Freshwater Wetlands in Maine

Executive Department

Maine State Planning Office
November 1979

Freshwater Wetlands: Their Relevance To The Critical Areas Program of the State Planning Office

by

TIMOTHY ZORACH

November 1979

A REPORT PREPARED FOR THE

MAINE CRITICAL AREAS PROGRAM

STATE PLANNING OFFICE

184 State Street

Augusta, Maine 04333

Planning Report # 70

Financial support for this project was provided by the U.S. Water Resources Council under the Water Resources Planning Act of 1965.

FOREWORD

The following report on Freshwater Wetlands, by Timothy Zorach, was prepared for Maine's Critical Areas Program. This program was established by an act of the Legislature in 1974 which directed the State Planning Office to develop an official Register of Critical Areas and to encourage and coordinate the conservation of such areas as part of its overall responsibility for comprehensive statewide planning and coordination of planning activities. The Act defines Critical Areas as natural features of statewide inportance because of their unusual natural, scenic, scientific, or historical significance.

The Act also created the Critical Areas Advisory Board to advise and assist the State Planning Office in the establishment of the Register and the conservation of critical areas. The program established by the Act is not regulatory, with the minor exception that notification of proposed alterations of critical areas is required of the landowners thereof. The program is primarily one of identifying critical areas and providing advice to and coordinating the voluntary activities of landowners, state and local government organizations, conservation groups and others to the end of encouraging the conservation of critical areas. The Critical Areas Program further provides a specific focus for the evaluation and coordination of programs relating to critical areas in Maine. The program also serves as a source of information on critical areas and their management.

The purpose of these reports is to present the results of thorough investigations of subject areas chosen for consideration in the Critical Areas Program. The reports are an intermediate phase in a systematic registration process which starts with the identification of subjects for consideration and concludes with the analysis of each potential critical area individually and, if appropriate, inclusion of areas on the Register.

In addition to the specific task they are intended to fulfill in the registration process, it is my hope that these reports will be useful in a more general sense as a source of information on the various topics they cover. For more information on wetlands or other aspects of the Critical Areas Program, feel free to contact me or other members of the staff at the State Planning Office.

R. Alec Giffen
Assistant Director

TABLE OF CONTENTS

PART I

The Significance of freshwater wetlands

Part II

A Trial Inventory and Identification of Significant Freshwater Wetlands in the Presumpscot River Basin, Saco River Basin and Associated Coastal Drainage Basins

PART I

The Significance of fresh water wetlands

Introduction

Maine's freshwater wetlands are valuable natural assets which serve numerous functions and deserve recognition for their economic and ecological importance. As interest in these ecosystems grows, more information accumulates about their value to human society. This report describes what is presently known about freshwater wetlands in Maine and develops criteria for identifying those wetlands with truly outstanding features. The types of wetlands are defined and different classification systems are discussed. The role of freshwater wetlands in preserving water quality, in flood control, in providing habitat for plants and wildlife, and nutrient cycling are also considered. In addition, successional changes in wetlands and management practices are briefly examined.

WETLAND CLASSIFICATION

Classification of inland or freshwater wetlands must be based on clear definitions of the different wetland types. A system of classification was developed by Martin et al. (1953) and provided a basis for the federal inventory of valuable wetlands conducted by Shaw and Fredine (1956). This classification has been widely used; however, it has limited value for wetlands research and fails to promote understanding at the regional or local level (Golet and Larson, 1974). Martin et al. (1953) utilized water depth during the growing season, degree of seasonal flooding, and the dominant form of vegetation. Further, Martin et al. (1953) ignored certain ecologically critical differences such as the distinction between fresh and subsaline inland wetlands (Cowardin et al., 1977). Primary emphasis was placed on waterfowl habitat so that vegetated areas received more attention than non-vegetated areas. The failure to define types clearly led to inconsistencies in application (Cowardin et al., 1977).

Various classifications, usually with only regional significance, have been developed since the 1953 system. These have been ennumerated by Cowardin et al. (1977) who attempt to provide a classification scheme that can provide a basis for a new national wetlands inventory. Golet and Larson's (1974) classification of freshwater wetlands offers a fairly accurate description of wetland types in Maine. Problems in classification remain, however, largely due to the marked variation in the State's freshwater wetlands and the researcher's approach to classification systems.

Freshwater wetlands have been defined in both simple and complex terms according to the needs of particular interest groups. Lefor and Kennard (1977), for example, have provided the most detailed summary of then extant definitions and ennumeratedthem as follows:

> existing in Connecticut statute, dictionary, layman's conceptual, geohydrological, systems, hydrologic, economic, delineational, societal, theoretical, and proposed legal.

Perhaps the only common thread in these definitions is the general agreement that wetlands are wet and can be characterized by high water content. Lefor and Kennard (1977) proceeded to analyze the definitions and proposed a new legal definition which would provide a clear image of what constitutes a wetland and yet not be so all inclusive that misinterpretation results. They determined to find a balance between a single, all purpose term and a large number of terms. Their discussion included criticisms of the various definitions and a description of their historical development. The following proposed amendment to the Connecticut wetland statute offers their definitions for wetland, marsh, swamp, and bog.

" "Wetlands" means land, including submerged land, which consist(s) of any of the soil types designated as poorly drained, very poorly drained, alluvial or flood plain by the National Cooperative Soils Survey, as may be amended from time to time, of the Soil Conversation

Service of the United States Department of Agriculture; and shall include, but not be limited to, marshes, swamps, bogs, rivers, streams, river and stream banks, areas subject to flooding or storm flowage, areas where ground water, flowing or standing, surface water or ice provide a significant portion of the supporting substrate for a plant community; emergent and submergent plant communities in water bodies; and that portion of any bank which touches any inland waters.

"Marsh" means those areas where a vegetational community shall exist in standing or running water, and where that community shall include, but not be limited to, some, but not necessarily all, of the following: Horsetails (Equisetaceae); Bur-Reeds (Sparganiaceae); Cattails (Typhaceae); Pondweeds (Zosteraceae); Water-Plantains (Alismaceae); Frog's-Bits (Hydrocharitaceae); Hydrophytic Grasses (Gramineae); Sedges (Cyperaceae); Arums (Araceae); Duckweeds (Lemnaceae); Rushes (Juncaceae): Pickerelweed (Pontederiaceae); Pipeworts (Eriocaulonaceae); Sweet Gale (Myrica gale); Tearthumbs (Polygonaceae); Water Lillies (Nymphaeaceae); Water-Milfoils (Halorrhagidaceae); Dogwoods (Cornus spp.); Buttonbush (Cephalanthus occidentalis) and Arrowwood (Viburnum spp.).

"Swamp" means those areas where ground water shall be at or near the surface for a significant portion of the growing season, or where runoff water from surface drainage shall collect frequently, and where the vegetational community shall include, but not be limited to, some but not necessarily all, of the following: Hemlock (Tsuga canadensis); Eastern White Cedar (Chamaecyparis thyoides); Skunk Cabbage (Symplocarpus foetidus); Wild False Hellebore (Veratrum viride); Willows (Salix spp.); Birch (Betula alleghaniensis); Alders (Alnus spp.); Marsh Marigolds (Caltha palustris); Spice Bush (Lindera benzoin); Red Maple (acer rubrum); Sweet Pepper Bush (Clethra alnifolia); Blueberries (Vaccinium corymbosum group); Swamp Azaleas (Rhododendron spp.); Ash (Fraxinus spp).

"Bog" means those areas where standing or slowly running water shall be at or near the surface during a normal growing season, and where the vegetational community shall have a significant portion of the ground or water surface covered with Sphagnum Moss (Sphagnum sp.), and where the vegetational community shall include, but not be limited to, some but not necessarily all, of the following: Eastern White Cedar (Chamaecyparis thyoides); Black Spruce (Picea mariana); Sedges (Cyperaceae); Bog-Cotton (Eriophorum spp.); Orchids (Orchidaceae); Pitcher Plant (Sarraceniaceae); Sundews (Droseraceae); Blueberries (Vaccinium corymbosum group); Cranberries (Vaccinium oxycoccos, V. macrocarpon); Leatherleaf (Chamaedaphne calyculata); Bog Rosemary (Andromeda glaucophylla); Swamp Azaleas (Rhododendron spp.).

"Growing season", for purposes of this act, shall mean the period from April 1 to October 1, inclusive, of any calendar year."

Cowardin et al. (1977) have provided a simpler definition for wetlands, but one which is clearly adequate for many purposes.

"WETLAND is defined as land where the water table is at, near or above the land surface long enough to promote the formation of hydric soils or to support the growth of hydrophytes." In certain types of wetlands, vegetation is lacking and soils are poorly developed or absent as a result of frequent-and drastic fluctuations of surface-water levels, wave action, water flow, turbidity or high concentrations of salts or other substances in the water or substrate. Such wetlands can be recognized by the presence of surface water or saturated substrate at some time during each year and their location within, or adjacent to, vegetated wetlands or deep-water habitats.

Their designation for wetland boundaries provide a satisfactory limit on most wetland areas. Martin et al. (1953) developed a classifiction which until recently has been generally followed. For example, it served as a basis for the Maine Department of Inland Fisheries and Game's inventory of wetlands. Of the 20 wetland types of Martin et al. (1953), however, only nine types were clearly freshwater wetland types (seasonally flooded basins or flats, inland fresh meadow inland shallow fresh marsh, inland deep fresh marsh, shrub swamp, wooded swamp, bog, coastal shallow fresh marsh, and coastal deep fresh marsh). Other categories in Maine's inventory which clearly were not strictly freshwater wetlands were coastal salt meadow, regularly flooded salt marshes, inland open freshwater, coastal open freshwater, and sounds and bays.

McCall (1972) used the following categories which can be considered freshwater wetlands in the strict sense:

"Type 1 - Seasonally flooded basins or flats.

These flats occur in upland depressions, which may fill with water during periods of heavy rain or melting snow, and along river courses, where flooding ordinarily occurs in late fall, winter, or spring. The soil is covered with water or is waterlogged during variable seasonal periods, but is generally well drained during the growing season. Where the water recedes early, smartweeds, fall panicum, chufa, wild millet, and cockleburs are likely to occur. Areas that are only temporarily submerged rarely develop any wetland vegetation. Ducks often use flooded upland depressions when feeding - eating seeds that were present before flooding and invertebrates that developed either before or after submergence.

Type 2 - Inland fresh meadow.

These meadows often fill shallow lake basins or potholes; they may also be found bordering the landward side of shallow marshes. The soil is waterlogged to within a few inches of the surface during the growing season. Vegetation characteristic of northern meadows includes carex, rushes, redtop, reed grasses, mannagrasses, prairie cordgrass, and mints. When associated with permanent water areas, fresh meadows are commonly used by nesting waterfowl. Deer and moose frequent them while resting and feeding.

Type 3 - Inland shallow fresh marsh.

Shallow marshes may nearly fill shallow lake basins or potholes, or they may border the landward side of deep fresh marshes occupying such depressions. The soil, normally waterlogged during the growing season, may be flooded with as much as 6 inches of water. Common plant species found in northern regions are plume grass, rice cutgrass, carex, and giant burreed. Various other marsh plants (cattails, arrowheads, pickerel weed, smartweeds) may also be found. These marshes are used heavily by nesting and feeding waterfowl, and they are visited frequently by other birds, moose, deer, and various furbearers.

Type 4 - Inland deep fresh marsh.

These marshes often occupy shallow lake basins and potholes, or they may border open water occurring in such areas. The soil is covered with 6 inches to 3 feet of water during the growing season. Shallow-water vegetation consists mainly of cattails, plume grass, spikerushes, and wild rice; pondweeds, duckweeds, coontail, and spatterdock sometimes occur in the more open areas. These areas are important not only to nesting and feeding waterfowl, but also to numerous other wildlife species, such as herons and rails, muskrats, otters, and beavers, turtles, frogs, and fish.

Type 6 - Shrub swamp.

Shrubby swamps occur primarily along sluggish streams. The soil is generally waterlogged but may be covered with a foot or more of water. Alder and dogwood predominate on the drier areas; willow, buttonbush, and sweet gale characterize the wetter sites. These swamps are used to varying degrees by ducks, moose, deer, woodcock, and raccoons.

Type 7 - Wooded swamp.

These swamps occur along sluggish streams, on flat uplands, and in shallow lake basins and potholes. The soil is normally waterlogged but may be seasonally covered with as much as one foot or more of water. (When such areas are flooded for a period of one or more years, the trees die and the site reverts to a meadow association). Northern swamps are composed of tamarack, arborvitae, black spruce,balsam fir, red maple, and black ash. The coniferous swamps usually have a thick carpeting of mosses; deciduous swamps often support duckweeds, smart-weeds, and other herbaceous vegetation. Wooded swamps are frequently used by hole-nesting ducks, feeding waterfowl, deer, moose, beaver, and numerous small birds and mammals.

Type 8 - Bog.

Bogs occur most often in shallow lake basins, and potholes, along sluggish streams, and on flat uplands. The soil is generally saturated and supports a spongy ground-cover of mosses or other plant material. Vegetation may be woody, herbaceous, or both. Northern representatives include Labrador-tea, leather-leaf, cranberries, carex, cottongrass, sweet gale and sphagnum moss. Stunted black spruce and tamarack may also occur. In Maine, these bogs, especially those with an interspersion of open water, are of importance to some nesting waterfowl. Moose, deer, beaver, and hares also frequent these areas.

Type 12 - Coastal shallow fresh marsh.

These marshes occur along tidal rivers and adjacent [to] the landward side of deeper marshes. The soil is waterlogged and may be flooded with as much as 6 inches of water at high tide. Vegetation consists of various grasses and sedges, cattails, arrowheads, smartweeds, and arrow-arum. These marshes are highly important to feeding wildfowl and herons; they are of lesser importance to mink, raccoons, and snipe.

Type 13 - Coastal deep fresh marsh.

These deep marshes occur primarily along tidal rivers. During the growing season the soil is covered with 6 inches to 3 feet of water at average high tide. Common plants found are cattails, wildrice, pickerel weed, and spatterdocks; pondweeds, widgeon grass, and other submersed species often occur in marsh openings. Where suitable vegetation dominates, these marshes are heavily used by feeding waterfowl, sora rails, and herons. Raccoons, mink, muskrats, and fish also utilize these areas."

The most detailed, applicable overview of freshwater wetland types in Maine has been prepared by Golet and Larson (1974). They have subdivided the freshwater wetland types into 24 wetland subclasses although their wetland classes (open freshwater, deep fresh marsh, shallow fresh marsh, fresh meadow, seasonally flooded basins and flats, shrub swamp, wooded swamp, and bog) are synonymous with Martin et al. (1953). These classes and subclasses can be outlined as follows:

WETLAND CLASS	WETLAND SUBCLASS	
Open water	(OW-1)	Vegetated
	(OW-2)	Nonvegetated
Deep marsh	(DM-1)	Dead woody
	(DM-2)	Shrub
	(DM-3)	Sub-shrub
	(DM-4)	Robust
	(DM-5)	Narrow-leaved
	(DM-6)	Broad-leaved
Shallow Marsh	(SM-1)	Robust
	(SM-2)	Narrow-leaved
	(SM-3)	Broad-leaved
	(SM-4)	Floating-leaved
Seasonally Flooded Flats	(SF-1)	Emergent
	(SF-2)	Shrub
Meadow	(M-1)	Ungrazed
	(M-2)	Grazed
Shrub Swamp	(SS-1)	Sapling
	(SS-2)	Bushy
	(SS-3)	Compact
	(SS-4)	Aquatic
Wooded Swamp	(WS-1)	Deciduous
	(WS-2)	Evergreen
Bog	(BG-1)	Shrub
	(BG-2)	Wooded

Whether the classification of Golet and Larson (1974), Cowardin et al. (1977), or Martin et al. (1953) is used depends on a number of considerations:

which system is most applicable? for the scientist? for the planner? for the layman?

is there an advantage to standardization with a national classification system?

which one best improves our understanding of freshwater wetlands in Maine?

It would appear that Golet and Larson (1974) as an extension of Martin et al. (1953) offers the clearer, more practical approach. With any classification system, errors can occur and indeed wetland conditions can change. Thus, beaver activity can create new wetlands or destroy existing ones, natural successional processes can lead to strikingly different vegetative conditions in just a few years, and changing climatic conditions can either cause a wetland to revert to a preexisting vegetative pattern or develop an entirely new one.

The main problem with Golet and Larson's (1974) system is that the freshwater wetlands in Maine often include more than one type present within the ecosystem. For example, bogs can grade into swamps, swamps into marshes, or discrete subclasses can occur in juxtaposition. Nevertheless, the recognition of the distinct subclasses improves our understanding of the existing variation in Maine's freshwater wetlands. Golet and Larson's (1974) discussion on five wetland size categories, six site types, eight cover types, three vegetative interspersion types, and six surrounding habitat types offers additional descriptive information which furthers our appreciation for the important scientific/education/recreational values of a wetland.

While Golet and Larson (1974) present a regional classification, Cowardin et al. (1977) offer one of national scope. They use a hierarchical structure based on systems (Marine, Estuarine, Riverine, Lacustrine, and Palustrine) and subsystems. Riverine, Lacustrine, and Palustrine apply to freshwater wetlands and, in turn, are subdivided into classes, subclasses and dominance types. Special modifers have also been utilized to adequately describe wetlands. These include: water require modifiers, water chemistry modifiers, and soil modifiers.

Ecology of Freshwater Wetland Ecosystems in Maine

Very limited scientific research has been conducted in Maine's freshwater wetlands. As a result, large gaps exist in our knowledge of how these systems function, how they are regulated by natural processes, their species composition, range of environmental conditions, and how best to manage and/or protect them. We are left with the options of extrapolating from studies in other regions and utilizing the scattered existing studies from Maine. Despite the paucity of information, the values of freshwater wetlands are now well documented and a number of conclusions can be reached.

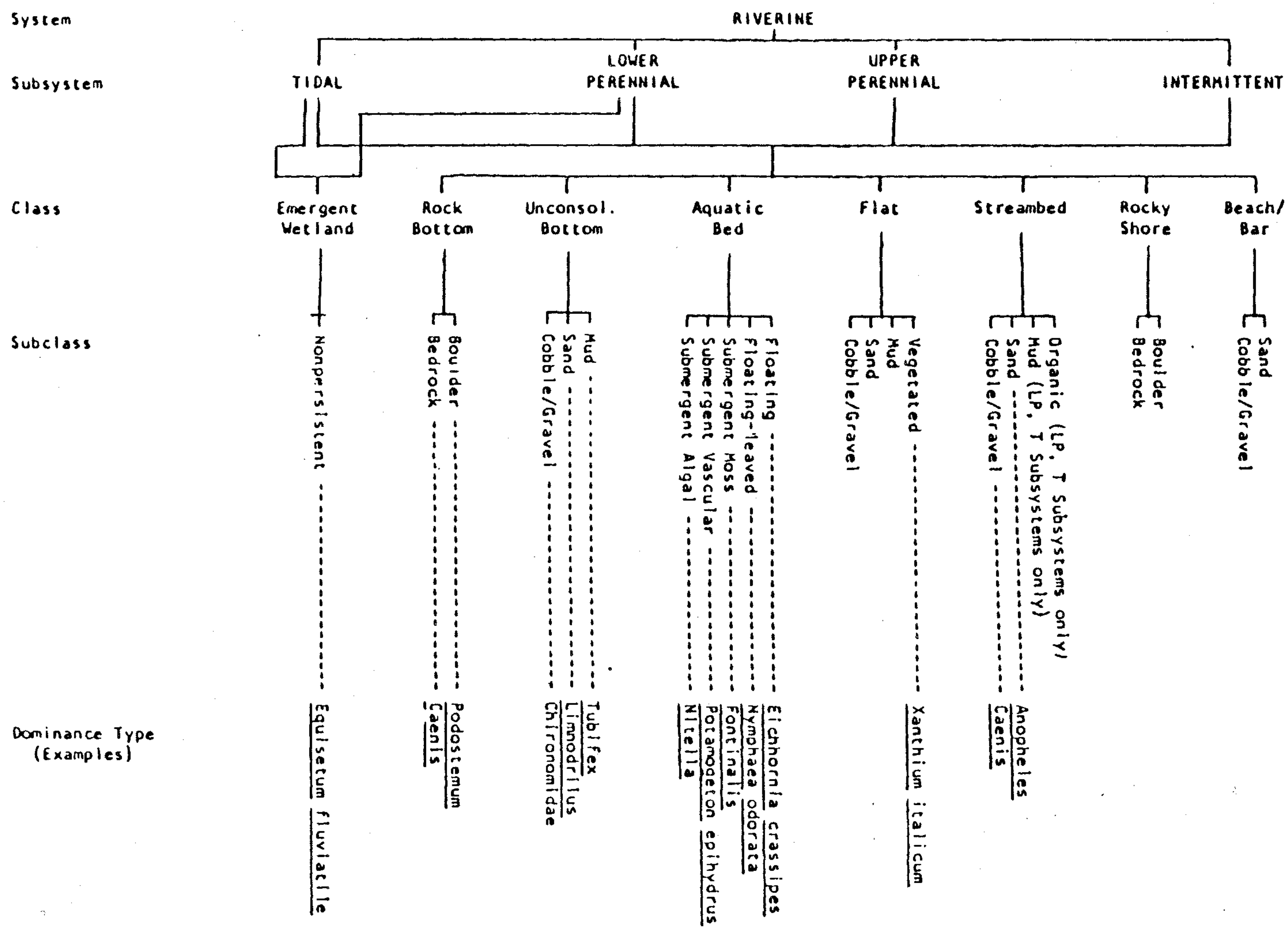

DIAGRAM OF THE CLASSIFICATION HIERARCHY FOR THE RIVERINE SYSTEM.

(from Cowardin et al., 1977)

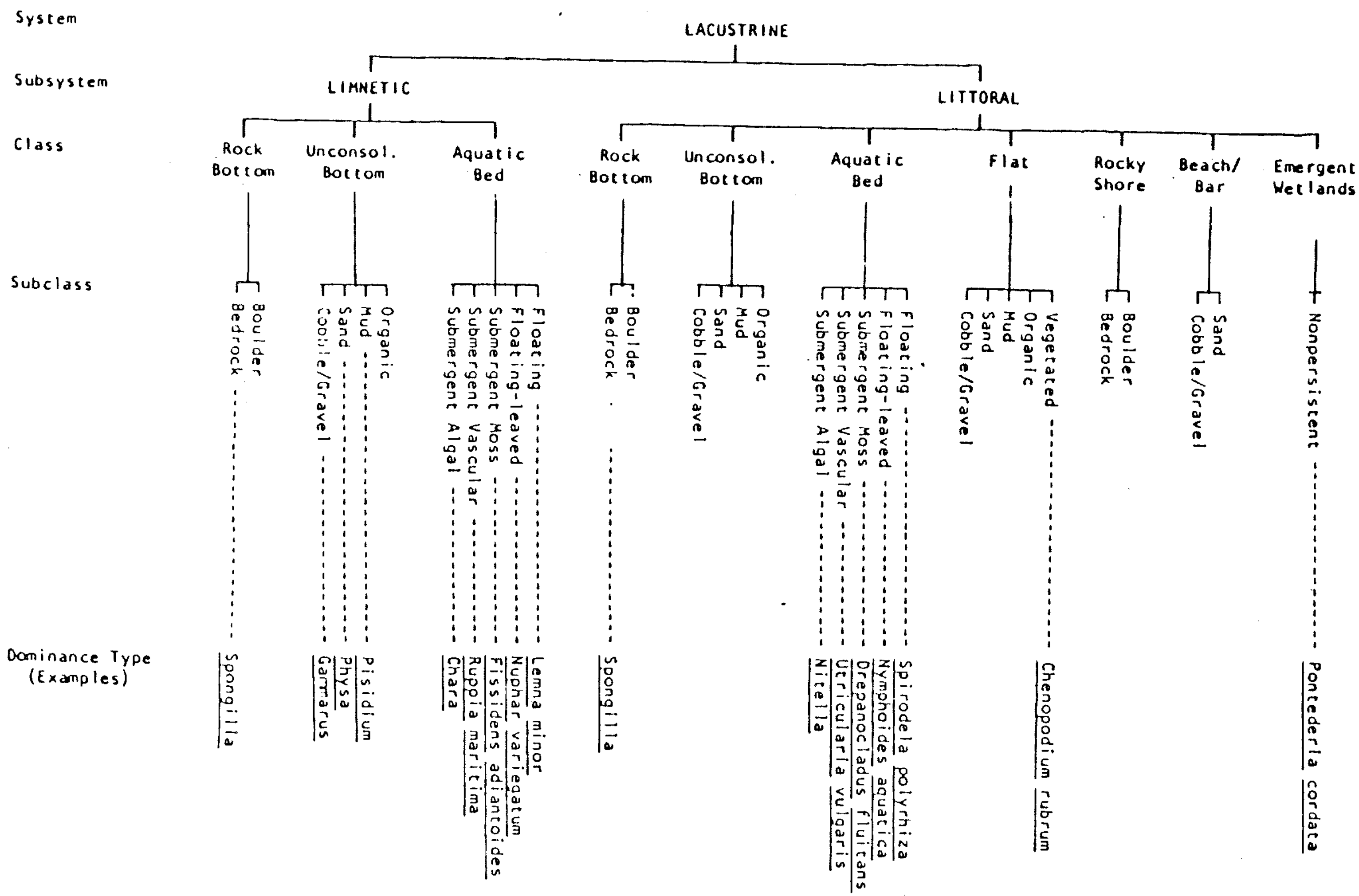

DIAGRAM OF THE CLASSIFICATION HIERARCHY OF THE LACUSTRINE SYSTEM.

(from Cowardin et al., 1977)

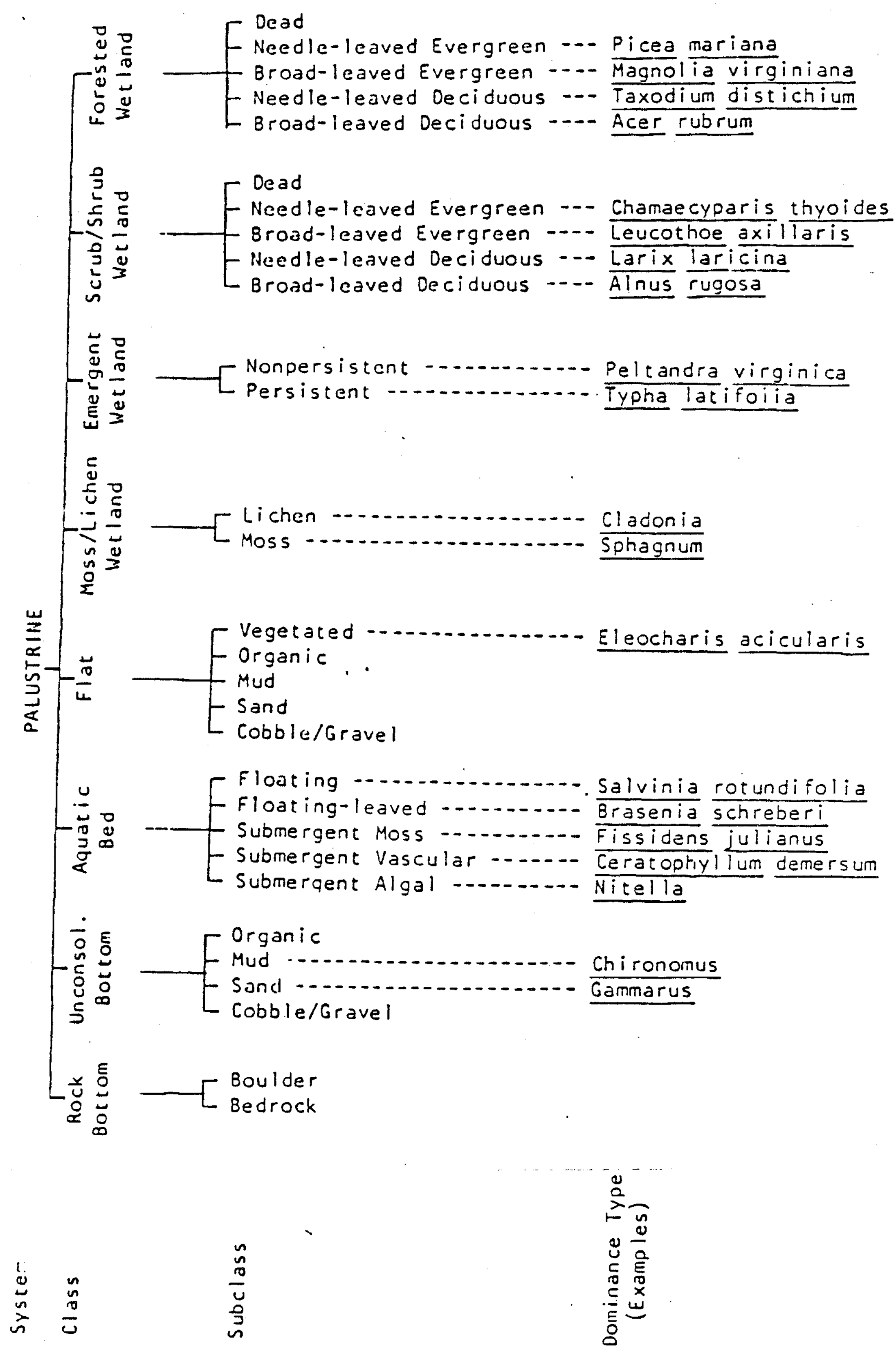

DIAGRAM OF THE CLASSIFICATION HIERARCHY OF THE PALUSTRINE SYSTEM.

(from Cowardin et al., 1977)

Each wetland can be characterized by its own special biological, chemical, and physical characteristics, i.e., it is a unique entity. Its size, location, and a variety of other attributes contribute to the nature and value of the particular wetland. As this report will demonstrate a wetland can possess a number of values depending on its special environmental context.

Hydrology

Freshwater wetlands serve various hydrologic functions which include flood water storage, ground water discharge, and ground water recharge. For example, during heavy rainfall wetlands hold large volumes of water and spread the water over an extensive surface area. As a result of such temporary retention, less water discharges rapidly downstream to erode riverbanks, to flood lowland areas, to cause economic loss and to endanger public health.

A number of research efforts support these contentions. In 1971 studies in Massachusetts on the Neponset and Charles River basins indicate that wetland losses of 25% could lead to serious flooding (Larson, 1973). Recognition of this fact led the Army Corps of Engineers to recommend acquisition of 8500 acres in the Charles River flood plain to maintain the potential for flood control. Niering (1972) also refers to a red maple swamp which can hold 330,000 gallons of water per acre when flooded to a depth of one foot. Hall et al. (1972) demonstrated that a wetland can release significant quantities of water through evaporation and transpiration (1.7 times more through evapotranspiration than from an open water surface). Clearly, then, some wetlands can reduce the flood crests of streams and later release some of the retained water to the atmosphere or more slowly to the streams which drain the wetland.

If freshwater wetlands are lost, less storage capacity results, and more rapid release of water into streams and rivers occurs. Normally, the movement of water is slowed and, in turn, the water held for longer periods and released slowly so as to regulate both flow and supply. The peat (partially decayed and disintegrated plant remains) soils of wetlands can enable wetlands to act in a sponge-like manner and absorb large quantities of water, but the peat is typically saturated so the spreading action is more critical.

The natural rise and fall of water within wetlands assure proper conditions for plant growth and waterfowl nesting sites. This natural cycle can be altered, however, through poor agricultural or forest practices in surrounding lands which can cause excessive runoff.

Freshwater wetlands can act as both recharge and discharge areas for ground water although in Maine they act primarily as sites for discharge. Water temporarily stored in wetlands is gradually released to streams, lakes, or the atmosphere. More water typically enters a wetland then leaves, especially in the growing season when increased evapotranspiration from plants occur. Wetlands with areas of dense vegetation are particularly prone to this atmospheric loss of water (Hall et al., 1972). Holzer's (1973) study in Connecticut has broad applicability to Maine. He confirms that most wetlands in that state are areas of groundwater discharge. Since most wetlands have underlying deposits of impermeable clay, bedrock or a combination of non-porous materials ground water or aquifer recharge typically cannot occur. Water is then prevented from percolating downward into sand and gravel or bedrock aquifers. If, however, a low-lying area adjoins an upland wetland ecosystem, some recharge of the lower altitude area can result.

In other regions of the United States hydrologic studies indicate that wetlands have underlying deposits which transmit water. Studies are conflicting, however, and point to the need for additional research. In Massachusetts, for example, Motts and Healy (1973) suggest that 40-50% of the wetlands may serve in a recharge capacity. One specific study in the headwaters of the Ipswich River, Massachusetts found that swamps and marshes occasionally acted as ground water recharge areas (U.S. Dept. Interior, 1962). Obviously, each wetland varies in its underlying geologic structure and other characteristics. Filling or draining could destroy a wetland's ability to function in a recharge capacity, and certainly, prior to any alteration, the unique hydrologic conditions of the wetland require proper analysis.

Gosselink and Turner (1978) suggest strongly that more research emphasis is required on the hydrology of wetland ecosystems. They consider the need for more detailed observations on water depth and on the frequency, duration, and regularity of inundation.

<u>Sedimentation, pollution filtration, water quality</u>

Freshwater wetlands serve an important role in nutrient assimilation (Sloey et al., 1978). Nutrients which enter a wetland can be transformed through the chemical processes of sorption, coprecipitation, active uptake, nitrification, and denitrification. These processes tend to remove phosphorus and nitrogen from the water and transfer them to the substrate and biota. In other words, wetland plants change inorganic material into organic material, store the latter in their stems, leaves or roots or in their dead remains as peat. Swamp soils underlying standing water can also rapidly remove nitrates (Engler and Patrick, 1974). The processes, however, are incredibly complex and many variables must be considered in determing the role of marshes and other wetland in water quality (Greij, 1976).

The potential to protect water quality, nevertheless, has importance to both natural and managed systems. When adjacent to or connected with either standing water (lakes) or flowing water (streams), wetlands can limit nutrient enrichment or eutrophication by minimizing the movement of the nutrients to these systems.

In addition, sediment removal in freshwater wetlands has been well documented (Wharton, 1970). Studies on the swamps adjoining the Alcovy River in Georgia indicate a value of $1,000,000 per annum in terms of maintaining water quality. Wharton (1970) also found significant pollution reduction in a stretch of six miles of river where extensive swamps occurred. Wetland plants slow the movement of water and encourage settling of particulate matter. Large beds of cattails or other marsh-type plants or stands of swamp trees can serve to provide this settling function for silt.

Odum (1978) has suggested a value for wetlands as domestic ecosystems which can process human wastes as long as the quantity is not excessive nor the toxicity too great.

As noted by Sloey et al. (1978) the wetland biota is adapted to wide ranges in water level and nutrients, but different species vary in their tolerance of nutrient inputs. Some plants disappear, others decrease in number, and some actually increase. Little information, however, is available on the impact of nutrient loading on insects or wildlife.

Prentki et al. (1978) suggest that in some cases lakeshore marshes may be ineffective nutrient traps if there is significant upward nutrient translocation by marsh vegetation. The role of waterflow may be important in nutrient supply and in determining vegetation composition (Gosselink and Turner, 1978). As an example, wetlands subjected to flooding in the form of sheet flow tend to be more uniform and have large areas of monospecific (single species) stands.

Richardson et al. (1978) also believe that complete hydrologic and nutrient budget data are necessary before conclusions can be reached regarding the role of wetlands as nutrient traps or natural biological filters. They also stress that different wetland classes vary in internal processes, structure, and chemical output. Further, they observed that, despite a capacity for efficient filtering of nutrients, they may still allow for high losses since they already have high nutrient loading. Valiela and Teal (1978) emphasize the "leaky" nature of wetlands in respect to limiting nutrients, e.g. many nutrients are lost to the system directly from the plants and are not returned to the sediments. Leaching and downstream movement may occur with plant senescence (aging).

Rich and Kowalczewski (1976) suggest that a wetland can, through its impact on water color, prevent an overgrowth of macrophytic vegetation. Light penetration is hindered and thereby limits the potential for photosynthesis. Without the bog "effect" macrophytes might colonize small lakes and quickly reduce them to overgrown mats of vegetation.

Sloey et al. (1978) have also reviewed the concept of managing wetlands for nutrient assimilation. They discuss the nutrient transformations, the storage of nutrients within the wetlands, and the potential for managing wetlands for nutrient assimilation. Their admonition seems especially apropos:

"In the past, we caused the deterioration of the quality of our surface waters by using them to treat our wastes. When the practice was initiated, we marvelled at the remarkable ability of water to "self-purify". We based our decisions on short-term observations and immediate economics. Years later, the results of long-term overloading became evident. Lest we make the same mistake in handling our valuable and diminishing wetlands, it is mandatory that we carry out long-term, carefully monitored experiments at a severely limited number of sites. It is also important that those conducting the experiments document changes very carefully in the natural system that could signal future problems."

Wetlands perform several functions in terms of water quality: they enhance the recreational value of waterways by minimizing turbidity or water cloudiness; they maintain relatively high oxygen levels by preventing oxygen-utilizing organic matter from reaching the waterway; they maintain healthy fish populations since nests are not covered by silt and eggs are not harmed by low oxygen concentrations; and they can minimize the cost of treatment for drinking water through their own filtering and processing activity.

Wetlands cannot, however, prevent deterioration in water quality if improper land use practices persist or if human inputs become excessive. The natural activity of bacteria can deal with high nutrient levels up to a point, but when nutrient input reaches excessive levels, a wetland and adjoining water bodies can degrade rapidly. Healthy wetlands greatly assist the proper and natural function of associated aquatic ecosystems; however, wetland protection must, by necessity, involve proper land use practices in the surrounding watershed. Failure to establish buffer strips or broad protection zones around wetlands has been one of the glaring weaknesses of many wetland protection ordinances.

McLeese and Whiteside (1977), in particular, have described the negative impacts of improperly planned highway construction. Natural soil drainage conditions and circulation patterns can be disrupted and problems of erosion, salt contamination, and increased fire hazard can arise.

Production, Productivity

Although still limited, information regarding production processes in freshwater wetlands has accumulated in the last decade. In a recent summary of the status of primary production studies de la Cruz (1978) suggests that freshwater wetlands include some of the most productive natural ecosystems. Unfortunately, the present knowledge of production processes is at a very early stage. Bernard and Gorham (1978) have examined primary production in sedge wetlands and suggest the importance of life history studies for obtaining accuracy in production estimates. Reader (1978) has found the productivity of "northern bog marshes" or fens, minerotrophic peatlands, and sedge meadows to be relatively low, most likely as a reflection of their northern locations. According to Gorham (1974) a positive correlation exists between peak plant standing crop and maximum monthly summer air temperature. Understandably, mineral availability also influenced standing crop. Reader (1978) has concluded:

"It should be obvious that further experimentation, both in the field and in the laboratory, will be necessary to draw firm conclusions concerning the effects of substrate conditions and the climatic regime on primary production in northern bog marshes. The only facts apparent at the present time are that individual bog marshes vary considerably both in their productivity and in their response to nutrient enrichment and that the northern climate restricts the production potential of bog marshes."

Further research into production rates will be especially important if peat bogs are ever mined to produce reed-sedge peat for energy. In this manner an accurate assessment could be obtained for the regeneration rates of peat deposits.

Fisheries

As Jaworski et al. (1977) have indicated, little is known about the abundance and population density of fishes which inhabit freshwater wetlands. In Maine sport fishing, rather than commerical, can be pursued in certain wetland areas. Fish species tend to be warmwater, non-salmonid varieties and forage or bottom feeders predominate. Predators such as chain pickerel and large mouth bass can also occur in abundance in those marshes with adequate water quality and depth. In terms of importance, however, wetlands in Maine are valued far more highly for their role in providing breeding, feeding, or migratory habitat for waterfowl.

Wildlife and plants

Freshwater wetlands in Maine have a remarkable wealth of interesting plants and animals. Indeed, Maine's wetlands are well known for their recreational and other special opportunities. They provide habitat for breeding and migratory waterfowl as well as numerous other species of birds. Fresh marshes offer the most critical habitat while some of the other wetland classes are supplementary in value. Large wading birds such as egrets, herons, and ibises feed in wetlands and nest in adjacent woodlands. Rails lurk in the cattails, rushes, and other tall emergent plants. Short-eared owls and marsh hawks course over the wetlands in search of prey. Woodcock may be found in the alders so typical of the swampy shrub-scrub wetlands. The list of species is long. Also, the mammalian fauna including moose, deer, bear, beaver, muskrat, raccoons, and hare occur in wetlands. The Department of Inland Fisheries on Wildlife actively manages more than 40,000 acres of important habitat - much of which is comprised of wetlands valuable for bird nesting, resting, and feeding during migratory stopovers, as well as for recreational fishing, boating, or swimming. The Department further recognizes the need for more acquisition to assure that adequate habitat for wetland species be provided in the face of growing pressures to alter wetlands (Perry, 1973).

Lavine et al. (1974) have ennumerated factors which affect the suitability of freshwater wetlands for wildlife habitat. A brief review of their discussion will provide more understanding for the evaluation of a wetland for wildlife value.

Number of wetland classes. If two or more wetland classes occur in close proximity, the habitat diversity, in turn, enhances the numbers of plant and animal species which can be found in the wetland system.

Dominant wetland class. For example, an inland freshwater meadow may have less value for waterfowl than a shallow freshwater marsh. Different classes provide for the special needs of particular species.

Vegetative life form interspersion. Mixed stands of vegetation or the interspersion of different vegetative types create more habitat diversity and hence a richer species composition.

Percentage cover. Wetlands with more equal proportions of open water and vegetation generally enhance the productivity of wildlife more than wetlands with low percentages of either of the two cover types.

Wetland site type. Wetlands located in lowland areas or flood plains show a marked increase in productivity over upland, isolated wetlands. Apparently, both longer retention of surface water and higher nutrient levels lead to the increased diversity.

Size. Larger wetlands tend to be more valuable in terms of diversity than smaller ones even though the latter may be more productive on a per acre basis.

Surrounding habitat type and land use patterns. Since many wildlife species utilize adjacent areas to feed or breed, it is important to analyze the habitat type in the surrounding landscape. Again, mixed habitat types, such as fields and woodlands are better than single habitat types.

Juxtaposition. Wetlands connected by streams or geographically near one another have greater wildlife value than isolated wetlands.

Water chemistry. Alkaline waters tend to be more productive than more acidic waters. Similarly, the presence of nutrients, if not in excess, tends to promote more diversity and productivity. Golet and Larson (1974) have described in detail the rationale for examining these characteristics for determining the wildlife value of particular wetlands.

In addition to their often high value for wildlife, wetlands also offer unusual opportunities to study rare or unusual plants and to learn ecological principles and thereby serve as outdoor biological laboratories. Their non-consumptive values, *i.e.*, their ability tc support a variety of educational, scientific, and recreational activities, makes them especially interesting and unusual ecosystems. Their consumptive values can be described briefly in terms of hunting, fishing, trapping, and timber operations. It must be recognized that the wildlife value of wetlands may change with ecological succession. Golet (1976) describes this situation very aptly:

"It should be evident that as a wetland changes from one class to another, its wildlife populations will change as well. Today the majority of our northeastern wetlands are wooded swamps and shrub swamps. We can assume that during the period since glacial retreat there has been a gradual change from a regional wetland fauna dominated by such open water, and marsh wildlife such as waterfowl and muskrats, to a fauna comprised predominantly of swamp wildlife such as raccoons, opossums, deer and forest songbirds. A diversity of wildlife species can only be maintained through periodic reversals of the successional process or creation of new wetland basins, either by natural agents such as beavers or by Man."

Golet (1976) has provided tables which indicate the presence of various species of mammals and birds in southern New England wetlands. The tables are included here because the species are generally similar in Maine.

The scientific-ecological value of wetlands deserves special mention in this report.

1. Past climates. Many wetlands have preserved pollen grains, spores, and other organic remains from terrestrial plants in their sediments. By using coring techniques and then radiocarbon dating the samples, these materials can be accurately assigned ages and then by examining different levels in the sediments we can develop a fairly clear picture of how the vegetation changed in response to climatic change since the last glaciation approximately 10,000 years ago. Rainfall and temperature changes, soil development, and human-induced changes can, in addition, be recorded. Davis (1973) emphasizes that the wetlands can provide an indication of how natural successional processes occurred prior to the influence of industrial man. Wetlands further can record changes that ensued with agricultural development, deforestation, and reversion to woodland.

2. Rare or endangered species.. Wetlands can provide habitat for unusual species of plants such as the insectivorous varieties, e.g., pitcher plant, bladderwort, and sundew, and members of the orchid family.

Wildlife Species	Wetland Classes							
	OW	DM	SM	SF	M	SS	WS	BG
BIRDS								
Pied-billed Grebe	X	X						
Great Blue Heron		X	X	X				
Green Heron		X	X	X		X		
Black-crowned Night Heron		X	X	X				
American Bittern		X	X	X				
Mute Swan	X	X	X					
Canada Goose	X	X	X	X				
Mallard		X	X	X	X	X	X	
Black Duck		X	X	X	X	X	X	X
Green-winged Teal		X	X	X	X			
Blue-winged Teal		X	X	X	X			
American Widgeon		X	X	X				
Wood Duck		X	X	X		X	X	X
Ring-necked Duck	X	X		X				
Common Goldeneye	X							

Wildlife Species	Wetland Classes							
	OW	DM	SM	SF	M	SS	WS	BG
Bufflehead	X							
Hooded Merganser	X							
American Merganser	X							
Red-tailed Hawk							X	X
Red-shouldered Hawk							X	X
Marsh Hawk			X	X	X			
Osprey	X	X		X			X	
Ruffed Grouse						X	X	X
Bobwhite				X	X	X	X	
Ring-necked Pheasant			X	X	X	X		
Sora		X	X	X				
American Coot		X	X					
Killdeer			X	X	X			
American Woodcock				X	X	X	X	
Common Snipe		X	X	X	X			
Spotted Sandpiper		X	X	X	X			
Great Horned Owl							X	X
Barred Owl							X	X
Belted Kingfisher	X	X						
Common Flicker							X	X
Hairy Woodpecker							X	X
Downy Woodpecker							X	X
Eastern Kingbird		X		X		X	X	X

Wildlife Species	Wetland Classes							
	OW	DM	SM	SF	M	SS	WS	BG
Great Crested Flycatcher							X	X
Eastern Phoebe						X	X	X
Tree Swallow	X	X	X	X	X	X	X	X
Barn Swallow	X	X	X	X	X	X	X	X
Blue Jay							X	X
Common Crow							X	X
Black-capped Chickadee				X			X	X
Tufted Titmouse							X	X
White-breasted Nuthatch							X	X
Red-breasted Nuthatch							X	X
Brown Creeper							X	X
House Wren						X	X	
Long-billed Marsh Wren		X	X	X				
Gray Catbird				X		X	X	X
American Robin				X	X	X	X	
Wood Thrush							X	
Veery							X	X
Eastern Bluebird					X	X	X	
Cedar Waxwing		X					X	X
Starling				X	X	X	X	
White-eyed Vireo				X		X	X	
Red-eyed Vireo				X		X	X	
Black-and-white Warbler							X	X

Wildlife Species	Wetland Classes							
	OW	DM	SM	SF	M	SS	WS	BG
Yellow Warbler				X		X	X	X
Yellow-rumped (Myrtle) Warbler			X	X		X	X	X
Ovenbird							X	X
Northern Waterthrush				X		X	X	X
Common Yellowthroat		X	X	X	X	X	X	X
Canada Warbler							X	
American Redstart							X	
Red-winged Blackbird		X	X	X	X	X		X
Northern (Baltimore) Oriole						X	X	
Common Grackle		X	X	X	X	X	X	X
Brown-headed Cowbird							X	
Rose-breasted Grosbeak							X	
American Goldfinch						X	X	X
Dark-eyed (Slate-colored) Junco						X	X	
Tree Sparrow				X	X	X	X	
White-throated Sparrow						X	X	X
Swamp Sparrow		X	X	X		X	X	X
Song Sparrow		X	X	X	X	X	X	X
MAMMALS								
Opossum				X	X	X	X	X
Masked Shrew				X	X	X	X	X

Wildlife Species	Wetland Classes							
	OW	DM	SM	SF	M	SS	WS	BG
Short-tailed Shrew		X	X	X	X	X	X	
Star-nosed Mole		X	X	X	X	X		
Little Brown Myotis (Bat)	X	X	X	X	X	X	X	X
Eastern Pipistrel (Bat)	X	X	X	X	X	X	X	X
Big Brown Bat	X	X	X	X	X	X	X	X
Eastern Cottontail			X	X	X	X	X	
New England Cottontail				X		X	X	
Snowshoe Hare							X	X
Gray Squirrel							X	
Red Squirrel							X	X
Southern Flying Squirrel							X	X
Beaver	X	X	X			X	X	X
White-footed Mouse						X	X	
Boreal Red-back Vole						X	X	X
Muskrat		X	X	X	X	X		
Meadow Jumping Mouse				X	X			X
Woodland Jumping Mouse				X		X	X	X
Red Fox			X	X	X	X	X	X
Gray Fox						X	X	X
Raccoon		X	X	X	X	X	X	X
Short-tailed Weasel			X	X		X	X	
Long-tailed Weasel			X	X	X	X		

Wildlife Species	Wetland Classes							
	OW	DM	SM	SF	M	SS	WS	BG
Mink		X	X	X	X	X	X	X
Striped Skunk			X	X	X	X	X	
River Otter	X	X	X	X		X	X	X
White-tailed Deer			X	X	X	X	X	X

(See page 6 for a key to wetland class abbreviations).

Nutrient Cycling

Deevey (1970) has discussed the role of nitrogen and sulfur cycling and stressed the critical importance of the mud environment in wetlands for these cycling processes. Specifically, certain microbial forms of the enzyme hydrogenase occur only in mud where free oxygen is absent. In the presence of hydrogenase which catalyzes the reaction, both sulfates and nitrates are reduced chemically in mud. Without such reduction the nitrogen and sulfur so critical for protein would be lost forever in this anaerobic environment. The implications of such a block to these biogeochemical cycles is self-evident. Deevey (1970) then stresses that ..."hydrogenase, like water and oxygen, is no longer a "free good", but a commodity more precious than we know." In other words, mud is just as important to life on earth as are water and air. The obvious conclusion to be drawn is that wetlands are not wastelands.

In a narrower context, Lee et al. (1975) have demonstrated the ability of marshes to transform nitrates into forms which have a less deleterious impact on water quality. Phosphates were not removed, however, and thus Lee et al. (1975) concluded that marshes could not be a complete barrier to the transport of nutrients within a wetland ecosystem. Particularly in wetlands traversed by flowing water, nutrient uptake or conversion would be limited. Marshes tend also to sotre more nutrients in the summer and fall while releasing nutrients in the spring. The benefits are clear: less eutrophication during the warm, summer months and more release in peak flow periods of spring. Thus, in effect, a cleansing action occurs.

Certain wetland plants, in addition, have been recognized for their ability to fix atmospheric nitrogen in the form of nitrates. Bond (1949, 1951, 1956) demonstrated that both alders (Alnus) and sweetgale (Myrica gale L.) can contribute to the nitrates present in wetlands. Sweetgale may be especially important for its role in nitrate formation in typically nutrient poor bog or bog-like habitats.

As Deevey (1970) has argued, the processes of decomposition that occur in wetlands are fundamentally necessary to planetary nutrient cycling. Unfortunately, our knowledge of decomposition is far from complete especially for below ground materials. Nevertheless, Gallagher (1978) has reviewed the available studies from both fresh and salt water marsh systems and has developed a conceptual model of decomposition in freshwater marshes. He concluded:

"In view of the past rapid rate of the commercial exploitation and destruction of freshwater wetlands, future research plans assume an added urgency because answers are needed for protection and management purposes. It seems that the most rapid progress in research in decomposition in these systems can be made by focusing on understanding the processes at work. This understanding will enable the scientist to give the resource manager reasonable answers to as yet unconceived questions about impacts on freshwater wetlands."

Peat Resources

More than 772,000 acres of peat soils occur in Maine (Farnham, 1978). Of this acreage, about 150,000 acres may be considered as peat bogs. Peat, as a potential source of energy in Maine, has attracted attention at various times. Most recently, through a cooperative effort of the Bureau of Geology and the Office of Energy Resources an inventory of peat resources was initiated.

In addition to the interest in mining peat for energy, several harvesting operations for horticultural peat already exist. These are located predominately in eastern Maine, e.g., Jonesport, Deblois, Centreville.

The issue of peat development deserves significant review; however, in this report comment will be restricted to the natural scenic, or scientific value of peat bogs. Prior to large-scale utilization of the peat resources an inventory of peat bogs from these perspectives should be undertaken. Some of the bog systems clearly have unique value either because they possess unusual assemblages of plants or rare species of plants. The character of one large bog, deserving special status, has already been compromised by a peat operation (pers. comm., Ian Worley). They form an integral component of the Maine landscape and hence preserve diversity in the state's environment. Until we have learned more about peat regeneration and the rehabitation of mined bogs, the promise of peat as a renewable resource will remain an open question.

Forest Products

Forested wetlands can provide areas of high productivity in many cases (Grace, 1976). Tree growth in such wetlands can be appreciable and under certain circumstances compares quite favorably with growth on drier sites. If managed properly, various valuable species can be harvested. According to recommendations for the Northeast, enhancement of good quality stands of red maple should be encouraged. In time, if successional processes are permitted to occur, white pine and hemlock become established. These species begin to develop in the understory and gradually become dominant. Their dominance, in a managed wetland, should be encouraged since they can be very productive on wet sites. As in any area where lumbering is the aim of forest management, care must be exercised in the logging activity. Wetland soils, in particular, are vulnerable to damage so that operations should be restricted to winter periods when the wetland surface is solid.

Life history of wetlands

Wetlands proceed through various evolutionary stages during their development. The successional stages have been described in the literature, but unfortunately many papers and books have uncritically followed the scheme of succession found in Lindemann's classic work on Cedar Bog, Minnesota (Wetzel, 1975). According to this general course lakes becomes bogs and ultimately dry land. While it is, however, frequently true that a common sequence for many wetlands might be: open water → development of littoral (shore) zone emergent vegetation (marshy) with gradually filling from the edges → swamp or bog conditions → drier (xeric) conditions more typical of the terrestrial environment. Tall emergents (Cyperus, Scirpus, Carex spp.) grow in the littoral zone and as their organic remains accumulate as peat, standing water disappears and the vegetation similarly changes.

For bogs to develop, climatic conditions of high humidity and precipitation are prerequisites. From examination of peat deposits it is clear that many bogs in Maine have proceeded through a stage of reeds and sedges, but it is not certain that their shallow basins originated with lakes. It appears as likely that the vegetation developed in the absence of standing water. Various discussions of bog development serve to illuminate the patterns followed by a bog over time (Rigg, 1940, 1951; Dansereau and Segadas-Vianna, 1952; Wright, 1964; Heinselman, 1963, 1970, 1975; Schwintzer and Williams, 1974; Malmer 1975). Time limits the detail of review devoted to this topic; however, some highlights can be noted.

Cameron (1975) describes three types of peat deposits. The first or filled-basin type is the most common in the United States while the raised bog type which develops in flat surfaces or gentle slopes is more common in Europe. In Maine, the third type, consists of "built-up deposits underlain by peat." Cameron (1975) has described the process:

"Development of a typical Maine deposit begins with deposition over the inorganic gray bottom clay of floating types of plants such as algae and pond weeds that lived in the shallow water. This organic sediment is an amorphous material with high colloidal content. It fills the depression to a depth permitting growth of rooted plants such as pond lilies and bulrushes. As vegetal remains accumulate and pond area decreases, water of the vestigial pond is eventually replaced by grass, reeds, sedge, and moss, and the deposit grows upward and outward beyond the margin of the original water body; the water table also rises. As soon as sphagnum moss dominates the vegetation, the convex surface, or dome, with perched water table begins to develop.

Peat growth within a basin displaces its own volume of water until it reaches the level at which inflow and outflow are balanced. Further peat growth creates a reservoir which holds a volume of water against drainage. There are two types of peat reservoirs. The first, composed of sedimentary organic material and reed-sedge peat, acts as a physical barrier to ground water, causing the water to back up. In this process of lateral paludification, the peat moss in the original basin, acting as a dam, produces newly flooded areas, in which more peat can develop. In suitable topography this peat can grow in thickness on bedrock or soil surface beyond the margin of the original pond or lake. The second type of peat reservoir, composed of moss peat is the raised bog, acts as a second reservoir above the regional level of the groundwater, producing a perched water table which is held against gravity within the peat moss by capillarity. This process is vertical paludification and is responsible for development of the domed sphagnum peat deposits so common in Washington and southeastern Aroostook Counties.

The terrestrialization of a shallow lake having inflow and outflow streams illustrates the hydrologic regime typical of the Maine deposits. Five stages of evolution are recognized. During stage 1 water from the inflowing stream moves over and through the developing peat deposit and leaves at the outlet. Movement is chiefly over the peat if much allochthonous material is being brought into the lake; the abundant oxygen decomposes the organic material to from a heavy peat. However, if the rate of flow is low, less allochthonous material collects, less oxidation or decomposition occurs, and the water flow is directed largely below a floating mass of relatively light peat. The accrual of peat (stage 2) tends to canalize the main flow of water. Continued peat growth (stage 3) divertsthe stream to the margin of the filled lake. The water supply to the deposit is restricted to rain falling directly on the surface and to seepage from the surrounding catchment. Portions of the deposit lying in the main-drainage tracts within the basin, however, may be subject to a slow continuous flow of ground and (or) surface water. Further accrual of peat (stage 4) leaves large areas of the deposit surface unaffected by moving water but subject to inundation when the water level of the basin rises during periods of rainfall. Because of continued peath growth, the deposit or bog surface rises above the effect of the vertical oscillations of the ground water. The convex surface or dome so produced possesses its own water table fed by rain falling directly on it (stage 5)."

According to Heinselman (1975) fire can actually retard paludification or bog formation. Fires can recycle nutrient stocks, consume large quantities of humus, and reduce peat. Heinselman has speculated that in the absence of fires paludification might increase. Beavers also have a significant factor in influencing wetland formation and development (Kaye, 1962; Heinselman, 1975). Certainly, their activities have accounted for the formation of many of the smaller wetlands in the Northeast.

Heinselman (1963) describes the theoretical implications of his studies in Minnesota:

"(1) Few bogs in this region are the result of a single successional sequence. (2) The bog types cannot be regarded as stages in an orderly development toward mesophytism. (3) Raising of bog surfaces by peat accumulation does not necessarily mean progression toward mesophytism. Such rises often cause concurrent rises of the water table and promote site deterioration. (4) The climax concept does not contribute to understanding bog history in this region."

His later conclusions (1975) coincide with these and random earlier suggestions. Peatlands change in ceaseless fashion, i.e., there is no specific direction. True, peat accumulates, but only to a point where paludification ceases and decomposition ensues. In the meantime climate changes may alter the processes and terminate the process of paludification.

Wetlands, then, under most circumstances are transitory features of the landscape. Exceptions occur as Odum (1971) has noted, but certainly in geologic terms they persist for only short periods of time. In human terms, however, they can last for very long periods and can go through both cyclic and non-cyclic change.

Wetland Management

Freshwater wetlands are vital ecosystems for a vast array of wildlife, but they are chiefly recognized as critical habitat for waterfowl which utilize the wetlands for breeding, resting, and feeding. Golet's (1976) review of freshwater wetlands as wildlife habitats lists many species which can be expected in the various types of wetlands in the Northeast. This review includes the criteria for evaluating wildlife habitat as detailed by Golet and Larson (1974).

Golet (1976) emphasizes that wetlands are not static and that through successional change certain wildlife values may be enhanced while others are diminished. For example, most wetlands in the Northeast today are wooded or shrub swamps whereas in the past more open water marsh type wetlands occurred. Waterfowl and muskrats have thus been replaced by swamp-favoring species such as raccoons, deer, woodcock, and forest songbirds. To maintain more diversity or, at least, to encourage a greater abundance of waterfowl some wetland ecosystems may require management. The successional process must be reversed, the existing stage maintained, or new wetlands must be created.

Wetland management for wildlife has been reviewed by Linde (1969) and Sanderson and Bellrose (1969), Weller (1978), and others. The former two sources detail methods of wetland management including impoundment construction, water level manipulation, nest island construction, vegetation control, controlled burning, land clearing, ditching, and seeding.

Weller (1978) is highly critical of past management programs which attempted to preserve marshes simply for single purposes such as hunting. He discourages artificial efforts as costly and of short-term value while he encourages those plans that are based on natural successional patterns without drastic alterations. Based on current knowledge the following conclusions can be drawn (Stearns, 1978):

"1) Management decisions whenever possible should complement natural functions and allow natural processes to accomplish the desired results.

2) Wastewater should not be applied to natural freshwater wetlands, other than experimentally, until more is known about long-term effects. Present information suggests that the risk of damage may not be worth the gain. Local tests are always necessary to determine suitable loading rates.

3) The rate of wetland conversion should be slowed until more is known about the functions of wetlands in regional systems.

4) Management should hold to a minimum, factors which tend to degrade marsh structure and function. Biological as well as non-biological approaches must be included in the evaluation of the health and future of wetlands.

5) In creating wetlands, the manager should remember that plants of different species vary greatly in vulnerability to physical stress and to animal damage as well as in adaptation to water depth and other factors.

6) In modifying wetlands (where this is essential), attempt to avoid disturbance; conduct the physical operation rapidly, reduce height of spoil banks, limit impoundments and maintain normal water circulation.

7) Natural perturbations may occur and management techniques successful at one point in the climatic cycle may not be applicable at others.

8) Informed and conservative management is essential in all wetlands; so large an area has already been lost that the remaining wetlands must be protected. This concept has been embodied in much recent legislation."

Freshwater Wetland Evaluation

Both ecological and economic justification often exist for protecting freshwater wetland ecosystems. As the previous sections on wetland functions demonstrate, these natural areas have a number of values for human society. While every wetland possesses some inherent value, frequently choices must be made regarding the future status of a specific wetland. In the absence of statewide, comprehensive legislation that broadly protects these areas, pertinent criteria for wetland evaluation are necessary to justify the protection of outstanding wetlands.

For the purpose of this report the scientific-recreational characteristics of freshwater wetlands will be emphasized although other features may suggest the need for protective status as well.

Lavine et al. (1974) briefly discussed the various cultural, scenic, historic, and educational attributes of wetlands which might lead to their designation as unique areas. They developed a checklist for a wetlands inventory and included four criteria for evaluating wetlands for human use: scope, vulnerability, relative scarcity, and proximity or accessibility.

Scope. A wetland's impact on the surrounding areas should be assessed. Does it have local, regional, state, or interstate significance? Generally speaking, the larger the wetland the more its impact will be felt in a geographic area. Obviously, its size, area, and position within the drainage system would contribute to the magnitude of its role.

Vulnerability. A wetland may suffer from human encroachment due to filling, draining, pollution, or other factors. Wetlands in rapidly developing areas are especially vulnerable. They can be in the process of being altered or their alteration could be predicted on the basis of existing trends. Another factor enters the picture here... wetlands are very fragile and cannot, in some cases, withstand much human traffic even by foot, *i.e.*, overuse, even in recreational forms, can occur. Thus, while a goal of outdoor recreation agencies may be to foster access a compromise may be required if the character of a wetland is to be maintained.

Relative scarcity. It wetlands or specific types of wetlands are unusual within certain geographic boundaries, their value is necessarily enhanced. On the contrary, in localities where wetlands abound citizens may judge the value of wetlands lower.

Proximity or accessibility. Proximity may refer to the position of a wetland within a watershed. A wetland upstream from a heavily populated area might serve as a flood storage basin. Proximity could also indicate distance from an educational institution or population center. Nearby hunting, scientific research, or field activities could, therefore, be much enhanced.

Golet (1973) and Larson (1971, 1973, 1975, 1976) have also listed criteria by which a wetland can be viewed as outstanding or of such noteworthy character that it deserves preservation. Any one feature would be satisfactory to designate a wetland as outstanding while the presence of more than one enhances its value still further. They recognize the following:

1. presence of rare, restricted, endemic or relict flora or fauna. Each of these categories requires a brief explanation. A rare species occurs in very few localities within a geographic area, *e.g.*, among others

Utricularia gibba - humped bladderwort

Habenaria leucophaea - Prairie white fringed orchis

Malaxis brachypoda - white adder's mouth

Orchis rotundifolia - small round-leaved orchis

Cypripedium arietinum - Ram's head lady's-slipper

A restricted species has a narrow habitat preference and is found only in specialized habitats, e.g., Sarracenia purpurea (pitcher-plant) in bogs. An endemic species is limited to specific geographic area while relict species were once more common, but as environmental conditions changes, their range became more limited (e.g., Labrador tea, bog laurel, cottongrass).

2. The presence of flora of unusually high visual quality and infrequent occurrence. For example, orchids would be considered here as would certain species of sundew and other insectivorous plants. Their presence should necessitate consideration for protection and at least some localities where they are found would likely deserve protection.

3. The presence of flora or fauna at, or very near, the limits of their range. These areas are important for scientific and educational interest (e.g., Atlantic white cedar, arrow-arum, nesting fox sparrows, etc., in southern Maine).

4. The juxtaposition, in sequence, of several stages of hydrarch succession or the presence in close proximity of two or more wetland types. A wetland which clearly illustrates a progression from open water to dry land provides a fine example of how wetlands change in time.

5. High production of native waterfowl and fish species. Breeding habitat is critically important, especially for ducks, and generally such prime wetland areas are few.

6. Use by great numbers of migrating waterfowl, shorebirds, marsh birds and wading birds.

7. The presence of outstanding or uncommon geomorphological features in, or associated with, a wetland (e.g., wetlands formed in association with sandy bars, eskers, unusual rock outcroppings, etc.)

8. The availability of reliable scientific information concerning the geological, biological or archeological history of a wetland. Unfortunately, few examples exist here.

9. Wetlands which are integral links in a system of waterways, or whose size dominates a regional watershed.

Smardon (1973) has considered visual-cultural values of wetlands which he describes in scenic, recreational, and educational terms. Wetlands contribute to scenic diversity and counter the trend toward monotony in the landscape. Such diversity includes variation in land forms, water bodies, vegetation types, and land use types. Smardon (1973) continues:

"Contrast occurs when different visual elements meet to form an edge. Some contributions of visual elements make sharper or clearer edges than others. For example, a cliff bordering a wetland and a coniferous forest adjoining a deep fresh marsh create distinct edges." In his scheme, scenic value depends on:

landform contrast: how much the land slopes down to a wetland determines the degree of contrast.

land-use contrast: a deep marsh-forest edge has more contrast than a wooded swamp-forest edge.

textural contrast: different surfaces such as water and vegetation provide contrast as opposed to similar vegetative surfaces.

wetland type diversity: different wetland types in close association enhance the visual contrast.

landform type: associated land forms, such as eskers, can provide greater accessibility.

wetland size: a recreational factor since the larger wetlands can accommodate more human activity.

water body size: the size of associated water body affects the degree to which a wetland can support recreational activity.

naturalness: the degree to which a wetland has been subjected to human interference.

Tans (1974) has developed a priority ranking for natural areas in Wisconsin. His broad divisions include biological characteristics, physical characteristics and use value, degree of threat, and availability

In summary, these researchers have identified the major considerations in the recognition of outstanding wetlands and their findings have important implications for a preliminary inventory of significant freshwater wetlands in Maine. One cautionary note should be provided at this juncture. Simply because a wetland apparently fails to meet at least one of the criteria outlined here should not suggest that it has no value. It may be that as more research is undertaken important characteristics will be found or through natural successional processes its characteristics (two or more) might become outstanding.

If a wetland meets two or more of the recognized criteria, it should be considered as outstanding. Such a wetland deserves protection, through either direct regulation or, as an alternative, through non-regulatory approaches. Larson's (1976) evaluative system, in addition, considers wildlife, visual-cultural, and ground water potential in a further level and finally attributes specific dollar values to a wetland. When conducting a state-wide or regional inventory where purchase through bond issue allocations is possible, Larson's methods via three levels might be a desirable approach. For a more limited survey his first level is necessary and useful while the second sub-models for wildlife and visual-cultural values also provide helpful guides for distinguishing the truly outstanding wetlands. If a wetland has outstanding values for its wildlife, *e.g.*, waterfowl resting, nesting; large wading birds, etc., then Larson's (1975) characteristics for determining wildlife value could be assessed in that specific wetland. Several other features of wetlands contribute to the value and/or need for protective status. These are as follows:

Characteristic	Significance Coefficient	Definition
Class richness[1]	5	Number of wetland classes on the site
Dominant class	5	Wetland class occupying the most area
Size	5	Acreage of the wetland
Subclass richness[2]	4	Number of wetland subclasses on the site
Site type	4	Upland, bottomland, associated water bodies
Surrounding habitat	4	Adjacent land use and vegetative types
Cover type	3	Ratio of vegetative cover to water on site
Interspersion	3	Amount of edge between subclasses
Juxtaposition	2	Location relative to other wetlands
Water chemistry	1	Total alkalinity or pH at the site

1 Classes are the same as wetland types of Martin et al. (1953)

2 Subclasses are the different life forms of vegetation found within classes.

Finally, vulnerability, relative scarcity, and proximity or accessibility (as described in Lavine et al., 1974) could be examined.

Evaluative approaches have been criticized frequently for their lack of objectivity. Certainly, subjective judgement is involved to a degree in the approach which is offered here; however, there is a strong component of standardization and an adequate number of variables to give a clear indication of a wetland's value.

References Cited and Selected Literature

Adamus, Paul R. and Garrett C. Clough. 1976. A preliminary listing of noteworthy natural features in Maine. Center for Natural Areas, South Gardiner, Maine. 397p.

Anderson, Kenneth H. 1971. Marsh areas - haven for waterfowl. Maine Fish and Game 13 (4): 12-13.

Anderson, P.H. et al. 1978. Transition zones of forested inland wetlands in Northeastern Connecticut. Inst. Water Res., Univ. Conn. Rept 29: 92p.

Aus, Philip B. 1969. What is happening to wetlands? N.A. Wild. and Natur. Res. Conf. 34: 315-323.

Avnimelach, Y. 1971. Nitrate transformation in peat. Soil Sci. III: 113:118.

Baker, John A. 1973. Wetland hydrology, p. 84-96. In: Helfgott, T. et al. (eds.), Proc. 1st Wetlands Conf., Univ. Conn., Storrs, Conn., June 20, 1973.

Banta, John S. et al. 1978. Legal issues, pp. 179-204. In: Proc. Natl. Wetland Protection Symp., Reston, Va., June 6-8, 1977 (FWS/OBS-78/97).

Barr, Louis M. 1963. The chain pickerel. Maine Fish and Game 5 (2): 13-15.

Barstow, C.J. 1971. Impact of channelization on wetland habitat in the Obion-Forked Deer Basin, Tennessee. Trans. N.A. Wildlife Natur. Res. Conf. 36: 362-375.

Bartelli, Lindo J. 1975. Using soil surveys for delineating wetlands p. 14-20. In: Proc. 2nd Wetlands Conf., Storrs, Conn., Jan. 9, 1974.

Bastin, E.S. and C.A. Davis. 1909. Peat deposits in Maine. U.S. Geol. Surv. Bull. 376: 125 p.

Bay, R.R. 1967. Ground water and vegetation in two peat bogs in northern Minnesota. Ecology 48(2): 308-310.

Bennett, Logan J. 1937. Grazing in relation to the nesting of the bluewing teal. Trans. N. Amer. Wild. Conf. 2: 393-396.

Bernard, John M. and Eville Gorham. 1978. Life history aspects of primary production in sedge wetlands, pp. 39-51. In: Ralph E. Good et al. (eds.), Freshwater wetlands - ecological processes and management potential. Academic Press, New York.

Black, Robert F. 1973. Wetland geology, p. 42-63. In: Helfgott, T. et al (eds.), Proc. 1st Wetlands Conf., Univ. Conn., Storrs, Conn. June 20, 1973.

Blanchard, Harold M. and Myron S. Smart. 1965. Beaver become march managers. Maine Fish and Game 7(1): 23-25.

Boelter, D.H. 1964. Water storage characteristics of several peats in situ. Soil Science Soc. Amer. Proc. 28: 433-435.

Boeltger, Robert W. 1966-67. Managing Maine's beavers: how and why. Maine Fish and Game 9(1): 4-6.

Bond, G. 1949. Root nodules of bog myrtle or sweet gale (Myrica gale L). Nature 163: 730.

________. 1951. The fixation of nitrogen associated with the root nodules of Myrica gale L., with special reference to its pH relation and ecological significance. Ann. Bot. 15: 447-459.

________.1956. Evidence for fixation of nitrogen by root nodules of alder (Alnus) under field conditions. New Phytol. 55: 147-153.

Borns, H.W., Jr. and P.E. Calkin. 1970. Quaternary history of northwestern Maine. In: New England Intercollegiate Geol. Conf., 62nd ann. mtg., Rangeley, Me., Oct. 2-4, 1970, Guidebook for field trips in the Rangeley Lakes - Dead River basin region, western Maine. Syracuse, N.Y., Syracuse Univ., Dept. Geology, variously paged.

Boyd, Claude E. 1978. Chemical composition of wetland plants, pp.155-167. In: Ralph E. Good et al. (eds.), Freshwater wetlands - ecological processes and management potential. Academic Press, N.Y.

Brewer, R. 1967. Bird populations of bogs. Wilson Bull. 79: 371-396.

Brewer, Thomas. 1978. Waterfalls in Maine and their relevance to the Critical Areas Program of the State Planning Office. Planning Rept. 60, Critical Areas Program, Natural Resource Planning Division, Maine State Planning Office. 43p.

Burke, W. 1975. Fertilizer and other chemical losses in drainage water from blanket bog. Ir. J. Agric. Res. 14: 163-178.

Cameron, Cornelia C. 1975. Some peat deposits in Washington and southeastern Aroostook counties, Maine. Geol. Surv. Bull. 1317-C: C1-40.

__________, and Whitney D. Massey. 1978. Some peat deposits in northern Hancock County, Maine. Open-file report, several pages.

Carter, Virginia. 1975. The use of remote sensing data in the management of inland wetlands, p. 31-50. In: Proc. 2nd Wetlands Conf., Storrs, Conn., Jan. 9, 1974.

Chamie, Jim P.M. and Curtis J. Richardson. 1978. Decomposition in northern wetlands, p. 115-130. In: Ralph E. Good et al. (eds.), Freshwater wetlands - ecological processes and management potential, Academic Press, N.Y.

Choate, Jerry S. 1972. Effects of stream channeling on wetlands in a Minnesota watershed. J. Wildl. Mgt. 36 (3): 940-943.

Conway, Verona M. 1949. The bogs of central Minnesota. Ecol. Monogr. 19: 175-205.

Clymo, R.S. 1963. Ion exchange in Sphagnum and its relation to bog ecology . Ann. Bot. (N.S.) 27: 309-327.

Coulter, Malcolm W. 1948. A study of movements and habitat preferences of muskrats. M.S. Thesis, Univ. Maine, Orono. 114p.

________. 1952. Food of wood ducks in Maine. J. Wildl. Mgt. 235-236.

________. 1955. Spring food habits of surface-feeding ducks in Maine. J. Wildl. Mgt. 19: 263-266.

________. 1957. Predation of snapping turtles upon aquatic birds in Maine marshes. J. Wildl. Mgt. 21: 17-21.

________ and H.L. Mendall. 1968. Habitat and breeding ecology - Northeastern states, p. 90-101. In: The black duck, evaluation, management and research, a symposium. Atlantic Waterfowl Council, Chestertown, Md. 193p.

________ and W.R. Miller. 1968. Nesting biology of black ducks and mallards in northern New England. Vt. Fish and Game Dept. Bull. 68: 74p.

Cowardin, L.M. et al. 1967. Stump and tree nesting by mallards and black ducks. J. Wildl. Mgt. 31: 229-235.

________, Virginia Carter, Francis C. Golet, and Edward T. LaRoe. 1977. Classification of wetlands and deep-water habitats of the United States (an operational draft). U.S. Dept. Interior Fish and Wildlife Service. 100p.

________ and V.T. Myers, 1974. Remote sensing for identification and classification of wetland vegetation. J. Wildl. Mgt. 38(2): 308-314.

Dachnowski - Stokes, A.P. 1929. The botanical composition and morphological features of highmoor peat profiles in Maine. Soil Sci. 27: 379-388.

________. 1930. Peat profile studies in Maine: the South Lubec "heath" in relation to sea level. J. Wash. Acad. Sci. 20(7): 124-135.

__________.1935. Peat land as a conserver of rainfall and water supplies. Ecology 16: 173-177.

__________.1939. Improvement of unproductive and abandoned peatland for wildlife and related uses. Ecology 20: 187-197.

Dammann, A.W.H. 1977. Geographical changes in the vegetation pattern of raised bogs in The Bay of Fundy Region of Maine and New Brunswick. Vegetatio 35 (3): 137-151.

Dansereau, P. and F. Segadas-Vianna. 1952. Ecological study of the peat bogs of eastern North America. I. Structure and evolution of vegetation. Can. J. Bot. 30: 490-520.

Darnell, Rezneat M. 1976. Impacts of construction activities in wetlands of the United States. U.S. Env. Prot. Agency (EPA) 600/3-76-045. 392p.

__________.1978. Overview of major development impacts on wetlands, p. 19-28. In: Proc. Natl. Wetland Prot. Symp., Reston, Va., June 6-8, 1977. (FWS/OBS-78/97).

Davis, Joel. 1979. Production and utilization of Maine's peat and resources. Dept. Agric. and Resource Econ., Univ. Maine, Orono, 42p.

Davis, Margaret B. 1965. Phytogeography and palynology of northeastern United States, p. 377-401. In: H.E. Wright, Jr. and David G. Frey (eds.), The Quartenary of the United States, Princeton University Press, Princeton, N.J.

Davis, Margaret B. 1973. Ecological history of wetlands, p. 113-121. In: Helfgott, T. et al. (eds.), Proc. 1st Wetlands Conf., Univ. Conn., Storrs, Conn., June 20, 1973.

DeBates, Lawrence W. 1967. The role of small wetland preservation in comprehensive prairie pothole region planning. Trans. North Amer. Wildlife and Nat. Res. Conf. 32: 325-331.

Deevey, E.S. 1970. In defense of mud. Bull. Ecol. Soc. America 51 (1): 5-8.

__________. 1958. (Oct.) Bogs. Scientific American: 114-122.

de la Cruz, Armando. 1978. Primary production processes: summary and recommendations, pp. 79-86. In: Ralph E. Good et al., Freshwater wetlands - ecological processes and management potential. Academic Press, N.Y.

Donovan, Gary G. 1977. Wildlife management areas: Ruffingham Meadow. Maine Fish and Wildlife 19 (4): 13-15.

Durno, S.E. 1961. Evidence regarding the role of peat growth. J. Ecol. 49: 347-351.

Eastman, L.M. 1978. Rare Maine vascular plants. Critical Areas Program, State Planning Office, Augusta, Maine.

Engler, R.M. & W.H. Patrick, Jr. 1974. Nitrate removal from floodwater overlying flooded soils and sediments. J. Env. Quality (Oct.) 3 (4): 309-413.

Errington, Paul L. 1957. Of men and marshes. Iowa State Univ. Press, Ames, Iowa. 150p.

Farnham, Rouse S. 1978. The Minnesota Alternative Energy Research and Development Policy Formulation Project. Subcommittee 8, Peat. Minnesota Energy Agency. 169p.

__________, and D.H. Boelter. 1976. Minnesota's peat resources: their characteristics and use in sewage treatment, agriculture and energy, p. 241-255. In: D.L. Tilton et al. (eds.), Freshwater wetlands and sewage effluent disposal. Univ. Michigan, Ann Arbor, Mich.

Fassett, N.C. 1957. A manual of aquatic plants. Univ. Wisc. Press, Madison, Wisc. 405p.

Fefer, Stewart I. 1977. Waterfowl populations as related to habitat changes in bog wetlands of the Moosehorn National Wildlife Refuge. Life Sci. and Agric. Exp. Stat., Univ. Maine at Orono Tech. Bull. 85: 1-16.

Fernald, M.L. 1950. Gray's manual of botany. 8th ed. Amer. Book Co., N.Y. 1632p.

Foye, Robert E. 1965. Menace in Merrymeeting [on carp]. Maine Fish and Game 7 (1): 26-27.

Gallagher, John L. 1978. Decomposition processes: summary and recommendations, p. 145-151. In: Ralph E. Good et al (eds.) Freshwater wetlands - ecological processes and management potential. Academic Press, N.Y.

Garbisch, Edgar W., Jr. et al. 1978. Wetland rehabilitation, p. 217-224. In: Proc. Natl. Wetland Prot. Symp., Reston, Va. June 6-8, 1977, (FWS/OBS-78/97).

Gates, F.C. 1942. Bogs of northern lower Michigan. Ecol. Monogr. 12: 213-254.

Gawler, Sue. 1978. A revision of the Maine rare plant inventory process. State Planning Office, Augusta, Maine (draft report) 23p.

Germain, Clifford E. 1977. Wisconsin Scientific Areas 1977 - preserving native diversity. Wisc. Dept. Natur. Res. Tech. Bull. 102: 52p.

Gibbs, R.M. 1961. Breeding ecology of the common goldeneye, Bucephala clangula americana in Maine. M.S. Thesis, Univ. Maine, 113 p.

Gillette, R. 1972. Crow Creek: case history of an ecologic disaster. Science: 890-894.

Godshalk, Gordon L. and Robert G. Wetzel. 1978. Decomposition in the littoral zones of lakes, pp. 131-143. In: Ralph E. Good et al. (eds.), Freshwater Wetlands - ecological processes and management potential. Academic Press, N.Y.

Goldstein, Jon H. 1971. Competition for wetlands in the Midwest: an economic analysis. Resources for the Future, Wash., D.C. 105 p.

Golet, F.C. 1973. Criteria for identification of outstanding wetlands. Mimeo, 4 p.

__________. 1976. Freshwater wetlands as wildlife habitats, p. 84-103. In: M.W. Lefor et al. (eds.), Proc. 3rd Wetlands Conf., Storrs, Conn.

__________. 1976. Wildlife wetland evaluation model, pp. 13-34. In: J.S. Larson (ed.), Models for assessment of freshwater wetlands. Publ. 32 Water Res. Research Center, Univ. Mass., Amherst.

__________ and Joseph S. Larson. 1974. Classification of freshwater wetlands in the glaciated Northeast. Bureau of Sport Fisheries and Wildlife Resource Publ. 116 : 56 p.

Good, Ralph E. et al. (eds.) 1978. Freshwater Wetlands - ecological processes and management potential. Academic Press, N.Y. 378 p.

__________. 1974. Inland wetlands: their ecological role and environmental status. Bull. Ecol. Soc. America 55(2): 2-6.

Goodwin, Richard H. and William A. Niering. 1975. Inland wetlands of the United States evaluated as potential registered natural landmarks. National Park Serv. Natural Hist. Theme Stud. No. 2.

Gore, A.J.P. 1961. Factors limiting plant growth on high-level blanket peat: I. Calcium and phosphate. J. Ecol. 49: 399-402.

Gorham, Eville. 1950. Variation in some chemical conditions along the borders of a Carex lasiocarpa fen community. Oikos 2: 216-240.

__________. 1953. A note on the acidity and base status of raised and blanket bogs. J. Ecol. 41: 153-156.

__________. 1957. The development of peat lands. Quart. Rev. Biol. 32: 145-166.

__________. 1961. Water, ash, nitrogen and acidity of bog peats and other organic soils. J. Ecol. 49: 103-106.

__________. 1974. The relationship between standing crop in sedge meadows and summer temperature. J. Ecol. 62: 487-491.

Gosseling, J.G. and R.E. Turner. 1978. The role of hydrology in freshwater wetland ecosystems, p. 63-78. In: Ralph E. Good et al. (eds.), Freshwater wetlands - ecological processes and management potential. Academic Press, N.Y.

Gracè, James. R. 1976. The management of wetland forest, p. 104-115. In: W. Lefor et al.(eds.), Proc. 3rd Wetlands, Conf., Storrs, Conn.

Grant, Robert R., Jr. and Ruth Patrick. 1970. Tincium Marsh as a water purifier, p. 105-122. In: Two Studies of Tinicum Marsh, The Conservation Foundation.

Greij, Eldon D. 1976. The effects of a marsh on water quality. Institute of Water Research, Michigan State University, PB-250 498, 23 p.

Grealich, Gunther. 1975. Problems in delineating wetlands boundaries, p. 55-66. In: Proc. 2nd Wetlands Conf., Storrs, Conn. Jan. 9, 1974.

Grittinger, T.F. 1970. String bogs in southern Wisconsin. Ecology 51: 928-930.

Gupta, T. 1976. Economics of freshwater wetland preservation in Massachusetts, p. 66-84. In: J.S. Larson (ed.), Models for the assessment of freshwater wetlands, Publ. 32, Water Resources Research Center, Univ. Mass., Amherst.

________ et al. 1973. Institutional framework affecting the use of inland wetlands in Massachusetts. Publ. 91, Coop. Ext. Serv., U.S.D.A., University of Mass., Amherst.

________ and J.H. Foster. 1973. Valuation of visual-cultural benefits from freshwater wetlands in Massachusetts. J. N.E. Agric. Econ. Council 2(1): 262-273.

________ and ______ 1975. Economic criteria for freshwater wetland policy in Massachusetts. Amer. Journ. of Agric. Econ. 57(1):40-45.

Hall, Francis R., Robert J. Rutherford, and Gordon L. Byers. 1972. The influence of a New England wetland on water quantity and quality. Water Resource Research Center Report (Univ. of New Hampshire) 4: 51 p.

Hall, L.C. 1971. Bibliography of freshwater wetlands ecology and management. Wisc. Dept. Natural Res. Dept. 33: 230 p.

Hammack, J. and G. Mallard Brown. 1974. Waterfowl and wetlands: toward bio-economic analysis, Johns Hopkins Univ. Press, Baltimore, 95 p.

Harris, Stanley W. and William H. Marshall. 1963. Ecology of water-level manipulations on a northern marsh. Ecology 44(2): 331-343.

Hasler, A.D. (ed.) 1975. Coupling of land and water systems, Springer-Verlag, N.Y.

Have, M.R. 1973. Effects of migratory waterfowl on water quality at the Montezuma National Wildlife Refuge, Seneca County, N.Y. J. Res. Nov-Dec. no. 6.

Heeley, R.W. 1973. Hydrogeology of wetlands in Massachusetts, M.S. Thesis, Univ. Mass., Amherst.

___________ and Ward S. Motts. 1976. A model for the evaluation of ground-water resources associated with wetlands, p. 52-56. in: J.S. Larson (ed.), Models for assessment of freshwater wetlands. Publ. 32 Water Res. Research Center, Univ. Mass., Amherst.

Heinselman, M.L. 1963. Landscape evolution, peatland types, and the environment in The Lake Agassiz peatlands natural area, Minnesota. Ecol. Monogr. 40: 235-261.

___________. 1963. Forest sites, bog processes, and peatland types in the glacial Lake Agassiz region, Minnesota. Ecol. Monogr. 33(4): 327-374.

___________. 1975. Boreal peatlands in relation to environment p. 93-103. In: A.D. Hasler (ed.), Coupling of land and water systems. Springer-Verlag, N.Y.

Helfgott, T.B., M.W. Lefor, and W.C. Kennard, 1976. Inland wetland definitions, p. 1-15. In: M.W. Lefor et al. (eds.), Proceedings 3rd Wetlands Conf., Storrs, Conn.

Herbst, Robert et al. 1978. Federal agency roles in wetland protection, p. 99-142. In: Proc. Natl. Wetland Prot. Symp., Reston, Va., June 6-8, 1977.

Hill, David E. 1973. Inland wetland soils, p. 30-39. In: Helfgott, T. et al. (eds.), Proc. 1st Wetlands Conf. Univ. Conn., Storrs, Conn., June 20, 1973.

Hodgdon, K.W. and J.H. Hunt. 1966. Beaver management in Maine. Game Div. Bull. 3, Dept. Inland Fish and Game. 102 p.

Holmes, Dana. 1967. Small marshes for Maine's Wildlife. Maine Fish and Game 9(3): 20-21.

Holzer, Thomas L. 1973. Inland wetlands and ground water in eastern Connecticut, p. 66-81. In: Helfgott, T. et al. (eds.), Proc. 1st Wetlands Conf., Univ. Conn., Storrs, Conn., June 20, 1973.

Horwitz, Elinor L. 1978. Our nation's wetlands. An interagency task force report. Council on Environmental Quality. 70 p.

Hosner, John F. 1960. Relative tolerance to complete inundation of fourteen bottomland tree species. Forest Science 6: 246-251.

Hotchkiss, N. 1970. Common marsh plants of the United States and Canada. Resource Publ. 93. Fish and Wildlife Service, U.S. Dept. of Interior, Wash., D.C. 99 p.

__________ 1972. Common marsh, underwater, and floating-leaved plants of the United States and Canada. Dover Publ., N.Y. 124 p.

Hunt, F.M. 1951. Effects of flooded soil on growth of pine seedlings. Plant Phys. 26: 363-368.

Hyland, Fay and Barbara Hoisington. 1977. The woody plants of sphagnous bogs of northern New England and adjacent Canada. Life Sci. and Agr. Exp. Stat., Univ. Maine, Orono, Maine Bull 744: 110 p.

Isaak, D. et al. 1959. A record of reverse plant succession in a tamarack bog. Ecology 40: 317-320.

Janssen, C.R. 1968. Myrtle Lake: a late-and post-glacial pollen diagram from northern Minnesota. Can. J. Bot. 46: 1397-1408.

Jasmin, J.J. and H.B. Heeney. 1960. Reclaiming acid dome peat bogs for agricultural use. Canad. Dept. Agr. Publ. 1089. 15 p.

Jaworski, Eugene et al. 1977. General functions and values of freshwater wetlands in the glaciated Midwest. Depts. of Geography and Geology, Eastern Michigan University. 69 p.

Jeglum, J.K. 1971. Plant indicators of pH and water level in peatlands at Candle Lake, Saskatchewan. Can. J. Bot. 49: 1661-1676.

Jeglum, J.K., A.N. Boissonneau, and V.G. Haavisto. 1974. Toward a wetland classification for Ontario. Can. For. Serv. Inf. Rep. 0-X-215. 54

Kaye, Clifford A. 1962. Early post-glacial beavers in southeastern New England. Science 138: 906-907.

Kennedy, R.A. 1964. Relationship of maximum peat depth to some environmental factors in bogs and swamps in Maine. Maine Agr. Exp. State Bull. 620: 57p.

Klopatek, Jeffrey M. 1978. Nutrient dynamics of freshwater riverine marshe and the role of emergent macrophytes, p. 195-216. In: Ralph E. Good et al. (eds.), Freshwater wetlands - ecological processes and management potential, Academic Press, N.Y.

Ladd, Elizabeth et al. 1975. Wetlands and the water cycle. Mass. Audubon Society, Lincoln, Mass. 22 p.

Larson, J.S. 1971. Progress toward a decision-making model for public management of freshwater wetlands. Trans. N.A. Wildlife and Natur. Res. Conf. 36: 376-382.

________. 1973. A guide to important characteristics and values of freshwater wetlands in the Northeast. Publ. 31, Water Res. Research Center, Univ. Mass., Amherst, 35 p.

________. 1975. Identification and delineation of freshwater wetland values, p. 1-10. In: Proc. 2nd Wetlands Conf., Storrs, Conn., Jan. 9, 1974.

________. 1975. Evaluation models for public management of freshwater wetlands. Trans. N.A. Wildlife and Natur. Res. Conf. 40: 220-228.

________. (ed.) 1976. Models for assessment of freshwater wetlands. Publ. 32, Water Res. Research Center, Univ. Mass., Amherst, 91 p.

________ et al. 1978. Research priorities, p. 243-250. In: Proc. Natl. Wetland Prot. Symp., Reston, Va., June 6-8, 1977 (FWS/OBS-78/97).

Lavine, David et al. 1974. Evaluation of inland wetland and watercourse functions. Connecticut Inland Wetland Project, Mimeo.

LeBarron, R.K. 1945. Adjustment of blackspruce root systems to increasing depth of peat. Ecology 26: 309-311.

Lee, G. Fred, E. Bentley, and R. Amundson. 1975. Effects of marshes on water quality, p. 105-127. In: A.D. Hasler (ed.), Coupling of land and water systems . Springer-Verlag, N.Y.

Lefor, M.W. and W.C. Kannard. 1977. Inland wetland definitions Inst. Water Res., Univ. Conn. Dept. 28: 63 p.

Leisman, G.A. 1957. Further data on the rate of organic matter accumulation in bogs. Ecology 38: 361.

Leitch, W.G. 1966. Historical and ecological factors in wetland inventory. Trans. N. Amer. Wild. Natur. Resource Conf. 31: 88-96.

Lindeman, Raymond L. 1941. Seasonal food-cycle dynamics in a senescent lake. Amer. Midl. Natur. 26: 636-673.

__________. 1941. The developmental history of Cedar Creek Bog, Minnesota, Amer. Midl. Natur. 25: 101-112.

Losee, David B. 1975. The taking clause of the United States Constitution and the Connecticut Inland Wetlands and Watercourses Act, p. 74-93. In: Proc. 2nd Wetlands Conf., Storrs, Conn., Jan. 9, 1974.

Low, L. Gregory et al. 1978. Role of the private sector and the public, p. 225-242. In: Proc. Natl. Wetland Prot. Symp., Reston, Va., June 6-8, 1977 (FWS/OBS-78/97).

Lowry, Dennis. 1976. An annotated wetland bibliography. Mass. Audubon Society, Lincoln, Mass. 61 p.

Maire, Barbara L. et al. undated. Wetlands and flood plains on paper. Mass. Audubon Society, Lincoln, Mass. 27 p.

Mairs, Donald F. 1967-8. The swampland singers. Maine Fish and Game 19(1): 16-18.

Malmer, Nils, 1975. Development of bog mires, p. 85-92. In: A.D. Hasler (ed.), Coupling of land and water systems, Springer-Verlag, N.Y.

Marston, Douglas L. 1967-8. Brownfield Bog. Maine Fish and Game 19(1): 24-26.

Martin, A.C., N. Hotchkiss, F.M. Uhler, and W.S. Bourn. 1953. Classification of wetlands of the United States, U.S. Fish and Wildlife Serv. Spec. Sic. Rep. Wildl. 20. 14 p.

Martin, Kenneth R. 1976-7. The wetlands controversy: a coastal concern washes inland. Notre Dame Lawyer 52: 1015-1034.

McCall, Cheryl A. 1972. Manual for Maine wetlands inventory. Maine Dept. Inland Fisheries and Game. 38 p.

McCormick, Jack. 1978. Ecology and regulation of freshwater wetlands, p. 341-355. In: Ralph E. Good et al. (eds.), Freshwater wetlands - ecological processes and management potential. Academic Press, N.Y.

McDermott, R.E. 1954. Effects of saturated soil on seedling growth of some bottomland hardwood species. Ecology 35(1): 36-41.

McLeese, R.L. and E.P. Whiteside. 1977. Ecological effects of highway construction upon Michigan woodlots and wetlands: soil relationships. J. Env. Qual. 6(4): 467-471.

Mendall, H.L. 1949. Breeding ground improvements for waterfowl in Maine. Trans. N. Amer. Wild. Conf. 14: 58-64.

__________. 1958. The ring-necked duck in the northeast. Univ. Maine Bull. 60(16): 317 p.

__________. 1972. The ring-neck. Maine Fish and Game 14(3):4-7.

Millar, John B. 1973. Estimation of area and circumference of small wetlands. J. Wild. Mgt. 37(1): 30-38.

Miller, E.G. 1965. Effect of Great Swamp, New Jersey, on stream flow during base-flow periods. U.S. Geol. Surv. Res. Paper 525-B. B177-179.

Moizuk, G.A. and R.B. Livingston. 1966. Ecology of red maple (Acer rubrum L.) in a Massachusetts upland bog. Ecology 47(6): 942-950.

Montanari, John H. and Bill O. Wilen. 1978. Wetland mapping, p. 205-216. In: Proc. Natl. Wetland Prot. Symp., Reston, Va., June 6-8, 1977 (FWS/OBS-78/97).

Mood, E.W. 1976. Epidemiologic and public health implications of wetlands, p. 116-120. In: M.W. Lefor et al. (eds.), Proc. 3rd Wetlands Conf., Storrs, Conn.

Moore, P.D. and D.J. Bellamy. 1974. Peatlands. Springer-Verlag, N.Y. 221p.

Nelson, Harvey K. 1977. Subcommittee to develop a model state wetlands act. Proc. 67th Conv. Int. Assoc. Fish and Wildl. Agencies, Sept. 12-14, 1977: 220-223.

Nevers, H.P. 1968. Waterfowl utilization of beaver impoundments in southeastern New Hampshire. Trans. N.E. Sect. Wildl. Soc., 25th N.E. Fish and Wildl. Conf. 14-17 Jan. 1968, pp. 105-120.

Nichols, E.G. 1919. Raised bogs in eastern Maine. Geogr. Rev. 7: 159-167.

Niering, William A. 1966. The life of the marsh: The North American wetlands. McGraw-Hill, N.Y. 227p.

__________. 1973. The ecological role of inland wetlands, p.100-109. In: Helfgott, T. et al. (eds.), Proc. 1st Wetlands Conf., Univ. Conn., Storrs, Conn., June 20, 1973.

__________, and Richard H. Goodwin. 1973. Inland wetland plants of Connecticut. The Conn. Arboretum, New London, Conn. 24p.

North Atlantic Division, Army Corps of Engineers. 1977. Wetland plants of the eastern United States.

Odum, Howard T. 1978. Value of wetlands as domestic ecosystems, p. 9-18. In: Proc. Natl. Wetland Prot. Symp., Reston, Va. (FWS/OBS-78/97).

Olson, D.P. 1964. The use of aerial photographs in studies of marsh vegetation. Maine Agric. Exp. Stat. Bull 13, Tech. Ser. 62p.

Osvald, H. 1955. The vegetation of two raised bogs in northern Maine. Svensk. Bot. Tidskr. 49: 110-118.

__________. 1970. Vegetation and stratigraphy of peatlands in North America: Nova Acta Regiae Societatis Scientarum Upsaliensis Ser. V: C. Vol. 1, 96p.

Peppard, J. William. 1971. Improve your land for waterfowl. Maine Fish and Game 13(4): 16-17.

Perry, Lee E. 1973. An important job has been started... Maine Fish and Game (fall issue).

Peterson, Roger T. and Margaret McKenny. 1968. A field guide to wildflowers. Houghton Mifflin, N.Y. 420p.

Petson, G.C. 1966. Marshland farming in the Sackville area of New Brunswick. Canad. Farm. Econ. 1(3): 20-26.

Post, Russell Lee, Jr. 1975. Policy considerations of the Connecticut Inland Wetlands Act. p. 69-71. In: Proc. 2nd Wetlands Conf., Storrs, Conn., Jan. 9, 1974.

Prentki, R.T., et al. 1978. Nutrient movements in lakeshore marshes, p. 169-194. In: Ralph E. Good et al. (eds.), Freshwater wetlands - ecological processes and management potential. Academic Press, N.Y.

Prince, H.H. 1968. Nest sites used by woodducks and common goldeneyes in New Brunswick, J. Wildl. Mgt. 32: 489-500.

Reader, R.J. 1978. Primary production in northern bog marshes, p. 53-62. In: Ralph E. Good et al.,Freshwater wetlands - ecological processes and management potential. Academic Press, N.Y.

__________, and J.M. Stewart. 1971. Net primary productivity of bog vegetation in southeastern Manitoba. Canad. J. Bot. 49: 1471-1477.

________and ________. 1972. The relationship between net primary production and accumulation for a peatland in southeastern Manitoba. Ecology 53: 1024-1037.

Redmond, Malcolm A. 1966. Water beetles. Maine Fish and Game 8(3): 21-23.

Reppert, Richard T. et al. 1979. Wetland values - concepts and methods for wetlands evaluation. Inst. Water Resources, U.S. Army Corps of Engineers, Fort Belvoir, VA. Research Dept. 79-R1. 109p.

Rich, Peter and Andrzej Kowalczewski. 1976. Wetland metabolism, p. 73-83. In: L.W. Lefor et al. (eds.) Proc. 3rd Wetlands Conf., Storrs, Conn.

Richardson, Curtis J., John A. Kadlec, W. Alan Wentz, Jim P.M. Chamie, and Robert H. Kadlec. 1976. Background ecology and the effects of nutrient additions on a central Michigan wetland, p. 34-72. In: M.W. Lefor et al. (eds.), Proceedings 3rd Wetlands Conf., Storrs, Conn.

Richardson, Curtis J. et al. 1978. Nutrient dynamics of northern wetland ecosystems, p. 217-241. In: Ralph E. Good et al. (eds.), Freshwater Wetlands - ecological processes and management potential, Academic Press, N.Y.

Rigg, George B. 1940. The development of sphagnum bogs in North America. Botan. Rev. 6:666-693.

____________. 1951. The development of sphagnum bogs in North America. II. Botan. Rev. 17: 109-131.

____________., and H.R. Gould. 1957. Age of Glacier Peak eruption and chronology of post-glacial peat deposits in Washington and surrounding areas. Am. J. Sci. 255: 341-363.

Ritzi,Charles F. 1967. The yellow perch: Zebra of the lily pads. Maine Fish and Game 9(3): 4-6.

Rose, B.J. and H.R. Morgan. 1964. A priority rating system for Canadian wetlands preservation. 29th North Amer. Wildl. and Natur. Res. Conf., 249-258.

Sanderson, Glen C. and Frank. C. Bellrose. 1969. Wildlife Habitat Management. An. Acad. brasil. Cienc. 41 (suppl.): 153-204.

Scafer, J.P. and J.H. Hartshorn. 1965. The Quartenary of New England, p. 113-127. In: H.E. Wright, Jr. and David G. Frey (eds.), The Quartenary of the United States, Princeton University Press, Princeton, N.J.

Schwintzer, Christa R. and Gary Williams. 1974. Vegetation changes in a small Michigan bog from 1917 to 1972. Amer. Mild. Natur. 92(2): 447-459.

Shaw, S.P. and C.G. Fredine. 1956. Wetlands of the United States. U.S. Fish and Wildl. Serv. Circ. 39. 67p.

Sherman, Edward A. 1963. Wetlands are not wastelands. Maine Fish and Game 5(1): 24-25.

Sjors, H. 1959. Bogs and fens in the Hudson Bay lowlands. J. Arctic. Inst. N.A. 12: 1-19.

____________. 1961. Surface patterns in boreal peatland. Endeavour 20: 217-224.

Sloey, William E. et al. 1978. Management of freshwater wetlands for nutrient assimilation, p. 321-340. In: Ralph E. Good et al. (eds.), Freshwater wetlands - ecological processes and management potential. Academic Press, N.Y.

Small, E. 1972. Photosynthetic rates in relation to nitrogen recycling as an adaptation to nutrient deficiency in peat bog plants. Canada. J. Bot. 50: 2227-2233.

__________. 1972. Ecological significance of four critical elements in plants of raised Sphagnum peat bogs. Ecology 53: 498-503.

Smardon, Richard C. 1973. Visual-cultural values of wetlands, p.9-11. In: J.S. Larson (ed.), A guide to important characteristics and values of freshwater wetlands in the Northeast. Water Resources Research Center, Univ. Mass. at Amherst, Publ. 31.

__________ and Julius G. Gabos. 1976. Visual-cultural sub-model, p. 35-51. In: J.S. Larson (ed.), Models for assessment of freshwater wetlands. Publ. 32 Water Res. Research Center, Univ. Mass., Amherst.

Spencer, H.E., Jr. 1957. Waterfowl-beaver relations study. Job Completion Dept., Project W-37 -R-6, Job 7A, Maine Dept. Inland Fisheries and Game, Augusta, ME.13 p.

__________. 1965-6. Nest boxes for ducks. Maine Fish and Game, 8(1): 9-11.

__________. 1968. Man-made marshes for Maine waterfowl. Game Division Bull. 9, Me. Dept. Inland Fisheries and Game, Augusta, ME. 79p.

__________. 1975-76. Blackducks: going, going..? Maine Fish and Wildlife 18(1): 8-10; 32.

Stearns, Forest. 1978. Management potential: summary and recommendations, p. 357-363. In: Ralph E. Good et al. (eds.), Freshwater wetlands - ecological processes and management potential, Academic Press, N.Y.

Steward, K. and W. Haroldornes. 1975. Assessing a marsh environment for wastewater renovation. Water Pollution Control Federation 47(7).

Swain, F.M. 1965. Geochemistry of some Quaternary lake sediments of North America, p. 765-781. In: H.E. Wright, Jr. and David G. Frey (eds.), The Quaternary of the United States. Princeton Univ. Press, Princeton, N.J.

Swan, J.M.A. and A. McGill. 1970. The origins spreads, and consolidation of a floating bog in Harvard Pond, Petersham, Mass. Ecology 51: 829-840.

Takos, Michael J. 1942. An ecological study of a muskrat habitat in central Maine. M.S. Thesis, Univ. Maine, Orono. 86p.

Tans, William. 1974. Priority ranking of biotic natural areas. Mich. Botanist 13: 31-39.

Taylor, Malcolm et al. 1978. State Wetland programs, p. 45-98. In: Proc. Natl. Wetland Prot. Symp. , Reston, Va., June 6-8, 1977. (FWS/OBS-78/97).

Thurow, Charles et al. 1977. Wetlands, p. 37-50. In: Performance controls for sensitive lands. Planning Advisory Service Dept. Nos. 307, 308. American Soc. Planning Officials, Chicago, ILL.

Tilton, D.L., R.H. Kadlec, and C.J. Richardson (eds.). 1976. Freshwater wetlands and sewage effluent disposal. Univ. Michigan, Ann Arbor, 343p.

Toth, L. 1972. Reeds control eutrophication of Balaton Lake. Water Research 6: 1533-1539.

Trefethen, J.M. and R.B. Bradford. 1944. Domestic fuel possibilities of Maine peat. Maine Geological Surv. Bull. 1: 47p.

Ursin, Michael J. 1975. Life in and around freshwater wetlands: a guide to plants and animals in wetlands east of the Mississippi. Thomas Crowell, N.Y. 116p.

U.S. Department of Agriculture. undated. Water Bank for the protection and management of wetlands. Orono, Maine 14p.

U.S. Department of the Interior. 1976. Proceedings of The National Wetland Classification and Inventory Workshop, College Park, MD. July 20-23, 1975 (FWS/OBS-76/09).

U.S. Department of the Interior. 1954. Wetlands Inventory of Maine. Fish and Wildlife Service, Office of River Basin Studies, Boston, Mass. 15p.

U.S. Department of the Interior. 1970. The value of wetlands to modern society, p. 6-11. In: Connecticut Arboretum, Connecticut College, New London, Conn. Bull. 17

U.S. Dept. Interior. 1978. An ecological characterization of Maine's Coast north and east of Cape Elizabeth. U.S. Fish and Wildlife Service, Wash., D.C.

van der Valk, A.G. and C.B. Davis. 1978. Primary production of prairie glacial marshes, p. 21-38. In: Ralph E. Good et al. (eds.) Freshwater Wetlands - ecological processes and management potential, Academic Press, N.Y.

Valiela, Ivan and John M. Teal. 1978. Nutrient dynamics, p. 259-263. In: Ralph E. Good et al. (eds.), Freshwater wetlands - ecological processes and management potential. Academic Press, N.Y.

van der Voo, E.E. 1962. Danger to scientifically important wetlands in the Netherlands by modification of the surrounding environment, p. 274-277. In: The conservation and management of temperate marshes, bogs and other wetlands. Project Mar, IUCN Publ. New Series 3.

Watt, Richard F. and M.L. Heinselman. 1965. Foliar nitrogen and phosphorus level related to site quality in a northern Minnesota spruce bog. Ecology 46(3): 358-361.

Welch, P.S. 1936. Limnological investigations of a strongly basic bog lake surrounded by an extensive acid-forming bog mat. Papers Mich. Acad. Sci. 21: 727-251.

Weller, M.W. 1975. Studies of cattail in relation to management for marsh wildlife. Iowa State J. Research 49: 383-412.

Weller, Milton W. 1978. Management of freshwater marshes for wildlife, p. 267-284. In: Ralph E. Good et al. (eds.), Freshwater wetlands - ecological processes and management potential. Academic Press, N.Y.

Weller, Milton W. and Cecil S. Spatcher. 1965. Role of habitat in the distribution and abundance of marsh birds. Agric. and Home Econ. Expt. Stat., Ames, Iowa, Spec. Rept. 43: 31p.

Wharton, Charles H. 1970. The southern river swamp - a multiple use environment. Bureau of Business and Economic Research, School of Business Administration, Georgia State Univ., Atlanta, Ga. 48p.

Winton, J. Martin 1971. Easements for maintaining environmental values. Trans. N.A. Wildlife and Natur. Res. Conf. 36: 89-96.

Wolf, Ken. 1955. Some effects of fluctuating and falling water levels on waterfowl production. J. Wildl. Mgt. 19(1): 13-23.

Wright, H.E., Jr. and David G. Frey (eds.). 1965. The Quarternary of the United States. Princeton University Press, Princeton, N.J.

Young, C.E. et al. 1972. Hydrologic model of a wetland forest Journ. Soil and Water Conservation 27(3): 122-124.

Zwerling, S. and F.W. Grupp, Jr. 1976. Inland wetland regulation in Connecticut (babes in the bogs), p. 121-135. In: M. W. Lefor et al. (eds.), Proc. 3rd Wetlands Conf., Storrs, Conn.

Part II

A Trial Inventory and Identification of Significant Freshwater Wetlands in the Presumpscot River Basin, Saco River Basin and Associated Coastal Drainage Basins.

Methods of locating significant freshwater wetlands

For the purpose of this study wetland evaluation concentrated on two river drainage systems, the Presumpscot and Saco, and smaller coastal drainages near the lower Kennebec River. The area was selected because of its proximity to the researcher, the presence of significant development pressure within the study area, and the discrete geographic nature of the basins. The inventory was conducted by river basin and by quadrangle within the basin. Color slides of recommended areas were taken during the trial inventory to record some of the important features of the wetlands. Before actual field surveys, the Department of Inland Fisheries and Wildlife's freshwater inventory files were examined. The following wetland types were noted: all bogs and all other wetlands although time and mileage constraints made actual site evaluation impossible in every case. In addition, letters were sent to every town conservation commission within the study area in a further attempt to locate significant wetlands. The United States Geological Survey maps were also used extensively to assist in locating wetland areas. The general approach might be described as fairly systematic and thorough, but with some degree of subjectivity. As a result, some important wetlands may not have been examined in this study.

Criteria for identifying significant wetlands in Maine

Any freshwater wetland meeting one or more of the primary criteria below should be considered for evaluation as a Critical Area. A significant wetland would be one which meets these guidelines. Wetlands which did not meet the criteria were rejected. Wetland types were indicated according to Golet and Larson (1974). Except on rare occasions, the area must be in a natural condition with minimal or no human encorachment and must be a well-buffered system. An exception might be, for example, the presence of very rare or endangered species.

Primary Criteria

I. The presence of rare, restricted, endemic, relict, or endangered vascular plant species. The following are some of the rare vascular plant species generally found in wetlands, and these species are considered rare in Maine according to Eastman (1978) and Gawler (1978). Terminology follows the Eighth Edition of Gray's Manual of Botany (1950).

Equisetum variegatum	Variegated Scouring-rush
Selaginalla selaginoides	Northern Spike-moss
Ophioglossum vulgatum	Adder's-tongue Fern
Chamaecyparis thyoides	Atlantic White Cedar
Pinus Banksiana	Jack Pine
Potamogeton confervoides	Pondweed sp.
Potamogeton pulcher	Pondweed sp.

Potamogeton vaseyi	Vasey's Pondweed
Zannichelia palustris	Horned Pondweed
Sagittaria subulata	Arrowhead
Carex alopecoidea	Fox-tail Sedge
Carex atherodes	
Carex Crawei	Crawe's Sedge
Carex saxatilus	
Eleocharis rostellata	Spike-rush
Hemicarpha micrantha	Hemicarpha
Rhynchospora macrostachya	Horned-rush
Scirpus lineatus	Tawny Bulrush
Wolffia columbiana	Water Meal
Xyris Congdoni	Yellow-eyed Grass
Heteranthera dubia	Water Stargrass
Juncus styguis	Rush sp.
Tofieldia glutinosa	False Asphodel
Arethusa bulbosa	Arethusa
Habenaria flava var. herbiola	Pale Green Orchis
Habenaria leucophaea	Prairie White Fringed Orchis
Malaxis brachypoda	White Adder's-mouth
Orchis rotundifolia	Small Round-leaved Orchis
Spiranthes lucida	Shining Ladies-tresses
Salix candida	Hoary Willow
Geocaulon lividum	Northern Toadflax
Polygonum puritanorum	Puritan Knotweed
Nymphaea tetragona	Pygmy Waterlily
Nuphar microphyllum	Tiny Cow-ily
Ranunculus ambigens	Spearwort
Ranunculus Gmelini	Small Yellow Crowfoot
Ranunculus lapponicus	Lapland Buttercup
Lindera Benzoin	Spicebush
Armoracia aquatica	Lake-cress
Subularia aquatica	Awlwort
Drosera linearis	Linear-leaved Sundew
Podostemum ceratophyllum	Riverweed
Parnassia glauca	Grass-of-Parnassus
Saxifraga pensylvanica	Swamp Saxifrage
Rubus chamaemorus	Baked-apple Berry
Polygala cruciata	Milkwort
Empetrum atropurpureum	Purple Crowberry
Ilex glabra	Inkberry
Ilex laevigata	Smooth Winterberry
Cryptotaenia canadensis	Honewort
Clethra alnifolia	Sweet Pepperbush
Rhododendron viscosum	Swamp Honeysuckle
Hottonia inflata	Featherfoil
Bartonia paniculata	Screw-stem
Gentiana crinita	Fringed Gentian
Galium obtusum	Large Bedstraw
Lonicera oblongifolia	Swamp Fly-Honeysuckle
Valeriana uliginosa	White Valerian
Lobelia Kalmii	Brook Lobelia
Eupatorium fistulosum	Hollow Joe-pye Weed
Eupatorium dubium	Triple-nerved Joe-pye Weed
Mikania scandens	Climbing Hempweed

[Compiled by Sue Gawler]

II. The area is an outstanding example of a particular wetland type (types according to Golet and Larson, 1974).

III. The area is an example of a wetland type which is rare in a particular region of the State.

IV. The area has other values related to its close association with one or more of the following surficial geological features:

A. Kettle-hole bogs (see Marsh, 1978)
B. Eskers (see Borns, 1978)
C. Deltas (see Borns, 1979)
D. Outwash plains
E. Complex or association with river, stream, or lake

V. The area is used significantly by breeding, migrating or feeding waterfowl, shorebirds, marsh birds, wading brids, spawning fishes or rare mammals.

VI. The area has several examples of the same wetland type or different wetland types in close geographic proximity, *e.g.*, a wetland complex.

Other Considerations

I. Scenic Attributes

A. Visual contrast

1. proximity to lakes, streams, rivers
2. proximity to mountain ranges
3. diversity of habitat types

II. Hydrologic Attributes

A. Lake water quality
B. Flood prevention
C. Size

III. The presence of flora of unusually high visual quality and infrequent occurrence (see lists in Gawler, 1978; Eastman, 1978).

1.	Arrowheads	_Sagittaria_ spp.
2.	Cotton grass	_Eriophorum_ spp.
3.	Hudson Bay Bulrush	_Scirpus hudsonianus_
4.	Jack-in-the-Pulpit	_Arisaema_ spp.
5.	Water Arum	_Calla palustris_
6.	Skunk Cabbage	_Symplocarpus foetidus_
7.	Pickerelweed	_Pontederia cordata_
8.	Blue Flag	_Iris versicolor_
9.	Grass-pink	_Calopogon pulchellus_
10.	Lady's slippers	_Cypripedium_ spp.
11.	Purple fringed orchid	_Habenaria psychodes_
12.	White fringed orchid	_Habenaria fimbriata_
13.	White fringed orchid	_Habenaria blephariglottis_
14.	Leafy white orchid	_Habenaria dilatata_
15.	Hooded ladies tresses	_Spiranthes romanzoffiana_
16.	Rose pogonia	_Pogonia ophioglossoides_
17.	Bog Birch	_Betula pumila_
18.	Yellow water lily	_Nuphar variegatum_
19.	White water lily	_Nymphaea aquatica_
20.	Marsh marigold	_Caltha palustris_
21.	Pitcher plant	_Sarracenia purpurea_
22.	Sundews	_Drosera_ spp.
23.	Shrubby cinquefoil	_Potentilla fruticosa_
24.	Swamp rose	_Rosa palustris_
25.	Violet	_Viola_ spp.
26.	Bog rosemary	_Andromeda glaucophylla_
27.	Creeping Snowberry	_Gaultheria hispidula_
28.	Sheep laurel	_Kalmia angustifolia_
29.	Bog laurel	_Kalmia polifolia_
30.	Rhodora	_Rhododendron canadense_
31.	Labrador tea	_Ledum groenlandicum_
32.	Forget-me-not	_Myosotis scorpiodies_
33.	Turtlehead	_Chelone glabra_
34.	Bladderworts	_Utricularia_ spp.
35.	Lobelias, Cardinal flower	_Lobelia_ spp.
36.	Bog aster	_Aster nemoralis_
37.	Bog goldenrod	_Solidago uliginosa_

IV. The juxtaposition in sequence of several seral stages of hydrarch succession or especially interesting associations, i.e., a high degree of community diversity.

V. Cumulative designation

In unusual instances a wetland may be considered significant when its characteristics, when evaluated together, suggest a unique condition even though it may not meet one of the primary criteria.

Preliminary Listing of Significant Wetlands

I. Highly Recommended

Name: Eastman Hill Bog — Type: Bog

Location: One-half mi. SW Eastman Hill, 0.6 mi S junction of Eastman Hill Road and tar road, access 0.2 mi by woods road, Town of Lovell, Center Lovell, North Waterford Quadrangle (7 1/2').

Description of Area: This 18 acre kettle-hole bog is surrounded by low-lying hills. It is in a late stage of succession with no open water and without significant tree cover. Near the border there are a few scattered pines and red maples. The remaining vegetation includes various ericaceous shrubs, pitcher plants, royal ferns, and sedges.

Consideration in Recommending This Area for Evaluation: It is a very natural, kettle-hole bog in a late successional stage with a flora that includes plants of high visual quality. In addition, it is unusual to find bogs in late successional stages in southern Maine.

Name: Shaker Bog — Type: Bog

Location: one-half mi NW Shaker Village, just west of Rt. 26, Town of Poland, Gray Quadrangle (15').

Description of Area: This bog covers about 175 acres and is approximately 50% open water, 50% bog mat. It is surrounded by wooded land except for hilly farmland to the northeast. The bog is dammed at the southeast edge before draining across, Rt. 26, (by a 15 foot stone dam.) The fauna includes great blue herons, beaver, and wood ducks and it would appear to have significant waterfowl value. The very extensive bog mat on the eastern side includes numerous pitcher plants, ericaceous shrubs, a few stunted larches and black spruces, and other bog species. In the areas of open water more typical marsh vegetation (spatterdock, button bush, tear thumb, pickerel weed, etc.) can be found. Its size would suggest an important hydrologic function. While its visual contrast is limited, it is presently undisturbed despite its high accessibility.

Considerations in Recommending This Area for Evaluation: Shaker Bog is a large bog with flora of high visual quality. It possesses a high degree of community diversity and probably an important hydrologic function. Bogs of this size are very rare in southern Maine.

Name: Kimball Pond   Type: bog and narrow-leaved deep mar

Location: Northeast side of Kimball Pond, about 2.2 road mi from North Fryeburg and 1 mi west of Rt. 112, Town of Fryeburg, Fryeburg Quadrangle (7 1/2').

Description of Area: Kimball Pond's northeast shore includes a bog and deep-fresh marsh area. The border of the pond itself is only partially developed and the wetland area remains in a natural state. Loons are known to breed on the pond and the acres of open water are probably important for waterfowl and fishes. The very rare *Utricularia gibba* occurs here and there is an outstanding diversity of flora which includes ericaceous species, another species of *Utricularia*, *Ranunculus*, meadow beauty, and others. The wetland area associated with open water provides high visual contrast with mountains of New Hampshire to the west. It is an exceptionally beautiful area. Human encroachment is still quite limited.

Considerations in Recommending This Area for Evaluation: The presence of rare species, flora of high visual quality, a high degree of community diversity, and high visual contrast should gain this area recognition as exceptional.

Name: Stow Bog   Type: bog

Location: About one-half mi W. of Rt. 113 and 1 mi N. of Stow, Town of Stow, Center Lovell Quadrangle (7 1/2').

Description of Area: This is a small 13 acre bog with about 5% open water. It is surrounded by coniferous forest which has been selectively cut within the past two years. The setting is otherwise quite natural. The bog mat includes various stunted trees: larch, black spruce, and white pine. Also, cottongrass, ericaceous species, pitcher plants, bladderworts, sundews, orchids, and the rare *Szeuchzeria*. The area is used by muskrats, moose, and other mammals, but its wildlife value is limited. Stow Bog is a kettle-hole bog with the mountains of New Hampshire visible to the west. Except for a few tops of trees which were left on the western edge of the bog, this area has suffered no significant human encroachment.

Considerations in Recommending This Area for Evaluation: This kettle-hole bog provides habitat for species of rarity and high visual contrast in a very scenic setting.

Name: Shaking Bog   Type: Bog

Location: About 2 mi. S. of Rt. 302 in East Fryeburg, just west of cemetary on Denmark Rd., Town of Denmark, Pleasant Mountain Quadrangle (7 1/2').

Description of Area: This 23 acre kettle-hole bog has 10% of its surface open water surrounded by a bog mat in various successional stages. The fauna is unknown, but the flora consists of black spruce, larch, pitch pine, ericaceous shrubs, cottongrass, pitcher plants, and other bog species. Pleasant Mountain is obvious to the west. Shaking Bog is also exceptionally natural in appearance.

Considerations in Recommending This Area for Evaluation: A bog of this quality is very rare. As a very natural, highly scenic, kettle-hole bog with various unusual plant species of high visual quality, Shaking Bog deserves special recognition.

Name: Sawyer Brook Bog   Type: Bog

Location: Just west of dirt road, 0.6 mi N. Rt. 302, about 0.2 mi W. Sawyer Brook, Town of Bridgton, Pleasant Mountain Quadrangle (7 1/2').

Description of Area: This 30 acre bog has about 5% of its surface as open water. There are scattered pitch pines on the sphagnum mat to the south with a very few larches, and virtually no black spruces. The mat vegetation also includes various ericaceous species, cotton-grass, pitcher plants, and other typical bog species. Peltandra occurs at the bog edge. This appears to be a kettle-hole bog with a high esker ridge to the west. Pleasant Mountain is visible to the south. The bog appears as a virtually pristine example of a kettle-hole bog.

Considerations in Recommending This Area for Evaluation: This bog is an exceptionally fine example of a kettle-hole bog with high scenic quality and unusual flora. It is somewhat coincidental that it is geographically near another very fine and similar example of a kettle-hole bog (Shaking Bog).

Name: Northwest River   Type: Shrub swamp

Location: South of Peabody Pond to south of Perley Pond, accessible by dirt road, 1 mi NE Rt. 107, Town of Sebago, Sebago Lake Quadrangle (7 1/2').

Description of Area: Approximately 600 acres of variable wetland mostly scrub/shrub bordering the Northwest River. The area includes adjacent ponds (Perley Pond) and at least one bog (in Sebago). The primary vegetation appears to be alder, red maple, buttonbush, and other shrubs. This area would apparently serve to hold back large quantities of water during heavy rains or snow melts. This flood plain area is a very natural stream wetland area with a diversity of habitat types and adjacent low lying mountains. An undisturbed, natural stream ecosystem of this variety and extent is very rare in southern Maine.

Considerations in Recommending This Area for Evaluation: The wetlands of the Northwest River provide an important hydrologic function, are located in a scenic, very natural setting, and deserve further recognition because of their extent. It is an excellent example of a stream-associated shrub swamp wetland.

Name: Rich Mill Pond Bog Complex Type: Bog

Location: N. of Rich Mill Pond, 0.5 mi W. Rt. 114 along a RR tracks. Also, two bog areas 0.3 mi W. of Rt. 114 along RR tracks and one E. of Rt. 114, Town of Standish, Sebago Lake Quadrangle (7 1/2').

Description of Area: This interesting bog complex occurs in a region of moderately level topography. The larger bog may be 100-200 acres or more and the smaller ones are considerably less than 10 acres. The vegetation includes pitcher plants, cottongrass in very dense stands, black spruce, larch, ericaceous shrubs, some alders, and other wetland plants. Important geologic features are not known;however, two smaller bogs could be kettle-hole bogs. Bog complexes of this nature are very rare. Only one other was found during this study (near Pettingill Pond, North Windham).

Considerations in Recommending This Area for Evaluation: This complex deserves recognition as several distinct units in close proximity. The largest bog is quite significant because of its size and a number of unusual, high visual quality plants are present.

Name: Saco Heath. Type: Bog

Location: A large wetland bounded by Flag Pond Road, Heath Road, Rt. 112 and Jenkins Road within The Saco City boundaries, Old Orchard Beach Quadrangle (7 1/2').

Description of Area: This bog is the largest bog wetland south of Rockland. It encompasses 775 acres entirely covered by vegetation. The Heath is covered by ericaceous shrubs, pitcher plants, black spruce, larch, and other typical bog plants. It has a large (60-70 acre) stand of Atlantic white cedar, a species near the northern most sector of its range. There has been very limited removal of peat from one small area, but, in general, the bog is undisturbed. A bog of this extent is very rare even for northern Maine.

Considerations in Recommending This Area for Evaluation: The size of the Saco Heath is especially noteworthy. It also includes unusual species of high visual quality as well as a very significant stand of cedars. It is an outstanding example of a bog wetland.

Name: Pleasant Pond   Type: broad-leaved shallow marsh

Location: Southern end of Pleasant Pond, both N. and S. of Rt. 197, Towns of Litchfield, Bowdoin, and Richmond. Gardiner Quadrangle (15').

Description of Area: The southern end of Pleasant Pond is an extensive, broad-leaved, shallow marsh, covered to as much as 85% of its area. To its borders it grades into alders, willows, and other trees while to the south, it becomes an extensive shrub/scrub swamp dominated by alders. This area obviously provides valuable habitat for fishes and waterfowl. It is dominated by a monospecific stand of pickerel-weed which provides close to 90% or more of the plant cover. Since Pleasant Pond is located upstream from a small city (Gardiner) these marshes can serve an important role in flood protection. The sight of 100-200 acres or more of pickerel-weed in bloom is striking. Marshes of this size are extremely unusual in southern Maine (south of Augusta).

Considerations in Recommending This Area for Evaluation: This is a large marsh with hydrologic, scenic, and fish and wildlife value. It is an excellent example of a shallow, fresh marsh in southern Maine.

Name: Duley Pond   Type: Bog

Location: E. of Rt. 209, 0.5 mi S. Jct, with road to Parker Head, Town of Phippsubrg, Phippsburg Quadrangle (7 1/2').

Description of Area: This is a deep bog with 50% open water. It is roughly circular with a narrow mat encircling the open water. The sphagnum mat grades sharply into black spruce, red maples, and pine trees. The flora includes pitcher plants and various ericaceous species. Beavers are present. This is possibly a kettle-hole bog in an isolated, natural setting. Pitcher plant communities are unusual in southern Maine, especially in coastal locations. Isolated and undisturbed areas such as this are quite noteworthy.

Considerations in Recommending This Area for Evaluation: Duley Pond is a very natural well protected bog community with a number of species of local occurrence and high visual quality. Its origin is unknown, however, its depth (possibly 80 feet) would make it unusual. Duley Pond is an excellent example of a bog wetland and there are very few examples of such bogs in southern Maine.

Name: Traffton Meadow   Type: bog and broad-leaved shallow marsh

Location: About 0.2 mi W. of junction of Bay Point Road and West Georgetown - Marrtown Road in Town of Georgetown, Phippsburg Quadrangle (7 1/2').

Description of Area: This is an interesting area which includes two distinct wetland types. The larger wetland to the north is a bog (approximately 10-15 acres) with only 2% of its surface open water and to the south it is a floating-leaved, shallow marsh (about 8-10 acres) with considerable open water. This bog is unlike many in southern Maine which have a high composition of ericaceous shrubs. In contrast, it is dominated by sedges and includes pitcher plants, bladderworts, royal fern and a variety of wetland plants often associated more with marshes. The adjacent wetland is dominated by arrowhead, pickerel weed, pond lily, and other species. While undisturbed and quite natural in appearance, the Meadow area may not be strictly natural. It is dammed at its lower end at the present time. Further, this area is a very rare example of two wetland types in close proximity.

Considerations in Recommending This Area for Evaluation: The presence of two distinct wetland types adjacent to each other is highly unusual and would constitute a wetland complex. In addition, three additional bog-type wetlands occur nearby, one 0.5 mi to the west on the West Georgetown Road and two on the Bay Point Road to the south. The presence of pitcher plants and other species of relative rarity and high visual quality deserves mention.

Name: Pettingill Pond Bog Complex   Type: bog, narrow-leaved shallow marsh, and shrub swamp

Location: This area lies to the north of Pettingill Pond, Town of North Windham, North Windham Quadrangle (8 1/2'). It is reached by dirt road from Rt. 302.

Description of Area: This complex of small wetlands includes a variety of different sizes and types separated by esker ridges. While none of the wetlands is especially distinctive in combination they comprise a truly unique system. Most of the wetlands have some surface area (10-15%) as open water. Because of the great variety in wetland types, the vegetation also varies significantly. Bogs in the area are dominated by cottongrass, leatherleaf, and other ericaceous shrubs and pitcher plants are absent. Trees include larch, white pine, pitch pine, and others. Whie oaks occur on the drier ridges. Esker ridges serve to create pockets for water accumulation and enhance wetland development. No other wetland complex in southern Maine (south of Augusta) approaches this area in number and diversity of wetlands present.

Considerations in Recommending This Area for Evaluation: This area first of all is a remarkable wetland complex with intertwining esker ridges. It includes several small wetlands just north of Pettingill Pond and at least two more to the northwest (reached by a dirt road from Rt. 302). Both are being filled by a construction company. Located in the fastest growing town in Maine, this complex must be viewed as endangered. It is geologically, botanically, and ecologically a truly valuable area which deserves recognition. One further note: Boody Meadow to the east might be considered as part of the entire complex. The bog on the east side of Rt. 302 and approximately one mile north of Pettingfill Road might also be considered.

II. Recommended

Name: Mill Brook Bog Type: Bog

Location: Just. E. Sebago on Rt. 107, Town of Sebago, Sebago Lake Quadrangle (7 1/2').

Description of Area: This bog is a relatively large example of a moss/lichen wetland type. It drains into Mill Brook of the Northwest River drainage system. Approximately 50% is a bog mat and 50% open water and shallow marsh. The bog mat includes larch, spruce, and various ericaceous shrubs. Any bog must be considered uncommon or rare in southern Maine.

Considerations in Recommending This Area for Evaluation: This area serves as habitat for species which are unusual and/or restricted. There are also several habitat types in juxtaposition. It is also readily visible and accessible from a state highway. While it may not rate as highly as other wetlands listed here, it probably deserves further consideration, especially as part of the Northwest River drainage complex.

Name: Scottaw Bog Type: Bog

Location: This bog occurs along Payne Road, adjacent to Scarborough Downs Racetrack, Town of Scarborough, Prouts Neck Quadrangle (7 1/2').

Description of Area: This bog has no open water. It is bisected by Payne Road and covers approximately 50 acres. Its surface is covered by larch, black spruce, red maple, ericaceous shrubs, and its flora also includes orchids and sundew. While somewhat dwarfed by the Saco Heath, this bog wetland is a large example of an entirely vegetated sphagnum mat - bog flora community.

Considerations in Recommending This Area for Evaluation: This area lies in a rapidly growing town and as a consequence is highly vulnerable to development. While crossed by Payne Road, it remains essentially intact and in a natural state. It again is a relatively large "heath-type" of bog community and serves as a habitat for a number of plants of high visual quality and uncommon occurrence.

Name: Kimble's Corner Bog Complex Type: Bog

Location: Just east of Kimble's Corner and 2.1 mi NE Kimble's Corner on Rt. 112. Town of Buxton, Buxton Quadrangle.

Description of Area: These two small bogs bordering Route 112 are covered entirely with vegetation. They are typical bogs in terms of plant cover and may be in a late stage of succession. Cottongrass, white pine, black spruce, ericaceous shrubs, and very few pitcher plants. These are possibly kettle-hole bogs. Bogs of this nature are scattered and relatively unusual in southern Maine.

Considerations in Recommending This Area for Evaluation: While these bogs represent ecosystems of relative rarity, they possess no truly outstanding features. They do serve as habitat for some species of high visual quality and could be examined in more detail although they are not as distinctive as other wetlands recommended in this report.

Name: The Heath   Type: robust shallow marsh

Location: E. of Rts. 202 and 4, SW of East Waterboro, NE of Waterboro, accessible from East Waterboro, Towns of Waterboro, Lyman and Buxton Quadrangle (15').

Description of Area: While only a portion of The Heath was examined, it covers a very extensive acreage (with very limited open water) which may approach 500 acres or more. It includes deep and shallow fresh marshes and may include other wetland types as well. The biota includes extensive stands of cattail, sweetgale alders, reed, red maple, pines, pond lily, ferns, and other species of lesser abundance. Any larger wetland has hydrologic significance and The Heath is no exception. While not especially "scenic", The Heath is an impressive wetland because of its large size.

Considerations in Recommending This Area for Evaluation: Aside from its size no truly outstanding features were noted in this study; however, it deserves further examination to determine whether it meets other criteria. It is truly, however, an outstanding example of a robust shallow marsh.

Name: Suckerville Bog   Type: Bog

Location: NE, Little Sebago Lake on tar road, about 0.8 mi W Rt. 26, Suckerville area, Town of Gray, Gray Quadrangle (15').

Description of Area: Two distinct wetland areas, one north of road, one south. The exact acreages are uncertain, but the total for the complex could be 50 or more. The level of the northern side of the area may be regulated by a dike. (There is a small 0.5 acre pond). Typical sphagnum mat vegetation (pitcher plant, ericaceous shrubs, larch, black spruce, pitch pine etc.) in more southern bog. The northern "bog" has a sphagnum mat with sweet gale, more rushes, and dead trees. It is very unusual to find two bog types in close proximity.

Considerations in Recommending This Area for Evaluation: The presence of two wetlands in close association as well as a flora of high visual quality gives this area significance.

Discussion and Evaluation of the Trial Inventory Methodology

At the present time available data on freshwater wetlands are of quite limited value in assessing wetlands significance. While the surveys from the Department of Inland Fisheries and Wildlife provide the most useful information, there are problems of accuracy and detail. The United States Geological Survey Quadrangle maps do not indicate what kinds of wetlands are present, and most aerial photographs do not provide adequate detail. Town Conservation Commissions often can supply information on local wetlands; however, differences exist among the Commissions and as a result obtaining information from these sources is not uniformly successful.

The proposed criteria work satisfactorily for identifying significant wetlands. There is some subjectivity involved, however, but strict adherence to the criteria can enable a rapid determination of a wetland's status. Many wetlands are unnamed. Names were assigned to wetlands where none existed; however, it must be recognized that confusion could result. Locating a wetland is ordinarily not difficult; however, time contraints made actual site visits to some wetlands impractical.

For the reasons indicated in Part I of this report, Maine's freshwater wetlands can be difficult to classify, however, a review of Golet and Larson (1974) will permit a rapid determination of wetland type.

No specific problems were encountered with this approach to wetlands inventory. The financial restrictions imposed on the project, however, necessitated a less thorough evaluation than desirable. As a result, the plants actually may not be adequately reflected and additional site visits during the growing season may be warranted.

The study area includes several very fine examples of wetlands and, in particular, of the bog type.

Recommendations

Because wetlands inventory and evaluation are time consuming and expensive, future inventory work should be adequately funded so that the results will be comprehensive and complete. In this manner a more thorough inventory of a region would be possible. Quadrangles would then be inventoried within a river basin in a systematic fashion. While such an approach is scientifically preferable, it may also take a much longer period of time.

Since development pressures in southern Maine are growing more acute, wetlands inventory should proceed in York County by quadrangle, and, where feasible, those listed in the following table should be field-checked.

Summary Listing of Significant Wetlands

Quadrangle	County	Town	Name	Wetland Type	Approximate Size
I. Highly Recommended					
North Waterford $7\frac{1}{2}'$	Oxford	Lovell	Eastman Hill Bog	Bog	18 acres
Gray 15'	Androscoggin	Poland	Shaker Bog	Bog	175 acres
Pleasant Mountain $7\frac{1}{2}'$	Oxford	Denmark	Shaking Bog	Bog	23 acres
Pleasant Mountain $7\frac{1}{2}'$	Cumberland	Bridgton	Sawyer Brook Bog	Bog	30 acres
Sebago Lake $7\frac{1}{2}'$	Cumberland	Sebago	Northwest River	Shrub Swamp	600 acres
Sebago Lake $7\frac{1}{2}'$	Cumberland	Standish	Rich Mill Pond Bog Complex	Bog	200 acres
Old Orchard Beach $7\frac{1}{2}'$	York	Saco	Saco Heath	Bog	775 acres
Gardiner 15'	Sagadahoc Kennebec	Litchfield Bowdoin Richmond	Pleasant Pond	Broad-leaved shallow marsh	200 acres
Phippsburg $7\frac{1}{2}'$	Sagadahoc	Phippsburg	Duley Pond	Bog	15-20 acres
Phippsburg $7\frac{1}{2}'$	Sagadahoc	Georgetown	Traffton Meadow	Bog and broad-leaved shallow marsh	25 acres
North Windham $7\frac{1}{2}'$	Cumberland	North Windham	Pettengill Pond Bog Complex	bog, narrow-leaved shallow marsh, and shrub swamp	200+ acres
Center Lovell $7\frac{1}{2}'$	Oxford	Stow	Stow Bog	Bog	13 acres
Fryeburg $7\frac{1}{2}'$	Oxford	Fryeburg	Kimball Pond	Bog and narrow-leaved deep marsh	30-40 acres

Quadrangle	County	Town	Name	Wetland Type	Approximate Size
II. Recommended					
Sebago Lake $7\frac{1}{2}$'	Cumberland	Sebago	Mill Brook Bog	Bog	50 acres
Prout's Neck $7\frac{1}{2}$'	Cumberland	Scarborough	Scottaw Bog	Bog	50 acres
Buxton 15'	York	Buxton	Kimble's Croner Bog Complex	Bog	15-20 acres
Buxton 15'	York	Waterboro Lyman	The Heath	Robust shallow marsh	500 acres
Gray 15'	Cumberland	Gray	Suckerville Bog	Bog	50 acres

List of Wetlands to be Checked in Study Area

Due to constraints of time during this study several wetlands were not field checked. The following list represents several wetlands (by quadrangle and township) which deserve future attention.

Quadrangle	County	Town	Wetland Name/Location
Pleasant Mountain ($7\frac{1}{2}'$)	Oxford	Sweden	Little Pond
Pleasant Mountain ($7\frac{1}{2}'$)	Oxford	Sweden	Berry Pond
Hiram ($7\frac{1}{2}'$)	Oxford	Brownfield, Denmark	Wetlands bordering Saco River
Brownfield ($7\frac{1}{2}'$)	Oxford	Brownfield	Brownfield Bog Wetlands west of Tibbetts Mountain
Kezar Falls ($7\frac{1}{2}'$)	Oxford	Porter	Wetlands north of Colcord Pond
Kezar Falls ($7\frac{1}{2}'$)	York	Parsonsfield	Wetlands on Great Brook
Sebago Lake (15')	Cumberland	Standish	Wetlands north and east of Steep Falls
North Windham ($7\frac{1}{2}'$)	Cumberland	Gray	Allen Bog
Boothbay ($7\frac{1}{2}'$)	Lincoln	Southport	Labrador Meadow
North Waterford ($7\frac{1}{2}'$)	Oxford	Sweden	Black Pond
Center Lovell ($7\frac{1}{2}'$)	Oxford	Lovell	Kezar Outlet
Fryeburg ($7\frac{1}{2}'$)	Oxford	Fryeburg	Wetlands bordering Saco River
Fryeburg ($7\frac{1}{2}'$)	Oxford	Fryeburg	Swimming Bog
Buxton (15')	York	Buxton	Prat Bog
Norway (15')	Cumberland	Harrison	Bog Pond
Sebago Lake (15')	Cumberland	Bridgton	Holt Pond
Gardiner (15') Bath (15')	Sagadahoc	Bowdoin, Bowdoinham	Cathance River

General Evaluation of Freshwater Wetlands for Inclusion on the Register of Critical Areas

Prepared by: Timothy Zorach

1. Considerations in Registration

A. Values and qualities represented by the feature (specifically including any unique or exemplary qualities of the feature).

Maine's freshwater wetlands include a vast array of different sizes, botanical and zoological variation, geologic features, and often scenic beauty. They may possess both economic and ecological values depending on their particular characteristics. They often serve as habitats for rare and unusual species as well as aesthetically interesting plants.

B. Probable Effects of uncontrolled use (specifically in relation to its intrinsic fragility).

To date, relatively little alteration of Maine's freshwater wetlands has occurred. Pulp and paper, as well as lumber operations, peat mining, and other human activities have been limited in their overall impact. Development in southern Maine and large-scale peat mining could threaten many very valuable wetland ecosystems.

C. Present and probable future use (specifically present and future threats of destruction).

Peat mining, filling for development, and excessive human use (recreation) pose serious threats in the future. The human pressure is particularly acute in the southern and coastal counties of the State.

D. Level of Significance

The freshwater wetlands listed in this report possess superior attributes in terms of their biotic, scenic, and geologic characteristics.

E. Probable effects of registration -- positive and negative (specifically including the economic implications of inclusion of the feature on the Register).

The expected positive effect of registration will be to give official recognition of the importance of freshwater wetlands. Also, the landowner will be informed of the importance of protecting and managing these ecosystems. Registration will help to encourage monitoring of the wetland, and also will encourage the conservation of the area.

The expected negative effect of registration would be publicity generated by the registration process. Publicity could attract visitors who might inadvertently prove destructive to the values of these fragile areas. There should be minimal or no economic effects from the registration of freshwater wetlands.

F. Management Suggestions

1. The freshwater wetlands should be maintained in a natural state.

2. The feature should be monitored periodically to check on the condition of the Critical Area.

3. The wetland should be brought to the attention of the landowners, selectmen, planning boards, conservation commissions, and State Foresters and biologists except in the case of very fragile ecosystems.

4. These areas should be maintained in a natural state, i.e. such activities as raising or lowering water levels artificially should be discouraged.

5. Buffer areas bordering wetlands should be maintained.

G. Programs which directly affect or are particularly relevant to the use and management of the feature.

Shoreland Zoning.

2. Conclusions and Recommendations

A. Conformance with definition contained in the Act.

The Act defines a critical area as meaning: "areas containing or potentially containing plant and animal life or geological features worthy of preservation in their natural condition, or other natural features of significant scenic, scientific, or historical value."

The areas selected conforms to the Critical Areas Act.

B. Conformance with the Guidelines for the Registration of Critical Areas, adopted by the Critical Areas Advisory Board on September 11, 1975.

Section 1. Knowledge of the feature: The report, "Freshwater Wetlands: Their Relevance to the Critical Areas Program," by Timothy Zorach, was prepared for the Critical Areas Program in order to provide detailed documentation about freshwater wetlands in Maine.

Section 2. Representation on the Register: Freshwater Wetlands are not included on the Register of Critical Areas at this time.

Section 3. Variety of Values: Freshwater Wetlands possess different values which include biotic, scenic, and geologic.

Section 4. Scarcity: Each recommended wetland is outstanding for one or more reasons.

Section 5. Quality: The recommended wetlands are of uniformly high quality.

Section 6. Persistence: All of the recommended wetlands can and will change through successional processes. With no human interference they can continue to exist for hundreds or thousands of years with relatively little change.

Section 7. Geographic Distribution: This study was limited to the Presumpscot and Saco River basins and small coastal drainages in the Mid Coast region.

Section 8. Use: Freshwater Wetlands have the potential for scientific and educational uses.

Section 9. Manageability: Freshwater Wetlands can be easily managed to perpetuate the described characteristics.

Section 10. Potential Economic Effects: Registration of Freshwater Wetlands should result in little economic implications for the landowner.

Section 11. Potential Effect on the Conservation of the feature: The conservation of Freshwater Wetlands should be enhanced by a program to identify and describe the salient features of outstanding wetlands.

RECOMMENDATIONS

1. Because freshwater wetlands are an important part of Maine's natural heritage, they should be further investigated and the most outstanding ones should be considered as candidates for inclusion on the Register of Critical Areas.

2. Registered wetlands should be monitored periodically.

3. New natural wetlands that are found in Maine should be field checked and evaluated. If a wetland meets the criteria of a critical area, the area should be registered.

DIRIGO

MAINE