02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.C.a. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: Deron E Burkepile

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race:
(Select one or more)

☐ American Indian or Alaska Native
☐ Asian
☐ Black or African American
☐ Native Hawaiian or Other Pacific Islander
☒ White

Disability Status:
(Select one or more)

☐ Hearing Impairment
☐ Visual Impairment
☐ Mobility/Orthopedic Impairment
☐ Other
☒ None

Citizenship: (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☐

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☒

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.
Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

WHY THIS INFORMATION IS BEING REQUESTED:

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization's eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

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PI/PD Name: Nathan Lemoine

Gender: ☐ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race:
(Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status:
(Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☐ None

Citizenship: (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☒

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☐

Ethnicity Definition:
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List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:
Not Listed

REVIEWERS NOT TO INCLUDE:
Not Listed

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 11-1 NSF 12-590 11/09/12	FOR NSF USE ONLY NSF PROPOSAL NUMBER
FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.) DEB - Population and Community Ecology	

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
				071298814	

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN) 650177616	SHOW PREVIOUS AWARD NO. IF THIS IS ☐ A RENEWAL ☐ AN ACCOMPLISHMENT-BASED RENEWAL	IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE Florida International University AWARDEE ORGANIZATION CODE (IF KNOWN) 0096354000	ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE Florida International University 11200 SW 8TH ST Miami, FL. 331990001
NAME OF PRIMARY PLACE OF PERF Florida International University	ADDRESS OF PRIMARY PLACE OF PERF, INCLUDING 9 DIGIT ZIP CODE Florida International University 11200 SW 8TH ST Miami ,FL ,331990001 ,US.

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions) ☐ SMALL BUSINESS ☐ FOR-PROFIT ORGANIZATION ☐ MINORITY BUSINESS ☐ WOMAN-OWNED BUSINESS ☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **DISSERTATION RESEARCH: Assessing the effects of climate change on biotic interactions structuring herbivore communities**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 15,294	12 months	05/01/13	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

☐ BEGINNING INVESTIGATOR (GPG I.G.2)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C.1.e)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
☐ HISTORIC PLACES (GPG II.C.2.j)
☐ EAGER* (GPG II.D.2) ☐ RAPID** (GPG II.D.1)
☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date ________
PHS Animal Welfare Assurance Number ________
☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number ________
Exemption Subsection ________ or IRB App. Date ________
☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
____
☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT Biological Sciences	PI/PD POSTAL ADDRESS 11200 SW 8TH ST Miami, FL 33199 United States
PI/PD FAX NUMBER 305-919-4030	

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME Deron E Burkepile	PhD	2006	305-919-4017	deron.burkepile@fiu.edu
CO-PI/PD Nathan Lemoine	MS	2010	305-348-2494	nlemo001@fiu.edu
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the Authorized Organizational Representative or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, lobbying activities (see below), responsible conduct of research, nondiscrimination, and flood hazard insurance (when applicable) as set forth in the NSF Proposal & Award Policies & Procedures Guide, Part I: the Grant Proposal Guide (GPG) (NSF 11-1). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

Conflict of Interest Certification

In addition, if the applicant institution employs more than fifty persons, by electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution’s expenditure of any funds under the award, in accordance with the institution’s conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

Certification Regarding Lobbying

The following certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ‘‘Disclosure of Lobbying Activities,’’ in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Certification Regarding Nondiscrimination

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:

(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:

(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
(2) for other NSF Grants when more than $25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

Certification Regarding Responsible Conduct of Research (RCR)
(This certification is not applicable to proposals for conferences, symposia, and workshops.)

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that, in accordance with the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.B., the institution has a plan in place to provide appropriate training and oversight in the responsible and ethical conduct of research to undergraduates, graduate students and postdoctoral researchers who will be supported by NSF to conduct research.
The undersigned shall require that the language of this certification be included in any award documents for all subawards at all tiers.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME		

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER

* EAGER - EArly-concept Grants for Exploratory Research
** RAPID - Grants for Rapid Response Research

Directorate for Biological Sciences
Division of Environmental Biology
Population and Community Ecology

Proposal Classification Form
PI: Burkepile, Deron

CATEGORY I: INVESTIGATOR STATUS (Select ONE)
☐ Beginning Investigator - No previous Federal support as PI or Co-PI, excluding fellowships, dissertations, planning grants, etc.
☐ Prior Federal support only
☑ Current Federal support only
☐ Current & prior Federal support

CATEGORY II: FIELDS OF SCIENCE OTHER THAN BIOLOGY INVOLVED IN THIS RESEARCH (Select 1 to 3)		
☐ Astronomy	☐ Engineering	☐ Psychology
☐ Chemistry	☐ Mathematics	☐ Social Sciences
☐ Computer Science	☐ Physics	☑ None of the Above
☐ Earth Science		

CATEGORY III: SUBSTANTIVE AREA (Select 1 to 4)		
☐ BIOGEOGRAPHY	☐ Decomposition	☐ Molecular Evolution
☐ Island Biogeography	☐ Biogeochemistry	☐ Methodology/Theory
☐ Historical/ Evolutionary Biogeography	☐ Limnology/Hydrology	☐ Isozymes/ Electrophoresis
☐ Phylogeography	☐ Climate/Microclimate	☐ Nucleic Acid Analysis (general)
☐ Methods/Theory	☐ Whole-System Analysis	☐ Restriction Enzymes
☐ CHROMOSOME STUDIES	☐ Productivity/Biomass	☐ Nucleotide Sequencing
☐ Chromosome Evolution	☐ System Energetics	☐ Nuclear DNA
☐ Chromosome Number	☐ Landscape Dynamics	☐ Mitochondrial DNA
☐ Mutation	☐ Chemical & Biochemical Control	☐ Chloroplast DNA
☐ Mitosis and Meiosis	☐ Global Change	☐ RNA Analysis
☐ COMMUNITY ECOLOGY	☑ Climate Change	☐ DNA Hybridization
☐ Community Analysis	☐ Regional Studies	☐ Recombinant DNA
☑ Community Structure	☐ Global Studies	☐ Amino Acid Sequencing
☐ Community Stability	☐ Forestry	☐ Gene/Genome Mapping
☐ Succession	☐ Resource Management (Wildlife, Fisheries, Range, Other)	☐ Natural Products
☐ Experimental Microcosms/ Mesocosms	☐ Agricultural Ecology	☐ Serology/Immunology
☐ Disturbance	☐ EXTREMOPHILES	☐ PALEONTOLOGY
☐ Patch Dynamics	☐ GENOMICS (Genome sequence, organization, function)	☐ Floristic
☐ Food Webs/ Trophic Structure	☐ Viral	☐ Faunistic
☐ Keystone Species	☐ Microbial	☐ Paleoecology
☐ COMPUTATIONAL BIOLOGY	☐ Fungal	☐ Biostratigraphy
☐ CONSERVATION & RESTORATION BIOLOGY	☐ Plant	☐ Palynology
☐ DATABASES	☐ Animal	☐ Micropaleontology
☐ ECOSYSTEMS LEVEL	☐ MARINE MAMMALS	☐ Paleoclimatology
☐ Physical Structure	☐ MOLECULAR APPROACHES	☐ Archeozoic
		☐ Paleozoic
		☐ Mesozoic

☐ Cenozoic ☐ POPULATION DYNAMICS & LIFE HISTORY ☐ Demography/ Life History ☐ Population Cycles ☐ Distribution/Patchiness/ Marginal Populations ☐ Population Regulation ☐ Intraspecific Competition ☐ Reproductive Strategies ☐ Gender Allocation ☐ Metapopulations ☐ Extinction ☐ POPULATION GENETICS & BREEDING SYSTEMS ☐ Variation ☐ Microevolution ☐ Speciation ☐ Hybridization ☐ Inbreeding/Outbreeding ☐ Gene Flow Measurement ☐ Inheritance/Heritability	☐ Quantitative Genetics/ QTL Analysis ☐ Ecological Genetics ☐ Gender Ratios ☐ Apomixis/ Parthenogenesis ☐ Vegetative Reproduction ☐ SPECIES INTERACTIONS ☑ Predation ☑ Herbivory ☐ Omnivory ☐ Interspecific Competition ☐ Niche Relationships/ Resource Partititioning ☐ Pollination/ Seed Dispersal ☐ Parasitism ☐ Mutualism/ Commensalism ☐ Plant/Fungal/ Microbial Interactions ☐ Mimicry ☐ Animal Pathology ☐ Plant Pathology	☐ Coevolution ☐ Biological Control ☐ STATISTICS & MODELING ☐ Methods/ Instrumentation/ Software ☐ Modeling (general) ☐ Statistics (general) ☐ Multivariate Methods ☐ Spatial Statistics & Spatial Modeling ☐ Sampling Design & Analysis ☐ Experimental Design & Analysis ☐ SYSTEMATICS ☐ Taxonomy/Classification ☐ Nomenclature ☐ Monograph/Revision ☐ Phylogenetics ☐ Phenetics/Cladistics/ Numerical Taxonomy ☐ Macroevolution ☐ NONE OF THE ABOVE

CATEGORY IV: INFRASTRUCTURE (Select 1 to 3)

COLLECTIONS/STOCK CULTURES ☐ Natural History Collections ☐ DATABASES FACILITIES ☐ Controlled Environment Facilities	☐ Field Stations ☐ Field Facility Structure ☑ Field Facility Equipment ☐ LTER Site ☐ INDUSTRY PARTICIPATION	☐ Technique Development TRACKING SYSTEMS ☐ Geographic Information Systems ☐ Remote Sensing ☐ NONE OF THE ABOVE

CATEGORY V: HABITAT (Select 1 to 2)

TERRESTRIAL HABITATS

☐ GENERAL TERRESTRIAL ☐ TUNDRA ☐ BOREAL FOREST ☐ TEMPERATE ☑ Deciduous Forest ☐ Coniferous Forest ☐ Rain Forest ☐ Mixed Forest ☐ Prairie/Grasslands ☐ Desert ☐ SUBTROPICAL ☐ Rain Forest ☐ Seasonal Forest	☐ Savanna ☐ Thornwoods ☐ Deciduous Forest ☐ Coniferous Forest ☐ Desert ☐ TROPICAL ☐ Rain Forest ☐ Seasonal Forest ☐ Savanna ☐ Thornwoods ☐ Deciduous Forest ☐ Coniferous Forest ☐ Desert	☐ CHAPPARAL/ SCLEROPHYLL/ SHRUBLANDS ☐ ALPINE ☐ MONTANE ☐ CLOUD FOREST ☐ RIPARIAN ZONES ☐ ISLANDS (except Barrier Islands) ☐ BEACHES/ DUNES/ SHORES/ BARRIER ISLANDS ☐ CAVES/ ROCK OUTCROPS/ CLIFFS ☑ CROPLANDS/ FALLOW FIELDS/ PASTURES ☐ URBAN/SUBURBAN ☐ SUBTERRANEAN/ SOIL/ SEDIMENTS ☐ EXTREME TERRESTRIAL ENVIRONMENT ☐ AERIAL

AQUATIC HABITATS

- ☐ GENERAL AQUATIC
- ☐ FRESHWATER
  - ☐ Wetlands/Bogs/Swamps
  - ☐ Lakes/Ponds
  - ☐ Rivers/Streams
  - ☐ Reservoirs
- ☐ MARINE
  - ☐ Open Ocean/Continental Shelf
  - ☐ Bathyal
  - ☐ Abyssal
  - ☐ Estuarine
  - ☐ Intertidal/Tidal/Coastal
  - ☐ Coral Reef
  - ☐ HYPERSALINE
- ☐ EXTREME AQUATIC ENVIRONMENT
- ☐ CAVES/ ROCK OUTCROPS/ CLIFFS
- ☐ MANGROVES
- ☐ SUBSURFACE WATERS/ SPRINGS
- ☐ EPHEMERAL POOLS & STREAMS
- ☐ MICROPOOLS (Pitcher Plants, Tree Holes, Other)

MAN-MADE ENVIRONMENTS

- ☐ LABORATORY
- ☐ THEORETICAL SYSTEMS
- ☐ OTHER ARTIFICIAL SYSTEMS

NOT APPLICABLE

- ☐ NOT APPLICABLE

CATEGORY VI: GEOGRAPHIC AREA OF THE RESEARCH (Select 1 to 2)

- ☐ WORLDWIDE
- ☐ NORTH AMERICA
  - ☐ United States
    - ☐ Northeast US (CT, MA, ME, NH, NJ, NY, PA, RI, VT)
    - ☐ Northcentral US (IA, IL, IN, MI, MN, ND, NE, OH, SD, WI)
    - ☐ Northwest US (ID, MT, OR, WA, WY)
    - ☑ Southeast US (DC, DE, FL, GA, MD, NC, SC, WV, VA)
    - ☐ Southcentral US (AL, AR, KS, KY, LA, MO, MS, OK, TN, TX)
    - ☐ Southwest US (AZ, CA, CO, NM, NV, UT)
    - ☐ Alaska
    - ☐ Hawaii
    - ☐ Puerto Rico
    - ☐ Canada
  - ☐ Mexico
- ☐ CENTRAL AMERICA (Mainland)
  - ☐ Caribbean Islands
  - ☐ Bermuda/Bahamas
- ☐ SOUTH AMERICA
  - ☐ Eastern South America (Guyana, Fr. Guiana, Suriname, Brazil)
  - ☐ Northern South America (Colombia, Venezuela)
  - ☐ Southern South America (Chile, Argentina, Uruguay, Paraguay)
  - ☐ Western South America (Ecuador, Peru, Bolivia)
- ☐ EUROPE
  - ☐ Eastern Europe
  - ☐ Russia
  - ☐ Scandinavia
  - ☐ Western Europe
- ☐ ASIA
  - ☐ Central Asia
  - ☐ Far East
  - ☐ Middle East
  - ☐ Siberia
  - ☐ South Asia
  - ☐ Southeast Asia
- ☐ AFRICA
  - ☐ North Africa
  - ☐ African South of the Sahara
    - ☐ East Africa
    - ☐ Madagascar
    - ☐ South Africa
    - ☐ West Africa
- ☐ AUSTRALASIA
  - ☐ Australia
  - ☐ New Zealand
  - ☐ Pacific Islands
- ☐ ANTARCTICA
- ☐ ARCTIC
- ☐ ATLANTIC OCEAN
- ☐ PACIFIC OCEAN
- ☐ INDIAN OCEAN
- ☐ OTHER REGIONS (Not defined)
- ☐ NOT APPLICABLE

CATEGORY VII: CLASSIFICATION OF ORGANISMS (Select 1 to 4)

- ☐ VIRUSES
  - ☐ Bacterial
  - ☐ Plant
  - ☐ Animal
- ☐ PROKARYOTES
  - ☐ Archaebacteria
  - ☐ Cyanobacteria
  - ☐ Eubacteria
- ☐ PROTISTA (PROTOZOA)
  - ☐ Amoebae
  - ☐ Apicomplexa
  - ☐ Ciliophora
  - ☐ Flagellates
  - ☐ Foraminifera
  - ☐ Microspora
  - ☐ Radiolaria
- ☐ FUNGI
  - ☐ Ascomycota
  - ☐ Basidiomycota
  - ☐ Chytridiomycota
  - ☐ Mitosporic Fungi
  - ☐ Oomycota
  - ☐ Zygomycota
- ☐ LICHENS
- ☐ SLIME MOLDS
- ☐ ALGAE
  - ☐ Bacillariophyta (Diatoms)
  - ☐ Charophyta
  - ☐ Chlorophyta
  - ☐ Chrysophyta
  - ☐ Dinoflagellata
  - ☐ Euglenoids
  - ☐ Phaeophyta
  - ☐ Rhodophyta
- ☐ PLANTS
  - ☐ N0N-VASCULAR PLANTS
    - ☐ BRYOPHYTA
      - ☐ Anthocerotae (Hornworts)
      - ☐ Hepaticae (Liverworts)
      - ☐ Musci (Mosses)
  - ☐ VASCULAR PLANTS
    - ☐ FERNS & FERN ALLIES
    - ☐ GYMNOSPERMS
      - ☐ Coniferales (Conifers)
      - ☐ Cycadales (Cycads)

- ☐ Ginkgoales (Ginkgo)
- ☐ Gnetales (Gnetophytes)
- ☐ ANGIOSPERMS
- ☐ Monocots
- ☐ Arecaceae (Palmae)
- ☐ Cyperaceae
- ☐ Liliaceae
- ☐ Orchidaceae
- ☐ Poaceae (Graminae)
- ☑ Dicots
- ☐ Apiaceae (Umbelliferae)
- ☐ Asteraceae (Compositae)
- ☐ Brassicaceae (Cruciferae)
- ☐ Fabaceae (Leguminosae)
- ☐ Lamiaceae (Labiatae)
- ☐ Rosaceae
- ☐ Solanaceae

☐ ANIMALS

- ☐ INVERTEBRATES
- ☐ MESOZOA/PLACOZOA
- ☐ PORIFERA (Sponges)
- ☐ CNIDARIA
- ☐ Hydrozoa (Hydra, etc.)
- ☐ Scyphozoa (Jellyfish)
- ☐ Anthozoa (Corals, Sea Anemones)
- ☐ CTENOPHORA (Comb Jellies)
- ☐ PLATYHELMINTHES (Flatworms)
- ☐ Turbellaria (Planarians)
- ☐ Trematoda (Flukes)
- ☐ Cestoda (Tapeworms)
- ☐ Monogenea (Flukes)
- ☐ GNATHOSTOMULIDA
- ☐ NEMERTINEA (Rynchocoela) (Ribbon Worms)
- ☐ ENTOPROCTA (Bryozoa) (Plant-like Animals)
- ☐ ASCHELMINTHES
- ☐ Gastrotricha
- ☐ Kinorhyncha
- ☐ Loricifera
- ☐ Nematoda (Roundworms)
- ☐ Nematomorpha (Horsehair Worms)
- ☐ Rotifera (Rotatoria)
- ☐ ACANTHOCEPHALA (Spiny-headed Worms)
- ☐ PRIAPULOIDEA
- ☐ BRYOZOA (Ectoprocta) (Plant-like Animals)
- ☐ PHORONIDEA (Lophophorates)
- ☐ BRACHIOPODA (Lamp Shells)
- ☐ MOLLUSCA
- ☐ Monoplacophora
- ☐ Aplacophora (Solenogasters)
- ☐ Polyplacophora (Chitons)
- ☐ Scaphopoda (Tooth Shells)
- ☐ Gastropoda (Snails, Slugs, Limpets)
- ☐ Pelecypoda (Bivalvia) (Clams, Mussels, Oysters, Scallops)
- ☐ Cephalopoda (Squid, Octopus, Nautilus)
- ☐ ANNELIDA (Segmented Worms)
- ☐ Polychaeta (Parapodial Worms)
- ☐ Oligochaeta (Earthworms)
- ☐ Hirudinida (Leeches)
- ☐ POGONOPHORA (Beard Worms)
- ☐ SIPUNCULOIDEA (Peanut Worms)
- ☐ ECHIUROIDEA (Spoon Worms)
- ☐ ARTHROPODA
- ☐ Cheliceriformes
- ☐ Merostomata (Horseshoe Crabs)
- ☐ Pycnogonida (Sea Spiders)
- ☐ Scorpionida (Scorpions)
- ☐ Araneae (True Spiders)
- ☐ Pseudoscorpionida (Pseudoscorpions)
- ☐ Acarina (Free-living Mites)
- ☐ Parasitiformes (Parasitic Ticks & Mites)
- ☐ Crustacea
- ☐ Branchiopoda (Fairy Shrimp, Water Flea)
- ☐ Ostracoda (Sea Lice)
- ☐ Copepoda
- ☐ Cirripedia (Barnacles)
- ☐ Amphipoda (Skeleton Shrimp, Whale Lice, Freshwater Shrimp)
- ☐ Isopoda (Wood Lice, Pillbugs)
- ☐ Decapoda (Lobster, Crayfish, Crabs, Shrimp)
- ☐ Hexapoda (Insecta) (Insects)
- ☐ Apterygota (Springtails, Silverfish, etc.)
- ☐ Odonata (Dragonflies, Damselflies)
- ☐ Ephemeroptera (Mayflies)
- ☐ Orthoptera (Grasshoppers, Crickets)
- ☐ Dictyoptera (Cockroaches, Mantids, Phasmids)
- ☐ Isoptera (Termites)
- ☐ Plecoptera (Stoneflies)
- ☐ Phthiraptera (Mallophaga & Anoplura) (Lice)
- ☑ Hemiptera (including Heteroptera) (True Bugs)
- ☐ Homoptera (Cicadas, Scale Insects, Leafhoppers)
- ☐ Thysanoptera (Thrips)
- ☐ Neuroptera (Lacewings, Dobsonflies, Snakeflies)
- ☐ Trichoptera (Caddisflies)
- ☑ Lepidoptera (Moths, Butterflies)
- ☐ Diptera (Flies, Mosquitoes)
- ☐ Siphonaptera (Fleas)
- ☑ Coleoptera (Beetles)
- ☐ Hymenoptera (Ants, Bees, Wasps, Sawflies)
- ☐ Chilopoda (Centipedes)
- ☐ Diplopoda (Millipedes)
- ☐ Pauropoda
- ☐ Symphyta (Symphyla)
- ☐ PENTASTOMIDA (Linguatulida) (Tongue Worms)
- ☐ TARDIGRADA (Tardigrades, Water Bears)
- ☐ ONYCHOPHORA (Peripatus)
- ☐ CHAETOGNATHA (Arrow Worms)
- ☐ ECHINODERMATA
- ☐ Crinoidea (Sea Lilies, Feather Stars)
- ☐ Asteroidea (Starfish, Sea Stars)
- ☐ Ophiuroidea (Brittle Stars, Serpent Stars)
- ☐ Echinoidea (Sea Urchins, Sand Dollars)
- ☐ Holothuroidea (Sea Cucumbers)
- ☐ HEMICHORDATA (Acorn Worms, Pterobranchs)
- ☐ UROCHORDATA (Tunicata) (Tunicates, Sea Squirts, Salps, Ascideans)
- ☐ CEPHALOCHORDATA (Amphioxus/Lancelet)
- ☐ VERTEBRATES
- ☐ AGNATHA (Hagfish, Lamprey)
- ☐ FISHES
- ☐ Chondrichthyes (Cartilaginous Fishes) (Sharks, Rays, Ratfish)
- ☐ Osteichthyes (Bony Fishes)
- ☐ AMPHIBIA
- ☐ Anura (Frogs, Toads)
- ☐ Urodela (Salamanders, Newts)
- ☐ Gymnophiona (Apoda) (Caecilians)
- ☐ REPTILIA
- ☐ Chelonia (Turtles, Tortoises)
- ☐ Serpentes (Snakes)
- ☐ Sauria (Lizards)
- ☐ Crocodylia (Crocodilians)
- ☐ AVES (Birds)
- ☐ Passeriformes (Passerines)
- ☐ MAMMALIA
- ☐ Monotremata (Platypus, Echidna)
- ☐ Marsupalia (Marsupials)
- ☐ Eutheria (Placentals)
- ☐ Insectivora (Hedgehogs, Moles, Shrews, Tenrec, etc.)
- ☐ Chiroptera (Bats)
- ☐ Primates
- ☐ Humans
- ☐ Rodentia
- ☐ Lagomorphs (Rabbits, Hares, Pikas)
- ☐ Carnivora (Bears, Canids, Felids, Mustelids, Viverrids, Hyena, Procyonids)
- ☐ Perissodactyla (Odd-toed Ungulates) (Horses, Rhinos, Tapirs, etc.)

☐ Artiodactyla (Even-toed Ungulates) (Cattle, Sheep, Deer, Pigs, etc.) ☐ Marine Mammals (Seals, Walrus, Whales, Otters, Dolphins, Porpoises)	☐ TRANSGENIC ORGANISMS ☐ FOSSIL OR EXTINCT ORGANISMS	☐ NO ORGANISMS

CATEGORY VIII: MODEL ORGANISM (Select ONE)

☑ NO MODEL ORGANISM MODEL ORGANISM (Choose from the list)	☐ Escherichia coli ☐ Mouse-Ear Cress (Arabidopsis thaliana)	☐ Fruitfly (Drosophila melanogaster)

Project Summary: Competition and predation are two interactions that can shape community structure. Environmental temperature can mediate the strength of these interactions. For example, predation rates often increase with temperature, suggesting that the importance of predation in structuring ecological communities likely increases with temperature. ***The goal of this study is to understand how rising temperature will affect biotic interactions among insect herbivores using three model plant-herbivore systems*.** Specifically, I will ask two main questions:

1) *Does temperature affect indirect competition among herbivores by increasing herbivore susceptibility to induced plant defenses?*
2) *Does temperature affect the role of predators in regulating exploitative competition among herbivores?*

I will address these questions using two experiments. The first experiment examines how temperature influences indirect competition among herbivores by increasing the efficacy of induced defenses in two model plants: *Oenothera biennis* and *Lindera benzoin*. The second experiment examines the joint effects of temperature and predation on exploitative competition between herbivorous insects on *Asclepias syriaca*. Two aphid species (*Aphis asclepiadis* and *Aphis nerii*) exhibit asymmetric competition, wherein one species is subdominant because it has lower growth rates and is preferred prey for a coccinelid predator. I hypothesize that temperature-driven increases in both predation rates and growth rates of the dominant species could lead to competitive exclusion of the subdominant species.

Intellectual Merit: The proposed work will address relevant but unstudied issues concerning the impact of climate change on ecosystem structure. For example, predicting the effects of climate change on species abundances remains difficult, likely because simplistic models overlook biotic interactions and the incredibly varied thermal response curves among co-existing species. ***This project will experimentally assess how temperature affects biotic interactions among a diverse set of herbivores on multiple plant hosts.*** Results may aid researchers attempting to model the effects of climate change on species abundance and distributions by providing empirical results describing the effects of climate change on species interactions. This research fills a critical gap in our understanding of the effects of climate change on multiple biotic interactions. Most previous work has examined the effects of climate change on individuals or single species in isolation. Alternatively, field experiments have described how community composition, typically of plants, changes with warming. Such experiments lack detailed examination of mechanisms driving changes in community composition, making it difficult to extrapolate results beyond a specific study system.

Broader Impacts: This proposal takes advantage of the intellectual atmosphere at the Smithsonian Environmental Research Center by integrating my dissertation research with ongoing research into the effects of climate change on plant communities. I have demonstrated a commitment to science outreach by participating in programs that provide hands-on science experience to at-risk high school students. I have requested additional funding for a social media-based outreach campaign to connect scientists directly with the public to provide the public with an in-depth view of the scientific method and direct access to my results. Finally, both labs at Florida International University and the Smithsonian Environmental Research Center provide research opportunities for undergraduates. In particular, FIU is one of the largest minority and urban serving institutions in the US, with over 70% of its students from underrepresented groups in science (59% Hispanic, 13% black, 4% Asian; 56% female). Volunteers recruited from FIU therefore come from a large pool of underrepresented minority students.

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*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

INTRODUCTION

Ecological consequences of climate change remain difficult to predict. The difficulty arises from the myriad species interactions possible in an ecological community, such that assessing the impacts of climate change on species' abundances and community structure is exceedingly difficult (Davis et al. 1998, Araújo and Peterson 2012). Moreover, thermal response curves (*i.e.* the curve relating individual fitness to temperature) are highly idiosyncratic among species (Dell et al. 2011, Englund et al. 2011, Lemoine and Burkepile 2012). Experimental studies assessing the role of temperature in mediating biotic interactions are therefore required if we are to accurately predict the effects of climate change (Gilman et al. 2010). ***This proposal builds on my previous research describing the impact of climate change on the feeding behavior of ecothermic herbivores by examining how climate change affects competitive and predatory interactions among insect herbivores.***

Competition and predation often impact ecological community composition. For example, insect herbivores coexisting on the same host plant experience strong interspecific competition that reduces the growth rate, abundance, fecundity, and survivorship of competing herbivore species (Denno et al. 1995, Kaplan and Denno 2007). Exploitative competition, wherein individuals compete by reducing the availability of limiting resources for competitors, occurs among insect herbivores that share narrow habitat requirements on the same host plant, such as aphids on common milkweed *Asclepias syriaca* (Mooney et al. 2008, Smith et al. 2008). More commonly, phytophagous insects compete indirectly when herbivory by an individual induces production of plant defense compounds, thereby lowering plant nutritional quality and reducing fitness of subsequent herbivores (Faeth 1986, Agrawal 1999). Rising temperatures may alter competitive interactions via two mechanisms: 1) increased consumption or population growth rates at high temperatures may strengthen exploitative competition among herbivore species by increasing rates of resource depletion (Tilman et al. 1981) or 2) increased efficacy of plant chemical defenses at high temperatures (Stamp and Yang 1996, Stamp and Osier 1998, Lemoine et al. *in review*) may strengthen indirect competition among herbivore individuals.

Predators can indirectly influence the abundance of primary producers via density-mediated or behaviorally-mediated indirect effects (Moran et al. 1996, Schmitz 2003). Furthermore, predators can enable the persistence of subdominant species by consuming competitively superior species (*i.e.* keystone predation*,* Paine 1966). Alternatively, predators can exacerbate competition among species when preferentially consuming the sub-dominant competitor (Gonzáles et al. 2002). In more complex systems, climate change will likely enhance the importance of predators as mediators of competitive interactions among multiple herbivores (*i.e.* temperature-dependent keystone predation, Sanford 1999).

Importantly, thermal response curves vary both among and within species. Variation among species stems from the evolutionary history of the species (Angilletta 2009). Within a species, thermal response curves are a product of adaptation to local environmental conditions and food quality (Eliason et al. 2011, Kingsolver and Woods 1998, Lemoine et al. *in review*). For example, my preliminary results show that three lepidopteran herbivores that coexist on *Lindera benzoin* have unique thermal response curves. Growth and consumption rates of *Epimecis hortaria* increase with temperature, *Melanophia canadaria* has a unimodal thermal response curve, and *Papilio troilus* fitness remains relatively constant over the same temperature range (Fig. 1). Effects of climate change on competition among these herbivores would be contingent on the identity of competing species. For example, at 25˚ C *E. hortaria* and *M. canadaria* have identical growth rates and warming leads to vast differences between these species. In contrast, the differences between *E. hortaria* and *P. troilus* fitness are not as affected by temperature. Warming therefore strengthens competitive interactions between *E. hortaria* and *M. canadaria* more severely than between *E. hortaria* and *P. troilus*. Thus, predicting how climate change affects species interactions requires species-specific knowledge of thermal response curves.

Funding from the DDIG would support mesocosm-based experiments designed to assess how climate change affects important biotic interactions. Specifically, I will examine the effects of temperature on indirect, chemically-mediated competition among individual herbivores feeding on *Oenothera biennis* and *Lindera benzoin*. Additionally, I will examine the joint influences of temperature and predation on populations of herbivores engaged in exploitative competition using *Asclepias syriaca* and its associated herbivores. My previous work has focused on understanding how climate change affects feeding behavior and growth of single herbivore species in isolation (Lemoine and Burkepile 2012, Lemoine et al. *in review*). This project expands on my earlier work by incorporating multiple biotic interactions to discern how climate change will alter plant-herbivore interactions.

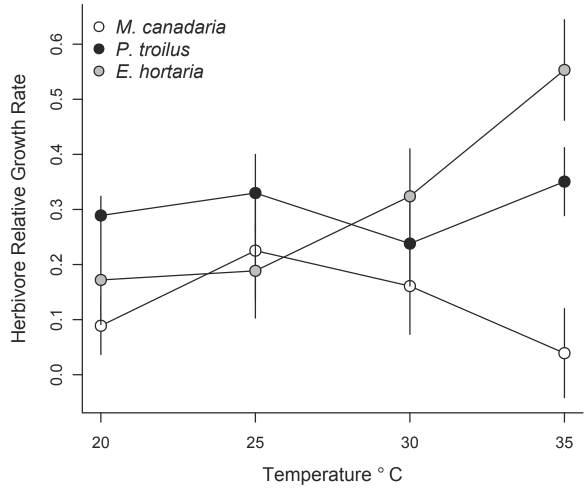

Figure 1. *Thermal response curves of growth rates for three lepidopteran herbivore species grown on* Lindera benzoin *(Lemoine, unpublished data).*

Research Questions

1) *Does temperature affect indirect competition among herbivores by increasing herbivore susceptibility to induced plant defenses?*
2) *Does temperature affect the role of predators in regulating exploitative competition among herbivores?*

Hypotheses, Previous Research, and Methods

Study System and General Experimental Design

The Smithsonian Environmental Research Center (SERC) in Edgewater, Maryland contains both forested and open-field habitats. *Asclepias syriaca* and *Oenothera biennis* are abundant open-field plants that host a diversity of specialized herbivores and predators. Specifically, *A. syriaca* hosts three aphid species, *Aphis nerii*, *Aphis asclepiadis*, and *Myzocallis asclepiadis*, as well as coccinelid aphid predators. *Oenothera biennis* is consumed by a variety of specialist coleopterans and hemipterans, as well as the generalist coleopteran *Popillia japonica*. The efficacy of plant chemical defenses against *P. japonica* varies with temperature (Lemoine et al. *in review*), making it an ideal herbivore to assess the effect of temperature on induced defenses in *O. biennis. Lindera benzoin* is a common forest understory shrub that hosts three caterpillar species, *Melanophia canadaria*, *Epimecis hortaria*, and *Papilio troilus* throughout the summer. The diverse herbivore and predator communities on these three plants make for unique model systems to examine the impacts of climate change on consumer-prey interactions.

Experiments will be conducted using greenhouses to establish different thermal environments. Small (~ 4 m^2 floor area) greenhouses will be assigned either 'ambient or 'warmed status (n = 3 greenhouses per temperature). Ambient summer temperatures at SERC range from 25 – 32˚ C. Target temperatures for 'warmed' treatments are 2 – 3˚ C above ambient. Greenhouses assigned 'warmed' treatments will have solar fiberglass panels to retain heat with a vented roof panel covered with insect screen to prevent excess heat buildup. Greenhouses assigned 'control' treatments will be covered with transparent insect screen to maintain ambient air temperature while preventing intrusion by insect predators and herbivores. Although the insulating greenhouse panels may alter light intensity, they allow over 90% PAR transmission (Chapin and Shaver 1985). In contrast, shade cloth can manipulate temperature in the field but also reduces PAR transmission by ~ 60% (Chapin and Shaver 1985). Since light intensity can affect expression of induced defenses in plants (Mooney et al. 2009), using fiberglass greenhouse panels is preferable over shade cloth to manipulate temperature. Two HOBO data loggers will be placed within each greenhouse to monitor temperature and light for the experimental duration.

Hypothesis 1: Higher temperatures will increase the strength of indirect competition among phytophagous insects by increasing the efficacy of inducible plant defenses.

Though exploitative competition is rare among insect herbivores, indirect competition via induced plant defenses is common and can have significant negative effects on herbivore fitness (Kaplan and Denno 2007). Climate change might increase the strength of such indirect competition by increasing the susceptibility of herbivores to plant secondary defenses. For example, though concentrations of secondary defense compounds are largely unaffected by rising temperatures (Zvereva and Kozlov 2006), direct effects of temperature on herbivore physiology can increase the effectiveness of secondary defenses (Stamp and Yang 1996, Lemoine et al. *in review*). Therefore, rising temperatures may increase the strength of indirect competition by enhancing the negative effects of plant secondary chemistry on herbivore fitness.

The effectiveness of plant chemistry, however, depends on the evolutionary history between the plant and herbivore. Generalist herbivores are often more susceptible to plant defenses than are specialists (Joshi and Vrieling 2005, Verhoeven et al. 2009, Ali and Agrawal 2012). In our study system, *L. benzoin* hosts at least two generalist (*E. hortaria* and *M. canadaria*) and one specialist (*P. troilus*) lepidopteran herbivores. *Oenothera biennis* hosts a number of specialist coleopteran herbivores and is also attacked by a generalist herbivore, *Popillia japonica*. Both *L. benzoin* and *O. biennis* up-regulate defensive compounds when attacked by generalist herbivores (McGuire and Johnson 2006, Mooney et al. 2009). Furthermore, my preliminary results suggest that the efficacy of *L. benzoin* secondary defenses increases at high temperatures (Fig. 2). The specialist herbivore, *P. troilus*, which feeds almost exclusively on *L. benzoin*, increases its preference for *L. benzoin* at high temperatures. In contrast, *M. canadaria*, which feeds on a diverse suite of woody plant species, decreases its preference for *L. benzoin* at high temperatures. These patterns, coupled with results from my earlier work (Lemoine et al., *in review*), suggest that plant chemistry becomes more effective at high temperatures, but affects generalist and specialist herbivores differently. Climate change

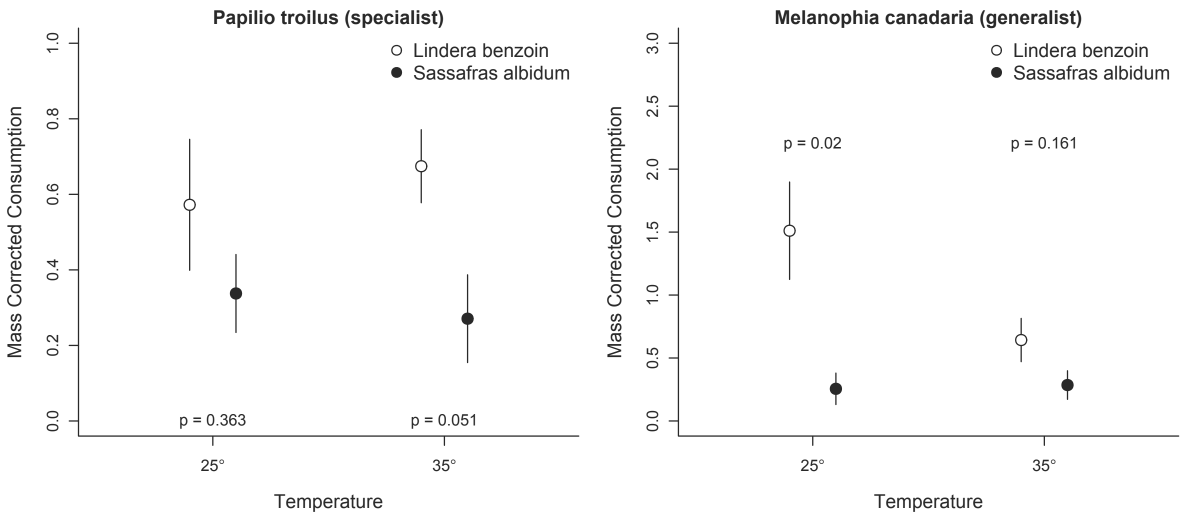

Figure 2. *Feeding preferences of a specialist* (Papilio troilus) *and generalist* (Melanophia canadaria) *lepidopteran herbivore at two temperatures.* p-*values are from one-sample t-tests of no difference in consumption rates between* Lindera benzoin *and* Sassafras albidum.

may therefore strengthen indirect competition among herbivore species, but this effect will be contingent upon co-evolutionary history between plant and herbivore species.

Methods

I will use both *L. benzoin* and *O. biennis* to evaluate the effects of temperature on indirect competition among phytophagous herbivores. *Lindera benzoin* is a woody shrub found in forest understories and edge habitats, while *O. biennis* is an open-field forb. These two plant species therefore represent distinct life histories, harbor different herbivore species, and manufacture potentially different chemical defense compounds. Seeds of each species were collected in October 2012. Over 300 *L. benzoin* seeds have been planted for germination in early spring 2013. *Oenothera biennis* seeds will be planted in spring 2013. The generalist herbivore *Spodoptera exigua* will be used to induce defenses in both *L. benzoin* and *O. biennis*. *Spodoptera exigua* is a widespread generalist herbivore that has previously been used to induce defenses in both *L. benzoin* and *O. biennis* (McGuire and Johnson 2006, Mooney et al. 2009).

Oenothera biennis seedlings will be randomly assigned to either 'control' or 'warmed' greenhouses (n = 60 per temperature, n = 20 per greenhouse). Within greenhouses, seedlings will be randomly assigned to either induction or control treatments (n = 10 per induction treatment per greenhouse, n = 30 per induction treatment per temperature). Seedlings assigned the induction treatment will have a single *S. exigua* larva placed on the leaves and allowed to feed for 72 hours before removal. Seedlings assigned to control treatments will be left intact. After 72 hours, a single, pre-weighed adult *Popillia japonica* individual will be placed on all seedlings and allowed to feed for 48 hours. After feeding, *P. japonica* will be reweighed and percent damage on each leaf quantified. During all assays, seedlings will be enclosed in mesh bags to inhibit herbivore movement among plants. Leaf damage and *P. japonica* growth rates will be analyzed with two-way ANOVAs, wit temperature and induction treatment as fixed factors.

For the second experiment, forty *L. benzoin* seedlings will be randomly assigned to each greenhouse (n = 120 per temperature). Within each greenhouse, a single *S. exigua* larva will be placed on twenty seedlings, while twenty seedlings will be left as controls. After feeding for 72 hours, *S. exigua* will be removed. A single, pre-weighed *E. hortaria* larva will be placed on half of the seedlings that experienced herbivory from *S. exigua*. *Epimecis hortaria* is a generalist herbivore that consumes a number of woody plant species from different families, including *L. benzoin*, *Sassafras albidum*, *Liriodendron tulipifera*, and *Asimina triloba* (Lemoine, *pers. obs.*). A single, preweighed larva of *P. troilus* will be placed on the other half of the seedlings attacked by *S. exigua*. Half of the control seedlings will have a single, preweighed *E. hortaria* individual placed upon them; the other half will be populated with a single preweighed *P. troilus* larva. After 48 hours, *E. hortaria* and *P. troilus* will be reweighed and leaf damage quantified. During all assays, seedlings will be enclosed in mesh bags to prevent herbivore movement. This design results four treatments: Control-Specialist, Control-Generalist, Induced-Specialist, and Induced-Generalist (n = 30 per treatment per temperature).

For both *O. biennis* and *L. benzoin*, leaf terpene concentrations from each induction-temperature treatment will be measured with gas chromatograph mass spectrometry (Lind et al. *in review*). A two-way ANOVA will compare leaf damage, herbivore growth rates, and terpene concentrations across induction and temperature treatments. Pairwise *post-hoc* comparisons will be used to answer several questions. First, contrasting Induced-Generalist to Control-Generalist treatments at each temperature will determine if *S. exigua* herbivory successfully induced plant defenses and whether the effect of plant defenses varied with temperature. Contrasting Induced-Specialist to Control-Specialist at each temperature will determine whether defense induction affected specialists and if this effect varied over temperature. Comparing Induced-Specialist to Induced-Generalist at each temperature will determine if the effect of induced defenses varied among herbivore species and whether temperature modifies this effect.

Expected Results

I expect that induced defenses will lower leaf damage and growth rates of *P. japonica* on *O. biennis*. However, because my previous research has shown that plant chemistry increases in effectiveness against *P. japonica* at high temperatures, I expect a significant interaction between temperature and induction treatment. Specifically, induced defenses will slightly reduce growth rates and leaf damage in 'control' temperatures. At 'warmed' temperatures, however, growth rates and leaf damage will be reduced substantially by induced defenses.

I also expect a significant interaction between induction treatment of *L. benzoin* and temperature. *Post-hoc* comparisons will likely reveal that induced defenses reduce growth rates and leaf damage by *E. hortaria*, and this effect will be stronger at 'warmed' temperatures than at 'control' temperatures. Induced defenses will have little effect on growth rates and consumption of the specialist herbivore *P. troilus* at low temperatures. At high temperatures, induced defenses may actually stimulate growth and consumption of *P. troilus* (Fig. 2).

Hypothesis 2: Increased temperature will increase the strength of exploitative competition among herbivore populations, thereby increasing the role of predators as mediators of competitive interactions.

Insect herbivores can compete directly, via exploitative competition, if they share similar microhabitat requirements on a plant of limited size. For example, two aphid species, *A. asclepiadis* and *A. nerii*, specialize on apical tissue of *A. scyriaca*. These two species exhibit asymmetrical competition, where interspecific competition reduces the abundance of *A. asclepiadis* but not *A. nerii* (Mooney et al. 2008). The competitive advantage of *A. nerii* stems from its more rapid population growth rates compared to *A. asclepiadis* (Mooney et al. 2008). Yet, aphid population growth rates are contingent on environmental temperature. Congeneric aphid species that specialize on the same host plant can have different thermal response curves (Komazaki 1982). Thus, increased temperature may strengthen or weaken the competitive ability of *A. nerii*, depending on the relative shapes of the thermal response curves of both *A. asclepiadis* and *A. nerii* (*e.g.* Gonzáles et al. 2002).

Predation can affect competitive interactions if predators preferentially consume one of the two competing species. For example, predation on competitively dominant species can allow subdominant species to persist (Paine 1966). Alternatively, predators can exacerbate competition if predators prefer subdominant species. On *A. syrica*, coccinellid predators reduce the abundances of both *A. asclepiadis* and *A. nerii* (Smith et al. 2008). However, *A. nerii* sequesters cardenolide compounds that effectively deter predation, leading coccinellid predators to prefer the subdominant *A. asclepiadis* (Mooney et al. 2008). Given that temperature increases predation rates of carnivorous insects (Rall et al. 2010, Vucic-Pestic et al. 2011), increased temperatures may further reduce the competitive ability of *A. asclepiadis* by increasing predation rates. Thus, *A. asclepiadis* might face stronger competition from *A. nerii* at high temperatures via more rapid population growth of *A. nerii* while simultaneously experiencing higher predation rates. *Aphis asclepiadis* may therefore suffer reduced population sizes below what would be expected in the presence of only competitors or predators. In fact, increased pressure from multiple sources might lead to local extinctions of *A. asclepiadis* if predation pressure and competition strength both increase substantially at high temperatures (Urban et al. 2012). This situation suggests that climate change might affect herbivore populations through multiple avenues such that the outcome is difficult to predict if one or more interactions are overlooked.

Methods

Asclepias syriaca seeds were collected from September through October 2012. Seeds will be planted in spring 2013 and assigned to either 'ambient or 'warmed' temperature treatments (*n* = 30 per greenhouse, *n* = 90 per temperature). Within each greenhouse, seedlings will be randomly assigned one of three competition treatments: 1) *A. asclepiadis* only, 2) *A. nerii* only, or 3) *A. asclepiadis* + *A. nerii* (*n* = 10 per treatment per greenhouse, *n* = 30 per competition treatment per temperature). For each competition treatment, six total individuals will be placed on each seedling (three of each aphid species for the *A. asclepiads* + *A. nerii* treatment to control for density of herbivores). Half of the seedlings in each competition treatment will be randomly assigned a 'predator present' treatment, wherein two coccinellid predators are placed on the seedling. Thus, there will be 15 replicates per predation-competition-temperature combination. Such experimental designs, wherein temperature is manipulated in blocks, are common for field-based experiments where logistical concerns preclude the possibility of 30 independent warming mesocosms (Laws and Joern 2012). Seedlings will be covered in mesh cages to prevent movement among plants by herbivores or predators. After two weeks, all aphids on each seedling will be counted. Two weeks represents 2 – 3 aphid generations and is commonly used in studies of aphid population dynamics (Mooney et al. 2008). Leaf latex and cardenolide concentration will be analyzed by mass and with spectrophotometry, respectively (Agrawal 2005). Aphid abundances will be analyzed with three-way ANOVAs (one per aphid species), with temperature, competition, and predation treatment as fixed factors.

In order to determine the mechanisms behind competitive interactions, I will quantify aphid feeding rates, reproductive rates, and coccinellid predation rates at each temperature. At each temperature, a single aphid will be placed on a seedling (*n* = 10 per aphid species per temperature). To quantify feeding rates, preweighed, dried filter paper will be placed under the seedling to collect aphid honeydew (Mooney et al. 2008). After 24 hours, the filter paper will be reweighed. Additionally, after 24 hours, any offspring will be counted to quantify reproduction rates (offspring per individual per day, Mooney et al. 2008). To estimate predation rates, six aphids will be placed on a plant leaf enclosed within a petri dish with a single coccinellid predator at each temperature (*n* = 10 per temperature). After one hour, remaining aphids will be counted estimate hourly aphids consumption rates. These experiments will be conducted with both *A. asclepiadis* and *A. nerii*. Each rate (consumption, reproduction, predation) will be analyzed with a two-way ANOVA, with temperature and aphid species as fixed factors.

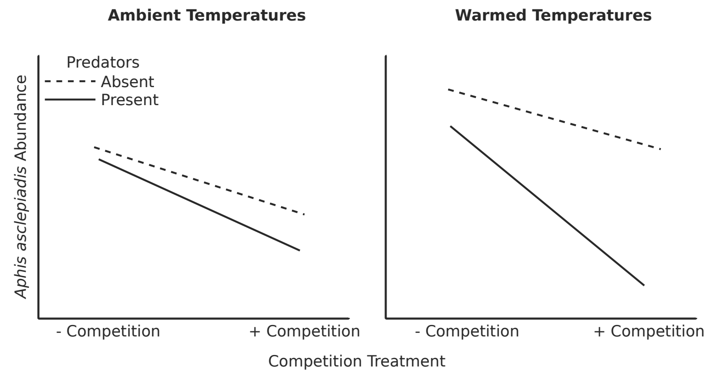

Figure 3. *Hypothesized effect of temperature, competitors, and predators on the abundance of* Aphis asclepiadis.

Expected Results

I expect a significant three-way interaction between temperature, competition, and predation on the abundance of *A. asclepiadis*. Specifically, the ability of predators to act as mediators of competitive interactions should increase substantially at high temperatures due to higher predation rates (Fig. 3). At ambient temperatures, *A. asclepiadis* abundance will be reduced in the presence of both predators and the competitor *A. nerii.* However, at ambient temperatures, the interaction between predator presence and competitor presence will likely be weak (Smith et al. 2008). Conversely, at warmed temperatures, predators will increase consumption of *A. asclepiadis.* Simultaneously, *A. nerii* will increase population growth and consumption rates. These two effects will severely depress *A. asclepiadis* abundances. These mechanisms will manifest as increased consumption and growth rates of *A. nerii* and increased predation rates on *A. asclepiadis* at high temperatures.

Significance of Proposed Research

Unfortunately, despite the wealth of information on the effects of climate change on single species, the effects of climate change on competition and predation remain remarkably understudied. This study uses three model plant-herbivore systems of competing herbivores to understand how climate change affects interspecific competition among herbivore species. Using three different plant-herbivore systems allows us to address two mechanisms of competition, exploitative competition and indirect competition.

Predation risk, competition, and temperature all have significant impacts on herbivore fitness and feeding behavior (Kaplan and Denno 2007, Barton et al. 2009, Lemoine and Burkepile 2012). ***The proposed projects fill a critical gap in our understanding of how these factors act in concert to structure herbivore feeding behavior.*** For example, temperature can alter competitive outcomes because species have different thermal response curves (Tilman et al. 1981). Predators can mediate competitive interactions (Paine 1966), and predation rates are sensitive to changes in temperature (Vucic-Pestic et al. 2011). Thus, the role of predators as keystone species is likely dependent upon environmental context (Sanford 1999). This study will combine these interactions to experimentally assess how temperature and predation interactively affect exploitative competition among herbivore species. Furthermore, herbivores compete indirectly via plant defenses (Denno et al. 1995, Kaplan and Denno 2007) and temperature can alter the efficacy of plant defenses against herbivores (Stamp and Yang 1996). My previous research has addressed the effects of climate change on herbivore foraging behavior in isolation from external forces. My proposed experiments will elucidate the mechanisms by which temperature affects herbivores by incorporating competition and predation. Additionally, my results will contribute to future climate change models that incorporate biotic interactions to describe the effects of climate change on species abundances.

BROADER IMPACTS

Nathan Lemoine has directly mentored three undergraduates (one underrepresented minority). N. Lemoine has also participated in the Partnership in Academic Communities program at FIU, which provides hands-on science experience for at-risk high school students, and given presentations to school groups at the Dauphin Island Sea Lab Estuarium aquarium. Funding from this proposal will allow N. Lemoine to integrate his experiments with on-going climate change research at SERC and to benefit from interacting with principle investigators from SERC working on climate change-related questions. In addition, one undergraduate will be hired through the NSF's Research Experience for Undergraduates run by Dr. John Parker at SERC. Applicants from FIU's diverse undergraduate student body will be given first consideration for this position. This student will be given one aspect of this proposal as his or her own project to provide the student with training in ecological theory, experimental design and methods.

Additionally, funding has been requested from the Smithsonian Women's Committee to hire two science-minded journalism interns from environmental studies programs with interests in becoming science writers or journalists. These interns will work on various aspects of these projects part time to obtain experience with scientific research. However, the primary responsibility of these interns will be to build an extensive public outreach platform for the proposed research using online social media (*i.e.* Facebook, Twitter, blogs). Interns will attempt to connect directly with the general public to provide an in-depth, transparent view of the scientific method from their own experiences working on these projects. Additionally, these interns will provide all researchers associated with this project with training in the use of social media to directly connect with the general public. The interns will also be responsible for writing an opinion letter detailing the impacts of climate change on ecological communities. These opinion pieces will be submitted to two prominent newspapers for publication.

The results of these research projects will be disseminated to the scientific community through journal publications and presentations at the Ecological Society of America annual meeting. Results will be made publicly available via social media and opinion columns.

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A. Professional Preparation

University of Mississippi	Biology/chemistry	B.A.	1999
Georgia Institute of Technology	Biology	Ph.D.	2006
Yale University	Community Ecology	Post-doc	2006-2008

B. Appointments

2008-present	Assistant Professor of Biological Sciences, Florida International University
2006-2008	Brown Post-doctoral Fellow, Yale University
2005-2006	IGERT Fellow, NSF-IGERT Program in Aquatic Chemical Signaling
2002	Graduate Fellow, Smithsonian Tropical Research Institute
2001-2004	Graduate Research Fellow, National Science Foundation
2001-2004	Associate, NSF-IGERT Program in Aquatic Chemical Signaling

C. Publications

Five Most Related Publications

Lemoine, N.P. and D.E. Burkepile. (2012) Temperature-induced mismatches between consumption and metabolism reduce consumer fitness. *Ecology – Preprint available online*

Burkepile, D.E. (2012) Comparing marine vs. terrestrial grazing ecosystems: is the grass really greener? *Oikos* - a*n invited paper on comparing herbivory in terrestrial and marine ecosystems*

Parker, J.D., D.E. Burkepile, M.J. Lajunesse, and E.M. Lind. (2012) Phylogenetic isolation increases plant invasiveness despite increasing susceptibility to generalist herbivores. *Diversity and Distributions* 18:1-9 DOI: 10.1111/j.1472-4642.2011.00806.x

Burkepile, D.E. and M.E. Hay. (2008) Herbivore species richness and feeding complementarity affect community structure and function on a coral reef. *Proceedings of the National Academy of Sciences* 105:16201-16206.

Burkepile, D.E. and M.E. Hay. (2006) Herbivore vs. nutrient control of marine primary producers: context-dependent effects. *Ecology* 87:3128-3139.

Five Publications of General Significance

Burkepile, D.E. and M.E. Hay. (2011) Feeding complementarity versus redundancy among herbivorous fishes on a Caribbean reef. *Coral Reefs* 2:351-362 DOI: 10.1007/s00338-011-0726-6

Burkepile, D.E. and M.E. Hay. (2010) Impact of herbivore identity on algal succession and coral growth on a Caribbean reef. *PLoS ONE* 5(1): e8963. DOI:10.1371/journal.pone.0008963

Buis, G.M, J.M. Blair, D.E. Burkepile, C.E. Burns, A.J. Chamberlain, P. Chapman, S.L. Collins, R.W.S. Fynn, N. Govender, K. Kirkman, M.D. Smith and A.K. Knapp. (2009) Controls of aboveground net primary production in mesic savanna grasslands: an interhemispheric comparison. *Ecosystems* 12:982-995 DOI: 10.1007/s10021-009-9273-1

Burkepile, D.E. and M.E. Hay. (2009) Nutrient vs. herbivore control of macroalgal community development and coral growth on a Caribbean coral reef. *Marine Ecology-Progress Series* 389:71-84.

Parker, J.D., D.E. Burkepile, and M.E. Hay. (2006) Opposing effects of native and exotic herbivores on plant invasions. *Science* 311:1459-1461.

D. Synergistic Activities

- **Professional service** – I have served as a reviewer for 24 different scientific journals including *Conservation Biology*, *Ecology*, *Ecology Letters*, *Ecological Monographs*, *Proceedings of the Royal Society B* and *PLoS One* in addition to reviewing grants for the National Science Foundation (Division of Environmental Biology and Biological Oceanography), CAMEO NOAA/NSF, and the Hawaiian Coral Reef Initiative.
- **Participant in NCEAS working group "Coral Reef Preservation"** – September 2012
- **Undergraduate and Graduate student training** are critical to my goals as a professor. I currently advise three graduate students at FIU, and mentor two undergraduate students working in my laboratory. I currently serve as a committee member of 13 graduate students both at Florida International University. As a post-doc I routinely advised 2-3 undergraduates on research projects during each field season in South Africa.
- **Outreach** – I strive to disseminate my research to local civic groups and other organizations as well as local elementary and junior high schools. My recent outreach talks have included the Sierra Club, the South African Wildlife College, and the Organization for Tropical Studies in South Africa. My lab has also produced videos on coral reef ecology for local Public Broadcasting Stations in Miami, FL and worked with Symbio Studios to produce educational videos on healthy coral reef ecosystems for Houghton Mifflin Harcourt's Science Fusion and High School programs

E. Collaborators and Other Affiliations

Collaborators and Co-authors: Jacob Allgeier (University of Georgia), Catherine Burns (University of Maine), John Blair (Kansas State University), Scott Collins (University of New Mexico), Richard Fynn (Harry Oppenheimer Okavango Research Center, Botswana), Mark Hay (Georgia Institute of Technology), Kevin Kirkman (University of KwaZulu-Natal, South Africa), Alan Knapp (Colorado State University), Julia Kubanek (Georgia Institute of Technology), Marc Lajunesse (NESCENT), Craig Layman (Florida International University), Eric Lind (University of Minnesota), Heath Mills (Florida State University), John Parker (Smithsonian Environmental Research Center), Melinda Smith (Yale University), David Thompson (South African Environmental Observation Network), C. Brock Woodson (Stanford University), Rebecca Vega Thurber (Florida International University)

Graduate and Post-doctoral Advisors:
Ph.D. advisor: Mark E. Hay (Georgia Institute of Technology)
Post-doctoral advisor: Melinda D. Smith (Yale University)

Thesis advisor and Postdoctoral sponsor:
Graduate students (5): Laura Bhatti (PhD - Florida International University), Andrew Shantz (PhD - Florida International University), Nathan Lemoine (PhD - Florida International University), Alain Duran (MS – Florida International University), Mark Ladd (PhD - Florida International University)
Postdoctoral researchers (3): Dr. Andrew Thurber (NSF Polar Programs Post-doctoral Fellow),
Dr. Jesse Zaneveld (co-advised with Dr. Rebecca Vega Thurber at Oregon State University), Dr. Thomas Adam (Florida International University)

NATHAN P. LEMOINE
Ph.D. Candidate
Florida International University, North Miami, FL

A. Professional Preparation

University of Richmond	BS	Environmental Studies/Biology	2006
University of South Alabama	MS	Marine Science	2010
Florida International University		Ph.D. Candidate in Biology	2010 – *present*

B. Appointments

Presidential Fellow	Florida International University	2010 – *present*
Graduate Research Fellow	University of South Alabama	2007 – 2009
Robert F. Smart Research Fellow	University of Richmond	2005 – 2006

C. Publications

Most Related Publications

Lemoine, N.P., W.A. Drews, J.D. Parker, D.E. Burkepile (*in review*) Temperature alters feeding preferences of a generalist herbivore. *Ecology*

Lemoine, N.P. and D.E. Burkepile (2012) Temperature-induced mismatches between metabolism and consumption reduce consumer fitness. *Ecology* 93(11):2483-2489

Five Publications of General Significance

Burkepile, D.E., J. Allgeier, A. Shantz, C.E. Pritchard, **N.P. Lemoine**, L. Bhatti, C.A. Layman (*in prep*) Carnivorous fishes as vectors of nutrients on coral reefs: the role of nutrient supply in facilitating seaweed abundance.

Giery, S.T., **N.P. Lemoine**, C.M. Hammerschlag-Peyer, R. Abbey-Lee, C.A. Layman (*in review*) Bidirectional trophic linkages couple canopy and understory foodwebs. *Oikos*

Parker, J.D, M.E. Torchin, R.A. Hufbauer, **N.P. Lemoine**, C. Alba, D.M. Blumenthal, O. Bossdorf, J.E. Byers, A.M. Dunn, R.W. Heckman, M. Hejda, V. Jarosik, A. Kanarek, L.B. Martin, S.E. Perkins, P. Pysek, K. Schierenbeck, C. Schloeder, R. van Klinken, K.J. Vaughn, W. Williams, L. Wolfe (*in review*) World's worst plant and animal invaders perform better abroad than at home. *Ecology*

Lemoine, N.P. and J.F. Valentine (2012) Structurally complex habitats provided by *Acropora palmata* alter ecosystem processes on a patch reef in the Florida Keys National Marine Sanctuary. *Coral Reefs* 31(3):779-786

Lemoine N.P., N. Buell, A.L. Hill, M.S. Hill (2007) Assessing the utility of sponge microbial symbiont communities as models to study global climate change: a case study with *Halichondria bowerbanki*. In: Custdio, M. R., G. Lbo-Hajdu, E. Hajdu, and G. Muricy (eds.). Porifera Research: Biodiversity, Innovation, and Sustainability, Srie Livros 28. Museu Nacional, Rio de Janeiro. pp:419-425

D. Synergistic Activities

- **Professional service** – I have reviewed manuscripts for 4 different journals: *Biological Invasions*, *Oecologia*, *Functional Ecology*, and *Ecology Letters.* I have also served as Vice President of the Graduate Student Organization and representative of the Graduate Student Housing Committee at the Dauphin Island Sea Lab.
- **Undergraduate training** – I have mentored three undergraduates, one Hispanic, at Florida International University and the Smithsonian Environmental Research Center. One undergraduate, W.A. Drews, is co-author on a manuscript in review at *Ecology*. I have also served as a teaching assistant or guest lecturer at the University of Richmond, Florida International University, and the Smithsonian Environmental Research Center.
- **Outreach** – I view outreach as the final objective of any research project. To this end, I have worked with at-risk high school students through the 'Partnership in Academic Communities' at Florida International University. I run a blog devoted to make climate change science accessible to the general public, and I have requested funding through the Smithsonian Women's Committee for marketing interns to establish an extensive social media-based outreach platform.

E. Collaborators

Collaborators and Co-authors:

Deron Burkepile (Florida International University), John Parker (Smithsonian Environmental Research Center), Craig Layman (Florida International University), Caroline Hammerschlag-Peyer (Florida International University), John Valentine (University of South Alabama), Ken Heck (University of South Alabama), Malcolm Hill (University of Richmond), April Hill (University of Richmond)

Graduate Advisors:

M.S. advisor: John F. Valentine (University of South Alabama)
Ph.D. advisor: Deron E. Burkepile (Florida International University)

SUMMARY PROPOSAL BUDGET

YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
Florida International University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Deron Burkepile

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1.	0.00	0.00	0.00		
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				0	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				0	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				0	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				3,700	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				8,438	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				8,438	
H. TOTAL DIRECT COSTS (A THROUGH G)				12,138	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) MTDC (Rate: 26.0000, Base: 12138)					
TOTAL INDIRECT COSTS (F&A)				3,156	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				15,294	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				15,294	

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Deron Burkepile

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

Cumulative

ORGANIZATION **Florida International University**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Deron Burkepile**				AWARD NO.		
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)	
1.	0.00	0.00	0.00			
2.						
3.						
4.						
5.						
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (0) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0		
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0		
3. (0) GRADUATE STUDENTS				0		
4. (0) UNDERGRADUATE STUDENTS				0		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (0) OTHER				0		
TOTAL SALARIES AND WAGES (A + B)				0		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				0		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				0		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				0		
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				3,700		
2. FOREIGN				0		
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0						
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				8,438		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0		
3. CONSULTANT SERVICES				0		
4. COMPUTER SERVICES				0		
5. SUBAWARDS				0		
6. OTHER				0		
TOTAL OTHER DIRECT COSTS				8,438		
H. TOTAL DIRECT COSTS (A THROUGH G)				12,138		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)						
TOTAL INDIRECT COSTS (F&A)				3,156		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				15,294		
K. RESIDUAL FUNDS				0		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				15,294		
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $					
PI/PD NAME **Deron Burkepile**				FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*				Date Checked	Date Of Rate Sheet	Initials - ORG

C *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

BUDGET JUSTIFICATION

Funding from the DDIG would allow N.P. Lemoine to expand on his previous work regarding the effects of temperature on plant-herbivore interactions. Specifically, previous work has focused on single plant-herbivore combinations. DDIG funding would allow N.P. Lemoine to incorporate multiple species interactions (*e.g.* competition, predation) to examine how temperature affects plant-herbivore interactions in the context of a more complete community. DDIG funding would be used for travel and supply costs, as the research would occur at an off-site location that currently lacks the infrastructure for manipulative warming experiments. Funding would also allow N.P. Lemoine to present his research to the scientific community at a national conference.

Travel - $3,700
ESA Conference (including airfare, registration, lodging) - $1,000
SERC Lodging (25 weeks @ $100/week) - $2,500
SERC Travel - $200

Supplies - $8,438
Greenhouses (FarmTek agricultural supply company, 6 @ $1,354 ea.) - $8,124
24’ x 100’ roll insect screen (3 @ $88) - $264
Spodoptera exigua eggs (Bio-SERV, 2 containers of 1,000 eggs each @ $25/container) - $50

Facilities and Administration Costs
F & A (off campus rate) costs at Florida International University are calculated at 26% (07/01/10-until amended) of the modified total direct cost which excludes equipment, capital expenditures, charges for patient care, tuition remission, rental costs of off-site facilities, scholarships and fellowships and the portion of each subcontract and/or subgrant in excess of $25,000 regardless of the period covered. Equipment means an article of nonexpendable tangible personal property having a useful life of more than one year, and an acquisition cost of $1000 or more per unit.

Total Direct Costs: $12,138

Total Indirect Costs: $3,155.88

DERON E. BURKEPILE – CURRENT AND PENDING

CURRENT

2013-2014	FIU Faculty Research Support Grant, *Is what you 'see' really what you get?: Developing non-invasive acoustic monitoring of coral reef fishes as a comparison for in situ sampling*, ($24,216), K. Boswell (P.I), D.E. Burkepile (Co-P.I.) – 0.5 months summer salary
2012-2013	FIU Faculty Research Support Grant, *Assessing the effects of climate change on the controls of exotic plant invasions*, ($22,613) D.E. Burkepile (P.I.) – o.5 months summer salary
2012	Research Experience for Undergraduates (REU), *Microbial dynamics of coral-algal competition*, National Science Foundation, Biological Oceanography, ($9800) D.E. Burkepile (P.I.)
2011-2014	National Science Foundation, Biological Oceanography, *Cascading interactions of herbivore loss and nutrient enrichment on coral reef macroalgae, corals, and microbial dynamics* D.E. Burkepile (P.I.), R. Vega Thurber (Co-P.I.) – ($822,778) – 2 months summer salary per year
2011-2013	NOAA Coral Reef Conservation Program, *The importance of parrotfish on the maintenance and recovery of coral-dominated reefs*, D.E. Burkepile (P.I.), B. Ruttenberg (Co-P.I.) ($210,000) - 0.5 months summer salary in 2013

PENDING

2013-2014	National Science Foundation, Doctoral Dissertation Improvement Grant, *Dissertation Research: Assessing the effects of climate change on biotic interactions structuring herbivore communities* – D.E. Burkepile (P.I.), N. Lemoine (Co-P.I.) - $15,294.00 (This Proposal)

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Nathan Lemoine

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Dissertation Research: Assessing the effects of climate change on biotic interactions structuring herbivore communities

Source of Support: NSF

Total Award Amount: $ 15,294 Total Award Period Covered: 05/01/13 - 04/30/14

Location of Project: Florida Internatioanl University and SERC

Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

FACILITIES

Laboratory:
Dr. John D. Parker will act as sponsor for N.P. Lemoine at the Smithsonian Environmental Research Center (SERC). Dr. Parker's lab includes scales, bench space, computer access, and field gear for insect collection and plant rearing. Dr. Parker's lab also houses a microplate spectrophotometer for nutrient analyses in plant and animal samples and a -20˚C/4˚C freezer-refrigerator for sample storage.

Animals:
Dr. John D. Parker has a large amount of insect rearing equipment, including rearing cups, collection nets, collapsible collection cages, and aluminum rearing cages. SERC also provides access, through Dr. Parker, to environmentally-controlled, reach-in growth chambers for insect rearing.

Computers:
Dr. Parker's lab houses four Windows-based, desktop computers for lab personnel.

Major equipment:
The labs of Dr. Burkepile (PI) and Dr. Parker (collaborator) include numerous types of ecological equipment. Moreover, SERC provides access to other important equipment when necessary, including:

- Environmentally-controlled growth chambers for insect rearing
- Microcentrifuges for nutrient analysis preparation
- Microplate spectrophotometer for nutrient analyses
- Carbon-hydrogen-nitrogen analyzer
- Balances and microbalances for insect weights
- Dissecting microscopes for insect identification
- -20˚ freezers and 4˚ refrigerators for sample storage

DATA MANAGEMENT PLAN

Data will be collected on multiple variables for each experiment, including greenhouse temperatures, herbivore growth rates, herbivore consumption rates, herbivore assimilation efficiency, herbivore mortality, and predation rates.

All data will be recorded on paper hardcopies that will be stored in the office. Data will be entered into spreadsheets (MS Excel) that will be stored on a personal computer (N.P. Lemoine), an external hard-drive, and an online backup server. All protocols will be stored as text documents (MS Word) in a similar fashion to data spreadsheets. All data spreadsheets will contain basic metadata listing the PIs, date and location of research, purpose of research, a brief methodological description, and descriptions of any variable names in the spreadsheet. Data will be provided in raw form to any researcher requesting access to the data after publication. Data will also be uploaded to the Knowledge Network for Biocomplexity online database.

Analytical code (R-statistics) will be stored on personal computers and an external hard-drive. In addition, to facilitate replication and increase transparency, all R code files, including graph creation, will be submitted as supplementary materials for any publications arising from these projects. All analytical code will be heavily annotated for easy accessibility by interested researchers.

Department of Biological Sciences • College of Arts and Sciences
University Park, Miami, Florida 33199 • Tel (305) 348-2201, Fax (305) 348-1986

24 October 2012

Doctoral Dissertation Improvement Grant Program
National Science Foundation
4201 Wilson Blvd.
Arlington, VA 22230

Dear Program Director,

Nathan Lemoine has advanced to candidacy for a Ph.D. degree.

Sincerely

Steven F. Oberbauer
Professor of Biological Sciences
Graduate Program Director
Department of Biological Sciences
Florida International University
Miami FL 33199
ph: 305-348-2580
oberbaue@fiu.edu

Smithsonian Environmental Research Center

To: NSF Doctoral Dissertation Improvement Grant Committee, Directorate for Biological Sciences
From: John D. Parker, Ph.D.
Research Ecologist, Senior Scientist
Smithsonian Environmental Research Center
647 Contees Wharf Road
Edgewater, MD 21037
Ph: 443-482-2221
Email: parkerj@si.edu, Web: fieldbio.net

By signing below (or transmitting electronically), I acknowledge that I am listed as a collaborator on this proposal entitled "**DISSERTATION RESEARCH: Effects of climate change on competition among generalist and specialist herbivores**", with Nathan Lemoine as the co-Principal Investigator. I agree to undertake the tasks assigned to me or my organization, as described in the project description of the proposal, and I commit to provide or make available the resources specified therein.

Signed:
Organization: Smithsonian Environmental Research Center
647 Contees Wharf Road
Edgewater, MD 21037
Ph: 443-482-2221
Date: 8November12

CONTEXT FOR IMPROVEMENT

Nathan P. Lemoine's dissertation focuses on the effects of climate change on plant-herbivore interactions. Rising temperatures are expected to alter fundamental physiological processes of many ectothermic herbivores. Such physiological changes may have profound consequences for herbivore feeding behavior (Lemoine et al. *in review*). Specifically, rising temperatures might alter herbivore nutritional demands, the efficacy of plant chemical defenses, predation rates, and the intensity of competition among herbivore species. This research would help ecologists understand how climate change will alter important biological interactions among species based on changes in herbivore physiology.

Nathan P. Lemoine has already completed one field season of research on the effects of temperature on plant-herbivore interaction. This work has generated two submitted publications and at least one more manuscript in preparation for submission. However, these previous experiments have focused exclusively on single herbivore species. Such an approach, while valuable for understanding how climate change might affect plant-herbivore interactions, represents an overly simplified view of ecological communities. In natural communities, herbivores experience intense competition and predation pressure. Thus, the effects of temperature on plant-herbivore interactions might be dramatically different than would be predicted by examining the herbivore in isolation. **Funding from the DDIG would allow N.P. Lemoine to expand on previous work by constructing more ecologically realistic communities to assess how predatory and competitive interactions are altered by climate change.**

Deron E. Burkpile has conducted extensive research on the effects of global change on plant-herbivore interactions. However, most of his previous work has considered global change agents other than temperature (*e.g.* nutrient enrichment, fire regimes). Additionally, D.E. Burkepile has traditionally focused on vertebrate herbivores in a variety of ecosystems, with most work occurring on coral reefs in the Florida Keys National Marine Sanctuary. Thus, despite Dr. Burkepile's expertise on plant-herbivore interactions, the experiments described in this proposal represent a significant departure from previous and on-going research projects.

Currently, D.E. Burkepile is PI on a NSF grant to assess how herbivores and nutrient enrichment interactively affect microbial interactions between corals and macroalgae on coral reefs. D.E. Burkepile has also received an internal grant from FIU for a field experiment designed to assess how temperature and herbivory interactively affect secondary succession in temperate forests. Thus, no experiments described in this proposal fall under the scope of any existing or pending grant.