Role of GIS and Remote Sensing in Wetland Delineation

A wetland is an area of land that is saturated in water, affecting the type of soil, vegetation, and species that inhabit that area. The determining factors when delineating wetlands are hydrophytic vegetation, hydric soils, and wetland hydrology as defined by the Environmental Protection Agency (EPA). Wetlands have been some of the most important habitats recognized around the world. They have been utilized for their recreational uses, their aesthetic, and their natural ability to store water and act as a filter system to improve water quality (Ozesmi, 2002). However, the discrepancies in wetland definitions and standards of delineation have resulted in a loss of these valuable resources. This reason alone promotes the need for rigorous wetland delineation standards.

However, several problems arise when delineating wetlands. Wetlands are some of the most difficult land cover classes to delineate as most occur in forested areas that can hinder both direct in field observation and the use of remote sensing data. Remote sensing can be a valuable tool for monitoring wetlands, but like many other techniques, it has several limitations that can hinder delineation processes. Remote sensing can provide yearly information on wetlands, but it is severely limited by the seasons. Trying to use satellite or aerial photographs to delineate wetlands through a tree canopy will often prove a fruitless endeavor. Additionally, satellite remote sensing spatial resolution may not be adequate to identify smaller wetlands, and the spectral resolution may not be able to discriminate between different types of wetlands (Ozesmi, 2002). Acquiring satellite and aerial photographs with sufficient spectral band and spatial resolution is key to defining wetlands as accurately as possible.

Geographic Information Systems (GIS) and remote sensing have played increasingly large roles in delineating wetlands over the years. In the studies that I researched, GIS has been an incredibly useful mapping and data storing tool. It has also been used in conjunction with other techniques to create a GIS model that can aid wetland delineation. Remote sensing, however, has played the larger part in supplying satellite images and aerial photographs for delineation and classification purposes. For the most part, the most recent Landsat 7 and Shuttle Radar Topography Mission (SRTM) data has been utilized for these studies.

Many methods were used to determine the best way to delineate wetlands. Two studies by Islam et al. (2008), and Kulawardhana et al. (2008) focused on the automated and semiautomated techniques of wetland delineation. Both studies were in agreement that the semiautomated method was more accurate when delineating and classifying wetlands, probably due to its added data analysis and enhancement (Islam, 2008). The automated method, while showing high accuracy in large open water delineation (Kulawardhana, 2008), had increased error levels due to its inability to discriminate between the spectral bands between wetlands and other land cover classes (Islam, 2008). Therefore, it was deemed possible to delineate wetlands using that method, as opposed to the automated method.

The study by Sader et al. tested four different methods; unsupervised classification, tassel cap, a hybrid classification, and a GIS rule based model. The results demonstrated that the unsupervised classification and tassel cap method were the least accurate of the four tested methods. However, the GIS model did not demonstrate an overwhelmingly better accuracy than the hybrid classification. The hybrid method was a combination of unsupervised clusters and supervised training techniques (Sader, 1995). Since both the hybrid method and the GIS model utilized data from the unsupervised classification method, this might account for the similar accuracy between them. Further studies are testing the results of inputing the hybrid data into the GIS model to determine if it increases delineation accuracy. This study demonstrated that both methods are only as accurate as the data used, thus identifying one of the persistent problems surrounding GIS and remote sensing.

Another study by Barrette et al. (2000) compared delineation between aerial photographs and digital orthophotographs. They also tested the accuracy of using Global Positioning Systems (GPS) in addition to using photographs during delineation. While only visiting half of the sites, they were able to determine the level of accuracy compared to the delineations only using the aerial photographs and digital orthophotos. This study is a prime example of how in situ observation can be monumentally useful, even though remote sensing provides advanced means of delineation. This study discovered little difference in accuracy between aerial photographs and digital orthophotos (Barrette, 2000). However, the digital orthophotos were easier to use and eliminated the
need to edge-match. This advantage, though not explicitly beneficial towards accuracy, saved precious time. Likewise, it was found that using a GPS was not necessarily reliable due to the potential for multipathing which would result in reduced accuracy (Barrette, 2000).

Remote sensing and GIS are immeasurably helpful tools during wetland delineations. Alone, or without the aid of in field observation, they can be inaccurate in regards to spatial arrangement and classification of wetlands. Thus, one should not merely forgo the benefits of direct observation for the benefits and ease that technology has to offer. Remote sensing and GIS have demonstrated that they can fill in the information gaps that direct observation can not hope to, but they too provide information gaps when not used in conjunction with in situ observation. Both techniques have merits, and both have flaws, but when they are used together for delineation purposes, they can provide detailed results that would have been time consuming and arduous otherwise.

I believe that remote sensing and GIS have a permanent place as a main tool in this area of study. Both have proven to be immensely useful for wetland delineation. As each case study has discovered, every technique has a certain level of error, but that error can be lessened when using additional, more accurate technology like remote sensing satellite images or aerial photographs. I do not think that remote sensing and GIS should be the only technique used to delineate wetlands, because both have limitations that prevent one hundred percent accuracy, but they have contributed to the progression of wetland delineation immensely. I am confident that they will continue to be relevant and helpful when addressing these issues.

**Annotated Bibliography**


In this study, Sader et al. tested wetland delineation and classification by utilizing the Landsat TM imagery and GIS software to compare mapping accuracies of wetlands. They tested four methods of classification: unsupervised classification, tassel cap, hybrid classification combining unsupervised clusters and supervised training statistics, and a GIS rule based model. This study was conducted in two areas in Maine, Orono and Acadia. Orono consisted of mostly lowland agriculture, wetland forest, and water body areas. Acadia was a larger study site and contained mostly forest upland with very few lowland wetland areas. They study concluded that, while the GIS rule based model had higher accuracy over the unsupervised classification and tassel cap method, it was not sufficiently more affective at mapping wetlands than the hybrid classification. Further studies are being conducted that combine hybrid data and the GIS model for increased accuracy.


This study by Islam et al. tested accuracy of wetland delineation using both aerial photographs and digital orthophotographs of the Ruhuna river basin. Landsat ETM+ 30m data was used primarily and the most useful secondary data was SRTM DEM 90m resolution data. This study tested automated and semi-automated delineation. The automated method was prone to higher levels of error due to confusion of spectral signatures between land cover classes and wetland types. This caused the results to be less acceptable than the semi-automated method which had an accuracy of 97% in regards to wetland delineation and 87% accuracy for wetland classification. The difference in accuracy could be attributed to the added data analysis and enhancement of the semi-automated method.

This article by Ozesmi et al. was an overview of the remote sensing techniques currently being utilized to classify and delineate wetlands. Ozesmi lists such techniques as supervised and unsupervised classification, visual interpretation, hybrid classifications, and regression analysis. For each technique he explains their merits and their disadvantages. He also lists the remote sensing sensors utilized for wetland classification. Remote sensing is described as being an incredibly useful tool, but difficult to utilize to its full potential. Ozesmi suggests that additional techniques are required to obtain the results that are desired.


This study by Barrette et al. compared the horizontal accuracy of wetland delineations through aerial photographs and digital orthophotographs. They used GPS receivers and GIS software to measure each set of wetlands and compare it to the true location. Half of the sites were visited during the study to measure the degree of accuracy obtained through assisted visitation. The other half were only visited after the study commenced to measure the degree of accuracy. The study determined that both methods of delineation were similarly accurate but the digital orthophoto delineation was easier and less time consuming because of the added benefit of GIS software that eliminated the need for arduous methods like edge matching. The use of GPS did not necessarily increase accuracy due to the likelihood of multipath because of the forest and terrain.


This study by Kulawardhana et al. investigated methods for delineating, classifying, and characterizing wetlands that could be applied globally. They understood the need for methods and data sets that would allow for rapid delineation and mapping. The data they utilized was the Landsat geocover for the year 2000 and the SRTM data because both are available free thus allowing easy application to other areas globally. The study site was the Limpopo river basin in South Africa. They used automated and semi-automated methods. The results showed that automated methods showed high delineation accuracy for large open water and associated wetlands but unsatisfactory accuracy when delineating smaller or seasonal wetlands. The semi-automated methods had much higher levels of accuracy. They concluded that it was possible to delineate wetlands using semi-automated methods.


This study by Torbick was conducted in Lucas County, Ohio. This was a dissertation aimed at using remote sensing to successfully delineate and classify wetlands. This study began with the understanding that the goal of the study controls which sensors are used since both have advantages and limitations based on their respective resolutions. Torbick used Landsat 7 ETM+ data and utilized GIS modeling techniques. Torbick utilized supervised classification with training signatures to train the software to find similar pixels. The results showed that remote sensing and GIS models can provide important data about wetlands but should not be used alone for delineation purposes. Instead, they can be used to supplement future studies, provide potential wetland locations, and give data about the conditions of the wetlands.