Identifying significant drivers for the tradeoff and synergy between carbon and water yield ecosystem services at the watershed/eco-region level in the Southeastern United States.

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1. Introduction

Ecosystem services are defined as "benefits people obtain from ecosystem" (MEA, 2005). The Ecosystem service provides ways to understand and deal with negative observation loop which is created by humans for their needs (Rodriguez et al., 2006). The millennium ecosystem assessment distinguishes four categories of ecosystem services: Provisioning (e.g., of Seafood, timber, Water), regulating (e.g., of climate, floods, Climate), supporting (e.g., Pollination and pest control for food production) and cultural (e.g., serenity, inspiration). Ecosystem functions are defined as the capacity of ecosystem to produce goods and service to support human needs for e.g. (nutrition, health, pleasure, etc.) (De Groot, 1992). Ecosystem process or component (e.g. evapotranspiration, Net ecosystem exchange) regulate the ecosystem structures or functions to understand the dynamic of ecosystem service provision. The ecosystem value is differentiated into ecological, socio-cultural and economic (MA, 2003). The ecological value refers to the bio-diversity and integrity, whereas the socio-cultural indicates importance of people on cultural and religious practices. The economic values can be classified into use values (e.g. timber and fish) and non-use values (for e.g. recreation, aesthetics). Nonuse values also includes the ecosystem services from nature such as pollination of crops, air and water purification etc.

Ecosystem can be characterized as land cover/land use and management that influence the ecosystem functions, process or components which finally determines the total level of ecosystem service provision (De Groot, 1992). Ecological indicators are the biophysical and social properties of landscape that can be used to investigate the location and potential ecosystem service provision. Ecological process works on different ranges of scales (Hein et al., 2006) for e.g. a local revamp may produce pollination service to close by crop land. Ecosystem service at hydrological level (i.e. water yield) depends on the range of ecosystem process that operates at watershed level. In global scale total ecosystem carbon sink or sequestration can be analyzed (de Groot et. al.,). Therefore analysis of ecosystem service change depends on the type of spatial scale implemented which regulates the ecological process and functions to produce sustainable ecosystem supply (de Groot et al.,)

Water yield is the run-off generated that includes the output from the amount of Precipitation minus the Evapotranspiration in a basin. (W.B. Langbein and Kathleen T. Iseri). As a result of land use and land cover change there is increases in evapotranspiration loss leading to decreased water yield. Aquatic ecosystem like rivers is largely impacted by land use change, climate change. The magnitude and timing of the river flows is changed as a result of dam construction, water withdrawals [Gerten et al., 2008], inter basin transfers[Jackson et al., 2001] and land-cover (Piao et al., 2007) change by humans. The river flow increases with land-cover change as a result of deforestation, improved agricultural practices (Piao et al., 2007) and urban development (Piao et al., 2007).

2. Proposed methodology.

Water yield and carbon (i.e. forest biomass) are two important ecosystem services. Spatial analysis of these services is crucial for forest management and conservation. This study focuses on understanding the trade-offs and synergies between the forest above ground carbon and water yield ecosystem services at the water shed and eco-region levels in the southeastern United States. To understand the dynamics between biophysical ecosystem pattern and process, this study applied hotspot analysis (high areas of ecosystem service provision) using the Water Supply Stress Index (WaSSI) model estimates for water yield and the carbon (i.e. forest biomass) map which is produced using the forest inventory data.

We identified the areas of significant hot and cold spots in carbon and water yield in the study area indicating trade-offs and synergies. Then we used statistical analysis operations to relate the hot and cold spots with ecosystem process drivers such as the climate (i.e. precipitation and Temperature), soil characteristics (total soil thickness and water capacity), elevation, forest management drivers for forest inventory plots (Stand age, site quality, ownership, treatment, disturbance and forest type) .

2.1 Quantification of ecosystem services.

The assessment of ecosystem functions with the ecosystem process is regulated by WaSSI (water supply and stress index) through water balance and ecosystem productivity modules. The water balance module is based on Land cover distribution at watershed level. Therefore the evapotranspiration, LAI (Leaf area index) ,Soil moisture soil storage, snow accumulation and melt, surface runoff, base flow and infiltration components of water balance modules varies under different conditions. On considering these assumptions, the water balance module computes run-off also termed as Water yield in mm at watershed level for United States.

The water balance module is not simulated to assess the changes in land cover distribution, but was computed to quantify the ecosystem supply at watershed level. The spatial data set of carbon is the above ground forest biomass produced from forest inventory plots (1990 to 2003) of conterminous U.S. (Blackard et al., 2007).

2.2 Identifying potential drivers.

In this study we are focused on developing framework to identify potential drivers or predictors of Tradeoffs and synergies at watershed level in south east U.S. regions. Biophysical characteristics (Elevation, slope, temperature and Land cover percentages) that regulate the watershed are used as drivers to define the tradeoffs and synergy between the ecosystem services. In this approach we are focused on studying the tradeoffs and synergy between the ecosystem services at watershed level. We used the FIA (forest inventory plot) level data to have information on the forest management, stand, land tenure and ecological disturbances of the forest plots for recent period within 1990-2003. This approach can used to identify the relationship between the ecosystem services (i.e. Carbon and water yield) and forest ecosystem process that regulate their relationship. This approach can be used to identify forest management strategies and potential conservation areas. It can be also used to analyze the effect of regional scale change in the Forest ecosystem functions on ecosystem structures for provision of services to human being.

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