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UC DAVIS NATURAL RESERVE SYSTEM
THE BARN
ONE SHIELDS AVE
DAVIS, CA 95616

http://nrs.ucdavis.edu

NATURAL RESERVE SYSTEM

2015

GRADUATE STUDENT RESEARCH GRANTS

APPLICATION FORM (Due 5:00 pm, March 2, 2015)

INSTRUCTIONS: Applicants must provide all requested information within the spaces provided. Type font should be no smaller than 10-point. Applications not adhering to these guidelines may be rejected. **Applications should be submitted to the NRS Administrator, Cathy Chun (cjchun@ucdavis.edu)**. Awards will be announced by **March 31, 2015**.

APPLICANT(S) INFORMATION

Name: Marina LaForgia

Mailing address:
647 D Street
Davis, CA 95616
Campus academic department / graduate program: Plant Sciences Department / Graduate Group in Ecology

Daytime phone number: 805-279-8803

E-mail address: marina.laforgia@gmail.com

Advisor: Dr. Andrew Latimer **Advisor's E-mail address:** amlatimer@ucdavis.edu

Have you ever received a Mathias Grant ? ☐ **yes** ✓ **no (note: this is not a disqualifying question)**
If yes, for which reserve and for what dates?

RESEARCH DESCRIPTION (Be clear, concise and complete. Please explain and justify the research to the review panel.)

Title of research project: Seedbank-mediated coexistence under a changing climate
Natural Reserve(s) to be used: McLaughlin Natural Reserve
Site(s) where research will be conducted: McLaughlin Natural Reserve & UC Davis Greenhouses

Purpose of research project: The purpose of this research is to understand how annual grassland communities respond to interannual variability in precipitation as well as to predict how these communities will be affected under future climate scenarios.

How is the reserve important to the study?
The McLaughlin Natural Reserve is necessary for this study to take place as my current research takes place at this reserve and this study would tie directly in with this research.

RESEARCH DESCRIPTION (continued)

Research objectives. As appropriate for your discipline, provide complete information, including: hypotheses, experimental/project design, methods, anticipated analyses, assessments, or exhibitions, and anticipated significance (as applicable). Please indicate how the research has relevance to or relies on the Natural Reserve System. Limit description to the space provided on this page and the next.

Introduction: The storage effect is arguably the most important coexistence mechanism in environments with high temporal variability (1). Under the storage effect, species differ in their response to the environment and perform better in favorable years (2). These gains in fitness are then "stored" for bad years through mechanisms such as seedbanks or overlapping generations (2). The storage effect has been found to operate in a wide range of aquatic (2,3) and terrestrial (4-6) systems. In California grasslands for example, the storage effect is thought to mediate coexistence of exotic annual grasses and native annual forbs via differential seed dormancy (7). Exotic annual grasses, which are competitively dominant (8), exhibit low seed dormancy and germinate nearly all of their annually produced seed each fall (9). Native annual forbs have much higher seed dormancy, which allows them to avoid drought years as well as wet years in which competition from grasses is extremely high.

How climate change will affect storage-mediated coexistence remains unknown (5). Climates are projected to become more variable through higher frequencies of both intense rainfall and extreme droughts (10), while the mean tendency is toward a drier climate in the western United States (11). These climate trends and their effects on plant communities are already evident in California grasslands. At McLaughlin Natural Reserve, over the past 15 years, precipitation during the important winter growth period has decreased substantially, extreme climatic events have occurred (e.g. the 2013-2014 drought), and the aboveground diversity of grassland communities has declined significantly, with native forbs declining the most (12). A critical question is whether seedbank storage can continue to maintain species coexistence, so that aboveground diversity will recover in favorable years. Alternatively, either increased variability (longer unfavorable periods), or decreased mean favorability (drier years on average) may undermine the capacity of seedbanks to buffer against environmental variation. By studying demographic responses of grasses and forbs to interannual variation in rainfall, I will identify the importance of temporal variability and forecast the limits on the capacity of storage-mediated systems to maintain coexistence in a changing climate.

Hypothesis: (H1) Forbs will have highest germination and per capita growth rates from consecutive wet years in the absence of grasses, but when grown with grasses, they will have highest germination and per capita growth rates in wet years following dry years, confirming that temporal variability in rainfall promotes coexistence.

(H2) Although interannual rainfall variability allows these two groups to persist, model projections forecasting longer unfavorable periods will differentially affect native forbs causing them to go extinct before grasses due to their inability to replenish seedbanks in both dry years and years in which grass competition is high.

Methods: To test how variability in type of year (wet versus dry) affects grass/forb persistence, I will conduct a two-year manipulative field experiment with one abundant invasive annual grass and one native annual forb. I will use a split-plot factorial design with four watering treatments at the whole-plot level and three planting treatments at the sub-plot level. During the first year, each whole plot will replicate either a dry year (50% less than 10-year average, imposed with rain-out shelters) or a wet year (50% more than 10-year average, delivered via sprinklers). Then, in the second year, I will switch half of all the watering treatments, so that each block has a total four of watering treatments as defined by their "year sequence" of rainfall (dry-dry, dry-wet, wet-dry, and wet-wet). I will transplant greenhouse-germinated seedlings into the three subplots treatments (grass alone, forb alone, and mixture) in the fall of year one. I will also bury seed bags to record germination response to each treatment. At the end of year one, I will collect a subsample from each treatment on which to measure seed production and thus estimate per capita population growth rates. For the second year, plots will be seeded naturally through seed output planted the previous year. By not replanting in the second year, I will allow thatch to build up from grasses, an important factor in grassland temporal dynamics, and I can better estimate the effects of a previous year on each species' current

RESEARCH DESCRIPTION (continued)

year response. At the end of year two I will collect another subsample to estimate per capita population growth rates. In both years, plots will be weeded periodically for background species. With these data, I will use generalized linear models with species, year sequence, and the interaction of species and year sequence as predictor variables. If germination and per capita growth rate for the forb are highest in wet years following dry years in the presence of grasses **(H1)**, this would provide evidence that temporal variability maintains forb persistence with invasive grasses.

To forecast beyond the timeframe of the study, I will use germination and per capita growth rate data to parameterize a two-species competition model for annual plants, as developed in Levine and Rees (7). Using this model I will explore simulated climate scenarios in accordance with recent and forecasted climate trends to determine how changes in the relative frequency of favorable (wet) and unfavorable (dry) years affect competition, germination, and per capita growth rate parameters of forbs and grasses. If I find that longer unfavorable periods limit the ability of forbs to replenish their seedbank **(H2)** and lead to negative growth rates, this would provide evidence that seedbank storage is insufficient to buffer native annual forbs against future climate variability.

Reliance on Reserve & Anticipated Significance: My current project takes advantage of a set of 80 long-term (2000-2014) vegetation-monitoring plots (5-m^2) at McLaughlin Natural Reserve. This study is testing the seedbank's ability to buffer forb persistence in light of recent climate events by comparing seedbank abundances before and after the recent California drought. Through my collaborations with Dr. Susan Harrison, who established the plots, and McLaughlin reserve, I have 15 years of plant community cover data and pre-drought (summer 2012) seedbank composition data for these plots. Following the 2012 seedbank study's protocol, I collected soil from the 80 plots after two years of drought (summer 2014) and I am currently watering the samples in a greenhouse to induce germination. If the storage effect is still mediating coexistence between grasses and forbs, high dormancy forbs, which have declined in richness and cover in the past 15 years, will remain abundant in the seedbank. This would indicate that they are persisting during this long-term drying trend. If, however, the seedbank is depleted in most species, this would provide evidence that climate trends are weakening the seedbank's ability to buffer population declines. My proposed project will tie directly into this work by confirming that rainfall variability is necessary for coexistence and also by evaluating climate scenarios under which these species may persist or be lost from the system.

Time schedule.

	2015				2016				2017			
Task Quarter	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Field Experiment: Collect Seed		■	■									
Field Experiment: Set up sprinklers & shelters			■									
Field Experiment: Transplant seedlings				■								
Field Experiment: Sampling Year 1						■						
Field Experiment: Switch watering treatments							■					
Field Experiment: Sampling Year 2										■		
Field Experiment: Model simulation & analysis										■	■	■

BUDGET INFORMATION

List the items for which support is requested, their cost, and the total amount requested. Funding may be requested for: necessary supplies and minor equipment; reserve user fees; actual cost of travel to, from and at the reserve; special logistical costs; access costs to special analytical equipment, etc. Non-allowable categories include: travel to scholarly meetings; preparation of thesis copy; publication costs; purchase of classroom books; purchase of computers and printers; mileage and food.

Supplies and minor equipment (itemize)	Sprinkler devices, piping, rain-out shelters	$	1500
	Greenhouse space ($10 per sq ft/yr) – 100 sq ft for 1 year	$	1000
Fees charged by the reserve (itemize)	$6 per night/25 days per year/2 years	$	300
Travel	Gas to and from reserve (4 trips per year for 2 years) = 16 one-way trips	$	160
		$	
Other (see non-allowable categories above)		$	
	Total request ($3,000 maximum):	$	2960

List all sources of funding for this project, including grants pending or awarded to you or your supervising faculty member, and state how this grant will supplement these other sources.

- Jastro Shields 2014, $1200
- Oren Pollak 2015, pending
- Jastro Shields 2015, pending

If awarded this grant, then the entirety of my 2014 Jastro Shields Award will go towards purchasing of water for this project. If the other grants are secured, I plan on purchasing iButtons to monitor soil moisture to ensure adequate timing and application of water treatments.

Budget explanation (present a brief but convincing argument for any requested items whose justifications are not obvious).

Although this is a multi-year study, the majority of funds will be used in 2015 for greenhouse use, equipment, and visits to the reserve for seed collection and project set up (~$2600). The rest of the funds will be used to secure reserve visits for sampling and weeding throughout the remainder of the study.

PLEASE ATTACH

References cited
Letter from supervising faculty
Current curriculum vita (2 page maximum)
Final or progress report of previously-funded Mathias Graduate Student Research Grant, if applicable.

References Cited

1. Chesson, P., and N. Huntly. 1997. The roles of harsh and fluctuating conditions in the dynamics of ecological communities. American Naturalist 150:519-553.
2. Chesson, P. L., and R. R. Warner. 1981. Environmental variability promotes coexistence in lottery competitive systems. American Naturalist 117:923-943.
3. Caceres, C. E. 1997. Temporal variation, dormancy, and coexistence: A field test of the storage effect. Proceedings of the National Academy of Sciences of the United States of America 94:9171-9175.
4. Runkle, J. R. 1989. Synchrony of regeneration gaps and latitudinal differences in tree species diversity. Ecology (Washington D C) 70:546.
5. Adler, P. B., J. HilleRisLambers, P. C. Kyriakidis, Q. Guan, and J. M. Levine. 2006. Climate variability has a stabilizing effect on the coexistence of prairie grasses. Proceedings of the National Academy of Sciences of the United States of America 103:12793-12798.
6. Angert, A. L., T. E. Huxman, P. Chesson, and D. L. Venable. 2009. Functional tradeoffs determine species coexistence via the storage effect. Proceedings of the National Academy of Sciences of the United States of America 106:11641-11645.
7. Levine, J. M., and M. Rees. 2004. Effects of temporal variability on rare plant persistence in annual systems. American Naturalist 164:350-363.
8. Dyer, A. R., and K. J. Rice. 1999. Effects of competition on resource availability and growth of a California bunchgrass. Ecology 80:2697-2710.
9. Jain, S. K. 1982. Variation and adaptive role of seed dormancy in some annual grassland species. Botanical Gazette 143:101-106.
10. Karl, T. R., and K. E. Trenberth. 2003. Modern global climate change. Science (Washington D C) 302:1719-1723.
11. Knapp, A. K., C. Beier, D. D. Briske, A. T. Classen, Y. Luo, M. Reichstein, M. D. Smith, S. D. Smith, J. E. Bell, P. A. Fay, J. L. Heisler, S. W. Leavitt, R. Sherry, B. Smith, and E. Weng. 2008. Consequences of More Extreme Precipitation Regimes for Terrestrial Ecosystems. Bioscience 58:811-821.
12. Harrison, S., E. Gornish, and S. Copeland. 2015. Climate-Driven Loss of Native Grassland Diversity. Proceedings of the National Academy of Sciences of the United States of America (*in review*).

MARINA LAFORGIA

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EDUCATION

University of California, Davis, 09/2013 – present
PhD Student, Graduate Group in Ecology
Restoration Emphasis

University of California, San Diego (UCSD), 09/2006 – 12/2010
B.A., International Studies-Economics
Graduated summa cum laude, 12/2010
Education Abroad Program: University of Bologna, Italy: 09/2008 – 06/2009

PUBLICATIONS

Cook-Patton, S., **M. LaForgia** & J. D. Parker. 2014. Positive feedback between enemies and plant diversity shape forest regeneration. *Proceedings of the Royal Society B: Biological Sciences* 281:20140261.

Yepsen, M., A. Baldwin, D. Whigham, E. McFarland, **M. LaForgia**, M. Lang M. 2014. Agricultural wetland restorations achieve diverse native wetland plant communities but differ from natural wetlands. *Agriculture, Ecosystems & Environment* 197:11-20.

Goodale, U. M., E. E. Cleland, J. Funk, & **M. LaForgia**. Photosynthetic physiology responds more strongly to soil moisture than nitrogen in eight Southern California Shrubs. In prep.

AWARDS AND DISTINCTIONS

- NSF Graduate Research Fellowship Honorable Mention, 2014
- Henry A. Jastro Research Fellowship, UC Davis, 2014
- Department of Plant Sciences Graduate Fellowship, UC Davis, 2013
- Graduate Group in Ecology Fellowship, UC Davis, 2013
- Best Poster, Ecology, Behavior, & Evolution Section, Undergraduate Research Symposium, UCSD, 2010
- Thurgood Marshall College Distinguished Senior Service Award, UCSD, 2010
- Provosts Honors, UCSD, Fall 2010 – Spring 2008, Fall 2009 – Winter 2010

SCIENTIFIC PRESENTATIONS & POSTERS

- LaForgia, Shue, Parker. 2012. Tree Seedling Diversity Affects Survival and Resistance to Enemies. Poster presentation. Mid-Atlantic Ecological Society of America Conference.
- LaForgia. 2011. Diversity in Tree Seedlings Affects Resistance to Enemies. Presentation. Smithsonian Environmental Research Center Intern Seminar.
- LaForgia, Lane, Goodale and Cleland. 2010. Variation in Water Use Efficiency and Soil Moisture Conditions of Eight Coastal Sage Scrub and Chaparral Species in Relation to Water and Nitrogen Treatments. Poster presentation. Undergraduate Research Symposium, UCSD.

RESEARCH & TEACHING EXPERIENCE

Graduate Student Researcher, University of California Davis
09/2013 – ongoing

Conduct greenhouse experiment to investigate decline of native forb diversity in California grasslands by studying seedbank composition.

Train undergraduate interns in science as they assist with greenhouse experiment to prepare soils and monitor seedling emergence.

Lead Research Technician for Dr. Peter Adler, Utah State University
05/2012 – 07/2013

Used demographic models to investigate the role of species interactions in determining mechanisms of coexistence in grass and shrub systems.

Investigated the comparative effects of organic sheep manure and chemical fertilizers on plant biomass and native vs. exotic growth through statistical analysis in R.

Acted as lead project manager on a study investigating species ecohydrological niches to uncover a mechanistic approach for predicting plant community response to climate change.

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Research Intern, Terrestrial Ecology Lab, Dr. John Parker, Smithsonian Environmental Research Center (SERC)
06/2011 – 04/2012
Studied the effects of diversity on ecosystem function by comparing tree seedlings grown in polycultures to those grown in monocultures to understand how diversity affects resistance to insects, deer, and pathogens.

Research Intern, Plant Ecology Lab, Dr. Dennis Whigham, SERC
09/2011 – 12/2011
Sampled herbaceous and woody biomass in 47 converted, restored, and natural wetland sites to assess the effectiveness of restoration efforts by comparing plant cover and nutrients across sites.

Undergraduate Researcher, Ecology and Environmental Change Lab, Dr. Elsa Cleland, UCSD
01/2010 – 12/2010
Conducted a manipulative greenhouse experiment to study effects of climate change on coastal sage scrub and chaparral plant species by altering precipitation and nitrogen in 500 individuals from 8 species and assessed fitness through photosynthesis, water use efficiency, and biomass data.

Undergraduate Teaching Assistant, BIEB 174: Ecosystems and Global Change, UCSD
09/2010 – 12/2010
Used understanding of ecology to teach students in weekly discussion sections and office hours

PROFESSIONAL EXPERIENCE & CO-CURRICULAR ACTIVITIES

Northern California Student Liaison, California Invasive Plant Council
09/2014 – ongoing
Foster student involvement in CAL-IPC activities including conferences, meetings, and seminars across California university campuses and participate in biannual board meetings to set goals for organization.

Student and Landowner Education and Watershed Stewardship Mentor, Center for Land-Based Learning, Davis, CA
09/2013 – ongoing
Lead groups of high school students in year-long projects to restore local natural areas.

Kids into Discovering Science Mentor, Davis, CA
09/2014 – ongoing
Mentor fifth graders from low-income schools through in-class lessons and hands-on projects to build their knowledge and interest in science and the environment.

Events Intern, Institute for International, Comparative, and Area Studies, UCSD
09/2009 – 12/2010
Organized, set-up, and monitored academic lecture events

Intern, Verno Systems Incorporated, Seattle, WA
06/2010 – 08/2010
Researched and compiled report addressing use of Camelina sativa *and* Jatropha curcas *as a biofuel feedstock and presented report on the importance of water use efficiency in crop science to company and investors*

Chair, Leadership Committee for Cultural Celebration, UCSD
09/2009 – 06/2010
Led weekly meetings to organize the 32nd annual festival celebrating diversity.