Cedar Hollow, an early Holocene faunal site From Whidbey Island, Washington

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Strata exposed along northern Puget Sound record 3 late Pleistocene glacial cycles, the greatest ice advance occurring approximately 15,000 yr BP during the Fraser Glaciation. By 10,000 yr BP the Fraser ice sheet had retreated north of the 49th parallel, leaving extensive deposits in its wake (Armstrong et al. 1965, Crandall et al. 1965, Easterbrook 1979, 1992, 1994). Whidbey Island’s central isthmus is the only location in Puget Sound that provides a detailed stratigraphic record of the late Pleistocene transition from glacial till to subaerial outwash and glaciomarine drift (Carlstad 1992). The scarcity of fossils has limited our ability to reconstruct faunal changes that occurred following the final retreat of the Cordilleran ice sheet, when the region was inhabited by mammoth, musk oxen, giant sloth, and other large mammals. Avian remains include hawks, geese, and seabirds, 3 groups that occupied quite different ecological niches. Early Holocene bird fossils from Whidbey Island are dissimilar to late Pleistocene avifaunas from inland sites in California and Oregon, evidence that the coastal environment offered habitat conditions quite unlike those of interior wetlands.

The purpose of this paper is to (1) provide a geologic and paleoenvironmental perspective on the fossil site and (2) provide a description of vertebrate paleofauna, including relationships to the modern fauna of the Whidbey Island region. We have divided responsibility for the work roughly as follows: Mustoe—collection of specimens and organization of background information, tables, figures, most references, and authorship of the 1st draft; Harington—identification, description, and discussion of most of the larger vertebrate fossils; Morlan—identification, description, illustration, and discussion of rodent fossils.

SITE DESCRIPTION

Cedar Hollow is located near Point Partridge, the westernmost projection of Whidbey Island. Coastal bluffs lie adjacent to an upland area of extensive kettle topography (Fig. 1). At Cedar Hollow coastal erosion has exposed a cross section of a kettle that is partially filled with dune sands (Fig. 2). In 1991 a brown bear (Ursus arctos) cranium was found near the base of these sand beds. Mustoe and Carlstad (1995) erroneously assumed the age of the fossil to be late Pleistocene based on radiocarbon ages of mollusk shells in glaciomarine drift underlying the dune sand (Easterbrook 1992). We now recognize that the fossiliferous strata were deposited during the early Holocene, as evidenced by dating of a deer vertebra (Odocoileus sp.) collected in 1999 from the bed that contained the bear skull. Collagen extracted from the specimen (Geochron GX-25892-AMS) yielded a radiocarbon age of 8840 ± 50 yr BP (10,009 ± 97 cal yr BP; CALIB v4.1, Stuiver and Reimer 1993). The early Holocene age has
been confirmed by a radiocarbon age of 8280 ± 40 yr BP (Beta Analytic, Inc. 199434) determined for vole bones collected approximately 1 m above the level of the deer vertebra (Polenz et al. 2005).

The basal sand bed at Cedar Hollow has a maximum thickness of 3 m on the southwest slope, decreasing to 0.5 m at the kettle’s lowest point, and pinching out on the northeast slope (Fig. 3). Overlying this stratum is a 0.5-m-thick

Fig. 1. Late Pleistocene kettles are a common landform at central Whidbey Island, but Cedar Hollow is unique because it has been dissected by coastal erosion.
sandy paleosol. The remainder of the kettle fill consists of well-sorted fine sand, separated from the paleosol by a fairly sharp contact. Gradual migration of the dunes in response to prevailing southeasterly winds caused the topographic low to shift northwest from the original kettle bottom. No samples suitable for radiometric dating have been obtained from upper strata, and both the sedimentation rate and the age of the youngest beds are unknown. Cedar Hollow eolian sediments date from a period when the climate was warmer and drier than today, a xerothermic interval that is well documented by macrofossil evidence from lacustrine sediments at Marion Lake, Vancouver, British Columbia, 120 km to the northeast (Wainman and Mathewes 1987; Fig. 3).

METHODS

Fossils were first discovered following the 1990–91 winter after unusually severe storms eroded a channel in the face of the bluff. For the next several years weathering continued to expose new specimens, but slumping of the sandy face eventually buried the fossiliferous strata. Figure 4 shows stratigraphic locations for most specimens collected between 1992 and 1995 and described in this report; not shown are a few additional fossils that were collected from basal strata during preliminary investigation. The seeming scarcity of specimens from middle and upper levels is partly a result of the loose sand and vegetation that obscures these beds. Specimens cataloged with a WWU-P prefix are part of the Western Washington University paleontology research collection. Canada Goose and rodent specimens collected in 1999 by Harington from the northwest flank of Cedar Hollow are labeled with a CR prefix. CMN catalog numbers indicate reference specimens in the collections of the Canadian Museum of Nature, Ottawa.

SYSTEMATIC PALEONTOLOGY

Birds (Class Aves)

Canada Goose (*Branta canadensis*).—CR-99-26 consists of 2 fragments of a right humerus: (1) a proximal portion running from near mid-shaft to a point just below the proximal articular end showing, in anterior view, the
lowermost end of the deltoid crest and the relatively broad convexity right of the lower 2/3 of the crest, as well as the nutrient foramen some 35 mm below the deltoid crest; the specimen compares closely in shape and size (within 0.2 mm in width and depth at midshaft and 1 mm in length, i.e., position of the nutrient foramen below the deltoid crest) to CMN 55031, a modern Canada Goose humerus from Ontario; (2) a smaller portion corresponding to the lower part of the shaft (with the posterior surface being slightly crushed), but which does not quite articulate with the proximal fragment. The surface bone shows a fine network of rootlet tracks, suggesting that after death the goose was buried in grassy surroundings. This specimen probably represents an ancestor of the dusky race that breeds along the southeastern coast of Alaska and makes landfall in southwestern Washington, following the Willamette Valley of Oregon to its wintering grounds (Bellrose 1976).

**Lesser Snow Goose (Chen hyperborea).**—Represented by 4 bones found together, all from the left front portion of the breast: WWU-P-43, proximal half of left scapula; P-44, proximal half of left furculum; P-45, complete left coracoid; P-46, proximal half of left humerus. Size is close to that of an adult female specimen from Eskimo Point, Northwest Territories (CMN-ZIC-35). Whidbey Island is within the present wintering range of Chen hyperborea, its entire range extending from arctic areas of Asia and North America in summer, and south as far as California in winter.

**Hawk (cf. Accipiter sp.).**—WWU-P-27A is a left femur of a hawk similar in size and form to modern specimens of Sharp-shinned Hawk (Accipiter striatus) and Cooper’s Hawk (A. cooperi). Both raptors today inhabit the Whidbey Island region, where they are usually found in fields, open woodlands, and woodland margins. Ranges of these hawks extend from Alaska to Mexico, where their habitats vary from tundra to freshwater marshes in desert regions (Clark and Wheeler 1987).

**Black-legged Kittiwake (Rissa tridactyla).**—WWU-P-48 is a nearly complete left humerus of a gull, lacking the distal spur (Fig. 6C). The maximum length of 87.0 mm is comparable to Rissa tridactyla specimens CMN-S-6061 and CMN-S-5946 from Red Bay, Labrador. Members of this species presently winter offshore along the Pacific Coast, including Whidbey Island (Robbins et al. 1983), breeding on coastal cliffs and headlands of the Arctic Ocean in summer.

**Clark’s Nutcracker (Nucifraga columbiana).**—WWU-P-27B is the distal 3rd of left humerus. The presence of Nucifraga columbiana in an early Holocene coastal environment was unexpected. The species presently winters in the Puget Lowlands (Robbins et al. 1983). Today these birds inhabit coniferous forests from southern British Columbia and Alberta to northern Baja California, most commonly being observed near timberline in mountain regions. They possess a sublingual pouch that allows them to transport seeds, an adaptation that permits nutcrackers to cache their entire food supply for their late winter nesting season. Heinrich (1989) reported that N. columbiana has been observed carrying pine seeds as far
as 22 km, supporting the possibility that the Cedar Hollow specimen came from a foraging visitor rather than an endemic inhabitant.

Tufted Puffin (*Fratercula cirrhata*).—WWU-P-49 is a complete left ulna (Fig. 6D), nearly identical to modern specimen CMN-S5540 from Vancouver Island. Tufted Puffins presently spend each winter at sea in a zone that extends along the Pacific Coast of North America as far south as the northern border of Mexico. Summer breeding grounds range from the Aleutian Islands south to the Queen Charlotte Islands and Vancouver Island, where these birds make nests in burrows in colonies on grassy slopes and headlands or singly or in small colonies in rock crevices on steep sea cliffs. Tufted Puffins are usually found in the company of hundreds or thousands of other seabirds (Harrison 1983).

Mammals (Class Mammalia)

Order Rodentia, Family Cricetidae.—Rodent fossils include individual bones and teeth, as well as elongated clusters that contain well-preserved skeletal elements of several animals of different species (Fig. 5). Jaws commonly contain all of their teeth even in taxa that have rootless molars, and some long bones have epiphyses that are still articulated with the diaphysis. There are no sedimentologic indications that these bone clusters were assembled as a result of eolian or fluvial processes. These assemblages may have originated as pellets regurgitated by owls or other raptors. Investigations of taphonomic characteristics of avian pellets have been summarized by Kusmer (1990), Lyman (1994), Lyman and Lyman (2003), and Lyman and Power (2003). Kusmer (1990) observed that bones recovered from owl pellets typically show little or no fragmentation or surface corrosion, consistent with the pristine Cedar Hollow rodent fossils. In contrast, bones found in modern Falconiforme pellets typically show obvious damage as a result of highly acidic gastric secretions. The following taxonomic identifications were made from assemblages WWU-P-42, WWU-P-54, and WWU-P-62.

Subfamily Cricetinae: Deer mouse (*Peromyscus* cf. *P. maniculatus*): One maxilla and 2 mandibles representing at least 2 individuals are tentatively assigned to *P. maniculatus*, the only species of *Peromyscus* that occurs in the area today. The modern range extends from Alaska to Mexico. These mice are particularly abundant in wooded or brushy environments, but they also inhabit open areas (Dalquest 1948, Hall 1981).

Subfamily Arvicolinae: Voles (*Microtus* spp.): Seven maxillae and 19 mandibles contain a total of 83 molars. Four of the best-preserved specimens are shown in Figure 6. At least 2 species are represented, appearing to have had approximately equal abundance based on
the fossils that we collected. Four maxillae have dentitions characteristic of *Microtus pennsylvanicus* (meadow vole). Three specimens have dentitions similar to that of *Microtus townsendii* (Townsend’s vole). The mandibular molars exhibit considerable morphological variation that makes species assignment difficult. Many of the M₁ molars fall within the range of variation seen in *M. pennsylvanicus*, a widespread, highly variable species (Barnosky 1990, 1994). Some M₁s are most similar to *M. townsendii*.

The genus *Microtus* is listed among many faunal assemblages from archaeological sites in Washington, but it is rarely identified to species (Morlan 2002). *Microtus pennsylvanicus* no longer occurs west of the Cascade Range, but this species is locally abundant on the Columbia Plateau of northeastern Washington, where individuals inhabit marshes and damp meadows (Dalquest 1948, Maser and Storm 1970). There is no obvious reason for the apparent contraction of its range during the Holocene. *Microtus townsendii* inhabits some Puget Sound islands where it lives in meadows and salt marshes and often nests beneath driftwood (Dalquest 1948). The species has been reported previously in late Holocene faunal assemblages on southernmost Vancouver Island (Blacklaws 1979, Hanson 1991) and at the Umpqua-Eden site on the Oregon coast (Lyman 1991).

**ORDER CARNIVORA.—Gray wolf (*Canis lupus*):** Specimen WWU-P-22 is a right mandible (Fig. 7) found on the upper beach at Fort Ebey picnic area near the trailhead to Lake Pondilla, at the base of eolian sand beds that are correlative to Cedar Hollow, 2.5 km to the southeast. Five teeth (RP₂-RM₂) are preserved, with alveoli for M₃, C₁, and 2 incisors (Table 1). Nowak (1983) suggested that wolves migrated to the Cascade Range from the southern Great Plains at the close of the Pleistocene, but bones from a variety of wolf species found at Rancho La Brea and McKittrick, California (Merriam 1912, Schultz 1938) and Fossil Lake, Oregon (Elftman 1931) indicate that wolves were well established in the western United States by this time. Prior to eradication efforts that began in the late 19th century, wolves were the region’s most abundant carnivore; by 1939 Washington’s *C. lupus* population had dwindled to only 10 individuals (Laufer and Jenkins 1989). The Whidbey Island mandible most likely represents an ancestor of the Cascade Mountain wolf, *Canis lupus fuscus* Richardson (1839).

**Brown bear (*Ursus arctos*):** Cedar Hollow provides the 1st evidence of *U. arctos* in western Washington from the early Holocene. The specimen (WWU-P-60; Fig. 8) consists of a large cranial fragment, including 4 teeth. Three detached incisors were found in the adjacent sediment. The dentition compares closely to modern specimens of *Ursus arctos horribilis* (Mustoe and Carlstad 1995).

Harington (1989) noted that brown bears had reached northwestern North America from...
Asia by middle Wisconsinan time when lowered sea level created a land connection (Bering Isthmus) between Siberia and Alaska. This interpretation is based on 2 *U. arctos* specimens from the Yukon that yielded radiocarbon ages of 41,000 ± 1050 and 36,000 ± 1150 yr BP. Kurtén (1976) believed that brown bears migrated to the Pacific Northwest between 12,000 and 11,000 yr BP. However, Churcher and Morgan (1976) identified a partial humerus from middle Wisconsinan till at Woodbridge, Ontario, as *U. arctos*, which they interpreted as evidence that the migration of this species from the Beringia refugium had begun by 40,000 to 50,000 yr BP. Holocene history of *U. arctos* in the Pacific Northwest is poorly known. Of 110 archaeological sites in eastern and central Washington that preserve faunal remains, only 5 contain brown bear bones (Lyman 1986).

**ORDER ARTIODACTYLA.—(Columbian black-tailed deer (Odocoileus cf. *O. hemionus columbianus*): Specimen WWU-P-57 is an atlas vertebra centrum collected approximately 1 m above the kettle's basal contact. Collagen extracted from this bone yielded a radiocarbon age of 8840 ± 50 yr BP (GX-25892-AMS). WWU-P-41 is the distal half of a left humerus, and WWU-P-14 is the diaphysis and fused distal epiphysis of a left tibia. The proximal end of the latter specimen has been crushed by a carnivore or omnivore. These deer bones are presumed to represent *O. hemionus columbianus* because this is the only subspecies known to have inhabited the Puget Lowlands. They

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Fig. 6. Dentition of vole specimens from Cedar Hollow: A, maxillary molars of Townsend’s vole (*Microtus townsendii*); B, C, maxillary molars of meadow vole (*M. pennsylvanicus*); D, E, mandibular molars presumed to be from *M. townsendii*.
are presently the region’s most abundant non-domesticated large mammal, and their remains are common at Holocene archaeological sites.

Mollusks (Class Mollusca)

Shells of *Monadenia fidelis* (sideband land snail) are common fossils found at all stratigraphic levels. Specimens WWU-P-20 and P-51 are shown in Figure 9. The modern range extends from Alaska to central California (Bran son 1977). Cameron (1986) observed that in modern coastal lowlands of British Columbia, *M. fidelis* typically inhabits mull soil (humus that incorporates underlying mineral matter)

Fig. 7. Right mandible of gray wolf (*Canis lupus*) WWU-P-22.
in forests of *Thuja plicata* (western red cedar) and deciduous hardwoods. Perhaps these fossils represent shells of dead snails that were transported into the kettle by wind or rain, but their abundance suggests that they were part of a flourishing local population.

**Discussion**

The early Holocene faunal history of western North America is poorly known (Lyman and Livingston 1983, Graham and Mead 1987). Most early Holocene fossil sites in Washington and Oregon are located east of the Cascade Range at latitudes well south of the maximum extent of the Cordilleran ice sheet, where the absence of topographic and climatic barriers allowed a long history of faunal interchange with the mid-continent region. The Cedar Hollow paleofauna is modern in character, very different from the fauna of the late Pleistocene when the Puget Lowlands were inhabited by *Bison, Mammuthus* (mammoth), *Rangifer* (caribou), *Symbos* (musk oxen), *Megalonyx* (giant sloth), and other large mammals (Harington 1975, 1996, McDonald 1998). The Manis Mastodon site near Sequim on the northern Olympic Peninsula (Gustafson et al. 1979, Petersen et al. 1983, Gustafson 1985, Bergland and Marr 1988) provides a useful comparison. Located 50 km southwest of Cedar Hollow, bog deposits at Manis date from 11,000 to 12,000 yr BP and preserve remains of mastodon, caribou, and muskrat, as well as human artifacts. Mammoth bones and teeth have been found in other late Pleistocene deposits in the local area (Harington 1975, Barton 1998). The final retreat of the Cordilleran ice sheet was accompanied by the extinction of most large mammals, and the Cedar Hollow paleofauna provides evidence of repopulation of the region. Although *Canis lupus* and *Ursus arctos* were driven to extinction during the past century by humans, and...
Microtus pennsylvanicus no longer resides west of the Cascade Range, all other Cedar Hollow fossils are from species that still inhabit central Whidbey Island.

The abundance and diversity of bird bones at Cedar Hollow is noteworthy. The avifauna includes 3 types of birds: raptors that probably fed on small rodents that inhabited the treeless coastal plain, geese that consumed lowland vegetation, and marine birds that primarily fed on fish. Early Holocene avifaunas are scarce and clues for interpreting these fossils come from late Pleistocene sites at Rancho La Brea and McKittrick, California and Fossil Lake, Oregon. These deposits all demonstrate the close relationship between avian remains and local environmental conditions. Asphalt deposits at Rancho La Brea and McKittrick preserve abundant avian remains of scavengers and raptors that were attracted by creatures trapped in the sticky tar. These deposits commonly preserve entire bird skeletons, in contrast to the disarticulated bones found at most other sites. Rancho La Brea has also yielded remains of a diverse array of passerines (perching birds) that indicate open meadows, brush, and woodlands surrounding the asphalt seeps. Bones of ducks, geese, grebes, herons, and other birds constitute only a minor part of the avifauna (Howard and Miller 1939, Stock 1958). McKittrick beds are also rich in predators and scavengers, but 67% of the bird remains come from water birds, representing a site where asphalt pools were part of a much larger wetland environment (Miller 1935). Fossil Lake, Oregon, is similar in age to the California asphalt beds, but the avifauna of this large inland lake is very different: 91% of the specimens are from water birds, and raptor remains comprise less than 1% (Miller 1911, Howard 1946, Allison 1966).

Raptors may have been year-round residents, but the other birds whose remains are preserved at Cedar Hollow presumably migrated great distances between their winter ranges and their summer breeding grounds. Presently, Tufted Puffins, Canada Geese, Lesser Snow Geese, and Black-legged Kittiwake breed at northern latitudes ranging from British Columbia to Arctic Alaska and travel as far south as California during the winter. Do avian remains at Cedar Hollow, Rancho La Brea, McKittrick, and Fossil Lake represent birds that were winter residents, or summer breeding populations that come from a time when migratory species nested far to the south of their present nesting grounds? The presence of continental glaciers must have been a major influence on flight paths and nesting areas, but no research has been conducted on avian migration patterns during the Pleistocene/Holocene transition. Cedar Hollow fossils show that several genera of migratory birds inhabited the Puget Sound region during the early Holocene, but evidence from other locations will be needed before the seasonal cycle and the travel routes of these birds can be determined.

CONCLUSIONS

With the exception of Ursus americanus (black bear) skeletons discovered in a cave on Vancouver Island (Nagorsen et al. 1995), Cedar Hollow contains the only known early Holocene paleofauna west of the Cascade Range. These remains provide evidence of the faunal transitions that occurred following the final retreat of continental glaciation at the close of the Pleistocene. Cedar Hollow is bordered on the west by the Pacific Ocean, on the east by the Cascade Mountains, and to the north by the Cordilleran ice sheet that persisted until approximately 10,000 yr BP (Armstrong et al. 1965, Easterbrook 1992). Despite these obstructions to faunal migration, the Cedar Hollow fossils show that the ecosystem that developed within 2000 years following deglaciation was populated by many of the species that presently inhabit the region.
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