The University of Illinois at Urbana-Champaign has given me many opportunities to develop as a scientist throughout my educational career, preparing me for graduate school. I actively explored research opportunities beginning as a freshman, ranging from a field-based collection survey of microlepidoptera in Illinois hill prairies to an independent research project examining task preferences of fungal growing ant colonies of the genus *Atta.* However, the bulk of my growth and development as a scientist has stemmed from my passion in plant environment interactions because of its merits in both basic and applied research.

During my third year of undergraduate, I carried out a physiological ecology study at the SoyFACE global change biology site in Urbana, Illinois under Dr. Donald Ort. I secured funding through the USDA STEPS program for undergraduates. SoyFACE simulates the atmospheric carbon dioxide concentrations [CO_2] projected for 2050. Elevated [CO_2] consistently reduces stomatal conductance across C_3 and C_4 species, driving a substantial reduction in transpiration[2]. I predicted that this reduction in transpiration would conserve soil moisture, thereby improving plant water status in both C_3 (soybean) and C_4 (maize) species. To test this assumption, I measured soil moisture content and leaf water status in ambient and elevated [CO_2] plots (N=4) of both soybean and maize. Soil moisture content was measured in 10-cm increments from 5-105 cm depths every 3-5 days from plant emergence until senescence. Leaf water potential, osmotic potential and turgor pressure were measured using portable thermocouple psychrometers during six key developmental stages of both species. This allowed me to construct a soil moisture record of over 30,000 data points, coupled with leaf water status that varied between treatments and over the development of both species. I was able to determine that in years when rainfall is frequent, elevated [CO_2] will not necessarily improve soil moisture content. This is very important because many climate change models assume that soil moisture always improves under elevated [CO_2]. Additionally, I found evidence of a novel mechanism operating in the C_3 species soybean which increased the amount of water within the leaf tissue of plants grown under elevated [CO_2]. Photosynthesis was stimulated by elevated [CO_2], resulting in greater contents of soluble sugars and amino acids in leaf tissue. This in turn made leaf osmotic potential more negative and caused water to be drawn into the cells by osmosis, making them more turgid. This mechanism may offer additional benefits to C_3 species by allowing them to avoid drought more efficiently under the climatic conditions of 2050. I am currently co-authoring a manuscript on this study. For this project I was awarded Distinction from the School of Integrative Biology and runner-up in the Proctor and Gamble Student Research Competition 2007. This finding is the basis for my current research proposal.

During my first year of graduate school, I co-authored a publication on how integrative genomic ecology can be used by climate change scientists and I have taken this framework and applied it to my own work. In the summer of 2008, I led an integrative genomic ecology project on the effects of elevated [CO_2] on field grown maize under two different nitrogen treatments. A previous study (Leakey *et al*. 2006)[10] showed that elevated [CO_2] does not directly stimulate photosynthesis or growth in C_4 maize with adequate soil moisture; however, this study was conducted under ample nitrogen availability. I hypothesized that elevated [CO_2] would provide a benefit to maize photosynthesis and carbon gain compared to ambient [CO_2] if these plants were grown under low nitrogen availability. Furthermore, this difference would be most pronounced during reproductive growth, when the demand for nitrogen is the highest. In order to answer these questions I organized 12 people to measure *in-situ* diurnal courses of photosynthetic gas exchange and to collect leaf tissue for physiological, biochemical and transcript profiling analysis on four dates corresponding to four key developmental stages. I measured photosynthetic capacity on leaves at different canopy heights to examine how this varies with development and corresponds to different nitrogen and chlorophyll distributions in the canopy. This experience has taught me how to coordinate large groups of researchers in a field setting and provided me with an opportunity to advise undergraduates and high school students that were conducting research within my project. A period of drought at the end of the season allowed me to show that even under low nitrogen availability, elevated [CO_2] only increased photosynthetic rates of maize under drought. I am following up on this finding by examining the key genes underpinning this response from the tissue I collected at the same time as these measurements were recorded. This finding is especially significant for subsistence farmers in arid environments that grow maize as their main crop, but cannot afford expensive synthetic fertilizers. These farmers can expect to have some benefit to their crops under elevated [CO_2] even under low nitrogen conditions.

Presently, I am in the grain belt of Victoria, Australia investigating how elevated [CO_2] alters the water relations and respiration of field grown wheat under drought conditions. Australia has been experiencing a drought for the past decade and formerly productive areas have had their yield potentials reduced by half. The Australian Grains Free Air Carbon dioxide Enrichment (AGFACE) experiment was established in 2007 in order to estimate how elevated [CO_2] might ameliorate these losses due to drought. I am testing two hypotheses through physiological, biochemical, and transcript profiling methods: (1) elevated [CO_2] will reduce stomatal conductance and soil moisture depletion and thereby reduce the impact of drought on stomatal conductance, photosynthesis and leaf water status (2) wheat dark respiration rates will be correlated with photosynthesis in the preceding light period and with carbohydrate availability, and therefore stimulated more by elevated [CO_2] in the irrigated compared to the non-irrigated treatment. During my time at this research station, I have been able to collaborate with Australian and Chinese researchers. The data I have already analyzed suggests that elevated [CO_2] can benefit wheat in terms of increased photosynthesis and improved water use, but under severe drought conditions there is little to no benefit. This is a crucial piece of information for modeling future yields in C_3 crops. I will collaborate with the Department of Primary Industries in the Victorian government to incorporate these findings into a model to predict future wheat yields in this region of Australia. The implications of climate change on plant physiology – particularly important food crops – cross all international borders and it is vital for researchers to actively share results, collaborate on solutions, and voice their findings to the general public.

<u>Publications</u> (1) Leakey ADB, Ainsworth EA, Bernard SM, **Markelz RJC**, Ort DR, Placella S, Rogers A, Smith MD, Sudderth EA, Weston DJ, Wullschleger SD, Yuan S (in press) Gene expression profiling – opening the black box of plant ecosystem responses to global change. *Global Change Biology*. **(2)** Leakey ADB, Sun J, **Markelz RJC**, Ort DR (in prep) Improved water status due to osmotic adjustment in soybean leaves grown under free-air CO_2 enrichment.

<u>Presentations</u> (1) Leakey ADB, Sun J, **Markelz RJC**, Ort DR (2008) Stimulated photosynthesis alters sugar and amino acid contents, lowers osmotic potential and improves water status of soybean leaves grown under free-air CO_2 enrichment. American Society of Plant Biologists Annual Meeting. Merida, Mexico. Poster Presentation. **(2) Markelz RJC** (2007) How will elevated [CO_2] alter soil and plant water status of the C_3-crop soybean and the C_4-crop maize*?* Proctor and Gamble Student Research Competition 2007. Oral Presentation. Runner-up; partial stipend winner. **(3) Markelz RJC**, Leakey ADB, Ort DR (2007) Elevated [CO_2] does not always improve soil and plant water status in the C3-crop soybean or the C4-crop maize. Environmental Horizons, University of Illinois Urbana-Champaign. Poster Presentation.