United States Department of Agriculture

Forest Service

Pacific Northwest Research Station

Research Note PNW-RN-536

February 2003

Calcareous Fens in Southeast Alaska

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Abstract

Calcareous fens have not been identified previously in southeast Alaska. A limited survey in southeast Alaska identified several wetlands that appear to be calcareous fens. These sites were located in low-elevation discharge zones that are below recharge zones in carbonate highlands and talus foot-slopes. Two of six surveyed sites partly met the Minnesota Department of Natural Resources water chemistry criteria for calcareous fens, with pH values of 6.7 to 7.4 and calcium concentrations of 41.8 to 51.4 mg/L but fall short with regard to specific conductivity (315 to 380 µS/cm). Alkalinity was not determined. The vegetation was predominately herbaceous, with abundant Sitka sedge (*Carex aquatilis*) and scattered shrubs such as Barclay's willow (*Salix barclayi*) and redosier dogwood (*Cornus sericea* ssp. *sericea*). The taxa found in these fens have been reported at other sites in southeast Alaska, although many were at the southern limits of their known ranges. The soils were Histosols composed of 0.6 to greater than 1 m of sedge peat. We found no evidence of calcium carbonate precipitates (marl or tufa) in the soil.

Keywords: Alaska (southeast), fens, calcareous fens, wetlands, peatlands, karst.

Introduction

Calcareous fens, a subtype of extremely rich fen, are important because of their rarity, their distinctive water chemistry, and because they frequently harbor rare or endangered plants (Calcareous Fen Technical Committee 1994). Leete (1993) suggests that calcareous fens may be the rarest of all North American wetland types. In recognition of these unique values, at least one state, Minnesota, has enacted special legislative protection for this wetland type in the Minnesota Wetlands Conservation Act (1991). Despite the widespread co-occurrence of wetlands and carbonate bedrock in southeast Alaska, calcareous fens have not been identified to date in this region (Lawrence 1958, Neiland 1971, Reiners and others 1971, Stephens and others 1970) or in adjacent north-coastal British Columbia (Banner and others 1987, 1988), although Shephard (1995) has described rich fens on the Yakutat Foreland of southeast Alaska. In this paper, we report the results of a small-scale survey in southeast Alaska that identified several wetlands that appear to be calcareous fens.

Calcareous fens have been described in northern Europe and Great Britain (Boyer and Wheeler 1989, Maas 1989, Tyler 1984) and in the Midwestern United States (Bultman 1992, Calcareous Fen Technical Committee 1994, Pearson and Loeschke

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1992), but the term "calcareous fen" does not appear in the national system of wetland classification (Calcareous Fen Technical Committee 1994). The Canadian Wetland Classification System (National Wetlands Working Group 1988) describes "extremely rich fens," a category that appears to include calcareous fens. A review group convened by the Minnesota Department of Natural Resources recently developed a set of criteria for identifying and delineating calcareous fens based on hydrology, water chemistry, soils, and vegetation (Calcareous Fen Technical Committee 1994). By their criteria, calcareous fens are wetlands that receive continuous groundwater discharge that is calcium enriched through contact with carbonate-containing bedrock or glacial deposits and is sufficient to maintain soil saturation. Histosols (or at least histic epipedons) develop under these conditions and often contain calcium carbonate precipitates such as tufa or marl. Water chemistry criteria include pH ≥ 6.7, calcium concentration ≥ 30 mg/L, alkalinity ≥ 1.65 milliequivalents/L, dissolved oxygen ≤ 2.0 mg/L, and specific conductance of ≥ 500 µS/cm. Their vegetation criterion defines minimum percentage of cover or summed index values of 28 calciphile indicator species (Calcareous Fen Technical Committee 1994).

Wetlands are common throughout much of southeast Alaska. For example, the 6.9-million-ha Tongass National Forest is 30 percent wetlands, three-fourths of which are palustrine systems (USDA Forest Service 1991). By far the most common palustrine wetland is that which is colloquially called "muskeg," which is often a complex system of raised and blanket bogs, open pools, forested wetlands, and poor fens (Neiland 1971). The groundwater within these wetlands is highly acidic and nutrient poor, and their productivity is correspondingly low. Extensive areas (ca. 207 690 ha) underlain with very pure carbonate bedrock are found on Chichagof, Kuiu, Hecata, and Prince of Wales Islands in southeast Alaska. In these areas, wetlands are found mostly over inclusions of poorly drained noncarbonate rocks or on compacted glacial deposits overlying carbonates (Baichtal 1993). We surmised that the juxtaposition of wetlands and carbonates in these areas could lead to the formation of extremely rich or calcareous fens, so we conducted a limited survey to seek out such sites. Our survey objectives were to ascertain whether calcareous fens—as defined by a subset of the Minnesota criteria (Calcareous Fen Technical Committee 1994)—exist in southeast Alaska and, if so, to characterize their hydrogeology, vegetation, soils, water chemistry, and landscape context.

Methods

We first reviewed aerial photos and geologic and topographic maps to identify areas with suitable lithology, landforms, and vegetation. We examined Prince of Wales, Hecata, Coronation, Kosciusko, and Chichagof Islands and found candidate sites on all of them. Generally these sites were low-lying discharge areas receiving groundwater from uphill recharge areas in carbonate highlands and talus foot-slopes. We made field visits to sites on Hecata Island and northern Chichagof Island during July 1994 (table 1) and observed water chemistry, vegetation, and soils.

We measured surface water pH and temperature in the field with a Beckman Model Phi 12 pH/ISE meter, specific conductivity with an Orion Model 122 conductivity meter, and dissolved O_2 with an Orion Model 840 dissolved-oxygen meter.[2] Instruments were

[2] The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

Table 1—Location and area of study sites, Hecata Island and Chichagof Island, Alaska

Site name	Location	Latitude	Longitude	Elevation	Area
				Meters	*Hectares*
Timber Knob	Hecata Is.	55°44′15″	133°35′15″	207	2.0
Bald Mountain	Hecata Is.	55°43′37″	133°34′40″	168	6.8
Cone Peak	Hecata Is.	55°46′15″	133°38′50″	23	10.0
Freshwater Creek	Chichagof Is.	57°57′35″	135°19′5″	122	6.0
Beaver	Chichagof Is.	57°57′30″	135°18′5″	91	8.0
Game Creek	Chichagof Is.	57°57′35″	135°25′20″	107	34.0

calibrated with appropriate standards at each site prior to taking measurements. Water samples were collected for later analysis by flame atomic absorption spectrophotometry for total calcium and magnesium.

We identified and recorded the vascular plant species present at the sites where the surface water appeared to meet our tentative criteria for calcareous fens (circumneutral-to-alkaline pH, specific conductivity greater than 300 µS/cm). Voucher specimens for some species were collected and placed in the University of Alaska (Fairbanks) herbarium. Klinka and others (1989) and Hultén (1968) were used to determine if species were known indicators of calcium-rich or alkaline soil.

Soil pits or soil-auger cores were used to determine soil characteristics and peat depth at each site. Sample locations were chosen based on surface features. We tested for the presence of marl or tufa by treating suspected samples with dilute hydrochloric acid and noting whether effervescence occurred.

Results and Discussion

Hydrogeology and Water Chemistry

Only the Freshwater Creek and Game Creek sites on northern Chichagof Island met our pH and conductivity criteria. Both of these minerotrophic (receiving groundwater from mineral soil) fens were downhill from limestone or marble ridges. Surface water on the upper ridges descends in streams from the alpine zone or emerges from caves and fissures high on the slope, only to disappear below the surface as it enters talus fields or karst features on the midslopes. Fens form along the base of the slopes where the water discharges in seeps and springs. The surface of the Freshwater Creek fen was very moist or wet throughout, but the Game Creek fen contained several terraces or levels that varied in surface moisture and, hence, vegetation. The third Chichagof Island site (Beaver) had a landscape position similar to the others, but appeared to have originated as a beaver pond.

With a single site visit, we could only infer continuous discharge from the deep peat accumulations and the large uphill recharge areas. We found no evidence of the floating mats that are observed in many Midwestern calcareous fens (Calcareous Fen Technical Committee 1994). Small channels were present in both fens, and it appeared that water flowed from the fens both as surface stream flow and groundwater discharge.

The Freshwater Creek and Game Creek fens (table 2) meet the criteria for pH (≥ 6.7) and calcium concentration (≥ 30 mg/L), but fall short of the Minnesota requirements for specific conductivity (≥ 500 µS/cm). Alkalinity was not determined. Because the dissolved oxygen levels were determined in surface waters, the values cannot be

Table 2—Characteristics of water samples collected at three sites in southeast Alaska

Site	Temperature	Conductivity	pH	Dissolved O_2	Ca	Mg
	°Celsius	*μS/cm*		- - - - - - *mg/L*	- - - - - -	
Beaver	15.1	184	6.3	4.1	29.9	2.24
Freshwater Creek	9.0	315	7.3	10.2	41.8	12.80
Game Creek pool	10.5	336	7.4	9.8	49.1	6.33
Game Creek seep	13.1	380	6.7	3.1	51.4	8.38

compared with the criteria for ground water. Thus, the water chemistry data do not entirely support the conclusion that the Freshwater Creek and Game Creek sites are calcareous fens. The Minnesota criteria, however, should be viewed only as preliminary guidelines when applied to Pacific coastal wetlands until further work defines the appropriate criteria for this region.

Plant Communities

The vegetation at the Freshwater Creek fen (table 3) was almost entirely herbaceous, very rich in species (52 species), and had an unusually high vegetation biomass. The sedge *Carex aquatilis* was dominant through much of the fen, with other *Carex* species and *Eriophorum russeolum* becoming more common at the fen edges. Of the species found, only *Cystopteris montana* is uncommon in Alaska and has been identified as an indicator of calcium-rich soils (Hultén 1968).

The vegetation pattern at the Game Creek fen (table 3) was more complex than that at Freshwater Creek. It was dominated by herbaceous plants, but included clumps of Barclay willow (*Salix barclayi*). We found 47 species in all, including several species noted as calciphiles: *Cystopteris montana*, *Carex flava* (Hultén 1968), *Deschampsia cespitosa*, *Dodecatheon pulchellum*, and *Parnassia fimbriata* (Klinka and others 1989).

These fens can be classified floristically as the Sitka sedge/forb community type.[3] Both fens lacked the *Pinus*, *Sphagnum*, ericaceous shrubs, and hummocky microrelief common in most other palustrine wetlands in this region. All the taxa found in these fens have been found at other sites in southeast Alaska, although many are at the southern limits of their known ranges. This finding is consistent with vegetation descriptions of Midwestern calcareous fens that support plants commonly found in more northern regions (Leete 1993). We found no threatened or endangered plant species, but *Cystopteris montana* and *Eriophorum viridicarinatum* have been collected from very few sites in southeast Alaska.

Soils

The Freshwater Creek site had more than 1 m of sedge peat accumulated at the center of the fen. The upper 40 cm was fibric (organic soil with mostly recognizable plant fibers); below that the peat became sapric (organic soil with few recognizable plant fibers). Nearer the fen margins, peat depths decreased to 50 to 60 cm overlying marine silt and glacial till. Fragments of wood were found at the base of one auger hole.

[3] U.S. Department of Agriculture, Forest Service. 1994. Game Creek watershed analysis report. Tongass National Forest, Chatham Area. Unpublished report. On file with: Tongass National Forest, 204 Siginaka Way, Sitka, AK 99835-7316.

Table 3—Wetland indicator status of vascular plants present in Freshwater Creek (FC) and Game Creek (GC) fens

Scientific name[a]	Common name	Indicator category[b]	FC	GC
Aconitum delphiniifolium DC.	larkspurleaf monkshood	FAC	X	
Actaea rubra (Ait.) Willd.	red baneberry	NC	X	
Agrostis aequivalvis (Trin.) Trin.	arctic bentgrass	OBL*		X
Agrostis exarata Trin.	spike bentgrass	FACW	X	X
Alnus rubra Bong.	red alder	FAC	X	
Androsace chamaejasme Wulfen	sweetflower rockjasmine	FACU		
Anemone parviflora Michx.	smallflowered anemone	FACU		
Anemone richardsonii Hook.	yellow thimbleweed	FAC	X	
Angelica genuflexa Nutt.	kneeling angelica	FACW	X	X
Arabis lyrata L.	lyrate rockcress	FACU		
Arctagrostis latifolia (R. Br.) Griseb.	wideleaf polargrass	FACW	X	X
Artemisia arctica Less.	boreal sagebrush	NC		
Athyrium filix-femina (L.) Roth	subarctic ladyfern	FAC	X	
Caltha palustris L.	yellow marsh marigold	OBL	X	X
Canadanthus modestus (Lindl.) Nesom	giant mountain aster	FAC		X
Cardamine oligosperma Nutt.	umbel bittercress	FACW	X	
Carex anthoxanthea J. & K. Presl	grassyslope arctic sedge	FACW	X	
Carex aquatilis Wahlenb.	Sitka sedge	OBL	X	X
Carex echinata Murr.	star sedge	OBL	X	X
Carex flava L.	yellow sedge	OBL		X
Carex pluriflora Hultén	manyflower sedge	OBL	X	
Castilleja unalaschcensis (Cham. & Schlecht.) Malte	Alaska Indian paintbrush	FAC		X
Chrysosplenium tetrandrum (Lund ex Malmgr.) Th. Fries	northern golden saxifrage	OBL	X	
Circaea alpina L.	small enchanter's nightshade	FACW	X	
Comarum palustre L.	purple marshlocks	NC	X	
Coptis aspleniifolia Salisb.	fernleaf goldthread	FAC	X	
Cornus sericea L. ssp. *sericea*	redosier dogwood	FAC		X
Cystopteris montana (Lam.) Bernh. ex Desv.	mountain bladder fern	FAC	X	X
Deschampsia caespitosa (L.) Beauv.	tufted hairgrass	FAC		X
Dodecatheon jeffreyi Van Houtte	Sierra shootingstar	FACW		
Dodecatheon pulchellum (Raf.) Merr.	darkthroat shootingstar	FACW		X
Elymus hirsutus J. Presl	northern ryegrass	NC		
Epilobium ciliatum Raf. ssp. *ciliatum*	fringed willowherb	FACU		X
Epilobium ciliatum Raf. ssp. *glandulosum* (Lehm.) Hoch & Raven	fringed willowherb	NC	X	X
Epilobium palustre L.	marsh willowherb	OBL	X	X
Equisetum arvense L.	field horsetail	FACU	X	
Equisetum fluviatile L.	water horsetail	OBL		X
Equisetum pratense Ehrh.	meadow horsetail	FACW		X
Erigeron humilis Graham	arctic alpine fleabane	FACW		
Erigeron peregrinus (Banks ex Pursh) Greene	subalpine fleabane	FACW	X	X
Eriophorum russeolum Fries ex Hartman	red cottongrass	FACW	X	X
Eriophorum viridicarinatum (Engelm.) Fern.	thinleaf cottonsedge	OBL		X
Fritillaria camschatcensis (L.) Ker-Gawl.	Kamchatka fritillary	FAC	X	X
Galium triflorum Michx.	fragrant bedstraw	FACU	X	X

Table 3—Wetland indicator status of vascular plants present in Freshwater Creek (FC) and Game Creek (GC) fens (continued)

Scientific name[a]	Common name	Indicator category[b]	FC	GC
Gentiana platypetala Griseb.	broadpetal gentian	NC		
Geranium erianthum DC.	woolly geranium	NC		X
Heracleum maximum Bartr.	common cowparsnip	FACU	X	X
Hieracium triste Willd. ex Spreng.	woolly hawkweed	NC		
Hierochloe odorata (L.) Beauv.	vanilla grass	FACU		X
Hippuris vulgaris L.	common mare's-tail	OBL	X	X
Leptarrhena pyrolifolia (D. Don) R. Br. ex Ser.	fireleaf leptarrhena	FACW	X	
Luzula wahlenbergii Rupr.	Wahlenberg's woodrush	OBL	X	X
Lysichiton americanus Hulten & St. John	American skunkcabbage	OBL	X	X
Malaxis brachypoda (Gray) Fern	white adder's-mouth orchid	FACW	X	X
Malus fusca (Raf.) Schneid.	Oregon crabapple	FACU		X
Menyanthes trifoliata L.	buckbean	OBL	X	X
Mimulus guttatus DC.	seep monkeyflower	OBL	X	
Mitella pentandra Hook.	fivestamen miterwort	FACW	X	
Nephrophyllidium crista-galli (Menzies ex Hook.) Gilg	deercabbage	FACW	X	
Osmorhiza purpurea (Coult. & Rose) Suksdorf	purple sweetroot	FACU*	X	
Parnassia fimbriata Koenig	fringed grass of Parnassus	FACW		X
Pedicularis oederi Vahl ex Hornem.	Oeder's lousewort	NC		
Platanthera dilatata (Pursh) Lindl. ex Beck	scentbottle	FACW	X	X
Platanthera stricta Lindl.	slender bog orchid	FACW	X	X
Pyrola minor L.	snowline wintergreen	FAC		
Ranunculus eschscholtzii Schlecht.	Eschscholtz's buttercup	FACW		
Ranunculus uncinatus D. Don ex G. Don	woodland buttercup	FACW	X	
Rubus arcticus L.	arctic blackberry	FAC		X
Rumex aquaticus L.	western dock	OBL	X	
Salix barclayi Anderss.	Barclay's willow	FAC		X
Salix sitchensis Sanson ex Bong.	Sitka willow	FAC		X
Sanguisorba canadensis L.	Canadian burnet	FACW	X	X
Sanguisorba menziesii Rydb.	Menzies' burnet	FAC		X
Saxifraga adscendens L.	wedgeleaf saxifrage	UPL*		
Saxifraga lyallii Engl.	redstem saxifrage	FACW	X	
Saxifraga oppositifolia L.	purple mountain saxifrage	FAC		
Scirpus microcarpus J. & K. Presl	panicled bulrush	OBL		X
Senecio moresbiensis (Calder & Taylor) G.W. Douglas & G. Ruyle-Douglas	cleftleaf ragwort	NC		
Senecio triangularis Hook.	arrowleaf ragwort	FACW	X	X
Silene acaulis (L.) Jacq.	moss campion	UPL		
Stellaria borealis Bigelow ssp. *borealis*	boreal starwort	FACW	X	
Stellaria crispa Cham. & Schlecht.	curled starwort	FAC	X	
Swertia perennis L.	felwort	FAC		X
Taraxacum phymatocarpum J. Vahl	northern dandelion	NC		
Tellima grandiflora (Pursh) Dougl. ex Lindl.	bigflower tellima	NC	X	
Tiarella trifoliata L.	threeleaf foamflower	FAC	X	
Tofieldia coccinea Richards.	northern asphodel	FAC		
Trientalis europaea L.	arctic starflower	FAC	X	X

Table 3—Wetland indicator status of vascular plants present in Freshwater Creek (FC) and Game Creek (GC) fens (continued)

Scientific name[a]	Common name	Indicator category[b]	FC	GC
Urtica dioica L.	stinging nettle	FACU	X	
Vahlodea atropurpurea (Wahlenb.) Fries ex Hartman	mountain hairgrass	FAC	X	
Viburnum edule (Michx.) Raf.	squashberry	FACU		X
Viola biflora L.	arctic yellow violet	FACW		
Viola glabella Nutt.	pioneer violet	FACW	X	

[a] Plant names are from USDA NRCS (2001).

[b] Plant wetland indicator status from Reed (1988): OBL: obligate wetland, FACW: facultative wetland, FAC: facultative, FACU: facultative upland, UPL: obligate upland. NC: not categorized. An asterisk (*) following a category code identifies a tentative assignment based on limited information.

Their presence could indicate a shift from forest to fen, the toppling of trees outside of the fen margin, or wood transported during mass wasting events. Further sampling would be required to determine the source of this wood. The depth of sedge peat at the Game Creek site was generally over 1 m. Layers and lenses of silt and fine sand mixed with organic material were common near the uphill boundary of the fen. This material was water-deposited organic matter and carbonate sediments, and it probably was deposited during flooding of nearby streams. Soils at both Freshwater Creek and Game Creek were Histosols and therefore meet the soil criterion for calcareous fens. We found no evidence of calcium carbonate precipitates (marl or tufa) in our sampling. Discussing calcareous fens described in the Midwestern United States and Great Britain, Almendinger and Leete (1998) note that the presence of precipitated calcium carbonate was not always reported.

Wildlife Use

We did not conduct formal surveys of wildlife use at these sites. However, we casually observed evidence of extensive use by large mammals (brown bear, wolves, and Sitka blacktail deer), including well-worn trails, crushed and matted vegetation, and scat. The tall, dense vegetation could serve both as forage and cover.

Conclusions and Management Implications

The evidence for classifying these wetlands as calcareous fens is equivocal, and we question whether criteria developed for the Midwestern United States can be applied to southeast Alaska without refinement of the criteria by local geochemistry, hydrogeology, and vegetation studies. The climate and landscape of southeast Alaska differ greatly from those of the upper Midwest, and this is likely to lead to important differences in wetland characteristics (see, for example, D'Amore and Lynn (2002) for differences in peat). In any case, whether these and similar sites are ultimately classified as true calcareous fens or as extremely rich fens is unimportant. What is important is that these fens are uncommon habitats that contribute to the regional biological diversity of southeast Alaska, and it is likely that they have ecological functions different from the ubiquitous forested wetlands, bogs, and poor fens.

Resource managers guided by the principles of ecosystem management seek to maintain biological diversity—in part by protecting exceptional or uncommon habitats (USDA Forest Service 1992). It follows that management activities in the recharge zones and areas near calcareous or extremely rich fens should be closely scrutinized, at least until better information is available on the distribution and abundance of this wetland type. Leete (1993) cites two key features necessary for the maintenance of calcareous fens: protection from surface disturbance and protection of the groundwater source. Foot and vehicle trails are common surface disturbances that channel surface-water flow and promote peat erosion. If adjacent timber stands are harvested, yarding of logs across fens could cause significant surface damage. Because calcareous fens depend on the upwelling of calcium-enriched groundwater, management activities may degrade these wetlands if they impede the movement of water into recharge areas or alter groundwater flows toward the discharge zone. The greatest potential threats come from road construction, ditching, and gravel or rock pit excavation, all of which are common activities on forested lands in this region.

In this study we examined only a handful of sites and a few easily measured variables. More extensive inventories are required to determine the number and distribution of similar sites in southeast Alaska. In addition, we need to better characterize the hydrogeology, water chemistry, vegetation, and wildlife use of these wetlands—in both undisturbed and disturbed conditions—if we are to make sound judgments about their functions, values, and management.

Acknowledgments

Caroline Parker and Michael Shephard provided assistance in the field. David D'Amore, Gregory Nowacki, and Michael Shephard reviewed this manuscript.

English Equivalents

When you know:	Multiply by:	To find:
Centimeters (cm)	0.39	Inches
Meters (m)	3.28	Feet
Square meters (m^2)	1.20	Square yards
Kilograms (kg)	2.21	Pounds
Grams (g)	0.035	Ounces
Hectares (ha)	2.47	Acres
Kilograms per hectare (kg/ha)	0.89	Pounds per acre
Liters (L)	1.057	Quarts
Milligrams per liter (mg/L)	1	Parts per million
Celsius (°C)	1.8 and add 32	Fahrenheit
Microsiemens (µS)	1×10^6	Mho

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