

Palm Fossils from Northwest Washington

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INTRODUCTION

'Ancient forests', 'global climate change', 'destruction of the rain forest'— these phrases appear almost daily in the pages of our newspapers, describing phenomena that are interpreted as important barometers of environmental change. We can also look at these 'barometric' concepts in a very different way, using fossils to study evolutionary progressions that occurred eons before humans arrived on the scene. Plant remains are particularly important for understanding our region's history because they provide an accurate indication of ancient climate and topography, and they are much more abundant than animal fossils.

Cretaceous leaf impressions provide the earliest evidence of Washington plant communities, but our first comprehensive

knowledge of ancient flora comes from the Early Tertiary, when the landscape was dominated by lowland environments conducive to both luxuriant plant growth and preservation of leaf imprints. Fossils from these deposits indicate that semi-tropical rain forests flourished on an extensive plain that existed prior to the rise of the Cascades. The abundance of palm fossils in the Eocene Chuckanut Formation provides prominent evidence that these plant communities were much different from the temperate forests that exist today. These fossils include large leaf imprints, wood casts, and pollen grains (Figs. 1–4). Palm fronds are on display at the Burke Museum (Univ. of Washington) in Seattle and at the Western Washington University Geology Department in Bellingham.

GEOLOGIC SETTING

The Chuckanut Formation consists of nearly 6,000 m of strata exposed in a 20 km by 60 km outcrop belt that extends from Puget Sound to the foothills of the North Cascades in western Whatcom and Skagit Counties (Fig. 5). Johnson (1984) subdivided the Chuckanut Formation into seven stratigraphic members that represent different depositional environments within an ancient fluvial system. Leaf impressions are particularly abundant in siltstones of the Bellingham Bay and Slide Mountain Members. These strata represent wetlands that bordered the ancient river, where the abundance of vegetation and conditions of sedimentation combined to offer an ideal environment for the preservation of fossils. In contrast, the arkosic sandstones and conglomerates that make up much of the Chuckanut Formation were deposited along beaches and river bars; they contain many driftwood impressions but few fossil leaves.

Fission-track dating of detrital zircon grains and volcanic interlayers suggests that Chuckanut sediments were deposited during the Eocene epoch and are younger than the Late Cretaceous–Paleocene age estimate previously deduced from plant fossils (Pabst, 1968). Johnson (1984) estimates that the base of the formation is no older than 55 Ma and the youngest strata were deposited about 40 Ma. He reported a tuff layer, 2,700 m above the base of the formation, that has a fission-track age of 49 ± 1.2 Ma. An interbedded rhyolite flow of uncertain stratigraphic position has been dated at 52.7 ± 2.5 Ma (Whetten and others, 1988).

PALEONTOLOGY

Descriptions of Chuckanut Formation fossils include brief reports by Lesquereux (1859), Newberry (1863, 1898), Knowlton (1902), LaMotte (1938), Chaney (1951), and Butala and Cridland (1973). Pabst (1968) studied fossil ferns, conifers, and horsetails, and her unpublished manuscripts contain de-



Figure 1. Palm frond imprints exposed on a bedding plane in the Mount Baker foothills near Canyon Lake, Whatcom County, Washington.



Figure 2. Cast of palm trunk preserved in growth position, discovered near the summit of Bacon Peak, North Cascades. Photo by R. A. Haugerud, USGS.

scriptions of many flowering plants (Pabst, 1952). Pollen has been examined by Crickmay and Pocock (1963), Hopkins (1966), Griggs (1970), and Reiswig (1982). Other fossils include a turtle, fresh-water mollusks, and tracks of a heron-like bird (Mustoe and Pevear, 1981; Mustoe, 1993).

The Chuckanut flora probably represents a paratropical rain forest, as defined by Wolfe (1977). These forests have more open canopies than true tropical rain forests and have a greater abundance of large single trees. Paratropical rain forests occur in humid climates that have a mean annual temperature of 20–25°C. The lowland forests of southern China provide a modern example.

Dicotyledonous leaves are common fossils in the Chuckanut Formation, but few have so far been identified. However, their vegetational characteristics (such as the abundance of large, simple leaves having smooth margins, and the relative scarcity of lobed or serrate margins) are typical of plants that inhabited a humid frost-free climate. Distinctive semitropical taxa include a tree fern, *Cyathea pinnata* (MacGinitie) La Motte, and a variety of climbing plants (such as the climbing fern *Lygodium kaulfussii* Heer, and two flowering vines, *Tetracera* and *Goweria*). However, the flora is diverse and includes *Platanus* (sycamore), *Alnus* (alder), *Corylus* (hazel), *Sassafras*, and other genera that now inhabit temperate forests. Conifers consisted of lowland-dwelling members of the Taxodiaceae (yew family) and Cupressaceae (cypress family) such as *Taxodium*, *Mesocyparis*, and *Glyptostrobus*.

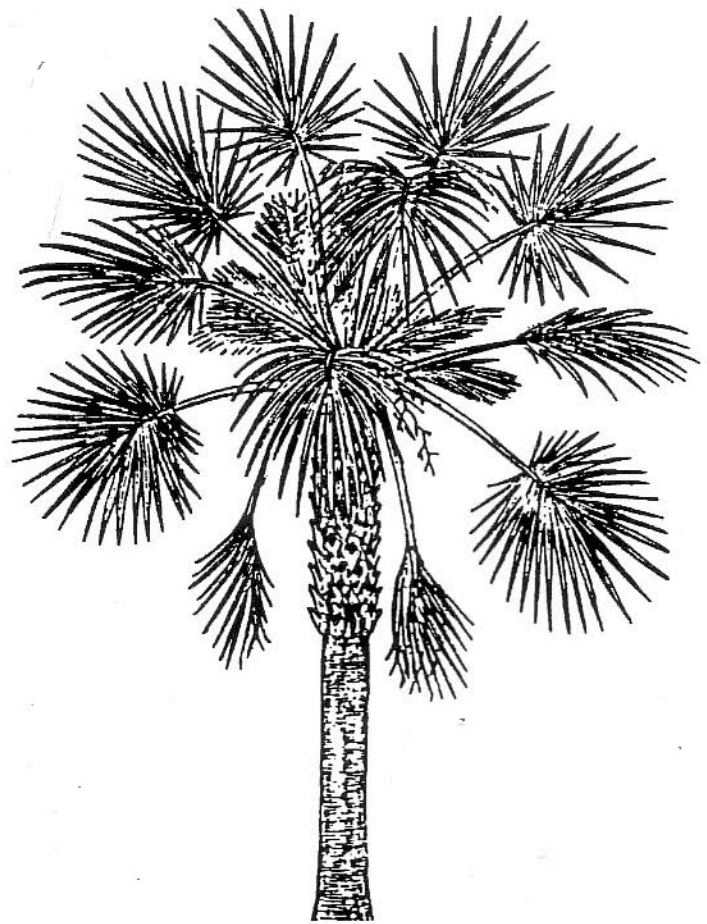


Figure 3. Reconstruction of *Sabalites* (Berry, 1930).

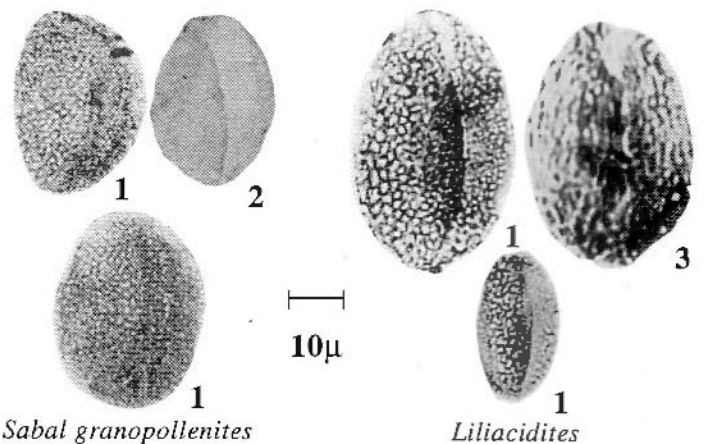
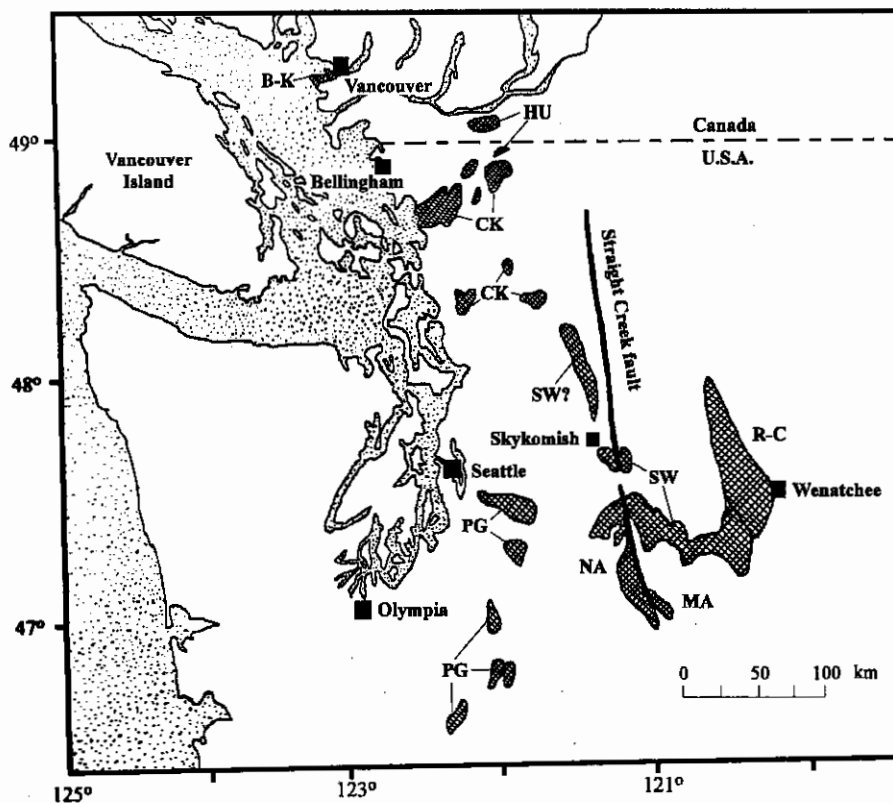


Figure 4. Fossil pollen from the Chuckanut Formation. (Sources: 1, Hopkins, 1966; 2, Griggs, 1970; 3, Reiswig, 1982.)

PALM FOSSILS

Early paleobotanists commonly attempted to classify ancient frond imprints using genus names previously established for living palms, an approach that proved to be unreliable. Instead, Read and Hickey (1972) proposed a classification scheme that divides ancient palms into ‘form genera’ based on leaf shape without regard to actual genetic relationships. Palmate (fan-shaped) fronds are identified as *Sabalites* or *Palmacites*, depending on the geometry of the leaf base; pinnate (feather-shaped) fronds are placed in the form genus *Phoenicites*. A



EXPLANATION

Middle to late Eocene (46–36 Ma)

- HU, Huntingdon Formation
- R-C, Roslyn and Chumstick Formations
- PG, Puget Group*
- NA, Naches Formation*

Early to middle Eocene (55–40 Ma)

- B-K, Burrard* and Kitsilano Formations
- SW, Swauk Formation*
- MA, Manastash Formation
- CK, Chuckanut Formation*

Figure 5. Early Tertiary nonmarine sedimentary rocks in western Washington and adjacent British Columbia. *, contains fossil palms. References: Heller and others (1987), Griggs (1970), and Gresens (1982).

similar form genus system has long been used to describe other types of plant tissue; fossil palm wood is identified as *Palmoxylon*, while seeds similar to those of living palms are named *Palmocarpon*. Fossilized roots, flowers, and pollen are identified using other generic names. Although this system results in the organs of a single plant being given a variety of scientific names, it provides a workable solution to a difficult taxonomic situation.

Palm leaf fossils collected from Bellingham Bay by the 1841 Wilkes Exploring Expedition were named *Sabal campbelli* (Newberry, 1863, 1898), amended to *Sabalites campbelli* by Lesquereux (1878). These identifications were later questioned by other paleobotanists. Duror (1916) identified imprints from the Swauk Formation near Skykomish, Washington, as *Sabal powelli*, a species first reported from the Eocene Green River Formation of Wyoming (Newberry, 1883). If outcrop map patterns are corrected for an estimated 190 km of north-south relative motion along the Straight Creek fault during the subsequent rise of the North Cascades range, the

Swauk and Chuckanut Formations appear to have been deposited as part of a single depositional basin (Frizzell, 1979).

Brown (1962) claimed that palms from the Chuckanut Formation were actually *Sabalites grayanus*, a species name first used to describe Eocene fronds from the southeastern U.S. (Lesquereux, 1878). Knowlton (1919) stated that Newberry's specimens of *S. campbelli* included a second species of palm, *Sabal (?) ungeri*, an allegation repeated by Knowlton (1930) and LaMotte (1952). Thorne (1976) independently observed that the Chuckanut flora contains at least two types of palms.

Leaves of *Sabalites campbelli* (Newberry) Lesquereux are the most common palm fossil in the Chuckanut flora (Fig. 6). Brown (1962) claims that these frond imprints should be identified as *Sabalites grayanus*. Lesquereux is doubtful for several reasons. The name *S. grayanus* was originally assigned to Eocene palm fossils from Lafayette County, Mississippi, by Lesquereux (1869), but his published description is vague, and the original specimens have been lost for nearly a century. The best available definition of the species is that of Berry (1916), who studied specimens from Lesquereux's type locality and about 40 other sites in Mississippi, Arkansas, Louisiana, Texas, and Tennessee. Examination of leaf cuticle indicates that these fronds actually represent several coryphoid palms that have similar leaf shapes (Dilcher, 1968; Daghljan, 1978). *S. grayanus* has also been used as a catchall term to describe a wide variety of palmate leaf impressions from the western U.S. For example, Brown (1962) uses this name to include eleven forms that he considered to be synonymous.

Fronds of *S. campbelli* and *S. grayanus* both have petioles that extend into to the underside of the leaf as an acutely terminated triangle (acumen) having concave margins. On the upper leaf surface, the acumen is very short with a rounded or broadly triangular margin. Despite these structural similarities, fronds from the Chuckanut Formation are much larger in diameter than specimens of *S. grayanus* from type locations in the southeastern states. *S. grayanus* fronds typically have diameters of about 1 m, approximately half the size of typical Chuckanut *S. campbelli* imprints. Although the size of a particular palm leaf may be related to stage of growth, environmental factors, or conditions of fossilization that selectively favor intact preservation of small fronds, the consistently observed differences in leaf diameter indicate that *S. campbelli* and *S. grayanus* are not synonymous. In addition, paleogeographic barriers that separated the Pacific Northwest from the southeastern region probably would have hindered the transcontinental dispersal of either species.

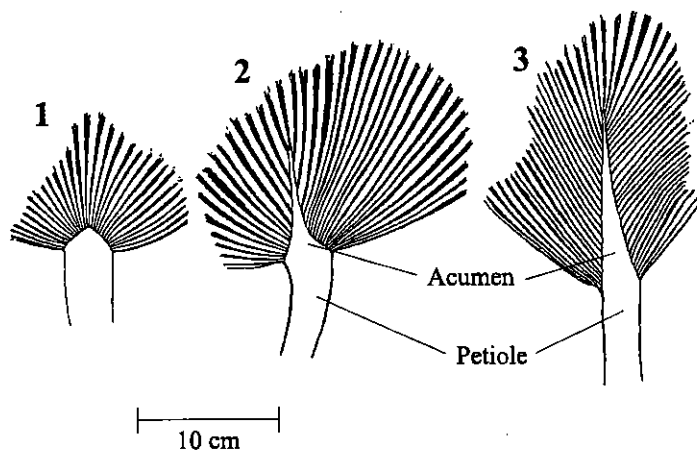


Figure 6. Sketches showing leaf base architecture of Chuckanut Formation palm imprints. 1, *Sabalites campbellii* (upper leaf surface); 2, *S. campbellii* (lower leaf surface); 3, *Sabalites* cf. *S. ungeri* (lower leaf surface). Specimens showing the upper surface of the latter species have yet to be found.

Sabalites campbellii occurs abundantly in fossiliferous strata of the Chuckanut Formation, regardless of geographic location and stratigraphic position. Less commonly, outcrops contain fronds of a second type, recognizable by the extension of the petiole into the lower surface of the leaf for a distance of 15 cm or more. This acumen is in the form of a narrow, straight-sided triangle, in contrast to the curved acumen margins characteristic of *S. campbellii*. These leaves closely resemble descriptions of *Sabal* (?) *ungeri* (Lesquereux) Knowlton from the Paleocene Raton Formation of New Mexico (Knowlton, 1917), later renamed *Sabalites ungeri* (Dorf, 1939).

The presence of two types of fronds is consistent with palynologic evidence. Griggs (1970) identified *Sabal granopollenites* Rouse from outcrops along Chuckanut Drive near Bellingham, a palynomorph that is similar to pollen of the modern *Sabal palmetto*. Griggs also recognized abundant occurrences of *Liliacidites*, a form genus of uncertain botanical affinity that he believed to be from a palm because of its presence in strata that also contain frond imprints. Although *S. campbellii* and *S. ungeri* fronds have not yet been found together, the mutual occurrence of *Sabal granopollenites* and *Liliacidites* pollen at sites spanning approximately 2,700 m of stratigraphic section exposed along Chuckanut Drive suggests that the two taxa were contemporaneous and broadly distributed in time. *S. granopollenites* and *Liliacidites* have also been identified from other sites in the Chuckanut Formation (Hopkins, 1966; Reiswig, 1982).

PALEOECOLOGY

Sabalites and *Palmicites* leaf imprints occur in other Tertiary formations in the Pacific Northwest, extending from Alaska to California (Table 1), and their distribution provides important indications of paleogeography and paleoclimate. Although early palms show great latitudinal range, their distribution was restricted to regions of low elevation and frost-free climate. Prior to the onset of the Cascade Range orogeny at the close of the Eocene, a broad coastal plain extended well into central Oregon and Washington, providing suitable habitat for palms and other subtropical vegetation. These plants are not present

Table 1. Occurrence of Tertiary palms in western North America. Data from La Motte, 1952; Lakhanpal, 1958; Tuta, 1967; Wolfe, 1968; Gregory, 1969

| Location | Formation |
|-----------------------------------|--|
| PALEOCENE: | |
| Colorado Springs, Colorado | Dawson Arkose |
| Pagosa, Colorado | Animas Formation |
| Golden, Colorado | Denver Formation |
| Fishers Peak, Colorado | Raton Formation |
| Raton Mountains, New Mexico | Raton Formation |
| Yellowstone River, Montana | Fort Union Formation |
| EOCENE: | |
| Plumas County, California | La Porte flora |
| Nevada County, California | Chalk Bluffs flora |
| Clarno, Oregon | Clarno Formation |
| Green River, Wyoming | Green River Formation |
| Tipperary, Wyoming | Bridger Formation |
| Bellingham, Washington | Chuckanut Formation |
| Skykomish, Washington | Swauk Formation |
| King County, Washington | Puget Group |
| Gulf of Alaska | various |
| Vancouver, British Columbia | Burrard Formation, Kitsilano Formation |
| OLIGOCENE: | |
| Cottage Grove, Oregon | Rujada flora |
| Multnomah County, Oregon | Eagle Creek Formation |
| Skamania County, Washington | Eagle Creek Formation |
| MIOCENE: | |
| Tehachapi, California | not listed |
| Barstow, California | not listed |
| PLIOCENE: | |
| Last Chance Canyon, California | Ricardo beds |
| Rosamond, Mohave area, California | not listed |

in sediments of the same age that were deposited at paleoaltitudes exceeding approximately 300 m (Axelrod, 1968). Examples of Early Tertiary upland floras where palms are absent include Republic (Wolfe and Wehr, 1987) and Pipestone Canyon, Washington (Royse, 1965), and Thunder Mountain, Idaho (Axelrod, 1990).

Evidence from the middle Eocene Allenby Formation near Princeton, British Columbia, is more complicated. Although silicified palm stem and leaf fragments are abundant in a thick sequence of chert beds, palms are absent in the nearby clastic sediments. Fossils in these shales indicate a mixed deciduous inland forest. In contrast, the chert unit was deposited within a marshy environment rich in monocotyledons (Erwin and Stockey, 1991). This botanical variation within a single geologic formation is significant because our knowledge of ancient plants mostly comes from fossils collected from shales and siltstones, which do not necessarily represent the only favorable palm habitat.

Palms began to disappear from the Pacific Northwest near the close of the Eocene Epoch in response to climatic cooling (Wolfe, 1978) and geographic changes associated with uplift of the Cascade and Coast Ranges. This orogeny destroyed the

extensive coastal plain, altered the pattern of rainfall, and reduced the influence of warm ocean currents on inland climate. Of these multiple factors, the decline in global temperatures seems to have been the most important factor in causing the extinction of palms. This observation is based on the presence of *Sabalites* imprints in the middle to late Eocene Swauk Formation of central Washington and their absence in the slightly younger Roslyn and Chumstick Formations. The petrologic similarity of these arkosic formations suggests that they were all deposited in similar fluvial settings and that paleobotanical differences are largely due to climatic variation rather than geographic change.

Sabalites occurs in the Rujada flora near Cottage Grove, Oregon (Lakhanpal, 1958), and in the Eagle Creek flora of the Columbia Gorge (Chaney, 1920). These sites are believed to be of Oligocene age, although neither has been dated with certainty. If these age estimates are correct, these fossils are the youngest known occurrence of palms in the Pacific Northwest. By the middle Tertiary, palms had retreated to the frost-free regions of southern California, as indicated by various Miocene and Pliocene fossils (Tuta, 1967). At present, the only remaining native palms of western North America are three species of *Washingtonia* that inhabit the dry interior regions of southern California and Mexico.

What ecologic lessons can be learned from the extinction of the palms that once inhabited the Pacific Northwest? For one thing, the phenomenon points out our poor understanding of global climatic trends, as we have little explanation for the Eocene-Oligocene temperature shift. The fossils also provide a reminder that major biologic transitions are not reversible. If we were able to change our region's climate back to the temperature and rainfall conditions of the Eocene Epoch, our forests would again take on a semitropical character, but they would not revert to the original floral composition. This is partly because many Early Tertiary plants became extinct, leaving no close modern relatives. In addition, we would see a proliferation of introduced species as the decorative plants of our greenhouses and living rooms escaped to the freedom of the great outdoors. If palms returned to a new Washington climate, they would likely be relatives of courtyard palms of hotels and shopping malls, rather than descendants of *Sabalites campbelli*.

It's also important to realize that the global-cooling episode that so greatly affected the ancient Pacific Northwest forests probably occurred at a rate that would have been undetectable by climatologists. Indeed, if the survival time of *Homo sapiens* as a species proves to be similar to that of other specialized mammals, our entire existence could have been played out during the Early Tertiary without our ever noticing a change in the weather.

Finally, modern plants and animals face environmental influences unlike those that existed 50 million years ago. Fossil palms are evidence of a major botanical shift that resulted from gradual natural processes, but the patterns of biologic change we observe today are different. Compared to the dominant organisms of the Early Tertiary, humans have an astonishing ability to alter the environment. We have become important agents of geologic and biologic change, and our activities influence the survival and extinction of many of the organisms with whom we share the planet. Rather than being caused by the uplift of new mountain ranges or changing posi-

tions of the continents, future climate change may possibly be due to the effects of air pollution. Extinction of species is commonly a result of habitat destruction, and unexpected patterns of succession may result when pests, predators, and disease-producing microbes are transported to distant regions on ships or planes. For these reasons, modern forests may be experiencing transition rates quite unlike their Cenozoic counterparts.

ACKNOWLEDGMENTS

We thank Wes Wehr for reviewing the manuscript and K. M. Reed for editorial help during preparation of the final draft.

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