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Remote sensing of net primary production as a function of hydrology in a coastal system

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Ecosystem state change between grassland and shrubland has occurred at an unprecedented rate worldwide. In coastal ecosystems, especially barrier islands, abrupt transitions are critical as these systems depend on a soil freshwater lens to support vegetative communities. Over the past 32 years, barrier islands within the Virginia Coast Reserve (VCR) Long-Term Ecological Research site have lost >25% of terrestrial upland area, island width has been reduced, yet salt and drought sensitive woody vegetation has expanded across the landscape. Remote sensing is a useful tool for rapid measurements of ecosystems and earth surface processes, and is now being used to detect vegetation dynamical functioning, yet methods to quantify ecosystem production and primary production remain challenging. Recent advances in hyperspectral remote sensing have made significant contributions for the potential to utilize vegetative features to provide estimates of plant physiological status. The Photochemical Reflectance Index (PRI) and algorithms from the visible and near-infrared (VIS-NIR) are linked to plant physiological functioning in laboratory studies, and have recently been tied to plant water stress in experimental settings. Thus, these algorithms have potential for using plants to characterize spatial-temporal variability in net primary production (NPP) at the landscape level. We examined the relationships between woody NPP, hydrology and corresponding reflectance signals from airborne collected hyperspectral imagery to link fluxes in vegetation physiology relative to environmental condition. Woody NPP was monitored spatially along a chronosequence for over 15 years on an Atlantic coastal barrier island. Summer hyperspectral airborne missions were collected over several years between 2001 and 2013. Rainfall and temperature data were obtained on a subdaily basis from a meteorological station on the barrier island. Water table depth was assessed on a daily basis from multiple wells across the island. During this timeframe, extreme drought and flooding occurred, providing good endpoints for variable climatic conditions. Spatial variations revealed that water table depth was different in wet and dry years. NPP was related to both precipitation and available groundwater. Numerous indices indicative of plant physiological function (PRI, R750/R710, R740/R850, D705/D722) were related to both field collected woody primary productivity and groundwater availability. Using empirical data and hyperspectral remote sensing imagery, these results demonstrate the important feedback between woody productivity response to changes in water availability and could apply to other systems with strong directional gradients in resources or freshwater lens. The strong relationship between hyperspectral indices, NPP and hydrological variables indicates that simple metrics can be used to make future predictions of coastal areas vulnerable to climate change effects. These results can be a reference to estimate local changes in the vegetation dynamics under the different climatic change scenarios proposed by the Intergovernmental Panel on Climate Change (IPCC) in terms of rainfall.