The Role of GIS and Remote Sensing in Wetlands Management

As spatial analysis technology continues to advance, so too does the ability to discover, understand, and manage natural resources. GIS and remote sensing tools have a number of useful applications when it comes to researching and managing wetlands. This paper will briefly cover basic concepts including the benefits of wetlands, the history and use of GIS and remote sensing tools in studying them, and where there is room for improvement moving forward.

Wetlands are also referred to as swamps, bogs, or fens, and often include diverse flora and fauna. Because these ecosystems can be composed of saltwater, brackish, or freshwater, they can vary greatly based on their location in the landscape and their place in the world (Schleupner and Schneider, 2012). They are found in areas between aquatic and terrestrial ecosystems, and while they cover less than one tenth of the planet’s surface, they provide a number of unique and valuable benefits to society. They are used for recreation, agriculture, and fiber products. To name a few of their natural capital services, wetlands can mitigate pollutants, reduce floods, and replenish aquifers (Mwita et al., 2013).

Unfortunately, wetlands are considered one of the most threatened types of ecosystems on Earth. To illustrate, understand that around two thirds of Europe’s wetlands have been lost since the start of the twentieth century (Schleupner and Schneider, 2012). Because of the known benefits wetlands provide society, as well their own intrinsic value and non-anthropocentric utility, it is critical that scientists, corporations, governments, and non-profits work to manage them in a way that ensures there existence in perpetuity. GIS and remote sensing, both integrating and rapidly evolving technologies, have been and will remain a critical aspect of this effort.

In order to sufficiently study wetlands, GIS and remote sensing are virtually a necessity. Remote sensing allows researches to overcome the challenges of inaccessibility and the sheer size of many wetlands. In fact, In situ investigation of wetlands can often be impossible because of constant flooding, thick flora, and dangerous fauna (Mwita et al. 2013). In addition, remote sensing allows for researchers to record changes in wetlands over time, or temporally, which is vital in understanding ecosystem hydrology, land cover, and overall extent or footprint of these systems (Quinn and Ephstein, 2014). Usually both satellite imagery and areal photography are used in conjunction to improve resolution and acquire spatial, temporal, and spectral data. Remote sensing is especially useful because it serves as an unbiased method of collecting data for later analysis using GIS (Hardisky et al., 1986).
Before the development of modern satellite data acquisition, areal photography was the most common form of remote sensing. Panchromatic, true color, and color infrared imagery were and remain critical components of researching wetlands (Hardisky et al. 1986). Today, however, satellites play a huge role in wetland data acquisition. Landsat, SPOT, ERS 1-2, and Terra are the most commonly used systems for wetland detection. MODIS can also be a useful tool because of its high temporal resolution (Chen et al., 2014). It is typical for researchers to acquire data with these technologies and integrate it with ancillary data, or information discovered without remote sensing technology. Examples include GIS data like topography and soil information that allow for mapping of entire aquatic ecosystems (Mwita et al. 2013). Although much less common, hand-held radiometers are sometimes used to record biomass found in relatively small wetlands (Hardisky et al., 1986).

While remote sensing and GIS can be applied to wetlands management in a great number of ways, there are some common themes found in much of the literature. One of the most common types of studies involves examining changes in land use and land cover for wetlands and the adjacent landscape. This type of research is especially helpful in informing policy makers about how land use decisions have impacted or will impact wetland vitality and function. For instance, as urbanization and development continues northwestern Sri Lanka’s capital city, it is estimated that significant portions of deep water, mangroves, and marshes will be lost as a result (Rebelo et al., 2009). If there is a desire to protect wetlands, policy makers in these kinds of situations will have to decide what to prioritize in zoning, building, and other regulatory ordinances.

Another common theme of research is found in classifying the multitude of different types of wetland vegetation. When researchers can increase the number of vegetation classes on record for specific wetland ecosystems, this allows them to increase their understanding of the vegetation profile. Honing sensors to detect the nuanced differences between the reflectance of many different kinds of vegetation allows researchers to better understand the diversity or lack thereof when interpreting the imagery (Townsend and Walsh, 2001). Quantifying the extent and inventorying current wetland coverage as well as finding opportunities for wetland creation is a third common topic in the literature. Because different groups using different data often create wetland inventories, tools that can integrate this information and still maximize resolution play a useful role (Schleupner and Schneider, 2012).

Undoubtedly, remote sensing and GIS will continue to be used in wetlands management strategies at regional, national, and global scales. Moving forward, stakeholders will need to focus on better methods of information sharing in order to understand where wetlands are, if and how they are changing, and what that means for society. Groups like the Ramsar Convention and the Food and Agricultural Organization of the United Nations are doing just that (Rebelo et al. 2009). One can hope that as technology continues to develop, the ability to manage these critical
resources will also improve. Indeed, one can even hope for a reversal of the trend of wetland loss moving forward as decision makers have more knowledge and information to work with.

Annotated Bibliography


In this study, the authors determine the practicality of studying land cover changes using remote sensing technology that offers relatively high temporal resolution at the expense of spatial resolution. The researchers specifically focus on China’s Poyang Lake because of its rapid fluctuations between the wet and dry seasons as well as overall land cover changes in the two decades leading up to the study. Researchers acquired imagery with Earth Explorer, created vegetation indices using MODIS, and used ground data as well as local hydrologic data to confirm final determination of land cover and land change within the study area. Findings supported the assertion that MODIS data used in combination with other technologies that can increase accuracy is incredibly beneficial when examining the temporal resolution of land cover in order to inform the decision making process in the fields of planning, conservation biology, and public health.


Hardisky, Gross, and Klemas provide a general overview of the utility that wetlands provide society. In particular, the authors focus on salt marshes and brackish systems found in coastal areas. They discuss the history of remote sensing in terms of studying wetlands, and they also provide examples of commonly used satellite sensors. Hardisky et al. also compare and contrast technologies used in-situ, aboard aircraft, and from satellites. Overall, the authors suggest that recording imagery and spectral information from wetland systems often requires a combination of areal photography and satellite imagery.

The authors examine the application and usefulness of remote sensing and GIS in mapping wetlands in two East African countries experiencing many different land uses. Specifically, the authors analyze relatively small wetlands in agrarian regions that are difficult or impossible to resolve from the landscape with regular Landsat imagery. By using satellite and aerial images as well as DEM datasets and ERDAS 2011 software, the researchers classify the wetlands and map them in such a way that illustrates their extent, vegetation types, and neighboring land uses and land covers. The authors convincingly assert that this classification system will serve as an effective decision support model guiding land management within the areas studied. In addition, they claim that the classification model can be used in other areas of East Africa dealing with similar land management issues.


Quinn and Ephstein discuss the importance of understanding seasonal fluctuation of wetland extent in order to guide watershed management decisions. The researchers use Landsat ETM+ imagery to analyze land cover at different temporal resolutions when flooding is and is not common. They are then able to quantify the distribution of wetlands within their study area, significantly improving the understanding of this spatial extent as well as natural processes, like evapotranspiration, that occur within the site. The authors argue that this study can be used as a model for delineating wetlands in areas with little or no current examples of these types of data.


In this article the authors discuss the importance of inventorying and monitoring wetlands in order to manage them for society’s benefit. They argue that while organizations like the Ramsar Convention and United Nations FAO are working to improve information sharing between the many groups that study wetlands, there still needs to be a better system in order to guide effective resource management. This is especially critical when inventories are originally based on global datasets. In addition, the authors explain the need for uniform standards across all sectors and disciplines in cataloguing wetland systems. The authors discuss two case studies that illustrate the societal benefit of wetlands management at local scales, arguing that the scope of these kinds of strategies will need to be expanded in order to find similar success managing wetlands at the international level amidst the increasing effects of climate change, population growth, and migration of peoples.

In this piece, Schleupner and Schneider attempt to reconcile the lack of data about wetland distribution within the European Union. In addition, the authors explain how to determine areas that show good potential for wetlands restoration projects. The authors argue that in studying wetlands, there is too much diversity in the types data, classification methods, and database formats among European countries. Because there is no stand-alone, high-resolution representation of wetlands across the region, land use decisions are then made without all of the necessary data. By using a GIS system and distribution model known as SWEDI, the authors improve the spatial accuracy and classification systems of region-wide wetlands data to address this issue.


Townsend and Walsh argue that in order to effectively manage wetland systems, it is critical to understand the location, extent, and vitality of the many vegetative constituents that make up the wetland. Townsend and Walsh attempt to use remote sensing data to increase the number of categories in a vegetation classification system and therefore improve their understanding of the system as a whole. By using a custom classification scheme, the researchers use Landsat TM to record spectral responses throughout the year from similar but distinct plant species in North Carolina. The researchers then use in-situ ground assessments to verify their findings. By vastly diversifying the vegetative hierarchy, the authors provide more data for future examinations and decisions made within the study area.