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Wetland Regulatory Assistance Program (WRAP)

Influence of Wetland Indicator Status Ratings on the Extent of Hydrophytic Vegetation during Wetland Delineations

Corinna Photos, Lindsey Lefebvre, John Klein,
Cristina E. McKernan, Jennifer Goulet, and Robert Lichvar

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Abstract

This study evaluated how far and how often hydrophytic vegetation exceeded the wetland boundary in three U.S. Army Corps of Engineers wetland regions. Wetland boundaries were delineated using methods described in the Corps of Engineers Wetland Delineation Manual and appropriate Regional Supplements. Hydrophytic vegetation determinations were made using the Dominance Ratio, the Prevalence Index, and the Hydrophytic Cover Index. Distances and frequencies were tested using nonparametric statistics.

Hydrophytic vegetation exceeded the wetland boundary by 5–49 m, in 65% of the upland plots. Differences in distance ($p = 0.88$) or frequency ($p = 0.14$) among the three methods were not significant. Most (83%) of the species with hydrophytic ratings occurred in wetland and upland plots, suggesting that NWPL ratings may overestimate wetland frequency in some circumstances. Hydrophytic vegetation determinations in uplands were driven by 38% of FACW and 54% of FAC species, which exhibited an upland abundance greater than or equal to that of wetlands. These data indicate that hydrophytic vegetation is a poor indicator of the wetland boundary when used without considering hydrology and soils. Periodic review of NWPL ratings is recommended to improve accuracy of delineated boundaries.

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Preface

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Acronyms and Abbreviations

AK	Alaska
ANOVA	Analysis of Variance
CO	Rocky Mountain National Park, Colorado, Sites
CRREL	U.S. Army Cold Regions Research and Engineering Laboratory
CT	Bloomfield, Connecticut, Sites
DR	Dominance Ratio
EPA	U.S. Environmental Protection Agency
FAC	Facultative
FACU	Facultative Upland
FACW	Facultative Wetland
ERDC	Engineer Research and Development Center
HCI	Hydrophytic Cover Index
MA	Plymouth, Massachusetts, Sites
NCNE	Northcentral and Northeast
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NTCWV	National Technical Committee for Wetland Vegetation
NWPL	National Wetland Plant List
OBL	Obligate Wetland
PI	Prevalence Index
RI	West Warwick, Rhode Island, Sites
RMNP	Rocky Mountain National Park

UPL	Upland
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
WMVC	Western Mountains, Valleys, and Coast
WRAP	Wetlands Regulatory Assistance Program

1 Introduction

1.1 Background

Ecological boundaries are transitional zones between adjacent distinct ecosystems, such as wetlands and uplands. Under section 404 of the Clean Water Act, four Federal agencies, the U.S. Army Corps of Engineers (USACE) along with the U.S. Environmental Protection Agency (EPA), the U.S. Fish and Wildlife Service (USFWS), and the Natural Resource Conservation Service (NRCS) are responsible for developing and implementing procedures for identification and delineation. Methods for determining wetland boundaries are based on the presence of certain hydrologic, soil, and vegetation characteristics defined in the Corps of Engineers 1987 Wetlands Delineation Manual and Regional Supplements (USACE 2007, 2010, 2012).

Wetlands have distinct vegetation and soil characteristics that are formed and maintained by hydrologic regimes (Cooper et al. 2012). The combination of wetland hydrologic, soil, and vegetation conditions on the landscape defines the wetland boundary with the exception of atypical scenarios (Environmental Laboratory 1987); and these conditions can occur individually or in any combination across the landscape. Soil and hydrologic conditions are identified using indicators listed in each regional supplement (e.g., USACE 2010). A plant species is considered to be a hydrophyte if it grows in water or on a substrate that is saturated at a frequency and duration during the growing period sufficient to affect plant occurrence (Tiner 2012). Hydrophytic vegetation is determined using mathematical methods based on percent areal cover estimates of plant species and indicator status ratings (Table 1) for species listed on the National Wetland Plant List (NWPL). Species rated Obligate Wetland (OBL), Facultative Wetland (FACW), and Facultative (FAC) are considered hydrophytes for delineation purposes. Under most circumstances, species rated Facultative Upland (FACU) or Upland (UPL) are not treated as hydrophytes.

To determine the presence of hydrophytic vegetation, two approaches are currently used: the Dominance Ratio (DR) and the Prevalence Index (PI). The DR is most commonly used among wetland delineators. Dominant species in each vegetative stratum, herbaceous, shrub, vine, tree, are selected using the 50/20 Rule. The total number of dominant hydrophytes

(OBL–FAC) is summed across strata, divided by the total number of dominant plant species (OBL–UPL) across all strata, and multiplied by 100 for a percentage of dominant hydrophytic species present (see “Methods” for a detailed description). Hydrophytic vegetation is present if the calculated percentage is greater than 50% (for detailed information, see Environmental Laboratory 1987; USACE 2007, 2010, 2012).

Table 1. Summary of wetland indicator status ratings on the NWPL (Lichvar et al. 2012).

Rating (Abbreviation)	Designation	Definition—Short Version
Obligate Wetland (OBL)	Hydrophyte	Almost always occurs in wetlands
Facultative Wetland (FACW)	Hydrophyte	Usually occurs in wetlands, but may occur in nonwetlands
Facultative (FAC)	Hydrophyte	Occurs in wetlands and nonwetlands
Facultative Upland (FACU)	Nonhydrophyte	Usually occurs in nonwetlands, but may occur in wetlands
Upland (UPL)	Nonhydrophyte	Almost never occurs in wetlands

The PI, another method for determining hydrophytic communities, is calculated using a weighted average by summing the total cover of all species in each wetland indicator category (OBL, FACW, FAC, FACU, and UPL) and multiplying each category by the indicator value (OBL = 1, FACW = 2, FAC = 3, FACU = 4, UPL = 5). Then the total weighted cover is divided by the total cover of all plant species. A value of 3.0 or less is considered hydrophytic for the PI (Equation 1):

$$PI = \frac{S_{OBL} + 2S_{FACW} + 3S_{FAC} + 4S_{FAC} + 5S_{UPL}}{S_{OBL} + S_{FACW} + S_{FAC} + S_{FAC} + S_{UPL}} \times 100 \qquad (1)$$

where S = sum of species cover. Accurate identification of the wetland–upland boundary is required under Section 404 of the Clean Water Act. However, hydrophytic vegetation determinations made by the DR and PI often disagree, affecting the location of the wetland boundary on the landscape. Disagreements have been attributed to many factors. For example, the larger weights assigned to nonhydrophytes in the PI may cause discrepancies (Lichvar and Gillrich 2014b). Problems associated with the DR include the use of strata, which creates overestimates of areal cover; elimination of species considered nondominant from DR calculations; and an odd-hydrophytic/even-nonhydrophytic bias, depending on the number of dominant species selected by the 50/20 Rule (Best et al. 1990; Davis et al. 1996; Wakeley and Lichvar 1997; Kirkman et al. 1998; Lichvar et al. 2011).

The Hydrophytic Cover Index (HCI) is a third method of determining if vegetation is hydrophytic. It was proposed by the National Technical Committee for Wetland Vegetation (NTCWV) (Lichvar and Gillrich 2014a). Like the PI and the DR, the HCI uses wetland ratings and percent areal cover of the plant species in a delineation plot to determine if hydrophytic vegetation is present. The HCI is calculated by summing the cover of all hydrophytic species (OBL–FAC) and dividing by the cover of all species (OBL–UPL) in the plot, then multiplying by 100 for an unweighted percentage. Hydrophytic vegetation is present when the HCI calculation is greater than 50% (Equation 2):

$$HCI = \frac{S_{OBL} + S_{FACW} + S_{FAC}}{S_{OBL} + S_{FACW} + S_{FAC} + S_{FAC} + S_{UPL}} \times 100 \qquad (2)$$

where S = sum of species cover. The HCI is designed to be an unbiased and easy field method for making vegetation determinations and follows methods outlined by Gage and Cooper (2010). Data collected for the HCI is consistent with standard scientific methods for vegetation analysis (McCune and Grace 2002). The HCI produces repeatable, consistent vegetation determinations regardless of plot size, plot shape, or the ability to identify all plant species present (Lichvar and Gillrich 2014a). When tested using delineation data collected across nine USACE regions, the HCI was found to be unbiased, producing index values identical to the actual percentage of hydrophytic cover in each plot (Lichvar and Gillrich 2014b). Therefore, HCI determinations provide an unbiased benchmark for assessing vegetation and illustrating how far and how often hydrophytic vegetation extends past wetland boundaries.

Using the wetland indicator status ratings of species on the NWPL to calculate the presence of hydrophytes has practical limitations. Wetland indicator status ratings are based on botanical literature, herbaria information, and best professional judgment of botanists and ecologists (Lichvar et al. 2012; Lichvar and Minkin 2008). To date, only one wetland indicator status rating has been statistically tested (Gage et al. 2016). Besides a preference for wetland conditions, many species occurrences in wetland or uplands may be influenced by genetic variation, and phenotypic plasticity (Tiner 1991). Many species commonly found in wetlands persist later in the growing season when wetland water tables can fall below 12 in. (0.3 m) of the soil surface (Kirkman et al. 1998) and may extend into transitional zones and uplands due to a variety of ecological principles such as niche overlap, competition, and tolerance or improperly assigned wetland indicator status ratings (e.g., Gleason 1926; Pianka 1974; Menge and Sutherland 1976; Tilman 1994).

The ecology of plant species distribution in wetlands and in uplands is indisputably complex. The contrast between wetland and upland ecosystems may be abrupt or gradual and largely dependent on underlying environmental factors, such as topographic, geomorphic, and hydrologic conditions (Johnston and Naiman 1987, Naiman et al. 1989, Strayer et al. 2003). Discrete changes in topographic and geomorphic conditions can create distinct and narrow wetland–upland boundaries while gradual changes can create indistinct boundaries that may vary temporally (Kirkman et al. 1998; Choesin and Boerner 2002; Gage and Cooper 2010). Gentle gradients and spatial heterogeneity of wetland environmental drivers reduce the magnitude of contrast between adjacent wetland and upland ecosystems, making discerning boundaries a challenging task for wetland delineators and practitioners (Johnston et al. 1992; Kent et al. 1997). As a single factor in certain types of wetlands, boundaries of vegetation communities may be poor indicators of wetland boundaries. Vegetation composition can vary continuously or discretely, depending on abruptness of hydrologic gradients and the environmental tolerances of individual species (Whittaker 1953; Curtis 1955; Gage and Cooper 2010). Furthermore, vegetation community boundaries are largely a consequences of complex landscape factors (Whittaker 1953; Austin and Smith 1989; Kent et al. 1997) and the differences between these adjacent systems. The personal observations and literature citations that form the basis of wetland ratings represent an effort to summarize the complex ecology of plant distribution into an estimate of wetland frequency.

1.2 Objectives

Since administrative responsibility for the NWPL was transferred from the USFWS to the USACE in 2006, the four cooperating Federal agencies have worked to reevaluate and update the indicator status ratings of species on the NWPL (Lichvar and Gillrich 2011). Ongoing updates are scheduled so that ratings may be reevaluated as new documentation describing the habitats and ranges of plant species is acquired (USACE 2016). In support of these efforts, this study was designed to provide new information on the effect of wetland ratings on the distance that hydrophytic vegetation extends beyond a delineated wetland boundary. The specific objectives include the following:

1. Compare the distance that hydrophytic vegetation exceeds the wetland boundary when vegetation determinations are made using the DR, PI, and HCI.
2. Compare the frequency with which the DR, PI, and HCI produce hydrophytic vegetation determinations in upland plots.
3. Compare the percentages of species with hydrophytic ratings that (a) occurred in only wetland plots and (b) occurred in both upland and wetland plots.
4. Examine relationships between wetland ratings, the extent of hydrophytic vegetation, and the methods used to make vegetation determinations.

1.3 Approach

This study examined hydrologic, soil, and vegetation data collected along a wetland–upland gradient by using standard delineation methods at eight wetland boundaries in three USACE regions (Environmental Laboratory 1987, USACE 2007, 2010, 2012). Hydrophytic vegetation determinations produced by the DR, PI, and HCI and nonparametric statistical analyses were used to compare the frequency and extent of hydrophytic vegetation in upland plots. Species frequency and abundance data were used to illustrate how ratings that may overestimate wetland frequency drive hydrophytic determinations in upland plots.

2 Study Area

Eight study sites were determined by the availability of long-term hydrologic monitoring data and occurred in three USACE regions: the Northcentral and Northeast (NCNE) region; Western Mountains, Valleys, and Coast (WMVC) region; and Alaska (AK) region (Figure 1). Distinct climatic, topographic, geologic and geomorphic, and land use conditions influence wetland types and ecology of each region (Table 2). Only field sites with existing hydrologic monitoring data were used.

The NCNE sites in Bloomfield, Connecticut (CT); Plymouth, Massachusetts (MA); and West Warwick, Rhode Island (RI), are characterized by strong annual temperature cycles, high summer precipitation, and glaciated landscape with broad, hilly, plateaus (Denny 1982). The CT site was a relatively flat, forested-shrub wetland dominated by *Acer rubrum* L. and *Lindera benzoin* (L.) Blume. It was underlain by mineral soils from a red parent material. During the growing season, water-table depth ranged from the soil surface to 66.0 cm below it. The MA site was a relatively flat, shrub-dominated wetland (*Vaccinium corymbosum* L.) with disturbed mineral soils. During the growing season, water-table depth ranged from the soil surface to 75.6 cm below it. In RI, a forested-shrub wetland dominated by *A. rubrum*, *Rosa multiflora* Thunb. Ex Murr., and *Impatiens capensis* Meerb. underlain by mucky mineral soils was selected. Mean water-table depth during the growing season ranged from 1.0 to −83.0 cm. Sites in this region are within the Lower New England Section of the Eastern Broadleaf Forest Province. Complex and varied bedrock geology consists of sedimentary, igneous, and metamorphic rocks. Sites are surrounded by suburban-urban development and agricultural land use (McNab et al. 2007).

Figure 1. Map of USACE NWPL regions. Wetland ratings for plants used in wetland delineation processes are specific to each region.

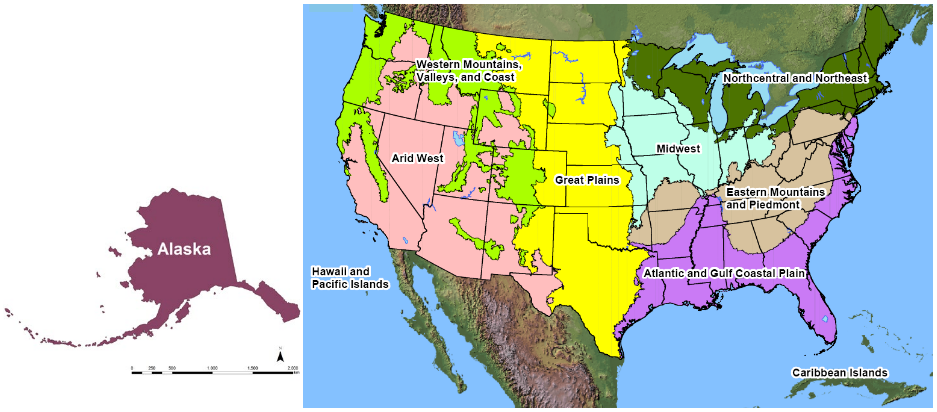

Table 2. Summary of climate, land use, and wetland types sampled.

Study Site (USACE Region)	Ecoregion	Precipitation (cm)	Snowfall (cm)	Growing Season (# days)	Surrounding Land Use	Wetland Type
Plymouth Municipal Airport, Plymouth, MA (NCNE)	Eastern Broadleaf Forest Province	122.7	56.4	194	Developed (Municipal)	Shrub-herbaceous wetland
Valley Country Club, Warwick, RI (NCNE)	Eastern Broadleaf Forest Province	134.3	78.7	215	Developed (Residential)	Forested wetland
Auer Farm, Bloomfield, CT (NCNE)	Eastern Broadleaf Forest Province	132	54.1	199	Developed (Agriculture)	Forested wetland
Timber Creek, Rocky Mountain National Park, CO (WMVC)	Northern Parks and Ranges Section	52.8	364	69	Protected (NPS)†	Shrub-herbaceous wetland
Timber Creek, Rocky Mountain National Park, CO (WMVC)	Northern Parks and Ranges Section	52.8	364	69	Protected(NPS)	Shrub-herbaceous wetland
Big Meadows, Rocky Mountain National Park, CO (WMVC)	Northern Parks and Ranges Section	52.8	364	69	Protected (NPS)	Shrub-herbaceous wetland
Tongrass National Forest, Douglas Island, AK (AK)	Coastal Western Hemlock Sitka Spruce*	293.3	56.4	202	Protected (USFS)‡	Forested wetland
Tongrass National Forest, Thorne Bay, AK (AK)	Coastal Western Hemlock Sitka Spruce*	262.1	129.3	241	Protected (USFS)	Forested wetland

* Alaska eco-subregions (Gallant et al. 1995). Other ecoregions are from McNab et al. (2007).

† National Park Service

‡ U.S. Forest Service

Sites in the WMVC are in Rocky Mountain National Park (RMNP), Colorado (CO), and are characterized by short, warm summers and long cold winters. Precipitation is moderate and increases considerably with altitude where much occurs as snow. RMNP is in the Northern Parks and Ranges Section of Baily's Ecoregions. Topography in RMNP is variable with hills, valleys, gently rolling parks, and high and low mountains. Lithology of the Northern Parks and Ranges is generally gneisses of various composition (McNab et al. 2007). Study sites in RMNP experience relatively low disturbance from development and agriculture compared to sites in New England, as RMNP is a national park preserved for conversation and is surrounded by other protected lands. All three sites were riverine fens and underlain by 1.5 to 2.0 m of peat on alluvial and glacial deposits. The most abundant plant species included *Carex utriculata* Boott, *Carex aquatilis* Wahlenb, and *Salix planifolia* Pursh. At Big Meadows, during the growing season, the water-table depth ranged from 0.7 to

−131.3 cm. Depths at Timber Creek 1 and 2 were −3.2 to −81.3 cm and 5.1 to −166.5 cm, respectively.

Sites in the AK region are at Thorne Bay and Douglas Island in the Coastal Western Hemlock Sitka Spruce region of southeastern AK and are influenced by a maritime climate with mild summer and winter temperatures (Gallant et al. 1995). Topography is characterized by steep mountains, dense forest cover, deep fjords, and large U-shaped valleys carved by glaciers. Lithology is volcanic, intrusive, and sedimentary. Thorne bay and Douglas Island are in the Tongrass National Forest and experience relatively low impact from development compared to sites in the NCNE region. Both forested-shrub wetlands were underlain by histosols and dominated by *Tsuga heterophylla* (Raf.) Sarg. and *Vaccinium ovalifolium* Sm. Mean water-table depth during the growing season ranged from 1 to −32 cm at Douglas Island and from 3 to −22 cm in Thorne Bay (D'Amore et al. 2015).

3 Methods

3.1 Sampling methods

Study plots were located within the wetland, at the boundary, and in upland positions in eight wetlands across three regions. For each region, two to three sites with existing hydrologic monitoring data were selected for sampling. Knowledge of groundwater depths during the growing season ensured proper placement of the wetland boundary (i.e., that wetland hydrology was present in the wetland and absent in the adjacent upland). Although the requirement for hydrologic monitoring data reduced the number of potential field sites, it did not introduce bias. Sites were located across the nation in palustrine or riverine wetlands underlain by either organic or mineral soils. Vegetation types included forested, shrub, or herbaceous. Study sites were located in flat to steeply sloped terrain and ranged from temporarily flooded, to permanently saturated, to seasonally saturated. Field sampling occurred in 2008.

At each study site, four to six 10 × 10 m plots were established along one transect following the wetland–upland hydrologic gradient. Plot distances from the wetland boundaries were recorded with negative values (−) given to plots on the wetland side and positive values (+) given to plots on the upland side. The wetland boundary was identified, and one plot was established on the wetland side of the boundary and one on the upland side of the boundary. In each 10 × 10 m plot, standard wetland delineation data was collected for all vegetation, hydrologic, and soil indicators according to the regional supplement for the appropriate region (Hurt and Vasilas 2006; USACE 2007, 2010, 2012). A wetland boundary plot of 10 × 10 m was placed adjacent to the hydrologic monitoring wells if there was no change in topography or vegetation. Successive plots were placed based on observed changes in plant community composition. Centroids were located up to 110 m into uplands and up to 122 m into wetlands. The number of vegetation plots and monitoring wells varied with 12 vegetation plots and 7 wells in NCNE, 14 plots and 8 wells in WMVC, and 9 plots and 8 wells in AK.

3.2 Abiotic variables

The average number of consecutive days the water table was within the first 12 in. of the soil surface during the NRCS growing season was determined for each monitoring well. If the average number of consecutive days was 14 or higher, wetland hydrologic conditions were met (Environmental Laboratory 1987). Wetland soil and hydrologic conditions were used to verify the extent of the wetland boundary.

At each study site, hydrologic data were collected from groundwater monitoring wells and evaluated using the wetland hydrology criterion of a water table within the top 12 in. of the soil surface for 14 consecutive days during the growing season. Monitoring years were considered normal years if average precipitation fell inside the 30th and 70th percentiles over a 30-year period (U.S. Army Corps of Engineers 2005). In 2007, hydrologic data was collected at the Plymouth site in MA (Rob Turstead, USDA-NRCS[*], unpublished data) and at the West Warwick Site in RI (Jim Turenne, USDA-NRCS, unpublished data). In 2006 and 2007, data was collected at the Bloomfield site in CT (Donald Parizek, USDA-NRCS, unpublished data). Annual and growing-season precipitation was lower than normal for 2007 at MA and CT sites and normal for RI. Monitoring data in MA was collected only over one growing season. In CT in 2006, average precipitation was higher than normal but likely did not affect hydrologic indicators as hydrologic indicators were present in years with lower than normal precipitation.

Hydrologic data from CO was gathered from 1987 to 2004 (David Cooper, Colorado State University, Fort Collins, CO, unpublished data). Of the 11 years, only 2003 fell within the range of normal precipitation. In 2004, the precipitation was above average; and groundwater measurements were collected in 2004 for just one well and could not be averaged with other years.

Hydrologic data for AK sites were calculated from data collected by David D’Amore of the USDA-Forest Service (D’Amore et al. 2015). AK sites were monitored from 1998 to 2003. Precipitation data from 1999 to 2000 for Juneau sites were not compared as monthly records for those years were incomplete. Annual precipitation totals for 1998, 2001, and 2003 were lower than normal while 2002 had higher than normal precipitation. In Thorne Bay, Alaska, hydrologic monitoring data from 1998, 1999, and 2002 were used. In 2002, precipitation was normal while 1999 was higher

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[*] Warwick, RI: U.S. Department of Agriculture, Natural Resources Conservation Service

and 1998 was lower than normal. Higher precipitation totals in 1999 may have quantitatively influenced the average number of days that ground water was within the first 12 in. of the soil surface. Sampling year 2007 was a normal year for AK sites.

3.3 Vegetation data

Hydrophytic vegetation determinations were made for each plot by using the DR, the PI, and the HCI methods, percent areal cover data, and the regional wetland indicator status of each species based on the 2014 NWPL (Lichvar et al. 2014).

To calculate the DR, dominant species were selected based on cover values, according to the 50/20 rule (Environmental Laboratory 1987; Federal Interagency Committee for Wetland Delineation 1989). The total cover of each vegetative stratum (e.g., tree, shrub, and herb) was calculated by summing the cover values for all species. The 50% and 20% thresholds for each stratum were identified by multiplying by 0.50 and 0.20 the total cover of each stratum containing at least 5% cover. The plant species in each stratum were ranked in descending order by percent cover, and species that were selected from the top of this list until the cumulative cover exceeded 50% were considered dominant species. If multiple species in a stratum had the same cover value and one was selected as dominant, then they all were selected. Once the 50% threshold was met, additional species were considered dominant if they had the same percent cover as a species previously considered dominant. If any species with percent cover greater than or equal to 20% of the total cover in the stratum had not been selected, those species were also considered dominant. Wetland ratings from the 2014 NWPL were applied (Lichvar et al. 2014), and the total number of hydrophytic dominant species from all strata was divided by the total number of all dominant species and then multiplied by 100 to yield the DR. Plots with DR values greater than 50% were considered hydrophytic; less than or equal to 50% were considered nonhydrophytic (Environmental Laboratory 1987).

Wetland ratings and percent areal cover data from each plot were used to calculate the PI and the HCI. The PI weights species with nonhydrophytic ratings (FACU and UPL) more heavily than species with hydrophytic ratings (OBL, FACW, and FAC) and then calculates the weighted percent of hydrophytic species cover to total species cover (Equation 1). Plots with PI values greater than 3.0 contained nonhydrophytic communities while plots with PI values of 3.0 or less contained hydrophytic vegetation (Environmental Laboratory 1987). The HCI uses an unweighted ratio of cover of hydrophytic species to cover of total species (Equation 2). Plots with HCI values greater than 50% contained hydrophytic communities while plots with HCI values of 50% or less contained nonhydrophytic communities.

The study sites were reproduced in AutoCAD, computer-aided drafting software commonly used to create scale-model blueprints for engineering and architecture applications. Distance that hydrophytic vegetation exceeded the wetland boundary was measured in AutoCAD based on the plot centroid, given the hydrophytic/nonhydrophytic vegetation determination for each plot, using each of the three calculation methods. For each region, plots were categorized as occurring in wetland or upland based on the hydrologic data and the presence or absence of hydric soil indicators.

3.4 Hydrophyte frequency and abundance

Although wetland ratings reflect the frequency at which a species occurs in a wetland, the combined use of abundance (percent areal cover) and frequency may better describe a species' preference for and fidelity to wetlands than frequency estimates alone (Lichvar and Minkin 2008). For instance, a species might occur in wetlands just as often as uplands. However, an increase in abundance in one of the two habitats can be a useful indicator of the species' preference for a particular type of habitat.

For the frequency and abundance analysis, the 101 species with hydrophytic ratings (OBL–FAC) were sorted into two groups, those that occurred in only wetland plots and those that occurred in both wetland and upland plots. Species that occurred in only one plot were not analyzed further (n = 26, Appendix B). The remaining 75 species were used to determine which wetland rating categories most influenced hydrophytic vegetation determinations in upland plots (Appendix A). Wetland plot frequency for each species was obtained by tallying the number of wetland plots in which it occurred in each region. Species that occurred in more than one Corps region were treated separately due to ratings differences among regions. The procedure was repeated with upland plots to obtain upland plot frequency. The average abundance of each species in wetland plots was calculated by summing its total cover in all wetland plots and dividing by the number of wetland plots in which it occurred. This procedure was repeated with upland plots to obtain the average abundance in upland plots. Species that exhibited a frequency or an average abundance in uplands that was greater than or equal to that observed in wetlands were identified using an excel spreadsheet.

3.5 Statistical analysis

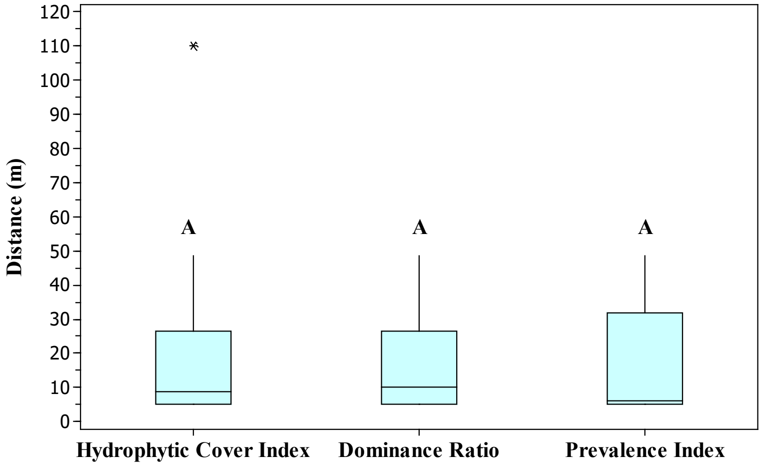
To compare the distance and frequency that hydrophytic vegetation extended past the wetland boundary, the DR, PI, and HCI results from 35 plots in 8 sites were analyzed in SYSTAT 12 (Systat Software, Inc., San Jose, CA). Levene's test for homogeneity of variance and Kruskall Wallis one-way analysis of variance (ANOVA) were used to compare the distance hydrophytic vegetation exceeded the wetland boundary for each vegetation index. Nonparametric tests were used because the data had a non-normal distribution. Fisher's exact test was used to compare the frequency of hydrophytic vegetation determinations in upland plots and the hydrophyte frequency and abundance in upland plots.

4 Results

4.1 Distance and frequency of hydrophytic vegetation

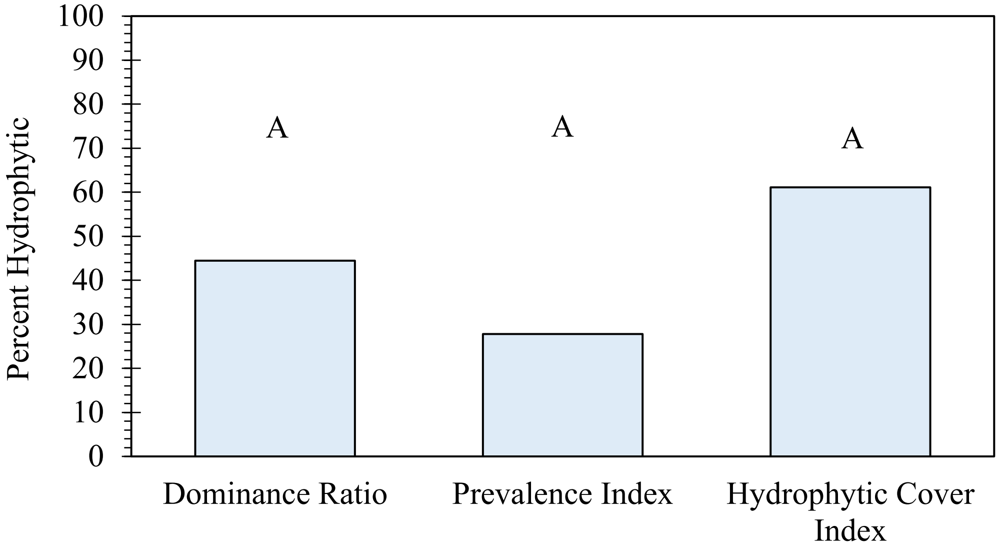
Hydrophytic vegetation extended 5–49 m past the wetland boundary, regardless of the method used to make vegetation determinations. The median distance did not differ among the three methods: HCI (8.5 m ± 30.6), DR (10.0 m ± 15.0), PI (6.0 m ± 19.1), and ($p = 0.88$) (Figure 2). Although the standard deviations of 15 to 31 may seem high, it was not unexpected since a wide range of vegetation and wetland types were sampled across the nation. Both the standard deviation and the variance, HCI (939), PI (321), and DR (226), were similar to or lower than standard deviations and variances reported in a similar study examining vegetation determinations made by the three formulas in 637 plots across nine USACE regions (Lichvar and Gillrich 2014a).

Figure 2. Distance (m) that hydrophytic vegetation extends past the wetland boundary based on vegetation determinations produced by three different indices. Values indexed with the same letter are not significantly different from one another ($p = 0.88$).



The HCI identified hydrophytic vegetation in 12 of the 18 upland plots across the three study regions. The DR and the PI identified hydrophytic vegetation in nine and six upland plots, respectively. These differences in frequency were not statistically significant ($p = 0.14$). Pairwise comparisons also showed no significant differences in the percentage of hydrophytic vegetation determinations made in upland plots by the HCI (64.7%) and the PI (29.4%, $p = 0.09$), the HCI and the DR (47.1%, $p = 0.50$), or by the PI and the DR ($p = 0.50$) (Figure 3).

Figure 3. The percentage of upland plots that contained hydrophytic vegetation determined by three different indices. Values indexed with the same letter are not significantly different from one another ($p = 0.14$).



4.2 Hydrophyte frequency and abundance

Of the 75 species with hydrophytic ratings, 62 (83%) occurred in both wetland and upland plots and were often abundant (Appendix A). Examples include *Picea engelmannii, Pinus contorta, Tsuga heterophylla,* and *Vaccinium ovalifolium* (all FAC) and *Calamagrostis canadensis, Impatiens capensis*, and *Fraxinus pennsylvanic*a (all FACW). The remaining 13 species (17%) occurred in only wetland plots, including *Betula glandulosa* and *Symplocarpus foetidus* (both OBL). These species were usually sparse although *Carex utriculata* in the WMVC region was an exception.

Species rated FAC ($n = 37$) showed significantly greater fidelity to upland plots than species rated OBL ($n = 14$) and FACW ($n = 24$) ($p = 0.02$, Figure 4). However, 14% of the OBL and 33% of the FACW species in this study occurred in upland plots more often, or just as often, as in wetland plots. Pairwise comparisons showed that the percentage of FAC species (73%) that exhibited this fidelity to upland plots was significantly larger than that of FACW ($p = 0.05$) or OBL ($p = 0.01$) species. Differences between the percentages of OBL and FACW species were not significant ($p = 0.71$).

Species with hydrophytic ratings were also abundant in upland plots. A total of 54% of the FAC and 38% of the FACW species in this study were more abundant or just as abundant in upland plots as in wetland plots.

These percentages were significantly different from those of OBL (0%) species ($p < 0.01$, Figure 5). Pairwise comparisons showed that differences between the percentage of FACW and FAC species were not significant ($p = 0.29$).

Figure 4. Percentage of species rated Obligate ($n = 14$), Facultative Wetland ($n = 24$), and Facultative ($n = 37$) that occurred in upland plots with a frequency greater than or equal to that of wetland plots. Data were collected at eight study sites in three Corps regions. Ratings are from the 2014 National Wetland Plant List (Lichvar et al. 2014). Values indexed with the different letters are significantly different from one another ($p = 0.02$).

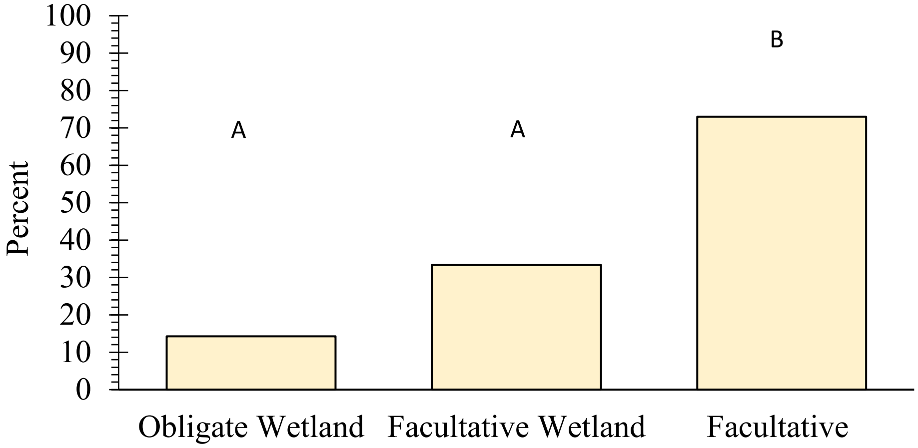
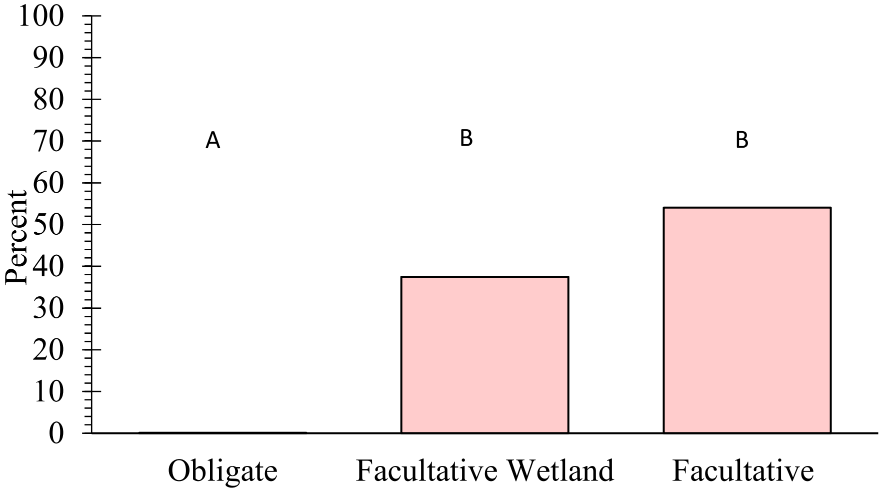


Figure 5. Percentage of species rated Obligate ($n = 14$), Facultative Wetland ($n = 24$), and Facultative ($n = 37$) with an abundance in upland plots that was greater than or equal to that of wetland plots. Data were collected at eight study sites in three Corps regions. Ratings are from the 2014 National Wetland Plant List (Lichvar et al. 2014). Values indexed with different letters are not significantly different from one another ($p < 0.01$).



5 Discussion

This study provided new information regarding the influence of wetland ratings on the extent of hydrophytic vegetation, in support of ongoing efforts to update the ratings of species on the NWPL (Lichvar and Gillrich 2011). The wetland ratings of species in a plant community are used during delineations to indicate whether or not wetland conditions are present (Environmental Laboratory 1987). Plant species that are the most useful wetland indicators for delineation purposes show high fidelity to wetlands and are also more abundant in wetlands than in adjacent uplands (Lichvar and Minkin 2008). For example, in the WMVC region, *Carex utriculata* occurred in five wetland but no upland plots with an average abundance of 29% (Appendix A). However, only 13 of the 75 species (17%) with hydrophytic ratings were restricted to wetland plots. Unlike *C. utriculata*, they were usually sparse; so their utility as indicators was limited. The remaining 83% of the species rated OBL–FAC occurred in both wetlands and adjacent uplands, creating hydrophytic vegetation determinations in upland plots. Consequently, hydrophytic vegetation often extended far beyond the wetland boundary. In this case, both the distance and frequency analyses and the hydrophyte frequency and abundance data suggest misapplied ratings that overestimate wetland frequency drive hydrophytic vegetation determinations in uplands.

Hydrophytic vegetation exceeded the wetland boundary by 5–49 m in 65% of the upland plots according to the HCI (Figures 2 and 3). The HCI is an unbiased benchmark for examining the effect of wetland ratings on hydrophytic vegetation determinations because results always reflect the actual percentage of hydrophytic vegetation in a plot (Lichvar and Gillrich 2014b). The HCI makes determinations using only ratings and percent cover. Therefore, these two variables caused the hydrophytic determinations in upland plots. The data show that species with hydrophytic ratings exhibited mediocre fidelity to wetlands at the study sites (Figure 4). For instance, 14% of OBL species occurred in upland plots more often than or just as often as they occurred in wetland plots. By definition, these species almost always occur in wetlands (Table 1). But hydrophytic vegetation determinations in upland plots were primarily driven by 54% of the FAC and 38% of the FACW species, which were more abundant or just as abundant in upland plots as they were in wetland plots. When several of these species occurred together as a plant community, species composition changed very little along a wetland–upland gradient. Their hydrophytic ratings

(FACW and FAC) and large abundances created hydrophytic vegetation determinations in delineation plots on both sides of the boundary. Examples from the study sites include communities of *Tsuga heterophylla–Vaccinium ovalifolium* (both FAC) in AK, *Pinus contorta* (FAC)–*Picea engelmannii* (FAC)–*Calamagrostis canadensis* (FACW) in the WMVC region, and *Fraxinus pennsylvani*ca–*Impatiens capensis* (both FACW) in the NCNE region (Appendix A). Overall, 83% of the species with hydrophytic ratings occurred in upland plots at the field sites (Appendix A), suggesting that some NWPL ratings may overestimate wetland frequency.

The influence of misapplied ratings that overestimate wetland frequency is less apparent in the hydrophytic determinations produced in the upland plots by the DR (47%) and the PI (29%). These data exhibited the same pattern seen previously although differences among the three methods were not significant likely due to the small sample size (18 upland plots). An earlier study that used data from 637 plots found that the HCI (80%) produced significantly more hydrophytic determinations than either the DR (76%) or the PI (69%) (Lichvar and Gillrich 2014b). In this study, the DR made nonhydrophytic determinations (DR = 50) in three upland study plots where 55%–75% of the total cover was hydrophytic and either four or six species were dominant. The DR often exhibits this nonhydrophytic bias when an even number of species are selected as dominants by the 50/20 Rule (Lichvar et al. 2011). Likewise, the PI made nonhydrophytic determinations (PI = 3.1–3.4) in six upland plots, where 55–91% of the total cover was hydrophytic. Because it weights nonhydrophytes more heavily than hydrophytes, the PI produces fewer hydrophytic determinations than the other methods (Dewey et al. 2006; Lichvar et al. 2011). Differential weighting increases the likelihood of an index value greater than 3.0 in wetland plant communities composed mainly of FAC species, such as those on wetland boundaries (Lichvar and Gillrich 2014b).

It may appear as if the PI and the DR are better methods for making vegetation determinations during wetland delineations because they produce nonhydrophytic determinations in upland plots where vegetation is actually hydrophytic due to the influence of misapplied ratings. There are two problems associated with this approach. First, neither the DR nor the PI reduced the distance that hydrophytic vegetation extended past the wetland boundary (Figure 2). When vegetation extends 5–49 m past the wetland boundary during routine delineations using standard plot sizes of 1.5–9 m in diameter (e.g., USACE 2010), hydrophytic vegetation may not always be a useful indicator of wetland conditions because it is present in plots on both sides of the boundary. Yet, it is still possible to delineate the boundary using indicators of wetland hydrology and hydric soils under routine conditions. However, in difficult situations where one of the three factors is problematic, such as those described in chapter five of the Regional Supplements (e.g., USACE 2010), it is imperative that the remaining factors are accurate and reliable. In the WMVC region, for example, wetlands may not exhibit hydrology indicators during the dry season. Sites assessed during the dry season are considered wetland if they contain hydrophytic vegetation and hydric soils and there is no evidence of significant hydrologic manipulation (USACE 2010). When hydrophytic vegetation extends far beyond wetland into adjacent upland and wetland hydrology is lacking, the location of the wetland boundary may be influenced by misapplied ratings.

A second drawback is that the PI and the DR are not accurate or consistent (Lichvar and Gillrich 2014b). Although this study focused on vegetation determinations in upland plots, both the PI and the DR also produce nonhydrophytic determinations in three-factor wetland plots (Wakeley et al. 1996, Dewey et al. 2006). For instance, the PI determined that vegetation was nonhydrophytic (PI = 3.4) in one NCNE wetland plot in this study where 59% of the total cover was composed of species rated FAC or wetter. Because both the PI and the DR are biased, efforts to update wetland ratings will not necessarily improve the accuracy or reliability of the vegetation determinations that they produce. In contrast, the HCI produces nonhydrophytic determinations in plots only where total hydrophyte cover is less than or equal to 50% (Lichvar and Gillrich 2014b). Thus, it is as accurate as NWPL ratings and each investigator’s ability to estimate percent areal cover. Therefore, efforts to improve the quality of wetland ratings will also improve the accuracy and reliability of the vegetation determinations made using the HCI.

Overall, these data show that a majority of hydrophytes commonly encountered during wetland delineations are not restricted to wetlands. In this study, they persist from wetland up to 49 m into adjacent upland. Hydrophytic vegetation determinations in upland plots were driven primarily by species rated FACW and FAC that exhibited upland abundances or frequencies that were greater than or equal to that of wetlands (Figures 4 and 5). Many species rated OBL also occurred in uplands but were less likely to be abundant. These results indicate that hydrophytic vegetation alone is a poor indicator of wetland conditions for delineation purposes 65% of the time within the sites evaluated for this study. Nevertheless, the wetland boundary would not have changed despite the abundance of hydrophytic vegetation in upland areas, which points out the importance of using all three factors when making a wetland boundary determination. It is important to note that this project, which examined trends in wetland ratings in three Corps wetland regions, should not be considered evidence that an individual species is in need of a rating reexamination. Such a determination is beyond the scope of this study. However, these results illustrate the need for periodic updates that can improve the accuracy of NWPL ratings as new data become available.

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Appendix A: Species Included in the Hydrophyte Frequency and Abundance Analysis

Table A-1. Frequency (F) and average abundance (X A) of species with hydrophytic ratings that occurred (*a*) in only wetland plots or (*b*) in both wetland and upland plots. Data were collected at eight study sites in the Alaska (AK); the Western Mountains, Valleys and Coast (WMVC); and the Northcentral and Northeast (NCNE) regions. Shading signifies that upland plot frequency, abundance, or both was greater than or equal to that of wetland plots.

Region	Rating	Species	Authority	Wetland		Upland	
				F	X A	F	X A
a) Only occurred in wetland plots							
WMVC	OBL	*Carex utriculata*	Boott	5.0	28.6	0.0	0.0
NCNE	OBL	*Symplocarpus foetidus*	(L.) Salisb. ex Nutt.	4.0	10.8	0.0	0.0
WMVC	OBL	*Betula glandulosa*	Michx.	3.0	4.3	0.0	0.0
WMVC	OBL	*Caltha leptosepala*	DC.	3.0	0.4	0.0	0.0
AK	OBL	*Caltha leptosepala*	DC.	2.0	11.0	0.0	0.0
WMVC	FACW	*Galium trifidum*	L.	5.0	0.3	0.0	0.0
WMVC	FACW	*Erigeron glacialis*	(Nutt.) A. Nels.	3.0	0.7	0.0	0.0
WMVC	FACW	*Rhodiola rhodantha*	(Gray) Jacobsen	2.0	1.1	0.0	0.0
WMVC	FACW	*Senecio triangularis*	Hook.	2.0	1.0	0.0	0.0
WMVC	FACW	*Swertia perennis*	L.	2.0	0.6	0.0	0.0
WMVC	FACW	*Conioselinum scopulorum*	(Gray) Coult. & Rose	2.0	0.1	0.0	0.0
WMVC	FAC	*Geranium richardsonii*	Fisch. & Trautv.	2.0	0.6	0.0	0.0
WMVC	FAC	*Luzula parviflora*	(Ehrh.) Desv.	2.0	0.6	0.0	0.0
b) Occurred in wetland and upland plots							
WMVC	OBL	*Salix planifolia*	Pursh	7.0	22.3	3.0	4.3
WMVC	OBL	*Carex aquatilis*	Wahlenb.	6.0	14.7	2.0	3.5
AK	OBL	*Lysichiton americanus*	Hultén & St. John	4.0	50.0	2.0	10.0
WMVC	OBL	*Salix wolfii*	Bebb	3.0	2.3	1.0	1.0
NCNE	OBL	*Chamaedaphne calyculata*	(L.) Moench	2.0	6.5	1.0	4.0
NCNE	OBL	*Glyceria striata*	(Lam.) A.S. Hitchc.	2.0	1.1	1.0	0.5
WMVC	OBL	*Pedicularis groenlandica*	Retz.	2.0	1.1	1.0	1.0
NCNE	OBL	*Scirpus cyperinus*	(L.) Kunth	1.0	10.0	1.0	1.0
AK	OBL	*Nephrophyllidium crista-galli*	(Menzies ex Hook.) Gilg	1.0	2.0	1.0	1.0
WMVC	FACW	*Deschampsia caespitosa*	(L.) Beauv.	7.0	12.2	5.0	18.0
WMVC	FACW	*Calamagrostis canadensis*	(Michx.) Beauv.	6.0	40.5	3.0	10.0
WMVC	FACW	*Salix geyeriana*	Anderss.	4.0	16.3	2.0	14.5
WMVC	FACW	*Mertensia ciliata*	(James ex Torr.) G. Don	4.0	1.0	1.0	1.0
NCNE	FACW	*Impatiens capensis*	Meerb.	3.0	30.0	1.0	40.0
NCNE	FACW	*Onoclea sensibilis*	L.	3.0	3.0	1.0	2.0
NCNE	FACW	*Fraxinus pennsylvanica*	Marsh.	3.0	2.0	1.0	25.0
WMVC	FACW	*Polemonium occidentale*	Greene	3.0	0.7	1.0	0.1
NCNE	FACW	*Lindera benzoin*	(L.) Blume	2.0	50.0	2.0	25.0
NCNE	FACW	*Quercus palustris*	Muenchh.	2.0	6.5	2.0	2.5
NCNE	FACW	*Vaccinium corymbosum*	L.	2.0	4.5	2.0	15.0
NCNE	FACW	*Cornus alba*	L.	2.0	3.0	1.0	8.0
NCNE	FACW	*Rubus hispidus*	L.	2.0	1.5	2.0	3.0
NCNE	FACW	*Echinocystis lobata*	(Michx.) Torr. & Gray	2.0	0.6	1.0	0.5
NCNE	FACW	*Ulmus americana*	L.	1.0	45.0	1.0	5.0
AK	FACW	*Vaccinium caespitosum*	Michx.	1.0	5.0	3.0	3.0

Region	Rating	Species	Authority	Wetland		Upland	
				F	X A	F	X A
b) Occurred in wetland and upland plots (cont.)							
NCNE	FACW	*Carex scoparia*	Schkuhr ex Willd.	1.0	2.0	1.0	2.0
WMVC	FACW	*Veronica wormskjoldii*	Roemer & J.A. Schultes	1.0	0.1	1.0	1.0
AK	FAC	*Tsuga heterophylla*	(Raf.) Sarg.	4.0	55.0	5.0	62.8
NCNE	FAC	*Acer rubrum*	L.	4.0	53.0	5.0	9.4
AK	FAC	*Vaccinium ovalifolium*	Sm.	4.0	46.3	5.0	46.2
AK	FAC	*Coptis aspleniifolia*	Salisb.	4.0	31.8	3.0	13.5
AK	FAC	*Rubus pedatus*	Sm.	4.0	13.0	5.0	6.0
NCNE	FAC	*Arisaema triphyllum*	(L.) Schott	4.0	5.8	2.0	1.0
NCNE	FAC	*Toxicodendron radicans*	(L.) Kuntze	4.0	3.8	1.0	0.2
WMVC	FAC	*Geum macrophyllum*	Willd.	4.0	3.3	1.0	1.0
WMVC	FAC	*Phleum pratense*	L.	4.0	0.8	4.0	1.5
NCNE	FAC	*Solidago rugosa*	P. Mill.	4.0	0.4	2.0	0.6
WMVC	FAC	*Dasiphora fruticosa*	(L.) Rydb.	3.0	9.7	5.0	5.4
WMVC	FAC	*Bromus ciliatus*	L.	3.0	1.4	4.0	2.3
WMVC	FAC	*Poa pratensis*	L.	2.0	13.5	2.0	26.0
AK	FAC	*Thuja plicata*	Donn ex D. Don	2.0	12.5	2.0	15.0
AK	FAC	*Athyrium cyclosorum*	Rupr.	2.0	8.0	2.0	2.0
WMVC	FAC	*Poa palustris*	L.	2.0	7.6	2.0	4.0
NCNE	FAC	*Frangula alnus*	P. Mill.	2.0	6.0	1.0	15.0
NCNE	FAC	*Gaylussacia dumosa*	(Andr.) Torr. & Gray	2.0	3.5	2.0	2.0
AK	FAC	*Blechnum spicant*	(L.) Sm.	2.0	3.5	3.0	1.2
WMVC	FAC	*Pinus contorta*	Dougl. ex Loud.	2.0	3.0	3.0	53.7
WMVC	FAC	*Trifolium repens*	L.	2.0	3.0	3.0	15.3
NCNE	FAC	*Viburnum dentatum*	L.	2.0	2.6	3.0	0.4
WMVC	FAC	*Antennaria corymbosa*	E. Nels.	2.0	1.1	5.0	2.1
WMVC	FAC	*Maianthemum stellatum*	(L.) Link	2.0	1.0	1.0	1.0
NCNE	FAC	*Trientalis borealis*	Raf.	2.0	1.0	1.0	5.0
WMVC	FAC	*Potentilla pulcherrima*	Lehm.	2.0	0.1	4.0	1.0
AK	FAC	*Rubus arcticus*	L.	1.0	15.0	2.0	15.0
NCNE	FAC	*Kalmia angustifolia*	L.	1.0	12.0	1.0	3.0
NCNE	FAC	*Betula populifolia*	Marsh.	1.0	6.0	1.0	6.0
WMVC	FAC	*Vaccinium caespitosum*	Michx.	1.0	4.0	2.0	18.5
NCNE	FAC	*Euthamia graminifolia*	(L.) Nutt.	1.0	3.0	1.0	0.1
WMVC	FAC	*Picea engelmannii*	Parry ex Engelm.	1.0	2.0	3.0	19.3
WMVC	FAC	*Poa interior*	Rydb.	1.0	1.0	1.0	1.0
WMVC	FAC	*Agoseris glauca*	(Pursh) Raf.	0.0	0.0	3.0	0.4
WMVC	FAC	*Elymus trachycaulus*	(Link) Gould ex Shinners	0.0	0.0	2.0	2.5

Appendix B: Species Excluded from Hydrophyte Frequency and Abundance Analysis

Table B-1. Abundance values (A) of species with hydrophytic ratings that occurred in only one plot (Frequency [F] = 1). Data were collected at eight study sites in the Alaska (AK), Western Mountains, Valleys and Coast (WMVC), and the Northcentral and Northeast (NCNE) regions.

Region	Rating	Species	Authority	Wetland		Upland	
				F	A	F	A
a) occurred in one wetland plot							
WMVC	OBL	*Beckmannia syzigachne*	(Steud.) Fern.	1.0	8.0	0.0	0.0
AK	OBL	*Vaccinium oxycoccos*	L.	1.0	2.0	0.0	0.0
WMVC	OBL	*Glyceria borealis*	(Nash) Batchelder	1.0	2.0	0.0	0.0
NCNE	OBL	*Ludwigia palustris*	(L.) Ell.	1.0	1.0	0.0	0.0
NCNE	OBL	*Juncus effusus*	L.	1.0	0.5	0.0	0.0
NCNE	OBL	*Scirpus atrovirens*	Willd.	1.0	0.1	0.0	0.0
WMVC	OBL	*Viola macloskeyi*	Lloyd	1.0	0.1	0.0	0.0
AK	FACW	*Carex canescens*	L.	1.0	20.0	0.0	0.0
AK	FACW	*Rhododendron tomentosum*	Harmaja	1.0	1.0	0.0	0.0
WMVC	FACW	*Oxypolis fendleri*	(Gray) Heller	1.0	1.0	0.0	0.0
NCNE	FACW	*Agrostis stolonifera*	L.	1.0	0.5	0.0	0.0
WMVC	FACW	*Juncus drummondii*	E. Mey.	1.0	0.1	0.0	0.0
NCNE	FAC	*Rhamnus cathartica*	L.	1.0	10.0	0.0	0.0
AK	FAC	*Veratrum viride*	Ait.	1.0	2.0	0.0	0.0
WMVC	FAC	*Alopecurus pratensis*	L.	1.0	1.0	0.0	0.0
NCNE	FAC	*Juncus tenuis*	Willd.	1.0	0.2	0.0	0.0
b) occurred in one upland plot							
WMVC	OBL	*Salix monticola*	Bebb	0.0	0.0	1.0	6.0
AK	OBL	*Equisetum fluviatile*	L.	0.0	0.0	1.0	0.5
NCNE	FAC	*Morella pensylvanica*	(Mirbel) Kartesz	0.0	0.0	1.0	8.0
NCNE	FAC	*Matteuccia struthiopteris*	(L.) Todaro	0.0	0.0	1.0	1.0
NCNE	FAC	*Smilax rotundifolia*	L.	0.0	0.0	1.0	1.0
NCNE	FAC	*Panicum capillare*	L.	0.0	0.0	1.0	0.2
WMVC	FAC	*Agrostis scabra*	Willd.	0.0	0.0	1.0	0.1
WMVC	FAC	*Lonicera involucrata*	(Richards.) Banks ex Spreng.	0.0	0.0	1.0	0.1
NCNE	FACW	*Salix discolor*	Muhl.	0.0	0.0	1.0	0.5
WMVC	FACW	*Juncus longistylis*	Torr.	0.0	0.0	1.0	0.1

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14. ABSTRACT

This study evaluated how far and how often hydrophytic vegetation exceeded the wetland boundary in three U.S. Army Corps of Engineers wetland regions. Wetland boundaries were delineated using methods described in the Corps of Engineers Wetland Delineation Manual and appropriate Regional Supplements. Hydrophytic vegetation determinations were made using the Dominance Ratio, the Prevalence Index, and the Hydrophytic Cover Index. Distances and frequencies were tested using nonparametric statistics.

Hydrophytic vegetation exceeded the wetland boundary by 5–49 m, in 65% of the upland plots. Differences in distance ($p = 0.88$) or frequency ($p = 0.14$) among the three methods were not significant. Most (83%) of the species with hydrophytic ratings occurred in wetland and upland plots, suggesting that NWPL ratings may overestimate wetland frequency in some circumstances. Hydrophytic vegetation determinations in uplands were driven by 38% of FACW and 54% of FAC species, which exhibited an upland abundance greater than or equal to that of wetlands. These data indicate that hydrophytic vegetation is a poor indicator of the wetland boundary when used without considering hydrology and soils. Periodic review of NWPL ratings is recommended to improve accuracy of delineated boundaries.

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