Here's Looking at You Sensors - The Eyes and Ears of Environmental Monitoring – 2018

"Every breath you take… Every move you make… I'll be watching you" — The Police, 1983

This well-known song could be talking about sensors. Sensors—those tiny instruments sometimes as small as a bug, often hidden, have become ubiquitous in our lives. They are found in smartphone Fitness Apps that count every step we walk, to automatic flush systems in urinals, to tire pressure sensors in cars. Quiz yourself—take any place or field of activity, such as a supermarket or your home, and list as many sensors in action as you can think of. You'll be surprised at how many you find!

A weather station (left) and Eddy Flux tower (right) at MAERC used to measure uptake and emissions of greenhouse gases by soils, cows, and vegetation. Photo by Archbold Biological Station.

When it comes to managing our farms, ranches, natural areas, and water resources in an environmentally sustainable manner, sensors have become indispensable. They tell us in real time answers to questions like how much water is flowing from a farm culvert, how low is the water in a lake, how much dissolved oxygen is there in a canal for fish to breathe, what is the concentration of nutrients from agrochemicals entering Lake Okeechobee, and so on. Real-time data then allows managers to quickly respond to conditions. Long-term data helps scientists understand the effects of management, thereby identifying suitable methods to manage lands.

Scientists at Archbold's MacArthur Agro-ecology Research Center (MAERC) are working with various state and federal agencies to find ways to better manage water on cattle ranches. Cattle ranches in Florida typically have a mosaic of pastures, wetlands and hammocks, where cows coexist with wildlife. The overall objective at MAERC is to maintain livestock and food production while sustainably managing the environment that provides people important services such as fisheries and automatic maintenance of clean water.

Dr. Betsey Boughton, Program Director at MAERC, describes sensors as “the eyes, ears, and noses” of environmental monitoring. For instance, a pressure transducer is used to monitor water level in canals inside a ranch, in an effort to slow the flow of rainwater. Says MAERC ecohydrologist Dr. Amartya Saha, “Just like how our ears feel pressure when we dive into a swimming pool, the pressure transducer measures the pressure of the water column above, and from that we can calculate the height of the water column above the sensor”. Pressure transducers at MAERC are programmed to measure pressure every 15 minutes and send the data to a datalogger which stores the data and sends it to the MAERC command room via a cellular modem. Being located in the field far from any electrical source, the whole system is powered by solar panel and 12V battery. These particular data tells us how much water is being retained in the ranch water management system and how much storage space is available for future rainfall.

Water level monitoring station showing a weir on the left, and the datalogger on the right, including solar panel, rain gauge and antenna. The water level transducer is submerged in the ditch (not seen in the image). Photo by Archbold Biological Station.

An example of a sensor at MAERC that behaves like an “eye” is a phenocam, or phenology camera. Phenology refers to the change in leaf growth and color through the seasons. Dr. Saha noted, “This camera is the same as the cameras at traffic intersections, except that here the phenocams are monitoring the growth of plants over seasons.” A photograph is taken every half hour during daylight hours, and automatically uploaded via modem to a global network for phenocams housed at the University of New Hampshire (https://phenocam.sr.unh.edu/webcam/). Over a year, the photos show precisely how green the vegetation gets in the rainy season, and how much plants die back to shades of yellow and brown in fall. According to University of Florida rangeland scientist, Dr. Raoul Boughton, “These colors in the images can be used to analyze the productivity of the vegetation in different

seasons. Having these data allows scientists to understand how plant growth and dieback varies with climate, rainfall, fire, grazing and location."

Another set of sensors, called the Eddy Flux system measures the "breathing" of the ecosystem – gases like carbon dioxide, methane and water vapor that are breathed in, and respired out, by plants, grazing cows, and microorganisms in the soil. Dr. Saha explained that "Eddy flux sensors measure gas and vapor concentrations along with wind speed and wind direction, and in this manner measure how this 'breathing' changes with plant growth, flooding, and pasture management such as grazing and fire. Data from these towers are helping improve understanding of greenhouse gas fluxes from tropical pastures." Dr. Betsey Boughton added "These data also feed into large-scale computer models which estimate how much greenhouse gases trap heat from sunshine, collectively acting as our atmospheric blanket, which makes life possible on Earth. It is important to measure increasing concentrations of these gases, to evaluate how they may be contributing towards a thicker blanket that traps more heat."

Dr. Saha concluded "These are just three examples of electronic ears, eyes, and noses at MAERC that help scientists and ranchers better manage natural resources and the environment. As our world gets increasingly interconnected with the Internet of Things (IoT), designing and maintaining sensors, networks, and applications is emerging as a rewarding new career."