Procedures for estimation of the livestock ecological footprint in US drylands

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Introduction: The ecological condition and trend of the United States' 3,902,000 km² of Drylands and the extent to which human management actions contribute to degradation are unknown at the national spatial scale (Washington-Allen et al. 2006). Our research seeks to develop procedures for determining the impact of ecological footprint of livestock grazing on the productive capacity of Drylands at the national spatial scale.

Approach: The study approach has been to develop a Geographic Information System (GIS) consisting of digital maps of gross and net primary productivity (GPP and NPP), U.S. Department of Agriculture National Agricultural Statistics Office (NASO) national livestock number and distribution maps, transportation and power consumption networks, gridded climate data, land cover, and land use. Maps of GPP and NPP were derived from annually integrated normalized difference vegetation index (NDVI) from the Moderate Resolution Infrared Spectroradiometer (MODIS) and the Advanced Very High Resolution Radiometer (AVHRR) satellite data. Climatic data, particularly mean annual potential evapotranspiration [MAPET, Zomer et al. (2006)], was derived from the WORLDCLIM dataset developed by Hijmans et al. (2005).

Secondly, a Dryland extent map was generated using gridded population, transportation data, e.g., data of roads and railways, power consumption, land use/land cover and aridity index (AI) data in a subtractive overlay GIS procedure. AI is the United Nations Convention on Desertification's definition of Drylands where AI is the ratio of mean annual precipitation (MAP) to MAPET that is ≈ 0.85.

Thirdly, the NASO data is used to generate livestock number and distribution maps which are intersected with the dryland extent map to yield a livestock footprint map. Lastly, this footprint map is then converted to an annual requirement of forage map and subtracted from a livestock map to yield a livestock appropriation of net primary productivity map (LANPP).

References:


Grasslands/Rangelands Resources and Ecology: Indicators for Sustainable Use and Conservation of Grasslands/Rangelands Resources
INTRODUCTION

Drylands occupy 4,972,000 km² of the United States land surface and cover 41% of the world’s terrestrial surface while producing ecosystem goods and services to some 38% of the human population (Millennium Ecosystem Assessment (MEA) 2005). The ecological condition and trend of these lands is unknown at national, regional, and global scales (The N. John Herr Center 2002, West 2003, Millennium Ecosystem Assessment (MEA) 2005, Washington et al. 2006). Large geographic areas of dryland are unmonitored at regional and national scales. Major problems are that dryland condition is measured in different ways by different agencies at local scales and thus subject to different interpretations. Further, water-limited systems are driven to some extent by climatic events such as the El Niño–Southern Oscillation (ENSO) and La Niña events that have return intervals of between 5 to 10 years. Equilibrium data sets for replication of treatments, in this case both grading and climatic change. Consequently, monitoring and assessment require time series of 15 to 20 years of data to detect trends. Additionally, for forage production is an important indicator of climate change and is known to respond to changes in rainfall, temperature, and other climatic variables. Public and governmental responses from previous assessments have shown that interest in dryland condition is paramount. However, until national and federal agencies and NGO’s adopt consistent indicators of ecological conditions that are broadly monitored, a different approach is needed. Consequently, an index of human impacts on the terrestrial surface: the ecological footprint and indicators of human impacts on the face of the earth: the ecological footprint and the aridity index (AI) that is used to assess the state of a land surface (Figure 1A). The result is the intersection and union of these areas as an estimate of the area of production impacted by livestock (LAPP).

METHOD

Our approach is to use a Geographic Information System (GIS) based approach to look at the spatial distribution of the intensity of livestock grazing at the national level of U.S. drylands in relation to dryland productivity. Specifically, this study will focus on the year 2002, because this was when national statistics on both the number and spatial distribution of livestock across the United States became publicly available.

Result

The National Agricultural Statistics Service (NASS, http://www.nass.usda.gov) conducts twice-yearly livestock surveys for the USA at the county level. The US Census Bureau also collects agricultural and livestock data, which is used by NASS to spatially express US livestock distribution (Figure 1A and B). These number can be converted into forage required or used by livestock.

Figure 1. Out maps of the spatial distribution of beef cattle (A) and sheep and lambs (B) across the US. Each dot represents a livestock value of 2,000 (NASS in 2000) = 1 beef cow or sheep and lamb. The number of dots within a particular land cover was based on weighting factors that were likely estimate of each type of livestock occurring in a particular cover. The determined number of dots were then randomly distributed within the specific land cover polygon (http://www.nass.usda.gov/research/letals/livestock.html).

Data

Figure 2. Net primary productivity (NPP) for 2000 derived from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor.

Figure 3. The global extent of drylands as defined by the aridity index (AI) which covers 41% of the terrestrial surface.

RESULTS

The extent of livestock impact in drylands is the goal of this study. However, there are over 100 definitions of drylands that can be used to set the scene. Fortunately, the United Nations Convention to Combat Desertification (UNCCD) had defined drylands globally as the area of mean annual precipitation (MAP) to mean annual evaporation (MAPET) referred to as the Aridity (or Humidity) Index (AI) that is used to assess the state of a land surface (Figure 1). We will use the AI index developed by (Zomer et al. 2008) that was derived from the WCRUCLIM dataset developed by Hynes et al. (2005).

LITERATURE CITED