MAPPING AND ANALYSIS OF HUMAN DOMINATED ECOSYSTEMS ON A GLOBAL SCALE: A LOOK AT THE WORLDS CROPS AND CROPPING SYSTEMS

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ABSTRACT

The global characterization of ecosystems is not a new research topic; however, there still is room for improvement in the detail of the feature being mapped and the phenomena being analyzed. In addition, much work has been done analyzing and classifying natural ecosystems (Vogelmann et al., 2001; Cihlar et al., 2000; DeFries et al., 2000; Belward et al., 1999; Lobo et al., 1997; Brown et al., 1993; Loveland et al., 1991), while only recently we are questioning whether human-dominated systems can indeed be called "ecosystems". We are interested in understanding the resources in human-dominated ecosystems, in quantifying the relationship between people and the environment and in analyzing the impact of humans on the availability of resources. With these goals in mind, the focus of our current presentation is on the global mapping of one of several human-dominated ecosystems – croplands. We have developed an approach to synthesize census and geospatial data, through statistical analysis and modeling, to generate global crop data sets of the spatial distribution of eighteen major crops and crop categories. This presentation is a follow up to our April ASPRS presentation in which we revealed preliminary results. We have since completed the data sets for the global distribution of eighteen major crops, validated the data and have prepared it for distribution.

INTRODUCTION

Humans now dominate the landscape. The world's agricultural lands occupy roughly a third of the global land surface (Ramnakutty and Foley, 1998), since pre-agricultural times forests have declined by approximately one-fifth worldwide and by a third in the temperate forest regions (Goudie, 2000), and more than the entire 1960 world population now lives in urban areas (Srinivas, 1997). Although humans are not responsible for all the environmental malice with which they are credited, they have transformed the essence of whole landscapes. In turn, large-scale changes in land use and land cover have had enormous consequences for the provision of ecosystem goods and services. Through their interaction with the environment, humans have modified soils (Meyer and Turner 1994), influenced global and regional climates (Shukla et al., 1990), changed the global cycles of carbon, nitrogen, and water (Vitousek et al., 1997), induced the loss of biodiversity, affected geomorphic processes, and changed the quality and quantity of some natural waters (Goudie, 2000).

The most extensive of the human-dominated ecosystems is croplands. Although croplands as an ecosystem have replaced mostly forests, they are in themselves a vital resource, providing food for the world's six billion people. Therefore, mapping the extent, intensity and characteristics of the world's croplands is important for both understanding the consequences of cultivation on natural ecosystems and processes, and for assessing the global potential for food provision.

Not too long ago, Ramankutty and Folley (1998) have on a global scale synthesized satellite and cropland census data to create a continuous geospatial data set of the world's croplands circa 1992. Their data set, although not extensively validated, is consistent with present-day knowledge of agricultural geography. An important next step in this direction is to further delineate the specific crops found within the extent of these cultivated lands. Such a delineation would enhance our estimates of the food production capacity of the world's cultivated lands, better our capability to perform spatial analysis of the human impact on natural ecosystems, and improve our understanding of global biogeochemical processes such as carbon sequestration and nutrient cycling. The science in turn, can be used to aid in policy and economics decisions related to food security, environmental regulation, and bettering the quality of human and natural ecosystem life.

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MAPPING CROPS AND CROP CATEGORIES

Some researchers have looked at the distribution of croplands in the world (Ramankutty et al., 1998) and throughout time (Ramankutty et al., 1999), while others have modeled irrigation requirements for major crop categories (Doll et al., 2000). In terms of the scale and detail, these efforts lay between the methodology used to generate global land use and land cover data sets with a few discrete categories, and the methodology used to generate the regional continuous crop specific data sets with restricted area and crop category coverage. Although still limited in the number of crop categories, in Doll's data set each pixel is classified as a rice or a non-rice crop and crop irrigation requirements are modeled accordingly. In Ramankutty and Foley's global data set each pixel is classified as cropland or not, but also included is a fractional or continuous component - the intensity of cropland cultivation per pixel. Our current efforts are aimed at extending the above into global continuous data sets for individual crops and crop categories.

The scale of the project was imperative because of our desire to understand global processes and the crop and crop category selection process was driven by considerations for the data use. The selected crops and crop categories had to have distinct biochemical, phenological and food resource descriptions. We chose seventeen major crops (barley, cassava, cotton, ground nuts, maize, millet, oil palm fruit, potatoes, rapeseed, rice, rye, sorghum, soybeans, sugar cane, sugar beets, sunflower, and wheat), one major crop category (pulses, which includes many beans, peas, lentils, etc.) and ten other crop categories (fibers, fruit, nuts, oil-bearing crops, other cereals, other roots, others, spices, and vegetables). All agricultural census data was regrouped into those categories and data sets were generated for all "major" crops and crop categories, while all "other" crops and crop categories were grouped into a single category for the time being.

Some preliminary remote sensing classification efforts show promise in delineating paddy crops and large-scale grain cultivation, such as in the Midwestern U.S. (R. DeFries, University of Maryland, personal communication, 2002), however we were unable to use a remote sensing classification alone to derive the crop data sets because of the lack of ground truth information and because of the inseparability of crops and natural vegetation at global scale. On the other hand, agricultural census data alone does not possess the desired spatial resolution or consistency on a global scale for such data sets. Some researchers are developing and testing comprehensive approaches to spatially distribute cropland census data on the basis of land suitability, price, and other parameters, however, these efforts are currently only at regional scales (S. Wood, International Food Policy Research Institute, personal communication, 2002). While these techniques are being developed and image classification is being improved, we have chosen to use a simple approach to derive a "first cut" global data set of the distribution of major crops. This approach consists of the synthesis of crop-specific agricultural census data on harvested area, and Ramankutty and Foley's global geospatial cropland data set, to derive the spatial patterns of eighteen major crops in the world. Then, we use an unsupervised classification of NDVI imagery based on the agricultural census data to compare and validate the two products generated. Through both approaches we have created eighteen data sets which are global, crop or crop-category-specific and continuous.

The current presentation will first examine and compare both approaches for creating the eighteen crop data sets. Then we will discuss some research results related to major patterns in the world's crops and cropping systems, global crop diversity and crop geography.

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