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Moss and vascular plant indices in Ohio wetlands have similar environmental predictors

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ABSTRACT

Mosses and vascular plants have been shown to be reliable indicators of wetland habitat delineation and environmental quality. Knowledge of the best ecological predictors of the quality of wetland moss and vascular plant communities may determine if similar management practices would simultaneously enhance both populations. We used Akaike's Information Criterion to identify models predicting a moss quality assessment index (MQAI) and a vascular plant index of biological integrity based on floristic quality (VIBI-FQ) from 27 emergent and 13 forested wetlands in Ohio, USA. The set of predictors included the six metrics from a wetlands disturbance index (ORAM) and two landscape development intensity indices (LDIs). The best single predictor of MQAI and one of the predictors of VIBI-FQ was an ORAM metric that assesses habitat alteration and disturbance within the wetland, such as mowing, grazing, and agricultural practices. However, the best single predictor of VIBI-FQ was an ORAM metric that assessed wetland vascular plant communities, interspersion, and microtopography. LDIs better predicted MQAI than VIBI-FQ, suggesting that mosses may either respond more rapidly to, or recover more slowly from, anthropogenic disturbance in the surrounding landscape than vascular plants. These results supported previous predictive studies on amphibian indices and metrics and a separate vegetation index, indicating that similar wetland management practices may result in qualitatively the same ecological response for three vastly different wetland biological communities (amphibians, vascular plants, and mosses).

1. Introduction

Recent work indicated that habitat alteration and development were the most important predictors of an amphibian index of biological integrity (AmphIBI), its component metrics, and an index of wetland vegetation biological integrity (OVIBI) developed for the State of Ohio, USA (Stapanian et al., 2013, 2015; Micacchion et al., 2015). Thus, similar management practices were identified that would result in increasing the biological integrity of two different wetland biological communities (amphibians and vascular plants). Progress toward a more unified theory of ecological indicators was an unexpected result.

OVIBI has several shortcomings as an index of biological integrity of vascular plants (Gara and Stapanian, 2015). First, OVIBI has 10 component metrics, which are different for each wetland vegetation type (e.g., emergent, forested, or shrub). Early stages of plant community development are extremely dynamic, as a site can transform from emergent to shrub to forest within a decade. Although the various metrics used in OVIBI are strongly correlated with a human disturbance gradient (Mack, 2007), how individual metrics respond during the early stages of plant community development is not clear (Gara and Stapanian, 2015). Thus, OVIBI scores generated for mitigation sites may be difficult to interpret. Finally, the OVIBI score is separately calibrated to a wide variety of vegetation community types, hydrogeomorphic classes, and ecoregions. Thus, comparing scores across various wetland types may be questionable.

In response to these concerns, a vegetation index of biological integrity based on floristic quality (VIBI-FQ) was developed (Gara, 2013; Gara and Stapanian, 2015). The index was designed so that scores of different vegetation and community types can be compared directly. Further, the index was simplified to two metrics (described below) that are conceptually familiar to most ecologists. Although the VIBI-FQ has been shown to be quite versatile in application (Gara and Stapanian, 2015; Gara and Schumacher, 2015), the best environmental predictors of VIBI-FQ have not yet been determined.

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Mosses (Division Bryophyta, Class Bryopsida) have been shown to be reliable indicators of habitat boundaries and environmental quality (Reed, 1998; Hallingbäck and Hodgetts, 2000). Mosses can be used to define the boundaries of wetlands (Reed, 1998; Tiner, 1991; Gillrich and Bowman, 2010). Different species assemblages of mosses have been found in different wetland types (e.g., Andreas et al., 2004; JNCC, 2005). Moss populations and species assemblages have been shown to be useful indicators of climate change (Frahm and Klaus, 2001 and references therein). The comparatively strict habitat and microclimate requirements make some moss species good indicators of pollution and changes in temperature and water availability (e.g., Glime and Vitt, 1987; Kimmerer and Allen, 1982; Arscott et al., 2000; Hallingbäck and Hodgetts, 2000; Turner and Pharo, 2005). Moss assemblages and growth forms were found to be useful for discerning hydrologic permanence of forested headwater streams (Fritz et al., 2009). Moss species richness was found to be positively associated with diversity of plants and birds in certain habitats (Wierzcholska et al., 2008). Despite these advantages, predictive models of moss communities or biological indices of mosses (sensu Andreas et al., 2004) are lacking.

In this paper, we identify the best predictors of VIBI-FQ and a moss quality assessment index (MQAI: Andreas et al., 2004). As predictors we use the six metrics of the Ohio rapid assessment method for wetlands (Mack, 2001), which has been used to assess wetland disturbance in Ohio, USA, and two landscape development intensity indices (LDIs) (Brown and Vivas, 2005), which assess anthropogenic effects in the landscape surrounding the area of interest. Our goal is to determine if a set of management practices (sensu Micacchion et al., 2015) can be identified from the best set of predictors that would simultaneously increase the floristic quality of vascular plant and moss species assemblages, as assessed by the VIBI-FQ and MQAI.

2. Methods

2.1. Study areas and field methods

Data for this study were obtained from 40 wetlands (range: 0.004–86.1 ha) in Ohio, USA. These included 27 wetlands with emergent vegetation and 13 forested wetlands. Plot layout and assessment of vascular plants were conducted according to the National Wetland Condition Assessment (NWCA) protocols (U.S. EPA, 2011).

Complete field methods for plot layout and collection of vascular plant data are described elsewhere (U.S. EPA, 2011). In brief, transect lines were laid out in the four cardinal compass directions, with each line extending 40 m from the plot center. Five 10-m × 10-m subplots were established at fixed distances along these transect lines. There were two subplots on the South line, and one subplot on each of the remaining three lines. Each subplot had one side on a cardinal line; one side parallel to, and 10 m from, that line; and two sides 10 m apart that were perpendicular to that same cardinal 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. On the North and West lines, the subplot had corners that were 15 m and 25 m from the plot center. On the East line, the subplot had corners that were 20 m and 30 m from the plot center. In each subplot we estimated aerial cover class according to Peet et al. (1998) for each vascular plant species we found.

A trained bryologist inspected the five vegetation subplots and determined, using best professional judgment, which subplot was the most diverse with respect to substrates for mosses (Gara and Schumacher, 2015). Once this subplot was selected, the bryologist identified the different substrates (Andreas et al., 2004) and recorded their approximate percentages with respect to cover. Individual mosses were collected and put into small paper bags, each with a unique collection number. If the bryologist was not sure if a specimen belonged to a species that had already been collected, the specimen was collected in order to miss as few species as possible. The remaining subplots were subsequently inspected and any other moss species that had not already been collected on other subplots were then collected. Again, oversampling occurred by design to help ensure that as many moss species as possible were collected. In the laboratory, the collected bryophytes were identified to the lowest possible taxonomic level according to taxonomic keys (Welch, 1957; Crum and Anderson, 1981; Ireland, 1982; Crum, 2004; Allen, 2006, 2014; Flora of North America Editorial Committee, 2007, 2014).

2.2. Moss quality assessment index (MQAI)

The MQAI is a quality assessment index for mosses, developed by Andreas et al. (2004). MQAI score can range from 0 to 100 points on a wetland. Each moss species is assigned a coefficient of conservatism (CC) that ranges between 0 and 10 (Appendix B in Andreas et al., 2004). The CC describes a species' degree of fidelity to substrate and plant communities relative to other species in the moss 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 (Andreas et al., 2004). Species that are associated with anthropogenic disturbance and are 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. In contrast, species with CCs of 6–8 are fairly substrate-specific and are associated with mature communities. CCs of 9–10 are reserved for species growing on specific substrates or in specific plant communities. For each wetland, the MQAI score was calculated as the sum of the CCs for all moss species divided by the square root of the total number of species recorded in the five subplots (Andreas et al., 2004: Eq. (7)).

2.3. Vegetation index of biological integrity based on floristic quality (VIBI-FQ)

The VIBI-FQ score can range from 0 to 100 points and has two component metrics, "diversity" and "dominance" (Gara, 2013). Details on calculating VIBI-FQ score are found elsewhere (Gara, 2013; Gara and Stapanian, 2015). In brief, the "diversity" and "dominance" metrics each are assigned a maximum total of 50 points. For each wetland the VIBI-FQ "diversity" metric was calculated as:

$$\left[\frac{(\text{FQAI} - 10)}{20}\right] \times 50 \tag{1}$$

where FQAI = floristic quality assessment index (Andreas et al., 2004) score for the species list recorded within the sampling plot.

The FQAI score was calculated as the sum of the CCs for all vascular plant species divided by the square root of the total number of species recorded in the five subplots (Andreas et al., 2004). Wetlands with an FQAI score less than 10, and therefore, having a negative "diversity" metric value were assigned 0 points and all sites scoring above 50 (i.e., FQAI > 30) were truncated to 50 points. A shortcoming of FQAI as a "stand alone" index of vegetation quality is that it does not incorporate abundance or dominance of plant species (Gara and Stapanian, 2015).

The second metric, "dominance", was calculated by multiplying the relative cover of each species by its assigned CC value (Gara, 2013; Gara and Stapanian, 2015). More formally, the "dominance"