ERDC/CRREL TN-10-2

Cold Regions Research and Engineering Laboratory

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Sphagnum as an Indicator of Wetland Hydrology in the Atlantic and Gulf Coastal Plain Region

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July 2010

Cover: *Sphagnum* mounds in wet pine flatwoods in Essex County, Virginia.

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Prepared for Atlantic and Gulf Coastal Plain Regional Working Group
Wetland Regulatory Assistance Program
U.S. Army Corps of Engineers
Washington, DC 20314-1000

Abstract: Using the presence of *Sphagnum* mats as a hydrology indicator during Federal delineations was suggested during field testing for the Southeastern Regional Supplement. However, some species of *Sphagnum* occur occasionally in uplands in the Atlantic and Gulf Coastal Plain Region, so this genus is not reliable enough to be a primary indicator of wetland hydrology. Instead, *Sphagnum* mats or cushions could be used as a secondary Class D hydrology indicator, which provides contemporary evidence of a saturated surface. A minimum cover requirement should be considered to ensure that *Sphagnum* is not mistakenly used as evidence of wetland hydrology in uplands. An on-site evaluation of the wet and mesic flatwood pine types is recommended to verify the association between the presence of wetland hydrology and increased percent cover. Some *Sphagnum* species appear bleached or whitened when desiccated, so the presence of “dead” plants should not be used as evidence that wetland hydrology is lacking.

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Preface

The work was performed by Jennifer J. Gillrich and Robert W. Lichvar, both of the Remote Sensing/Geographic Information Systems (RS/GIS) and Water Resources Branch, U.S. Army Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory (ERDC-CRREL), at the request of the Atlantic and Gulf Coastal Plain Regional Working Group. Funding was provided through the Wetlands Regulatory Assistance Program (WRAP). The authors appreciate the timely input from David M. Lane of the University of New Hampshire at Durham. At the time of publication, Timothy Pangburn was Chief, RS/GIS and Water Resources Branch. The Deputy Director of ERDC-CRREL was Dr. Lance Hansen and the Director was Dr. Robert E. Davis.

COL Gary E. Johnston was the Commander and Executive Director of ERDC, and Dr. Jeffery Holland was the Director.

1 Introduction

By definition, jurisdictional wetlands are delineated using three diagnostic characteristics: hydrophytic vegetation, hydric soils, and wetland hydrology (U.S. Army Corps of Engineers [USACE] 1987). These three factors do not always co-occur. Wetland hydrology is the least exact and can be difficult to document in the field (USACE 1987). When water cannot be directly observed, a variety of landscape, soil, or vegetation indicators provide indirect evidence that wetland hydrology is continuous. For instance, aquatic *Sphagnum* species are used in Florida as hydrology indicators in state delineations (Gilbert et al. 2007). During field testing for the Southeastern regional supplement to the Corps of Engineers *Wetland Delineation Manual* (USACE 2008), the Norfolk District suggested using *Sphagnum* mats as a hydrology indicator during Federal delineations. In response to this suggestion, we present and review the characteristics that make *Sphagnum* a possible environmental indicator, discuss desiccation tolerance and avoidance strategies, and examine *Sphagnum* habitat types in the southeast. The nomenclature is according to Anderson et al. (2009).

2 *Sphagnum* as an Environmental Indicator

The genus *Sphagnum* has many of the same characteristics that make vascular plants useful environmental indicators, such as association with certain landscape positions and other environmental variables. The genus occupies a wide geographic range but is mostly restricted to moist, cool, montane, or oceanic habitats throughout much of its range (Flora of North America Editorial Committee 2007). *Sphagnum* distribution is determined primarily by the continuity of the water supply and water chemistry (Clymo and Hayward 1982; Andrus 1986). Species response curves of most *Sphagnum* species along a complex depth-to-water-table/microtopographic gradient are most often monotonic or bell-shaped (Økland 1986; Rydgren et al. 2003), suggesting that water table depth is an important determinant of species distribution. According to Andrus (1986), *Sphagnum* species fill a wider range of niches than is commonly recognized, and they should not be lumped into one large ecological group. They are well known for their microsite specificity, occupying specific niches based on gradients of shade, height above water table, pH, and specific conductivity (Slack et al. 1980; Lane and Dubois 1981; Andrus et al. 1983). Some *Sphagnum* species occupy niches on or near the wetland boundary with greater frequency than other bryophytes (Lichvar et al. 2009).

3 Desiccation Tolerance and Avoidance Strategies

Bryophytes obtain moisture from a variety of sources, including humidity, dew, mist, precipitation, and surface and ground waters. Yet, in Southeast Coastal Plain wetlands, the growth of some *Sphagnum* species is limited by moisture availability for two reasons. First, the hydroperiods of southern wetlands fluctuate; seasonal dry periods occur in many wetland types (USACE 2008). Second, bryophytes are physiologically active only when hydrated. During dry periods, they become dormant, resuming normal metabolism when water is available (Proctor et al. 2007). Lane and Dubois (1981) divided Coastal Plain *Sphagnum* species into four groups based on microsite height in relation to the water table measured from February to April. Aquatic species grow at the water table, while semi-aquatic *Sphagnum* species occur up to 0.5 cm above the water table. Terrestrial species occupy microsites from 2.2 to 29.0 cm above the water table. The fourth group consists of highly variable species spanning the entire range. Terrestrial *Sphagnum* species can be further divided to create a total of five ecological groups. Carpet/hollow species grow closer to the water table, whereas lawn/hummock species grow farther from it (Sjors 1950).

Physiologically, four of the five groups tolerate some degree of desiccation. The main difference between their microsites is the length of time that they are wet and dry (Proctor et al. 2007). Aquatic species, such as *S. macrophyllum*, *S. torreyanum*, or *S. cuspidatum*, grow in or along margins of ponds or pools and in roadside ditches and embankments (Reese 1984; Anderson et al. 2009). Semi-aquatic species, such as *S. cyclophyllum* or *S. fitzgeraldii*, inhabit very small pools or puddles that dry out much more quickly. Anderson et al. (2009) suggests that aquatic *Sphagnum* species outcompete *S. fitzgeraldii* in larger water bodies. *S. fitzgeraldii* may prove unreliable for delineation purposes, despite its aquatic occurrences because it is ephemeral, colonizing disturbed habitats and reproducing frequently (Andrus 1986). Terrestrial hollow/carpet species, such as *S. fallax* or *S. recurvum*, form carpets or mats in mesic to wet, shallow depressions in roadside ditches, flatwoods, pocosin margins, and swamps (Flora of North America Editorial Committee 2007; Anderson et al. 2009). In New Jersey, *S. fallax* is an important species in the carpets of weakly minerotrophic peatlands (Karlin and Andrus 1988). Hollow species, such as *S.*

fallax, tolerate longer periods of desiccation and restore photosynthesis at higher rates after rehydration than do hummock species (Wagner and Titus 1984). Aquatic, semi-aquatic, and carpet/hollow species have similar morphologies: lax, weak-stemmed, or sprawling. The presence of widely spaced groups of branches, or fascicles, suggests that external water retention and transport are unnecessary (McQueen 1990). At the extreme, *S. cyclophyllum* often lacks branches and a well-developed capitulum.

In contrast, terrestrial hummock-formers resist desiccation (Wagner and Titus 1984) by forming cushions or mounds in mesic to wet shallow depressions. The compact morphology of species such as *S. bartlettianum* or *S. flavicomans* (Lane and Dubois 1981; Reese 1984; Karlin and Andrus 1988) creates an external matrix of tightly packed branches, leaves, and capillary spaces that retains water. Plants also store water internally in large empty hyaline cells that are dead at maturity. The humid oceanic climate, the ability to obtain water from sources other than the soil, and the ability to store water externally and internally keeps the actively growing capitulum hydrated during summer dry periods (Clymo and Hayward 1982). Conservative hummock-formers grow more slowly than opportunistic hollow species, creating the conditions necessary to ensure their survival far above the summer water table (Luken 1985; Andrus 1986). While some hummock-formers grow in wetlands, others occur mainly in areas considered to be uplands. For instance, *S. strictum* is recognized as a pioneer that colonizes mesic to wet disturbed areas, such as roadside embankments, ditches, and recently burned savannas (Reese 1984; Flora of North America Editorial Committee 2007; Anderson et al. 2009). Likewise, *S. tenerum* is common in mesic savannas, pine barrens, moist roadbanks, and ditches, but it is also sometimes found in swamps.

Highly variable species, such as *S. lescurii*, *S. molle*, and *S. perichaetiale*, inhabit many microsite types (Lane and Dubois 1981). Their morphology varies from lax and sprawling to compact, depending on the hydrologic conditions of their microsite. For instance, *S. molle* forms compact cushions in savannas, pine barrens, and ditches. Plants tend to be thin with widely spaced fascicles in hardwood swamps. *S. lescurii* grows in ditches, floodplains, flatwoods, wet savannas, pocosins, and swamps. Plants that grow submerged or emergent are larger and plumper than terrestrial versions. *S. perichaetiale* is a ruderal species that occurs in compact cushions or in loose mats in drier habitats such as roadbanks, power line right-ofways, moist to wet soil in savannas, and cedar swamps (Reese 1984; Flora of North America Editorial Committee 2007; Anderson et al. 2009).

4 *Sphagnum* Habitat Types in the Southeast

Approximately 31 *Sphagnum* species occur in the Atlantic and Gulf Coastal Plain Region (Karlin and Andrus 1988; Karlin et al. 1991; Anderson et al. 2009). *Sphagnum* occurrences depend on some level of hydrologic continuity (Clymo and Hayward 1982), but a small group of *Sphagnum* species can be found in environments that lack hydrophytic vegetation, hydric soils, or both. When hydrologic conditions are adequate, *Sphagnum* species inhabit many substrates, including rocks, root collars, sand, and peat (Gilbert et al. 2007; Hill et al. 2007; Anderson et al. 2009). The genus is not common in the Mississippi Alluvial Valley, the Florida Peninsula, or the Inner Coastal Plain, occurring mainly along streambanks and on lake or pond margins.

Field studies and herbarium records show that *Sphagnum* occurs in both uplands and wetlands in the Northern and Outer Coastal Plains. The genus is found in many plant communities and habitats that are not wetlands, such as pineland tree—awn grass (*Aristida stricta*) dominated sand hills, maritime live oak (*Quercus virginiana*)—pine forests, roadside ditches, borrow pits, and exposed rock outcrops (Lane and Dubois 1981; Reese 1984; Karlin and Andrus 1988; Anderson et al. 2009). However, *Sphagnum* species also occur in many of the wetland types described in the Atlantic and Gulf Coastal Plain Regional Supplement (USACE 2008), such as hardwood bottomland swamps, depressional wetlands, pocosins, savannas, and pine barrens. The distinction Anderson et al. (2009) makes between wet pine flatwoods [dominated by loblolly pine (*Pinus taeda*) (cover photo) and pond pine (*P. serotina*)] and mesic pine flatwoods [dominated by *P. taeda*, longleaf pine (*P. palustris*), shortleaf pine (*P. echinata*), and spruce pine (*P. glabra*)] may be of particular interest if this distinction between pine types is associated with occurrences of *Sphagnum*. According to Anderson et al. (2009) the genus is not abundant in mesic pine flatwoods, occurring only in low places, but is more frequent in wet pine flatwoods, where it forms mats in swales, on pool margins, and in wet depressions.

5 Conclusion

Given that some species of *Sphagnum* occur occasionally in uplands of the Atlantic and Gulf Coastal Plain Region, we believe that this genus is not reliable enough to be a primary indicator of wetland hydrology. The region's annual moisture surplus, its humid oceanic climate, and *Sphagnum*'s unique morphologies enable some species of *Sphagnum* to grow in uplands. Yet, as xerophytic hydrophytes (List and Andrus 1989), *Sphagnum* species associated with wetlands can provide evidence of continuing hydrology since their morphology and physiology are adapted to persist through the seasonal dry periods that are common in many southeastern wetlands. Therefore, we recommend using *Sphagnum* mats or cushions as a secondary Class D hydrology indicator, which provides contemporary evidence of a saturated surface. A minimum percent cover threshold should also be set to ensure that *Sphagnum* is not mistakenly used as evidence of wetland hydrology in uplands, where it occurs occasionally but is not abundant.

Caution should be exercised in pine flatwoods. We recommend an on-site evaluation of the wet and mesic flatwood pine types (Anderson et al. 2009) for refining the use of *Sphagnum* as a hydrology indicator. In wet pine flatwoods dominated by *Pinus taeda* and *P. serotina*, a minimum threshold cover value will verify the association between the presence of wetland hydrology and increased percent cover. In mesic flatwoods, a similar minimum cover threshold should be set to ensure that *Sphagnum* cover represents the presence of wetland hydrology (i.e., in low areas with a high water table) and not the humid oceanic climate.

Finally, inexperience with the genus could lead to incorrect conclusions. For example, when desiccated, *S. fitzgeraldii* could be mistaken for dead, given its whitened, scruffy appearance, while *S. cyclophyllum* might not even be recognized as a member of the genus. Hence, the lack of *Sphagnum* or the presence of "dead" plants should not be used as evidence that wetland hydrology is lacking.

References

Andrus, R. E. 1986. Some aspects of *Sphagnum* ecology. *Canadian Journal of Botany* 64: 416–426.

Andrus, R. E., D. J. Wagner, and J. E. Titus. 1983. Vertical zonation of *Sphagnum* mosses along hummock-hollow gradients. *Canadian Journal of Botany* 61: 3128–3139.

Anderson, L. E., A. J. Shaw, and B. Shaw. 2009. *Peat mosses of the southeastern United States.* New York: The New York Botanical Garden Press.

Clymo, R. S., and P. M. Hayward. 1982. The ecology of *Sphagnum*. In *Bryophyte ecology* (A. J. E. Smith, ed.). 1st ed., 229–290. New York: Chapman and Hall.

Flora of North America Editorial Committee. 2007. *Flora of North America north of Mexico.* 1st ed., Vol. 27. New York: Oxford University Press.

Gilbert, K. M., J. D. Tobe, R. W. Cantrell, M. E. Sweeley, and J. R. Cooper. 2007. *The Florida wetlands delineation manual.* Tallahassee, FL: Florida Department of Environmental Protection. (http://www.dep.state.fl.us/water/wetlands/delineation/manual.htm) (accessed 9/28/2008).

Hill, M. O., C. D. Preston, S. D. S. Bosanquet, and D. B. Roy. 2007. *Attributes of British and Irish mosses, liverworts and hornworts.* Norwich, England: NERC Centre for Ecology and Hydrology, Natural Environment Resources Council. (http://www.ceh.ac.uk/products/publications/bryoatt.html).

Karlin, E. F., and R. E. Andrus. 1988. The *Sphagnum* species of New Jersey. *Bulletin of the Torrey Botanical Club* 115: 168–195.

Karlin, E. F., R. E. Andrus, and C. F. Reed. 1991. The *Sphagnum* flora of Delaware. *Bulletin of the Torrey Botanical Club* 118: 43–51.

Lane, D. M., and S. Dubois. 1981. Water analysis of habitats of *Sphagnum* in the coastal plain of North and South Carolina. *The Bryologist* 84: 408–413.

List, A., Jr., and R. E. Andrus. 1989. Bryophytes of Pennsylvania wetlands. In *Wetlands ecology and conservation: Emphasis in Pennsylvania* (S. K. Majumdar, R. P. Brooks, F. J. Brenner, and R. W. Tiner, ed.). 1st ed., 124–138. Easton, PA: The Pennsylvania Academy of Science.

Lichvar, R. W., G. A. Laursen, R. D. Seppelt, and W. R. Ochs. 2009. Selecting and testing cryptogam species for use in wetland delineation in Alaska. *Arctic* 62: 201-211.

Luken, J. O. 1985. Zonation of *Sphagnum* mosses: Interactions among shoot growth, growth form, and water balance. *The Bryologist* 88: 374–379.

McQueen, C. B. 1990. *Field guide to the peat mosses of boreal North America*. 1st ed. Hanover, NH: University Press of New England.

Økland, R. H. 1986. Rescaling of ecological gradients. II. The effect of scale on symmetry of species response curves. *Nordic Journal of Botany* 6: 661–669.

Proctor, M. C. F., P. Alpert, N. Cleavitt, B. D. Mishler, M. J. Oliver, L. R. Stark, and A. J. Wood. 2007. Desiccation tolerance: A review. *The Bryologist* 110: 595–621.

Reese, W. D. 1984. *Mosses of the Gulf South, from the Rio Grande to the Appalachicola*. Baton Rouge, LA: Louisiana State University Press.

Rydgren, K., R. H. Økland, and T. Økland. 2003. Species response curves along environmental gradients. A case study from SE Norwegian swamp forests. *Journal of Vegetation Science* 14: 869–880.

Sjors, H. 1950. Regional studies in north Swedish mire vegetation. *Botaniska notiser* 2: 173–222.

Slack, N. G., D. H. Vitt, and D. G. Horton. 1980. Vegetation gradients of minerotrophically rich fens in western Alberta. *The Canadian Journal of Botany* 58: 330–350.

U.S. Army Corps of Engineers (USACE). 1987. *Corps of Engineers wetland delineation manual.* Wetlands Research Program Technical Report Y-87-1 (on-line edition). Vicksburg, MS: U.S. Army Engineer Research and Development Center, Environmental Laboratory.

______. 2008. *Interim regional supplement to the Corps of Engineers wetland delineation manual: Atlantic and Gulf Coast Plain region*. ERDC/EL TR-08-30. Vicksburg, MS: U.S. Army Engineer Research and Development Center, Environmental Laboratory. (www.usace.army.mil/cw/cecwo/reg/fld_test_protocol_coastalplain_6-15-2007.pdf) (accessed 12/22/08).

Wagner, D. J., and J. E. Titus. 1984. Comparative desiccation tolerance of two *Sphagnum* mosses. *Oecologia* 62: 182–187.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
July 2010

2. REPORT TYPE
Technical Note

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE

Sphagnum as an Indicator of Wetland Hydrology in the Atlantic and Gulf Coastal Plain Region

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Jennifer J. Gillrich and Robert W. Lichvar

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

U.S. Army Engineer Research and Development Center
Cold Regions Research and Engineering Laboratory
72 Lyme Road
Hanover, NH 03755-1290

8. PERFORMING ORGANIZATION REPORT NUMBER

ERDC/CRREL TN-10-2

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Headquarters
U.S. Army Corps of Engineers
Washington, DC 20314-1000

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Using the presence of *Sphagnum* mats as a hydrology indicator during Federal delineations was suggested during field testing for the Southeastern Regional Supplement. However, some species of *Sphagnum* occur occasionally in uplands in the Atlantic and Gulf Coastal Plain Region, so this genus is not reliable enough to be a primary indicator of wetland hydrology. Instead, *Sphagnum* mats or cushions could be used as a secondary Class D hydrology indicator, which provides contemporary evidence of a saturated surface. A minimum cover requirement should be considered to ensure that *Sphagnum* is not mistakenly used as evidence of wetland hydrology in uplands. An on-site evaluation of the wet and mesic flatwood pine types is recommended to verify the association between the presence of wetland hydrology and increased percent cover. Some *Sphagnum* species appear bleached or whitened when desiccated, so the presence of "dead" plants should not be used as evidence that wetland hydrology is lacking.

15. SUBJECT TERMS
Hydrology
Southeastern U.S.
Sphagnum
Wetland hydrology
Wetlands

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER	19a. NAME OF RESPONSIBLE PERSON / 19b. TELEPHONE NUMBER (include area code)
U	U	U	U	16	