Dr. Mike Aspinwall, Assistant Professor, Department of Biology, University of North Florida

Title: Does range size predict tree species vulnerability to climate warming and heatwaves?

Project overview. Predicting climate change impacts on biodiversity is amongst the most pressing challenges in science. This project will test hypothesized relationships between tree species range size and vulnerability to climate warming and heatwaves.

Project description. Increasing mean temperatures and more frequent and intense heatwaves (several consecutive hot days, usually 5 °C higher than the norm) are hallmarks of climate change[1]. By the end of the century, mean temperatures could rise 2 to 6 °C and the frequency of heatwaves could double[1]. Importantly, the impacts of climate warming and heatwaves on biodiversity remain uncertain. Some organisms might 'acclimate' to modest warming[2], with little change in growth or fitness. Short-term heat events might push organisms beyond their physiological limits[3], leading to reduced growth and fitness. Yet, acclimation to warmer temperatures might make some organisms more resistant or resilient to heatwave impacts.

Predictions of climate change impacts on biodiversity are often based on the assumption that species range size (i.e. geographic distribution) scales positively with species environmental tolerance[4,5]. As a result, species with small range sizes are predicted to be most vulnerable to climate change[6,7]. Yet, empirical tests of the relationship between species range size and vulnerability to climate change are rare.

This project will examine climate warming and heatwave impacts on small and large range size tree species. **I will test the following hypotheses:** 1) trees grown under continuous warming will maintain higher carbon uptake and productivity than trees exposed to repeated heatwaves (and no warming), 2) trees grown under warming will cope better with heatwaves than trees grown without warming, and 3) small range size species will show greater vulnerability (lower carbon uptake and growth) to warming and heatwaves than large range size species. The project will utilize seedlings of ten oak (*Quercus*) species, five with large range sizes and five with comparatively small range sizes. Oaks are the most diverse tree genus in North America, and by focusing on one genus I account for effects of non-relatedness. Trees will be grown outdoors for 7-8 months (March – September) in irrigated 5-liter pots under one of four treatments: Control, Warmed, Heatwave, Warmed + Heatwave. 'Control' trees will be grown in the open under ambient temperatures. 'Warmed' trees will be grown under continuous warming (2 – 3 °C above ambient) inside passive air-warming chambers. The chambers are 1.5m x 1.5m x 1.5m in dimension, framed with PVC, wrapped in greenhouse film, and are open on top. The chambers 'trap' radiation causing the chamber air to warm without overheating. My lab has already constructed, tested, and deployed these chambers in another experiment on campus (Fig. 1). 'Heatwave' trees will be grown under ambient temperatures but will be subjected to a week-long heatwave once a month for the duration of the experiment. Heatwaves will be applied using the same chamber design but with a partially closed roof that traps more heat and increases daytime air temperatures 8 – 10 °C above ambient. 'Warmed + Heatwave' trees will be grown under continuous warming (+2 – 3 °C) and will be subjected to the same heatwaves applied to the 'Heatwave' trees. The experiment will be replicated six times (10 species × 4 treatments × 6 replicates = 240 seedlings). Experimental conditions will be monitored hourly using air temperature and relatively humidity sensors (iButton). Tree growth, carbon uptake (photosynthesis), water use (transpiration), and carbon use (respiration) will be measured throughout the experiment. Final biomass will be measured at harvest. This experimental design/approach will allow us to determine whether trees respond differently to continuous warming compared to heatwaves, whether warm-acclimated trees are more resistant to heatwave impacts than trees that are not warm-acclimated, and whether small range size species are more vulnerable to warming and heatwaves than large range size species.

Fig 1. 'Passive' warming chambers in the Sawmill Slough Preserve on the UNF campus.

Project impact. This project will inform models that predict climate change impacts on biodiversity by testing the assumption that species range size scales with vulnerability to climate change. This work will also provide science-based information for guiding management aimed at conserving biodiversity. Thus, this relatively simple experiment has the potential for global impact, while benefiting the UNF community, students, and my scholarly agenda (see below).

Involvement of UNF students. This project will engage undergraduates interested in plant biology, conservation, and botany; fields that desperately need enthusiastic young scientists to address global challenges. I aim to recruit and pay two part-time students to assist with all aspects of the project (with my mentorship): experimental design/construction, data collection and management, and data analysis. Students will also receive training in field and laboratory techniques for examining plant stress physiology. Their contributions will result in co-authorship of journal articles, and students will be given the opportunity to present at undergraduate research conferences or a national conference (Ecological Society of America).

Ongoing scholarly agenda. My research program seeks to improve our understanding of relationships between plant species biogeography, environmental adaptation, and responses to environmental change. This project will directly address the goals of my program. Results will form the basis of one or more manuscripts submitted for publication in top journals in my field. Results will also provide preliminary data for submitting external grants to the National Science Foundation, USDA, or Department of Energy.

Award History. I have not received funding from the Dean's Leadership Council.

Project budget

Itemized budget	**Proposed budget**
Student support (2 part-time students)	$1600
Consumables for photosynthesis and respiration measurements	$200
Oak seedlings	$400
Potting soil	$300
Chamber supplies and sensors	$1500
Total budget requested	**$4000**

Most essential equipment has already been purchased. This includes a LiCor LI-6400XT portable photosynthesis system, portable leaf area meter, soil moisture sensor, and several hundred tree pots.

References

[1]IPCC (2013) *Long-term climate change: projections, commitments, and irreversibility. In: Climate change 2013: the physical science basis. Contribution of working group I to the fifth assessment report of the intergovernmental panel on climate change*. Cambridge, UK & New York, NY, USA: Cambridge University Press, Chapter 12, 1029–1136.

[2]Aspinwall *et al.* (2016). Convergent acclimation of leaf photosynthesis and respiration to prevailing ambient temperatures under current and warmer climates in *Eucalyptus tereticornis*. *New Phytologist*, 212, 354–367.

[3]Aspinwall *et al.* (2019). Range size and growth temperature influence *Eucalyptus* species responses to an experimental heatwave. *Global Change Biology* 25, 1665-1684.

[4]Leimu R, *et al.* (2006) How general are positive relationships between plant population size, fitness and genetic variation? *Journal of Ecology*, 94, 942-952.

[5]Morin X, Thuiller W (2009) Comparing niche- and process-based models to reduce prediction uncertainty in species range shifts under climate change. *Ecology*, 90, 1301-1313.

[6]Pacifici M, *et al.* (2015) Assessing species vulnerability to climate change. *Nature Climate Change*, 5, 215-225.

[7]González-Orozco CE, *et al.* (2016) Phylogenetic approaches reveal biodiversity threats under climate change. *Nature Climate Change*, 6, 1110–1114

Curriculum vitae: Michael J. Aspinwall

Education

- (2004) BS, Horticulture, The Ohio State University, Columbus, OH
- (2007) MS, Forestry, North Carolina State University, Raleigh, NC
- (2010) PhD, Forestry, North Carolina State University, Raleigh, NC

Appointments and professional experience

- (2017-present) Assistant Professor, Department of Biology, College of Arts and Sciences, University of North Florida.
- (2012-2017) Research Fellow, Hawkesbury Institute for the Environment, Western Sydney University, Australia
- (2010-2012) Postdoctoral Research Scientist, Biology, University of Texas at Austin, Austin, TX

Grants

- 'How do temperature adaptation and acclimation regulate photosynthetic and respiratory temperature responses in switchgrass?' United Stated Department of Agriculture – National Institute of Food and Agriculture (NIFA), Agriculture and Food Research Initiative (AFRI). Principle Investigator: Michael Aspinwall. Total $462,500. Project Active (2019-2022).
- UNF Faculty Enhancement Plan (2019). Course Release.
- UNF Faculty Development Scholarship Grant (2018). $7,500.
- UNF Environmental Center Grant (2018). $6000.
- 'An assessment of root to shoot balance in tree stock for landscape planting in Australia.' Horticulture Innovation Australia. CI's: Mark Tjoelker, Michael Aspinwall, Remko Duursma, Sebastian Pfautsch, David Thompson. Funding received: $276,400. Project Active (2015-2017).

Representative publications (42 publications total, 832 citations)

- **Aspinwall MJ**, Pfautsch S, Tjoelker MG, Varhammar A, Possell M, Drake JE, Reich PB, Tissue DT, Atkin OK, Rymer PD, Dennison S, Van Sluyter SC. (2019). Range size and growth temperature influence *Eucalyptus* species responses to an experimental heatwave. *Global Change Biology* 25, 1665-1684.
- **Aspinwall MJ**, Blackman CJ, Resco de Dios V, Busch FA, Rymer PD, Loik ME, Drake JE, Pfautsch S, Smith RA, Tjoelker MG, Tissue DT. (2018). Photosynthesis and carbon allocation are both important predictors of genotype productivity responses to elevated CO_2 in *Eucalyptus camaldulensis*. *Tree Physiology*, 38, 1286-1301.
- Drake JE, Tjoelker MG, Varhammar A, Medlyn BE, Reich PB, Leigh A, Pfautsch S, Blackman CJ, Lopez R, **Aspinwall MJ**, Crous KY, Duursma RA, Kumarathunge D, De Kauwe MG, Jiang M, Nicotra AB, Tissue DT, Choat B, Atkin OK, Barton CVM (2018) Trees tolerate an extreme heatwave via sustained transpirational cooling and increased leaf thermotolerance. *Global Change Biology*, 24, 2390-2402.

- **Aspinwall MJ**, Jacob VK, Blackman CJ, Smith RA, Tjoelker MG, Tissue DT (2017) The temperature response of leaf dark respiration in 15 provenances of *Eucalyptus grandis* grown in ambient and elevated CO_2. *Functional Plant Biology*, 44, 1075-1086.
- Blackman CJ, **Aspinwall MJ,** Tissue DT, Rymer PD (2017) Genetic adaptation and phenotypic plasticity contribute to greater leaf hydraulic tolerance in response to drought in warmer climates. *Tree Physiology*, 37, 583-592.
- **Aspinwall MJ**, Varhammar A, Blackman CJ, Tjoelker MG, Ahrens C, Byrne M, Tissue DT, Rymer PD (2017) Adaptation and acclimation both influence photosynthetic and respiratory temperature responses in *Corymbia calophylla*. *Tree Physiology*, 37, 1095-1112.
- **Aspinwall MJ**, Drake JE, Campany C, Varhammar A, Ghannoum O, Tissue DT, Reich PB, Tjoelker MG (2016) Convergent acclimation of leaf photosynthesis and respiration to prevailing ambient temperatures under current and warmer climates in *Eucalyptus tereticornis*. *New Phytologist*, 212, 354-367.
- **Aspinwall MJ**, Loik ME, Resco de Dios V, Tjoelker MG, Payton PR, Tissue DT (2015) Utilizing intraspecific variation in phenotypic plasticity to bolster agricultural and forest productivity under climate change**.** *Plant, Cell and Environment*, 38, 1752-1764.
- Drake JE, **Aspinwall MJ**, Pfautsch S, Rymer PD, Reich PB, Smith RA, Crous KY, Tissue DT, Ghannoum O, Tjoelker MG (2015) The capacity to cope with climate warming declines from temperate to tropics within two widely distributed Eucalypts: a climate shift experiment. *Global Change Biology*, 21, 459-472.
- **Aspinwall MJ,** Lowry DB, Taylor SH, Juenger TE, Hawkes CV, Johnson MVV, Kiniry JR, Fay PA (2013) Genotypic variation in traits linked to climate and aboveground productivity in a widespread C_4 grass: evidence for a functional trait syndrome. *New Phytologist*, 199, 966-980.
- **Aspinwall MJ,** King JS, McKeand SE, Bullock BP (2011) Genetic effects on stand-level uniformity, and above- and belowground biomass production in juvenile loblolly pine. *Forest Ecology and Management*, 262, 609-619.
- **Aspinwall MJ,** King JS, McKeand SE, Domec JC (2011) Leaf-level gas-exchange uniformity and photosynthetic capacity among loblolly pine (*Pinus taeda* L.) genotypes of contrasting inherent genetic variation. *Tree Physiology*, 31, 78-91.

Synergistic activities

- Associate Editor for *Frontiers in Forests and Global Change*, Forest Ecophysiology Section
- Member of the Ecological Society of America – Physiological Ecology Section
- Reviewer for several journals including: *Nature Climate Change, Proceedings of the National Academy of Sciences, Global Change Biology, New Phytologist*

Mentorship (since joining UNF in 2017)

Postdoctoral scientists: Dr. Jeff Chieppa (2019-current), Graduate/honors students: Matt Sturchio, MS (2019-current), Susannah Dorrance, MS (2019-current), Undergraduate students: Lynsae Davidson (2018-2019), Amy Neece (2018-current), Alexis Rogers (2018), Kylie Harris (2018-current), Morgan Golden-Ebanks (2019-current), Madison O'Toole (2018-current), Vrinda Jerome (2019-current)