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Use of Native Macrophytes as Indicators of Suitable Eurasian Watermilfoil Habitat in Wisconsin Lakes

STANLEY A. NICHOLS[1] AND L. A. J. BUCHAN[2]

ABSTRACT

The association between Eurasian watermilfoil (*Myriophyllum spicatum* L.) and 66 native Wisconsin submersed macrophytes was tested with a Z-test to determine which species co-occurred with milfoil more or less than expected by chance. Sixteen species occurred with milfoil significantly more than expected and one species significantly less than expected. These species may indicate habitat that is suitable (for positive associating species) or unsuitable (for the negative associating species) for milfoil invasion and growth and by using these plants as bioindicators, it may be possible to target areas to search for invading milfoil, thus preventing or slowing local milfoil invasion or discovering milfoil when eradication is still possible.

Key words: habitat similarity, joint occurrence, plant indicator, *Potamogeton*, *Myriophyllum spicatum*, *Sparganium*.

INTRODUCTION

Eurasian watermilfoil (hereafter called milfoil, *Myriophyllum spicatum* L.) is an exotic invader that has significant negative impacts on native macrophyte diversity and human recreational activity in the Upper Great Lakes Region (Trudeau 1982, Nichols 1994a). The species was first found in southeastern Wisconsin lakes in the mid-1960s and since has spread northward and westward (Engel 1993), now occurring in more than 200 lakes in the state.

Once an exotic invader becomes established, it is often impossible to eradicate; efforts turn to managing the undesirable consequences, if any, of its presence. On a regional scale, however, it may be possible to prevent or slow local invasions or at least discover invaders when eradication is possible and to predict which waterbodies are most susceptible to invasion. Waters most at risk are those with suitable habitat found along the predicted pathway of expansion. Lack of success at dispersal, survival, or reproduction prevents a species from expanding its range.

Human transport of plant fragments on boating equipment is most often cited for inter-lake dispersal of milfoil (Scales and Bryan 1979, Johnstone et al. 1985, Nichols and Shaw 1986, Smith and Barko 1990). Milfoil appears to be

[1]Wisconsin Geological and Natural History Survey, 3817 Mineral Point Rd., Madison, WI 53705.

[2]Department of Zoology, University of Wisconsin-Madison, 430 Lincoln Dr., Madison, WI 53705. Received for publication July 8, 1996 and in final form January 15, 1997.

broadly tolerant of a variety of physical and chemical habitat parameters (Nichols and Shaw 1986, Smith and Barko 1990), and these factors act in concert to define suitable or unsuitable habitat (Nichols 1994b, Nichols and Yandell 1995). Disturbances like sedimentation, ice scouring, wave action, bioturbation, herbivory, water level fluctuation, water clarity, temperature, nutrient loading, and past aquatic nuisance control can promote or discourage milfoil establishment and growth (Nichols 1994a, Nichols and Lathrop 1994).

With the variety of factors, even if well defined, determining suitable milfoil habitat in the approximately 15,000 Wisconsin lakes (Wisconsin Department of Natural Resources 1991) would be nearly physically and economically impossible. We propose a different approach in this paper. A number of primarily submersed species (some species develop floating leaves or reach the water surface late in the growing season) were assessed as potential indicators of suitable milfoil habitat. This was done by determining the proportion of lakes where each species is or was historically that also contains milfoil. Although the proportion of co-occurrences cannot predict all possible sites of successful milfoil establishment, certain species with a high or low association with milfoil may be useful indicators of habitat suitability for milfoil growth.

Specifically, this study looks at the association between milfoil and other species on a whole-lake scale. Previously, the interspecific association of many Wisconsin lake plants were described for a smaller number of lakes but at a finer spatial resolution (2-m diameter, Nichols 1990). The two studies are complementary for assessing plant indicators of habitat suitability, and we make recommendations for potential plant indicators of suitable milfoil habitat on the basis of both studies.

MATERIALS AND METHODS

Initially, the distributions of 66 species of submersed lake plants were developed by combining the information in the Wisconsin Lake Plants Database (Nichols and Martin 1990) with herbarium records from the University of Wisconsin-Madison, Milwaukee, Oshkosh, Stevens Point, and La Crosse and the Milwaukee Public Museum. The database was stored in Paradox[R] (Borland International 1994) and provided a list of lakes where each species occurred. In addition, the database contained geographical and water-chemistry information for the lakes from the Wisconsin Department of Natural Resources surface-water inventories. The occurrences of milfoil used in this report are based on fall 1995 data, however the occurrences of the other species are more historical but were developed during the past five years.

The number of species occurrences and the joint occurrence between a species and milfoil were tabulated using Paradox[R]. A Z-score, developed from the normal approximation of the binomial distribution (Spiegel 1961) was used to test if the number of joint occurrences was significantly ($p<0.05$) more or less than would be expected on a random basis. The expected number for milfoil used in the Z-test was developed by determining its occurrence (4.7%) in a random selection of lakes (Lillie and Mason 1983).

All species with a Z-score between ±2 were eliminated from the list of potential indicator species as were species where the expected number ± 2 standard deviations did not fall within the range between 0 and the number of occurrences. This later group of species generally had a low number of occurrences and the normal approximation of the binomial may not be adequate for developing a valid Z-score (Mendenhall 1967). Boxplots (Reckhow and Chapra 1983) were used to display habitat distributions.

RESULTS

Sixteen species had significantly more joint occurrences with milfoil than would be expected by chance (Table 1) and therefore are likely indicators of conditions suitable for milfoil growth. All are common Wisconsin lake plants and their joint occurrence with milfoil ranged from 11.9 to 33.9%. *Sparganium angustifolium* is the only species that showed a negative association with milfoil and no joint occurrences between milfoil and *S. angustifolium* were found.

Because milfoil is still expanding its range, the results reported in Table 1 are conservative estimates of the true level of association between milfoil and other lake plants. It is possible that milfoil will invade lakes of different habitat types than those where it is now found, lack of association between milfoil and another species may reflect lack of dispersal rather than different habitat tolerances. However, to be a useful management tool the need for development is now, while milfoil is still expanding its range.

DISCUSSION

To be a valuable management tool for lake managers and volunteers, the plant indicator approach should be simple to use. All species in Table 1 are fairly distinctive, so the identity of many indicator species can be easily learned. To further simplify the process, the following discussion highlights a few species that may be the "most" useful indicators.

Potamogeton illinoensis, *P. pectinatus*, *P. gramineus*, and *Najas flexilis* were also close associates of milfoil at a finer (2-m) spatial resolution (Nichols 1990). These species may be useful for indicating not only lakes that have suitable habitat for

TABLE 1. SUBMERSED SPECIES SHOWING SIGNIFICANT (Z>±2) ASSOCIATION WITH *MYRIOPHYLLUM SPICATUM* IN WISCONSIN LAKES.

Species	Percent joint occurrence with *M. spicatum*	Z
Potamogeton illinoensis	33.9	15.2
P. pectinatus	30.9	18.5
Zosterella dubia	24.8	10.3
Myriophyllum sibiricum	24.4	11.9
Elodea canadensis	20.6	11.6
Ceratophyllum demersum	20.5	12.5
P. zosteriformis	18.8	11.2
P. natans	18.5	10.0
Vallisneria americana	16.9	9.6
P. praelongus	16.7	7.0
P. gramineus	16.3	7.7
P. amplifolius	15.9	8.4
Najas flexilis	13.9	8.1
P. richardsonii	12.8	5.6
P. pusillus	11.9	4.3
Utricularia vulgaris	11.9	4.3
Sparganium angustifolium	0.0	-2.1

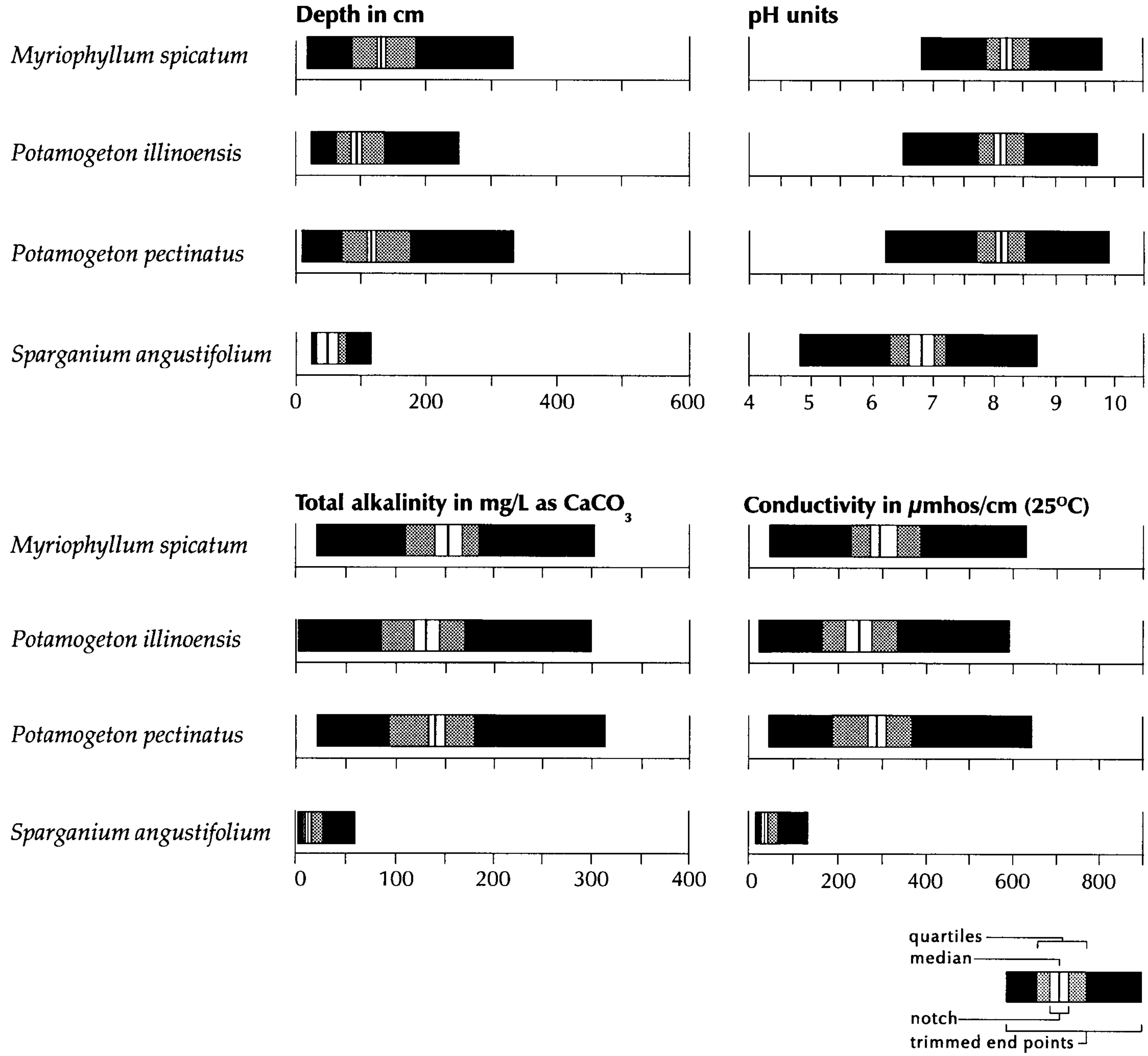

Figure 1.Boxplots comparing the distribution of selected habitat characteristics between *M. spicatum* and three species which show strong positive (*P. illinoensis*, *P. pectinatus*) or strong negative (*S. angustifolium*) association with it.

milfoil invasion but also areas of the lake that have the most suitable milfoil habitat. *Potamogeton illinoensis* and *P. pectinatus* have similar alkalinity, pH, and conductivity preferences as milfoil (Figure 1) and have the highest percentage of joint occurrence which indicates they may be the most useful indicators. *Potamogeton pectinatus* is common, tolerant of pollution and disturbances, and can quickly invade new areas (Davis and Brinson 1980, Kantrud 1990), so it is similar to milfoil in more than just habitat preference. *Potamogeton illinoensis* is not as common, does not spread as rapidly, and is not as disturbance tolerant as some other species on the list (Davis and Brinson 1980). Its usefulness as an indicator species may be more limited. *Najas flexilis* is an annual species that rapidly invades disturbed areas (Engel and Nichols 1984) and because milfoil also often invades disturbed areas (Nichols and Lathrop 1994, Nichols 1994a) may be a very good indicator of both suitable habitat and disturbed areas that would be advantageous for milfoil establishment.

Potamogeton praelongus, *P. zosteriformis*, and *P. richardsonii* showed a negative association with milfoil at a fine spatial resolution (Nichols 1990). They may be useful for determining lakes that are suitable for milfoil growth but less suitable for predicting areas of a lake most susceptible to invasion.

Vallisneria americana was the dominant species in some large Wisconsin lakes that were invaded by milfoil (Nichols and Lathrop 1994, Rogers et al. 1995, Bumby 1977), but the sample is too small to determine the predictive capabilities of this observation. *Ceratophyllum demersum* became the dominant plant in the Madison, Wisconsin, area lakes when milfoil populations declined (Nichols and Lathrop 1994).

Sparganium angustifolium is found in low to moderate conductivity and alkalinity waters in northern Wisconsin (Figure 1). *Utricularia resupinata*, *Gratiola aurea*, *Utricularia purpurpea*, *Sparganium chlorocarpum*, *Najas gracillima*, *Myriophyllum alterniflorum*, *Lobelia dortmanna*, *Myriophyllum humile*, and *Sparganium fluctuans* are additional species that should be considered as indicators of conditions unsuitable for milfoil. Like *S. angustifolium*, they live in low to moderate alkalinity and conductivity waters in northern Wisconsin and milfoil was not found in any lakes where these species occurred. Because they are not common and because of the present low frequency of milfoil occurrence, these species could not fulfill the statistical criteria for inclusion in Table 1. They often show low association with other species even though they have similar habitat requirements (Nichols 1990, Nichols and Yandell 1995).

Although the geographic range of this study is limited, our findings may be applicable to other regions. The distribution of *P. pectinatus* is nearly cosmopolitan (Kantrud 1990). *Potamogeton illinoensis* is found from Nova Scotia to Ontario and Minnesota, south to Florida and Mexico, and west to California (Gleason and Cronquist 1991). *Najas flexilis* is reported from Newfoundland to British Columbia and south to Virginia and Nebraska (Gleason and Cronquist 1991). Habitat distributions and preferences for these species can differ between regions and testing their association with milfoil in a geographic area larger than Wisconsin will help determine the scope of their utility as indicators of milfoil habitat.

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