisory Committee Working Group, Institute for Defense Analyses, 2002
M.P.H. Merit Scholarship, George Washington University, 1998 (Tuition remission for one course)

**C. Selected peer-reviewed publications (**Selected from 17 peer-reviewed publications**).**

**Most relevant to the current application**

1. **Brown, H.E.,** Doyle, M.S., Cox, J., Eisen, R.J., Nasci, R.S. "The effect of spatial and temporal subsetting on *Culex tarsalis* abundance models - a design for the sensible reduction of vector surveillance." *Journal of the American Mosquito Control Association*. 2011. 27(2), 120-128.
2. Hartemink, N., Purse, B.V., Meiswinkel, R., **Brown, H.E.,** de Koeijer, A., Elbers, A.R., Jan Boender, G., Rogers, D.J., Heesterbeek, H. "Mapping the basic reproduction number ($R_0$) for vector-borne diseases: A case study on bluetongue virus." *Epidemics*. 2009, 3(1), p. 153-161.
3. **Brown, H.E.,** Childs, J.E., Diuk-Wasser, M.A., and Fish, D. "Ecological factors associated with West Nile virus transmission, northeastern United States." *Emerging Infectious Diseases*. 2008, 14(10), p. 1539-1545.
4. **Brown, H.E.,** Diuk-Wasser, M.A., Andreadis, T.G., and Fish, D. "Remotely-Sensed Vegetation Indices Identify Mosquito Clusters of West Nile Virus Vectors in an Urban Landscape in the Northeastern United States." *Vector-borne and Zoonotic Diseases*. 2008, 8(2), p. 197-206.
5. **Brown, H.E.,** Diuk-Wasser, M.A., Guan, Y., Caskey, S., and Fish, D. "Comparison of three satellite sensors at three spatial scales to predict larval mosquito presence in CT Wetlands." *Remote Sensing of the Environment*. 2008, 112(5), p. 2301-2308.
6. Diuk-Wasser, M.A., **Brown, H.E.,** Andreadis, T.G., and Fish, D. "Modeling the spatial distribution of mosquito vectors for West Nile virus in Connecticut, USA." *Vector-Borne and Zoonotic Diseases*. 2006, 6(3), p. 283-95.

**Additional recent publications of importance to the field (in chronological order)**

1. Sedda, L., **Brown, H.E.,** Purse, B.V., Burgin, L., Gloster, J., Rogers, D.J. "A new algorithm quantifies the roles of wind and midge flight activity in the bluetongue epizootic in North-West Europe." *Proceedings of the Royal Society Biology*. 8 February 2012. doi:10.1098/rspb.2011.2555.
2. Cox, J., **Brown, H.E.,** Rico-Hesse, R. "Variation in vector competence for dengue viruses does not depend on mosquito midgut binding affinity." *PLoS Neglected Diseases*. 2011, 5(5): e1172

**D. Research Support**

COMPLETED

ORISE Research Participation Program — 16 Sept 2008 – 15 Sept 2009
ORISE - CDC
**Oak Ridge Institute for Science and Education Fellowship Program**
The purpose of this program is to provide fellows with research experience related to CDC's core missions.

BBSRC Research Grant BBS/B/00603; Defra Research Grant SE4104 — 16 Sept 2007 – 15 Sept 2008
BBSRC
**Epidemiology & control of orbiviral diseases in the UK, with particular reference to bluetongue & African horse sickness**
The purpose of this grant is to identify risk from Bluetongue virus within the United Kingdom.

T01-CCT122306-04 (CDC Fellow) 30 Sep 2002 – 30 Apr 2007
CDC
**Fellowship Training Program in Vector-borne Diseases**
The purpose of this grant is to provide fellowships to graduate students for interdisciplinary research in vector-borne diseases.

No Sponsor Number November 2005
Northeast Mosquito Control Association
**The McColgan Grant-in-Aid**
The purpose of this grant is to support research regarding Wetland Types: Hyperspectral Image Analysis and Mosquito Sampling.

No Sponsor Number July – August 2005
Yale University
**Council on Southeast Asia Studies Student Grants**
The purpose of this grant is to support summer work with the Institute for Research Development at Mahidol University, Bangkok Thailand regarding “Modeling of Vector-Borne Disease Epidemics.”

Program Director/Principal Investigator (Last, First, Middle):

## BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors in the order listed on Form Page 2.
Follow this format for each person. **DO NOT EXCEED FOUR PAGES.**

| NAME | POSITION TITLE |
|---|---|
| Joceline Lega | Professor of Mathematics<br>University of Arizona |
| eRA COMMONS USER NAME (credential, e.g., agency login) | |

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable.)*

| INSTITUTION AND LOCATION | DEGREE *(if applicable)* | MM/YY | FIELD OF STUDY |
|---|---|---|---|
| University of Paris VI, France | BS (Licence) | 06/85 | Physics |
| University of Paris VI, France | MS (Maîtrise) | 09/85 | Physics |
| University of Nice, France | DEA | 06/86 | Dynamical Systems and Turbulence |
| University of Nice, France | Doctorate | 03/89 | Theoretical Physics |

Please refer to the application instructions in order to complete sections A, B, C, and D of the Biographical Sketch.

### A. Personal Statement

My research interests are in the modeling of nonlinear phenomena, with applications to physics and biology. My work combines modeling, mostly in terms of differential equations, mathematical analysis of the models, and numerical simulations, each approach building upon and informing the others.

At the University of Arizona, I have supervised numerous research projects for undergraduate and graduate students, and in the past 10 years, worked extensively with postdoctoral fellows. In particular, I acted as a mentor for the following individuals:

- Stéphane Lafortune, a postdoctoral fellow supported by the Canadian NSERC (2000–2002) and later our department's Hanno Rund Postdoctoral Fellow (2002–2004), who is now Associate Professor of Mathematics at the College of Charleston, SC.
- Derek Moulton, our 2008–2010 department's Pierce Postdoctoral Fellow, who recently accepted a lecturer position at the University of Oxford, UK.
- Christopher Bergevin, a joint HHMI–VIGRE (Howard Hughes Medical Institute–NSF) post-doctoral fellow (2007–2010), who started on a faculty position in the Physics & Astronomy department at York University, Canada, in fall 2012.
- Alan Lindsay, our 2010–2012 department's Pierce Postdoctoral Fellow, who is now a lecturer of Applied Mathematics at Heriot-Watt University, UK.

I have taught a wide range of mathematics courses, both at the undergraduate and graduate levels, and worked on the development of a few others, including Advanced Analysis for Engineers (MATH 322), Explorations in Integrated Science (MCB/MATH/PHYS 303), and Mathematical Modeling (MATH 485/585).

In can assist Dr. Brown with the development of mathematical models that incorporate the data she and her collaborators have collected. I can share with Dr. Brown the tools and methods that applied mathematicians commonly use in modeling activities, including deciding what components to include, and what elements to neglect, at least at first. My goal will be to help Dr. Brown build enough expertise to independently develop models of her own in the future.

Program Director/Principal Investigator (Last, First, Middle):

## B. Positions and Honors

| | |
|---|---|
| 1989 – 1993 | Chargée de Recherche 2ème classe at CNRS, Laboratoire de Physique Théorique, Nice, France |
| 1993 – 1997 | Chargée de Recherche 1ère classe at CNRS, Institut Non Linéaire de Nice, France |
| 1997 – present | On leave without pay from CNRS (French National Center for Scientific Research) |
| 1997 – 2000 | Assistant Professor, Department of Mathematics, University of Arizona |
| 2000 – 2006 | Associate Professor, Department of Mathematics, University of Arizona |
| 2006 – present | Professor, Department of Mathematics, University of Arizona |
| 2007 – 2009 | Assistant Director, Institute for Mathematics & Education, University of Arizona |
| 2008 – 2011 | Director, Program in Integrated Science, University of Arizona |
| 2009 – present | Director, Institute for Mathematics & Education, University of Arizona |

Visiting Positions

| | |
|---|---|
| Jan 90-Jun 91 | Visiting Assistant Professor, Department of Mathematics, University of Arizona |
| Oct-Dec 1991 | Post-doctoral fellow, Department of Applied Mathematics and Theoretical Physics, University of Cambridge, UK |
| Fall 1993 | Research Associate, Department of Physics and Applied Physics, University of Strathclyde, Glasgow, UK |
| 1994 – 1997 | Visiting Assistant Professor, Department of Mathematics, University of Arizona |
| Fall 2004 | Visitor, Fields Institute for Research in Mathematical Sciences, Toronto, Canada |

Honors

Fellow of the Institute of Physics (London), since 2004
National Academies Education Fellow in the Life Sciences for 2005 – 2006
Editor-in-Chief, Physica D: Nonlinear Phenomena, since 01/2008
Editorial Board member, Nonlinearity, since 01/2004

## C. Selected Peer-reviewed Publications


1. A.E. Lindsay and J. Lega, *Multiple Quenching Solutions of a Fourth Order Parabolic PDE with a Singular Nonlinearity Modeling a MEMS Capacitor*, SIAM J. Appl. Math. **72**, 935-958 (2012).
2. J. Lega, *Collective Behaviors in Two-dimensional Systems of Interacting Particles*, SIAM J. Appl. Dyn. Sys. **10**, 1213-1231 (2011).
3. S. Lafortune, J. Lega, and S. Madrid, *Instability of local deformations of an elastic rod: numerical evaluation of the Evans function*, SIAM J. Appl. Math. **71**, 1653-1672 (2011).
4. M. Herrera-Valdez and J. Lega, *Reduced models for the pacemaker dynamics of cardiac cells*, Journal of Theoretical Biology **270**, 164-176 (2011).
5. D. Moulton and J. Lega, *Reverse draining of a magnetic soap film - Analysis and simulation of thin film equation with non-uniform forcing*, Physica D **238**, 2153-2165 (2009).
6. J. Lega and T. Passot, *Hydrodynamics of bacteria colonies*, Nonlinearity **20**, C1-C16 (2007).
7. J. Lega and T. Passot, *Hydrodynamics of bacterial colonies: phase diagrams*, Chaos **14**, 562-570 (2004).
8. J. Lega and T. Passot, *Hydrodynamics of bacterial colonies: a model*, Phys. Rev. E **67**, 031906 1-18 (2003).
9. B.R. Schöne, J. Lega, K.W. Flessa, D.H. Goodwin and D.L. Dettman, *Reconstructing daily temperatures from growth rates of the intertidal bivalve mollusk Chione cortezi (northern Gulf of California, Mexico)*, Palaeogeography, Palaeoclimatology, Palaeoecology **184**, 131-146 (2002).

10. T.A. Christensen, G. D'Alessandro, J. Lega and J.G. Hildebrand, *Morphometric modeling of olfactory circuits in the insect antennal lobe: I. Simulations of spiking local interneurons*, Biosystems **61**, 143-153 (2001).
11. J. Lega and N. Mendelson, *A control-parameter dependent Swift-Hohenberg equation as a model for bioconvection patterns*, Phys. Rev. E **59**, 6267-6274 (1999).
12. N. Mendelson and J. Lega, *A complex pattern of traveling stripes is produced by swimming cells of Bacillus subtilis*, Journal of Bacteriology **180**, 3285-3294 (1998).
13. D. Hochheiser, J.V. Moloney and J. Lega, *Controlling optical turbulence*, Phys. Rev. A **55**, 4011-4014 (1997).
14. A. C. Newell, T. Passot and J. Lega, *Order parameter equations for patterns*, Ann. Rev. Fluid Mech. **25**, 399-453 (1993).
15. P. Coullet, L. Gil, and J. Lega, *Defect-mediated turbulence*, Phys. Rev. Lett. **62**, 1619-1622 (1989).

**D. Support**

Ongoing support:

Intel Foundation Lega (PI) 12/01/2012-11/30/2013
Research plan to study the efficacy of the Intel Math Program in the Chandler School District

Intel Foundation Lega (PI) 09/01/2012-08/31/2013
Intel Math National Training Agency: Revision of the Intel Math Curriculum, Intel Foundation

NSF DGE 0841234 Lega (PI) 04/24/2009-04/30/2014
GK-12: Graduate Students and Teacher Engaging in Mathematical Sciences (G-Teams)

Completed support

Intel Foundation Lega (PI) 07/01/2011-06/30/2012
Intel Math National Training Agency

Intel Foundation Lega (PI) 12/01/2009-02/01/2011
Intel Math National Training Agency

Gateway Strategic Alliance Grant, University of Arizona 2008
Laptops for the Program in Integrated Science

NSF DUE 0737137 Burd (PI) 07/01/2008-06/30/2011
Explorations in Integrated Science: An Interdisciplinary Laboratory Course

NSF DUE 0633379 Dixon (PI) 01/01/2007-12/31/2009
Q-Bio: Integration of Quantitative Concepts into Introductory Biology

Arizona Biomedical Research Commission Dixon (PI) 2006-2009
Imaging of markers for skin cancer risk

NSF DMS 0405551 Lega (PI) 07/15/2004-06/30/2008
Current problems in nonlinear dynamics: Macroscopic modeling of microscopic interactions and instability of coherent structures

NSF DMS 0308970 Lega (PI) 07/01/2003-12/31/2004
Junior US-based Mathematicians at 03/04 Special Year at Fields Institute

Program Director/Principal Investigator (Last, First, Middle):

NSF DMS 0075827 Lega (PI) 09/01/2000-08/31/2004
Analysis and modeling of pattern formation in biological and physical systems

NSF OISE 9909866 Lega (PI) 04/01/2000-03/31/2004
Hydrodynamics of bacterial colonies (U.S. – France Cooperative Research)

The University of Arizona Research Foundation Lega (PI) 1999-2000
Hydrodynamics of bacterial colonies

NATO Tabor (PI) 1997-1999
Modeling of filament dynamics with applications to bacterial growths

European Union Moloney (PI) 1994-1996
Dynamic response, stabilisation, modulation and control of semiconductor lasers and laser amplifiers

Principal Investigator/Program Director (Last, First, Middle): Brown, Heidi Elizabeth

## BIOGRAPHICAL SKETCH

Provide the following information for the key personnel and other significant contributors in the order listed on Form Page 2.
Follow this format for each person. **DO NOT EXCEED FOUR PAGES.**

| NAME | POSITION TITLE |
|---|---|
| Barrera, Roberto | Chief, Entomology and Ecology Activity, Dengue Branch |
| eRA COMMONS USER NAME | |

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training.)*

| INSTITUTION AND LOCATION | DEGREE *(if applicable)* | YEAR(s) | FIELD OF STUDY |
|---|---|---|---|
| Central University of Venezuela | B.S. | 1978 | Biology |
| The Pennsylvania State University | Ph.D. | 1988 | Ecology |
| University of Florida | | 1995 | Mosquito Ecology |

## A. Personal Statement

I have worked with mosquito ecology and control for over thirty years, first as a university faculty for 25 years, and more recently as the Chief of the Entomology and Ecology Activity at the Dengue Branch, CDC. As a former professor I tutored several doctoral students. Also, we regularly host under- and graduate student interns at Dengue Branch. As a leading scientist in vector-borne disease, I have a large network of contacts which can assist Dr. Brown both for this project and in her career. I can provide contacts both within the U.S. and internationally and on a range of biological systems and fields of study. My current position involves maintaining a research program, supporting a staff, participating as an editor for journals, and serving as a community contact for dengue reduction strategy.

## Positions and Honors.

### Positions and Employment

2009 - Present *Adjunct Professor*, School of Medicine, University of Puerto Rico
2003 - Present *Chief*, Entomology and Ecology Activity, Dengue Branch, Centers for Disease Control and Prevention (CDC), San Juan, Puerto Rico
1978 - 2002 *Professor*, *Assoc. Prof.*, *Assist. Prof*, *Instructor*, Central University of Venezuela
1994 - 2002 *Graduate Commission*, Graduate Schools in Ecology and Parasitology, Central University of Venezuela
1996 - 2000 *Chairman*, Biology and Environment Committee, National Council of Science and Technology, Venezuela
1990 - 1993 *Director*, Tropical Zoology Institute, Central University of Venezuela - *other Faculty assignments*

### Other Experience, Honors and Professional Memberships

2008 *Award of Excellence* – Health Equity Award, Centers for Disease Control and Prevention (CDC)
2007 *Nakano Citation Award*, Centers for Disease Control and Prevention (CDC)
2006 *Research Performance Award*, Centers for Disease Control and Prevention (CDC)
Associate Editor, Journal of Medical Entomology
Subject Editor, PLoS Neglected Tropical Diseases

Principal Investigator/Program Director (Last, First, Middle): PI Name

## B. Selected peer-reviewed publications (since 2009).

**Most relevant to the current application**


1. **Barrera R**, Bingham AM, Hassan HK, Amador M, Mackay AJ, Unnasch TR. 2012. Vertebrate hosts of *Aedes aegypti* and Aedes *mediovittatus* (Diptera: Culicidae) in rural Puerto Rico. Journal of Medical Entomology 49: 917-921.
2. **Barrera R**. 2011. Spatial stability of adult Aedes aegypti populations. American Journal of Tropical Medicine and Hygiene (in press).
3. **Barrera R**, Amador M, Mackay AJ. 2011. Population dynamics of *Aedes aegypti* and dengue as influenced by weather and human behavior in San Juan, Puerto Rico. PLoS Neglected Tropical Diseases 5(12): e1378. doi:10.1371/journal.pntd.0001378.
4. Little E, **Barrera R**, Seto KC, Diuk-Wasser M. 2011. Co-occurrence patterns of the dengue vectors *Aedes aegypti* and *Aedes mediovitattus*, a dengue competent mosquito in Puerto Rico. EcoHealth DOI: 10.1007/s10393-011-0708-8.
5. **Barrera R**. 2010. Dengue and *Aedes aegypti* dynamics in Puerto Rico. Rev Biomed 21: 179-195 [Spanish].
6. Burke R, **Barrera R**, Kluchinsky T, Lewis M and Claborn DM. 2010. Examination of a Miniaturized Funnel Trap for *Aedes aegypti* Larval Sampling. J Med Entomol 47: 1231-1234.
7. Burke R, **Barrera R**, Lewis M, Kluchinsky T, Claborn D. 2010. Septic tanks as larval habitats for *Aedes aegypti* in Playa-Playita, Puerto Rico. Med Vet Entomol 24: 117-123.
8. Grillet ME, **Barrera R**, Martínez JE, Berti J, Fortin MJ. 2010. Disentangling the effect of local and global spatial variation on a mosquito-borne infection in a neotropical heterogeneous environment. Am J Trop Med Hyg 82: 194-201.


**Additional recent publications of importance to the field**


1. Cohnstaedt LW, Rochon K, Duehl AJ, Anderson JF, **Barrera R**, Su NY, Gerry AC, Obenauer PJ, Campbell JF, Lysyk TJ, Allan SA. 2012. Arthropod Surveillance Programs: Basic Components, Strategies, and Analysis. Annals of the Entomological Society of America 105: 135- 149.
2. **Barrera R**, Amador M, Young G, Komar N. (2011). Mosquito (Diptera: Culicidae) blood meal sources during a period of West Nile virus transmission in Puerto Rico. Journal of Medical Entomology 48: 701-704.
3. Guidelines for Chikungunya virus introduction preparedness and response in the Americas. Pan American Health Organization/CDC. 2010. Collaborator.
4. **Barrera R**, MacKay A, Amador M, Vasquez J, et al. 2010. Mosquito vectors of West Nile virus during an epizootic outbreak in Puerto Rico. J Med Entomol 47: 1185-1195.
5. WHO Dengue Guide 3rd Edition. 2009. Collaborator
6. Grillet ME, Martínez JE, **Barrera R**. 2009. Hot spots of malaria transmission: Implications for effective, informed control in Venezuela. Bol Malariol Salud Ambiental 49:7-22.
7. Mackay AJ, Amador M, Diaz A, Smith Josh and **Barrera R**. 2009. Dynamics of *Aedes aegypti* and *Culex quinquefasciatus* (Diptera: Culicidae) in septic tanks in Southern Puerto Rico. Journal of the American Mosquito Control Association 25:409-416.
8. **Barrera R**. 2009. Simplified *Aedes aegypti*'s pupal-surveys for entomological surveillance and dengue control. Am J Trop Med Hyg 81:100-107.


## D. Research Support (last 3 years)

**Ongoing Research Support**

CDC's internally funded research.

## BIOGRAPHICAL SKETCH

Provide the following information for the key personnel and other significant contributors in the order listed on Form Page 2.
Follow this format for each person. **DO NOT EXCEED FOUR PAGES.**

| NAME | POSITION TITLE |
|---|---|
| Comrie, Andrew Charles | Professor, Geography & Development, Atmospheric Sciences, Public Health |
| eRA COMMONS USER NAME | |

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training.)*

| INSTITUTION AND LOCATION | DEGREE *(if applicable)* | YEAR(s) | FIELD OF STUDY |
|---|---|---|---|
| University of Cape Town | B.Sc. | 1984 | Geography |
| University of Cape Town | B.Sc.(Hons) | 1985 | Atmospheric Sciences |
| University of Cape Town | M.Sc. | 1988 | Environ & Geog Sci. |
| The Pennsylvania State University | Ph.D. | 1992 | Geography |

### A. Personal Statement

I am an interdiscilpinary climate scientist with a primary appointment in Geography. My additional formal appointments include Atmospheric Sciences, Arid Lands Resource Sciences, Entomology & Insect Science, Global Change, Public Health, Remote Sensing and Spatial Analysis, and Statistics. I have conducted broadly interdisciplinary research in climate variability and change, with particular focus on connections between climate and health, and also including air quality. I have served as editor and editorial board member for multiple journals. In my lab we work on dynamic models linking climate and mosquitoes as disease vectors, West Nile virus and dengue in particular, as well as climatic controls on valley fever (coccidioidomycosis) and the fungus that causes it, urban climate and Chagas disease in Latin America, and the causes of influenza seasonality. We collaborate with scientists here at the University of Arizona and elsewhere to solve critical and complex questions about the links between climate and disease, using empirical approaches, dynamic process modeling, and field studies. My work is explicitly in the area of the proposed project, dealing with climate and mosquito disease vectors, and I am therefore well-suited to act as a mentor for this award. I have successfully mentored 6 postdocs and several junior faculty members, as well as a dozen primary doctoral advisees. Despite my administrative duties, I am known for actively making time for my mentoring responsibilities and I see my mentees regularly in group and individual meetings.

### B. Positions and Honors

**Positions & Employment**

1992-1999 Assistant Professor, Geography and Regional Development, University of Arizona
1999-2005 Associate Professor, Geography and Regional Development, University of Arizona
2005-present Professor, Geography and Development, University of Arizona, (Joint Appts: Atmospheric Sciences, Arid Lands Resource Sciences, Entomology & Insect Science, Global Change, Public Health, Remote Sensing & Spatial Analysis, Statistics)
2006-2012 Associate Vice President for Research, Dean of the Graduate College, University of Arizona.
2012-present Senior Vice President for Academic Affairs & Provost, University of Arizona.

**Other Experience and Professional Memberships**

2010-present Graduate Record Examinations (GRE) Board
2008-2010 Board of Directors, Council of Graduate Schools
2004-2012 Editor for the Americas, *International Journal of Climatology*
2009-present Editorial Advisory Board, *Progress in Physical Geography*
2007-present Editorial Board, *Environmental Science & Policy*
2006-present Editorial Board, *Annals of the Association of American Geographers*

2001-2003 Editor, *Climate Research*, 2001-2003 (Editorial board 1999-2000)
2000-2008 Editorial Advisory Board, *Atmospheric Environment*
2003-2005 Board member, Applied Climate Committee, American Meteorological Society
2002-2004 Chair, Climate Specialty Group, Association of American Geographers
2000 Research Professorship, University of Arizona, Social and Behavioral Sciences Res. Inst.
Memberships: Fellow, Royal Meteorological Society, American Geophysical Union, American Meteorological Society, Assoc. of American Geographers, American Assoc. for the Advancement of Science.

**Honors**

2012 Honored Faculty Award, Graduate Interdisciplinary Programs, University of Arizona
2007 Special Contrib. to American Indian Educ. Award, Univ. of Arizona American Indian Alumni Club
1997 Faculty Appreciation Award, Business and Public Admin. Student Council, Univ. of Arizona
1996-1997 Visiting Fellow, Udall Center for Studies in Public Policy, University of Arizona

**C. Selected Peer-reviewed Publications** (Maximum 15, selected from 52 peer-reviewed publications)

**Most relevant to the current application**


1. Comrie, A.C., 2005: Climate factors influencing coccidioidomycosis seasonality and outbreaks. *Environmental Health Perspectives* 113, 688-692.
2. Tamerius, J., Wise, E.K., Uejio, C.K., McCoy, A., and Comrie, A.C. 2007: Climate and human health: synthesizing environmental complexity and uncertainty. *Stochastic Environmental Research and Risk Assessment (SERRA)* 21, 601-613.
3. Morin, C. and Comrie, A.C. 2010: Modeled response of the West Nile virus vector Culex quinquefasciatus to changing climate using the dynamic mosquito simulation model. *International Journal of Biometeorology* 54,517-529, doi:10.1007/s00484-010-0349-6.
4. Tamerius, J.D. and Comrie, A.C., 2011: Coccidioidomycosis incidence in Arizona predicted by seasonal precipitation. *PLoS ONE* 6(6): e21009. doi:10.1371/journal.pone.0021009.
5. Uejio, C.K., Kemp, A. and Comrie, A.C. 2012: Climatic controls on West Nile virus and Sindbis virus transmission and outbreaks in South Africa. *Vector-Borne and Zoonotic Diseases* 12(2): 117-125, doi:10.1089/vbz.2011.0655.


**Additional recent publications of importance to the field**


1. Komatsu, K., Vaz, V., McRill, C., Colman, T., Comrie, A., Sigel, K., Clark, T., Phelan, M., Hajjeh, R. and Park, B., 2003: Increase in coccidioidomycosis – Arizona, 1998-2001. *Morbidity and Mortality Weekly Report* 52, 109-112.
2. Kolivras, K.N. and Comrie, A.C., 2003: Modeling valley fever incidence based on climate conditions in Pima County, Arizona. *International Journal of Biometeorology* 47, 87-101.
3. Kolivras, K.N. and Comrie, A.C., 2004: Climate and infectious disease in the southwestern United States. *Progress in Physical Geography* 28, 387-398.
4. Park, B.J., Sigel, K., Vaz, V., Komatsu, K., McRill, C., Phelan, M., Colman, T., Comrie, A.C., Warnock, D.W., Galgiani, J.N. and Hajjeh, R.A., 2005: An epidemic of coccidioidomycosis in Arizona associated with climate changes, 1998-2001. *Journal of Infectious Diseases* 191, 1981-1987.
5. Comrie, A.C. and Glueck, M.F. 2007: Model Sensitivity for Assessing Climatologic Effects on the Risk of Acquiring Coccidioidomycosis. *Annals of the New York Academy of Sciences* 1111, 83–95.
6. Comrie, A.C. 2007: Climate Change and Human Health. *Geography Compass* 1, 325–339.
7. Delgado, S., Neyra, R.C., Machaca, V.Q., Juarez, J.A., Chu, L.C., Verastegui, M., Apaza, G.M., Bocángel, C.D., Tustin, A.W., Sterling, C.R., Comrie, A.C., Naquira, C., del Carpio, J.C., Gilman, R., Bern, C. and Levy, M. 2011: A history of Chagas disease transmission, control, and re-emergence in peri-rural La Joya, Peru. *PLoS Neglected Tropical Diseases* 5(2): e970. doi:10.1371/journal.pntd.0000970.
8. Stacy, P.K.R., Comrie, A.C. and Yool, S.R. 2012: Modeling valley fever incidence in Arizona using a satellite-derived soil moisture proxy. *GIScience & Remote Sensing* 49, 299-216, doi: 10.2747/1548-1603.49.2.299.

9. Scott, C.A., Robbins, P.F. and Comrie, A.C., 2012: The mutual conditioning of humans and pathogens: implications for integrative geographical scholarship. *Annals of the Association of American Geographers* 102 (5), 977-985.
10. El Vilaly, A.E., Arora, M., Butterworth, M.K., El Vilaly, M.A.M., Jarnagin, W. and Comrie, A.C., 2012: Climate and Rift Valley Fever. *Progress in Physical Geography*, in press.

**D. Research Support** (Last 3 years)

**Ongoing Research Support**

Support: Current

0948334 National Science Foundation (Comrie) 09/15/09-02/28/13
ULTRA-EX: Assessing emerging hazards and adaptive capacities in southwestern metropolises: The case of mosquito disease vectors.
The major goals of this project are to examine the relationship between institutions and insects in the burgeoning conurbanized Arizona metropolises. Using field work, mosquito modeling, surveys, workshops and interviews we test basic theories that predict the match and mismatch of state and public knowledge in the complex ecological-mosquito system.

NA07OAR4310382 National Oceanic and Atmospheric Administration (Overpeck) 09/01/12-08/31/17
Variability, Social Vulnerability, and Public Policy in the SW United States: A Proposal for Regional Assessment Activities.
The major goals of this project are to answer the question: how can we reduce the vulnerability of, and help the Southwest adapt to, climatic extremes and thresholds across multiple sectors, such as water and health? A hallmark of the project is a multi-year synthesis across the program and an explicit focus on the nexus of sectoral challenges integrating natural and social sciences.

K25HL103970 National Heart, Lung, and Blood Institute (Beamer) 08/16/11-07/31/13
Relating Diesel Exhaust Exposure to Respiratory and Immune Outcomes in Early Life.
The major goals of this project are to understand if exposure to diesel-related pollutants as an infant results in alterations of the immune and respiratory systems that could result in early childhood wheezing or development of asthma. The findings will be used to engineer intervention strategies that can then be tested in community settings and hopefully help reduce the burden of wheezing in childhood.

DGE1143953 National Science Foundation (Comrie) 07/15/11-06/30/16
Graduate Research Fellowship Program.
The major goals of this project are to recognize and support outstanding graduate students in NSF-supported science, technology, engineering, and mathematics disciplines who are pursuing research-based master's and doctoral degrees at the University of Arizona. Students compete nationally for these awards, and are enrolled in graduate programs across the whole university.

K25HL103970 National Institute of Allergy and Infectious Disease (Ernst) 09/01/12-08/31/17
On the Edge: Dengue and Climate.
The goals of this project are to collect pilot information on Ae. aegypti dynamics in the southern United States (Arizona, Florida and Texas) and compare longevity, vector competence and density across areas where dengue has caused outbreaks and where no noted transmission had occurred. We will also be collecting preliminary information on potential distal factors that lead to these differential dynamics such as climate, social and environmental context.

National Physical Sciences Consortium (Comrie) 07/01/09-06/30/13
National Physical Sciences Consortium Graduate Fellowship
The major goals of this project are to recognize and support outstanding graduate students in physical science disciplines who are pursuing research-based graduate degrees. Students compete nationally for these awards, and are enrolled in various graduate programs.

Science Foundation Arizona (Comrie) 07/01/12-06/30/14
UA 2012 Bisgrove Scholar Program
The major goals of this project are to support outstanding postdoctoral fellows in science and engineering at the University of Arizona.

**Completed Research Support**

Council of Graduate Schools/ORI (Comrie) 07/01/08-07/01/10 (est.)
Research Ethics Throughout the Curriculum: Promoting Scientific Integrity at the University of Arizona.
The major goals of this project were to develop research ethics and integrity materials through a set of campus-wide mini grants across multiple disciplines.

Science Foundation Arizona (Comrie & Tolbert) 07/01/07-07/01/12 (est.)
Strategic Growth of Integrated Graduate Programs for Arizona, Graduate Research Fellowship Program.
This project was a prestigious graduate fellowship program.

U.S. Environmental Protection Agency (Comrie) 07/01/06-07/01/09 (est.)
A Valley Fever (Coccidioidomycosis) Public Health Decision Support System Based on Climate and Environmental Changes.
This project developed the science and modeling to understand and predict the role of climate in outbreaks of valley fever.

National Science Foundation (Robbins) 07/01/06-07/01/09 (est.)
Geographies of Insects and Institutions: Mosquito Governance in the US Southwest.
This project was an interdisciplinary social science and natural science investigation of mosquito vector disease ecology and policy. It produced novel insights into how public intervention into mosquito control is structured as well as greater understanding and improved models of climate controls on mosquito vectors for West Nile Virus.

Program Director/Principal Investigator (Last, First, Middle):

## BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors in the order listed on Form Page 2.
Follow this format for each person. **DO NOT EXCEED FOUR PAGES.**

| NAME | POSITION TITLE |
|---|---|
| Lynn B. Gerald, PhD, MSPH | Associate Dean for Research<br>Canyon Ranch Endowed Chair for Lifestyle and Behavioral Science/Professor |
| eRA COMMONS USER NAME (credential, e.g., agency login)<br>geraldl | |

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable.)*

| INSTITUTION AND LOCATION | DEGREE *(if applicable)* | MM/YY | FIELD OF STUDY |
|---|---|---|---|
| University of Alabama at Birmingham | BS | 1990 | Psychology/Gerontology |
| University of South Alabama | MA | 1992 | Sociology/Gerontology |
| University of Alabama at Birmingham | MSPH | 1997 | Epidemiology |
| University of Alabama at Birmingham | PhD | 1997 | Medical Sociology |

### A. Personal Statement

I have extensive experience and expertise in clinical and epidemiological research in pulmonary disease. I have been PI of five large federally funded grants and served on investigator and collaborator on many others. I have extensive experience in mentoring junior faculty and graduate students in research design, grant writing and grants management. As examples of my current mentorship activities, I serve as PI of a HRSA funded training grant and as a mentor on a faculty member's K25. I have a demonstrated record of successful and productive research projects and the expertise necessary to appropriately mentor Dr. Brown in her proposed K activities.

### B. Positions and Honors

*Positions*

| | |
|---|---|
| 1992-1994 | Instructor, Department of Sociology, University of South Alabama, Mobile, AL |
| 1996-1997 | Instructor, Department of Sociology, University of Alabama at Birmingham, Birmingham, AL |
| 1997-2002 | Assistant Professor, Department of Critical and Diagnostic Care, School of Health Related Professions, University of Alabama at Birmingham, Birmingham, AL |
| 1997-2008 | Scientist, Lung Health Center, University of Alabama at Birmingham, Birmingham, AL |
| 1999-2004 | Assistant Professor, Division of Pulmonary, Allergy & Critical Care Medicine, School of Medicine, University of Alabama at Birmingham, Birmingham, AL |
| 1999-2007 | Assistant Director, Lung Health Center, University of Alabama at Birmingham, Birmingham, AL |
| 2000-2004 | Associate Scientist, Center for Health Promotion, University of Alabama at Birmingham, Birmingham, AL |
| 2001-2004 | Assistant Professor, UAB Graduate School, University of Alabama at Birmingham, Birmingham, AL |
| 2004-2007 | Associate Professor, Division of Pulmonary, Allergy & Critical Care Medicine, University of Alabama at Birmingham, Birmingham, AL |
| 2007-2008 | Director, Lung Health Center, University of Alabama at Birmingham, Birmingham, AL |
| 2007-2008 | Professor, Division of Pulmonary, Allergy & Critical Care Medicine, University of Alabama at Birmingham, Birmingham, AL |
| 2009-Present | Canyon Ranch Endowed Chair for Lifestyle and Behavioral Health, Mel and Enid Zuckerman College of Public Health, University of Arizona, Tucson, AZ |
| 2009-Present | Professor, Health Promotion Sciences, Mel and Enid Zuckerman College of Public Health, University of Arizona, Tucson, AZ |
| 2009-Present | Scientist, Arizona Respiratory Center, University of Arizona. |
| 2012-Present | Associate Dean for Research, Mel and Enid Zuckerman College of Public Health, University of Arizona, Tucson, AZ |

Program Director/Principal Investigator (Last, First, Middle):

2012-Present Interim Director, Women's Center of Excellence, Mel and Enid Zuckerman College of Public Health, University of Arizona, Tucson, AZ

2012-Present Scientist, Canyon Ranch Center for Prevention and Health Promotion, Mel and Enid Zuckerman College of Public Health, University of Arizona, Tucson, AZ

*Honors*

2012 Nominated (1 of 5 women) for the **American Thoracic Society's Elizabeth A. Rich Award** for outstanding scientific achievement among female scientists in pulmonary disease.

2007 Nominated (1 of 6 women) for the **American Thoracic Society's Elizabeth A. Rich Award** for outstanding scientific achievement among female scientists in pulmonary disease.

2007 Jefferson County American Federation of Teachers, **JCAFT Partners in Health Award.**

2006 **Max Cooper Award for Research Excellence**. University of Alabama at Birmingham, School of Medicine.

2005 Nominated (1 of 15 candidates) for the CHEST Foundation's **Alfred Soffer Research Award**.

2004 Featured as a "**Lung Disease Champion**" in the American Lung Association's *How We Help Today Annual Report 2004.*

2003 American Thoracic Society Behavioral Science Assembly **Junior Scholar Award**. *(Given to the individual who has made the most outstanding scientific contributions relevant to behavioral science and lung diseases early in his or her career.)*

**C. Selected Peer-reviewed publications (in chronological order)**

1. Bailey, William C., Connie L. Kohler, James M. Richards, Richard A. Windsor, C. Michael Brooks, **Lynn B. Gerald,** Beverly Martin, Darlene M. Higgins, & Tiepu Liu. (1998). "Asthma Self-Management: Do Patient Education Programs Always Have an Impact?" Archives of Internal Medicine, 159(20):2422-2428. PMID: 10665890
2. Holbrook, Janet T., Robert Wise, & **Lynn B. Gerald.** (2001). "Drug Distribution for a Large Cross-Over Trial of the Safety of Inactivated Influenza Vaccine in Asthmatics." Controlled Clinical Trials 23:87-92. PMID: 11852170
3. Bailey, William C., **Lynn B. Gerald,** Michael E. Kimerling, Nancy Brook, Frank Bruce, David Redden, Shenghui Tang, Steve Duncan, C. Michael Brooks, & Nancy E. Dunlap. (2002). "Predictive Model to Identify Positive Tuberculosis Skin Test Results During Contact Investigations" Journal of the American Medical Association 287(8):996-1002. PMID: 11866647
4. **Gerald, Lynn B.**, Shenghui Tang, Frank Bruce, Michael E. Kimerling, Nancy Brook, Nancy Dunlap, & William C. Bailey. (2002). "A Decision Tree for Tuberculosis Contact Investigation." American Journal of Respiratory and Critical Care Medicine 166(8):1122-1127. PMID: 12379558
5. Eichenhorn, Michael S., Robert Wise, Thelma Madhok, **Lynn B. Gerald,** William C. Bailey, Donald P. Tashkin, Paul D. Scanlon, & the Lung Health Study Research Group. (2003). "Lack of Long Term Adverse Effects from Inhaled Triamcinolone: Lung Health Study II." CHEST 124(1):57-62. PMID: 12853502
6. **Gerald LB**, Turner-Henson A, Hains C, Tang S, Feinstein R, Wille K, Erwin S & Grad R. (2004). "Validation of a multi-stage asthma case detection procedure for elementary school children." Pediatrics,114(4):e459-e468. PMID: 15466072
7. **Lynn B. Gerald,** Marianna M. Sockrider, Roni Grad, Bruce G. Bender, Leslie P. Boss, Stanley P. Galant, Jorrit Gerritsen, Christine L. M. Joseph, Robert M. Kaplan, Julie A. Madden, Joan M. Mangan, Greg J. Redding, Diana K. Schmidt, Christina D. Schwindt, Virginia S. Taggart, Lani S. Wheeler, Kristin N. Van Hook, Paul V. Williams, Barbara P. Yawn, and Bulend Yuksel, on behalf of the ATS Ad Hoc Committee on Issues in Screening for Asthma in Children. (2007). "An Official ATS Workshop Report: Issues in Screening for Asthma in Children." Proceedings of the American Thoracic Society 4:133-141. PMID: 17494724
8. Joan M. Mangan, Angelina Wittich, & **Lynn B**. **Gerald**. (2007). "The potential for reducing asthma disparities through improved family and social function and modified health behaviors." CHEST 132:789-801. PMID: 17998343
9. Dransfield, Mark*, Steven M. Rowe*, James Johnson, William C. Bailey, & **Lynn B. Gerald**. (2007) "Beta Blocker Use and the Risk of Death in Hospitalized Patients with Acute Exacerbations of COPD."

Thorax. 63:301-305. PMID: 17951276

10. McClure, Leslie A., Kathy F. Harrington, Holli Graham, & **Lynn B. Gerald.** (2008). "Internet-based monitoring of asthma symptoms, peak flow meter readings, and absence data in a school-based clinical trial". Controlled Clinical Trials. 5:31-37. PMID: 18283077
11. **Gerald, Lynn B.,** Leslie McClure, Kathy Harrington, Joan M. Mangan, Linda Gibson, Jody Atchison, & Roni Grad. (2008) "Design of the supervised asthma therapy study: implementing an adherence intervention in urban elementary schools." Contemporary Clinical Trials. 29(2):304-310.
12. **Gerald, Lynn B.**, Joan M. Mangan, Leslie McClure, Linda Gibson, Jody Atchison, & Roni Grad. (2009). "Increasing adherence to inhaled steroid therapy among schoolchildren: randomized controlled trial of school based supervised asthma therapy." Pediatrics.*123:466-474.* PMID: 19171611
13. **Gerald, Lynn B.**, Joe K. Gerald, Linda Gibson, Karna Patel, Sijian Zhang, & Leslie A. McClure. (2009). "Changes in ETS exposure and asthma morbidity among urban school children." CHEST; 135:911-916. PMID: 19017893
14. Gerald, Joe K., Yanhui Sun, Roni Grad, & **Lynn B. Gerald.** (2009). "Respiratory symptoms, emergency department visits and hospitalizations in a school-based asthma case detection study." Pediatrics. 124(5):927-933. PMID: 19841121
15. Pisu, Maria, Joe Gerald, James Shamiyeh*, & **Lynn B. Gerald.** (2009). "Targeted TB Contact Investigation Saves Money Without Sacrificing Health." J of Public Health Management and Practice. 15(4):319-327. PMID: 19525776
16. Gerald, Joe K., Roni Grad, William C. Bailey, & **Lynn B. Gerald**. (2010). "Cost-Effectiveness of School-Based Asthma Screening in an Urban Setting". *Journal of Asthma and Clinical Immunology.* 125:643-650. PMID: 20226298. A*ccompanying Editorial by Sean McElligott and Daniel Polsky 651-652.*
17. Kalhan, R., Alexander Arynchyn, Laura A. Colangelo, Mark T. Dransfield, **Lynn B. Gerald**, & Lewis J. Smith. (2010). "Lung Function in Young Adults Predicts Airflow Obstruction 20 Years Later." *American Journal of Medicine.* May;123(5):468.e1-7. PMID: 20399325
18. Wheeler, L., Rebecca Buckley, **Lynn B. Gerald**, Sarah Merkle, & Teresa Morrison. (2011). "Working with Schools to Improve Pediatric Asthma Management." *Pediatric Asthma, Allergy, and Immunology.* 22(4):197-207.
19. Gerald, Joe K., Nancy Stroupe, Leslie A. McClure, Lani Wheeler, **& Lynn B. Gerald.** (2012). "Availability of Asthma Quick Relief Medication in Five Alabama School Systems." *Journal of Pediatric Asthma, Allergy, and Immunology.*25(1): 11-16. PMID: 22454787.
20. Gerald, Joe K., Leslie A. McClure, Kathy F. Harrington, Terri Moore*, Ana Celia Hernandez-Martinez*, & **Lynn B. Gerald.** (2012). "Measurement Characteristics of the Pediatric Asthma Health Outcome Measure (PAHOM)?" *Journal of Asthma.* 49(3): 260-266. PMID: 22335297.
21. **Gerald, Lynn B.,** Joe K. Gerald, Bin Zhang, Leslie A. McClure, William C. Bailey, & Kathy Harrington. (2012). "Can A School-Based Hand Hygiene Program Reduce Asthma Exacerbations Among Elementary School Children?" *Journal of Asthma and Clinical Immunology.* PMID: 23069487.

## D. Research Support

**Ongoing Research Support**

American Lung Association Gerald (PI) 01/01/04—06/30/14

Asthma Clinical Research Center. The American Lung Association's Asthma Clinical Research Centers consists of 19 clinical centers and a data and coordinating center who have the mission of improving asthma care through clinical research in diverse populations. The ALA-ACRC conducts various clinical studies related to asthma.

T76MC04925

HRSA/MCHB Gerald (PI) 06/01/10 – 05/31/15

*Maternal and Child Health Public Health Training Program.* The over arching goal for the training program is to increase the number and quality of culturally competent MCH professionals who will provide the next generation of MCH public health leadership for the development of evidence-based policies, programs, and program evaluation to address the health and wellness women, children and families throughout the Southwest and Rocky Mountain region, and nationally.

Program Director/Principal Investigator (Last, First, Middle):

K25 HL103970-01A1
NIH/NHLBI Beamer (PI) 07/01/11-06/30/16
*Relating Diesel Exhaust Exposure to Respiratory and Immune Outcomes in Early Life.* The research objective of this K25 Mentored Quantitative Scientist proposal is to assess if exposure to diesel-related pollutants is associated with development of transient wheezing or asthma in childhood.

**Completed Research Support (in past three years selected)**

1R01HLHL086972
NIH/NHLBI Gerald (PI) 08/01/07 -- 05/31/12
*Effect of a School Based Hand Sanitizer Program on Asthma.* This project will test the effect of a school based hand sanitizer program on asthma exacerbations in elementary school children.

1R40MC08728
HRSA/MCH Gerald (PI) 09/01/07 – 08/31/2010
*The Impact of Caregiver's (Parent) Health Literacy on Pediatric Asthma Outcomes.* This project will examine the effect of a caregiver's health literacy on their child's asthma outcomes.

1R01HL072817-01
NIH/NHLBI Gerald (PI) 04/15/04 – 04/15/09
*Effectiveness of the TB Contact Priority Model.* This project will use a behaviorally focused intervention to implement and test the effectiveness of the TB contact priority model in field implementation.

National Aeronautic and Space Administration McClure (PI) 06/01/2007 – 05/31/2012
*A Collaborative Agreement Between the UAB School of Public Health and NASA.* The goal of this research is to utilize remote sensing data collected by NASA satellites, in applications to public health outcomes. A further goal of the research is the development and evaluation of methods to relate environmental data collected by remote sensing with data collected at ground level.

OMB Number: 4040-0001
Expiration Date: 06/30/2011

*** ORGANIZATIONAL DUNS:** 8063456170000

*** Budget Type:** ☒ Project ☐ Subaward/Consortium

**Enter name of Organization:** Arizona Board of Regents, Unive

Delete Entry *** Start Date:** 12/01/2013 *** End Date:** 11/30/2014 **Budget Period** 1

**A. Senior/Key Person**

| | Prefix | * First Name | Middle Name | * Last Name | Suffix | * Project Role | Base Salary ($) | Cal. Months | Acad. Months | Sum. Months | * Requested Salary ($) | * Fringe Benefits ($) | * Funds Requested ($) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | | Heidi | E | Brown | | PD/PI | [redacted] | 9.00 | 0.00 | 0.00 | [redacted] | [redacted] | [redacted] |
| 2. | | | | | | | | | | | | | |
| 3. | | | | | | | | | | | | | |
| 4. | | | | | | | | | | | | | |
| 5. | | | | | | | | | | | | | |
| 6. | | | | | | | | | | | | | |
| 7. | | | | | | | | | | | | | |
| 8. | | | | | | | | | | | | | |

9. **Total Funds requested for all Senior Key Persons in the attached file** 0.00

**Total Senior/Key Person** [redacted]

**Additional Senior Key Persons:** Add Attachment Delete Attachment View Attachment

**B. Other Personnel**

| * Number of Personnel | * Project Role | Cal. Months | Acad. Months | Sum. Months | * Requested Salary ($) | * Fringe Benefits ($) | * Funds Requested ($) |
|---|---|---|---|---|---|---|---|
| 0 | Post Doctoral Associates | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Graduate Students | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Undergraduate Students | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Secretarial/Clerical | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Other | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Other Professionals | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Allocated Admin Support | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| 0 | **Total Number Other Personnel** | | | | **Total Other Personnel** | | 0.00 |

**Total Salary, Wages and Fringe Benefits (A+B)** [redacted]

## RESEARCH & RELATED BUDGET - SECTION C, D, & E, BUDGET PERIOD 1

*** ORGANIZATIONAL DUNS:** 8063456170000

*** Budget Type:** ☒ Project ☐ Subaward/Consortium

**Enter name of Organization:** Arizona Board of Regents, Unive

Delete Entry *** Start Date:** 12/01/2013 *** End Date:** 11/30/2014 **Budget Period 1**

**C. Equipment Description**

**List items and dollar amount for each item exceeding $5,000**

| | Equipment item | * Funds Requested ($) |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |
| 6. | | |
| 7. | | |
| 8. | | |
| 9. | | |
| 10. | | |
| 11. | **Total funds requested for all equipment listed in the attached file** | 0.00 |
| | **Total Equipment** | 0.00 |

**Additional Equipment:** Add Attachment Delete Attachment View Attachment

**D. Travel**

| | | Funds Requested ($) |
|---|---|---|
| 1. | Domestic Travel Costs ( Incl. Canada, Mexico and U.S. Possessions) | 0.00 |
| 2. | Foreign Travel Costs | 0.00 |
| | **Total Travel Cost** | 0.00 |

**E. Participant/Trainee Support Costs**

| | | Funds Requested ($) |
|---|---|---|
| 1. | Tuition/Fees/Health Insurance | 0.00 |
| 2. | Stipends | 0.00 |
| 3. | Travel | 0.00 |
| 4. | Subsistence | 0.00 |
| 5. | Other Other | 0.00 |
| 0 | **Number of Participants/Trainees** **Total Participant/Trainee Support Costs** | 0.00 |

RESEARCH & RELATED Budget {C-E} (Funds Requested)

## RESEARCH & RELATED BUDGET - SECTION F-K, BUDGET PERIOD 1

Next Period

*** ORGANIZATIONAL DUNS:** 8063456170000

*** Budget Type:** ☒ Project ☐ Subaward/Consortium

**Enter name of Organization:** Arizona Board of Regents, Unive

Delete Entry *** Start Date:** 12/01/2013 *** End Date:** 11/30/2014 **Budget Period**

| F. Other Direct Costs | Funds Requested ($) |
|---|---|
| 1. Materials and Supplies | [redacted] |
| 2. Publication Costs | 0.00 |
| 3. Consultant Services | 0.00 |
| 4. ADP/Computer Services | 0.00 |
| 5. Subawards/Consortium/Contractual Costs | 0.00 |
| 6. Equipment or Facility Rental/User Fees | 0.00 |
| 7. Alterations and Renovations | 0.00 |
| 8. Other | [redacted] |
| 9. | |
| 10. | |
| **Total Other Direct Costs** | [redacted] |

| G. Direct Costs | Funds Requested ($) |
|---|---|
| **Total Direct Costs (A thru F)** | [redacted] |

**H. Indirect Costs**

| | Indirect Cost Type | Indirect Cost Rate (%) | Indirect Cost Base ($) | * Funds Requested ($) |
|---|---|---|---|---|
| 1. | MTDC | 8.00 | [redacted] | [redacted] |
| 2. | | | | |
| 3. | | | | |
| 4. | | | | |
| | **Total Indirect Costs** | | | [redacted] |

**Cognizant Federal Agency** DHHS Audit Agency, Regional Inspector General for Audit 415-43

(Agency Name, POC Name, and POC Phone Number)

| I. Total Direct and Indirect Costs | Funds Requested ($) |
|---|---|
| **Total Direct and Indirect Institutional Costs (G + H)** | [redacted] |

| J. Fee | Funds Requested ($) |
|---|---|
| | |

**K. * Budget Justification** BudgetJustification.pdf Add Attachment Delete Attachment View Attachment

(Only attach one file.)

OMB Number: 4040-0001
Expiration Date: 06/30/2011

Previous Period

## RESEARCH & RELATED BUDGET - SECTION A & B, BUDGET PERIOD 2

*** ORGANIZATIONAL DUNS:** 8063456170000

*** Budget Type:** ☒ Project ☐ Subaward/Consortium

**Enter name of Organization:** Arizona Board of Regents, Unive

Delete Entry *** Start Date:** 12/01/2014 *** End Date:** 11/30/2015 **Budget Period** 2

### A. Senior/Key Person

| | Prefix | * First Name | Middle Name | * Last Name | Suffix | * Project Role | Base Salary ($) | Cal. Months | Acad. Months | Sum. Months | * Requested Salary ($) | * Fringe Benefits ($) | * Funds Requested ($) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | | Heidi | E | Brown | | PD/PI | [redacted] | 9.00 | 0.00 | 0.00 | [redacted] | [redacted] | [redacted] |
| 2. | | | | | | | | | | | | | |
| 3. | | | | | | | | | | | | | |
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| 5. | | | | | | | | | | | | | |
| 6. | | | | | | | | | | | | | |
| 7. | | | | | | | | | | | | | |
| 8. | | | | | | | | | | | | | |

9. **Total Funds requested for all Senior Key Persons in the attached file** 0.00

**Total Senior/Key Person** [redacted]

**Additional Senior Key Persons:** Add Attachment Delete Attachment View Attachment

### B. Other Personnel

| * Number of Personnel | * Project Role | Cal. Months | Acad. Months | Sum. Months | * Requested Salary ($) | * Fringe Benefits ($) | * Funds Requested ($) |
|---|---|---|---|---|---|---|---|
| 0 | Post Doctoral Associates | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Graduate Students | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Undergraduate Students | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Secretarial/Clerical | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Other | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Other Professionals | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Allocated Admin Support | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| 0 | **Total Number Other Personnel** | | | | | **Total Other Personnel** | 0.00 |

**Total Salary, Wages and Fringe Benefits (A+B)** [redacted]

## RESEARCH & RELATED BUDGET - SECTION C, D, & E, BUDGET PERIOD 2

*** ORGANIZATIONAL DUNS:** 8063456170000

*** Budget Type:** ☒ Project ☐ Subaward/Consortium

**Enter name of Organization:** Arizona Board of Regents, Unive

Delete Entry *** Start Date:** 12/01/2014 *** End Date:** 11/30/2015 **Budget Period 2**

**C. Equipment Description**

**List items and dollar amount for each item exceeding $5,000**

| | Equipment item | * Funds Requested ($) |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |
| 6. | | |
| 7. | | |
| 8. | | |
| 9. | | |
| 10. | | |
| 11. | **Total funds requested for all equipment listed in the attached file** | 0.00 |
| | **Total Equipment** | 0.00 |

**Additional Equipment:** Add Attachment Delete Attachment View Attachment

**D. Travel**

| | | Funds Requested ($) |
|---|---|---|
| 1. | Domestic Travel Costs ( Incl. Canada, Mexico and U.S. Possessions) | 0.00 |
| 2. | Foreign Travel Costs | 0.00 |
| | **Total Travel Cost** | 0.00 |

**E. Participant/Trainee Support Costs**

| | | Funds Requested ($) |
|---|---|---|
| 1. | Tuition/Fees/Health Insurance | 0.00 |
| 2. | Stipends | 0.00 |
| 3. | Travel | 0.00 |
| 4. | Subsistence | 0.00 |
| 5. | Other Other | 0.00 |
| 0 | **Number of Participants/Trainees** **Total Participant/Trainee Support Costs** | 0.00 |

RESEARCH & RELATED Budget {C-E} (Funds Requested)

## RESEARCH & RELATED BUDGET - SECTION F-K, BUDGET PERIOD 2

Next Period

* ORGANIZATIONAL DUNS: 8063456170000

* Budget Type: ☒ Project ☐ Subaward/Consortium

Enter name of Organization: Arizona Board of Regents, Unive

Delete Entry * Start Date: * End Date: 11/30/2015 Budget Period 2

| F. Other Direct Costs | Funds Requested ($) |
|---|---|
| 1. Materials and Supplies | [redacted] |
| 2. Publication Costs | 0.00 |
| 3. Consultant Services | 0.00 |
| 4. ADP/Computer Services | 0.00 |
| 5. Subawards/Consortium/Contractual Costs | 0.00 |
| 6. Equipment or Facility Rental/User Fees | 0.00 |
| 7. Alterations and Renovations | 0.00 |
| 8. Other | [redacted] |
| 9. | |
| 10. | |
| **Total Other Direct Costs** | [redacted] |

| G. Direct Costs | Funds Requested ($) |
|---|---|
| **Total Direct Costs (A thru F)** | [redacted] |

**H. Indirect Costs**

| | Indirect Cost Type | Indirect Cost Rate (%) | Indirect Cost Base ($) | * Funds Requested ($) |
|---|---|---|---|---|
| 1. | MTDC | 8.00 | [redacted] | [redacted] |
| 2. | | | | |
| 3. | | | | |
| 4. | | | | |
| | **Total Indirect Costs** | | | [redacted] |

**Cognizant Federal Agency** DHHS Audit Agency, Regional Inspector General for Audit 415-43

(Agency Name, POC Name, and POC Phone Number)

| I. Total Direct and Indirect Costs | Funds Requested ($) |
|---|---|
| **Total Direct and Indirect Institutional Costs (G + H)** | [redacted] |

| J. Fee | Funds Requested ($) |
|---|---|
| | |

**K. * Budget Justification** BudgetJustification.pdf Add Attachment Delete Attachment View Attachment

(Only attach one file.)

OMB Number: 4040-0001
Expiration Date: 06/30/2011

Previous Period

## RESEARCH & RELATED BUDGET - SECTION A & B, BUDGET PERIOD 3

*** ORGANIZATIONAL DUNS:** 8063456170000

*** Budget Type:** ☒ Project ☐ Subaward/Consortium

**Enter name of Organization:** Arizona Board of Regents, Unive

Delete Entry *** Start Date:** 12/01/2015 *** End Date:** 11/30/2016 **Budget Period** 3

### A. Senior/Key Person

| | Prefix | * First Name | Middle Name | * Last Name | Suffix | * Project Role | Base Salary ($) | Cal. Months | Acad. Months | Sum. Months | * Requested Salary ($) | * Fringe Benefits ($) | * Funds Requested ($) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | | Heidi | E | Brown | | PD/PI | [redacted] | 9.00 | 0.00 | 0.00 | [redacted] | [redacted] | [redacted] |
| 2. | | | | | | | | | | | | | |
| 3. | | | | | | | | | | | | | |
| 4. | | | | | | | | | | | | | |
| 5. | | | | | | | | | | | | | |
| 6. | | | | | | | | | | | | | |
| 7. | | | | | | | | | | | | | |
| 8. | | | | | | | | | | | | | |

9. **Total Funds requested for all Senior Key Persons in the attached file** 0.00

**Total Senior/Key Person** [redacted]

**Additional Senior Key Persons:** Add Attachment | Delete Attachment | View Attachment

### B. Other Personnel

| * Number of Personnel | * Project Role | Cal. Months | Acad. Months | Sum. Months | * Requested Salary ($) | * Fringe Benefits ($) | * Funds Requested ($) |
|---|---|---|---|---|---|---|---|
| 0 | Post Doctoral Associates | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Graduate Students | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Undergraduate Students | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Secretarial/Clerical | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Other | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Other Professionals | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Allocated Admin Support | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| 0 | **Total Number Other Personnel** | | | | **Total Other Personnel** | | 0.00 |

**Total Salary, Wages and Fringe Benefits (A+B)** [redacted]

## RESEARCH & RELATED BUDGET - SECTION C, D, & E, BUDGET PERIOD 3

*** ORGANIZATIONAL DUNS:** 8063456170000

*** Budget Type:** ☒ Project ☐ Subaward/Consortium

**Enter name of Organization:** Arizona Board of Regents, Unive

Delete Entry *** Start Date:** 12/01/2015 *** End Date:** 11/30/2016 **Budget Period 3**

**C. Equipment Description**

**List items and dollar amount for each item exceeding $5,000**

| | Equipment item | * Funds Requested ($) |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |
| 6. | | |
| 7. | | |
| 8. | | |
| 9. | | |
| 10. | | |
| 11. | **Total funds requested for all equipment listed in the attached file** | 0.00 |
| | **Total Equipment** | 0.00 |

**Additional Equipment:** Add Attachment | Delete Attachment | View Attachment

**D. Travel**

| | | Funds Requested ($) |
|---|---|---|
| 1. | Domestic Travel Costs ( Incl. Canada, Mexico and U.S. Possessions) | 0.00 |
| 2. | Foreign Travel Costs | 0.00 |
| | **Total Travel Cost** | 0.00 |

**E. Participant/Trainee Support Costs**

| | | Funds Requested ($) |
|---|---|---|
| 1. | Tuition/Fees/Health Insurance | 0.00 |
| 2. | Stipends | 0.00 |
| 3. | Travel | 0.00 |
| 4. | Subsistence | 0.00 |
| 5. | Other Other | 0.00 |
| 0 | **Number of Participants/Trainees** **Total Participant/Trainee Support Costs** | 0.00 |

RESEARCH & RELATED Budget {C-E} (Funds Requested)

## RESEARCH & RELATED BUDGET - SECTION F-K, BUDGET PERIOD 3

Next Period

*** ORGANIZATIONAL DUNS:** 8063456170000

*** Budget Type:** ☒ Project ☐ Subaward/Consortium

**Enter name of Organization:** Arizona Board of Regents, Unive

Delete Entry *** Start Date:** 12/01/2015 *** End Date:** 11/30/2016 **Budget Period 3**

| F. Other Direct Costs | Funds Requested ($) |
|---|---|
| 1. Materials and Supplies | [redacted] |
| 2. Publication Costs | 0.00 |
| 3. Consultant Services | 0.00 |
| 4. ADP/Computer Services | 0.00 |
| 5. Subawards/Consortium/Contractual Costs | 0.00 |
| 6. Equipment or Facility Rental/User Fees | 0.00 |
| 7. Alterations and Renovations | 0.00 |
| 8. Other | [redacted] |
| 9. | |
| 10. | |
| **Total Other Direct Costs** | [redacted] |

| G. Direct Costs | Funds Requested ($) |
|---|---|
| **Total Direct Costs (A thru F)** | [redacted] |

**H. Indirect Costs**

| | Indirect Cost Type | Indirect Cost Rate (%) | Indirect Cost Base ($) | * Funds Requested ($) |
|---|---|---|---|---|
| 1. | MTDC | 8.00 | [redacted] | [redacted] |
| 2. | | | | |
| 3. | | | | |
| 4. | | | | |
| | **Total Indirect Costs** | | | [redacted] |

**Cognizant Federal Agency** DHHS Audit Agency, Regional Inspector General for Audit 415-43

(Agency Name, POC Name, and POC Phone Number)

| I. Total Direct and Indirect Costs | Funds Requested ($) |
|---|---|
| **Total Direct and Indirect Institutional Costs (G + H)** | [redacted] |

| J. Fee | Funds Requested ($) |
|---|---|
| | |

**K. * Budget Justification** BudgetJustification.pdf Add Attachment Delete Attachment View Attachment

(Only attach one file.)

OMB Number: 4040-0001
Expiration Date: 06/30/2011

Previous Period

## RESEARCH & RELATED BUDGET - SECTION A & B, BUDGET PERIOD 4

*** ORGANIZATIONAL DUNS:** 8063456170000

*** Budget Type:** ☒ Project ☐ Subaward/Consortium

**Enter name of Organization:** Arizona Board of Regents, Unive

Delete Entry *** Start Date:** 12/01/2016 *** End Date:** 11/30/2017 **Budget Period** 4

### A. Senior/Key Person

| | Prefix | * First Name | Middle Name | * Last Name | Suffix | * Project Role | Base Salary ($) | Cal. Months | Acad. Months | Sum. Months | * Requested Salary ($) | * Fringe Benefits ($) | * Funds Requested ($) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | | Heidi | E | Brown | | PD/PI | [redacted] | 9.00 | 0.00 | 0.00 | [redacted] | [redacted] | [redacted] |
| 2. | | | | | | | | | | | | | |
| 3. | | | | | | | | | | | | | |
| 4. | | | | | | | | | | | | | |
| 5. | | | | | | | | | | | | | |
| 6. | | | | | | | | | | | | | |
| 7. | | | | | | | | | | | | | |
| 8. | | | | | | | | | | | | | |

9. **Total Funds requested for all Senior Key Persons in the attached file** 0.00

**Total Senior/Key Person** [redacted]

**Additional Senior Key Persons:** Add Attachment Delete Attachment View Attachment

### B. Other Personnel

| * Number of Personnel | * Project Role | Cal. Months | Acad. Months | Sum. Months | * Requested Salary ($) | * Fringe Benefits ($) | * Funds Requested ($) |
|---|---|---|---|---|---|---|---|
| 0 | Post Doctoral Associates | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Graduate Students | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Undergraduate Students | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Secretarial/Clerical | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Other | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Other Professionals | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Allocated Admin Support | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| 0 | **Total Number Other Personnel** | | | | | **Total Other Personnel** | 0.00 |

**Total Salary, Wages and Fringe Benefits (A+B)** [redacted]

## RESEARCH & RELATED BUDGET - SECTION C, D, & E, BUDGET PERIOD

*** ORGANIZATIONAL DUNS:** 8063456170000

*** Budget Type:** ☒ Project ☐ Subaward/Consortium

**Enter name of Organization:** Arizona Board of Regents, Unive

Delete Entry *** Start Date:** 12/01/2016 *** End Date:** 11/30/2017 **Budget Period 4**

**C. Equipment Description**

**List items and dollar amount for each item exceeding $5,000**

| | Equipment item | * Funds Requested ($) |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |
| 6. | | |
| 7. | | |
| 8. | | |
| 9. | | |
| 10. | | |
| 11. | **Total funds requested for all equipment listed in the attached file** | 0.00 |
| | **Total Equipment** | 0.00 |

**Additional Equipment:** Add Attachment Delete Attachment View Attachment

**D. Travel**

| | | Funds Requested ($) |
|---|---|---|
| 1. | Domestic Travel Costs ( Incl. Canada, Mexico and U.S. Possessions) | 0.00 |
| 2. | Foreign Travel Costs | 0.00 |
| | **Total Travel Cost** | 0.00 |

**E. Participant/Trainee Support Costs**

| | | Funds Requested ($) |
|---|---|---|
| 1. | Tuition/Fees/Health Insurance | 0.00 |
| 2. | Stipends | 0.00 |
| 3. | Travel | 0.00 |
| 4. | Subsistence | 0.00 |
| 5. | Other Other | 0.00 |
| 0 | **Number of Participants/Trainees** **Total Participant/Trainee Support Costs** | 0.00 |

RESEARCH & RELATED Budget {C-E} (Funds Requested)

## RESEARCH & RELATED BUDGET - SECTION F-K, BUDGET PERIOD 4

Next Period

*** ORGANIZATIONAL DUNS:** 8063456170000

*** Budget Type:** ☒ Project ☐ Subaward/Consortium

**Enter name of Organization:** Arizona Board of Regents, Unive

Delete Entry *** Start Date:** *** End Date:** 11/30/2017 **Budget Period 4**

| F. Other Direct Costs | Funds Requested ($) |
|---|---|
| 1. Materials and Supplies | [redacted] |
| 2. Publication Costs | 0.00 |
| 3. Consultant Services | 0.00 |
| 4. ADP/Computer Services | 0.00 |
| 5. Subawards/Consortium/Contractual Costs | 0.00 |
| 6. Equipment or Facility Rental/User Fees | 0.00 |
| 7. Alterations and Renovations | 0.00 |
| 8. Other | [redacted] |
| 9. | |
| 10. | |
| **Total Other Direct Costs** | [redacted] |

| G. Direct Costs | Funds Requested ($) |
|---|---|
| **Total Direct Costs (A thru F)** | [redacted] |

**H. Indirect Costs**

| | Indirect Cost Type | Indirect Cost Rate (%) | Indirect Cost Base ($) | * Funds Requested ($) |
|---|---|---|---|---|
| 1. | MTDC | 8.00 | [redacted] | [redacted] |
| 2. | | | | |
| 3. | | | | |
| 4. | | | | |
| | **Total Indirect Costs** | | | [redacted] |

**Cognizant Federal Agency** DHHS Audit Agency, Regional Inspector General for Audit 415-43

(Agency Name, POC Name, and POC Phone Number)

| I. Total Direct and Indirect Costs | Funds Requested ($) |
|---|---|
| **Total Direct and Indirect Institutional Costs (G + H)** | [redacted] |

| J. Fee | Funds Requested ($) |
|---|---|
| | |

**K. * Budget Justification** BudgetJustification.pdf Add Attachment Delete Attachment View Attachment

(Only attach one file.)

OMB Number: 4040-0001
Expiration Date: 06/30/2011

Previous Period

## RESEARCH & RELATED BUDGET - SECTION A & B, BUDGET PERIOD 5

*** ORGANIZATIONAL DUNS:** 8063456170000

*** Budget Type:** ☒ Project ☐ Subaward/Consortium

**Enter name of Organization:** Arizona Board of Regents, Unive

Delete Entry *** Start Date:** 12/01/2017 *** End Date:** 11/30/2018 **Budget Period** 5

### A. Senior/Key Person

| | Prefix | * First Name | Middle Name | * Last Name | Suffix | * Project Role | Base Salary ($) | Cal. Months | Acad. Months | Sum. Months | * Requested Salary ($) | * Fringe Benefits ($) | * Funds Requested ($) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | | Heidi | E | Brown | | PD/PI | [redacted] | 9.00 | 0.00 | 0.00 | [redacted] | [redacted] | [redacted] |
| 2. | | | | | | | | | | | | | |
| 3. | | | | | | | | | | | | | |
| 4. | | | | | | | | | | | | | |
| 5. | | | | | | | | | | | | | |
| 6. | | | | | | | | | | | | | |
| 7. | | | | | | | | | | | | | |
| 8. | | | | | | | | | | | | | |

9. **Total Funds requested for all Senior Key Persons in the attached file** 0.00

**Total Senior/Key Person** [redacted]

**Additional Senior Key Persons:** Add Attachment Delete Attachment View Attachment

### B. Other Personnel

| * Number of Personnel | * Project Role | Cal. Months | Acad. Months | Sum. Months | * Requested Salary ($) | * Fringe Benefits ($) | * Funds Requested ($) |
|---|---|---|---|---|---|---|---|
| 0 | Post Doctoral Associates | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Graduate Students | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Undergraduate Students | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Secretarial/Clerical | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Other | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Other Professionals | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | Allocated Admin Support | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| 0 | **Total Number Other Personnel** | | | | **Total Other Personnel** | | 0.00 |

**Total Salary, Wages and Fringe Benefits (A+B)** [redacted]

## RESEARCH & RELATED BUDGET - SECTION C, D, & E, BUDGET PERIOD 5

*** ORGANIZATIONAL DUNS:** 8063456170000

*** Budget Type:** ☒ Project ☐ Subaward/Consortium

**Enter name of Organization:** Arizona Board of Regents, Unive

Delete Entry *** Start Date:** 12/01/2017 *** End Date:** 11/30/2018 **Budget Period 5**

**C. Equipment Description**

**List items and dollar amount for each item exceeding $5,000**

| | Equipment item | * Funds Requested ($) |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |
| 6. | | |
| 7. | | |
| 8. | | |
| 9. | | |
| 10. | | |
| 11. | Total funds requested for all equipment listed in the attached file | 0.00 |
| | **Total Equipment** | 0.00 |

**Additional Equipment:** Add Attachment Delete Attachment View Attachment

**D. Travel** **Funds Requested ($)**

| | | |
|---|---|---|
| 1. | Domestic Travel Costs ( Incl. Canada, Mexico and U.S. Possessions) | 0.00 |
| 2. | Foreign Travel Costs | 0.00 |
| | **Total Travel Cost** | 0.00 |

**E. Participant/Trainee Support Costs** **Funds Requested ($)**

| | | |
|---|---|---|
| 1. | Tuition/Fees/Health Insurance | 0.00 |
| 2. | Stipends | 0.00 |
| 3. | Travel | 0.00 |
| 4. | Subsistence | 0.00 |
| 5. | Other Other | 0.00 |
| 0 | **Number of Participants/Trainees** **Total Participant/Trainee Support Costs** | 0.00 |

RESEARCH & RELATED Budget {C-E} (Funds Requested)

## RESEARCH & RELATED BUDGET - SECTION F-K, BUDGET PERIOD 5

*** ORGANIZATIONAL DUNS:** 8063456170000

*** Budget Type:** ☒ Project ☐ Subaward/Consortium

**Enter name of Organization:** Arizona Board of Regents, Unive

Delete Entry *** Start Date:** 12/01/2017 *** End Date:** 11/30/2018 **Budget Period 5**

| F. Other Direct Costs | Funds Requested ($) |
|---|---|
| 1. Materials and Supplies | [redacted] |
| 2. Publication Costs | 0.00 |
| 3. Consultant Services | 0.00 |
| 4. ADP/Computer Services | 0.00 |
| 5. Subawards/Consortium/Contractual Costs | 0.00 |
| 6. Equipment or Facility Rental/User Fees | 0.00 |
| 7. Alterations and Renovations | 0.00 |
| 8. Other | [redacted] |
| 9. | |
| 10. | |
| **Total Other Direct Costs** | [redacted] |

| G. Direct Costs | Funds Requested ($) |
|---|---|
| **Total Direct Costs (A thru F)** | [redacted] |

**H. Indirect Costs**

| | Indirect Cost Type | Indirect Cost Rate (%) | Indirect Cost Base ($) | * Funds Requested ($) |
|---|---|---|---|---|
| 1. | MTDC | 8.00 | [redacted] | [redacted] |
| 2. | | | | |
| 3. | | | | |
| 4. | | | | |
| | **Total Indirect Costs** | | | [redacted] |

**Cognizant Federal Agency** DHHS Audit Agency, Regional Inspector General for Audit 415-43

(Agency Name, POC Name, and POC Phone Number)

| I. Total Direct and Indirect Costs | Funds Requested ($) |
|---|---|
| **Total Direct and Indirect Institutional Costs (G + H)** | [redacted] |

| J. Fee | Funds Requested ($) |
|---|---|
| | |

**K. * Budget Justification** BudgetJustification.pdf Add Attachment Delete Attachment View Attachment

(Only attach one file.)

# BUDGET JUSTIFICATION

## Personnel

Dr. Heidi Brown (Principal Investigator) at .75 FTE per year (9.0 calendar months) will provide project oversight, statistical analysis and results interpretation, writing of research paper for submission in peer-reviewed international journals.

Undergraduate Assistant(s) to work part-time each year with Dr. Brown in Biosphere-2 and participate in manuscript preparation and presentations. (1.26 academic months)

### *Fringe Benefits*

The University of Arizona applies fringe benefit rates/employee related expenses in accordance with rates approved by the Federal Government. Only actual fringe benefits incurred are charged to sponsored projects.

### *Travel*

Mileage between Biosphere-2 and the University in years one through four (Yr 1: $1,645, Yr 2-4: $2,056). Travel support to conferences for Dr. Brown: one trip per year in years one through four and two trips in year five. Travel support for the Undergraduate Assistant to attend a conference in years three and four. Conference travel costs include transportation, per diem, and travel related expenses ($1,500 per conference). Per diem rates and allowable travel expenses for University staff are determined by University travel policy.

### *Participant Support*

The undergraduates will be hired on an hourly basis. Training costs for the PI include tuition and fees for training workshops, coursework, and on-line training. Workshops include specific modeling training opportunities; coursework will be completed at the UA in the mathematics, statistics and ecology departments; online training is primarily for software specific training. Because specific training opportunities are to be determined costs were estimated at $1000 in travel expenses per year and tuition/registration costs of $1,000 for the first year and $3,000 thereafter). Participant travel costs include transportation, per diem, and travel related expenses. Per diem rates and allowable travel expenses for University staff are determined by University travel policy.

### *Operations*

Funds for materials and supplies include a microscope, light source and chill table for mosquito identification, and collapsible field cages (BioQuip). Additional Laboratory supplies include flasks and glassware and insectary supplies. Year 1 is the most expensive as experimentation supplies must be purchased ($8,966). In subsequent years, only maintenance costs and disposable laboratory supplies are requested ($2000 per year).

Publication funds are requested for years four and five ($ 1,000 per year).

Specialized software/user licenses such as ArcGIS ($215: MatLab is free for UA Faculty) will be installed.

Facility usage fees for Biosphere-2 are $565.75 per week for years one through four. Insectary usage fees are estimated at $1000 annually for year 1 and 4 and $2000 for years 2 and 3.

### *Indirect Costs*

Indirect costs are calculated at 8% modified total direct costs as dictated by the sponsor.

## RESEARCH & RELATED BUDGET - Cumulative Budget

| | | Totals ($) |
|---|---|---|
| **Section A, Senior/Key Person** | | [redacted] |
| **Section B, Other Personnel** | | 0.00 |
| Total Number Other Personnel | 0 | |
| **Total Salary, Wages and Fringe Benefits (A+B)** | | [redacted] |
| **Section C, Equipment** | | 0.00 |
| **Section D, Travel** | | 0.00 |
| **1.** Domestic | 0.00 | |
| **2.** Foreign | 0.00 | |
| **Section E, Participant/Trainee Support Costs** | | 0.00 |
| **1.** Tuition/Fees/Health Insurance | 0.00 | |
| **2.** Stipends | 0.00 | |
| **3.** Travel | 0.00 | |
| **4.** Subsistence | 0.00 | |
| **5.** Other | 0.00 | |
| **6.** Number of Participants/Trainees | 0 | |
| **Section F, Other Direct Costs** | | [redacted] |
| **1.** Materials and Supplies | [redacted] | |
| **2.** Publication Costs | 0.00 | |
| **3.** Consultant Services | 0.00 | |
| **4.** ADP/Computer Services | 0.00 | |
| **5.** Subawards/Consortium/Contractual Costs | 0.00 | |
| **6.** Equipment or Facility Rental/User Fees | 0.00 | |
| **7.** Alterations and Renovations | 0.00 | |
| **8.** Other 1 | [redacted] | |
| **9.** Other 2 | | |
| **10.** Other 3 | | |
| **Section G, Direct Costs (A thru F)** | | [redacted] |
| **Section H, Indirect Costs** | | [redacted] |
| **Section I, Total Direct and Indirect Costs (G + H)** | | [redacted] |
| **Section J, Fee** | | |

# PHS 398 Cover Page Supplement

OMB Number: 0925-0001

## 1. Project Director / Principal Investigator (PD/PI)

Prefix:
* First Name: Heidi
Middle Name: E
* Last Name: Brown
Suffix:

## 2. Human Subjects

Clinical Trial? ☒ No ☐ Yes

* Agency-Defined Phase III Clinical Trial? ☐ No ☐ Yes

## 3. Applicant Organization Contact

Person to be contacted on matters involving this application

Prefix:
* First Name: Sherry
Middle Name: L
* Last Name: Esham
Suffix:

* Phone Number: 520-626-6000
Fax Number: 520-626-4130
Email: sponsor@email.arizona.edu

* Title: Director, Sponsored Projects-Services

* Street1: P.O. Box 210158
Street2:
* City: TUCSON
County/Parish:
* State: AZ: Arizona
Province:
* Country: USA: UNITED STATES
* Zip / Postal Code: 85721-0158

# PHS 398 Cover Page Supplement

## 4. Human Embryonic Stem Cells

* Does the proposed project involve human embryonic stem cells? ☒ No ☐ Yes

If the proposed project involves human embryonic stem cells, list below the registration number of the specific cell line(s) from the following list: http://stemcells.nih.gov/research/registry/. Or, if a specific stem cell line cannot be referenced at this time, please check the box indicating that one from the registry will be used:

**Cell Line(s):** ☐ Specific stem cell line cannot be referenced at this time. One from the registry will be used.



Tracking Number:GRANT11349911 Funding Opportunity Number:PA-11-190 Received Date:2013-03-10T13:34:58-04:00

# PHS 398 Checklist

OMB Number: 0925-0001

## 1. Application Type:

From SF 424 (R&R) Cover Page. The responses provided on the R&R cover page are repeated here for your reference, as you answer the questions that are specific to the PHS398.

* Type of Application:

☐ New ☒ Resubmission ☐ Renewal ☐ Continuation ☐ Revision

Federal Identifier: AI101224

## 2. Change of Investigator / Change of Institution Questions

☐ Change of principal investigator / program director

Name of former principal investigator / program director:

Prefix:
* First Name:
Middle Name:
* Last Name:
Suffix:

☐ Change of Grantee Institution

* Name of former institution:

## 3. Inventions and Patents (For renewal applications only)

* Inventions and Patents: Yes ☐ No ☒

If the answer is "Yes" then please answer the following:

* Previously Reported: Yes ☐ No ☐

**4. * Program Income**

Is program income anticipated during the periods for which the grant support is requested?

☐ Yes ☒ No

If you checked "yes" above (indicating that program income is anticipated), then use the format below to reflect the amount and source(s). Otherwise, leave this section blank.

| *Budget Period | *Anticipated Amount ($) | *Source(s) |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |

**5. * Disclosure Permission Statement**

If this application does not result in an award, is the Government permitted to disclose the title of your proposed project, and the name, address, telephone number and e-mail address of the official signing for the applicant organization, to organizations that may be interested in contacting you for further information (e.g., possible collaborations, investment)?

☐ Yes ☒ No

# PHS 398 Career Development Award Supplemental Form

OMB Number: 0925-0001

## 1. Application Type:

From SF424 (R&R) Cover Page. The response provided on that page, regarding the type of application being submitted, is repeated here for your reference, as you attach the sections that are appropriate for this Career Development Award.

☐ New ☒ Resubmission ☐ Renewal ☐ Continuation ☐ Revision

## 2. Career Development Award Attachments:

Please attach applicable sections, below.

| | | | | |
|---|---|---|---|---|
| **Introduction (if applicable)** | | | | |
| 1. Introduction to Application *(for RESUBMISSION applications only)* | Introduction.pdf | Add Attachment | Delete Attachment | View Attachment |
| **Candidate Information** | | | | |
| 2. Candidate's Background | CandidateBackground.pdf | Add Attachment | Delete Attachment | View Attachment |
| 3. Career Goals and Objectives | CareerGoalsObjectives.pdf | Add Attachment | Delete Attachment | View Attachment |
| 4. Career Development/Training Activities During Award Period | CareerDevActivities.pdf | Add Attachment | Delete Attachment | View Attachment |
| 5. Training in the Responsible Conduct of Research | RCR.pdf | Add Attachment | Delete Attachment | View Attachment |
| 6. Mentoring Plan *(when applicable)* | | Add Attachment | Delete Attachment | View Attachment |
| **Statements of Support** | | | | |
| 7. Statements by Mentor, Co-Mentors, Consultants, Contributors *(as appropriate)* | LetterSupport_all3.pdf | Add Attachment | Delete Attachment | View Attachment |
| **Environment and Institutional Commitment to Candidate** | | | | |
| 8. Description of Institutional Environment | InstEnvironment.pdf | Add Attachment | Delete Attachment | View Attachment |
| 9. Insitutional Commitment to Candidate's Research Career Development | InstCommitment.pdf | Add Attachment | Delete Attachment | View Attachment |
| **Research Plan** | | | | |
| 10. Specific Aims | SpecificAims.pdf | Add Attachment | Delete Attachment | View Attachment |
| 11. * Research Strategy | ResearchStrategy.pdf | Add Attachment | Delete Attachment | View Attachment |
| 12. Inclusion Enrollment Report *(for RENEWAL applications only)* | | Add Attachment | Delete Attachment | View Attachment |
| 13. Progress Report Publication List *(for RENEWAL applications only)* | | Add Attachment | Delete Attachment | View Attachment |
| **Human Subject Sections** | | | | |
| 14. Protection of Human Subjects | | Add Attachment | Delete Attachment | View Attachment |
| 15. Inclusion of Women and Minorities | | Add Attachment | Delete Attachment | View Attachment |
| 16. Targeted/Planned Enrollment | | Add Attachment | Delete Attachment | View Attachment |
| 17. Inclusion of Children | | Add Attachment | Delete Attachment | View Attachment |



Tracking Number:GRANT11349911 Funding Opportunity Number:PA-11-190 Received Date:2013-03-10T13:34:58-04:00

# PHS 398 Career Development Award Supplemental Form

## 2. Career Development Award Attachments (continued):

Other Research Plan Sections

| | | | | |
|---|---|---|---|---|
| 18. Vertebrate Animals | | Add Attachment | Delete Attachment | View Attachment |
| 19. Select Agent Research | | Add Attachment | Delete Attachment | View Attachment |
| 20. Consortium/Contractual Arrangements | | Add Attachment | Delete Attachment | View Attachment |
| 21. Resource Sharing Plan(s) | | Add Attachment | Delete Attachment | View Attachment |

Appendix (if applicable)

22. Appendix Add Attachments | Delete Attachments | View Attachments

## 3. * Citizenship:

- ☒ U.S. Citizen or noncitizen national
- ☐ Permanent Resident of U.S.
  *(If a permanent resident of the U.S., a notarized statement must be provided by the time of award)*
- ☐ Permanent Resident of U.S. Pending
- ☐ Non-U.S. Citizen with temporary U.S. visa

## INTRODUCTION

The feedback from reviewers is greatly appreciate, particularly the compliments to the team assembled, that Aim 1 is “very clear and the experimental design is excellent,” they foresee “the project is likely to be successful” and that “the potential public health significance of the work propose is very high.” There were two concerns expressed by all reviewers: 1) a vague career plan, lacking detail and 2) Aim 2 was incomplete, not clear or carefully delineated, and the mentoring was incomplete. All additional comments are addressed in this revised submission. A summary of the changes is provided here. Because Aim 2 and the candidate information sections have been completely revised, changes in the text are not highlighted.

1. Career development plan: The Candidate Information (background, goals, development and training) has been restructured. These sections now include a rationale for seeking a career development award, short and long term goals, training goals and experiences (with course titles and descriptions), and a time line of activities.
2. Aim 2: Dr. Joceline Lega, Professor of Mathematics at the University of Arizona (UA) with expertise in non-linear modeling, is now the primary mentor to guide Aim 2. With Dr. Lega’s assistance the Aim has been re-written for clarity and further refined. How the data collected in Biosphere-2 (Aim 1) will be incorporated into Aim 2 is now explicit. Specific math modeling courses at the UA and summer workshops have been identified and included in the timeline. As per comments, the model will be constructed in MATLAB, a more powerful and generally applicable package. In the original submission, the methods were to be self-taught. With Dr. Lega, this project has the support of an enthusiastic mentor who is eager to turn her modeling skills to infectious diseases and who has many years of experience guiding academic development.
3. Additional Comments:

a. A new Institutional support letter is provided by Dr. Iman Hakim, Dean of the UA College of Public Health, where I have been hired into a junior faculty position, Assistant Professor (start date 21 Jan 2013).

b. Mentor roles have been fully clarified both in their scientific expertise as it relates to the projects, as well as in their mentoring capacity. The mentoring team now includes Dr. Lega as the primary mentor for this modeling focused project; Drs. Roberto Barrera and Andrew Comrie are co-mentors due to their subject matter expertise as well as their experience and distinction within their fields; a new collaborator, Dr. Lynn Gerald at the UA has been added because of her mentoring capabilities as well as her extensive experience successfully competing for NIH funding.

c. The Training in the Responsible Conduct of Research has been re-written to reflect NIH requirements.

d. As noted, most of my publications are in journals read by most vector-borne disease researchers, but with limited wider audience and, thus, a lower impact factor. The exceptions include publications in EID (impact factor 6.2) and the recent Proceedings of the Royal Academy – B (impact factor 5.4). An additional manuscript has just been submitted to Environmental Health Perspectives (impact factor 7.0). I co-wrote the chapter on Climate Change and Health, for the Southwest Regional Technical Report in response to the National Climate Assessment. Publications from the proposed work are expected to support wider interest and solidify my place as an internationally recognized expert in dengue epidemiology, disease modeling, and public health outcomes research.

e. Information has been added with respect to the experiments being conducted in Biosphere-2. Specifically 1) it has been made explicit how this component of the project, in addition to its importance as a facility allowing for a scale of research not available anywhere else, will allow for me to engage with the public by presenting my research to tours and docents who will give the tours, and 2) how the data generated in empirical investigations of Aim 1 will be utilized in the modeling component (Aim 2) has been described.

f. International conferences (ASTMH, International Conference on Dengue and Dengue Hemorrhagic Fever, Society of Vector Ecology (every other year outside the US)) have been identified as venues to present the research findings and these enrichment opportunities have been added to the timeline.

This revised proposal describes research to improve dengue control and advance my career as an independent researcher able to lead a team of research scientists in addressing critical public health concerns. Moreover, it will provide me pilot data and mathematical modeling skills to generate additional research topics.

## CANDIDATE BACKGROUND

My goal in seeking a Mentored Research Career Development Award is to broaden my approach to vector-borne disease research. I have begun to incorporate dynamic models into my epidemiological skill set. Even with my elementary modeling abilities I have been asked to contribute to other research teams. This K01 award would allow me the protected time to take the necessary course work to ensure that I generate mathematically sound models while working on an independent project to test the efficacy of a public health intervention. The results from the projects described in this K01 application will facilitate a deeper understanding of the interconnections between vectors, hosts, and the environment and the tools useful in quantifying these relationships. The outcome I propose to model has implications for dengue control and prevention both in terms of best practice and resource allocation, but more importantly the training will fill gaps in my CV that solidly position me for an independent career.

**Experience:** My research focus is environmental influences on human risk for vector-borne disease and interpreting scientific discovery for a practical purpose. Melding field, laboratory and modeling work, I utilize remotely sensed imagery and meteorological data to model the distribution and abundance of vectors. These models are then related to host distribution and disease outcomes to inform public health practice.

For my dissertation in the Department of Epidemiology and Public Health at Yale University I studied West Nile virus and its mosquito vectors. My studies allowed me to design and conduct independent field work and gain experience running an insectary. I collaborated with medical entomologists, virologists, ecologists, epidemiologists and geographers in order to develop static habitat suitability models of vector distribution.

My post-doctoral experience expanded upon my graduate work. Concluding a four year project evaluating the emerging threat of bluetongue virus in Northern Europe, I started as bluetongue virus made its first foray in the United Kingdom. Working in the Department of Zoology at Oxford University, I collaborated with researchers focusing on livestock diseases and animal husbandry. By including climatic data I added another dimension to the static vegetation based habitat models I had so far been developing.

Working at the Division of Vector-borne and Infectious Diseases at the Centers for Disease Control and Prevention I learned additional disease systems. I led tick collection field teams and continued to develop statistical models for a variety of disease systems (tularemia, West Nile virus disease, and plague). I became increasingly reliant on meteorological data but was unaware of the right sources or how best to use the data.

To address this gap in knowledge, I joined Dr. Comrie's group at the School of Geography and Development at the University of Arizona. Using a dynamic modeling textbook and the assistance of a student adept in using the STELLA platform (ISEE Systems), I amended a meteorological data driven dynamic model of mosquito abundance to include two additional United States West Nile virus vectors. This model, parameterized using published laboratory findings on temperature dependent development, is driven by local meteorological data to simulate mosquito abundance. Thus we are able to estimate mosquito abundance for areas where surveillance data are not collected. By changing the input weather data, I can estimate changes in abundance due to future climate scenarios (everything else being equal) and assess potential changes in entomologic risk.

**This Proposal:** In addition to positioning me as an independent researcher, the work proposed in this K01 award connotes important gains for a more comprehensive model testing the role of mosquito dispersal in dengue spread. Often models are built by individuals who see the parameters as mathematical functions rather than the systems they represent. This may lead to inappropriate assumptions about vector behavior and representation in the model. The assembled team for this Mentored Career Development award has the expertise necessary to insure the development of a mathematically sound model grounded in appropriate biological and abiotic parameters. The proposed tutelage, coursework, and workshops will strengthen my ability as a disease modeler and establish a research foundation from which I will be able to continue to generate independently funded research projects.

The outcomes from this proposal will appreciably contribute to the field of dengue prevention and control. I address two critical questions: 1) how does oviposition site density influence flight range and 2) how effective is

the removal of gravid females on a mosquito population. This furthers our understanding of how infected vectors move through a population and has practical implications for vector control strategies. This project and the identified mentoring team will insure the best science possible and propel me along the path for an independent career researching environmental determinants of human disease transmission.

## CAREER GOAL AND OBJECTIVES

**Professional Goal:** My career goal is to establish a respected research group focused on understanding the public health implications of human/environment interactions. Asking fundamental questions and discovering practical solutions will always be a focus of my work. My interdisciplinary approach will allow me ease in communicating within multiple disciplines and, by excelling at communicating across disciplines; I will be better able to communicate science to the public.

Short-Term Professional Goals:

1. Acquire training in mathematical modeling as it is uniquely applied to disease systems.
2. Expand professional network in infectious disease, entomology, modeling, and climate change communities.
3. Publish peer-reviewed manuscripts in high impact journals with broad readership.
4. Successfully compete for extramural funding.

Long-Term Professional Goals:

1. Establish a recognized research team focused on understanding disease dynamics.
2. Contribute reducing the global impact of vector-borne disease.
3. Use novel approaches to quantify climate change and health associations.
4. Advance science for promotion within academics.

**Rationale for Seeking a Career Development Award:** In my development as an independent researcher, I am increasingly finding a need to incorporate more advanced modeling techniques. This proposal was developed to address this gap in my training and current approaches while learning a new disease system. I have identified three training goals: 1) Become expert in *Aedes aegypti* life cycle and dengue, 2) Improve my capacity to incorporate climate data into vector-borne disease analysis, and, 3) Gain skills in mathematical modeling and advanced statistical programming.

Despite my analytic skills, lack of knowledge in these three additional areas of expertise impedes my ability to measure and identify practical interventions for improving human health. With this Mentored Research Scientist Development Award, I will have the opportunity to focus on acquiring these skills. The mentors I selected have the scientific expertise to guide me in attaining the appropriate skills, and are widely respected in their fields and thus can facilitate my professional development. At the end of this study, I will have published broadly in peer-reviewed journals, gained skills that are novel and applicable to many disease systems, have pilot data for additional independent research projects, and have assembled a diverse research team to address a substantial public health issue using novel approaches.

## CAREER DEVELOPMENT/TRAINING ACTIVITIES DURING AWARD PERIOD

The proposed career development and training activities during the award period include courses to improve my skills as a disease modeler and researcher, engaging with the scientific community and with the public, and mentoring by established researchers.

Table1. List of mentor, co-mentors and collaborators

| Name | Title | Expertise related to this project |
|---|---|---|
| Mentor | | |
| Joceline Lega. Ph.D. | Professor of Mathematics, Director Inst. Mathematics and Education | Modeling non-linear phenomena with applications to Biology, pattern formation |
| Co-Mentor | | |
| Roberto Barrera, Ph.D. | Chief, Entomology and Ecology Activity | Medical entomology, Dengue surveillance & control |
| Andrew Comrie, Ph.D. | Professor of Geography, Associate Vice President for Research | Climate change and health, and spatial analysis |
| Collaborator | | |
| Lynn Gerald, Ph.D., M.S.P.H. | Professor of Health Promotion Sciences, Associate Dean for Research | Epidemiological research, NIH grant writing |

The three training goals of this Mentored Career Development Award apply to both aims of this project:

**1. Become an authority on the *Aedes aegypti* life cycle and dengue.** Mosquito-borne disease systems are complex and those involving *Ae. aegypti* even more so (an endophilic, small container breeding, anthrophilic vector). Experiments or models which treat all mosquito species equally cannot effectively describe a system. While I have experience with *Culex* vectors of West Nile virus and other vector-borne disease systems, dengue offers unique challenges because of the vector's peridomestic behavior.

*Tutorials*: Dr. Barrera is a leading expert on dengue and an important component for this project. Because he is in Puerto Rico, we will rely on email and telephone to discuss this project. To understand the field data collected and the nuances of *Ae. aegypti,* Dr. Barrera and I will have weekly phone calls in the first two months of the project. Thereafter we will correspond on a sliding scale of frequency as I become more independent. In addition, we will meet at the annual American Society of Tropical Medicine and Hygiene.

*Outreach:* Beyond the scientific merit of this proposal, since some of the work occurs in Biosphere-2 there is a unique outreach component to this project. Biosphere-2 was originally designed as an enclosed system to test the possibility of human colonization of space. Now this 3.14 acre facility with climate controlled Tropical Rain Forest, Savanna, and Dessert biomes allows for ecosystem level experiments. In 2011, Biosphere-2 was acquired by the University of Arizona. Each year 110,000 guests tour the facilities and are able to interact with the researchers. Thus, my work will reach a broad audience.

**2. Improve my capacity to incorporate climate data into vector-borne disease analysis.** Climate data are important in the methods I use to investigate vector-borne disease transmission. However, much like epidemiological data, there are nuances with respect to how data are collected and aggregated which may influence how they are utilized. Working with Dr. Comrie, I will gain a better understanding of the advantages and limitations of different sources of climate data, and how to appropriately interpret them.

*Tutorials:* In addition to the course, Dr. Comrie and I will meet regularly (bi-weekly) during the model development stages to insure appropriate use of climate data. It must be noted that while Dr. Comrie has considerable administrative responsibilities, he is known across campus for his ability to juggle commitments and make time for his mentees.

*Coursework*: Each spring, I will participate in Dr Comrie's graduate seminar (Geog 696C *Physical Geography Seminar*). This course rotates through topics such as Climate Applications Toolbox; Climate Drivers of Environmental Change; Climate & the Ecology of Infectious Disease; Analysis of Disease and Climate; IPCC AR4 Climate Change in the Southwest.

**3. Gain skills in mathematical modeling and advanced statistical programming.** The K01 award would allow me the freedom to engage in training opportunities to improve my modeling capability, adding a significant new skill to my epidemiological toolset. The identified coursework blends the fundamentals of mathematical modeling as well as software specific training to optimize working within those platforms.

*Tutorials:* Dr. Lega will assist me with the modeling component. She designed the *Mathematical Modeling* course (MATH 485/584) and has an interest in developing epidemiological models of infectious disease. During the first year of the project we will meet occasionally to discuss the project and coursework. Once the data have been collected at Biosphere-2, we will meet regularly (bi-weekly). In addition, Dr. Barrera and Dr. Comrie both have expertise in statistical analysis with applications for vector-borne diseases.

*Coursework:* Formal training in mathematical modeling will come from courses at the University of Arizona, on-line independent study, and workshops. Courses at the UA include: *Mathematical Modeling* (MATH 585 - Development, analysis, and evaluation of mathematical models for physical, biological, social, and technical problems (Spring 2014)); *Complex Systems: Networks & Self-organization in Biology* (ECOL 596G – complex systems research at multiple levels, including gene regulatory networks, neural net(work)s, ecological networks, and social networks (Spring 2015)); *Quantitative Modeling of Biological Systems* (APPL 572 - Techniques for development of mathematical models (Spring 2016)). On-line, independent study courses will be taken in summers and when available – at least one per year. They include courses such as *Introduction to Stata Programming* and *Advanced Stata Programming* provided through StataCorp. Stata is the statistical software program I use most. The course work will help me to automate analyses and make them more efficient. In addition, specific topics of interest include modeling workshops (examples include: *Ecology and Evolution of Infectious Diseases* sponsored by the Department of Biology at Colorado State University), the National Institute for Mathematical and Biological Synthesis (NIMBioS), Rutgers University's DIMCAS workshops, and international workshops such as those organized at the London School of Hygiene and Tropical Medicine (e.g., *Introduction to Infectious Disease Modelling and Its Applications*) or the Imperial College, London (e.g., *Introduction to Mathematical Models of the Epidemiology and Control of Infectious Diseases*).

Table1. Career Development Plan for Completion of K01 Award

| Period | Training and Research Activities |
|---|---|
| Year 1<br>8/13-7/14 | Coursework: Mathematical Modeling, Intro to Stata Modeling, Matlab Fundamentals, Physical Geog. Seminar, Workshop<br>Research: Set-up and conduct of optimization experiments. Literature review for model parameters. |
| Year 2<br>8/14-7/15 | Coursework: Complex Systems, Advanced Stata Programming, Matlab Programming Techniques, Physical Geog. Seminar, Workshop<br>Research: Collect data on oviposition site density (Winter & Summer). Model development. |
| Year 3<br>8/15-7/16 | Coursework: Quantitative Modeling, Physical Geog. Seminar, Workshop, Grantsmanship for a Winning Proposal<br>Research: Collect data on oviposition site density (Winter & Summer). Model development and analysis of intervention impact. Begin preparation of R01 to investigate quantitative modeling of climate change and health issues. |
| Year 4<br>8/16-7/17 | Coursework: Physical Geog. Seminar, Workshop<br>Research: Collect data on oviposition site density (Winter & Summer). Compare model output across climate scenarios. |
| Year 5<br>8/17-7/18 | Coursework: Physical Geog. Seminar, Workshop<br>Research: Analysis of oviposition data (for publication). Incorporate empirical data to model and analysis of spatial extent of removal trapping dispersal. |

***Professional Development.*** Presenting findings is an integral part of being a research scientist. The research budget of this K01 award would be used to support presentation of the research findings at the American Society of Tropical Medicine and Hygiene (an international meeting held annually in November/December) and the Society of Vector Ecology (alternates between US and International each year in the Fall) meetings. I will also present my work in laboratory meetings and departmental seminars (e.g., the College of Public Health has a weekly departmental seminar with required attendance by MPH and PhD students, the Entomology Department has a weekly seminar in the Fall semester); guest lecture in relevant courses in Geography (varies), Public Health (e.g., CPH 660: *Infectious Disease Epidemiology*), Entomology (e.g., ENTO 457- *Medical Veterinary Entomology*), and attend additional meetings and conferences as they present themselves.

As with the conferences, the workshops identified above also provide me the opportunity to network with members of the modeling and disease community.

Successful grant writing is also an important facet to a career in academics. Dr. Gerald has been added as a collaborator in part due to her exceptional skill at securing NIH funding. Dr. Gerald is the Associate Dean of Research in the College of Public Health and has a vested interest in helping me to successfully prepare proposals. Dr. Gerald teaches *Grantsmanship for a Winning Proposal* (CPH 652), which I will attend in the 3rd year of this project. She co-hosts a monthly luncheon on topics important for junior faculty, which I currently attend.

Through the skills, expertise, and contacts made during this project, I will establish myself as an independent researcher. Engaging in an official mentoring capacity with these researchers will advance the next generation of innovative ideas to address the public health burden caused by dengue. For the duration of this grant, I will be integrating the empirical experiments at Biosphere-2 and the modeling project. I will be guided by mentors with expertise in entomology, climatology, statistical methods, mathematical modeling, and grant writing who themselves link research and public outreach. The identified mentors are experienced in their fields and have contacts in a variety of fields relevant to vector-borne disease research, thus expanding collaborative opportunities. At the end of the 5 years, I will be a highly skillful disease modeler, dengue transmission and control expert, adept at incorporating climate information for public health application, well published and more broadly connected within the scientific community. With the proficiency of a seasoned investigator, I will be on course for a highly productive career in academic research.

## TRAINING IN THE RESPONSIBLE CONDUCT OF RESEARCH

It is policy for all researchers at the University of Arizona to engage in at least 8 hours of Responsible Conduct of Research Training, which must be renewed every four years. Training covers a broad range of topics including research misconduct, data sharing and ownership, authorship, animal welfare, laboratory safety, and human subjects. I completed the on-line training (2 hours) which is incorporated into the start-up paper work completed by all new researchers through the Collaborative Institutional Training Initiative (CITI). Discussions with my mentors (one hour) about responsible research conduct will occur formally within the first 90 days of the award and the topics will be revisited through the experimentation, data analysis and manuscript preparation stages of this grant. The University of Arizona's Office for the Responsible Conduct of Research holds workshops (4 hours) and seminars (1 hour) throughout the year. As part of my training as a graduate student, I completed a course entitled *Research Ethics and Responsibilities*. Training will be completed within 90 days of the award, and I will remain current on all training for the duration of this award. My training will be recorded in the University's Office for the Responsible Conduct of Research tracking system.

THE UNIVERSITY OF ARIZONA.

MATHEMATICS
UASCIENCE

Joceline Lega
617 N. Santa Rita Avenue
Tucson, Arizona 85721
TEL (520) 621-4350
FAX (520) 621-8322
http://math.arizona.edu/~lega

**MENTOR'S STATEMENT** 15 November, 2012
**Mentor: Dr. Joceline Lega, FInstP**

I will be delighted to act as the primary mentor for Dr. Heidi Brown on the project described in her proposal for a K01 Mentored Research Scientist Development Award.

I am a tenured full professor of Mathematics at the University of Arizona. My research interests are in the modeling of nonlinear phenomena, with applications to physics and biology. My work combines modeling, mostly in terms of differential equations, mathematical analysis of the models, and numerical simulations, each approach building upon and informing the others. I have published 46 peer reviewed articles and have a longstanding experience in doing collaborative work with experimentalists, in areas as diverse as fluid dynamics, nonlinear optics, geosciences, neuroscience, and molecular and cellular biology. I am Editor-in-Chief of *Physica D: Nonlinear Phenomena*, and have been a member of the Editorial Board for *Nonlinearity* since 2004. Both are leading peer-reviewed journals at the interface between applied mathematics and nonlinear dynamics.

At the University of Arizona, I have supervised numerous research projects for undergraduate and graduate students, and in the past 10 years, worked extensively with postdoctoral fellows. In particular, I acted as a mentor for the following individuals:

- Stéphane Lafortune, a postdoctoral fellow supported by the Canadian NSERC (2000–2002) and later our department's Hanno Rund Postdoctoral Fellow (2002–2004), who is now Associate Professor of Mathematics at the College of Charleston, SC.
- Derek Moulton, our 2008–2010 department's Pierce Postdoctoral Fellow, who is completing a second postdoctoral position in the Mathematical Institute at the University of Oxford, UK.
- Christopher Bergevin, a joint HHMI–VIGRE (Howard Hughes Medical Institute–NSF) post-doctoral fellow (2007–2010), who started on a faculty position in the Physics & Astronomy department at York University, Canada, this fall.
- Alan Lindsay, our 2010–2012 department's Pierce Postdoctoral Fellow, who is now a lecturer of Applied Mathematics at Heriot-Watt University, UK.

I view myself as both a researcher and an educator, and fully embrace the multifaceted workload of a full professor at a Research I American university. I direct the Institute for Mathematics & Education (IM&E), whose mission is to bring together mathematicians, researchers in mathematics education, mathematics K-12 educators, and policy makers, to address issues in the teaching of mathematics at the K-16 levels. Our work includes running a Math Circle for high school students, two Teachers' Circles (at the middle and high school levels), offering professional development to K-8 teachers, and offering workshops for mathematicians interested in becoming involved in K-12 education, as well as conferences for teachers, administrators, and policy makers, on the topic of the new Common Core State Standards in Mathematics. In particular, I am PI of a $2.95M 5-year GK-12 grant from the National Science Foundation, which pairs graduate students with school

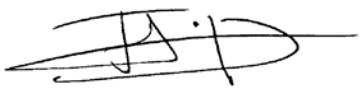
teachers, and PI for a series of grants from the Intel Foundation, which supports the work of the IM&E as the National Training Agency for the Intel Math professional development program for K-8 teachers.

At the university level, I have taught a wide range of mathematics courses, both at the undergraduate and graduate levels, and worked on the development of a few others, including Advanced Analysis for Engineers (MATH 322), Explorations in Integrated Science (MCB/MATH/PHYS 303), and Mathematical Modeling (MATH 485/585).

In my role of mentor for Dr. Brown, I will assist with the development of mathematical models that will incorporate the data she and her collaborators will have collected. Good mathematical models should not only reproduce experimental measurements, but should also be able to capture the main ingredients that contribute to the phenomenon that is being analyzed, in as simple a way as possible. Only then, can they be explanatory and predictive. I will thus work with Dr. Brown to develop such models and, as part of this process, share with her the tools and methods that applied mathematicians commonly use in modeling activities, including deciding what components to include, and what elements to neglect, at least at first. Dr. Brown and I have already had two substantial conversations on the kind of data that is or will be available, and how to incorporate this information in models of increasing complexity. We have also discussed what types of models will be suitable to answer the questions she poses in her K01 proposal, as well new questions that might naturally arise from the outcome of her study. My goal will be to help her build enough expertise to independently develop models of her own in the future. In terms of technology, the University of Arizona has a campus-wide MATLAB license with numerous toolboxes, which can be used as part of this project.

I will be available for regular in-person meetings, as well as for consultations over the phone or by Skype or email. I will also be able to guide Dr. Brown through some of her coursework, since I have written the course notes for our mathematical modeling course (MATH 485/585) and have a research interest in complex systems (for instance, I was one of the co-authors of the report on the 2008 NSF workshop on Foundations for Complex Systems Research in the Physical Sciences and Engineering). In terms of outreach / broader impact, Dr. Brown will have the opportunity to reach out to K-12 mathematics teachers and students through the IM&E; it is indeed well-known that “real-world” applications of mathematics can help students develop a long-term interest in pursuing STEM careers, and I am certain that the interdisciplinary nature of her project would attract a lot of attention at the middle or high school levels. Finally, I believe that our collaborative work will go beyond the proposed K01 project; we have in particular started discussing interdisciplinary activities that could be developed as follow on to the proposed K01 project.

Sincerely,



Joceline Lega
Professor of Mathematics
Fellow of the Institute of Physics
Director, Institute for Mathematics & Education
Editor-in-Chief, Physica D: Nonlinear Phenomena
The University of Arizona

Department of Health and Human Services

Centers for Disease Control and Prevention (CDC)
National Center for Infectious Diseases
Division of Vector-Borne Infectious Diseases
Dengue Branch
1324 Calle Cañada
San Juan, Puerto Rico 00920-3860
Tel: (787) 706-2399
Fax: (787) 706-2496

**December 03, 2012**

**Dear review committee members**
**NIH Mentored Research Scientist Development Award (K01)**

This letter is to inform you that I am very willing and glad to become a co-mentor for Dr. Heidi Brown in the Mentored Research Career Development Award. I have known Dr. Brown for several years now and I am convinced that she is a talented, very motivated young researcher.

I have worked with mosquito ecology and control for over thirty years, first as a university faculty for 25 years, and more recently as the Chief of the Entomology and Ecology Activity at the Dengue Branch, CDC. As a former professor I tutored several doctoral students. Also, we regularly host under- and graduate student interns at Dengue Branch. As a leading scientist in vector-borne disease, I have a large network of contacts which can assist Dr. Brown both for this project and in her career. I can provide contacts both within the U.S. and internationally and on a range of biological systems and fields of study. When relevant, I will invite Dr. Brown to collaborate when I am asked to co-author reviews and book chapters on dengue. My current position involves maintaining a research program, supporting a staff, participating as an editor for journals, and serving as a community contact for dengue reduction strategy. Balancing these responsibilities is a challenge in which new faculty rarely receive advice and training. Dr. Brown and I will discuss some of the strategies I've learned. My position is different from Dr. Brown's other mentors in that I work for a government agency tasked with identifying and providing operational outcomes. As a result, I provide a different view on research prioritization and interpretation which will be beneficial to Dr. Brown's goal of becoming a successful public health scientist.

Though Aim 1 of the proposed project is elegant in its simplicity, the nuances of *Aedes aegypti* biology and vector flight range dynamics are complex. I will help Dr. Brown to identify which aspects of dengue research, and vector-borne diseases in general, are most in need of attention and have the greatest potential for impact. My participation as a co-mentor of Dr. Brown will be as an advisor on aspects of the biology and ecology of *Aedes aegypti*, the main vector of dengue, helping her obtain field data on distribution and abundance of mosquitoes so she can incorporate that information into her models, advise on data analysis or interpretation, monitor her progress, and help with the publication or presentation of results.

Beyond collaborating on the science of this project, my role as mentor includes guiding her on choosing which journals, crafting the manuscript for specific journals, making impactful presentations, and tailoring presentations for particular audiences. I am an Associate Editor for PLoS Neglected Tropical Diseases and Journal of Medical Entomology and am widely published in the vector-borne disease and tropical medicine realm. I regularly attend international conferences related to dengue and other mosquito-borne diseases. I am uniquely qualified to help Dr. Brown navigate these aspects of dengue research. On the scientific side, our facilities and personnel will assist Dr. Brown if additional field data needs to be collected. We are developing gravid ovitraps to control *Ae. aegypti* mosquitoes and dengue virus transmission. We are deploying the traps in the field to establish their impact on the gravid mosquito population. Our research group is interested in optimizing the number of traps per household that would be necessary to significantly reduce the mosquito population. We have also investigated the relationship between weather, mosquito populations, and dengue incidence in San Juan, Puerto Rico. Such database will be useful to define the parameters for Dr. Brown's model.

I intend to frequently communicate with her by e-mail and telephone, and to meet and discuss this project in detail at scientific meetings (e.g. the American Society of Tropical Medicine and Hygiene, which we both regularly attend). I will provide her with regular feedback as to her progress as an independent researcher. I am willing to provide an annual evaluation of her progress.
Sincerely,

Roberto Barrera, Ph.D.
Chief,
Entomology and Ecology Activity

THE UNIVERSITY OF ARIZONA

College of Social and Behavioral Sciences
School of Geography and Development

Harvill Building, Box #2
Tucson AZ 85721-0076
(520) 621-1652
FAX: (520) 621-2889

**MENTOR'S STATEMENT**
**Co-Mentor: Andrew C. Comrie, Ph.D.**

I am delighted to provide a mentor statement for **Dr. Heidi Brown**, who is applying for a K01 Mentored Research Scientist Development Award.

***Introduction & Research Background***
I am a climate scientist working to understand and ultimately predict the role of climate in health and disease. My primary academic appointment is as a tenured full Professor in the School of Geography & Development, with joint appointments in Atmospheric Sciences and in Public Health here at the University of Arizona. I also serve currently as interim Senior Vice President for Academic Affairs and Provost. My biosketch details my research and related experience, which includes 50 peer-reviewed articles, $24M in grants as PI or co-PI, several honorific awards and positions on national boards, and service as editor for a leading international journal.

In the 20 years that I have been at the University of Arizona, I have focused on building an interdisciplinary research program in climate variability and change, with particular emphasis on the connections between climate and human environmental issues including health, air quality, and environmental policy. My research has been funded by a range of agencies. I am co-PI on an NIH award examining the potential for changes in the range of *Aedes aegypti* mosquitoes and expansion of the risk of dengue transmission in the Southwest United States. Most of my funding comes from non-NIH sources, and although most of Dr. Brown's work fits well within the NIH funding scheme, in her field knowing how to apply for alternate sources is also important.

As part of the CLIMAS project I have led development of a new climate-driven Dynamic Mosquito Simulation Model (DyMSiM). This tool enables first-principle mathematical modeling of mosquito disease vectors, with additional modules currently being tested for pathogens and transmission to humans. It is in this area of climate and vector/disease modeling that my expertise and interests overlap very closely with Dr. Brown's, and for which they are particularly relevant to her mentored development proposal.

***Mentoring role***
I am committed to the role of co-mentor at multiple levels of training. My grant funding sustains undergraduates, graduate students and postdoctoral scientists through my Applied Climatology for Environment and Society (ACES) research laboratory. I have been closely involved in training undergraduates on multiple projects (e.g., via an NSF Research Experience for Undergraduates grant and via NASA Space Grant support). At the graduate level I have chaired 23 master's student committees and 12 doctoral committees. While these students reap obvious rewards from their degree programs and working in my lab, I too gain deep satisfaction from mentoring them and it is the power of this relationship that drives me in my current administrative role as graduate dean. My PhD students have gone on to postdoc and tenure-track positions at major research universities (e.g., Columbia, UNC, LSU) as well as to Federal agencies and the private sector. I have trained 5 postdoctoral scholars in my lab, and I have served as formal faculty mentor for three junior professors. I currently serve as a faculty mentor/consultant on a K25 award to one junior faculty member in the UA College of Public Health.

Dr. Brown has selected a challenging and significant problem at the intersection of the environmental and health sciences. Climate can strongly influence the population dynamics of disease vectors and is consequently a key component of disease ecology and epidemiology. Future climate change and variability may alter the location and seasonality of many disease vectors, possibly increasing the risk of disease transmission to humans. Mosquitoes are major vectors of disease worldwide and their life cycle and biogeography are strongly mediated by climate. Yet, overcoming the general lack of sufficiently long and detailed data series for disease-carrying mosquitoes is a major challenge in understanding their links to climate. This is particularly true for statistical approaches that rely on empirical modeling of observed data. Dynamic simulation modeling is a useful alternative approach that has been used successfully in other fields, but until recently was rarely applied to mosquito vectors in the context of climate and disease. Dynamic simulation models are based directly on fundamental processes and can therefore be used in situations where observed data are unavailable. As part of the mentoring process I will be working closely with Dr. Brown on her proposed research in this area.

I am firmly committed to providing Dr. Brown the support needed to develop her career and the proposed research. My major contribution to Dr. Brown's development is to provide her direct mentoring in health applications of climate science, climatological techniques, spatial analysis, and climate change and climate-health research more broadly. Her proposed work to measure and understand climate controls on *Aedes aegypti* mosquito oviposition distance is fundamental to understanding the spread of the vector in the environment, and by extension to improved modeling of dengue pathogen survival and human transmission.

In my role as co-mentor I will meet regularly with Dr. Brown, weekly or as necessary, and work with her to organize regular individual and group meetings with other formal and informal mentors and colleagues. Our interactions will include in-person meetings, phone calls, emails, etc. as we deal with specific research issues a well as broader mentoring advice. This schedule will facilitate the review of her progress at the level of career and research goals, while simultaneously enabling discussions of project details, individual analysis results and review of manuscripts. I will provide annual evaluations of the candidate's progress as required in the annual progress report.

***The trainee and her development***

Dr. Brown's expertise is in vector-borne infectious disease epidemiology and the controlling environmental factors that influence disease risk. She is looking to expand her knowledge of climate science and its application to health and disease research. The topic of climate effects on health is a significant interdisciplinary research area under climate change and Dr. Brown is an emerging junior scholar helping to develop this field. There are surprisingly few established scientists working directly at this interface of explicit climate connections to diseases and their vectors – a quick look at the UN Intergovernmental Panel on Climate Change report chapter on human health impacts demonstrates one of the shorter reference lists compared to the other impact areas.

Dr. Brown has worked with some of the world's leading experts in environment and disease. As I noted, Dr. Brown is very productive: she already has a dozen publications, many as first author and all in excellent and appropriate journals. She has a strong record of awards and is actively applying for fellowships and grants. In her short time in the ACES lab, in addition to publishing with her own collaborators and mentoring my graduate students, she published a book chapter on Climate Change and Health, a book section on coccidioidomycosis, and has submitted a manuscript using DyMSiM.

As part of her development in her proposed award, I will monitor Dr. Brown's research productivity, advise her on publications with an eye to career development, and encourage her already well-developed progress towards independence as a researcher. As part of that process, I will advise and support her in progress in a tenure-track position so that she can transition from the mentored stage of her career to the status of independent research investigator during the course of the award period.

I have no doubt that Dr. Brown will make further important scientific advances in the climatic dimensions of disease and vector ecology. She has already demonstrated her potential in this area, with an impressive background of training and publications to prove that she can achieve her goals and communicate her work. I am very impressed with her science, her productivity, her promise, her collegiality and her determination. I see her going very far indeed.

Sincerely,

Andrew C. Comrie, Ph.D.

Professor, Geography & Development
Atmospheric Sciences, Public Health

Senior Vice President for Academic Affairs & Provost

THE UNIVERSITY OF ARIZONA
Mel and Enid Zuckerman College of Public Health

Associate Dean for Research

Roy P. Drachman Hall
1295 N. Martin Ave., Bldg.202A
P.O. Box 245163
Tucson, AZ 85724-5163
Tel: (520) 626-8315
Fax: (520) 626-6093
www.publichealth.arizona.edu

**MENTOR'S STATEMENT**
**Collaborator: Lynn B. Gerald, PhD, MSPH**

I am delighted to serve as a collaborator for **Dr. Heidi Brown** in her Mentored Research Scientist Development Award.

I am the Associate Dean for Research and tenured full professor in the Mel and Enid Zuckerman College of Public Health. I also serve as the Canyon Ranch Endowed Chair and as a Scientist in the Arizona Respiratory Center. My primary research passion is epidemiological and behavioral research in respiratory disease and I have been consistently funded in this area for the past 15 years. I have extensive experience writing and managing NIH grants and have served as the PI for 5 NHLBI funded R01s and as Investigator on over 15 other NIH funded grants. Mentoring junior faculty has been one of the most rewarding aspects of my career and I look forward to continuing to work with Dr. Brown.

One of my primary roles in our College is to work with new investigators on writing and managing their federal grants. I also teach a graduate level grant writing course in which many junior faculty from across the University enroll to facilitate their learning of the grant writing and submission process. The course is taught in a workshop format and students get significant feedback from each other as well as faculty mentors. The final exam is submission of an R01 proposal which is evaluated by a mock study section of faculty from across campus. Dr. Brown will enroll in my course during the 3rd year of her award and will use this experience to prepare an R01 submission.

In addition to specific mentoring related to NIH grant writing, I am committed to assisting Dr. Brown with other areas of professional development. In collaboration with our Associate Dean for Academic Affairs, I run a monthly seminar for junior faculty which covers topics of their choice related to professional development. Sample topics for this year have included: How to manage your time between research and teaching responsibilities, Review of the NIH grant review process, Tips for successful teaching, Expectations in the area of research for promotion and tenure, How to develop grant budgets and Ethical issues in the classroom. Dr. Brown has been attending these seminars and will continue to do so each month. I will also meet monthly with Dr. Brown to discuss specific professional development issues and, since my office is in close proximity to hers, will be available as often as needed for any questions she may have or issues that arise. While I am not an expert in Dr. Brown's area of research, she has an excellent scientific mentoring team. I believe that I can add a useful "outsider's perspective" to her science and mentor her in general professional development issues. I will work closely with Dr. Comrie to advise her on publications and productivity to ensure that she makes progress towards promotion and tenure and manages the transition from the mentored stage of her career to that of an independent investigator.

Dr. Comrie details the research environment at our University that is available to support Dr. Brown and her work. His leadership ensures that she will have access to those resources and I am committed to working with him to ensure she has access to anything else for which the need may arise. Other resources available to her as a junior faculty member in the College of Public Health include the junior faculty development seminars mentioned above, a Program Manager who is dedicated to the submission of junior faculty grants and the availability of scientific pre-review of grant applications. Our College seeks to develop a sense of cohort among our junior faculty and instill a sense of scientific camaraderie even with the great variety of disciplines found within our College.

I am committed to Dr. Brown's success and I have no doubt that she will contribute to the scientific knowledge in the area of climate change and health. As her biosketch indicates, she has already been very productive and I am confident that this career development award will facilitate her growth. I am excited to have her in our College and look forward to seeing the exciting things that the future holds for her.

Sincerely,

Lynn B. Gerald, PhD, MSPH
Associate Dean for Research/Professor
Canyon Ranch Endowed Chair
Scientist, Arizona Respiratory Center

## DESCRIPTION OF INSTITUTIONAL ENVIRONMENT

The University of Arizona (UA) is the leading public research university in the American Southwest, and is an ideal interdisciplinary academic community for the proposed mentoring development award. UA is a land grant public university and a member of the Association of American Universities. The 387-acre campus in Tucson, Arizona includes 159 buildings on the main campus and 25 buildings at the adjacent Arizona Health Sciences Center (AHSC). With greater than 38,000 students enrolled (student-faculty ratio 21:1) in 19 colleges and 12 schools, UA provides an amazing environment for interacting with students, faculty and researchers from many diverse disciplines. UA has 14 libraries including over 5 million print volumes. The University's commitment to research was recognized by its ranking from the National Science Foundation as 18th among public and 30th among all universities in the United States for research and development expenditures with over $458 million in annual research funding.

The University is committed to providing a cadre of scientists and educators who, through interdisciplinary training, are able to develop new and imaginative methods of teaching and research, and create new fields of endeavors as evidenced by 14 recognized graduate interdisciplinary programs. To consolidate the University's standing as one of the top research universities in America, UA is dedicated to strengthening research and outreach in 9 interdisciplinary areas that are critical to Arizona's future through enhancing education and addressing social, cultural and economic needs. Two of the strategic areas directly align with the research goals described in this project: Climate, Environmental, Water and Energy Sustainability and Biomedical and Behavioral Health. Recently, the University completed two major faculty hiring initiatives to further establish the UA's leading positions in Environmental Science, Engineering, and Policy and in Translational Medicine. These two initiatives demonstrate the UA's commitment to investing in these strategic priorities and will provide additional collaborators across multiple colleges and programs.

With a central focus on environmental and biomedical research, the UA provides an unparalleled opportunity to develop an independent research career with collaborations and support of colleagues from across the University. There are several relevant interdisciplinary research centers. These include the Arizona Respiratory Center, the Bio5 Institute for Collaborative Bioresearch, the Institute for Environment, the Southwest Environmental Health Sciences Center. In addition to in the College of Public Health, there are several long-standing departments throughout UA in both environmental and biomedical fields that have faculty who try to understand the effects of the environment on human health. These include: Atmospheric Sciences, Environmental Engineering, Geography, Entomology, Soil Water and Environmental Science, Toxicology, Cell Biology, Cancer Biology, Pediatrics and Microbiology.

**The Mel and Enid Zuckerman College of Public Health (MEZCOPH).** MEZCOPH is part of the AHSC which is a 48 acre complex adjacent to the UA, which includes the Colleges of Medicine, Nursing, Pharmacy, Public Health, the University Medical Center and 11 specialty centers officially recognized by the Arizona Board of Regents. During fiscal year 2008, AHSC generated almost 128 million dollars in grants and contracts for research, patient care, and education. MEZCOPH is dedicated to promoting the health of communities in the southwest and has extensive experience in community based research and translating research findings into community programs. Research and service grants and contracts provide 60% of the College's total budget. Funding includes federal sources (e.g., NIH, CDC, HRSA, EPA, FEMA, USDA), state/local sources (e.g., Arizona Department of Health Services (ADHS); Maricopa County Health Department; Yuma County; Arizona Office of the Governor; Governor's Office for Children, Youth and Families; Arizona Department of Education) and Foundations (e.g., Science Foundation of Arizona, Kellogg Foundation, University of Arizona Foundation). In addition to grants and contracts funded directly through the College, many faculty work in conjunction with other academic and research units on campus.

THE UNIVERSITY OF ARIZONA.
Mel and Enid Zuckerman College of Public Health

Office of the Dean

Roy P. Drachman Hall
1295 N. Martin Ave., Bldg. 202A
P.O. Box 245163
Tucson, AZ 85724
Tel: (520) 626-7083
Fax: (520) 626-6093
www.publichealth.arizona.edu

February 12, 2013

Dear Review Committee Members:

I write in full support of Dr. Heidi Brown's K-01 application *"Simulation Modeling of Public Health Interventions on Dengue Vector Abundance: Current and Future Estimations."* Dr. Brown has a solid training background in infectious disease epidemiology and has had several years of experience in conducting research on vector-borne diseases. During this proposed research training, she plans on completing a number of courses, seminars, and dialectic research trainings on modeling complex systems for investigating the spread and occurrence of vector-borne diseases. The support of this K-01 will provide her protective research and training time allowing her to develop an independent research career and become a leader in the important scientific area on environmental factors and infectious diseases.

We are committed to supporting Dr. Brown's career as her research interests and goals are in line with the University's and College's strategic plans. The University of Arizona is a leading institute on environmental science and climate change as well as Epidemiology. Dr. Brown brings exciting initiative, vigor, innovation and valuable ideas to these areas of research. We consider Dr. Brown an exceptional young scientist who has the motivation, background and experience to become a leader in the proposed research. In addition, both the University and the College could provide her with the ideal intellectual community for additional training to develop her research career.

Dr. Heidi Brown is a new assistant professor on the tenure track in the Epidemiology section of the Division of Epidemiology and Biostatistics, and the College has committed many resources to help develop her career. We have provided her with $100,000 in start-up funds to help initiate her research; she has a designated office; research space; and a graduate research assistant. The College's research office provides training on research conduction and our business office provides accounting and grant preparation support. Administrative support is provided by the administrative associate in the division. Dr. Brown has already developed research collaborations with individuals from other UA departments.

Dr. Brown has assembled a strong mentor team that will provide comprehensive guidance and support to her research career development. Her proposal takes full advantage of the outstanding academic and research resources of our college and our university. The training program presented in the K01 application will allow Dr. Brown to expand her existing knowledge base and skill set in infectious disease epidemiology and to receive training in statistical modeling of disease systems. In addition, she will expand her network with epidemiologists, entomologists, statisticians, and climate scientists.

**Institutional Commitment**

In support of the K01 Research Career Development Award application, the Mel and Enid Zuckerman College of Public Health (MEZCOPH) at the University of Arizona is committed to provide strong support to Dr. Brown as stated below:

1. Dr. Brown will maintain her academic appointment as an Assistant Professor within the Division of Epidemiology and Biostatistics. The appointment, the rights and privileges pertain to full-faculty status, the continuation of the salary is not dependent on this award.
2. We are committed to ensuring that Dr. Brown will have 75% protective time for her research throughout the K award funding period.
3. We will assign teaching service duties only if they are related to Dr. Brown's career development.
4. The college will continue providing computational resources, office and lab space, financial and administrative support to Dr. Brown during her K award period.
5. The college will provide mentoring support in addition to her research mentoring team to ensure Dr. Brown's progress towards promotion and tenure.

I am enthusiastic in my support for Dr. Brown's application and hope this letter communicates our strong institutional commitment to helping Dr. Brown become an independent and leading researcher in addressing important global health issues in vector-borne infectious diseases. I will be glad to provide any additional information to assist your review. Thank you for your serious consideration on this important application.

Sincerely,

Iman Hakim, MD, PHD, MPH
Dean and Professor

## SPECIFIC AIMS

Dengue is an important vector-borne disease of the tropics. It is transmitted primarily by the yellow fever mosquito, *Aedes aegypti.* This particular mosquito has adapted to human habitats feeding primarily on humans and breeding within and around homes. Because it breeds in containers and is adapted to the human environment, it is a notoriously difficult mosquito to control. Billions of people are at risk of infection and between 50-100 million cases occur annually. There is no vaccine and exposure prevention is the only way to prevent disease. The **goal of the proposed work is to develop a model to test how manipulating oviposition sites influences *Aedes aegypti* flight range and abundance**, thereby assessing the effectiveness of a newly designed gravid removal trap and potentially adding another tool to the toolbox of public health personnel fighting this deadly infection. The proposed work incorporates empirical studies and mathematical modeling. The empirical studies take advantage of the University of Arizona's Biosphere-2, which provides a controlled environment for experimentation which is of a grander scale than can be conducted in an insectary. The mathematical modeling incorporates these data and published data on mosquito development to model the real world application of a novel mosquito removal trap. Beyond this project, the model will be useful to test and generate additional hypotheses about temperature dependent vector dynamics, spatial extent of trapping requirements (by scaling up from 30 m flights to between region analyses), and dengue transmission.

**Aim 1: Statistically describe the effects of oviposition site density on *Aedes aegypti* dispersal**
I hypothesize that clustering of oviposition sites results in shorter dispersal for blood-fed *Aedes aegypti.* To test this hypothesis I will conduct a series of experiments in the controlled environments of Biosphere-2 which vary the distance between oviposition traps. Comparisons will be made based on the number of eggs laid per oviposition trap. This allows me to assess how the vector disperses from a potentially infected household which, in addition to being important in and of itself, provides data that will be used in Aim 2.

**Aim 2: Model the effect of gravid female removal on *Aedes aegypti* population dynamics**
The fall and summer of 2011-12, the Centers for Disease Control and Prevention (CDC) conducted a field test of their new gravid removal trap. This trap entices gravid *Ae. aegypti* to oviposit but prevents their escape thereby removing the most important mosquitoes from the population (those who have already consumed a potentially infectious bloodmeal). Since vector control is an integral part to controlling dengue, this low-labor strategy could revolutionize how this notoriously resilient vector is controlled.

I hypothesize that gravid removal traps have a greater effect on *Ae. aegypti* population dynamics than source reduction alone. I will code existing mathematical models of temperature dependent mosquito population dynamics into MATLAB using difference equations specific to this species. Because this model will include an oviposition site density module, I will be able to manipulate the model to simulate the CDC field trial data and to manipulate the model under variable oviposition site densities and climatic scenarios. Unlike the current dynamic mosquito simulation models, this model will be made spatially explicit so that I can investigate vector movement between populations. With the skills I gain through his project, I will to develop new proposals to test a variety of assumptions about dengue transmission.

This Mentored Research Career Development Award will catapult my career in vector-borne disease systems. Through the described work, I will show evidence of my skills as a basic science researcher; gain expertise in mathematical modeling such that I cannot merely manipulate other people's models, but code my own; expand my network in the dengue, climate and health, vector-borne disease, health applications of mathematical modeling, and medical and veterinary entomology communities. In addition to publications and evidence that I can successfully complete an NIH funded project, at the end of this project I will have a model and framework to develop new research questions and a broad team of collaborators.

# RESEARCH STRATEGY

## SIGNIFICANCE

The goal of the proposed work is to develop a model that will allow me to test how manipulating oviposition sites influences *Aedes aegypti* flight range and abundance. The proposed work will **test the effect of oviposition site density on vector flight range** which has implications on human disease risk. That is, will *Ae. aegypti* be more or less likely to disperse from an infected home when the distance between oviposition sites is small? In addition, I will **model the effect of epidemiologic interventions on dengue vector population dynamics.** That is, does the removal of gravid females have a negative effect on population dynamics in the absence of other epidemiologic interventions? Both of these questions have implications on dengue vector control. Using both empirical studies and mathematical modeling, I will explore the importance of oviposition sites in *Ae. aegypti* population dynamics and relate it to dengue incidence.

## BACKGROUND

**Dengue.** Dengue is the most important human arboviral disease and is primarily transmitted by *Ae. aeygpti*. This tropical disease puts over 2.5 billion people at risk of infection worldwide (1). Prior to the 1980s, dengue in Central America presented as relatively infrequent epidemics (1-3). During the last two decades, the tropical regions of central and South America and most of the Caribbean have experienced classic dengue and dengue hemorrhagic fever (4). The breakdown of vector control and increased trade are believed to have contributed to *Aedes aegypti* spread across the region leading to increased incidence and frequency of epidemics (1). To date, there is no vaccine to prevent disease, and no specific medical treatment is available.

Dengue is no stranger to the United States and its territories. In Puerto Rico, the 1994-1995 epidemic resulted in the largest number of dengue hospitalizations to date costing over $12M in hospitalizations alone (5). For the decade spanning 1984-1994 the number of reported dengue cases was 92,325. The average disability-adjusted life years (DALYs) lost per year per one million population was estimated at 658 (6). Cities along the Texas-Mexico border occasionally experience dengue outbreaks affecting both sides. In 2009-2010, 28 individuals in Key West, Florida contracted dengue as a result of local transmission (7).

***Aedes aegypti* Flight Range.** Because *Ae. aegypti* must bite an infected human to become infected, their flight range after consuming an infecting blood meal becomes a critical matter. If the vector does not fly far after infection, prevention must focus on the immediate vicinity of infected homes. If, however, the vector disperses over greater distances, then alternative strategies become more important in the midst of an epidemic. Thus, it is important to understand the linear flight distances of these disease vectors.

A 1994 Pan American Health Organization report stated that *Ae. aegypti* was rarely collected more than 100 meters from homes. Their conclusion was that dispersal greater than 100 m should be considered rare though long range (3 km) flights had been observed (8). A study which released rubidium labeled mosquitoes into an open area with oviposition sites calculated the mean distance traveled within 40-67 hours after feeding was 181 meters (range 9-432 m (9)). Another study found dispersal of rubidium labeled *Aedes albopictus* and *Ae. aegypti* across an urban area for up to 320 m (10). A mark-release-recapture study using indoor traps only recaptured 6.3% of released mosquitoes with a mean travel distance of 288 m (maximum 690 m (11)). Using data from Iquitos, researchers found a clustering effect among adult *Ae. aegypti* collections for 10 m around homes with weak clustering up to 30 m (12).

Perhaps more closely simulating the natural course of dengue by releasing within the home, marked-released mosquitoes were most often recaptured within the home or the neighboring home with rare recaptures of up to 512 m (13). In another study with low recapture rates (38%), which the authors attribute primarily to mortality, 48% of recaptures occurred within the home in which they were released and only 4% dispersed beyond 40 m (14). These findings led to the conclusion that, while occasional long distance dispersal is possible, most dengue vector activity remains close to the home (within about 30 m).

**Oviposition Sites and Disease Transmission.** Due to their preference for breeding in artificial containers, dengue vectors have assimilated well into urban spaces making urban centers foci for infection (15, 16). Water

storage and the lack of waste removal frequently provide oviposition sites (17-19). Mosquito abundance is positively associated with dengue cases during outbreaks (20). Thus, it is important to understand the effect of oviposition site density on vector abundance and flight range.

Vector indices, such as the Breteau Index (number of positive containers per 100 houses), the House Index (percentage of houses positive for larvae), and Container Index (percent of positive containers among water filled containers at a residence) are problematic when trying to tie them back to human dengue incidence. Recently Barrera described methods to use the Pupal Index (number of pupae per 100 houses) to estimate the number of pupae per person and associate this index with entomological risk (21). Reliably associating dengue risk to larval, pupal, or adult indices remains challenging (21).

Removal of oviposition sites is recommended for vector control in response to dengue (22). By removing oviposition sources, vector abundance and thus disease risk is reduced. However, the counter argument could be made that source reduction around an identified case may serve to encourage greater travel distances of infected vectors (9, 23). In fact, one study manipulating the number of oviposition sites around homes where the vectors were released, found that of the 7% which dispersed outside the home in which they were released, significantly more were recaptured around homes with a greater number of oviposition sites (24).

Using both empirical studies and field observations, I aim to **statistically describe the effect of oviposition site density on *Ae. aegypti* flight range**. This has the potential for being a significant improvement to our understanding of dengue transmission with implications for targeted control. I hypothesize that altering the availability and proximity between oviposition sites will effect mosquito dispersal.

**Simulation Models.** In contrast to statistical correlations or static habitat models, dynamic models allow us to test individual components and their interactions in complex systems (25). Rather than relying on surveillance data, models like the Dynamic Mosquito Simulation Model (DyMSiM) are driven by meteorological data and simulate mosquito abundance over time (26). DyMSiM has been used to estimate changes in West Nile virus vector population dynamics with the expected change in climate (27). A similar model was recently used to show certain parameters in dengue transmission (vector survival, human biting rate, and duration of viremia in humans) lack sufficient field verification to adequately understand dengue dynamics (28).

An *Ae. aegypti* population model will allow me **to test the effect of epidemiologic interventions on dengue vector population dynamics**. Phase 1 will be to use a model similar to DyMSiM, which does not incorporate spatial effects and therefore can only describe the global mosquito population of a given area. I will be able to simulate vector abundance under current meteorological conditions. Phase 2 will be to use this model to test a variety of assumptions about *Ae. aegypti.* Specifically, by adding a spatial component I will be able to test the effect of source reduction and removal trapping in a given location, under various climate change scenarios, and with variable assumptions about flight based repopulation.

## RESEARCH DESIGN AND METHODS

The proposed work will allow me to explore the importance of oviposition sites in the linear flight range and abundance of *Ae. aegypti*. In Aim 1 I investigate how oviposition site density effects vector flight potentially lending insight into how an infected vector might disperse from an infectious household. This has implications for re-establishment after a vector control intervention. Then, I use dynamic simulation to test the impact of gravid removal traps on vector populations. Source reduction and gravid removal traps have been field tested by the Centers for Disease Control and Prevention (CDC) as a means to reduce dengue transmission in Puerto Rico. The model will be benchmarked against available data and help to determine the effectiveness of these techniques to simulate vector populations under other intervention strategies in different locations and under alternative climatic scenarios.

Flight range, how far a gravid *Ae. aegypti* flies to oviposit, is important in understanding the spread of dengue by infected vectors. **In Aim 1 I will statistically describe the effects of oviposition site density on *Aedes aegypti* dispersal** by testing the hypothesis that clustering of oviposition sites results in shorter dispersal for blood-fed *Ae. aegypti.* The UA's Biosphere-2 provides a controlled environment which meets the linear (≤30m) requirement to mimic a mosquito's dispersal activity between neighbors.

Meeting Aim 1 requires 4 steps: 1) establish an experimental *Ae. aegypti* population, 2) construct the experimentation cages, 3) optimize the experimental design, and 4) conduct experiments to test the following statements about oviposition site density and dispersal: a) Shorter distances between oviposition sites lead to less dispersal than longer distances, b) Uniform distribution of oviposition sites will lead to greater dispersal than clustered oviposition sites, c) Dispersal will be less from covered versus uncovered release sites, d) Gravid females preferentially select oviposition sites with attractant, e) No significant difference exists between dispersal in the summer (long days) and the winter (short days), and f) The external environment (tropical forest, savanna, or desert) has a negligible effect on dispersal compared to the effect of oviposition site density.

**1) Establish experimental *Ae. aegypti* population.** Using ovitraps and egg papers, I will collect *Ae. aegypti* in Tucson, AZ. Eggs will be hatched in the insectary, raised to 4$^{th}$ instar larvae when species confirmation will occur. Development of all *Ae. aegypti* will be continued and a breeding cage established. Using eggs ensures the mosquitoes are clear of human pathogens.

Wild mosquitoes (less than 3 generations within the lab) will be utilized in all experiments rather than laboratory-adapted lines since I would like to capture the natural diversity among mosquitoes and maintain experimental conditions as close to the natural system as possible.

**2) Construct experimentation tubes.** In order to test flight ranges without an open release or mark-release-recapture, I will construct experimentation tubes of framed netting. Collapsible field cages (12x12x12 inch frames from BioQuip Products Inc.) will be connected by altering the cage covers from a bag to a tube. This netting mesh will prevent mosquito escape but allow the conditions inside the tube to match the external conditions. Connections between cages will allow them to be combined for the appropriate deployment length. These linear experimental cages provide better control of extraneous variables that influence the low recapture rates of most mark-release-recapture experiments. By restricting vertical movement, we can evaluate just the horizontal flight by which vector disperse, as between houses.

**3) Optimize the experimental design.** Before assuming a linear mesh tube of 30 m is representative of how a mosquito might experience the world, I will test the experimental design. Each of the optimization experiments described below answers questions in themselves and add to the current body of knowledge on vector life span.

a) Does access to sucrose affect our design? Using the uniform distribution of 1 oviposition trap per 5 m, I will test whether access to 10% sucrose (Sigma) in water affects egg laying patterns (the presence/absence and abundance).

b) What is the effect of flying around corners? Using a uniform distribution of 1 oviposition trap per 5 m I will test whether egg laying patterns remain constant when the 30 m cage is linear, “L” shaped (two 15 m segments connected at a right angle); “U” shaped (three 10 m segments connected at right angles) or square (two 10 m and two 5 m segments).

c) Do mortality rates differ across biomes? In each of the three Biosphere-2 biomes (see Aim1 Step 4.f), I will place 4 breeding cages with 15 blood fed females and calculate daily mortality rates for 1 month.

**4) Conduct a series of experiment to test the effect of oviposition site density on dispersal**. At the initiation of experiments, adult mosquitoes will be provided with a blood meal using the blood-feeding system comprised of a glass feeder with a sausage casing membrane and a jacket of circulating warm water to maintain the defibrinated rabbit blood (Colorado Serum Company) at 37°C.

Fed females will be aspirated from the breeding cage and transported to the experimental cage which is at one end of the 30 m linear experimentation tube. Oviposition papers will be replaced daily and number of eggs counted for 5 days: 2 days longer than the average *Ae. aegypti* gonotrophic period [8]. This will allow us to examine both the spatial and temporal dimension corresponding with disease transmission. Mortality rates will be calculated. Each experiment (uniform distribution of oviposition sites, clustered, covered, uniform with attractant, and clustered with attractant) will be repeated 6 times (once per winter 2014-2016 and summer 2015-2017) using 15 gravid mosquitoes to allow for difference in fecundity.

4.a) To test the hypothesis that shorter distances between oviposition sites lead to less dispersal than longer distances, I will vary the distance between oviposition sites. Four experimental conditions will be considered in the uniform distribution experiment: oviposition traps placed every 15 meters, 10 m, 5 m, and 2.5 m (Figure 1.a.). These 4 experimental conditions will be run simultaneously to account for minute differences in the environment between days.

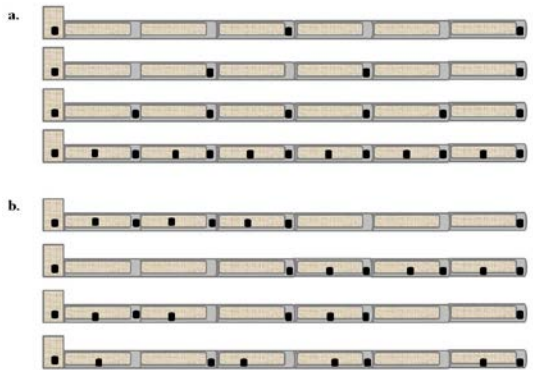



**Figure 1:** Experimental design for a) uniform and b) clustered conditions.

4.b) To test the hypothesis that uniform distribution of oviposition sites leads to greater dispersal than clustered oviposition sites, I will compare the uniform distribution distances to a similar experiment with clustering of oviposition sites. For the clustering experiment there will be 4 experimental conditions: oviposition traps placed at 2.5 m intervals from the release point or from the end, placed every 2.5 m skipping the 10 m, 12.5 m, 22.5 m, 25 m, and 27.5 m positions, and placed every 2.5 m in couplets and skipping every other couplet (Figure 1.b). The distances were selected to mimic oviposition sites around a home and between neighbors with differing levels of oviposition site maintenance on their properties.

4.c) To test the hypothesis that dispersal will be less from covered versus uncovered release sites, the high density uniform design (an oviposition trap placed every 2.5 m along the length of the experimental tube) will be tested under 'indoor' conditions by constructing a roof structure over the first 15 m of the experimental tube. This will test for the effect seen by Harrington et al. (13) where 50% of vectors remain within the indoor release sites.

4.d) To test the hypothesis that gravid females preferentially select oviposition sites with attractant, the uniform distribution experiment will be repeated with attractant in the final oviposition trap and the covered clustered distribution experiment will be repeated with attractant in the final oviposition trap. I will use hay-infusion which is a commonly used attractant.

4.e) To test the hypothesis that no significant difference exists between dispersal in the summer (long days) and the winter (short days), the 5 experiments (uniform, clustered, covered, uniform with attractant, and clustered with attractant) will be repeated in the summer and winter to account for differences in daylight. Since temperature is quite stable throughout the year in Biosphere-2, the main effect, if there is one, will be related to the length of day. The winter experiments will be conducted in January-February and the summer in June-July to take advantage of the greatest differences in daylight length.


**Figure 2:** Biomes available for experiments. Each biome (rainforest (43x43 m); savanna (53x9 m), and desert (36x36 m)) has a controlled climate (temperature and humidity). While the temperature is controlled, diel and minimal changes in temperature will be experienced by the vector – as in nature.

4.f) To test the hypothesis that the external environment (tropical forest, savanna, or desert) has a negligible effect on dispersal compared to the effect of oviposition site density, I will conduct these under multiple environments. Utilizing UA Biosphere-2, I will be able to conduct a medium scale controlled test of dispersion in the tropical rainforest, savanna, and desert biomes (Figure 2). The 5 experiments (uniform, clustered, covered, uniform with attractant, and clustered with attractant) will be simultaneously conducted in each of these biomes.

**Data Analysis and Interpretation.** For the experiments investigating linear dispersal from a single source, I will use ANCOVA to test whether the number of eggs recovered at each distance differs among the different

oviposition site densities while controlling for the biome (tropical rainforest, savanna, desert) or oviposition site distribution (uniform or clustered). This will allow us to determine the effect of the biomes and experimental design on dispersal. For both the uniform and the clustered experiment, I will use regression to compare the number of eggs recovered from the furthest oviposition site based on the density of intervening oviposition sites. This latter analysis provides a measure of long distance dispersal. The covered and non-covered clustered distribution will be compared to assess whether there is an effect of 'indoor' versus 'outdoor' release and the attractant experiment will be compared to its reciprocal non-attractant conditions. The results from these experiments will be published in a vector ecology journal.

**Potential Problems and Alternative Approaches.** The optimization experiments will allow me to test the assumptions in using the linear experimental cage. Amendments to the protocol will be made based on the outcomes of the optimization experiments. The linear distance is limited to 30 m. While this is comparable to dispersal between houses, literature has shown dispersal of up to hundreds of meters. If the 30 m length is saturated, I will repeat the experiment either with turns (Aim 1.3.b) or outside Biosphere-2 where, though meteorological variability will be greater, I will not be limited by distance.

In Aim 2 I will **model the effect of epidemiologic interventions on dengue vector population dynamics** by testing the hypothesis that gravid removal traps have a greater effect on *Ae. aegypti* population dynamics than source reduction alone. In order to model the outcome (reduction in *Ae. aegypti* abundance) of the CDC's public health intervention field test, I must first (Phase 1) establish a flexible model of *Ae. aegypti* population dynamics using empirically derived temperature dependent development rates and local meteorological data. It will be used to test a variety of assumptions about vector dynamics and to identify additional parameters that need to be empirically tested. Specific to this project, I will test the effect of source reduction versus removal trapping and simulate population dynamics under climate change scenarios. For Phase 2 of the project, I will make the model spatially explicit to allow me to estimate spatial extent of removal trapping. Additional applications for the model will be identified resulting in additional studies beyond this proposed work.

**1) Phase 1: Code a dynamic model in MATLAB to simulate *Aedes aegypti* abundance.** I will translate available dynamic mosquito models (26, 29) into MATLAB to simulate *Ae. aegypti* abundance based on temperature and precipitation. The Container Inhabiting Mosquito Simulation Model is a deterministic life table simulation model which, though the parameters have been published (29, 30), is not freely available. Dynamic Mosquito Simulation Model (DyMSiM (26)) is discrete deterministic model specific to *Culex* species and reaching its utility limits due to its current software platform. Translating these validated models into MATLAB will teach me the mechanics behind mathematical modeling and also provide me with a model I am adept at manipulating for testing additional hypotheses. Through course work, workshops, and working with Dr Lega I will be able to design new models, alter existing models to additional species (e.g., fleas, which have very different life cycles), and test additional hypotheses.

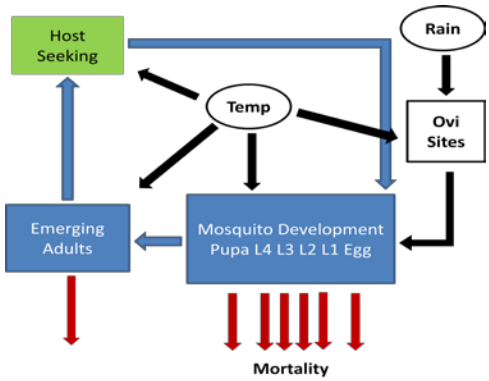



**Figure 3**. Schematic of DyMSiM showing the association between meteorology and development.

Weather drives these models with precipitation filling oviposition sites and temperature evaporating water from these sites and influencing mosquito development and behavior (Figure 3). For instance, the total adult mosquito population at a given point in time is estimated as:

$$M_{t+1} = M_t + \lambda P_t - \mu M_t \ ,$$

where $M_t$ is the abundance of mosquitoes at time $t$ (measured in development cycles), $P_t$ is the number of pupae, which eclose at a given temperature-dependent rate, $\lambda$, and $\mu$ is the mortality rate for adult mosquitoes. Temperature also affects the development rates for eggs, larvae, and pupae. Moreover, the number of eggs laid per cycle depends on the number of oviposition sites and therefore on precipitation as well as temperature.

Three sets of meteorological data are required for this analysis, daily minimum and maximum temperature (°C) and daily precipitation (mm), which will be derived either from the HOBO Weather Stations deployed in the field with the traps or from other weather stations (interpolating between stations as necessary to provide the appropriate estimates).

*Temperature dependent development:* Using stage specific, temperature dependent development rates (obtained the literature and validated using data from Aim 1) it will be possible to estimate the amount of time it takes for a mosquito to go through each development stage at any given temperature.

*Precipitation:* Oviposition sites are incorporated as containers which fill with precipitation and evaporate based on temperature (26). In Puerto Rico and for most regions where *Ae aegypti* populations are established, precipitation may fill oviposition sites, however, there is evidence to suggest that it is not necessarily the best predictor for vector abundance. Human regulated water collection, flower pots, or gravestone vases also provide oviposition sites (32). Permanent sources can also be included in the model. In DyMSiM temporary and permanent water sources are modeled as a surface area up to a depth of 8 cm.

Model accuracy will be assessed using previously collected data from two locations in Puerto Rico provided by Dr. Barrera (Co-Mentor on this grant). These data include adult abundance from 40 BG-Sentinel mosquito traps (Biogents, Regensburg, Germany) deployed from November 2007 to December 2008. Each trap was operated for four consecutive days every three weeks yielding 20 sampling dates each for a total of 6,107 samples.

**2) Model the effect of intervention on the population dynamics.** Once the model is developed I will test the effect of source reduction and of gravid removal traps on the population. Dr. Barrera has developed a new gravid trap that traps adult females attempting to oviposit and thus removes them from the population. A field trial of this trap that was conducted between October 2011 and July 2012 included an intervention area (325 buildings) and a control area (280 buildings). Both areas were subjected to initial source reduction and larvaciding but the gravid removal traps were only deployed in the intervention area. A generalized linear model showed a 60% reduction in *Ae. aegypti* in the intervention area.

I will test the hypothesis that a dynamic model of mosquito abundance can be used to capture the effect of source reduction versus removal trapping. More precisely, I can assess how the output of the model (i.e., the total population of mosquitoes as a function of time) is affected when a constant portion of the breeding populations (adult mosquitoes) is removed after each development cycle. The proportion removed will be estimated based on the numbers of gravid females collected in the gravid removal traps. As before, weather data will be included. It is available from the weather stations that were deployed during the field testing. The results of this study will be published as part of the manuscript being prepared by Dr. Barrera and his team on the effectiveness of the gravid removal trap.

**3) Simulate population dynamics under alternative climate scenarios**. The “Phase 1” model can also be used to estimate the number of gravid removal traps necessary to maintain populations to a specified threshold under a variety of locations and climate. As has previously been performed for *Culex* species in Dr. Comrie’s laboratory (Co-Mentor on this grant), once the model has been parameterized for current climate, I will use this model to estimate *Ae. aegypti* abundance under a variety of climate change scenarios. Using a stochastic weather generator like Long Ashton Research Station – Weather Generator (LARS-WG) (33), I can estimate the changes in vector abundance and removal trap requirements under Intergovernmental Panel on Climate Change (IPCC) future climate scenarios. LARS-WG uses daily weather data (temperature min, max and precipitation) from meteorological stations in specific locations to generate statistically identical weather series. These statistically identical simulations will be generated for two of the IPCC 4$^{th}$ assessment report’s A2 and B1 scenarios. These two scenarios will represent the range of future climate assumptions (A2 assumes a high populations growth with slow technological advances; B1 assumes the world population peaks in the middle part of the century and rapid changes in economic structure toward service) (34). The version of the model I currently work with (26), as other abundance models (29, 35), is limited by a rescue parameter necessary to keep the population stable. I currently lack the mathematical background to address this limitation. Under the guidance of Dr. Lega and with the identified coursework, we will be able to develop a model which is more realistic. Removing the reliance on a rescue effect would allow for testing whether populations will establish or die out: a critical question in climate change related investigation (36). By running the vector abundance model

with the simulated daily weather, I will be able to estimate vector dynamics for future climate change scenarios. The results will be published in an international peer reviewed journal.

**4) Phase 2: Identify the spatial extent of removal trapping.** Utilization of dynamic models is increasingly common for studying mosquito-borne disease dynamics (28, 29, 37-39). However rarely are these models spatially explicit. They consider the population of vectors to be evenly distributed over a geographic area. Thus, they are limited in their ability to inform vector control because they cannot account for dispersal across a landscape and re-infestation.

Incorporating the data from Aim 1 and the literature on flight ranges, I will develop a spatially explicit model wherein the populations are affected by their neighbors. Incorporating the flight range data as a directional weight, I will couple Phase 1 models and allow the mosquitoes to flow from one house to another. The model will be validated using the data collected in Specific Aim 1. Assuming success at modeling these spatially explicit dynamics between homes, I will scale up the spatial scale by coupling the models again and model neighborhoods. The neighborhood model will be validated using the control neighborhood from the CDC field project. This will allow us to estimate the spatial extent of the intervention necessary to allow for re-population from non-treated areas. This analysis will provide the most compelling results and will be publishable in a high impact journal. With this success, I envisage submitting an R01 to model inter-island vector dynamics: a much larger project which will involve collaborators at the UA in entomology and bio-5 to compare population genetics with the modeled flow, field collections and human subject data with collaborators from my graduate studies on the Caribbean island of Dominica, and the researchers on this proposal.

**Data Analysis and Interpretation.**

Model accuracy assessment poses some challenge a deterministic simulation is but one iteration among a distribution of possible iterations and likewise, observed data are but one iteration. Nonetheless, when observed data are available they can serve to validate the models. Standard model verification will be utilized including withholding some of the data to test model robustness and sensitivity analyses on critical variables. Model fit will be tested using Pearson's correlation between observed and expected, Willmott's *d*, and Root Mean Square Error (40).

The model will allow me to specifically test the effect of gravid removal traps on dengue vector abundance, enabling control personnel to estimate the number of gravid removal traps per household necessary for a given community to limit dengue vectors to a specified abundance threshold. This has potential implications for dengue control in Puerto Rico and other areas.

This temperature and precipitation driven model allows for the simulation of *Ae. aegypti* populations under future climate scenarios in regions where dengue is endemic. Using the Students t-test, I will compare measures of abundance and vector activity between the scenarios to test for measurable changes related to climate change.

I will be able to estimate re-infestation probabilities by distance beyond a target zone in order to estimate intervention effectiveness. This will be done by estimating a buffer zone around the target area beyond which *Ae*. *aegypti* is likely to travel for, given the density of oviposition sites and the identified flight ranges (Aim 1).

**Potential Problems and Alternative Approaches.** Dengue is a notoriously difficult system to model. The vectors' propensity to breed in urban areas and in containers that are often maintained more by human behavior than by rainfall makes purely weather driven models difficult. The model I propose incorporates both human maintenance of containers and those that would be rain filled. The seasonal fluctuations evident in dengue as well as the maintenance population will thus be integrated. I expect to be able to at least model the observed data and then to test the robustness of the model (i.e., susceptibility to changes in parameters) through a sensitivity analysis (28). Mathematical models are dependent on the assumptions they make and the quality of data that is used to parameterize them. For those parameters which have weak support, I will design additional studies to generate those data.

As an alternative to the spatially explicit modeling described above, Spatiotemporal Wind Outbreak Trajectory Simulation (SWOTS), developed by colleagues at the Department of Zoology at Oxford University, UK, has been successfully used to describe the spatial spread of the 2006 bluetongue virus outbreak in North-

West Europe (41). SWOTS utilizes wind field data and the geographic coordinates of infected farms and reports the correlation between winds and disease spread. Parameterized by a range of biological data about midges and bluetongue (flight range, wind tolerance, duration of flight, density of targets, host/target attraction), the model then optimizes each parameter based on the correlation analysis and simulates the disease spread using local stochastic wind fields. Working with my colleagues in Oxford and Dr. Lega at the University of Arizona, the SWOTS model will be an alternative method to assess the spatial spread of *Ae. aegypti*.

**OVERALL SUMMARY AND CONCLUSIONS**

Dengue continues to be a significant disease internationally and increasingly in the United States. It is a complex system involving multiple mosquito vectors and viral serotypes with varying effects on human immunity. Moreover, despite all that we know about this disease, there remains a considerable lack of knowledge about some of the fundamental biological processes involved in transmission (28). In this proposal, I aim to generate flight range and vector dispersal data and to test the implications of removal of adult females on vector population dynamics.

The project described provides useful empirical data on flight ranges, furthers my engagement with the UA community and the applied mathematics, vector-borne disease, and climate communities more broadly. It answers some fundamental questions about dengue spread through a population. Most importantly, it provides me with both knowledge in disease modeling and a fully prepared model which can be amended to answer new questions.

As a result of this protected time, I will acquire a valuable skill set which will put me in a position to develop new research projects on a variety of emerging and re-emerging disease systems. For example, in response to calls like the NIH-NSF Ecology and Evolution of Infectious Diseases (NOT-TW-12-022) request: I will be positioned to pull together a team to model dengue dissemination in the Caribbean working with local epidemiologists, climatologists, mathematicians, entomologists and myself as the modeler. The innovative research described in this proposal and the skills that I will acquire make me distinctly able to incorporate epidemiology, mathematical modeling, and climate science to address emerging global concerns such as preventing disease in a changing world, model disease invasions and elimination, and thereby protect and improve human health both here in the US and abroad.

**TIMELINE**

The first year of the project will focus on preparing the experimental tubes (Aim 1. Step 2, Summer 2013) and optimizing the experiments (Aim 1. Step 3, Fall and Winter 2013). The following three years balance between experiments (Aim 1. Step 4: winter (5 weeks in January and February) and summer (5 weeks in June and July)) and model development (Aim 2. Step 1). The final 2 years will focus on data analysis, model manipulation (Aim 2. Steps 2-4), manuscript preparation, presentation of results, and grant writing.