Biology/Spring

Introduction

High elevation rock outcrops in the Southern Appalachian Mountains often contain rare species or communities, and disjunct plant populations reproductively isolated from neighboring populations (Wiser 1996). Plant habitat on high rock outcrops is characterized by shallow soil and frequent cloud immersion (Reinhardt and Smith 2008). Due to low water retention in the shallow patches of soil on rock outcrops, water is a likely limiting factor to plant growth. Cloud immersion may be an important phenomenon that reduces water stress in plants in these environments (Reinhardt and Smith 2008). However, under proposed climate change scenarios, the cloud ceiling is likely to rise, resulting in fewer cloud-immersed days (Richardson et al. 2003).

A recent study found that at least two hours of cloud immersion occurs on 61% of days at Mt. Mitchell NC, and that cloud immersion increased xylem water potential in two high elevation tree species, enabling high photosynthetic rates at a given light level while conserving water (Berry and Smith 2012). One important effect of cloud immersion on plants is that it decreases vapor pressure deficit (VPD), which is the difference between the concentration of water vapor inside the leaf and the concentration in the surrounding air. Decreased VPD, as in the presence of cloud immersion, reduces the rate of water loss from high to low concentration through the stomatal openings (Burgess 2004, Reinhardt 2008). Cloud immersion can encourage growth by decreasing water loss, but may also slow growth by decreasing light availability and, thus, photosynthetic carbon gain (Reinhardt 2009). Therefore, the optimal conditions for a plant may vary according to water stress and photosynthetic requirements.

During summer 2012, we monitored the leaf gas exchange characteristics of eight plant species on two rock outcrops to variance over a range of conditions (sunny, cloudy and cloud immersed). We collected seeds for three species, *Phlox subulata*, *Saxifraga michauxii*, and *Viola hirsutula*, that differed in their response to VPD. These seeds are currently being cold stratified for germination in the spring. For all three species, stomatal conductance decreased with increasing VPD, in attempt to limit water loss. However, transpiration of *V. hirsutula* increased significantly ($p = 0.002$) with increasing VPD, while that of *P. subulata* showed a marginally significant ($p = 0.082$) and that of *S.michauxii* showed no significant increase ($p = 0.252$). These differences resulted in a significant decrease in water-use efficiency (a ratio of carbon gained per unit of water lost) in *V. hirsulata*, which could represent a greater susceptibility to water stress in this species, and, thus, a greater reliance on cloud immersion-mediated changes in VPD. In our field study, we were unable to fully test the effects of cloud immersion on plant physiological performance due to the isolated locations of the outcrops and sampling limitations. The proposed study would build on the preliminary data collected in summer 2012 in a controlled study of the effects of cloud immersion on water status, leaf gas exchange and growth in these species.

The reproductive isolation and specific habitat requirements of many rock outcrop species decrease the plants’ ability to adapt to changes in climate conditions, such as the increase in temperature and possible decrease in cloud immersion (Johnson 2008) caused by climate change. This study would test the response of outcrop plants to proposed climate change, and help to predict the viability of outcrop populations.

Methods

Three microcosms will be installed in the greenhouse at UNCA. Each microcosm will be enclosed in clear polyethylene plastic to isolate each microcosm from the others. Each will receive the same lighting from above (both ambient and supplemented with metal halide lamps). Seedlings of each species will be planted in pots containing rocks and shallow soil to simulate the soil environment observed on the outcrops. Individuals of each species will be randomly assigned to one of the three microcosms. The microcosms will then be randomly assigned to one of three cloud immersion treatments: *current cloud immersion* which will provide the same duration of cloud immersion observed in the field, *reduced cloud immersion* which will provide half the duration of cloud immersion observed in the field, and *no cloud immersion* which will not have any cloud immersion. Cloud immersion will be provided with the use of ultrasonic mist makers on timers. The control treatment will receive no immersion. At least three individuals of each of three species, *Viola hirsutula*, *Saxifraga michauxii*, and *Phlox subulata*, will be subjected to each treatment. Temperature, light and humidity will be monitored in each microcosm with sensors attached to Hobo dataloggers. We will measure leaf gas exchange and plant water potential at intervals during the three month duration of the study. At the end of the experiment, plants will be harvested, dried and weighed for biomass. Data will be analyzed with an analysis of variance with species and treatment as factors.

Timetable

Fall 2012: Seeds have been collected and are currently being cold stratified

Early Spring 2013:

1. Seeds will be germinated and microcosms will be constructed.
2. Proper use of mistmakers will be determined to get the desired duration of cloud immersion in each treatment
3. Seedlings will be randomly assigned to treatments

Spring 2013: Plants will be allowed to grow for 3 months in the microcosms with periodic measurements of leaf gas exchange, water status, and growth (height, # leaves, etc.)

Late Spring/Early Summer:

1. Plants will be harvested and final growth and biomass measurements will be taken.
2. Data will be analyzed and manuscript and presentations will be prepared

Budget

1. Two M-005 Ultrasonic Mist Makers ($97.50 each)	$195.00

2. Two Hudson self-contained float valves ($35 each)		$70.00
3. PVC and plastic sheeting		$75.00
4. Metal halide lamp w/ballast		$125.00
5. Soil and gravel		$35.00
	Total	**$500.00**

Funds are requested for two ultrasonic mist makers, one for each of the simulated cloud immersion treatments. These will be connected to a large water reservoir with two self-contained float valves to regulate water flow to the mist maker. Funds are also requested for the basic hardware (pvc and plastic sheeting) to construct the microcosms, as well as gravel and soil in which to plant the seedlings. Finally, funds are requested for a 400 W metal halide lamp to supplement the lighting already available in the greenhouse.

Sources of additional funding

No other sources of funding are being sought for this project, however, the results of this study will be used in future submissions by Dr. Horton to funding agencies, such as, the National Science Foundation.

Literature Cited

Berry ZC, Smith WK. 2012. Cloud pattern and water relations in *Picea rubens* and *Abies fraseri*, Southern Appalachian Mountains, USA. Agricultural and Forest Metorology 162-163: 27-34.

Burgess SSO, Dawson TE. 2004. The contribution of fog to the water relations of *Sequoia sempervirens* (D. Don): foliar uptake and prevention of dehydration. Plant, Cell, and Environment. 27:1023-1034.

Godt MJW, Johnson BR, Hamrick JL. 1996. Genetic diversity and population size in four rare southern Appalachian plant species. Conservation Biology. 10(3): 796-805.

Johnson DM, Smith WK. 2008. Cloud immersion alters microclimate, photosynthesis and water relations in *Rhododendron catawbiense* and *Abies fraseri* seedlings in the southern Appalachian Mountains, USA. Tree Physiology. 28: 385-392.

Reinhardt K. 2009. Clouds and cloud immersion alter photosynthetic light quality and leaf reflectance in a temperate mountain cloud forest [dissertation]. Winston Salem, North Carolina: Wake Forest University.

Reinhardt K, Smith WK. 2008. Impacts of cloud immersion on microclimate, photosynthesis and water relations of *Abies fraseri* in a temperate mountain cloud forest. Oecologia. 158(2): 229-238.

Richardson AD, Denny EG, Siccama TG and Lee X. 2003. Evidence for a rising cloud ceiling in eastern North America. Journal of Climate Science 16:2093-2098

Wiser SK, Peet RK, White PS. 1996. High-elevation rock outcrop vegetation of the Southern Appalachian Mountains. Journal of Vegetation Science. 7: 703-722.

Publication Outlet

Research will be presented at the UNC Asheville Undergraduate Research Symposium and a research paper will be submitted to the UNC Asheville Journal of Undergraduate Research. Research will also be submitted to the Big South Undergraduate Research Symposium and to the Meeting of the Association of Southeastern Biologists.