Ecological Survey
of the
Chignecto Coastal Lowlands

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Ecological Survey of the Chignecto Coastal Lowlands

by

Dr. Hinrich Harries

Department of Biology Mount Allison University

Sackville, New Brunswick

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Introduction

This report summarizes information on the ecology of the Chignecto Coastal Lowlands, obtained during the first year of a two-year survey. Generalizations and conclusions in this report are in many instances in need of support by further evidence, They are presented here, in order that their validity can be tested, and to elicit comments and suggestions. For this reason, information in this report is not be be quoted in publications, except by permission of the author. No literature references are given; the following sources were, however, of special importance for an understanding of conditions in the area:

(1) Ganong, A. 1903. The vegetation of the Bay of Fundy salt and tidal marshes. Bot.Gaz.36:1, 161-186, 280-302, 349-367, 429-455.

(2) Boyer, G.F. 1966. Birds of the Nova Scotia-New Brunswick border region. Canad.Wildlife Serv. Occasional Papers No. 8. 52 pp.

(3) Smith, A.D. 1967. Waterfowl habitat, productivity and management at Missaquash Marsh, Nova Scotia. M.Sc.Thesis, Acadia University. 121 pp.

(4) Price, J.E. 1968. Water chemistry and distribution of aquatic plants and mollusks in the Chignecto Coastal Lowlands. Honours Thesis, Mt. Allison University. 39 pp.

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Scope and Objective of Investigation

Between New Brunswick and Nova Scotia, along the coasts of Chignecto Bay and its extension, Shepody Bay and Cumberland Basin, there are about 80 square miles of coastal lowlands which owe their existence to the direct or indirect influence of the high Fundy tides and which in this report will be referred to as Chignecto Coastal Lowlands. These lowlands have been used for agriculture for about 300 years, with periods of intensive use and progressive reclamation alternating with periods of neglect and abandonment. The Chignecto Coastal Lowlands have been famous for an abundance of wildlife, and thus as a hunting area. Their interesting geology and ecology has attracted seientists, beginning with Dawson in 1855. In the last few decades, land planning and use in this area has involved provincial and federal governments, in both the reclamation and acquisition of land for agriculture, and in the appropriation and management of land as wildlife areas.

Objective of the present study is an ecological survey of the Chignecto Coastal Lowlands with emphasis on their wildlife component. This survey will provide

information for the consideration of wildlife values in land planning and for the planning and evaluation of wildlife habitat manipulation through control of water levels and other means. The results of this survey will also be important for the acquisition and management of wetlands as wildlife habitat elsewhere in areas with similar conditions.

As originally proposed, the survey was to be restricted to the Jolicure Lakes area, of about 5 square miles, near Sackville, New Brunswick. This area is, however, too small to contain representative samples of all important wetland conditions. The Chignecto Coastal Lowlands, furthermore, from the low tide line to the upland border, form a geomorphic and ecological unit and conditions in any part can be understood only if the whole landscape is taken into consideration.

Work Done to Date

Prior to the present contract, a cursory ecological survey has been conducted in summer 1966. Chemical properties, vascular plant flora, and mollusk fauna of water bodies were studied in more detail together with Miss J. Price, then an honours student at Mount Allison University (Price, 1968). During the same summer Mr. A. Smith, now with the Canadian Wildlife Service in Sackville, investigated the Missaquash Marsh (Smith, 1967).

In 1967/68, during the first year of the present contract, field work was confined largely to the Jolicure Lakes area. In summer 1967, the investigator spent a total of 124 hours in the field. The main objective of this field work was the recognition of "landscape units" for the purpose of an ecological land classification and mapping, and the study of the "landscape pattern" formed by these units. To this purpose observations were made on vegetation, soils, water levels, and topography. Water samples were taken and analyzed in the laboratory for pH, alkalinity, chloride concentration, and conductivity. Water gauges were established at the three major lakes and water levels were read at frequent intervals from May onward. A plant collection was started which will be deposited at the conclusion of this study with the Sackville office of the Canadian Wildlife Service. Mr. W. Grant, employed through the C.W.S., was field assistant. Herbarium work was done in July and August by Miss J. E. Price, while Mr. Donald Trenholm analyzed water samples for three weeks in July

Observations on winter conditions in the area were conducted in February 1968, with 40 field hours by the investigator. Investigations include determinations of ice thickness, water depth, oxygen contents, and coring of bottom deposits. During fall and winter, Mr. Daniel Welsh worked for a total of 119.5 hours as field and laboratory assistant.

Literature on wetland ecology was studied with emphasis on the following three subjects: (a) Description and classification of wetland ecosystems and plant communities. (b) The dynamics of wetland landscapes. (c) Productivity and energy flow pattern in wetlands.

A total of 150 hours was spent by the investigator with desk work, including literature studies and writing of the report.

Landscape Units

The large variety of different surface conditions found in the area have been grouped into a limited number of "landscape units". With consideration of ecosystems, soil conditions, and plant communities described elsewhere in the literature, these landscape units have been defined on the basis of physiognomy and floristic composition of the vegetation, water levels, soil morphology, salt content, and base status of water and soil. Thirty-one of such units have provisionally been established. The landscape units will serve as mapping units and for the organization and correlation of data. They will also be units of land use value and land use potential.

A list of landscape units occurring in the area is given in Table I. A key to soil conditions is presented in Table II. Table III contains a key to landscape units.

Table I. Landscape Units of the Chignecto Coastal Lowlands

1. Tidal Mud Flat
   - 1a. Erosional Tidal Mud Flat
   - 1b. Depositional Tidal Mud Flat
2. Tidal Creek
3. Tidal Salt Marsh
   - 3a. Depositional Salt Marsh
   - 3b. Lower Salt Marsh
   - 3c. Central Salt Marsh
   - 3d. Upper Salt Marsh
4. Salt Marsh Pan
5. Running Waters
6. Standing Waters
   - 5a. Eutrophic Waters
   - 5b. Afja Waters
   - 5c. Mesotrophic Waters
   - 5d. Dys-oligotrophic Waters
7. Marsh
   - 6a. Eutrophic Marsh
   - 6b. Mesotrophic Marsh
8. Fen
   - 7a. Wet Fen
   - 7b. Sphagnum Fen (also Wooded Sphagnum Fen)
9. Bog
   - 8a. Sphagnum Bog
   - 8b. Bog Heath (also Wooded Bog Heath)
10. Lake Beach
11. Ruderae Area
12. Cropland
13. Meadow
   - 12a. Hay Meadow
   - 12b. Pasture
   - 12c. Swamp Pasture
   - 12d. Old Field Meadow
   - 12e. Swamp Meadow

Table I. Landscape Units of the Chignecto Coastal Lowlands (concluded)

14.	Carr
	13a. Spiraea Carr (also Wooded Spiraea Swamp)
	13b. Alder Carr
15.	Forest
	14a. Bog Forest
	14b. Swamp Forest

Table II. Key to Soil Conditions in the Chignecto Coastal Lowlands

1. Soil up to the surface composed mainly of mineral material.
   2. Soil parent material a wave-worked and wave-deposited sand of low salt content and base status. Without distinct humus layer or profile differentiation. (Lake Shore Sand).
   2. Soil parent material a saline silt of high base status, deposited by the tides.
      3. Not leached, of high salt content and base status up to the surface; without distinct humus layer.
         4. Grey to reddish-brown up to the surface, either terrestrial or semi-aquatic and ± regularly flooded by the tides. (Tidal Silt).
         4. With surface layer of olive to black color due to component of finely dispersed FeS (addition of HCl resulting in H_2S smell and color loss); may be covered by brown surface film. (Sapropel on Tidal Silt).
      3. Solum leached, of low salt content and base status; with ± distinct humus layer. (Leached Tidal Silt).

1. Mineral material, generally tidal silt, overlain by an organic layer.
   5. Organic layer composed largely of dark-colored, greyish-brown to black, amorphous humus material.
      6. Organic layer formed under semi-aquatic conditions. (Muck).
      6. Organic layer formed under subaqueous conditions, largely composed of fecal pellet, of < 1 mm. diameter. (Gyttja).
   5. Organic layer composed largely of ± decomposed plant structures.
      7. Of greenish color, formed by algae. (Äfja).
      7. Of yellowish-brown to reddish-brown color, formed by bryophytes and/or vascular plants.
         8. Subaqueous deposit of fine plant detritus and flocculated humus. (Detritus Dy).
         8. Subaqueous to semiterrestrial deposit of large plant structures. (Peat).

Table III. Key to Landscape Units of the Chignecto Coastal Lowlands

1. Alternation between tidal flooding and exposure. Water and soil pronouncedly saline. Soil with only small component of organic matter, influenced by tidal erosion and/or deposition. Woody plants lacking.

    2. In lower part of intertidal zone; flooded with sea water at every tide. Devoid of macrophyte vegetation except for patches of salt marsh cordgrass (Spartina alterniflora).

        3. Between open water and tidal salt marsh (Tidal Mud Flats).

            4. Gently sloping towards the sea; with indications of erosion. Bare of plant and animal life, except possibly for microscopically small forms. (Erosional Tidal Mud Flats).

            4. Mudflats with prevalent deposition (Depositional Tidal Mud Flats.).

        3. Dissecting the tidal salt marsh; generally with indications of severe erosion. Devoid of macrophyte vegetation, except for above-mentioned patches of salt marsh cordgrass. (Tidal Creeks).

    2. In uppermost part of the intertidal zone. Generally not flooded at every tide. Mostly with ± dense vegetation of vascular plants.(Tidal Salt Marsh)

        5. Surface covered permanently by at least several inches of water. Soil a sapropel. Dominant plan widgeon grass (Ruppia maritima). (Tidal Pans)

        5. Surface exposed or only shallowly covered by water during low tide. Soil and vegetation different.

            6. Relatively dry areas with heavy tidal deposition, as especially along major tidal creeks. Open vegetation with alkali grass (Puccinellia maritima); sea-blite (Suaeda maritima); and samphire (Salicornia europaea). (Depositional Salt Marsh)

            6. With light to moderate deposition. Vegetation dense, with other dominants.

                7. Regularly flooded during spring tides.

                    8. Tidal flooding relatively frequent and long-lasting. Dominant and sole species Salt-marsh cordgrass (Spartina alterniflora) (Lower Salt Marsh)

Table III. Key to Landscape Units of the Chignecto Coastal Lowlands (continued)

8. Tidal flooding relatively rare and brief. Dominant generally salt-meadow cordgrass (Spartina patens). Other species include arrow-grass (Triglochin maritima), sea-side plantain (Plantago maritima), sea lavender (Limonium nashii). (Central Salt Marsh).

7. Only occasionally reached by spring tides. Dominants are a rush (Juncus balticus), fresh-water cordgrass (Spartina pectinata), couch grass (Agropyron repens), sea-side goldenrod (Solidago sempervirens). (Upper Salt Marsh)

1. Not influenced by tidal flooding. Salt content of water and soil low. Wide range of soil organic matter. Vegetation may include woody plants.

2. Aquatic conditions. Soil surface covered normally by at least several inches of water even during driest part of the year. Soil either subject to continuing sedimentation of particles settling out from the water or to disturbance and/or erosion by waves or currents. - Waters

10. With distinct current. Dominants include the pondweed (Potamogeton epihydrus) and the water buttercup (Ranunculus trichophyllus)- Running Waters.

10. Without distinct current. - Standing Waters.

11. Bottom mud a thick "afja". Water colorless. Floating-leaf aquatics lacking. Submerged aquatics lacking or scarce. Microscopic algae may be prominent. - Afja Waters.

11. Bottom mud different.

12. Submerged aquatics, such as pondweeds (Potamogeton), milfoils (Myriophyllum), naiad (Najas), coontail (Ceratophyllum), wild celery (Vallisneria), waterweed (Elodea), prominent.

13. Floating-leaf aquatics such as pond lily (Muphar variegatum), burreed (Sparganium fluctuans), Pond weed (Potamogeton natans), lacking. Water colorless. Bottom mud sapropel or gyttja.

Table III. Key to Landscape Units of the Chignecto Coastal Lowlands (continued)

13. With floating-leaf aquatics. Water colorless to humus-stained. Bottom mud a gyttja. - Mesotrophic Waters.

12. Submerged aquatics, such as mentioned above, scarce or lacking. Floating-leaf aquatics prominent, especially pondlily (Nuphar variegatum), frequently also the submerged bladderwort (Utricularia vulgaris). Water strongly humus-stained. Bottom mud gyttja or dy. - Dys-oligotrophic Waters.

9. Semiaquatic to terrestrial conditions.

14. Soil throughout the year water-logged close to or up to the surface, or shallowly covered by water. Soil generally peat.

15. Dominants are tall robust reeds. - Marsh.

16. With component of fen species, such as sweet gale (Myrica gale), marsh-cinquefoil (Potentilla palustris), buckbean (Menyanthes trifoliata). Soil a peat, either shallow or, together with rhizomes and roots, forming a floating mat. - Mesotrophic Marsh.

16. Without component of fen species. Soil conditions various, but never a floating mat. - Eutrophic Marsh.

15. Dominants different. Soil always a peat.

17. Dominants include low to medium -sized delicate sedges, rushes, and cottongrasses (spp. of Carex, Eriophorium, Rhynchospora), Sweet gale (Myrica gale), marsh cinquefoil (Potentilla palustris), buckbean (Menyanthes trifoliata), and mosses, especially sphagna. Soil a peat, either shallow or, together with rhizomes and roots, forming a floating mat. - Fen

18. Sphagna dominant. Soil water-logged up to surface but not covered by water throughout the year. - Sphagnum Fen.

18. Sphagna only in occasional patches. Soil surface covered largely by 2 to 4 in. of water throughout the year. In floristic composition transitional between Sphagnum Fen and Mesotrophic Marsh. - Wet Fen.

Table III. Key to Landscape Units of the Chignecto Coastal Lowlands (continued)

17. Dominants include Sphagnum mosses, lichens, heath shrubs, cloudberry (Rubus chamaemorus), the cottongrass Eriophorum spissum, the rush Scirpus cespitosus. Soil a thick and compact peat. - Bog

19. Sphagna dominant, heath shrub layer low and open, lichen component patchy. Peat actively growing. Sphagnum Bog.

19. Heath shrubs and/or lichens dominant, Sphagna less prominent. Peat either as above or not actively growing. - Bog Heath

14. Soil at least superficially drained during the growing season. Soil generally not a peat.

20. Vegetation composed mainly of herbaceous plants.

21. Vegetation open, soil frequently or recently mechanically disturbed.

22. Along exposed lakeshores between low water line and high water line. Vegetation and soil disturbed by wave action and possibly also ice. - Lake-Beach.

22. Not along lakeshores. Disturbance by human activities.

23. Disturbance unintentional. Vegetation composed of wild plants. - Ruderal Area.

23. Disturbance unintentional. Vegetation composed of crop plants. - Cropland.

21. Vegetation dense, composed of perennial grasses and herbs. - Meadow.

24. Not regularly disturbed by mowing or grazing. Dominants tall grasses and herbs. - Tall Meadow.

25. Soil wet, dominants are blue-joint (Calamagrostis canadensis), and/or fresh-water cordgrass (Spartina pectinata) - Swamp Meadow.

25. Soil at least moderately well drained. Dominants include tall Compositae, such as goldenrods (Solidago spp.), aster (Aster umbellatus), Joe-Pye-weed (Eupatorium maculatum) - Old Field Meadow.

Table III. Key to Landscape Units of the Chignecto Coastal Lowlands (concluded)

24. Regularly disturbed by mowing or grazing. Dominants different.

26. Mown once a year. Soil at least moderately well drained; main dominant timothy (Phleum pratense); may contain the clovers Trifolium pratense and/or T. hybridum. - Hay Meadow.

26. Grazed. Vegetation different.

27. Soil at least moderately well drained. Dominants include bent (Agrostis spp.) and white clover (Trifolium repens) - Pasture

27. Soil poorly drained. Dominants include the unpalatable pasture weeds, wool-grass (Scirpus cyperinus), soft rush (Juncus effusus), and blue flag (Iris versicolor) - Swamp Pasture.

20. Vegetation composed mainly of woody plants. Soils ± poorly drained.

28. Dominants are shrubs. - Carr

29. Main dominant meadow-sweet (Spiraea latifolia) - Spiraea Carr.

29. Main dominant alder (Alnus rugosa) - Alder Carr

28. Dominants are Trees. - Forest

30. Dominants include black spruce, larch heath shrubs, and bryophytes (Sphagnum spp., Pleurozium schreberi, Ptilidium ciliare, Dicranum spp.). - Bog Forest.

30. With component of more demanding species, such as red maple (Acer rubrum), currants (Ribes spp.), violets (Viola pallens), Miter wort (Mitella nuda), and sensitive fern (Onoclea sensibilis).- Swamp Forest.

Besides forest, with relatively dense tree layer and lower strata composed of a ± shade-tolerant species, there occur in the area also open stands of either black spruce or larch. Depending on the composition of the lower strata, these stands are referred to, respectively, as Wooded Bog Heath, Wooded Sphagnum Fen, and Wooded Spiraea Swamp.

Landscape Pattern

On the basis of occurrence and distribution of landscape units, the landscape of the Chignecto Coastal Lowlands can be subdivided into four zones: mudflat zone, salt marsh zone, reclaimed marsh zone; and peatland zone. Special conditions are found in the upland border.

Mudflat Zone. The mudflat zone extends from the low tide line landward to a steep erosional scarp, several feet in height. Landscape units are: Erosional tidal mud flat, depositional tidal mud flat. With every tide there is an alteration between flooded and exposed conditions. The zone is subject to erosion and/or deposition. Soil and water are pronouncedly saline, of high base status and neutral reaction. The soil is raw, a tidal silt without humus layer or other profile differentiation. The mudflat zone is bare of vegetation. Notable is the lack of the eelgrass (*Zostera marina*) which is common in this zone on Northumberland Strait.

Salt Marsh Zone. The salt marsh zone extends from the rim of the scarp landward to the limit of flooding by saline tidal water. Landscape units are: tidal creek, depositional salt marsh, lower salt marsh, central salt marsh, upper salt marsh. Except for tidal creeks, this zone is flooded only at especially high tides. The zone

is subject to tidal deposition, except for the creeks where erosion is prevalent. Soil and water are pronouncedly saline and of high base status. Reaction is neutral in the soil, but may be strongly alkaline in the water of the pans. The soil is raw, a tidal silt without humus layer or other profile differentiation except for a surface sapropel layer in the pans. The vegetation is generally dense and largely composed of salt marsh grasses, except for the tidal creeks which are esstntially bare. Woody plants and bryophytes are lacking.

Reclaimed Marsh Zone. The reclaimed marsh zone extends from the dyke landward to the upland border or to the edge of a thick (2 ft.+) peat cover. Landscape units are: running waters, eutrophic waters, "afja waters, eutrophic marsh, ruderal area, cropland, hay meadow, pasture, swamp pasture, swamp meadow, spiraea carr, alder carr. This zone is former salt marsh which has been reclaimed by exclusion of tides with dykes and sluices (aboiteaus) and through drainage.

The reclaimed marsh zone is distinguished by wide seasonal fluctuations in water levels. In early spring extensive flooding is frequent, while the water table may be quite low in summer and early fall. The soil is a tidal silt which has been leached of salts and bases and

is strongly to very strongly acid. The subsoil, however, is still saline and has a pH of about 7. Generally, soils have a more or less distinct humus layer, but the mineral soil component is prevalent up to the surface. Under conditions of poor drainage and salt and base impoverishment, towards the transition with the peatland zone, the mineral soil may, however, be overlain by a layer of muck to peat, up to about 2 feet in thickness.

In running or standing waters, the bottom mud may be of predominantly mineral character with a sapropel surface layer, or there might be a high-organic "afja or gyttja layer. Because of drainage from the saline subsoils, these waters have relatively high salt contents and might even be weakly brackish. Their alkalinity ranges largely from medium to hard, while their pH fluctuates widely around a neutral mean.

The vegetation is generally dense and largely composed of grasses. Woody plants are absent over wide areas, but become increasingly prominent, with spiraea, alder, and larch, towards the transition to the peatland zone. The bryophytes show a similar distribution. The appearance of sphagnum mosses indicates the transition towards the peatland conditions.

The aquatic vegetation is distinguished by a prominence of pondweeds with narrow, linear or strap-shaped

leaves and of arrowheads. The appearance of floating-leaf aquatics and bladderworts marks the transition to the peatland zone.

Peatland Zone. The peatland zone extends from the landward edge of reclaimed marsh zone to the upland border. Landscape units are: Mesotrophic waters, dystrophic waters, mesotrophic marsh, wet fen, sphagnum fen, sphagnum bog, bog heath, bog forest.

The peatland zone is distinguished by thick (2 ft +) peat cover which is continuous except for water bodies. The peat is thick and compact in the bogs and of a floating mat character in fens and mesotrophic marsh. Throughout, the peat is water-logged close to or up to the surface or is shallowly covered by water throughout the year. There is no, or little, seasonal change in water levels relative to the soil surface, the peat layer expands and contracts or rises and falls with changes in absolute levels. The water in these peatlands is mostly salt-poor, very soft, extremely acid, and stained brown by humus substances; conditions are, however, less extreme in wet fen and especially in the mesotrophic marsh. The vegetation is formed mainly by sphagnum mosses, delicate sedges, rushes, and cottongrasses, heath shrubs, and the conifers larch and black spruce. Grasses are lacking almost entirely.

The water bodies in this zone occupy holes in the peat cover. They are of a dystrophic to mesotrophic character, but less acid and generally also less salt- and base-poor than the adjacent peatlands. Their bottom deposits are high-organic, either a gyttja or detritus dy. Floating-leaf aquatics and bladderworts are prominent under sheltered conditions. Other submerged aquatics are absent or scarce in dystrophic waters, but may be common in mesotrophic ones.

Upland Border. The transition from peatland zone to uplands is generally occupied by a belt of alder carr. Where lakes or ponds border onto uplands, there may be, in addition, belts of spiraea carr, swamp meadow, and lake beach. Soils in this transition zone are very variable, but are distinguished from both upland soils and peatland soils by a pH of about 5, as compared to values of 3.5 to 4.5, prevalent in peatlands and upland forests.

Drainage Pattern

Water is brought into the Chignecto Coastal Wetlands from the sea with the tides, as surface water or ground water from the adjacent uplands, and as precipitation from above. Water from the first source is saline, rich in bases and has a heavy load of sediments. Drainage water from the uplands is fresh, with moderate contents of salts

and bases, and with some sediments in the case of surface water; its properties vary with soils, vegetation, and land use in the watershed. Precipitation water is fresh and poor in dissolved and suspended substances. The influence of water from these three different sources varies greatly for the different landscape zones. Conditions in the salt marsh zone are determined by saline tidal water. Conditions in the reclaimed marsh zone are the result of two opposing influences, that of a residual store of salts and bases, inherited from the former tidal condition, and the influence of precipitation, progressively diminishing the former. Precipitation water is the dominant influence in the peatland zone, exclusively so in the bogs. In some landscape units of this zone, there may, however, still be a residual effect of underlaying tidal deposits, especially in some of the lakes, where such deposits are covered by an only thin layer of gyttja. Drainage water from the uplands can be assumed to be an important factor in the upland border, in lakes bordering onto uplands, and generally in drainage courses carrying water from the uplands across the lowlands into the sea.

The drainage pattern differs greatly for the different landscape zones.

Salt Marsh Zone: The drainage system in the salt marsh zone is formed by tidal creeks. They are winding, much-branched, and increase seaward with depth and width.

When at high tides the water rises above their banks and floods the salt marsh, much of its sediment load is dropped in close vicinity to the creek, forming "natural levees" occupied by depositional salt marsh. Away from the creeks, where there is less tidal deposition and more strongly impeded drainage, are lower and central salt marsh, interspersed with scattered tidal pans.

Reclaimed Marsh Zone: The reclaimed marsh zone has inherited from its former salt marsh state a system of tidal creeks. The best-drained and agriculturally most valuable land is found close to the larger creeks, while drainage deteriorates and agricultural potential decreases with increasing distance from them. Superimposed over this natural drainage system is a man-made system of canals and ditches. These, together with the lower portions of the major tidal creeks, form the present drainage system. It is protected from the tides by sluices. The remaining portions of the former tidal creeks are now either occupied by standing water or eutrophic marsh. Some of the larger canals have served in former times also for the controlled access of the tides.

Peatland Zone: The peatland zone appears to lack a well-developed natural drainage system. Streams draining into it from the adjacent uplands terminate in lakes, located at the upland border. These lakes may be connected to other

lakes in the peatland zone by open runs. The lakes apparently did not drain into the tidal creeks by definite drainage ways, but instead water appears to have seeped or flowed diffusely through fen or marsh. Man, however, has dug canals and ditches connecting the lakes with the drainage system of the reclaimed marsh zone and has thus made provisions for the free flow of water from the uplands through peatland zone and reclaimed marsh zone into the sea.

Water Bodies

Lakes and ponds occur scattered throughout the peatland zone and in the landward part of the reclaimed marsh zone. On the basis of bottom deposits, water properties, vegetation, invertebrate and vertebrate animal life, and adjacent landscape units, these water bodies can be arranged along a trophic gradient, extending from eutrophic over mesotrophic to dys-obgotrophic conditions (Table IV). It seems likely that this wide range of conditions is related to differences in the residual effect of tidal deposits underlaying the bottom mud formed since the cessation of tidal influence, and to properties of the watershed. It can thus be assumed that the trophic gradent from dy-oligotrophic to eutrophic conditions, is controlled by a gradient of increasing proximity of tidally deposited silt to the mud surface and/or by a gradient of increasing

Table IV. Trophic gradient in water bodies of the Chignecto Coastal Lowlands

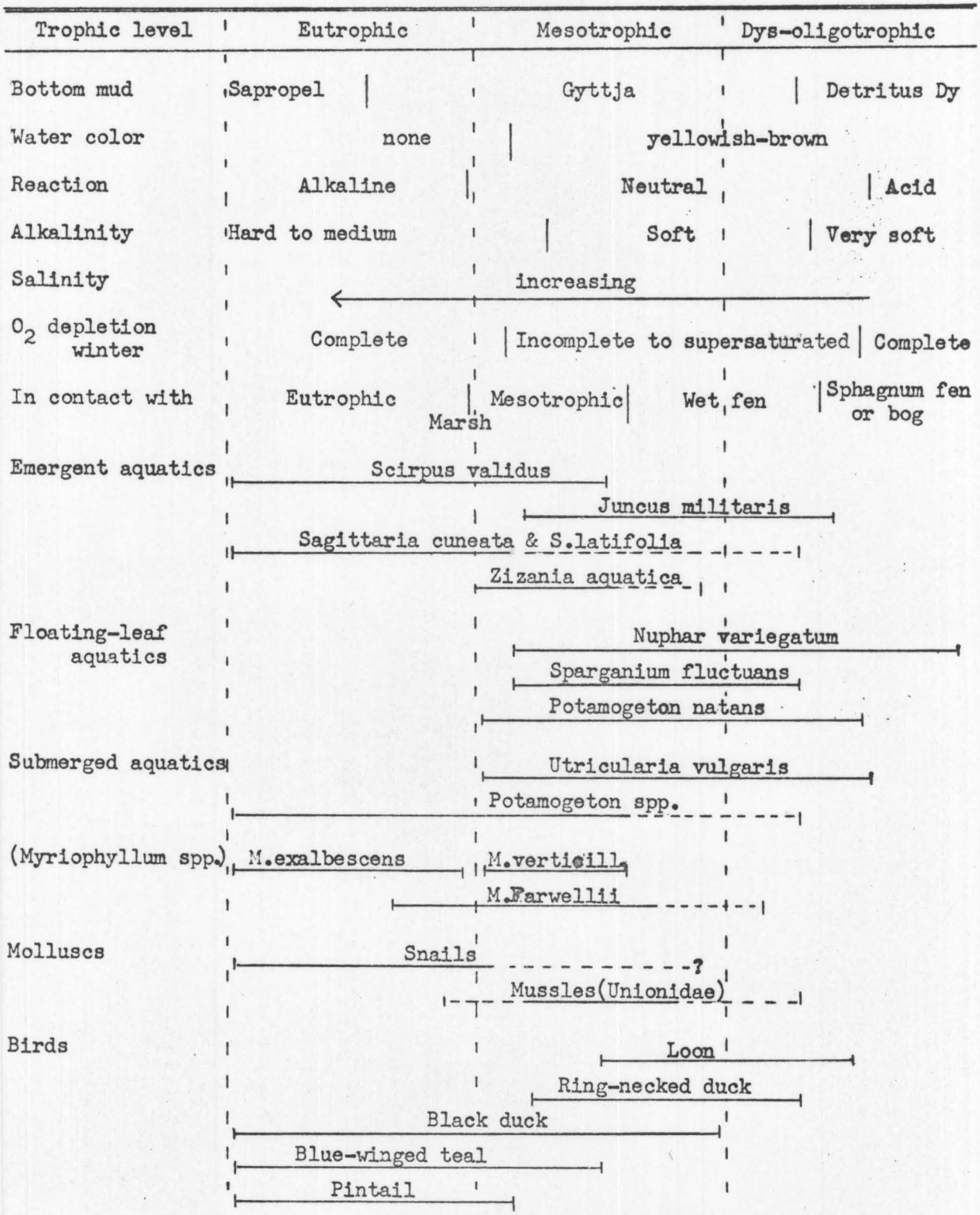


Table IV. Trophic gradient in water bodies of the Chignecto Coastal Lowlands (concluded)

Trophic level	Eutrophic	Mesotrophic	Dys-oligotrophic
Muskrat	⊢——————————— - - - - ?		
Lakes	X Amherst Point Sanctuary		
	X Tower's Goose Lake		
	X Blair Lake		
	X Gravelly Beach Pond		
	X Large Lake, S.W. extension		
		⊢———Long Lake near Cookville, Front Lake, Patten Lake	
		X Long Lake near Jolicure	
			⊢———⊣ Large Lake, N. extension, several lakes and ponds in Missaquash area.

Note: For reaction, alkalinity, and salinity, summer values have been used; O_2 depletion is considered only for shallow lakes of 2 to 4 ft. depth.

concentrations of salts, bases, and nutrients in the water draining into the water bodies. The former is in turn related to the time past since the cessation of the tidal influence, while the latter depends on soil parent material, soil conditions, and land use in the watershed.

In spite of much diversity, several features are common to most water bodies: seasonal changes in water levels are small, probably not more than 1 to 2 feet. Water bodies are shallow, summer depth ranging largely from 2 to 4 feet. They are, however, deep enough so as not to freeze down to the bottom in winter. Borders are generally steep. In the peatland zone, the lakes are holes in a solid or floating-mat peat cover. In the reclaimed marsh zone, they occupy sharp-edged depressions in the surface of the tidal silt. Water flowing today into these lakes is largely free of mineral sediments and bottom deposits over-laying the tidal silt are thus of essentially organic nature, composed of fecal pellets of aquatic invertebrates in the gyttja, of semi-decomposed algae in the ″afja, and of flocculated humus and fine plant detritus from the adjacent peatlands in the detritus dy. In the sapropel there is ± complete decomposition and thus no, or little, accumulation of organic materials.

A gently sloping shore is found under wind-exposed conditions between larger lakes and adjacent uplands.

Here the soil is a lake shore sand. Above the summer water line it is part of a lake beach landscape unit. Below, there is a belt of the mesotrophic or dys-oligotrophic waters distinguished by quillwort (Isoetes muricata), the pondweed Potamogeton Spirillus, and by an abundance of caddis-fly larvae.

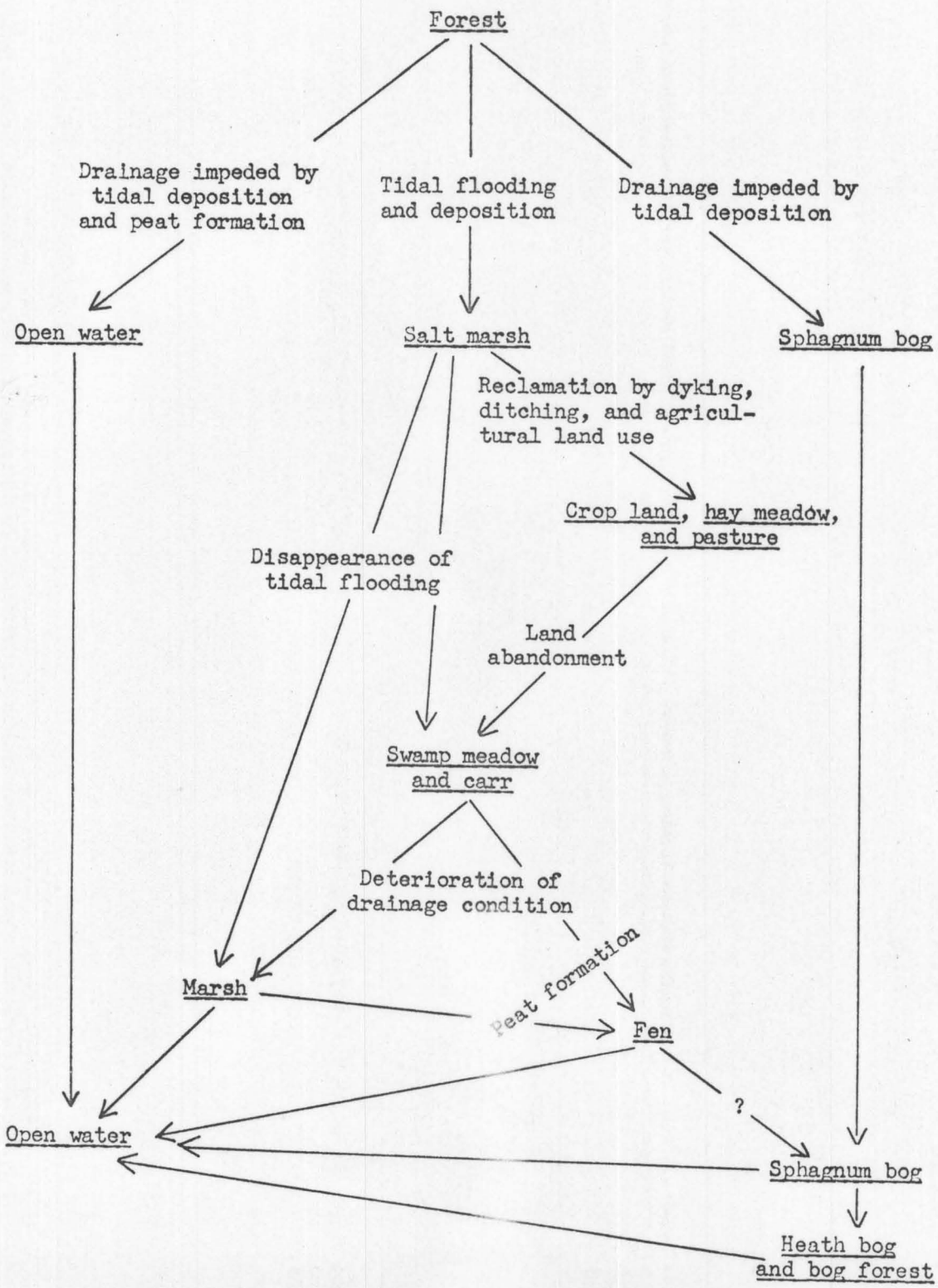
Water bodies which have still to be investigated are shallow pans in eutrophic cattail marsh. They are essentially devoid of aquatic vascular plants, may have "afja bottom deposits, and fall dry in the summer of dry years. The tidal pans are similarly shallow but are permanently water-filled.

Landscape History

A schema of historical developments and successional trends in the Chignecto Coastal Wetlands is given on Table V, p.23a . Three historical periods can be distinguished: prior to reclamation, reclamation with controlled access of tides, reclamation with exclusion of tides.

Prior to Reclamation. The development of the Chignecto Coastal Lowlands was initiated by a subsidence of the land and resultant advance of the sea between about 2,000 and 1,000 B.C. Prior to this event, the area can be assumed to have been gently rolling to almost flat country, occupied by forest or bog. Remains of this fossil landscape can be found today at the base of the tidal deposits. Subsequent events in the area took place under the influence of further subsidence, continuing apparently up to the present.

Table V. Historical developments and successional trends in the Chignecto Coastal Lowlands



Under the influence of the tides, the Chignecto Coastal Lowlands became differentiated into three zones; the mudflat zone, distinguished by predominant tidal deposition, and the peatland zone, not directly affected by tidal flooding and deposition, but indirectly, through blockage of drainage seaward.

The erosional character of the landward parts of the mud flat zone and of the cliff, separating this zone from the salt marsh zone indicate a progressive encroachment of the former zone onto the latter. In the salt marsh zone, continuing tidal deposition, raising the surface of the marsh, should result in a gradual decrease and final cessation of the tidal influence and a corresponding succession over lower, central, and upper salt marsh, and finally to freshwater wetlands. Such a tendency is, however, counteracted by the continuing subsidence of the land.

The occurrence of a retreat of tidal flooding and salt marsh zone is indicated by conditions in the peatland zone. In this zone, there is with increasing distance from the tidal influence a sequence of landscape units including swamp meadow, carr, or marsh seaward, and fen landward. Along this sequence there is an increasingly thick muck or peat layer over the tidal silt. Parallel there is a decrease in base and nutrient status and a corresponding increase in dystrophic plant taxa as especially in sphagnum mosses. It

can safely be assumed that this sequence in space does represent also a sequence in time, resulting from a seaward shift of individual zones. It appears thus that the salt marsh zone has gradually narrowed losing seaward to the mud-flat zone and landward to the peatland zone.

Closest to the upland border in the peatland zone are the bogs. The transition towards a bog condition is generally an abrupt one, occurring over a distance of only a few feet. At the edge of the bog, there is a rise of about 1 to 3 feet and an abrupt increase in the thickness of the peat cover, with corresponding depression in the surface of the tidal silt. This condition indicates that bogs and tidal salt marsh have occurred in close contact over a long time, with the transition zone between the two having a very stable position. It must be assumed that the development of the bogs has proceeded parallel to that of the adjacent salt marsh and that the obstruction of drainage by tidal deposition in the latter created conditions favourable for the development of bogs.

The development of lakes in the peatland zone is obviously complex. Lakes have developed along the upland margin of the freshwater zone through the drowning of stream valleys by drainage obstruction through tidal deposition and bog development. Lakes may have formed also in the low areas between tidal creeks, possibly developing

from salt marsh pans, following a recession of the tidal influence. In some instances, lakes have become enlarged as a result of erosion into adjacent bogs. Other lakes seem to have originated in formerly continuous marsh or fen areas, following the death of the dominant plants and subsequent breakdown of the peat cover. In some cases, such lakes may have originated from drainage ways or "runs" through the peat country. The process by means of which lakes thus expand at the expense of adjacent marsh, fen, or bog, are not yet understood.

Reclamation with Controlled Access of Tides. Reclamation of the Chignecto Coastal Lowlands began about 1670 with the arrival of the first Acadian settlers. They brought with them from their homeland along the French west coast a knowledge of the great agricultural potential of the tidal salt marsh and a technology for its reclamation. Reclamation involved the exclusion of the tides by means of dykes and drainage by open ditches. Streams and largest tidal creeks were generally left in the tidal condition, with their banks being followed by dykes. Within the "bodies" of dyked marsh, ditches formed an artificial drainage system, which was separated from and connected to the tidal system by means of sluices (locally called aboiteaus). Exclusion of tides and drainage resulted in a desalinization and leaching of the soils, progressing from the surface

downward, and the land became thus available for agriculture. With continued agricultural use, there was, however, a deterioration of soil fertility. For its restoration, the Acadian readmitted the tides temporarily, thus causing the deposition of a fresh layer of tidal silt. The Acadian settlers used, thus, a system of land use which accomplished the maintenance of high levels of soil fertility independent of liming or fertilization.

The expulsion of the Acadians in 1755 initiated a period of decline in the dyke and drainage system. The English farmers, settling subsequently in the area, learned however the techniques of land reclamation from returning Acadians. The English immigrants included settlers from Yorkshire who may have brought with them a knowledge of farming in tidal lands from their own home country. Following this temporary decline, land reclamation was thus resumed and continued throughout the 19th century.

The Acadians built their dykes close to the seaward edge of the salt marsh and beginning with their efforts, reclamation proceeded landward. By the early 19th century almost all of the salt marsh had thus been brought into cultivation. At this point Toler Thompson, a farmer of Upper Sackville, introduced a system which made possible an extension of reclamation landward into the peatland zone. Canals were dug from the major tidal rivers, the Tantramar,

Missaquash, and La Planche, into the peatland zone. Silt-laden tidal sea water would, during high tide, rush landward in these canals and flood areas in the peatland zone and bury vegetation and underlaying organic deposits under a layer of tidal silt. When this layer was considered to be thick enough, the tide was shut out and the area was reclaimed by means of ditching. Reclamation by these means continued throughout the 19th century, the last project being the digging of the Missaquash canal in 1896. This second phase in land reclamation terminated when all land accessible by this technique had been brought into cultivation. By this time, all of the tidal salt marsh, except for a very narrow coastal strip , and parts of the peatland zone which were transitional towards the salt marsh zone and of a less oligotrophic, more base- and salt-rich character had become converted into the man-made reclaimed marsh zone.

Towards the end of the 19th century there was some deterioration in use and management of the reclaimed marsh zone. This deterioration accelerated after 1900 and progressed rapidly in the time between the two wars. Failure to maintain the dykes resulted in the reversion of substantial areas of reclaimed marsh to salt marsh. Much larger areas of agriculturally used marsh remained protected by the dykes but were abandoned by agriculture, especially along the landward edge of the cultivated marsh zone,and became occupied by swamp meadow, spiraea carr, and eutrophic marsh, with indications of further development towards mesotrophic marsh or fen.

Reclamation with Exclusion of Tides. The progressive shrinkage of cultivated land, deterioration of dykes and drainage system, and encroachment of salt marsh and peatlands upon the reclaimed marsh was followed after the second world war by a period of reclamation, lasting up to the present, which so far has regained some of the land lost during the preceding period of neglect. Reclamation work included the building of a new dyke along the coast, stronger than any of the preceding ones, and the closing of the Tantramar, Missaquash, La Planche, and Nappan rivers by means of sluices. The old dykes following these rivers and the smaller sluices between these and the major drainage ditches are allowed to deteriorate. Thus, a new era in man's use of the lowlands has begun, in which he can no more avail himself of tidal flooding for the rejuvenation of deteriorated agricultural land and the reclamation of peatland. From now on, soil conditioners and fertilizers have to be relied upon instead.

Dynamics of Base and Nutrient Levels

In the Maritime Provinces, landscape units in the uplands tend to be fern-herb, moss, and heath forest with raw humus or moder soils with podzol or semi-podzol profiles and a pH between 3 and 5. In poorly drained areas there occur bog forest, bog, and fen with peat soils and similar pH range. Water bodies are predominantly very soft to soft

and of dys-oligotrophic character. Responsible for this condition is the cool-humid climate and the base-poor parent material. Development towards this condition may be suspended by the following factors: tidal flooding and/or salt spray along the coast, flooding by streams and rivers, agricultural land use, and base-rich parent material.

In the Chignecto Coastal Lowlands, irrigation with saline, base-rich sea water and deposition of unweathered silt particles by tidal flooding prevents both, a leached condition and the development of a peat cover and keeps soils in an immature state in both, the mud flat zone and the salt marsh zone. Even after the cessation of tidal flooding, as result of natural developments or human interference, a residual effect still persists, diminishing gradually due to progressive leaching or to build-up of a peat cover or of high-organic bottom deposits.

Agricultural land-use suspends or retards base- and nutrient impoverishment for several reasons. Land-use by grazing, mowing, or crop cultivation, results in reduced amounts of plant cover and of plant residues; these residues, furthermore, are easily decomposable. Thus, neither peat nor raw humus are formed and base- and nutrient- status remain relatively high. A slow deterioration nevertheless takes place, leading towards a condition at which further use of the land becomes uneconomical. Nutrient and base

losses have, therefore, to be compensated for by liming and fertilizing; if this is done properly, an equilibrium can be attained at a high level of soil fertility.

Soil parent material, soil conditions, and agricultural land use in the uplands will influence base and nutrient levels in water bodies, rivers, and streams, receiving drainage water from these uplands. Thus, Smith (1967) ascribed the relatively high alkalinity values of Portage Lake to its proximity to agriculturally used uplands. The high salt and base concentrations and eutrophic character of the lakes in the Amherst Point Sanctuary may be ascribed to the extensive occurrence of gypsum rocks in the adjacent uplands.

With the permanent exclusion of the tides, the residual effect of the underlaying tidal deposits in base- and nutrient status of soils will gradually weaken, and the maintenance of mesotrophic to eutrophic conditions will depend increasingly on agriculturally land use in the lowlands and the adjacent uplands. If such use should be discontinued, it can be assumed that ultimately most of the area behind the dyke will develop into bog forest, bog, fen, and dys-oligotrophic waters.

At the present time, especially fast changes can be expected to occur in the transition belt between reclaimed marsh zone and peatland zone, occupied by swamp meadow, carr,

marsh, and mesotrophic or eutrophic waters. Parts of this belt were affected until recently by tidal flooding. This influence, however, has been excluded since the 1950's by the closing of the larger rivers with sluices. In this belt there also has been during the past fifty years much land abandonment and resultant deterioration of the drainage system. Grass fires, occurring in this belt, may suspend succession following land abandonment at the swamp meadow stage.

Dynamics of Marsh and Waters

Standing waters are distinguished by a depth with ranges largely from 2 to 4 feet, deep enough as not to freeze to the bottom, but shallow enough as to have enough light penetration for rooting aquatics. This situation allows two alternative explanations. The present situation may be seen as a transitory phase, the lakes becoming progressively more shallow, to give way finally to marsh or fen. This interpretation is supported by the observed accumulation of gyttja since cessation of tidal deposition in several lakes. On the other hand, the very even depth over large areas of water bodies makes this explanation suspect. Instead, one might assume that at a water depth of 2 to 4 feet, some kind of equilibrium is reached at which the water depth becomes stabilized.

Because of their steep borders and even depths, there is generally no distinct depth zonation in the vegetation and a large number of different species combinations, including emergent, floating-leaf, and submerged aquatics, duckweeds, and various algae occur in the same depth range. There appears to be some correlation with the degree of respectively shelter and exposure and with bottom deposits and nutrient status. Much of this variation, however, can not yet be explained. For example, at 2 to 4 feet water depth, under sheltered conditions, and associated with a gyttja, there may be emergent vegetation formed by either bulrush (Scirpus validus) and other rhizome perennials or by the annual wild rice (Zizania aquatica), or there may be a combination of floating leaf and submerged aquatics, with the component of the latter varying greatly in species composition. The pattern formed by these different kinds of aquatic vegetation is apparently the result of very delicate equilibria of yet unknown character.

Four kinds of bottom deposits are present in the waters of the area, ä̈fja, sapropel, gyttja, and detritus dy. So far, only typical representatives of these four were observed and no intergrades. It appears that these four bottom deposits are the result of four alternative kinds of decomposition, the differences being due to differences in the raw material and in the chemical environment. The last

three form a sequence corresponding to a gradient of decreasing salt, base, and nutrient contents. It is not yet understood, what factors determine the formation of, alternatively, ä̈fja and sapropel. A sapropel is present in the lakes of the Amherst Point Sanctuary; associated with a dense aquatic vegetation, formed mainly by milfoil (Myriophyllum exalbescens) and the pondweeds Potamogeton pectinatus, and P. perfoliatus. These lakes support high densities of waterfowl, especially surface-feeding ducks. To the east of the sanctuary there is a pond with an ä̈fja, almost devoid of vascular plants, and less frequented by waterfowl. Common to all these water bodies are similar depths, chemical water properties, under-laying tidal silt, and position at border of uplands, the latter with gypsum bedrock. Thus, apparently only slight differences in the controlling factors seem to be responsible for two very different kinds of ecosystem.

The relationship between water bodies and adjacent floating-mat landscape units represents an interesting problem. Under the mesotrophic conditions, for example, with a water depth of 2 to 4 feet, there may either be open water or a mesotrophic floating mat marsh with cattail (Typha glauca) or with sweet flag (Acorus calamus) and burreed (Sparganium eurycarpum), the surface of the mat being some 10 to 24 inches below the water surface. It is

not yet understood what controls the relative distribution of these two very different conditions. Following the classical climax theory, one should expect the progressive invasion of the open water by the floating mat. The opposite, namely a dying back of the cattails, was observed, however, on Gravelly Beach Pond, where conditions were more carefully observed.

Other, yet unexplained patterns are formed by shallow pans of open water, occurring through the eutrophic cattail marsh, and by the tidal pans in the salt marsh.

Vertebrates

Mudflat Zone and Salt Marsh Zone. These two zones are distinguished by a number of shorebirds, including semipalmated plover, black-bellied plover, greater and lesser yellowlegs, pectoral, white-rumped, least, and semipalmated sandpiper, dunlin, short-billed dowitcher, and Hudsonian godwit. The species of this group depend on bare and wet areas, exposed or covered by only a few inches of water, such as mud flats, tidal pans, and along the edge of tidal creeks, and feed on small invertebrates, especially crustaceans. They occur commonly in often large flocks in fall, from mid-July to mid-November, and a few species also in lesser numbers in spring. They are found only occasionally away from areas presently influenced by the tides,

especially in the weakly brackish lakes of the Amherst Point Sanctuary. Scavenging herring gulls, black-backed gulls, and raven occur year-round in the same areas as the shorebirds.

In the spring, larger expanses of salt marsh support concentrations of Canada geese, peak numbers being reached in late March and early April. They feed presumably on the rhizomes of the salt marsh grasses. Lesser concentrations are found in fall. Some of the fresh-water lakes, such as Large Lake or Round Lake, are used occasionally in fall as resting places, but feeding by geese appears to be restricted to areas with more or less saline conditions.

In spring red-breasted merganser and common goldeneye occur in larger creeks and estuaries. In both spring and fall surface-feeding ducks, especially black duck, are found on the tidal pans. In fall, they might possibly feed here on the luxurious vegetation of widgeon grass (Ruppia maritima).

In winter, salt marsh and meadows of the reclaimed marsh are visited by seed-eating ground birds, including often large flocks of snow buntings, smaller numbers of horned larks, and occasionally Lapland longspurs. The latter two are restricted to areas close to the coast, while the snow bunting occurs throughout the two zones and in uplands, appears, however, to be likewise most common near the coast.

Meadows of the Reclaimed Marsh Zone. These landscape units are distinguished by a strong component of herbivors, including cattle, sheep, and meadow voles. The latter are preyed upon by foxes and ravens (?) the year round, by marsh hawks during the summer, and by rough-legged hawks in winter. Other predators, occurring more occasionally, are short-eared owl and snowy-owl.

Characteristic summer residents of the meadow lands are bobolink, Savannah sparrow, sharp-tailed sparrow, song sparrow, omnivors which, however, feed during the summer mainly on insects. The common snipe is a summer resident throughout this zone.

In winter, these areas are largely deserted of small song birds, except for occasional flocks of snow buntings.

Marsh Areas and Water Bodies in the Tantramar from Reclaimed Marsh Zone to Peatland Zone. These include the Amherst Point Sanctuary to Blair Lake area, the Missaquash Impoundment, Front Lake, the area from Large Lake, SW extension over Gravelly Beach Pond to Hog Lake, and Tower's Goose Lake. These areas contain the largest variety of vertebrate life. Principal mammal is the muskrat. Surface-feeding ducks, as summer residents and migrants, reach near their largest concentration, with black duck, pintail,

blue-winged teal, green-winged teal, baldpate, and occasionally shoveler. Rails are represented by sora, yellow rail, and, at least formerly, Virginia rail. Coot and ruddy duck occur in fall. The redwinged blackbird is common. Another summer resident is the swamp sparrow. All these species are omnivors, using both plant and animal food.

Carnivors are represented by the American bittern, pied-billed grebe, and black tern, and, at least formerly, both short-billed and long-billed marsh wren. Night heron and least bittern are occasional visitants.

Water Bodies of the Peatland Zone. The water bodies of the peatland zone, except for those mentioned above, are distinguished by ring-necked duck, common loon, and osprey. The black duck is the only surface-feeding duck which breeds regularly. The muskrat is either lacking or, if present, depends heavily on fresh-water clams (Unionidae) as a supplement to its plant diet. The beaver occurs in scattered colonies, in spite of apparently very poor habitat, the only larger woody plants present in the vicinity of these colonies being alder, larch, and black spruce. In fall, these lakes serve as resting areas for Canada geese and scoters. Here, as in the reclaimed marsh zone, common merganser and occasionally black duck are found throughout the winter wherever currents prevent the water from freezing.

Fens and Bogs. Apart from animals depending on their tree component, fens and bogs appear to be devoid of mammals and birds, except for their occasional use as breeding habitat, as e.g. by the American bittern.

Alder Carr and Tree Stands on Carr, Fen, and Bog. The vertebrate fauna of these habitats is yet poorly known by the investigator. The yellow warbler is a summer resident of the alder carr, while the palm warbler is typical of bog and bog forest. In winter, the tree sparrow is found on the edge of alder carr, while snowshoe hare and its predators fox, bobcat, and snowy owl are occurring in bog margins.

Not considered in this discussion, because of insufficient knowledge, are fishes and amphibia. Reptiles are represented by the wood turtle, which was observed in Blair Lake near Amherst.

Wildlife Values and Management

On the basis of present knowledge and understanding the following recommendations can be made for the consideration of wildlife values in land planning and management of the Chignecto Coastal Lowlands:

Mud flat zone and salt marsh zone are important as habitat for Canada geese, surface-feeding ducks, and shorebirds during spring and fall migration. Possibilities

for habitat manipulation appear to be excluded or limited because of the tides. For the salt marsh zone there exists the possibility of reclamation for agriculture through dyking. In this case the loss of wildlife habitat should be weighed against agricultural gains.

The reclaimed marsh zone is largely occupied by landscape units of more or less eutrophic character. The agricultural land use counteracts the general successional tendency, typical of cool-humid regions, towards a more dys-oligotrophic condition. For this reason, this zone appears to have a high wildlife potential, especially for muskrat, surface-feeding ducks, and other species of eutrophic marsh and water bodies.

It appears that considerable habitat manipulation would be necessary to realize this potential. Any such manipulation would have to be coordinated with development for agriculture. Such coordination would, however, not appear to be too difficult because agricultural potential decreases and wildlife potential increases with decreasing drainage conditions. The reclaimed marsh zone could, therefore, be subdivided on the basis of drainage into potential agricultural areas and wildlife areas. It would be desirable if future reclamation work would be concerned with both, improvement of the former areas for agriculture and of the latter for wildlife.

The size of wildlife populations in the peatland zone appears to be estimated because of its predominantly mesotrophic to dys-oligotrophic character. It is, however, by far the most varied and therefore most interesting of the four zones, containing the largest number of different landscape units, plant, and animal species, including a few which reach in the Chignecto Coastal Lowlands the limit of their distribution, or occur here as outposts, widely separated from their main range. Because of its delicate and poorly understood equilibria, it would appear difficult to manipulate this zone with positive and predictable results. Management in this zone should be a conservative one, with emphasis on the preservation of present conditions and any manipulations which would threaten the persistence of interesting animal and plant species, landscape units, and landscape pattern should be avoided.

Work Planned for 1968/69

The work planned for 1968/69 does include the following items:

(1) Re-evaluation of the proposed landscape units on the basis of additional information, especially data on soils and bottom deposits including C /N / P ratios, and on invertebrates. Special attention will be given to landscape units of the reclaimed marsh zone, which so far have been studied only cursorily.

(2) Work for a definitive map of the area.

(3) Obtaining of more precise and detailed information on landscape history and dynamics through interviews of local residents, by comparison of descriptions, maps, and photographs made of the area at different times, from the investigation of peat and bottom deposits, and from tree-ring studies.

(4) Detailed mapping of selected marsh areas and water bodies to obtain an exact record which can be used as basis for assessment of future changes.

(5) Obtaining of much more precise and detailed information on vertebrate animals.

(6) Literature studies and field observation in order to obtain information on productivity and trophic structure in different landscape units, and on factors influencing the relative amounts of ecosystem energy flow through the consumer (animal) component. This information will be essential for manipulation of ecosystems so as to obtain maximum consumer productivity, as represented by different kinds of wildlife.

(7) Plan for wildlife management in the Chignecto Coastal Lowlands, with report on literature on the management of similar wetlands elsewhere.

Appendix I. List of vascular plant species of the Chignecto Coastal Lowlands

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Equisetaceae

Equisetum fluviatile L. - water horsetail

Lycopodiaceae

Lycopodium inundatum L. - bog clubmoss

Isoetaceae

Isoetes muricata Dur. - quillwort

Osmundaceae

Osmunda regalis L. - royal fern
Osmunda cinnamomea L. - cinnamon fern

Polypodiaceae

Onoclea sensibilis L. - sensitive fern
Dryopteris Thelypteris (L.) Gray - marsh-fern
Dryopteris cristata (L.) Gray - crested wood-fern

Pinaceae

Picea glauca (Moench) Voss - white spruce
Picea mariana (Mill.) BSP. - black spruce
Larix decidua (DuRoi) K.Koch - larch
Pinus Banksiana Lamb. - jackpine

Typhaceae

Typha latifolia L. - (Typha - cattail)
Typha angustifolia L.
Typha glauca Godr.

Sparganiaceae

Sparganium eurycarpum Engelm. - (Sparganium - burreed)
Spargunium chlorocarpum Rydb.
Sparganium angustifolium Michx.
Sparganium fluctuans (Morong) Robins.
Sparganium minimum (Hartm.) Fries

Appendix I. List of vascular plant species of the Chignecto Coastal Lowlands (continued)

Zosteraceae

Potamogeton filiformis Pers. - (Potamogeton - pondweed)
Potamogeton pectinatus L.
Potamogeton zosteriformis Fern.
Potamogeton pusillus L.
Potamogeton obtusifolius Mert. & Koch
Potamogeton Spirillus Tucherm.
Potamogeton epihydrus Raf.
Potamogeton alpinus Balbis
Potamogeton amplifolius Tuckerm.
Potamogeton natans L.
Potamogeton praelongus Wulfen
Potamogeton perfoliatus L.
Ruppia maritima L. - widgeon grass
Zanichellia palustris L. - horned pondweed

Najadaceae

Najas flexilis (Willd.) Rostk. & Schmidt - naiad

Juncaginaceae

Triglochin maritima L. - arrow-grass
Scheuchzeria palustris L.

Alismataceae

Alisma gramineum K.C.Gmel. - mud-plantain
Alisma triviale Pursh - mud-plantain (cfr. steril material only)
Lophotocarpus calycinus (Engelm.) J.G.Sm.
Sagittaria latifolia Willd. - arrow-head (cfr. sterile material only)
Sagittaria cuneata Sheldon - arrow-head

Hydrocharitaceae

Elodea canadensis Michx. - waterweed
Vallisneria americana Michx. - wild celery

Graminaceae

Bromus inermis Leyss. - brome-grass
Puccinellia maritima (Huds.) Parl. - alkali-grass
Glyceria borealis (Nash) Batchelder - float-grass
Glyceria canadensis (Michx.) Trin. - rattlesnake-grass
Glyceria grandis S.Wats. - reed-meadow grass
Phragmites communis Trin. - reed
Agropyron repens (L.) Beauv. - couch-grass
Agropyron cristatum (L.) Gaertn.
Hordeum jubatum L. - beach barley

Appendix I. List of vascular plant species of the Chignecto Coastal Lowlands (continued)

Calamagrostis canadensis (Michx.) Nutt. - blue-joint
Calamagrostis neglecta (Ehrh.) Gaertn.
Agrostis alba L. - redtop
Phleum pratense L. - timothy
Spartina pectinata Link - fresh-water cord-grass
Spartina alterniflora Loisel. - salt-water cord-grass
Spartina patens (Ait.) Muhl. - salt-meadow cord-grass
Leersia oryzoides (L.) Sw. - rice-cutgrass
Zizania aquatica L. - wild rice

Cyperaceae

Dulichium arundinaceum (L.) Britt. - three-way sedge
Eleocharis palustris (L.) R.&S. - spike-rush
Eleocharis halophila Fern. & Brack. - spike-rush
Scirpus cespitosus L.
Scirpus hudsonianus (Michx.) Fern.
Scirpus subterminalis Torr. - Swaying rush
Scirpus validus Vahl. - bullrush
Scirpus paludosus Nels. - bayonet grass
Scirpus atrovirens Willd.
Scirpus cyperinus (L.) Kunth - wool-grass
Eriophorum Chamissonis C.A.Mey. - (Eriophorum spp. - cotton-grass
Eriophorum spissum Fern.
Eriophorum tenellum Nutt.
Eriophorum angustifolium Honckeny
Eriophorum virginicum L.
Rhynchospora alba (L.) Vahl - beakrush
Rhynchospora capitellata (Michx.) Vahl - beakrush
Cladium mariscoides (Muhl.) Torr. - sawgrass
Carex chordorrhiza L.f. - (Carex spp. - sedge)
Carex diandra Schrank
Carex canescens L.
Carex interior Bailey
Carex scoparia Schkuhr
Carex lenticularis Michx.
Carex limosa L.
Carex lasiocarpa Ehrh.
Carex flava L.
Carex Pseudo-Cyperus L.
Carex rostrata Stokes

Araceae

Calla palustris L. - wild calla
Acorus Calamus L. - sweetflag

Appendix I. List of vascular plant species of the Chignecto Coastal Lowlands (continued)

Lemnaceae (duckweeds)

Spirodela polyrhiza (L.) Schleid.
Lemna trisulca L.
Lemna minor L.

Xyridaceae

Xyris montana Ries - yellow-eyed grass

Eriocaulaceae

Eriocaulon septangulare With. - white-buttons

Pontederiaceae

Pontederia cordata L. - pickerelweed

Juncaceae

Juncus Gerardi Loisel. - (Juncus - bog-rush)
Juncus filiformis L.
Juncus effusus L.
Juncus canadensis J.Gay
Juncus brevicaudatus (Engelm.) Fern.
Juncus pelocarpus Mey.

Liliaceae

Smilacina stellata (L.) Desf.
Smilacina trifolia (L.) Desf.

Iridaceae

Iris versicolor L. - blue flag

Orchidaceae

Cypripedium acaule Ait. - two-leaved Ladyslipper
Habenaria blephariglottis (Willd.) Hook. - White fringed orchis
Habenaria lacera (Michx.) Lodd. - ragged orchis
Pogonia ophioglossoides (L.) Ker - pogonia
Calopogon pulchellus (Salisb.) R.Br. - swamp-pink
Arethusa bulbosa L. - arethusa

Salicaceae

Salix lucida Muhl. - (Salix - willow)
Salix discolor Muhl.
Salix pyrifolia Anderss.
Populus balsamifera L. - balsam poplar

Appendix I. List of vascular plant species of the Chignecto Coastal Lowlands (continued)

Myricaceae

Myrica gale L. -sweet gale

Corylaceae

Betula populifolia Marsh. - wire birch
Betula papyrifera Marsh. - paper birch
Alnus rugosa (Du Roi) Spreng. - speckled alder

Santalaceae

Geocaulon lividum (Richards.) Fern. - northern comandra

Polygonaceae

Rumex orbiculatus Gray - (Rumex - dock)
Rumex maritimus L.
Polygonum ramosissimum Michx. - (Polygonum - knotweed)
Polygonum aviculare L. - knotweed
Polygonum amphibium L.
Polygonum sagittatum L.

Chenopodiaceae

Chenopodium leptophyllum Nutt. - goosefoot
Atriplex patula L. - Orach
Atriplex glabriuscula Edmondston - orach
Salicornia europaea L. - samphire
Suaeda americana (Pers.) Fern. - sea blite

Caryophyllaceae

Spergularia marina (L.) Griseb. - sand-spurrey
Arenaria lateriflora L. - sandwort

Ceratophyllaceae

Ceratophyllum demersum L. - coontail

Nymphaeaceae

Nuphar microphyllum (Pers.) Fern. - (Nuphar - pond-lily)
X Nuphar rubrodiscum Morong
Nuphar variegatum Engelm.
Brasenia Schreberi Gmel. - water-shield

Ranunculaceae

Ranunculus trichophyllus Chaix - (Ranunculus - buttercup)
Ranunculus Cymbalaria Pursh
Ranunculus Gmelini DC.
Ranunculus reptans L.
Ranunculus acris L.
Thalictrum polygamum Muhl. - meadow rue

Appendix I. List of vascular plant species of the Chignecto Coastal Lowlands (continued)

Cruciferae

Rorippa islandica (Oeder) Borbas - yellow cress

Sarraceniaceae

Sarracenia purpurea L. - pitcher plant

Droseraceae

Drosera intermedia Hayne - sundew
Drosera rotundifolia L. - sundew

Saxifragaceae

Ribes lacustre (Pers.) Poir. - bristly black currant

Rosaceae

Spiraea latifolia (Ait.) Borkh. - meadow-sweet
Spiraea tomentosa L. - meadow-sweet
Pyrus floribunda Lindl. - chokeberry
Pyus americana (Marsh.) DC. - mountain ash
Amelanchier spp. - juneberry
Fragaria virginiana Duchesne - strawberry
Potentilla palustris (L.) Scop. - swamp-cinquefoil
Rubus Chamaemorus L. - salmon-berry
Rubus idaeus L. - raspberry
Rosa virginiana Mill.-rose

Leguminosae

Trifolium pratense L. - red clover
Trifolium repens L. - white clover
Trifolium hybridum L. - alsike clover
Vicia Cracca L. - tufted vetch
Lathyrus palustris L. - vetchling

Callitrichaceae

Callitriche palustris L. - water-starwort

Empetraceae

Empetrum nigrum L. - crowberry

Aquifoliaceae

Ilex verticillata (L.) Gray - winterberry
Nemopanthus mucronata (L.) Trel. - mountain holly

Appendix I. List of vascular plant species of the Chignecto Coastal Lowlands (continued)

Aceraceae

Acer rubrum L. - red maple

Balsaminaceae

Impatiens capensis Meerb. - jewelweed

Guttiferae

Hypericum boreale (Britt.) Bickn. - (Hypericum - St. John's-wort)
Hypericum ellipticum Hook.
Hypericum virginicum L.

Elatinaceae

Elatine minima (Nutt.) Fisch. & Mey. - waterwort

Lythraceae

Lythrum salicaria L. - loosestrife

Onagraceae

Epilobium palustre L. - (Epilobium - willow-herb)
Epilobium leptophyllum Raf.
Epilobium glandulosum Lehm.

Haloragaceae

Myriophyllum exalbescens Fern. - (Myriophyllum - milfoil)
Myriophyllum verticillatum L.
Myriophyllum Farwellii Morong

Hippuridaceae

Hippuris vulgaris L. - mare's-tail

Umbelliferae

Hydrocotyle americana L. - water-pennywort
Cicuta bulbifera L. - water-hemlock
Sium suave Walt. - water-parsnip
Ligusticum scothicum L. - Scotch lovage

Cornaceae

Cornus stolonifera Michx. - red osier

Ericaceae

Ledum groenlandicum Oeder - Labrador tea
Rhododendron canadense (L.) Torr. - rhodora

Appendix I. List of vascular plant species of the Chignecto Coastal Lowlands (continued)

Kalmia angustifolia L. - sheep-laurel
Kalmia polifolia Wang. - bog-laurel
Andromeda glaucophylla Link - bog-rosemary
Chamaedaphne calyculata (L.) Moench
Gaylussacia dumosa (Andr.) T.& G. - dwarf huckleberry
Gaylussacia baccata (Wang.) K.Koch - black huckleberry
Vaccinium Oxycoccos L. - small cranberry
Vaccinium macrocarpon Ait. - large cranberry

Primulaceae

Lysimachia terrestris (L.) BSP. - swamp loosestrife
Lysimachia thyrsiflora L. - tufted loosestrife
Glaux maritima L. - sea-milkwort

Plumbaginaceae

Limonium Nashii Small - sea-lavender

Gentianaceae

Menyanthes trifoliata L. - buckbean

Convolvulaceae

Convolvulus sepium L. - morning-glory

Labiatae

Scutellaria lateriflora L. - skull cap
Scutellaria epilobiifolia A. Hamilton - skull cap
Stachys palustris L. - woundwort
Lycopus uniflorus Michx. - water-horehound
Lycopus americanus Muhl. - water-horehound
Mentha arvensis L. - mint

Lentibulariaceae

Utricularia geminiscapa Benj. - (Utricularia - bladderwort)
Utricularia vulgaris L.
Utricularia intermedia Hayne
Utricularia cornuta Michx.

Plantaginaceae

Plantago oliganthos R. & S. - seaside-plantain

Rubiaceae

Galium palustre L. - (Galium - bedstraw)
Galium trifidum L.

Appendix I. List of vascular plant species of the Chignecto Coastal Lowlands (concluded)

Caprifoliaceae

Lonicera villosa (Michx.) R.&S. - fly-honeysuckle
Viburnum cassinoides L. - witherod

Valerianaceae

Valeriana officinalis L. - valerian

Cucurbitaceae

Echinocystis lobata (Michx.) T.& G. - prickly cucumber

Compositae

Eupatorium maculatum L. - Joe-Pye-weed
Solidago uliginosa Nutt. - Solidago - goldenrod)
Solidago rugosa Ait.
Solidago canadensis L.
Solidago graminifolia (L.) Salisb.
Aster novi-belgii L. (Aster - aster)
Aster nemoralis Ait.
Aster umbellatus Mill.
Bidens cernua L. - (Bidens - bur-marigold)
Bidens frondosa L.
Megalodonta Beckii (Torr.) Greene - marsh-marigold
Achillea ptarmica L. - sneezeweed
Cirsium arvense (L.) Scop. - Canada thistle
Sonchus arvensis L. - sow-thistle

Appendix II. Description of landscape units of the Chignecto Coastal Lowlands

5. Standing Water

Bodies of standing water differ with regard to the following features: whether sheltered or exposed, mean depth and seasonal fluctuations in water level, water color and light penetration, chemical properties of water (chlorinity, alkalinity, pH, and O_2 content) and their seasonal fluctuations, morphology and chemical properties of bottom deposits, physiognomy and taxonomic composition of the vegetation, invertebrate fauna.

5a. Eutrophic water. Water colorless, of circumneutral to alkaline reaction, of high electrolyte content and alkalinity. Mostly shallow (< 4 ft.) and then with complete oxygen depletion in winter. Bottom mud either a sapropel or a gyttja.

Vegetation: Often surrounded by eutrophic Typha marsh. From shore to center of open water the following sequence: a bell of Scirpus validus, a generally narrow fringe of Sagittaria (S. cuneata and/or S. latifolia), along edge between emergent vegetation and open water a fringe of duckweeds, mainly Lemna minor and L. trisulca. Instead of this sequence, there may be under disturbed conditions, as by cattle, a prevalence of Callitriche palustris. In the open water, there is a dense vegetation of submerged aquatics, close to the shore often mainly Potamogeton pusillus s. lat., further out P. pectinatus, P. perfoliatus, and Myriophyllum exalbescens. Other species are Potamogeton filiformis, P. zosteriformis, and Zanichellia palustris.

The vascular plants are often densely overgrown with filamentous green algae, especially towards the end of the growing season.

Fauna: Distinguished by high frequency of snails (Lymnaea spp.) and absence of fresh-water clams (Unionidae).

5b. Äfja water. In water chemistry, the lack of fresh-water clams and frequency of snails identical with eutrophic water. Differing from it, however, in the bottom deposit being an äfja instead of a sapropel or gyttja and in the essential lack of vascular plants.

5c. Mesotrophic water. Water colorless to humus-stained, of moderately acid to circumneutral reaction, of low to moderate electrolyte content and alkalinity. Even when shallow ($\angle$ 4 ft.) in winter with wide oxygen range, from complete depletion to supersaturation. Bottom mud a gyttja, without hydrogen smell or strong methane development.

As other water bodies, mesotrophic waters are differentiated into zones, corresponding to differences in water depth and the degree of exposure. In sheltered situations, corresponding to the conditions described above for the eutrophic water, there occurs the most intricate zonation and the largest variety of species. Landward, the mesotrophic water is contiguous with mesotrophic marsh, often of floating mat character, or by wet fen. Contiguous is a belt of emergent vegetation with Scirpus validus, Eleocharis palustris, Juncus militaris, Equisetum fluviatile. On its outer edge locally some Lemna minor, or Spirodela polyrhiza, scattered plants of Sagittaria latifolia, or in places large areas of Zizania aquatica. Outside and between the emergent vegetation,

a dense vegetation of both floating-leaf and submerged aquatics. The former include commonly Potamogeton natans, Nuphar variegatum, and Sparganium fluctuans; more local is Brasenia Schreberi. Among the latter is a large number of species, including Potamogeton zosteriformis, P. pusillus s. lat., P. obtusifolius, Myriophyllum Farwellii, M. verticillatum, Elodea canadensis, Ceratophyllum demersum, Megalodonta Beckii, Najas flexilis, Utricularia vulgaris.

Along exposed shores, the marsh is replaced by an openly vegetated lake beach. Below, in shallow water with firm mineral bottom, there is a belt of open vegetation with Isoetes muricata and Potamogeton spirillus. Where the water becomes 2 to 3 feet deep, these are replaced by Potamogeton perfoliatus and Vallisneria americana. Frequent in shallow water in both exposed and sheltered conditions is Scirpus subterminalis. Further away from the shore, there may be large stands of Potamogeton amplifolius.

Fauna: Distinguished by low frequency of snails and considerable abundance of fresh-water clams.

5d. Dys-oligotrophic waters. Classified as belonging into this landscape unit are both dystrophic and oligotrophic water bodies and intergrades between them. Water humus-stained, of strongly acid to circumneutral reaction, of low electrolyte content and alkalinity. Bottom mud is either a dy or a gyttja.

Dysoligotrophic waters are in contact with either bog or fen. Most prominent in the vegetation are the insectivorous Utricularia vulgaris and the floating-leaf aquatics Nuphar variegatum, Potamogeton natans, and

Sparganium fluctuans. Submerged aquatics, such as Potamogeton spp. or Myriophyllum spp. are poorly represented. Under more extremely dystrophic conditions, vascular plants are frequently represented only by Nuphar variegatum or may be lacking entirely.

6. Marsh

Dominants are tall rhizome heliophytes growing in dense stands. After death, above-ground parts remain attached to the plants, often standing upright through the winter, and form ultimately the raw material for peat formation. The soil surface is at least during the wet season and frequently throughout the year covered by water. The soil is generally an actively growing peat, either shallowly overlaying the mineral soil or, more frequently, forming together with rhizomes and roots a floating mat.

Dominant over wide areas, occasionally in association with Scirpus validus, is Typha glauca; it is locally replaced by Typha angustifolia. Landward, under somewhat drier conditions, dominants are Sparganium eurycarpum, Acorus Calamus, tall sedges (espec. Carex rostrata), or Phragmites communis, Typha latifolia, elsewhere dominant over large areas, is found in the Chignecto Wetlands only in small patches, generally under less wet conditions than the first two species.

Other typical marsh plants are Sium suave, Cicuta bulbifera, Lysimachia terrestris, Scutellaria epilobiifolia, Lycopus uniflorus, and Utricularia intermedia.

6a. Eutrophic marsh. Soil and water of relatively high base and salt content. Soil mineral or a shallow peat (< 2 ft. from peak surfaces to surface of mineral subsoil), never a floating mat. Vegetation distinguished by the lack of fen species and other species typical of acid, nutrient-poor conditions.

6b. Mesotrophic marsh. Soil and water of moderately high base content. Soil a rather deep peat (> 2 feet from peat surface to mineral soil), generally a floating mat. Vegetation with a component of species typical of acid, nutrient poor conditions, such as Myrica Gale, Potentilla palustris, Menyanthes trifoliata, Lysimachia thyrsiflora, Hypericum virginicum, and Calla palustris.

7. Fen

Dominants include low to medium-sized delicate Cyperaceae, Myrica Gale, Potentilla palustris, Menyanthes trifoliata, and bryophytes (espec. Sphagnum spp.). Soil an actively growing peat, either shallowly overlaying a mineral subsoil or forming, together with shoots and rhizomes, a floating mat. The peat is water-logged up to the surface or shallowly covered by water. There are little or no seasonal changes in water-levels relative to the soil surface, the peat layer either expands and contracts or rises and falls with changes in absolute levels.

7a. Wet fen. Soil surface throughout the year covered largely by about 2 to 4 inches of water. Dominants different spp. of Carex, including C. lasiocarpa, C. chordorrhiza, C. canescens, C. limosa; other species

are Eriophorum tenellum, E. Chamissonis, Myrica Gale, Vaccinium macrocarpon, Menyanthes trifoliata, Potentilla palustris, and a number of species widely in wetlands of the area with high to moderate base and electrolyte content, including Galium palustre, Lysimachia terrestris, Hypericum virginicum, Iris versicolor, and Rumex orbiculatus. Sphagna occur only in occasional patches. The moss Mnium cincloides is locally important.

7b. Sphagnum fen. Soil water-logged up to the surface but not covered with water throughout the year. Dominant components of the vegetation are different species of Sphagnum. Other species are Carex limosa, Rhynchospora alba, Eriophorum virginicum, Scheuchzeria palustris, Chamaedaphne calyculata, Ledum groenlandicum, Smilacina trifolia, Calopogon pulchellus, Pogonia ophioglossoides, and Aster nemoralis.

8. Bog

Dominants include Sphagnum mosses, lichens, heath shrubs, black spruce and larch. Soil a thick and compact peat, composed mainly of Sphagnum, which may either be actively growning or stagnant. The soil is water-logged up to or close to the surface throughout the year.

8a. Sphagnum bog. Sphagnum spp. dominant, heath shrub layer low and open, lichen component patchy. Peat actively growing; towards the surface light-colored and composed of well-preserved plant structures. Soil water-logged up to the surface. Dominant species include Sphagnum fuscum, Sphagnum rubellum, Empetrum nigrum, Kalmia angustifolia,

Chamaedaphne calyculata, Gaylussacia baccata, G. dumosa, Vaccinium oxycoccos, Rubus Chamaemorus, Eriophorum spissum, Scirpus cespitosus, Arethusa bulbosa. Scattered throughout are stunted shrubs of Larix laricina and Picea mariana.

8b. Heath bog. Heath shrubs and/or lichens dominant; Sphagnum spp. less prominent. Less active peat growth; towards the surface peat may be dark-colored, due to decomposition and humification. Soil water-logged close to the surface. Dominant species include the heath shrubs Kalmia angustifolia, Ledum groenlandicum, Chamaedaphne calyculata, Gaylussacia baccata, and the lichens Cladonia alpestris, C. mitis, C. rangiferina. Throughout, Larix laricina and/or Picea mariana, generally less stunted than in the Sphagnum bog.

May contain an open stand of upright-growing larch and/or black spruce and is then referred to as Wooded Heath Bog. Soil conditions and lower strata of vegetation are similar to the Heath Bog without tree layer; cover of heath shrub is, however, denser and taller and lichen are less prominent, while the liverwort Ptilidium cilvare may be dominant.

In the bogs of the area, there is a concentric zonation. The central part is occupied by Sphagnum Bog. Towards the periphery this grades into Heath Bog and further into Wooded Heath Bog and locally even into Bog Forest, with the dominance shifting from black spruce to larch. Outside of the trees, there is a belt of tall shrubs, mainly Nemopanthus mucronata, followed by a belt of heath shrubs, generally Rhododendron canadense, which on the outside is contact with other, less dystrophic landscape units, surrounding the bog.

Appendix III. Bird species of the Chignecto Coastal Lowlands.

Note: This list is based mainly on the publication by Boyer . Species which occur regularly in the proper habitat and season are set out, while species which are occasional or irregular have been indented. Not included are species of the adjacent upland areas and of the sea coast habitat of Northumberland Strait which both may fly mor or less regularly over the area or may occasionally alight in it.

Common loon (Gavia immer)
Pied-billed grebe (Podilymbus podiceps)
Great blue heron (Ardea herodias)
    Little blue heron (Florida caerulea)
    Black-crowned night heron (Nycticorax nycticorax)
    Least bittern (Ixobrychus exilis)
American bittern (Botaurus lentiginosu)
Canada goose (Branta canadensis)
    Snow goose (Chen hyperborea)
Black Duck (Anas rubripes)
Mallard (Anas platyrhynchos)
Pintail (Anas acuta)
    Common teal (Anas crecca)
Green-winged teal (Anas carolinensis)
Blue-winged teal (Anas discors)
American widgeon (Mareca americana)
    Shoveler (Spatula clypeata)
Wood duck (Aix sponsa)
Ring-necked duck (Aythya collaris)
    Greater scaup (Aythya marila)
    Lesser scaup (Aythya affinis)
Common goldeneye (Bucephala clangula)
    Bufflehead (Bucephala albeola)
    Ruddy duck (Ox yura jamaicensis)
    Hooded merganser (Lophodytes cucullatus)
Common merganser (Mergus merganser)
Red-breasted merganser (Mergus serrator)

Appendix III. Bird species of the Chignecto Coastal Lowlands. (continued)

Rough-legged hawk (Buteo lagopus)

Bald eagle (Haliaeetus leucocephalus)

Marsh hawk (Circus cyaneus)

Osprey (Pandion haliaetus)

Peregrine falcon (Falco peregrinus)

Virginia rail (Rallus limicola)

Sora (Porzana carolina)

Yellow rail (Coturnicops noveboracensis)

American coot (Fulica americana)

Semipalmated plover (Charadrius semipalmatus)

Killdeer (Charadrius vociferus)

American golden plover (Pluvialis dominica)

Black-bellied plover (Squatarola squatarola)

Common snipe (Capella gallinago)

Whimbrel (Numenius phaeopus)

Spotted sandpiper (Actitis macularia)

Solitary sandpiper (Tringa solitaria)

Greater yellowlegs (Totanus melanoleucus)

Lesser yellowlegs (Totanus flavipes)

Pectoral sandpiper (Erolia melanotos)

White-rumped sandpiper (Erolia fuscicollis)

Least sandpiper (Erolia minutilla)

Dunlin (Erolia alpina)

Short-billed dowitcher (Limnodromus griseus)

Semipalmated sandpiper (Ereunetes pusillus)

Hudsonian godwit (Limosa haemastica)

Avocet (Recurvirostra americana)

Great black-backed gull (Larus marinus)

Herring gull (Larus argentatus)

Ring-billed gull (Larus delawarensis)

Bonaparte's gull (Larus philadelphia)

Black tern (Chlidonias niger)

Appendix III. Bird species of the Chignecto Coastal Lowlands (concluded)

Snowy owl (Nyctea scandiaca)
Short-eared owl (Asio flammeus)
Common night hawk (Chordeiles minor)
Chimney swift (Chaetura pelagica)
Belted kingfisher (Megaceryle alcyon)
Horned lark (Eremophila alpestris)
Tree swallow (Iridoprocne bicolor)
Bank swallow (Riparia riparia)
Barn swallow (Hirundo rustica)
Cliff swallow (Petrochelidon pyrrhonota)
Common raven (Corvus corax)
Common crow (Corvus brachyrhynchos)
Black-capped chickadee (Parus atricapillus)
Long-billed marsh wren (Telmatodytes palustris)
Short-billed marsh wren (Cistothorus platensis)
Water pipit (Antus spinoletta)
Northern shrike (Lanius excubitor)
Yellow warbler (Dendroica petechia)
Palm warbler (Dendroica palmarum)
Bobolink (Dolichonyx oryzivorus)
Eastern meadowlark (Sturnella magna)
Redwinged blackbird (Agelaius phoeniceus)
Brown-headed cowbird (Molothrus ater)
Savannah sparrow (Passerculus sandwichensis)
Sharp-tailed sparrow (Ammospiza caudacuta)
Tree sparrow (Spizella arborea)
Lincoln's sparrow (Melospiza lincolnii)
Swamp sparrow (Melospiza georgiana)
Song sparrow (Melospiza melodia)
Lapland longspur (Calcarius lapponicus)
Snow bunting (Plectrophenax nivalis)

Harries, H

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1969

Harries, H
Ecological survey of the Chignecto Coastal Lowlands.

Name

Date