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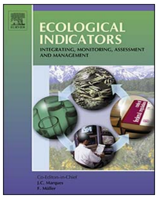

Building a potential wetland restoration indicator for the contiguous United States

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ABSTRACT

Wetlands provide key functions in the landscape from improving water quality, to regulating flows, to providing wildlife habitat. Over half of the wetlands in the contiguous United States (CONUS) have been converted to agricultural and urban land uses. However, over the last several decades, research has shown the benefits of wetlands to hydrologic, chemical, biological processes, spurring the creation of government programs and private initiatives to restore wetlands. Initiatives tend to focus on individual wetland creation, yet the greatest benefits are achieved when strategic restoration planning occurs across a watershed or multiple watersheds. For watershed-level wetland restoration planning to occur, informative data layers on potential wetland areas are needed. We created an indicator of potential wetland areas (PWA), using nationally available datasets to identify characteristics that could support wetland ecosystems, including: poorly drained soils and low-relief landscape positions as indicated by a derived topographic data layer. We compared our PWA with the National Wetlands Inventory (NWI) from 11 states throughout the CONUS to evaluate their alignment. The state-level percentage of NWI-designated wetlands directly overlapping the PWA ranged from 39 to 95%. When we included NWI that was immediately adjacent to the overlapping NWI, our range of correspondence to NWI ranged from 60 to 99%. Wetland restoration is more likely on certain landscapes (e.g., agriculture) than others due to the lack of substantive infrastructure and the potential for the restoration of hydrology; therefore, we combined the National Land Cover Dataset (NLCD) with the PWA to identify potentially restorable wetlands on agricultural land (PRW-Ag). The PRW-Ag identified a total of over 46 million ha with the potential to support wetlands. The largest concentrations of PRW-Ag occurred in the glaciated corn belt of the upper Mississippi River from Ohio to the Dakotas and in the Mississippi Alluvial Valley. The PRW-Ag layer could assist land managers in identifying sites that may qualify for enrollment in conservation programs, where planners can coordinate restoration efforts, or where decision makers can target resources to optimize the services provided across a watershed or multiple watersheds.

1. Introduction

Wetlands provide key functions in the landscape including removing water pollution, regulating water storage and flows, storing carbon, and providing habitat for wildlife (Zedler, 2003; Kayranli et al., 2010). These functions result in benefits to humans including flood abatement, climate regulation, clean water, and access to recreational resources. Wetlands contribute to the economy, protect community infrastructure, and provide benefits to overall health and well-being (MEA, 2005). Wetlands provide billions, perhaps trillions of dollars in ecosystem services with studies estimating a wide range of monetary values per hectare of wetland (Schuyt and Brander, 2004; Adusumilli, 2015). The contribution of ecosystem services provided by wetlands is disproportionately large considering that wetlands only account for 44.6 million ha or 5% of total area in the contiguous United States (CONUS; MEA, 2005)

Despite the millions of wetland hectares currently in the United States (U.S.), the number represents only half of the wetland area present 200 years ago (Dahl and Johnson, 1991; Mitsch and Hernandez, 2013; Dahl, 2011). The reduction in wetlands over time has been largely due to land use changes such as farming, urbanization, and the hydrologic alterations that were required to make alternative land uses possible (i.e., dikes, dams, tiles, ditches, and channels). The conversion of wetlands to other land uses was a standard practice between the

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1850s–1960s, but in recent decades, society has recognized the benefits wetlands provide, resulting in new procedures and policies that protect remaining wetlands. In addition to protection of the remaining wetlands, numerous efforts and policies have focused on wetland restoration to regain wetland acreage (Zedler, 2000; NRC, 2001; Zedler, 2003) and to mitigate for present-day wetland conversion. For example, payouts to farmers were instituted by United States Department of Agriculture (USDA) as a way to incentivize wetland restoration on agricultural land in the U.S. In the past several decades, over 930,000 ha of wetlands have been enrolled in the Wetland Reserve Program (WRP; NRCS, 2012). Between 2004 and 2009, around 200,000 ha of upland wetlands were reestablished on agricultural lands (Dahl, 2011). Incentive programs, like WRP, are voluntary and consequently restorations are often considered and planned individually. Wetland restoration success and the subsequent ecosystem benefits are linked to landscape-level processes including hydrology, soils, topography, and land cover within a watershed (Caldwell et al., 2011). Researchers recommend careful thought about the placement of wetland restorations within a watershed in order to optimize key wetland functions and services (NRC, 2001; Hansen and Hellerstein, 2006; Diebel et al., 2008; Palmer, 2009). By including consideration of spatial location in site selection, wetland restoration specialists can leverage benefits from existing natural wetlands including facilitating movement and colonization of plants and animals, flow accumulation, nutrient retention, and erosion capture (White and Fennessy, 2005). Planning restoration aimed at regaining services in a watershed can be daunting given the spatial and temporal complexity of biological, biochemical, and hydrologic patterns. Consequently, many restoration efforts tend to target one, or at most two, aspects of wetland function (Moreno-Mateos and Comín, 2010). For example, in the midwest, breaking drainage tiles in former agricultural fields is helping restore biodiversity and waterfowl habitat to farmland wetlands while integration of downstream wetlands that receive tile drainage is enhancing nutrient retention from fields (Crumpton et al., 2006).

The most complete spatial information on existing wetlands for the CONUS can be found in the U.S. Fish and Wildlife Service's National Wetland Inventory (NWI). With the exception of the modified hydric soils layer provided by the Natural Resources Conservation Service (NRCS) gridded Soil Survey Geographic (gSSURGO) database, there has been no systematic approach developed to identifying areas for planning new or restoring historic wetlands (Soil Survey Staff, 2012). In the regulatory field, wetlands have been defined by the presence of hydric soils, standing or saturated water during the growing season, and the presence of hydrophytic vegetation (USACE, 1987). Ecologically, wetlands are categorized first by landscape position (e.g., point of lowest relief in a field), then by land cover type, and then by hydrologic regime (Cowardin et al., 1979). When wetlands are converted to other land uses like agriculture, hydrophytic vegetation is removed and hydrology is often altered. However, long-term soil properties and landscape position remain. In this paper, we describe a method to identify areas and quantify the potential abundance of restorable wetlands in the CONUS where the restoration of wetlands could potentially result in a return of ecosystem services. By combining multiple nationally available data layers of soil drainage, topographic relief, and land cover, we create an indicator with four suitability classes for potential wetland restoration.

2. Methods

The creation of a potential wetland restoration data layer for the CONUS requires several national dataset inputs and derivations of those input layers. In the following paragraphs we describe in detail: 1) the necessary input data layers, 2) the creation of a topographic index, 3) a soil drainage data layer, 4) a categorized potential wetland area (PWA) data layer, and finally 5) a categorized potentially restorable wetlands on agricultural land (PRW-Ag) data layer.

2.1. National dataset inputs

Multiple national datasets were required as inputs for the creation of the PWA and PRW-Ag data layers. Each of these datasets were developed as, or converted and aligned into, 30 m grids for analysis and comparison on a grid cell by grid cell basis.

The National Elevation Data (NED), a gridded elevation product with a resolution of 1 arc-second or about 30 m, was downloaded from the U.S. Geological Survey (https://lta.cr.usgs.gov/NED). This layer was used to develop the topographic index.

Soils data used the NRCS Soil Survey Geographic Database (SSURGO) and the U.S. General Soil Map (STATSGO2) databases (Soil Survey Staff, 2006a,b). The more detailed digital SSURGO data covers 95% of the CONUS and has a spatial scale, usually mapped at 1:24k or 1:12k depending on the soil variable. Where SSURGO was unavailable (i.e., mountains, deserts, and military areas), we included the soils layers from STATSGO2 data that has an aggregated spatial scale of 1:250k (Appendix A). A soil map unit, which varies in size and shape, may be comprised of multiple soil types or components that are assigned a percentage of the whole map unit. Attribute data were primarily obtained from the map unit, component, and component horizon attribute tables in the associated attribute database. The SSURGO/STATSGO2 vector data were converted to 30 m grid rasters by assigning the soil drainage value from the map unit polygon intersecting the cell center. These layers were used to develop the soil drainage layer.

The NWI is a multi-decadal mapping effort of wetlands which relies on aerial photography and field assessments to identify wetlands with source imagery ranging from the 1970s through the present. The NWI consists of millions of vector/polygon shapes which represent multiple wetland types including freshwater marshes, forested wetlands, and open water ponds (Cowardin et al., 1979). We downloaded the NWI

Table 1

Area and percentage of potential water accumulation through the Compound Topographic Index (CTI ≥ 550), poorly drained and very poorly drained soils (PVP), National Wetland Inventory (NWI) emergent and forested wetlands, and the overlap between NWI, CTI, and PVP.

Location	CTI within state (ha)	% of State Area	PVP within state (ha)	% of State Area	NWI within state (ha)	% of State Area	CTI within NWI (ha)	% NWI	PVP within NWI (ha)	% NWI
CA	13,410,510	33	2,490,262	6	582,656	1	468,271	80	246,261	42
FL	11,202,005	76	10,547,262	72	3,974,476	27	3,654,980	92	3,840,031	97
GA	5,795,984	38	4,584,529	30	1,900,892	12	1,653,491	87	1,680,416	88
IA	4,853,453	33	7,007,811	48	232,546	2	178,324	77	206,242	89
MO	4,349,028	24	7,038,238	39	411,195	2	284,301	69	323,549	79
MS	4,475,464	36	9,368,422	76	1,508,841	12	1,046,533	69	1,326,921	88
NC	4,034,420	32	5,668,251	44	1,492,951	12	1,125,617	75	1,424,488	95
NY	3,412,688	27	2,064,464	16	697,476	6	517,082	74	485,548	70
OH	3,342,862	31	2,634,385	25	205,407	2	135,006	66	109,645	53
SD	7,806,264	39	12,783,969	64	681,749	3	607,911	89	633,865	93
WA	3,280,737	19	1,102,192	6	262,927	2	191,222	73	111,197	42