**ESRM499 Independent study**

**Plant Ecophysiology and Modeling Lab, School of Environmental and Forest Sciences**
Plant Ecophysiology and Modeling Lab (PEML) located at the Center for Urban Horticulture has undergraduate research opportunities for autumn quarter 2023 and is looking for motivated undergraduate students in ESRM and other related majors to participate in by taking ESRM 499 credits with Professor Soo-Hyung Kim. The PEML is a community of learners who are interested in studying the interactions between plants and the environment through physiological investigations and computer modeling.
Shown below includes the description of three research opportunities that are currently available. If interested in registering or have questions, please send email to both Arthur Hsin-Wu Hsu, PhD candidate (hwhsu@uw.edu), Miro Stuke, MS student (stuke@uw.edu) and/or Matt Hendrickson, MS student (matth16@uw.edu) to get the registration code by **December 16, 2022**.

1. **Pollen viability tests for studying temperature-induced reproductive failures in conifer species in the Pacific Northwest.**

   Research overview:
   Many plant species are already shifting their geographic ranges in response to ongoing climate change. Species range shifts in response to temperature are conditioned by many factors. New approaches to modeling suggest that climate change impacts on tree reproduction could be a major limitation on temperate tree distribution. Moreover, some researchers indicate that all species distribution models have to integrate or improve species dispersal and migration processes to be able to provide accurate projections of future distributions. Nevertheless, temperature-induced reproductive failure is rarely considered in species distribution models because this species-specific information is hard to obtain, especially for trees with long life spans. A mature tree is big and needs decades to start reproducing future generations. It is hard to apply temperature treatments on large trees. This makes running a controlled temperature experiment on tree reproduction quite difficult. In our study, we utilized pollen viability tests as an alternative method to study temperature effects on reproductive success. Seed germination tests combined with seedling growth and survival will serve as a way to understand potential seedling regeneration rates under climate change. Our goals are 1) to establish temperature response curves of reproductive success and recruitment and 2) to develop species displacement models with considerations of reproduction, recruitment, mature age, and dispersal distance. We anticipate these results will provide the information needed for improving current conifer species distribution models based on reproductive biology and will help researchers, policymakers, and stakeholders to develop climate adaptation strategies.

   Research questions:
   1. Will temperature warming affect pollen germination percentage?
   2. Will temperature warming affect pollen tube growth?
   3. Are the pollen germination behaviors different among species or within species from different elevations?
   4. Will among-population variation improve the chance of species persistence under climate change?
   5. Any questions you want to ask based on our pollen data.

   Research activities and responsibilities:

1. Students will spend approximately three hours of work/study (in-person or remote) each week for each credit earned. You are also expected to register one (3 hours/week) to five (15 hours/week) credits, depending on your schedule. CR/NC
2. One hour pollen-counting training at the beginning of the quarter: Follow the protocol to count germinated pollen and measure the pollen tube length.
3. Weekly individual process report (via e-mail): Report on how many samples have been processed and how many hours you have spent.
4. Biweekly group discussion (1 hour) on your group's research question, hypothesis, and literature review.
5. Final group presentation (10-15 minutes) on your findings in the finals week (date TBD).
6. Submit a one-page individual written summary of work completed (deadline TBD).

**2. Assessing stomatal morphology on seven taxa of landscape plants to determine the effect of water status across the spatial and climatic gradient of the Western United States.**

Research overview:
Plants respond to environmental stresses in numerous ways including changes in morphology and physiology. One such relationship is a shift in stomatal density and size as a response to drought. In the Climate Ready Landscape Plants (CRLP) trial, we have subjected landscape plants to controlled irrigation treatments across six sites in the Western United States, ranging from Washington to Arizona. Here we will image and measure stomatal impressions collected from seven taxa studied in the CRLP trial to determine the effect of water deficit, taxa, and location on stomatal morphology. Stomatal imaging will be performed using a compound microscope equipped with a digital camera. Measurements will be conducted with both semi-automated and manual methods utilizing machine learning (ML) to identify and count stomata and ImageJ to measure stomata size.

Research Questions

1. How does stomatal morphology vary across taxa and spatial gradient? Are there significant differences in stomatal characteristics or in the plasticity of these traits?
2. Do water deficit irrigation treatments impact stomatal morphology? Is there an interactive effect with location or taxa?
3. Does plant breeding and selection for polyploidy impact stomatal characteristics?
4. Do observable morphological responses and the plasticity of stomatal traits indicate any advantages for drought resistance and resilience to climate change?

Research activities and responsibilities:

1. Students will spend approximately three hours of work/study (primarily in-person with remote options available) each week for each credit earned. You are also expected to register one (3 hours/week) to five (15 hours/week) credits, depending on your schedule. CR/NC
2. One hour microscopy training at the beginning of the quarter: Follow the protocol to collect and organize stomatal images.
3. Weekly individual process report (via e-mail): Report on how many samples have been processed and how many hours you have spent.
4. Biweekly group discussion (1 hour) on your group's research question, hypothesis, and literature review.
5. Final group presentation (10-15 minutes) on your findings in the finals week (date TBD).

6. Submit a one-page individual written summary of work completed (deadline TBD).

### 3. Examining the impact of Salicaceae Endophytes on the stomatal morphology of Poplar (Populus trichocarpa) in response to water stress

Research overview:
Microorganisms may symbiotically enhance plant resilience to environmental stress by altering their hosts' physiology at the leaf level. Bacterial and yeast endophytes, isolated from the Salicaceae family, can improve the intrinsic water use efficiency (iWUE) of cultivated poplar (Populus) under drought by lowering stomatal conductance (gs) while maintaining carbon assimilation (An). However, the underlying traits that produce a lower gs remains unknown and determining these characteristics may illuminate the way endophytes boost host resilience to water stress. In the EndoPopulus (Endophyte + Poplar) project, we subjected endophyte-inoculated Populus trichocarpa to a water deficit and will examine the response in stomatal density and morphology using microscopic imaging, machine learning, and ImageJ. Students will take pictures of leaf epidermal impressions with a brightfield microscope and measure the length of individual stoma with ImageJ. Machine Learning will semi-automate the process for students to count the number of stomata within several fields of view.

Research Questions
1. How does stomatal density and size change in response to both endophytic inoculation and drought stress in poplar?
2. How do changes in stomatal density, size, and distribution on the leaf correspond to a lower gs?
3. Will these findings lead to differences in theoretical maximum stomatal conductances (gsmax) between treatments?
4. Can stomatal density and size explain differences in dynamic changes in gs over short intervals of time?

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