PEAT ANALYSIS FOR COASTAL WETLAND ENFORCEMENT CASES

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Abstract. This paper presents a step-by-step description of peat analysis, a technique for determining whether wetlands have been filled. Vertical core samples from suspected buried wetland profiles are analyzed with the aid of a peat key, a root-rhizome reference collection, and control samples. The technique not only potentially reinforces aerial photographic interpretations, but also appears to have probative value in itself for demonstrating the presence of filled, former wetlands. It has been applied to brackish marshes and saltmarshes in five coastal wetland enforcement cases in Maryland and Virginia, all involving litigation in which substantial penalties were levied against the defendants.

INTRODUCTION

In implementing wetland regulations, resource agencies frequently encounter violations which result in enforcement actions. Demonstrating, especially in court, that a violation has occurred, however, is not always easy. Agencies have traditionally relied on historical evidence, such as aerial photographs, to show that wetlands have been filled. Although historical evidence can be very useful, it may be challenged in the courts based upon contrary interpretations. The purpose of this paper is to present a technique, peat analysis, which not only potentially reinforces aerial photographic interpretations, but also appears to have probative value in itself as a tool for demonstrating the presence of filled, former wetlands.

Although this paper describes only peat analysis, application of this technique has usually been done in conjunction with an interagency investigatory team comprised of representatives of the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, the U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency, the National Oceanic and Atmospheric Administration, and sometimes state personnel. The team approach also involves aerial photographic interpretation of the fill site and any contiguous unfilled wetlands and contiguous undisturbed uplands, as well as the collection of floristic, soil and hydrologic data.

PEAT ANALYSIS

Vertical core samples from suspected buried wetland profiles (i.e., pre-fill surface vegetation, organic layer, including peat and muck, and underlying materials) are extracted and analyzed with the aid of a peat key, a root-rhizome reference collection, and control samples to determine the presence or absence of an organic layer, particularly peat, and its species' composition. Peat refers to the sod layer at and near the surface of a wetland as well as the deeper, partially decomposed, vegetation into which the sod eventually grades. When the organic material is decomposed to the extent that it is no longer fibrous, it is considered muck.

Because organic matter accumulates more rapidly than it decomposes under wet conditions, a major assumption underlying peat analysis is that the presence of peat is indicative of wetlands. This is a valid assumption since organic soils (Histosols), with two exceptions, always occur in wetlands. One exception is for certain Histosols called Folists which occur mostly in very humid climates from the Tropics to high latitudes. In the United States, Folists are found mainly in Hawaii and Alaska (Soil Survey Staff, USDA 1975). The second exception is for sites containing Histosols which have been drained to the extent that they are no longer hydrologically considered wetlands. Thus, for most of the United States, especially undrained sites, if *in situ* peat is found beneath fill material, it is generally safe to assume that wetlands existed prior to filling. For example, *in situ* peat beneath fill material in a Mid-Atlantic coastal area would be indicative of prior wetland conditions. In addition, Histosols are not the only wetland soils. Mineral soils with a histic epipedon (i.e., a thin, 8-16 inch, horizon of peat or muck), and sometimes sandy soils with an even thinner organic layer, are also considered wetland soils.

Because of the potential for use of this technique by personnel involved in wetland enforcement cases, a detailed, step-by-step procedure for applying peat analysis is given below.

Pre-Field Investigation Preparation

Examine pre-filling and post-filling aerial photographs, preferably natural color or color infrared, for the fill site and surrounding area. Photograph scale will depend upon what is available and site size and conditions. Large scale coverage is useful for locating peat sampling stations and to delineate the extent and types of wetlands filled. Small scale coverage provides a perspective of the fill site relative to the general area. Published soil surveys for the area are useful to determine whether the soil series shown for the site has wetness characteristics, such as gleying and mottling. In addition, the soil series could be compared with the list of hydric soils published by the Soil Conservation Service (1985).

Tentatively delineate wetlands that appear to have been filled, as well as any contiguous unfilled wetlands and contiguous undisturbed uplands, using acetate overlays.

Preselect the number and locations, of test core samples in the fill area and control core samples in both the contiguous undisturbed uplands and the contiguous unfilled wetlands. In the absence of contiguous uplands or wetlands, use the nearest uplands and similar available wetlands to obtain control samples. The purpose of upland control samples is to compare the fill material/buried wetland profile in the fill area with the upland profile in the contiguous uplands. The upland samples would not have peat or other wetness characteristics typical of wetland soils. Wetland control samples allow a comparison of the fill material/buried wetland profile in the fill area with the unfilled wetland profile in the contiguous unfilled wetlands in terms of peat thickness and composition and the presence or absence of other wetness characteristics. Rhizomes from the wetland control samples could also be used for identifying rhizomes found in test samples. The appropriate number of test and control samples will be a function of site characteristics, and thus will depend upon the size and shape of the fill area. Large areas, particularly large irregularly shaped areas, will obviously require more samples. In addition, more samples will be necessary if wetland boundaries must be delineated in the field as opposed to sampling simply to reinforce wetland photointerpretation. Tentatively delineate the test and control sample locations on the acetate overlay.

Assemble necessary equipment, such as post hole diggers or bucket augers for extracting samples, tape and containers (e.g., sturdy plastic trash bags or heavy duty freezer bags for collecting, sealing, and storing samples), labels, tape measurers for locating sampling stations in relation to reference points, and large numerical markers for identifying sampling stations on aerial photographs (assuming an overflight is planned as part of the investigation).

Field Procedures

Walk the periphery of the suspected fill site and modify the locations of tentatively delineated sampling stations on the aerial photograph as appropriate. Locate the test and control sampling stations on the ground and, assuming an aerial overflight is to be conducted, identify them with large numerical markers.

Using a posthole digger or bucket auger, extract core samples from the fill material/buried wetland profile (test samples) and from both the contiguous undisturbed uplands and the contiguous unfilled wetlands (control samples). All test and control cores should generally be to the same depths below the surface of the buried soil profile and the surface of the undisturbed soil profiles, respectively. In collecting control samples, be sure to keep above ground plant parts intact for easy identification of attached roots and rhizomes. Samples should also generally extend through the entire wetland profile and at least 6-12 inches into the underlying substrate. When thick Histosols are encountered, however, it is unnecessary and may be impracticable to examine the underlying mineral layer over which the peat developed.

As the material is extracted, deposit each core section end to end on the ground (preferably onto a ground cloth) radiating out and starting from the top of the hole. This will allow examination of the essentially continuous profile prior to bagging the sample. Selected photographs of the extracted material should also be taken at this time.

Examine and characterize the test and control samples in terms of texture and color. Describe the fill material overlying the organic layer, the organic layer, and the substrate below the organic layer in the test samples. For color designations, the Munsel Soil Color Charts (Kollmogen Corporation, 1975) are recommended. Check for other soil wetness characteristics, such as gleying and mottling, below the organic layer, especially at wetland sites having mineral soils with only a thin layer of peat or muck. A buried peat or muck layer will be compressed to varying degrees depending upon its thickness and density and the weight of the overlying fill. Consequently, it may be difficult to differentiate a thin, compressed peat or muck layer from a heavy deposit of litter and duff associated with an upland soil, unless plant species composition can be determined. Under such circumstances, reliance on other soil wetness characteristics will be necessary.

Bag, label, and seal each sample. Significant test sample material occurs in the pre-fill wetland soil profile, so be sure to include any pre-fill surface vegetation and the organic layer. Include as much of the wetland and upland control samples as necessary for comparative purposes. If more than one container is used for a single core sample, be sure to indicate the vertical position of each subsample in relation to the soil profile. No special measures are necessary to preserve the samples other than sealing containers and storing them in a cool area. Core samples can be stored for months without any physical or apparent chemical changes.

Measure and record the in situ thickness of the organic layer in each core hole, and its depth in relation to the surface of the fill. Also measure and record the depth to standing water in each test and control core hole. Such hydrologic information is useful for demonstrating periodic inundation or soil saturation, and in some instances, water levels can be correlated with tidal surveys.

Fill in all core holes with the extracted or adjacent fill material. Transfer the samples to a secure vehicle and eventually to a secure permanent storage facility.

Laboratory Procedures

Estimate and record the amount of peat and muck in each sample. Thoroughly sort through each sample and extract any plant parts (e.g., rhizomes, roots, leaves, and stems) that appear potentially identifiable. Wash residual sediment from plant parts in a water basin and separate like parts for identification purposes. Examine plant parts with 10x hand lens or a dissecting microscope as necessary. Make observations on gross morphology (e.g., rhizome diameter, rhizome scales and scale scars, rhizome color) and examine anatomy of rhizomes by sectioning.

Using a peat key (e.g., a saltmarsh peat key published by Niering, Warren and Weymouth, 1977), a root-rhizome reference collection and/or wetland control samples collected adjacent to the site, identify plant parts to species in each test sample. Although the use of all three of these tools is preferable, the control samples alone will suffice as a reference collection if the species dominating the wetland involved are all represented in the control samples. If the control samples are not representative of the dominant plants at the site and a root-rhizome reference collection is not available, an ad hoc root-rhizome collection could be compiled from the contiguous wetlands by extracting representative species with their roots and rhizomes attached. Representative species should be labeled and stored in a vasculum or plastic trash bag to keep them turgid prior to use in the peat analysis. Because the roots and rhizomes in both a reference root-rhizome collection and an ad hoc root-rhizome collection would have been collected in conjunction with attached above ground plants, it should be relatively easy to identify the below ground plant parts to species in test samples. Morphological and anatomical comparisons can be made as is readily done with herbarium specimens. For example, rhizomes of characteristically high and low marsh saltmarsh species were identified by Clark and Patterson (1984) using the above-referenced saltmarsh peat key and comparison with field specimens. Furthermore, the most important wetland diagnostic criterion in peat analysis in most instances is the presence of peat, which under undrained conditions supports only wetland plants (except for a suborder of Histosols known as Folists).

Another option is to prepare a permanent reference collection of glass slides showing the cross-sectional anatomy of various vegetative parts (e.g., rhizomes) of representative plant species. Vegetative parts found in test samples could be similarly prepared for comparison with the reference collection. Such plant anatomical studies are commonly done; two specific to halophytes are those by Anderson (1974) and Liphschitz and Waisel (1982). Standard methods for plant anatomical investigations are found in Johansen (1940).

Record species specific data, such as the number of rhizomes for each species. Unidentifiable plant parts should be recorded as such. Record which species/parts dominate each sample. Dominants are those species/ parts which either individually or in combination comprise the bulk of the plant material in the test and control samples. After each sample is examined, return it to its container, which should be sealed again for storage and possible use as evidence.

Report Preparation

Prepare a detailed report explaining the methods, results, and conclusions of the investigation. Include a table showing the composition of test and control samples, and indicate the location of sampling stations on either a map or an overlay of an aerial photograph. If an aerial photographic analysis of the site is done in conjunction

with the peat analysis, then a combined report should be prepared. The sampling stations could then be superimposed on an overlay of an aerial photograph delineating the type and extent of wetlands filled and any contiguous unfilled wetlands and contiguous undisturbed uplands.

APPLICATION OF TECHNIQUE

This technique was originally conceived in 1977 in conjunction with a tidal wetland program for the Maryland Department of Natural Resources. Although a root-rhizome reference collection was assembled at that time, it was never applied to an enforcement situation. In 1981, however, as an employee of the U.S. Environmental Protection Agency, I became involved in a coastal wetland enforcement case in Virginia. Through this effort and subsequent enforcement cases, I developed and refined the technique. To date, peat analysis has been applied to brackish marshes and saltmarshes in five coastal wetland cases in Maryland and Virginia, all involving litigation in which substantial penalties were levied against the defendants. It has been very successful in demonstrating whether wetlands existed under fill prior to disturbance. Cores were readily extracted, especially with a bucket auger, and peat was distinguishable from any litter and duff in the organic horizons of adjacent upland soils. Because of their diagnostic characteristics, rhizomes in particular have generally been easy to identify through the use of a peat key, a root-rhizome reference collection, and control samples. Those not identifiable were assumed to be wetland species as long as they occurred in the peat. In all instances, results from peat analysis were consistent with results from photographic interpretation and prior field investigations.

Although peat analysis was developed principally for use in coastal wetlands, particularly saltmarshes, the same approach could probably be applied to any wetlands that have perennial vegetation, especially rhizomatous vegetation. However, a representative root-rhizome reference collection would have to be compiled and/or an appropriate peat key would have to be developed.

This technique has not been applied before in coastal wetlands in relation to enforcement cases. A technique was successfully developed to anatomically differentiate ten coastal plant species through the use of leaf plant identification keys (Williams, 1981). After developing the keys, Williams buried leaf fragments in marsh substrate to simulate a dredging and/or filling operation and subsequently recovered them for identification using the keys. However, he has not (personal communication) applied his technique to an actual enforcement case, nor did he work with below-ground plant parts or peat. Personnel from the Baltimore District Corps of Engineers (personal communication with Alex Dolgas) have extracted peat from beneath fill material in conjunction with enforcement efforts, but they have not developed or applied a specific technique or tools, such as a diagnostic key or root-rhizome reference collection, for identifying peat composition. Many studies involving peat analyses have been conducted in wetlands, particularly bogs and coastal marshes (e.g., Heusser 1949; Elliott 1972;

Whitehead 1972; Niering et al. 1977; Clark and Patterson, 1984), but these studies related, for the most part, to the origin and developmental history of the sites involved or their surrounding vegetation. Consequently, the Maryland and Virginia enforcement cases mentioned above apparently represent the first systematic application of this technique to coastal wetlands (or perhaps any wetlands).

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LITERATURE CITED

Anderson, C.E. 1974. A review of structure in several North Carolina salt marsh plants. In Ecology of halophytes. Reinold and Queen, Eds. Academic Press, Inc. pp. 307-344.

Clark, J.S. and W.A. Patterson, III. 1984. Pollen, PB-210, and opaque spherules: An integrated approach to dating and sedimentation in the intertidal environment. Journal of Sedimentary Petrology. Vol. 54:1251-1265.

Elliott, G.K. 1972. The Great Marsh, Lewes, Delaware. The physiography, classification and geologic history of a coastal marsh. College of Marine Studies, University of Delaware, Newark, Delaware. 139 pp.

Heusser, C.J. 1949. History of an estuarine bog at Secaucus, New Jersey. Bulletin Torrey Botanical Club 76:385-406.

Johansen, D.A. 1940. Plant microtechnique. McGraw-Hill Book Comp., N.Y. 523 pp.

Kollmogen Corporation. 1975. Munsel soil color charts. Baltimore, Maryland.

Lipschitz, N. and Y. Waisel. 1982. Adaptations of plants to saline environments: Salt excretion and glandular structure. In Contributions to the ecology of halophytes. Sen and Rajpurohit, Eds. Dr. W. Junk Publishers, The Hague. pp. 197-214.

Niering, W.A., R.S. Warren, and C.G. Weymouth, 1977. Our dynamic tidal marshes: Vegetation changes as revealed by peat analysis. Bulletin No. 22. The Connecticut Arboretum, New London, Connecticut. 12 pp.

Soil Conservation Service, U.S. Department of Agriculture. 1985. Hydric soils of the United States 1985.

Soil Survey Staff. 1975. Soil taxonomy. Agriculture Handbook No. 436, Soil Conservation Service, U.S. Department of Agriculture. 754 pp.

Whitehead, D.R. 1972. Developmental and environmental history of the Dismal Swamp. Ecological Monographs 42:301-315.

Williams, B.F. 1981. The use of microscopic vegetative characteristics and leaf deterioration rates in the formulation of keys of some wetland plants. Masters Thesis, Old Dominion University. 36 pp.