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ASSESSMENT OF THE NATIONAL WETLANDS INVENTORY: IMPLICATIONS FOR WETLAND PROTECTION

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ABSTRACT: Historically, wetland loss and disturbance across the United States have been largely associated with agricultural land use practices. Recent trends in urban development within and around wetlands in response to growing populations, however, have attracted attention and concern. The increasing trend in wetland losses and knowledge of the functional values wetlands provide communities have led state and local governments to strengthen wetland regulations. Many local and state governments, however, lacking the resources to generate up-to-date and detailed wetland maps have mandated their wetland regulations be implemented based on the National Wetlands Inventory (NWI). Vermont, for example, enacted such legislation in 1990. Because NWI maps were not intended for regulatory purposes, however, their use has important implications for wetland protection across the U.S.

To address this issue, this study (1) compared the accuracy of NWI maps to updated wetland databases over a 50,000 acre area encompassing two townships in central Vermont, and (2) evaluated development histories within these townships over nearly a decade. Updated wetland databases were derived from 1:40,000 scale CIR photography and incorporated within a GIS framework for subsequent analyses. Not surprisingly, the NWI underestimated the areal extent of wetlands over the study area by 39%. In addition, analysis of building permits confirmed that development of parcels containing wetlands rose from 23% to 100% over the study period. In summary, this study confirms that relying solely on the NWI may fail to protect a significant fraction of wetland resources in Vermont and the U.S.
KEY WORDS: wetlands; development; mapping; map accuracy; National Wetlands Inventory

INTRODUCTION

Prior to the mid-1950s, as much as 87% of all wetland losses in the United States were attributed to agricultural practices, particularly the conversion of fertile wetland soils to cropland. By the mid-1980s, in contrast, agriculture accounted for only 20% of all wetland loss nationally (NRCS, 1992). Although this shift is due in part to the decline in agricultural land use across the country since 1950, wetland losses today are largely the consequence of urban development activities. Residential, commercial, and industrial development alone are estimated to be responsible for 48-57% of all wetland loss or impairment in the U.S. today and over 90% of all recent losses within New England (NRCS 1992, Brady and Flather 1994). Within Vermont, wetland losses in Chittenden County, the most rapidly developing county in the state, are twice that of any other county in the state (Vermont Agency of Natural Resources, 1996).

To protect the state's remaining wetlands from the increasing threat of development, the Vermont Wetland Rules (VWR) were enacted in 1990 which defined guidelines for the identification, protection, and regulation of significant wetlands. Under the VWR, state regulatory wetlands are defined as those identified on National Wetlands Inventory (NWI) maps (Vermont Water Resources Board, 1990). All such wetlands are subject to state regulation, as is any development that has the potential to compromise the ecological integrity or cultural values within a designated buffer zone extending from the wetland perimeter. Administration of the VWR lies with local municipalities, including requiring developers to seek state permits if their proposed activities fall within an identified wetland or its buffer zone.

Although National Wetlands Inventory (NWI) maps are the legal basis for the regulation of development near wetlands in Vermont, as well as many communities across the U.S., their limitations for local regulatory purposes are well recognized (Tiner, 1987; Dudley, 1997). When resources allow, local governments have led efforts to create wetland maps at scales and accuracies more appropriate to their needs. Unfortunately, these efforts are largely uncoordinated and, because of variable wetland definitions between political administrations, resultant maps are often non-standardized and thus difficult to share

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(Springston, 1993). For the many U.S. communities lacking the resources to independently map their wetlands, the NWI compiled largely from 1:80,000 scale aerial photography from the 1980's remain their primary source of wetland boundary information.

In recognition of these issues and the potential implications for wetland protection, this study assessed the accuracy of NWI wetland maps and analyzed development trends on lands adjacent to wetlands over an eight-year period (1990-1998) for two rural townships in Chittenden County, Vermont. The size, areal extent, number, and type of NWI wetlands were examined in relation to recently updated wetland maps commissioned by the townships and linked with building permit data within a Geographic Information System (GIS).

METHODOLOGY

GIS Database Development

This study was conducted for the adjacent townships of Charlotte and Hinesburg, Vermont within the Lake Champlain watershed. The townships are nearly equal in area and represented by a patchwork of agricultural and forested lands. Although striving to preserve their historic rural character, both towns are facing increasing development pressures from Burlington, the nearby urban center which is the largest and fastest growing in the state.

Wetland Mapping

Digital maps of each township's existing wetlands were derived from both the NWI and photo-interpreted 1:40,000 scale color-infrared (CIR) aerial photography acquired through the U.S. National High Altitude Photography (NHAP) program. The process used to create the updated wetlands maps was consistent in design between the two townships. In addition, all photo-interpretation and wetland delineations were performed by a single individual. The aerial photography was acquired during the spring of 1992-94 during leaf-off conditions to allow for canopy penetration and the identification of high water levels. Wetland boundaries were traced onto acetate overlays. The minimum mapping unit was approximately 1 acre. Identified wetlands were classified using the U.S. Fish and Wildlife Service Wetland Classification System (Cowardin et al., 1979) aided by site visits. Wetlands within the study area were thus classified into four functional groups: emergent, forested, scrub-shrub, and unconsolidated bottom.

Following photointerpretation, the CIR transparencies and acetate overlays were scanned, rectified to a map base, and the wetland boundaries screen digitized to create a vector wetland data layer. The resultant ground (pixel) resolution of the imagery was approximately 3 meters, twice that of the source photography from which the NWI maps were derived. The images were then ortho-rectified to remove inherent distortions and registered to a common map base using ground control points (GCP), the state's E911 road data layer (1:5,000 scale), and 1:5,000 digital elevation model (DEM) data provided by the Vermont Mapping Program. At least 25 GCPs were selected and distributed throughout each image. Using the delineations that were embedded in the rectified images, a wetland data layer was created by digitizing wetland boundaries on screen and adding attribute information. All image processing was completed using ERDAS Imagine and the OrthoMax module (ERDAS, 1997). Resultant wetland maps were saved as coverages within ESRI's ArcInfo (ESRI, 1997).

Subsequent spatial analyses examined the differences between the NWI wetland maps and the updated wetland maps for each township. The analysis examined the areal extent, type, number, and size of wetlands for each set of maps.

Development Permits

All local building and state wetland permits issued within the towns of Charlotte and Hinesburg between the years 1990 and 1998 were examined and tabulated as attribute data within the tax parcels data layer for each town. Detailed local building permits were reviewed at each Town Hall and used as an indicator of development activity. Permits issued by the VT Department of Environmental Conservation, in turn, identified parcels containing wetlands for which development was proposed, while the State's Wetlands Office provided detailed wetland descriptions for each permit administered.

RESULTS

Not surprisingly, the NWI dramatically underestimated both the number and areal extent of wetlands within the Charlotte and Hinesburg townships (Figure 1). Compared to the updated wetland maps derived from the NHAP imagery, the NWI underestimated the areal extent of wetlands over the ~50,000 acre study area by 39%. Whereas the NWI identified 383 palustrine wetlands encompassing 2425 acres or approximately 4.7%of the study area, the updated wetland maps identified

1791 wetlands encompassing 3980 acres representing 7.7% of the study area. Figures 2 and 3 illustrate that wetlands less than or equal to the three-acre nominal minimum mapping resolution of the NWI were most often omitted. In fact, 82% of wetlands ≤ 3 acres both in number and areal extent were omitted from the NWI maps. More surprisingly, 68% by number and 64% of the areal extent of wetlands ranging in size from 3 to over 20 acres were also omitted (Figure 2) from the NWI maps. The error in the overall NWI wetland inventory due to omission of both the smaller and moderate-sized wetlands was largely offset, however, by NWI's gross overestimation (83%) of the areal extent of wetlands greater than 20 acres in size (Figure 3). As the results indicate, the 1:80,000 scale of the NWI source photography is simply inappropriate to capture the numerous small wetlands or accurately delineate the complex boundaries that are common in heterogeneous landscapes characteristic of many rural areas, such as in Vermont.

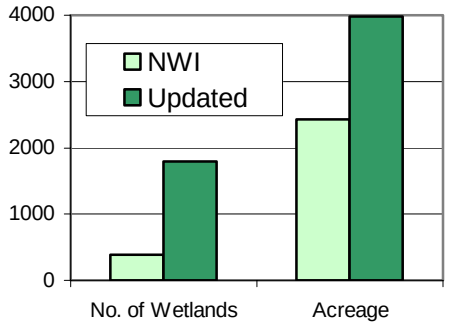

Figure 1. Wetland inventories by number and areal extent for the NWI and updated wetland maps for the townships of Charlotte and Hinesburg, VT. The updated wetland maps identified 4.5 fold more wetlands and 39% more wetland area.

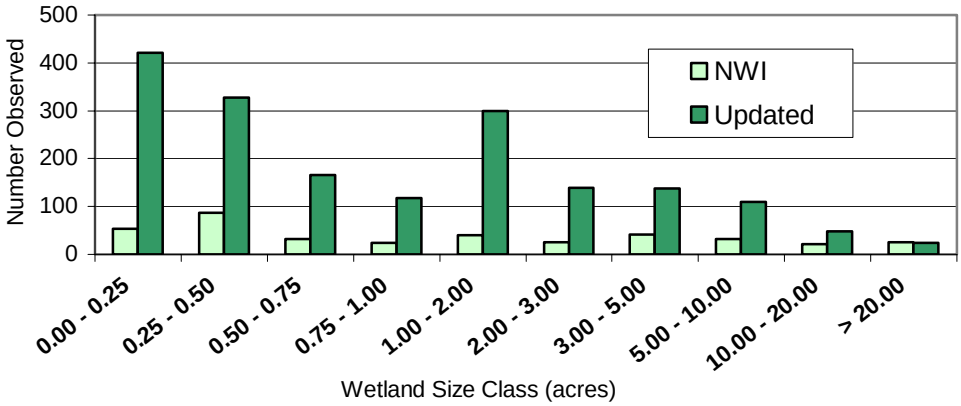

Figure 2. Frequency distribution by wetland size class for the NWI and updated wetland maps for the towns of Charlotte and Hinesburg, VT. Although the majority of the wetlands omitted (1210) from the NWI maps were smaller than the NWI's minimum mapping unit of 3 acres, over 200 wetlands ranging in size from 3 to over 20 acres were also omitted.

Overall, NWI classification accuracy was also clearly related to wetland type (Figure 4). In particular, the NWI omitted 79% of the emergent wetland area and 64% of the forested wetlands and their associated complexes. Only a small fraction of the total wetland area within the townships was represented by the scrub-shrub and unconsolidated bottom wetlands. Historically, forested wetlands were considered the most difficult to photo-interpret and thus regarded as the most likely to be omitted from maps derived from aerial photography (Kudray and Gale, 2000). As demonstrated here, however, the detection of emergent wetlands may also prove difficult, particularly when located in or adjacent to agricultural fields appearing similar in tone and texture. Importantly, it is often these marginal agricultural lands that are increasingly sought for development throughout the region. These emergent wetlands, therefore, could be readily overlooked when faced with the pressures of development if not accurately mapped.

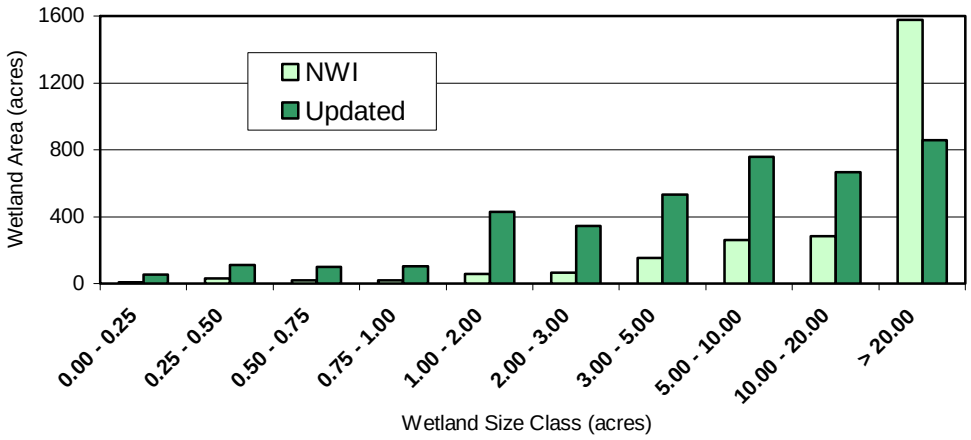

Figure 3. Wetland area by wetland size class for the NWI and updated wetland maps for the towns of Charlotte and Hinesburg, VT. Nearly 82% of the areal extent of wetlands ≤ 3 acres and 64% of wetlands in the 3-20 acre size class were omitted from the NWI maps. In contrast, the NWI overestimated the areal extent of wetlands over 20 acres in size by 83%.

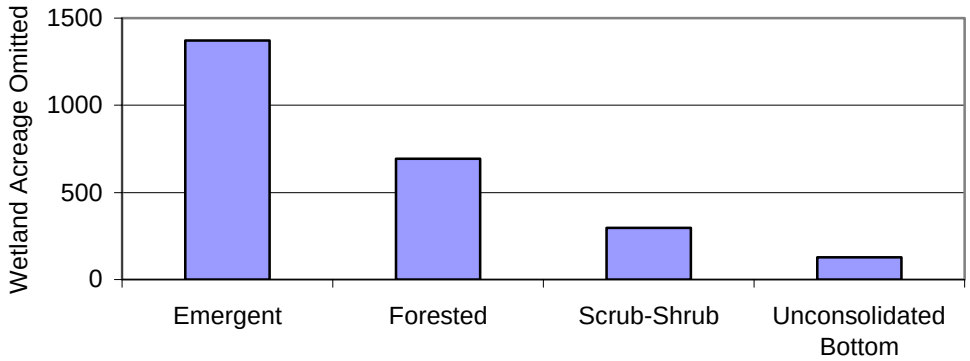

Figure 4. Wetland area omitted by the NWI by wetland class for the towns of Charlotte and Hinesburg, VT. Emergent wetlands were the most commonly omitted (79% by area), followed by forested wetlands (64% by area).

Using the NWI and updated wetland data layers, we identified parcels that both included wetlands and that were developed during the period of this study. Although the presence of a wetland on a developed property does not necessarily mean that construction took place within the wetland or its associated buffer zone, it does provide insight into the proximity of new development to wetland resources. Despite some variability over time in the number of building permits for new development, the fraction of parcels developed that included wetlands rose from 23% in 1992 to 100% in 1998 (Figure 5). These results suggest that although the trend of urban growth began in the 1980s, it is only in the last decade that the use of marginal land, including parcels on which wetlands are located, has become commonplace.

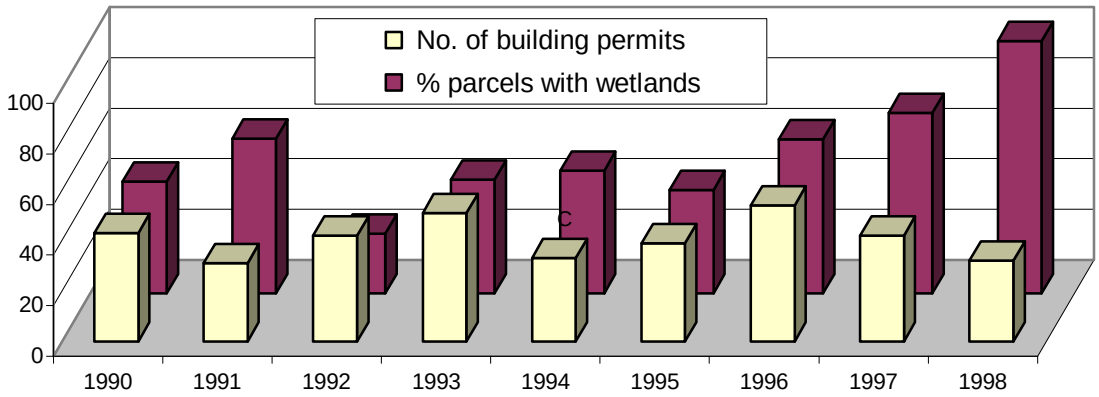

Figure 5. Distribution over time in the number of building permits and percentage of developed parcels containing wetlands for the towns of Charlotte and Hinesburg, VT. In the last decade the use of marginal land, including parcels on which wetlands are located, has become commonplace.

CONCLUSIONS

Although changes in wetland boundaries over the approximately 15 year intervening period between when the NWI and updated maps were produced cannot be ruled out as contributing to the observed differences between these data, the results summarized here clearly indicate that the relatively poor spatial resolution, generalized delineation of wetland boundaries, and poor classification accuracy of the NWI severely compromises its value to aid management of wetland resources in spatially-complex landscapes such as in Vermont. Although this is not a new realization for the many communities charged with administering their state wetland regulatory programs, the reality is that many municipal planning departments across the country do not have the resources or trained staff to generate more accurate and detailed wetland maps. As a consequence, the effectiveness of many wetland protection programs may be limited in part by the accuracy of the NWI and, therefore, may fail to effectively protect many wetlands despite the intent of regulatory legislation. Investment in higher spatial resolution and updated wetland maps, in contrast, offers the potential to strengthen wetland protection, particularly in the face of increasing development pressures, and improve management of development in and near wetlands in rural areas throughout the U.S.

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