Coastal Impervious Cover and Watershed Scale: Implications for Environmental Management, New Hanover County, North Carolina

Michael T. Griffin, East Carolina University, Greenville, NC, USA
James Dean Edwards Jr., University of South Carolina, Columbia, SC, USA
Thomas R. Allen, East Carolina University, Greenville, NC, USA

ABSTRACT

Environmental planners seek techniques that will enable them to analyze impervious cover to develop sound management plans for coastal regions. The spatial scale in which impervious cover has traditionally been widely analyzed is mismatched to the fine-scale resolution needed for local environmental management. This study examines impervious cover in New Hanover County, North Carolina using LiDAR derived subwatersheds and United States Geological Survey (USGS) 14-digit hydrologic unit watersheds to evaluate potential scale-dependency of impervious cover estimates. Spatial analysis of impervious cover across multi-scale watersheds indicates that fine scale subwatersheds exhibit patterns not revealed with coarser watersheds. Spatial and cartographic analyses suggest that localized impervious development and its expansion in first-order drainages originating in coastal lagoon watersheds is more appropriately analyzed using fine-scale, LiDAR-derived watersheds. Results stress the importance of using scale in watershed management and hydrogeomorphic context to aid planners when making decisions involving impervious cover.

KEYWORDS
Impervious Cover, Impervious Surfaces, Scale, Water Resources, Watershed Delineation

INTRODUCTION

Water resource issues in coastal regions of North Carolina have been a major concern in recent years. Historically, this region has been thought of as a water-rich region (Griffin et al., 2013). However, with the rapid increase in population in coastal regions of North Carolina, illustrated by 71% growth in the coastal New Hanover county from 1989-2010 (U.S. Census), water resource concerns involving both supply and quality have arisen. Obviously, issues related to availability can be linked to population growth due to the increase in demand. Additional deleterious environmental impacts of population growth are also linked to water resource impacts. Population influences water resources not only through water use, but through land use and climate change as well, including long-term ecosystem disruption (Lotze et al., 2006; Turner & Rabalais, 2003). A primary by-product of population growth is that of land use change. Therefore, this study seeks to evaluate impervious cover, a negative by-product of land use change, across varying watershed scales, to include fine scale LiDAR delineated watersheds.

DOI: 10.4018/IJAGR.2016010104

Copyright © 2016, IGI Global. Copying or distributing in print or electronic forms without written permission of IGI Global is prohibited.
POPULATION AND LAND USE DRIVERS

Land use change is inevitable with population growth, especially in areas of high growth rates such as coastal southeast North Carolina. With land use change comes the addition of impervious surfaces, considered broadly as any feature or structure that hinders precipitation from infiltrating the soil. Chief among these features are concrete and asphalt surface roads and buildings (Griffin et al., 2013). With population growth the need for more transportation infrastructure as well as housing adds to the impervious surface cover of a region. Excessive impervious surface cover can impact both water quantity and quality within a region, particularly if the source of impervious runoff is close to potential sinks, as with the abundance of first-order watersheds in low-relief coastal plains.

IMPACTS AND FEEDBACKS ON LOCAL HYDRO-CLIMATOLOGY

Local hydro-climatological feedbacks may arise from impervious surfaces impacting hydrology directly via soil moisture. If precipitation does not infiltrate the soil, soil moisture status for that region decreases. When soil moisture decreases, evapotranspiration also decreases (Praskievicz & Chang, 2009). As a result of the decrease in evapotranspiration, the atmospheric moisture content may also decrease, which could lead to less precipitation recycling for the region. Precipitation recycling refers to the redistribution of water on a local scale that was evaporated from the surface (Brubaker, 1993). Therefore, as evapotranspiration decreases so could the local precipitation. This potential decrease in local precipitation could negatively impact the fresh water availability for the region. However, water quality impacts arising from additional impervious cover are more commonly noticed.

Water quality issues that can arise from the expansion of impervious surfaces are primarily due to the contaminants that tend to accumulate on the impervious surfaces. Urbanization, which increases impervious surface cover by way of buildings and infrastructure, can impact the flashiness of runoff with precipitation events (Praskievicz & Chang, 2009). The processes in which water quality and quantity are affected depend on the frequency and duration of events. If a precipitation event is over an area with impervious surfaces, that moisture is not going to infiltrate the surface, but rather be directed into surface runoff. This runoff accumulates contaminants, which are then transported to the water supply. The impact on water quality can be substantial, and coastal ecosystems are under increasing stress from a variety of human activities that cause increased pollution, floral and faunal changes, and physical alteration of the environment (Mallin et al., 2000). Water quality is of particular interest to these coastal systems. In this context, water quality refers broadly to the physical, biological, and chemical status of the water (Wang, 2001), which tends to have an inverse relationship to intensity of human land uses. Water quality directly influences faunal and floral community composition through its degree of toxicity. Shellfish are particularly sensitive to deteriorating water quality and are valuable economically. Research, such as Line et al., (2008), suggest that fecal coliform water contamination following storm events is not primarily a product of impervious surface cover, but is highly correlated to the frequency of septic tanks in the area (Line et al., 2008). While a strong correlation between impervious cover and fecal coliform is not found in their study, a more detailed, finer scale representation of the impervious cover could have produced a different outcome. The resolution of underlying digital elevation models (DEMs) routinely applied for spatial hydrologic modeling and watershed delineation may poorly characterize the boundaries of basins and assessments of areal impervious cover as well as the representation of flow routing and the potential runoff and stream, ditch or other interception. Geographic Information System (GIS) spatial models have demonstrated their ability to provide for accurate runoff predictions, groundwater infiltration and vulnerability analysis (e.g., GIS-based Depth, Recharge, Aquifer, Soil, Topography, Impact, Conductivity (DRASTIC) groundwater model, Babiker et al., 2005), and are accepted modeled simulation data for storm water permit applications in model ordinances. Potential mis-interpretation of basin-scale percent impervious cover in large basins to analyze fine-scale problems is also a
Structure Analysis of Hedgerows With Respect to Perennial Landscape Lines in Two Contrasting French Agricultural Landscapes
www.igi-global.com/chapter/structure-analysis-of-hedgerows-with-respect-to-perennial-landscape-lines-in-two-contrasting-french-agricultural-landscapes/222947?camid=4v1a