

# Office of Research Services Funding Application (Large Grant)

**DEADLINES: June 30, 2015 and December 31, 2015**

Please refer to

<http://www.ucdenver.edu/about/WhoWeAre/Chancellor/ViceChancellors/Research/OAVCRCA/Pages/Research%20Services.aspx> for other information.

**NOTE WELL: THIS APPLICATION MUST BE WRITTEN FOR AND ACCESSIBLE TO LAY REVIEWERS. (LINE SPACING NO LESS THAN 1.5, FONT SIZE NO LESS THAN 12, FONT MUST BE TIMES NEW ROMAN)  
PLEASE ATTACH A 2-PAGE CV.**

## Applicant Information

Name: Briles Christy Date: 6/29/2015  
*Last First*

Department: Geography and Environmental Science. Research conducted in the  
Paleoecology, Palynology and Climate Change Laboratory

Phone: 970-765-6931 Email christy.briles@ucdenver.edu

Title of Project: Understanding Drivers of Environmental Change in Tropical Ecosystems of Northern  
Vietnam

Amount of Request: \$24,930

## Required Match

*A 20% match is required.*

Please have the responsible party for the match send an email verification to [carie.carroll@ucdenver.edu](mailto:carie.carroll@ucdenver.edu).

## Project Abstract

*Provide a project abstract (one-third page)*

Coastal northern Vietnam has experienced several wars, at least 3000 years of agriculture, and long-term climate change. Consequently, the region is ideal for addressing questions about the influence of climate and human activity on tropical environmental change. A recent hypothesis that warfare had a greater impact on the Vietnamese landscape than agriculture or climate will be tested. The research involves collecting sediment cores from depositional environments and examining different proxies (e.g., pollen, charcoal, sediment properties and biomarkers) to reconstruct past vegetation, fire and human impacts. Current records only provide a local signal of environmental change and additional records will allow us to assess regional patterns of past burning and vegetation change. The funding would provide needed information on tropical ecosystems, support international research opportunities for students with UROPs, build on existing international collaborations, and enable development of a past environmental change training course for an existing Vietnam field school.

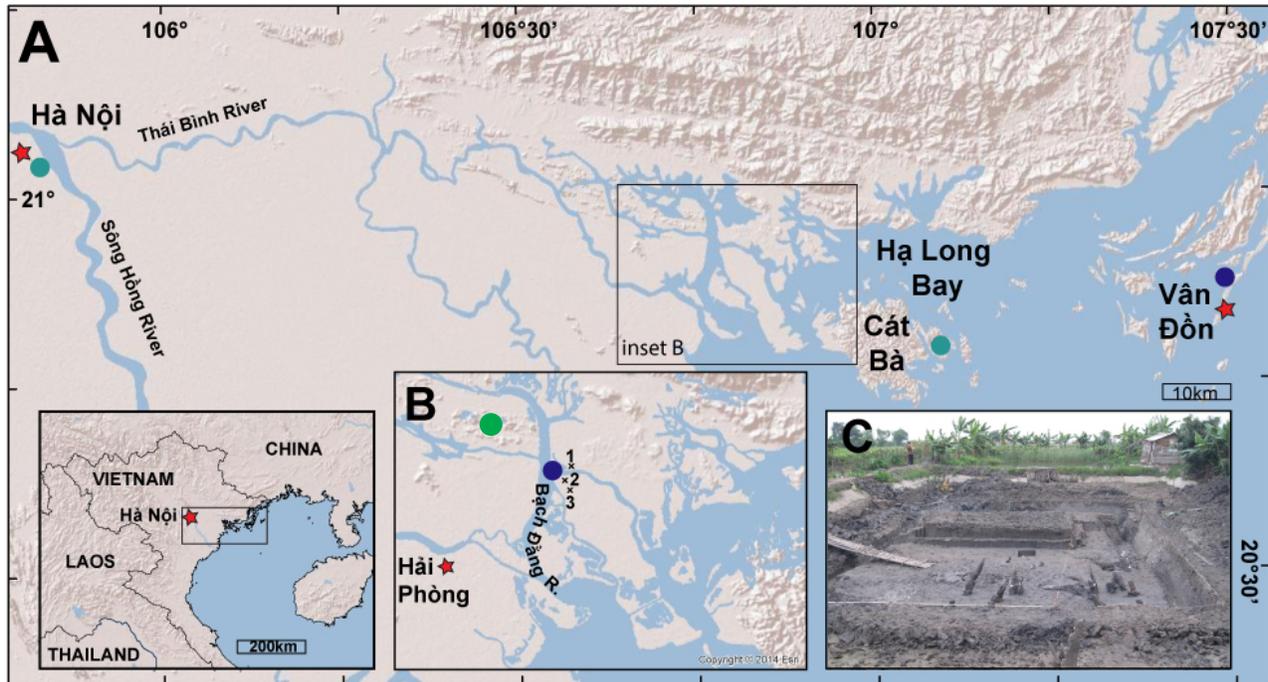
## Project Description

*Provide a project description indicating the significance of the creative activity (limited to three and a half pages)*

**Introduction/Background:** The long-term role of humans on the environment continues to be widely debated, with some arguing that humans have significantly altered the environment for the last 8000 years (1), while others suggest that climate was the dominant driver up until several hundred years ago (2-4). Northern Vietnam is an area where early agriculture developed. Archeological records suggest that rice cultivation and pond aquaculture expanded along the coasts and major waterways beginning 3000 years ago and expanded with technological improvement, population increases (5-8), and coastline stabilization (9). The region has also experienced significant fluctuations in precipitation due to changes in monsoon intensity (10) and El Niño South Oscillation variability (11). Neither ecosystem changes caused by land-use nor those from climate change are well documented for northern Vietnam. Therefore, we understand neither the extent of change nor what driver(s) had the most significant impact. We propose to build on two existing paleoecological records to examine the role of late Holocene (4000 years ago to the present) human land-use and climate variability on tropical ecosystem development (Figure 1). New sites will allow us to assess the spatial pattern and extent of environmental change.

Concurrent with the development of a rice-dominated agricultural system and changing climate was frequent warfare. The ecological impacts of war are no less important than those deriving from food production. Northern Vietnam has a long history of invasions from neighboring and foreign entities, making it an ideal location to explore the environmental impacts of war, an emerging area of study in physical geography (12). The period between 900 and 1300 CE had several notable battles (such as

the Battle of Bach Dang in 1288 CE) enabling us to examine the immediate effects of early and recent warfare on tropical ecosystems (Figure 1C). This particular period of battles defines Vietnamese national identity and will help address the contention by Li et al. (2009) that warfare, not agriculture, had the most significant influence on fire regimes in northern Vietnam.



**Figure 1.** A) Study area and coring sites in northern Vietnam. Blue symbols=current cores, green symbols=possible coring locations. B) Inset shows three battle-related stake yards dated to the Battle of Bach Dang in 1288 CE (C). Our mainland site in mangroves near stake yards in photo C.

**Research Plan:** We propose to use a network of 4000-year-old ecological records from lake and estuarine sediments to understand the relative role of human and natural factors influencing the northern Vietnam environment (Figure 1). Proxy indicators, such as pollen (indicating vegetation), charcoal (fire), biogeochemistry (human/animal biomarkers/population, fires, environmental productivity) and sediment properties (magnetics and particle size, indicating erosion and changes in deposition), will be examined from the sediments to reconstruct the paleoenvironment and human impacts. Radiocarbon dates from the sediment cores will be used to build a chronology. The project requires careful site selection of both human-impacted (farmed) and unmodified (unfarmed) locations to minimize or maximize specific effects related to wars, agriculture, and climate. We assert that northern Vietnam, a hotspot of biodiversity (containing 10% of the world's flora/fauna) and a location of long-term human occupation, provides an ideal setting to understand environmental drivers operating in Southeast Asia and to better understand tropical ecosystem dynamics. We propose two hypotheses: H1. *The effects of warfare on fire regimes and ecosystem changes are highly localized and subservient to the overriding effects of agriculture and climate.*

*Rationale:* Charcoal and pollen data from riverine sediments were used to suggest that warfare was a primary driver of fire regimes over the past 1500 years in northern Vietnam (6). The study did not use contiguous sampling for charcoal, which makes the results suspect. It also did not adequately address the geographic extent of the impacts of war or the climatic controls operating during periods of heightened warfare. Naval battles were common but isolated to the river ways and were technologically deficient in comparison to contemporary battles, and thus, should exhibit a relatively small geographic footprint. However, the authors (6) argue, there were likely secondary impacts (such as farmers neglecting agriculture to fight in the wars, damage to land, or damage to the economic structure making agriculture unviable) that affected agriculture and ecosystems. An abrupt disruption to the estuarine environment would have taken place near the battle site during each conflict, including burning of ships and vegetation, removal of large hardwoods for battle materials, increased soil erosion, and decreased ecosystem productivity. At locations further from the river, a prolonged decline in agricultural crops along with an increase in weedy species, and if fields were left fallow for a decade or more, a return of some shrub species may have occurred.

H2. *Agriculture and climate governed ecosystem changes for the last 2400 years, but prior to that climate was the primary driver.*

*Rationale:* Prior to 2400 years ago, humans were not concentrated in significant enough numbers and lacked the technology to have a lasting impact on the broader ecosystem (13). Although they could have had local environmental effects, climate variability (particularly monsoonal variability and drought) overrode the human impacts. Starting around 2400 years ago, a gradual increase in human population would have resulted in corresponding increases in agricultural crops, soil erosion and burning, and a decrease in ecosystem productivity and native tree species in habited locations. In unfarmed locations and on islands, vegetation, fire, and ecosystem productivity would correspond with regional climate variability.

**Separating drivers of environmental change in northern Vietnam:** Individual and composite records (see methods) will be examined along with independent records of climate and archeological information on occupation, wars, population levels and agricultural practices. Battles are instantaneous events that can have significant and long lasting environmental impacts, involving burning to remove vegetation, destruction of property, and sinking of ships. Ships would release fecal matter and other concentrated pollutants into the local area where the ship sank. Heavy concentrations of people and battle equipment in a localized area could result in further vegetation loss, soil erosion, and fecal matter inputs. To examine these human impacts in the sediment record, my collaborator at CSU-Long Beach is measuring coprostanol (sterol) biomarkers indicating fecal matter levels of humans and other organisms (e.g., pig, water buffalo, birds; each with distinct fecal biomarkers) and

relative population levels, hydrocarbons for additional evidence of burning, and carbon and nitrogen isotopes to determine ecosystem productivity. Additionally, a “warfare signature” in the sediment record will likely be represented by charcoal and magnetic susceptibility peaks, increased grain size and sediment flux, a sharp decrease in arboreal and >40µm grass (rice) pollen.

Agriculture has long lasting environmental impacts including removal of native vegetation, increased weedy species, and the planting of crops (primarily rice). An “agricultural signature” in the sediment record would consist of prolonged moderate-to-high charcoal concentrations (without charcoal peaks), initial peak in magnetic susceptibility at the start of agriculture, but then tapering off as soils stabilize (indicated by larger to smaller grain size and decreased sediment flux), high >40µm grass (rice) pollen, and high weedy pollen types, sustained elevated nitrogen levels, and sustained elevated levels of hydrocarbons. Agriculture includes animal husbandry, and thus, ruminant sterols would likely increase when animals are abundant.

Climate, like agriculture, has a long-term control on ecosystem processes, although abrupt events like drought can result in short-lived environmental changes. Climate varies due to incoming solar radiation, greenhouse gases, and internal feedbacks among the ocean/atmosphere/continental systems. We will identify changes in our records that can only be caused by climate/natural events when human biomarkers are low, suggesting less anthropogenic impact. In addition, island sites were selected where agriculture, settlement, and warfare were likely minimal to non-existent. Changes in vegetation, charcoal, and erosional records at these sites would follow general trends in climate including terrestrial records of precipitation variability (14) and proximal (i.e., South China Sea) marine records (15). The highest resolution estimates of climate change come from tree-rings in Vietnam (16), speleothems from southern China (10 & 17) and corals from the South China Sea (15).

**Research Impacts:** Determining the influence of human and natural drivers of tropical ecosystem change is a focus of national and international climate change research agendas. We will provide data on how human and climate factors interact and operate separately. The project will also contribute to Vietnamese national identity and history by providing evidence for ancient events (e.g., Battle of Bach Dang in 1288 CE). Two undergraduates who have been working on the project for over a year received UROPs to conduct field research in Vietnam in December 2015. We need additional funding and faculty support to build a network of additional records and develop a more robust historical timeline of northern Vietnamese events. Currently, my Australian and Japanese colleagues are running field schools in northern Vietnam and we would like to develop a paleoecological component into the school and involve CU Denver students, perhaps as a Maymester course. Finally, the results of the project have already been presented at a national conference by the undergraduates and we have plans to publish these findings in the fall. We would do the same for this proposed research.

## Methodology Description

*Provide a description of the methodology to be used in approaching the project (one-half page)*

Standard procedures for pollen, charcoal, and lithological analyses will be used. Similar data have been collected on a mainland core near Hai Phong and results are very promising and contradict the findings of Li et al. (2009). Our data suggest that periods of stability and agriculture correspond with greater charcoal levels than periods of instability and wars. Additionally, periods of low charcoal and instability correspond to periods of drought or shifts in the timing of monsoonal moisture and the ideal growing times for rice. Our historical timeline is largely based on western historical interpretations. One goal of our Vietnam fieldwork is to meet with historians and archeologists at the Institute of Archeology (IA) in Hanoi to expand and verify the timeline. We will also be taking additional cores (2-3) from both mainland and island locations to separate local from regional variability. Archeologists from Australia, the IA, and Dr. Peter Anthamatten (GES), with GIS expertise, will help determine the best coring locations. Human population change and impacts will be inferred from biomarkers and other isotopic signatures undertaken by my colleague Dr. Lora Stevens at CSULB. Preliminary data on Van Don Island closely tracks known population, which makes us confident we can reconstruct human population and impacts. To determine the regional signal of burning and vegetation change, composite records of individual proxies will be developed for all sites using R and statistical code and packages available through CRAN (e.g., paleofire package) (18).

## Additional Project Information

**(i) How does this project advance the applicant's career:** I am an early career researcher building a research theme around environmental change and human impacts in northern Vietnam. Involving students in both international field and laboratory research is one of my top priorities at CU Denver. The project will allow me to develop an international field course that involves other researchers and students from around the world. I have also built a network of international collaborators (Australia, Japan, Vietnam) that are working on different aspects of common themes (i.e. environmental change and cultural history of Vietnam) and the project will help me build and expand those collaborations.

**(ii) Provide future funding activities, agency, program name, program officer, and deadlines identified**  
The additional cores will allow us to submit a much stronger proposal to the NSF Geography and Spatial Science program September 3, 2016 (po: Sunil Narumalani). Our previous submission in 2014 did not have enough preliminary data and therefore was too ambitious in terms of scope and the funding request too large. It was recommended that for this type of project we need more than half the project completed before resubmission, which this funding will come close to fulfilling. We have plans to submit a proposal to National Geographic's Committee for Research and Exploration (seed grant) to fund the remainder.

**(iii) What specific outlets for the work accomplished in the project are likely (exhibits, journal articles)**  
The results of the project will be published in high-impact open access journals such as the *Proceedings of the National Academy of Sciences* or *PLOS ONE*. The research will also be presented at national and international conferences (e.g., Association of American Geographers and International Quaternary Association). Data will be made public on public research databases.

**(iv) What other support might arise upon successful completion of the project**

Currently unknown.

## Applicant's Pending and Current Funding

- (a) Pending proposals: (title, agency, amount, date submitted, when will decisions be made): NA  
(b) Current funding: (title, agency, amount, duration) : CU Denver faculty startup, \$10k until 2018

**References:** (1) Ruddiman, W.F., 2003. *Climatic Change* 61: 261-293; (2) Marlon, J.R., et al. 2013. *Quaternary Science Reviews* 65: 5-25; (3) Marlon, J.R., et al. 2008. *Nature Geoscience* 1: 697-702.; (4) Power, M.J., et al., 2012. *The Holocene* 23: 3-13.; (5) Huong, N.T.M. 2013. *Journal of Austronesian Studies* 4: 51-71.; (6) Li, Z., et al., 2009. *Proceedings of the National Academy of Sciences of the United States of America* 106: 11472-11477.; (7) Oscar, C., 1995. Praeger. p. 240.; (8) Maloney, B.K., 1994. In Hather, J.G *Tropical Archaeobotany: Applications and New Developments*. London, Routledge. p. 139-171.; (9) Tanabe, S., et al. 2003. *Quaternary Science Reviews* 22: 2345-2361.; (10) Wang, Y., et al. 2005. *Science* 308: 854-857.; (11) Buckley, B.M., et al. 2014. *Quaternary Science Reviews* 95: 1-19.; (12) Fransis, R.A., 2014. *Progress in Physical Geography* 38: 265-270.; (13) Taylor, K.W. 2013. *A History of the Vietnamese*. New York: Cambridge UP, 2013.; (14) Cook, E.R., et al., 2010. *Science* 328: 486-489.; (15) Deng, W., et al. 2014. *Paleoceanography* 29: 115-125.; (16) Sano, M., et al. 2009. *Climate Dynamics* 33: 331-340.; (17) Chu, P.C., et al. 2012. *Journal of Quaternary Science* 27: 901-910.; (18) Blarquez, O., et al. 2014. *Computers & Geosciences* 72: 255.

## Detailed Budget

Provide a detailed budget

### **Travel to and within Vietnam**

Two round trip airfares to Vietnam = \$2500

Per diem for 10 days for 4 people= \$150 per person per day= \$6000

Vietnamese interpreter at \$20/hour for 10 days and 10 hours/day = \$2000

Shipping of cores back to the US using a bonded carrier = \$500

### **Laboratory Analyses and Supplies**

20 radiocarbon dates at \$350 per date at LLNL = \$7000

Miscellaneous laboratory supplies (i.e. chemicals, storage bags, vials) = \$1500

### **Student Salary (2 undergraduates; Olga Serenchenko and Chris Andersen)**

28 weeks for 8 hours/week @ \$12/hour (+1% fringe) = \$5430

### **Total Request = \$24,930**

**Matching:** My department (Geography and Environmental Science) will be providing a course release for the 2015-2016 academic year (\$7200) and CLAS will cover two radiocarbon dates (\$700) and partial 2016 summer salary for a student (\$500).

## Detailed Budget Justification

Provide a short detailed budget justification

**Travel to and within Vietnam:** Two round trip airfares are requested for travel to Vietnam in early December 2015 for ten days for Drs. Briles and Anthamatten. In addition to GIS support for the project, Anthamatten will also help with logistics and coring while in Vietnam. Quote is from Denver to Hanoi on kayak.com for a US carrier. UROPs will cover expenses for two additional airfares for the undergraduates. Foreign maximum per diem rates are \$278/day; however, based on expenses incurred on previous trips we are budgeting \$150/day/person for four researchers. An interpreter from the IA will help organize the trip, negotiate and navigate travel through northern Vietnam, and translate. On the return trip, a package of cores will be sent Fedex to Denver from Hanoi (75 lbs at \$500 each).

**Laboratory Analyses and Supplies:** Expenses cover the cost of radiocarbon dating wood, charcoal, or other plant remains in sediment cores every 600-800 years to establish a well-dated chronology. Laboratory supplies include materials needed to process samples and the amounts are estimates based on previous analyses on similar Vietnam cores.

**Student Salary (2 undergraduates; Olga Serenchenko and Chris Andersen):** Undergraduate hourly salary is requested. Each will work with Briles to process, analyze and publish paleoecological data from Vietnam. The appointments will begin August 17, 2015 for the 2015-2016 academic year.

## Pledge to Report Signature

*I pledge to report to the Office of Research Services the projects outcomes at its conclusion and to update ORS on future developments related to the initial funding.*

Signature: \_\_\_\_\_

Date: 06/29/2015

## **Christy E. Briles**

Department of Geography and Environmental Science, University of Colorado-Denver  
1201 5th Street-NC 3014, Denver, CO 80204

Phone: (970)765-6931; email:christy.briles@ucdenver.edu

### **a. Professional Preparation**

Institution	Major	Degree	Year
University of Denver	Environmental Science	B.S.	1999
University of Oregon	Geography	M.S. & Ph.D.	2003, 2008
Montana State University	Earth Sciences	Post Doc	2008-2009
Texas A&M University	Anthropology	Post Doc	2009-2011

### **b. Appointments**

- 2013-present Assistant Professor, Department of Geography and Environmental Science, University of Colorado, Denver.
- 2011-2013 Lecturer, School of Geography and Environmental Science, Monash University, Melbourne, Australia.
- 2009-2011 Adjunct Faculty, Department of Anthropology, Texas A&M University, College Station.

### **c. Products**

- Serenchenko, O., Andersen, C. and **Briles, C.E.** 2015. Anthropogenic controls on late Holocene fire activity in northern Vietnam. Abstracts of the Association of American Geographers 111<sup>th</sup> Annual Meeting in Chicago, IL. Also presented at RaCAS 2015. (poster)
- Higuera, P.E., **Briles, C.E.**, and Whitlock, C. 2014. Fire-regime complacency and sensitivity to centennial- through millennial-scale climate change in Rocky Mountain subalpine forests, Colorado, U.S.A. *Journal of Ecology*. 102: 1429-1441.
- Dunnette, P.V., Higuera, P.E., McLauchlan, K.K., Derr, K.M., **Briles, C.E.**, and Keefe, M.H., 2014. Biogeochemical impacts of wildfires over four millennia in a Rocky Mountain subalpine watershed. *New Phytologist* 203: 900-912.
- Morey, A.E., Goldfinger, C., **Briles, C.E.**, Gavin, D., Colombaroli, D. and Kusler, J.E. 2013. Are great Cascadia earthquakes recorded in the sedimentary records from small forearc lakes? *Natural Hazards and Earth System Science* 13, 2441-2463.
- Briles, C.E.**, Whitlock, C., and Meltzer, D. 2012. Late-glacial-interglacial environments in the southern Rocky Mountains, USA and implications for Younger Dryas-age human occupation. *Quaternary Research* 77: 96-103.
- Marlon, J.R., Bartlein, P.J., Long, C., Gavin, D.G., Anderson, R.S., **Briles, C.E.**, Brown, K.J., Colombaroli, D., Hallett, D.J., Power, M.J., Scharf, E.A., Walsh, M.K. 2012. A long-term perspective on wildfires in the western U.S. *Proceedings of the National Academy of Sciences* 109: E535-E543.
- Briles, C.E.**, Whitlock, C., Skinner, C., and Mohr, J. 2011. Holocene forest development and maintenance on different substrates in the Klamath Mountains, northern California. *Ecology* 92: 590-601.
- Whitlock, C., **Briles, C.E.**, Fernandez, M.C., and Gage, J. 2011. Holocene vegetation, fire, and climate history of the Sawtooth Range, central Idaho, USA. *Quaternary Research* 75: 114-124.

- Whitlock, C., Higuera, P.E., McWethy, D., **Briles, C.E.** 2010. Paleoecological perspective on fire ecology: revisiting the fire-regime concept. *The Open Ecology Journal* 3: 6-23.
- Marlon, J.R., Bartlein, P.J., Walsh, M.K., Harrison, S.P., Brown, K.J., Edwards, M.E., Higuera, P.E., Power, M.J., Anderson, R.S., **Briles, C.E.**, Brunelle, A., Carcaillet, C., Daniels, M., Hu, F.S., Lavoie, M., Long, C., Minckley, T., Richard, P.J.H., Shafer, D.S., Tinner, W., Umbanhowar, C.H., Whitlock, C. 2009. Wildfire responses to abrupt climate change in North America. *Proceedings of the National Academy of Sciences* 106: 2519-2524.
- Briles, C.E.**, Whitlock, C, Bartlein, P.J and Higuera, P.E. 2008. Regional and local controls on postglacial vegetation and fire in the Siskiyou Mountains of northern California and southern Oregon. *Palaeogeography, Palaeoclimatology, Palaeoecology* 265: 159-169.
- Briles, C.E.**, Whitlock, C., and Bartlein, P.J. 2005. Postglacial vegetation, fire and climate history of the Siskiyou Mountains, Oregon, USA. *Quaternary Research* 64: 44-56.

#### **d. Grants**

##### ***External Grants and Contracts***

- 2010-'16** USDA Forest Service Cooperative Research Grant (Pacific Southwest Research Station). *Species responses to past climate change: A closer look at the histories of Douglas-fir and mountain hemlock in northern California* (PI-Cathy Whitlock; CO-PI Christy Briles and Carl Skinner); funding ends August 2016. **Amount:** \$144,000

##### ***Competitive Internal Grants and Contracts***

- 2014-'15** CU Denver, College of Liberal Arts & Sciences Research Innovation Seed Programs (CRISP). *Environmental impacts of 4000 years of war, agriculture, and climate change in northern Vietnam*. (PI Christy Briles). **Amount:** \$7000
- 2014-'15** CU Denver, College of Liberal Arts & Sciences Dissemination Grant. *Four thousand years of climate and human influences on northern Vietnam coastal ecosystems*. (PI Christy Briles). **Amount:** \$1000

##### ***Undergraduate Research Opportunity Program (UROP) Sponsorships***

- 2015-'16** *Exploring Vietnamese History Through a Charcoal Lens*  
**Role:** Faculty Sponsor of students Olga Serenchenko and Christopher Andersen.  
**Amount:** \$2400
- 2015-'16** *Product Labeling and Geographic Origins of Colorado Honeys*  
**Role:** Faculty Sponsor of student Ashley Bouck. **Amount:** \$1200

#### **e. Collaborators & Advising**

##### **1. Vietnam Collaborators**

Mark Staniforth (Monash University); Lora Stevens (California State University, Long Beach); Mai Hong (Institute of Archeology, Vietnam ); Jun Kimura (Tokai University); Le Lien Thi (Institute of Archeology, Vietnam); Vanessa Wong (Monash University); Paddy O'Toole (Monash University); Tom Guilderson (Lawrence Livermore National Laboratory); Tim Denham (Australian National University)

##### **2. Advising: CU Denver only**

###### **MS Environmental Science**

Alex Kaufman 2015-present (intake advisor); Zara Hickman 2014-present (thesis committee chair); Tera Del Priore 2013-2015 (thesis committee chair); James Sudderth 2013-2014 (thesis committee chair)

###### **Undergraduates**

Ashley Bouck 2013-present; Olga Serenchenko 2014-present; Chris Andersen 2015- present; Beth Machosky (2013-2014)