METER
ENVIRONMENT

CLIMATE CHANGE, GENETICS AND THE FUTURE WORLD

Climate change scientists face a particular challenge— how to simulate climate change without contributing to it. Paul Heinrich, a Research Informatics Officer associated with the Southwest Experimental Garden Array (SEGA) remembers looking at the numbers for a DOE project that would have used fossil fuel to measure forests' response to temperature change. "It would have been very, very expensive in fossils fuels to heat a hectare of forest," he says.

The alternative is, "to use elevation change as a surrogate for climate change so we could do climate change manipulations without the large energy costs."

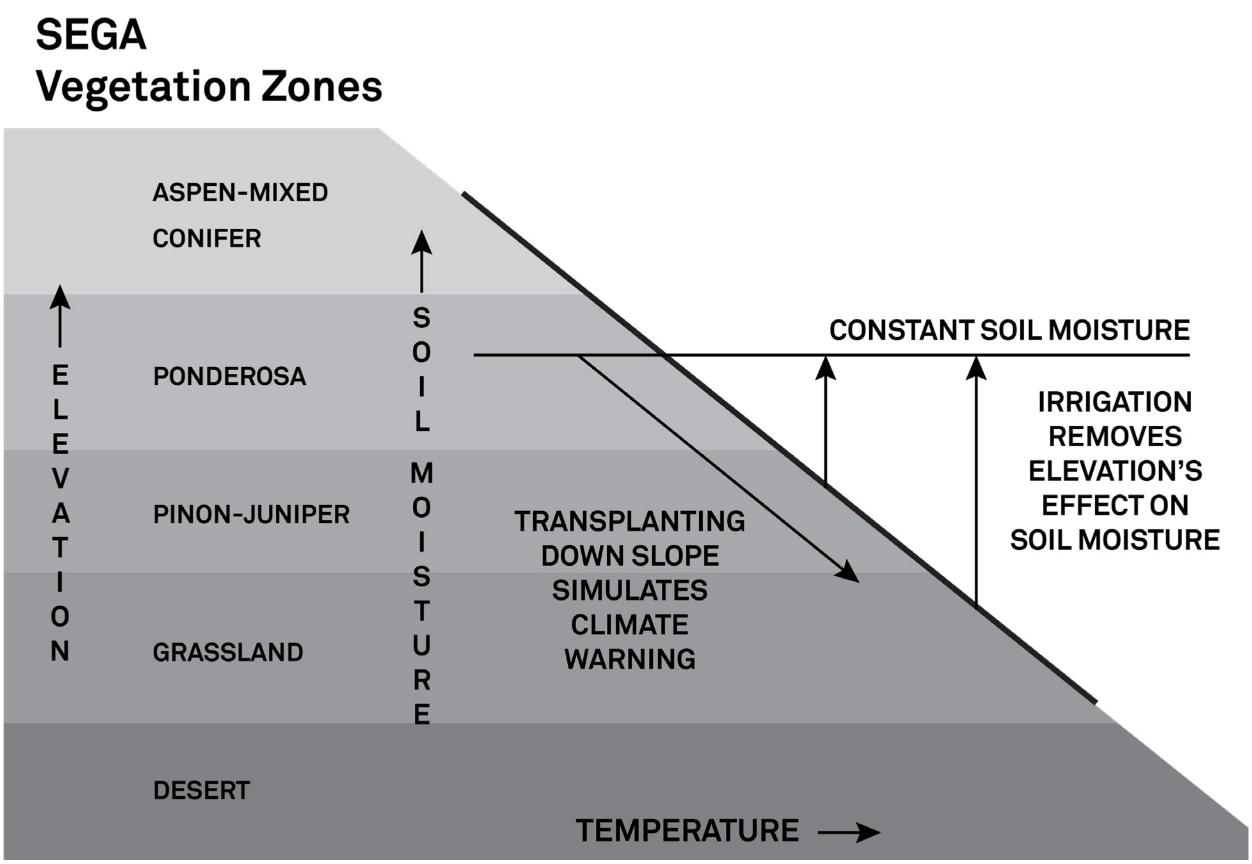


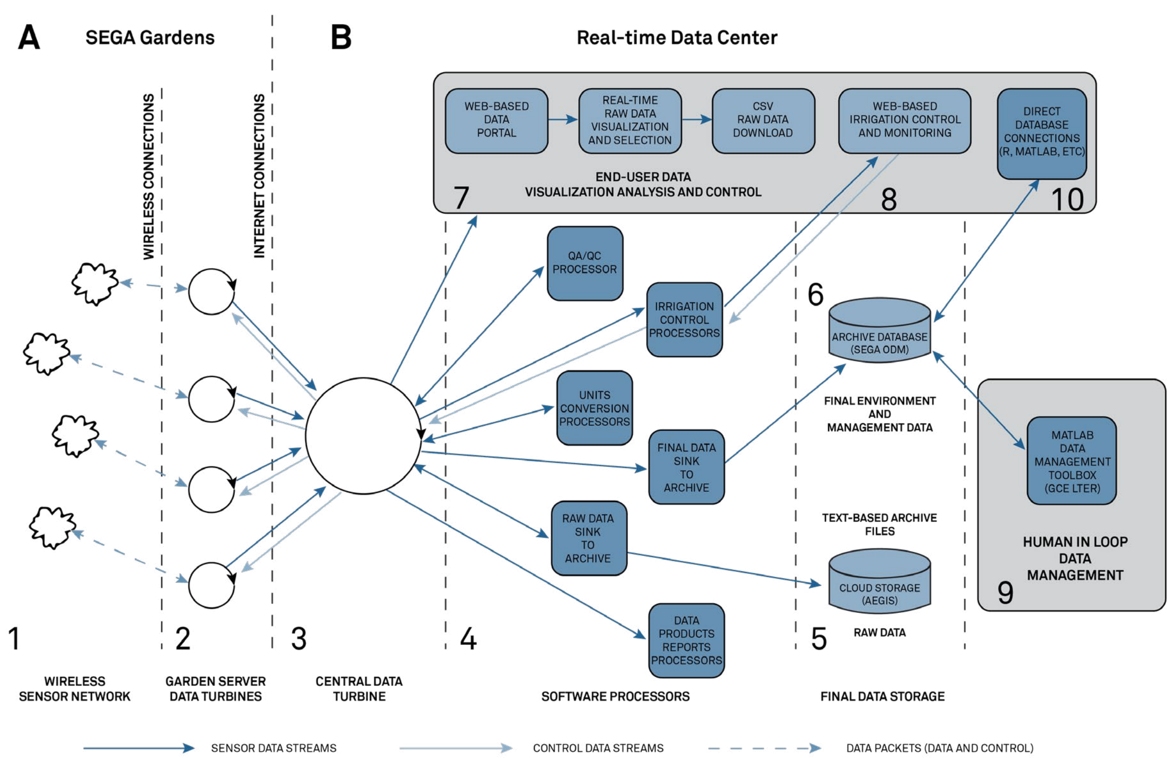
Figure 1. An overview of the SEGA sites using elevation change as a surrogate for climate change

By monitoring organisms across a temperature gradient it is possible to identify genetic variation and traits within a species that could contribute to a species survival under projected future climates.

CONTROL AND MONITORING INFRASTRUCTURE

SEGA is an infrastructure project started in 2012 after researchers at Northern Arizona University's Merriam-Powell Center for Environmental Research were awarded a $2.8 million dollar NSF grant with a $1 million match from NAU. Consisting of ten fenced garden sites for genetics-based climate change research, SEGA is set on an elevation gradient from 4000 to 9000 feet in the Southwestern United States. Each SEGA site has an elaborate data collection and control system with meteorological stations and site-specific weather information. Custom-engineered Wireless Sensing Actuating and Relay Nodes (WiSARDs) send data packets to a hub which then send the data back to a centralized server.

Because there is inherent moisture content variability from site to site, METER volumetric water content and soil water potential sensors have been installed to monitor and maintain moisture levels. If there is a change in soil moisture at one site, water potential and soil moisture sensors will detect the difference. Software on the server notes the difference and sends a signal to the other sites, turning on irrigation until the soil moisture matches across sites.



The SEGA Cyberinfrastructure Major Components

Figure 2. An illustration of SEGA's cyberinfrastructure and data management system

Having such an elaborate infrastructure creates an opportunity for researchers looking to conduct climate change research. By offering access to the pre-permitted SEGA sites, the hope is that research will generate much-needed data for climate projections and land management decisions.

When asked if the data stream was overwhelming to manage Heinrich said, “Well, not yet. We are just getting started. The system is designed for what SEGA is expected to look like in ten years, where we expect to have 50 billion data points.”

RESEARCH CONSIDERATIONS

Climate change projections show temperatures increasing rapidly over the next 50 to 100 years, bringing drought with it. The impact of these changes will be dramatic. Temperature and drought tolerant species will survive, those that are not will die, drastically changing the landscape in areas that are currently water stressed. Pests like the pine beetle and invasive species like cheatgrass will do well in a drier environment where water-stressed natural species will not be able to compete.

“Foundational species,” or species that have a disproportionate impact on the ecosystem, are the primary focus of the research efforts at SEGA sites. These are the species that drive productivity, herbivore habitat, and carbon fixation in the ecosystem. Unlike forests in other parts of the United States, forests in the Southwest can be dominated by one or two species, which makes potential research subjects easier to identify.

GENETIC VARIANCE

Amy Whipple, an Assistant Professor in Biology and the Director of the Merriam-Powell Research Station who oversees the day-to-day activities at SEGA, has been conducting some of her own research at the garden sites. Whipple has studied Piñon Pine, Southwestern White Pine, and has a proposal to study Cottonwood in process.

TEROS 21 water potential sensor measures water availability

Whipple says that models currently suggest that Piñon Pine will be gone from Arizona within the next 50 years, adding that the models do not take into account possibilities for evolution or genetic variance that might help the Piñon survive. Her research is largely asking, will trees from hotter, drier locations have a better chance of surviving climate change? “We’re trying to do that with a number of different species to look for ways to mitigate the effects of climate change in the Southwest.”

In some of her research on Piñon Pine, it was discovered that four different species were grouped morphologically and geographically from southern Arizona to Central Mexico. While this suggests that the divergence of species has occurred, it also suggests a low migration rate for these tree species. Migration rates of drought and temperature tolerant species is an important consideration when modeling for a future climate. If the migration of genetically adapted species cannot keep up with climate, the land could become marginal as a foundational species dies off.

CLIMATE CHANGE PREDICTIONS AND CONSIDERATIONS

In the Southwest, there are entire forests that could become grassland in 50 years because the genetic characteristics of the foundational species currently in those regions will not adapt to higher temperatures and drought stress. But what does this mean from a land management perspective?

Environmental conservationists maintain that we should protect the unique species that are in a place and that introducing other organisms or genetic material would be an ethical violation. Environmental interventionists make the argument that climate change has been caused by humans, so we have lost the option of remaining bystanders.

RESEARCH, LAND MANAGEMENT, AND POLICY

Paul Heinrich says that the route we take to manage the land will depend on our end goals. “Places that have trees now, if you want them to have trees 50 years from now, you are going to have to do something about it. The trees that are on the landscape right now are locally adapted to the past climate. They are not necessarily adapted to the future climate. They are probably maladapted to the future climate.”

To be clear, SEGA’s goal is not to promote or implement assisted migration. Instead, Amy Whipple says, SEGA can test what the effects of assisted migration might be. “In a smaller experimental context, we’re asking: how will these plants do if we move them around? What will happen to them if we don’t move them around?” The goal is to provide decision makers with the data they need to make informed decisions about how to manage the land.

Whipple’s own view is that we may no longer have the option of doing nothing. “Unless major changes are made for the carbon balance of the planet, keeping things the same is not a viable option. Managing for a static past condition is not viable anymore.”

REMAINING QUESTIONS

Both Heinrich and Whipple acknowledge that these are inherently difficult questions. Ultimately the public and land managers must make these decisions. In the meantime, data from SEGA research may help ensure better predictions, better decisions, and better outcomes.

To find out more about conducting your own climate change research using SEGA go to: http://www.sega.nau.edu/use-sega.

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