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# Surrounding land cover types as predictors of palustrine wetland vegetation quality in conterminous USA

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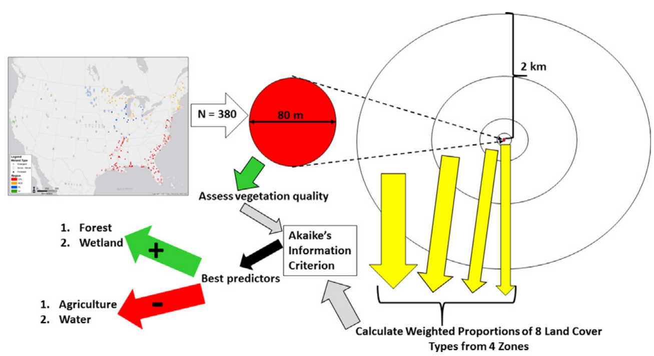
## HIGHLIGHTS

- We calculated 2 indices of wetland vegetation quality at 380 sites in 4 regions of USA.
- 8 land cover types in 4 zones surrounding wetlands were used to predict the indices.
- Forest, followed by wetland, had the greatest overall positive effect on the indices.
- Agriculture had the greatest overall negative effect on the indices.
- Forest buffers and wetland contiguity should increase regional vegetation quality.

## GRAPHICAL ABSTRACT

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## ABSTRACT

The loss of wetland habitats and their often-unique biological communities is a major environmental concern. We examined vegetation data obtained from 380 wetlands sampled in a statistical survey of wetlands in the USA. Our goal was to identify which surrounding land cover types best predict two indices of vegetation quality in wetlands at the regional scale. We considered palustrine wetlands in four regions (Coastal Plains, North Central East, Interior Plains, and West) in which the dominant vegetation was emergent, forested, or scrub-shrub. For each wetland, we calculated weighted proportions of eight land cover types surrounding the area in which vegetation was assessed, in four zones radiating from the edge of the assessment area to 2 km. Using Akaike's Information Criterion, we determined the best 1-, 2- and 3-predictor models of the two indices, using the weighted proportions of the land cover types as potential predictors. Mean values of the two indices were generally higher in the North Central East and Coastal Plains than the other regions for forested and emergent wetlands. In nearly all cases, the best predictors of the indices were not the dominant surrounding land cover types. Overall, proportions of forest (positive effect) and agriculture (negative effect) surrounding the assessment area were the best predictors of the two indices. One or both of these variables were included as predictors in 65 of the 72 models supported by the data. Wetlands surrounding the assessment area had a positive effect on the indices, and ranked third (33%) among the predictors included in supported models. Development had a negative effect on the indices and was included in only 28% of supported models. These results can be used to develop regional management plans for wetlands, such as creating forest buffers around wetlands, or to conserve zones between wetlands to increase habitat connectivity.



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## 1. Introduction

The loss of wetland habitats and their often-unique biological communities is a major environmental concern (e.g., Gibbs, 2000; Johnson, 1994). The National Wetland Condition Assessment (NWCA) was conducted in response to the Nation-wide loss of wetlands and the lack of knowledge of the overall ecological condition of wetlands in the USA (U.S. EPA, 2016). The NWCA is a statistically-based, interagency survey of wetlands in the conterminous USA. The survey provides data on numerous components of wetland ecosystems, particularly vascular plants. Objectives of the NWCA include assessing the ecological condition of the Nation's wetlands and the stressors associated with wetlands of poor condition. Mitigating these stressors is intended to be part of future wetland restoration and construction projects.

Wetland mitigation projects in the USA have not been overly successful. The National Research Council (NRC) reviewed wetland mitigation and restoration projects in the USA and concluded that only about 7% resulted in "good" quality wetlands, whereas >40% resulted in "poor" or lower quality wetlands (NRC, 2001). Among the recommendations the NRC made for improving the success of wetland restoration, mitigation, and construction was the identification of cost-effective indicators for use in wetland monitoring and restoration programs. Quality assessment indices (QAIs) and indices of biological integrity (IBIs) and their component metrics are useful for assessing the responses of taxa from different regions in response to environmental stressors (e.g., Stapanian et al., 2013).

IBIs and QAIs are used in many States for important management decisions, such as whether or not development can occur in wetlands. In Ohio, indices have been developed for vascular plants (Mack, 2007; Gara, 2013; Mack and Gara, 2015), amphibians (Micacchion, 2004); and mosses (Andreas et al., 2004; Schumacher et al., 2016). Modeling studies (Gara and Stapanian, 2015; Micacchion et al., 2015; Stapanian et al., 2013, 2015, 2016a) revealed that a metric assessing habitat and substrate disturbance, alteration, and development within the wetland was found to be the best overall predictor of these indices. Thus, management practices aimed at those characteristics at a wetland site might simultaneously enhance all three biological communities. Evaluation of the association between wetland condition and these on-site stresses would enable management agencies to more efficiently allocate resources for wetland restoration. However, some disturbances that are assessed within the wetland and affect vegetation quality, such as excess soil nutrients from agricultural runoff (Stapanian et al., 2016b), are directly due to land use in the area surrounding the wetland (Brinson, 1993). Further, land use and anthropogenic disturbances in the area surrounding wetlands may take longer to cause measurable or observable effects on vascular plants, particularly in wetland communities dominated by long-lived species such as trees (Stapanian et al., 2013). Finally, many possible aspects of plant condition that are associated with atmospheric conditions (e.g., Tingey et al., 1976) were not assessed in those plant indices (Stapanian et al., 2016a). Cumulative alteration of the landscape may be a major impediment to wetland restoration (e.g., Bedford, 1999).

Some land use types in the area surrounding wetlands can mitigate the effects of disturbances that may affect wetland plant communities, whereas others can be deleterious. For example, forests surrounding emergent wetlands can mitigate the negative effects on wetland plant communities resulting from excess soil phosphorus from agricultural runoff (Stapanian et al., 2016b). In contrast, certain land use types may provide seed dispersal corridors that enhance invasion by non-native plant species into wetlands (e.g., Cutway and Ehrenfeld, 2010).

In this paper we examine data collected from NWCA surveys for three types of palustrine wetlands (emergent, forested, and scrub-shrub) in four large, multi-State regions of the USA. For each wetland, we determine two indices of vegetation quality. We test for regional differences in the two indices for each of the three wetland vegetation types. Next, we calculate the weighted proportions of eight general land cover types in four zones, extending out to 2 km, surrounding the area in which the vegetation was assessed in each wetland. Using these weighted proportions as independent variables, we use a linear regression modeling approach to determine which combinations of land cover types best predict the two indices of wetland vegetation quality. Separate analyses are performed for each wetland vegetation type in each region. A goal is to identify which land cover types are most influential in determining wetland vegetation quality at the multi-State scale. Such information may be useful for applying effective, broad-scale management policies.

## 2. Material and methods

### 2.1. Study areas

Data were obtained from the NWCA database for 380 wetlands from the Eastern Mountains and Upper Midwest (hereafter, "North Central East"), Coastal Plains, Interior Plains, and West regions (U.S. EPA, 2016; Fig. 1). We restricted our analyses to palustrine emergent (hereafter, "emergent"; N = 162), palustrine forested ("forested"; N = 156), and palustrine scrub-shrub ("scrub-shrub"; $N = 62$) wetlands, as described by U.S. EPA (2011). We considered only those combinations of region and wetland vegetation type for which the number of wetlands > 18. This limit was determined both for statistical reasons described below and for practicality. We further restricted our analyses to wetlands for which the assessment area was circular, as described below and by U.S. EPA (2011). These restrictions enabled a more standardized assessment of the zones surrounding each wetland.

### 2.2. Field methods

Vegetation data were collected during 2011. Complete field methods for plot layout and collection of vascular plant data are described elsewhere (U.S. EPA, 2011). Briefly, the vegetation data were collected in five 10 m × 10 m subplots within the "assessment area," which was defined by a circle of radius of 40 m. Transect lines were laid out in the four cardinal compass directions, with each line extending 40 m from the plot center. The five subplots were established at fixed distances along these transect lines. Two subplots were established on the South line; one subplot was established on each of the remaining three lines. One side of each subplot was on a transect line; one side was parallel to, and 10 m from, that line; and the remaining two sides were 10 m apart and perpendicular to that same line. On the North and West lines, the subplot had corners that were 15 m and 25 m from the plot center, along the transect line. On the East line, the subplot had corners that were 20 m and 30 m from the plot center, along the transect line. On the South line, one of the subplots had corners that were 2 m and 12 m from the plot center; the other subplot had corners that were 22 m and 32 m from the plot center. In each subplot plant species were identified, and aerial cover class was estimated according to Peet et al. (1998) for each vascular plant species we found.

### 2.3. Calculation of the dependent variables

For each wetland, we calculated two indices of vegetation quality, the Floristic Quality Assessment Index (FQAI; Andreas et al., 2004) and the Weighted Coefficient of Conservatism (WTCC). A critical component of both metrics is the Coefficient of Conservatism (CC; e.g., Andreas et al., 2004; Gara, 2013; Stapanian et al., 2016a). Each plant species was assigned a coefficient of conservatism (CC) that ranges between 0 and 10. The CC describes a species' degree of fidelity to habitat relative to other species in the flora. A CC of 0 is assigned to species with a wide range of ecological tolerances, including all non-native species and native species that are associated with highly disturbed habitats. Species that are associated with anthropogenic disturbance and found on a variety of substrates receive CCs of 1–2. Species with CCs of 3–5 are somewhat intermediate in tolerance to disturbance and substrate fidelity.