Wyoming Landscape Conservation Initiative

"Conserving world-class wildlife resources. Facilitating responsible development."

What are Plants Doing and When? Using Plant Phenology to Promote Sustainable Natural Resources Management

Climate change models for the northern Rocky Mountains predict changes in temperature and water availability that in turn may alter vegetation. Changes include timing of plant life-history events, or phenology, such as green-up, flowering and senescence, and shifts in species composition. Moreover, climate changes may favor different species, such as nonnative, annual grasses over native species. Changes in vegetation could make forage for ungulates, sage-grouse, and livestock available earlier in the growing season, but shifts in species composition and phenology may also result in earlier senescence (die-off or dormancy) and reduced overall forage production.

Plant green-up is one of the landscape changes a resource manager could monitor to improve decision making. For example, spring green-up can be used as an indicator of forage production, which affects seasonal habitat condition. However, knowing exactly when plants green-up in the spring is not easy. Land managers are responsible for large parcels of land and may have neither the time nor the resources to scout the entire landscape. Satellite imagery may be used to calculate an index of greenness, such as the remotely sensed Normalized Difference Vegetation Index (NDVI). But satellite-derived NDVI is limited in the timing of acquisition. Weeks or even months may pass without good satellite data, the spatial resolution may be too coarse, and in areas with complex topography or vegetation structure early green-up may not be detected. Ideally, resource managers would have access to more precise green-up data to facilitate decisions regarding elk feedgrounds, fuel production (fire hazard), and nonnative plant species control, for example.

U.S. Geological Survey researchers, in collaboration with Wyoming Landscape Conservation Initiative (WLCI) partners, are testing inexpensive, near-surface greenness sensors on specially engineered platforms nicknamed a "mantis" because it resembles a praying mantis (fig. 1). The goal is to provide resource managers with a tool for early detection of green-up by plant species of interest. For the tool to be useful, it must be determined if green-up detection is more precise by mantis sensors than satellite sensors and if there is a measurable correlation between mantis and satellite sensor measurements. Twenty-one mantis platforms were installed in the Upper Green River Basin during the 2010 growing season. Sites included cheatgrass (*Bromus tectorum*) treatment sites on the Jonah Field and near the Fall Creek elk feedground.

Figure 1. David Kesonie (USGS) downloading data from mantis sensors near the Fall Creek elk feedground, Pinedale, Wyoming. The "mantis" near-surface sensor platform (developed by Heidi Steltzer, Fort Lewis College, and others) has downward-facing sensors (for visible and near-infrared light) for measuring greenness in approximately 1 square meter and an upward-facing sensor for monitoring cloud cover. Reflectance and incoming solar radiation data were collected with 21 platforms from May 1 to September 1, 2010. Each site also had sensors to record air temperature and soil moisture 5 centimeters below the surface. Photograph by Geneva Chong, U.S. Geological Survey.

In addition to calculating a NDVI from the mantis data, plant species composition (native and nonnative) and structure (cover and height) were sampled, and phenology events on specific individual plants (for example, bud burst, leaf opening, flowering, seed set, and senescence) were monitored. These data allow WLCI researchers to gage what the mantis sensors are actually "seeing" when the data indicate a change in greenness. For example, they may be able to see the start of green-up, maximum greenness, and the start of senescence (fig. 2) with the mantis data, but only maximum greenness with the satellite data.

Preliminary analyses indicate mantis sensors can detect green-up and maximum greenness values of selected plant species (perennial grasses, shrubs, or annual weeds, like cheatgrass; fig. 3) that traditional satellite imagery cannot (see Steltzer and others, 2011).

The results of WLCI's mantis work are encouraging and could have many applications for sustainable land management. For example, mantis sensors could be used to identify green-up of plants of interest to managers—these could be preferred forage species, non-native species that require control, or species used for reclamation, for example. Unexpected

The WLCI is a long-term, science-based program to assess and enhance aquatic and terrestrial habitats at the landscape scale in southern Wyoming, while facilitating responsible development through local collaboration and partnerships.

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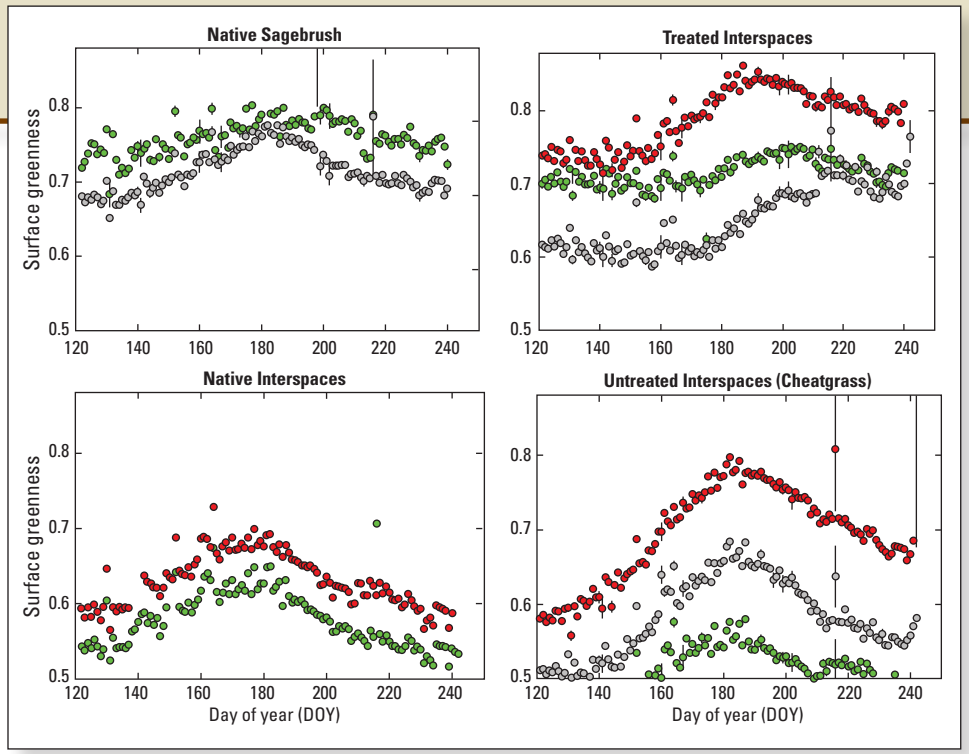

Figure 2. The mantis sensors were able to detect green-up, peak growth, and senescence near the Fall Creek elk feedground, Pinedale, Wyoming. Raw data from 10 sensors are plotted here. Calibrating data to account for individual variation between sensors would reduce the variation between replicate sensors. The normalized difference vegetation index (NDVI or Surface greenness) indicates the greenness of the vegetation, which changes during the growing season (Day of Year (DOY), which started April 30, 2010, and ended September 1, 2010). We are currently gathering multiple satellite scenes for the site to test for correlations between the near-surface mantis reflectance data and satellite data.

green-up might indicate the presence of undesired plant species, and that area could be selected for on-the-ground examination and weed management if needed. Mantis sensors could be used to monitor the short- and long-term effects of sagebrush treatments or reclamation, thus helping to develop guidelines for future vegetation treatments, including invasive species control. Because greenness is a response to temperature and moisture, long-term monitoring may also detect vegetation changes associated with changing weather and climate patterns (see Steltzer and Post, 2009).

Ideally, for plant phenology information to be useful to natural resource managers, remotely sensed greenness indices like the NDVI could be correlated with near-surface measurements that capture fine-scale, rapid changes in phenology. The results of this technique may assist managers in making resource-management decisions ranging in scope from the design, application, and monitoring of habitat treatments and restoration activities to the timing of when to provide supplemental feed for elk, or when to move elk off supplemental feedgrounds.

Figure 3. A mantis near-surface sensing platform with downward- and upward-facing sensors and the utility box, which contains the HOBO data logger (Onset Computer Corporation), circuitry and battery pack. The system is weatherproof through growing season conditions, and the platform alone was stable left out through the winter (protected from cattle with solar electric fence). The greenness sensors are centered on a patch of cheatgrass (*Bromus tectorum*), which is an invasive, nonnative of concern throughout the western US. The sensors measure reflectance from an approximately 1-square-meter area. Photograph by Geneva Chong, U.S. Geological Survey. (Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.)

References

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The WLCI partnership formally includes the Bureau of Land Management (BLM), U.S. Fish and Wildlife Service (USFWS), U.S. Geological Survey (USGS), U.S. Forest Service, Wyoming Department of Agriculture, Wyoming Game and Fish Department (WGFD), local conservation districts, and local county commissions. Additional groups and individuals participate as well.

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