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SARGENT'S FIR HYBRID: *ABIES AMABILIS* × *LASIOCARPA*

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ON A SHORT TRIP into the northern Olympic Mountains of Washington in the summer of 1896, Professor Charles Sprague Sargent found a fir tree that he thought might be a natural hybrid between *Abies amabilis* (Dougl.) Forbes and *A. lasiocarpa* (Hook.) Nutt. The founder and Director of the Arnold Arboretum, Sargent was generally recognized as America's pre-eminent dendrologist. His brief description of the putative hybrid (Sargent, 1898) is still the only report of natural hybridization between *A. amabilis* and any of the firs with which it grows (Klaehn & Winieski, 1962). On the same trip Sargent encountered a tree that he identified as *A. nobilis* (Dougl.) Lindley (since renamed *A. procera* Rehd.). His report that this species grew in the Olympic Mountains persisted in the literature of botany and forestry for many years before it was dropped for lack of confirmation. In this paper the identity of these firs is reexamined, and the unusual circumstances of their collection is reviewed.

Sargent visited the Olympic Peninsula in his official capacity as chairman of a blue-ribbon committee charged with formulating a policy for the federal forest lands of the United States. The committee was appointed by the President of the National Academy of Sciences at the request of the Secretary of the Interior, and was in existence from early 1896 to mid-1897. The group lacked a formal name, but has most commonly been called the National Forest Commission ("U. S. Forestry Commission" on Sargent's printed herbarium labels). Most of the Commission members were elder statesmen of American science and members of the National Academy. The only exception was Gifford Pinchot, who was on the Commission at Sargent's request. Pinchot was one of the few professionally trained foresters in the country, and later became the first head of the Forest Service.

Between early July and late October of 1896, Sargent and most of the other Commission members visited the forested regions of the West. An unofficial member of the party was the naturalist John Muir (Badè, 1923). Except for Pinchot, who set out for the West a month earlier and joined the others only intermittently (Pinchot, 1972), they traveled as a group.

The recommendations of the Commission focused national attention on the forests of the public domain for the first time, led to more than doubling the area in Forest Reserves, and influenced the timing and content of the Organic Act of 1897. The continuing importance of the Organic Act was demonstrated in 1975, when it provided the legislative basis for the Monongahela decision concerning timber-harvesting practices on eastern National Forest lands (U. S. Court of Appeals, 4th Circuit, 1975).

Considering the lasting significance of the Commission's work, remark-

ably little is known about its western journey. If Sargent kept journals or field books, they have not survived (S. B. Sutton, personal communication). John Muir's published letters place the Commission in the Black Hills of South Dakota in early July, at the start of the trip, and in southern Oregon in late August, after they had visited western Washington (Badè, 1923; Wolfe, 1938). Pinchot's autobiography gives a fairly detailed account of his travels, but he did not accompany the others to Washington. He left them in Montana some time in late July and rejoined them — probably in Portland, Oregon — for the train trip south to Ashland, where they arrived on August 26 (Pinchot, 1972; U. S. Senate, 1897).

The only published mention of the Commission's whereabouts between late July and late August is Sargent's footnote concerning the putative hybrid fir (Sargent, 1898, p. 126): "On a ridge of the Olympic Mountains separating the waters of the Solduc from those of the Quillyhute, I found, on August 19, 1896, at an elevation of four thousand five hundred feet above the sea, an *Abies* sixty to eighty feet in height, growing with *Abies lasiocarpa* and *Abies amabilis*, with the slender spire-like head and the foliage of the former and the cones of the latter. It was, perhaps, a natural hybrid between those species."

In 1896 the Olympic Peninsula was still one of the least explored parts of the country. The *Seattle Press* and O'Neil expeditions had penetrated the mountainous interior only six years earlier, and the highest point on the peninsula (the West Peak of Mt. Olympus) may not have been climbed until 1907 (El Hult, 1954). Only months before the Commission's trip, the first reasonably good map of the interior was published in the April issue of *National Geographic Magazine* (Gilman, 1896).

The Commission's trip into the Olympics seems to have been overlooked by local historians, although the ridge where Sargent may have collected his putative hybrid is deep in the mountains. El Hult (1954), whose account of the exploration of the Olympics extends through 1907, does not mention the Commission. Piper (1906) does not list either Sargent or the Commission among the plant collectors on the Olympic Peninsula through 1903, nor does Jones (1936) in his survey of the botanical exploration of the peninsula.

Sargent's published note and specimen labels (in the herbarium of the Arnold Arboretum) do not mention his companions on the expedition into the Olympics. One likely candidate is Commission member Arnold Hague of the U. S. Geological Survey, who was the same age as Sargent (55). John Muir would certainly have made the trip if he was with the Commission in Washington. The other two Commission members on the western trip, Professor William H. Brewer of Yale University and General Henry L. Abbot of the Army Engineers, were much older than the others and less likely to have taken part in what must have been an arduous expedition.

Sargent and his companions must have followed the Soleduck River into the mountains. The small tree that he identified as *A. nobilis* was growing near "the Solduck River at an elevation of three thousand feet"

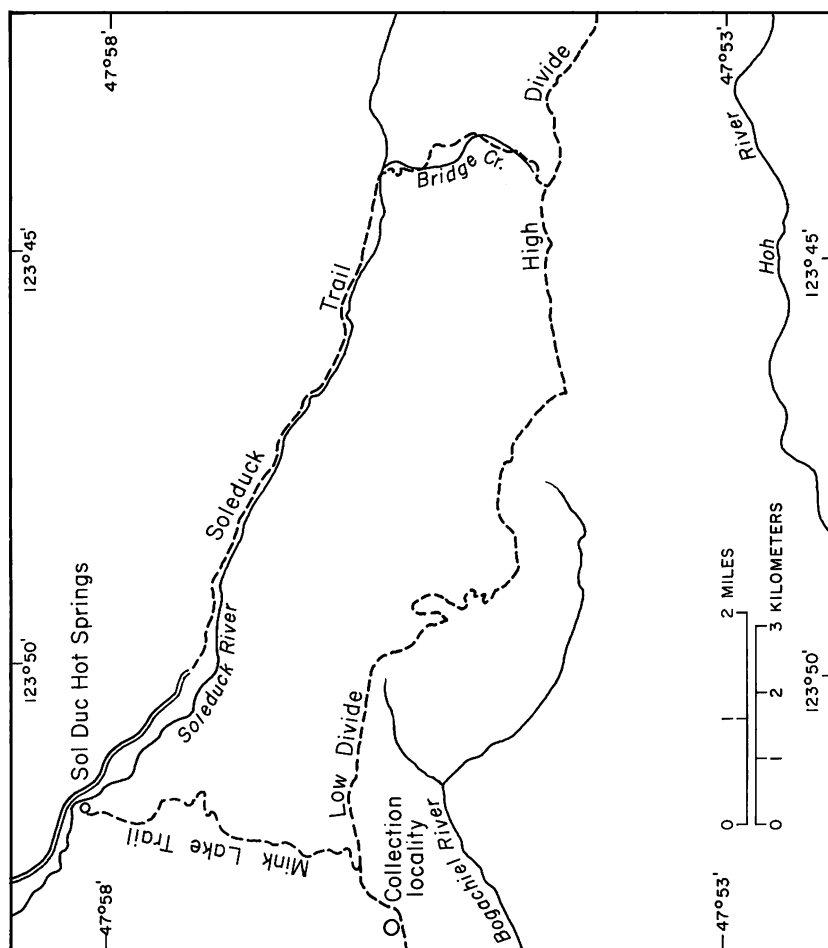
(Sargent, 1898, p. 134). The map accompanying the Dodwell-Rixon forest survey of 1899 (U. S. Geological Survey, 1900) shows a wagon road or well-marked trail along the Soleduck River as far as the vicinity of Sol Duc Hot Springs, near the end of the present road (MAP 1). Their report noted that a traveled trail extended beyond this point to the head of the Soleduck River (U. S. Geological Survey, 1900, p. 158). If this trail existed three years earlier, it is probably the route that Sargent and his party followed.

One puzzling feature of Sargent's hybrid is its location. His description — a ridge between the Soleduck and Quillayute drainages — was a geographical impossibility even in 1896. The name "Quillayute River" is, and apparently always has been, restricted to the short stretch of river between the confluence of the Soleduck and Bogachiel rivers and the river mouth on the Pacific Ocean. The Quillayute, Bogachiel, and Soleduck rivers all have their present names (with variations in spelling) and locations on Gilman's map (Gilman, 1896) and earlier maps I have seen. The ridge Sargent referred to is probably either the Low Divide, which separates the headwaters of the Bogachiel River from the Soleduck drainage, or the High Divide, between the headwaters of the Soleduck and the major drainage of the Hoh River (MAP 1).

The Low Divide is the less likely of the two, even though the Bogachiel River is part of the system that ultimately forms the Quillayute River. In 1896 the Low Divide may have been much more difficult to reach than the High Divide. The first evidence of trail access from the Soleduck River is a 1912 map of the Olympic National Forest (on file at the Forest Supervisor's Office in Olympia) showing the Mink Lake trail to the Low Divide. At the end of this trail, the Low Divide is mostly below the lower limits of *Abies lasiocarpa*. However, that species and *A. amabilis* occur together on a 4300 foot knoll on the Low Divide about a mile west of the Mink Lake trail (MAP 1). In 1970 I collected bark resin and foliage from both species in this grove. None of the trees showed any indication of intermediacy in either morphology or resin composition (Zavarin *et al.* 1973).

The High Divide is the most likely candidate for the ridge where Sargent collected his hybrid, although the elevation is 500 to 600 feet higher than Sargent's estimate of 4500 feet. The High Divide is only a few hundred yards from the head of Bridge Creek, one of the headwaters of the Soleduck River. Bridge Creek is still the only headwater stream accessible by trail, and the only one with a nearby ridge separating major drainages.

The High Divide must have been fairly accessible by 1897, two years before Dodwell and Rixon mentioned a trail to the head of the Soleduck. In August, 1897, just a year after the Commission was in the Olympics, Gifford Pinchot visited the Olympic Forest Reserve as Confidential Forest Agent for the U. S. Department of the Interior. By chance, at Lake Crescent, he encountered Dr. C. Hart Merriam, head of the U. S. Department of Agriculture's Division of Biological Survey. Pinchot and Merriam, together with a local woodsman named Blackwood, retraced Sargent's



MAP 1. A portion of the northern Olympic Mountains, Washington.

probable route, traveling "by way of Soleduck Hot Springs to the Hoh River divide, from which the view of Mt. Olympus was beyond description" (Pinchot, 1972). Merriam apparently turned back at that point, but Pinchot and Blackwood descended from the High Divide into the Bogachiel River drainage and followed the river back to civilization. Pinchot thought it was possible that he and his companion were the first white men in the upper Bogachiel drainage, and he may have been right; El Hult (1954) records no earlier exploration of the area.

Although the location of Sargent's hybrid cannot be established with certainty, the specimen he collected is in the herbarium of the Arnold Arboretum, and I have checked its identity. The discrepancies between the specimen and Sargent's published description of the tree (quoted in full above) raise the question of why Sargent thought this tree might be a hybrid.

The leaves on vegetative and male branches of *Abies lasiocarpa* and *A. amabilis* are most reliably identified by stomatal distribution, orientation, and resin canal location, but shape is also helpful. The rather uniform leaves of *A. amabilis* have a well-defined notch at the tip and a deep groove in the upper surface from the notch to the base. The extremely variable leaves of *A. lasiocarpa* usually have a less well-defined groove, and the tip may be rounded, pointed, or notched. Stomata are present on both surfaces of the leaves of this species. On *A. amabilis* leaves they are usually restricted to the abaxial surfaces, but sometimes the adaxial surfaces are stomatiferous near the notch. Leaf orientation is strikingly different in the two firs: the adaxial surfaces of *A. lasiocarpa* leaves are oriented in varying planes, but the green, stomata-free, adaxial surfaces of *A. amabilis* leaves face upward. They achieve this orientation by a sharp twist at the leaf base. *Abies lasiocarpa* is the only Northwestern fir with medial resin canals in the leaves; in *A. amabilis* the canals are external and adjacent to the abaxial epidermis.

Cone and seed characteristics are not too helpful in identifying these firs, although the cones of *Abies amabilis* are usually larger in all dimensions than those of *A. lasiocarpa*. One fairly reliable distinction is the shape of the bract subtending the cone scale. In *A. lasiocarpa*, the bract narrows abruptly to a point 2–3 mm. long, and in *A. amabilis* it narrows gradually to a point about the same length. The wings of *A. amabilis* seeds are straw-colored (Harlow & Harrar, 1941), and usually lack the flecks and streaks of pigment that give the seed-wings of *A. lasiocarpa* their darker color.

Sargent's specimen includes vegetative branches, branches with staminate strobili, and separately packaged cones. On the labels Sargent noted that the cones are like *Abies amabilis* and the foliage is like *A. lasiocarpa*. The collection date on the labels is August 18, 1896, a day earlier than the published date. The leaves on both kinds of branches correspond to *A. amabilis* in all respects: shape, stomatal distribution, orientation, basal twist, and position of resin canals. The cones, which had probably reached their final size by August 18 or 19 (see Franklin & Ritchie, 1970), are intermediate in size — large for *A. lasiocarpa* and small for *A. amabilis*.

Three detached (and possibly incomplete) cones are 8.5–8.8 cm. long. The single cone still attached to the branch is 10.5 cm. long, at the lower end of the size range of *A. amabilis* cones. The cone bracts have gradually tapered points like *A. amabilis*, and the nearly mature seeds have the straw-colored wings of *A. amabilis*. Included with the cones is this note dated June 24, 1913, by W. H. Lamb, a student of the western firs (Lamb, 1912): "An examination of the cone-bracts and the position of the resin ducts in the leaves will show that these specimens are all *Abies amabilis*, and not of hybrid origin."

A few years after Sargent's note appeared in print, Masters (1901, fig. 26) published illustrations of the putative hybrid, entitled "Professor Sargent's hybrid *Abies*." Masters quoted Sargent's published note without comment, but the sketches clearly portray leaves of *A. amabilis*. The upper and lower surfaces of a leaf (Masters, fig. 26C) show the notched tip and basal twist, and a leaf transection (Masters, fig. 26E) shows the external resin canals of *A. amabilis*. The crudely drawn bracts (Masters, fig. 26A, B) are completely unlike those of *A. lasiocarpa*. They lack a long, well-defined point, and might possibly fall within the range of variation of *A. amabilis*.

Although the specimen Sargent labeled a putative hybrid is *Abies amabilis*, his field observation of a tree with intermediate characteristics cannot be disregarded. In the late summer of 1896, he was particularly familiar with the distinguishing characteristics of the western firs. He must have just recently completed the text of Volume XII of "Silva of North America" dealing with *Abies* and related genera; his comments on the firs of the Olympic Mountains were added as footnotes before the book was printed in 1898. And, just before the trip into the Olympics, the Commission probably had seen all of the northwestern firs in the Cascade Mountains of Washington.

Abies lasiocarpa and *A. amabilis* have abundant opportunities to cross in nature. They grow together in many places in the mountains of the Pacific Northwest, and overlap in flowering time (Ebell & Schmidt, 1964; Franklin & Ritchie, 1970). In its resin composition (Smedman *et al.*, 1969; Zavarin *et al.*, 1973) and morphology, *A. amabilis* has no close affinities with the other American firs. It is usually classified with *A. concolor* (Gord. & Glend.) Lindley and *A. grandis* (Dougl.) Lindley, primarily because of the external location of the leaf resin canals, but it also resembles *A. lasiocarpa* and its relatives in some respects (Zavarin *et al.*, 1973). We have looked for evidence of chemical and morphological intermediacy in mixed stands in the Olympic Mountains, as noted earlier, and in the Oregon Cascades, but so far without success.

The other puzzling collection made by Sargent on the trip into the Olympics is the *Abies procera* tree he found near the Soleduck River, the only *A. procera* ever reported on the Olympic Peninsula. Although he saw no other trees of this species on the trip, he considered its presence in the Olympics confirmed: "the following year this species was seen by Dr. C. Hart Merriam in the same region" (Sargent, 1898, p. 134). Sargent may

have been referring to an observation made on Merriam's 1897 trip with Gifford Pinchot up the Soleduck drainage to the High Divide.

Sargent's extension of the range of *Abies procera* to the Olympic Mountains was quoted by Piper (1906), and enlarged on by Sudworth (1908): "North side of Olympic Mountains on Solduck River, at about 3,000 feet, and general at higher elevations." Munns (1938, *Map 46*) further expanded the distribution to a broad band of *A. procera* around the high-mountain core of the peninsula. However, Jones (1936), in his botanical survey of the peninsula, pointed out the lack of recent evidence that *A. procera* grows there. The last published report of this fir in the Olympics appears to be Little's 1949 map showing a limited distribution in the northern part of the peninsula (Little, 1949, *Map 133*).

The vegetative specimen labeled "*Abies nobilis*," collected on the same day as the putative hybrid, is *A. lasiocarpa* rather than *A. procera*. The leaves are flattened, not quadrangular in section; the groove on the upper surface is broad and ill-defined rather than narrow and sharply defined, and the resin canals are medial, not external as in *A. procera*. Sargent's estimate of 3000 feet is very low for *A. lasiocarpa* in the Olympic Mountains. However, he noted on the label that the tree was growing on the bank of the Soleduck River, and it is not uncommon for montane trees to occur along streams well below their usual elevational range.

How did Sargent happen to mislabel or misidentify these two important collections from the Olympic Peninsula? The explanation probably lies in the hectic schedule of the Commission on its western journey. Sutton (1970) notes that Sargent "collected specimens furiously all along the way, lugging his increasingly cumbersome possessions with him as the party sped from one place to the next." These difficult circumstances may explain Sargent's identification of *Abies lasiocarpa* as *A. procera* and his labeling of an *A. amabilis* specimen as a putative hybrid.

LITERATURE CITED

- BADÈ, W. F. 1923. The life and letters of John Muir. Vol. 1. 399 pp. Vol. 2. 454 pp. Houghton Mifflin Co., Boston.
- EBELL, L. F., & R. L. SCHMIDT. 1964. Meteorological factors affecting conifer pollen dispersal on Vancouver Island. Canad. Dept. Forest. Publ. 1036. 28 pp.
- EL HULT, R. 1954. The untamed Olympics. 267 pp. Binfords & Mort, Portland, Oregon.
- FRANKLIN, J. F., & G. A. RITCHIE. 1970. Phenology of cone and shoot development of noble fir and some associated true firs. Forest Sci. 16: 356-364.
- GILMAN, S. C. 1896. The Olympic country. Natl. Geogr. Mag. 7: 133-140.
- HARLOW, W. H., & E. S. HARRAR. 1941. Textbook of dendrology. 542 pp. McGraw-Hill, New York.
- JONES, G. N. 1936. A botanical survey of the Olympic Peninsula. Wash. Univ. Publ. Biol. 5. 286 pp.
- KLAHN, F. U., & J. A. WINIESKI. 1962. Interspecific hybridization in the genus *Abies*. Silvae Genet. 11: 130-142.

- LAMB, W. H. 1912. A synopsis of the red firs. *Proc. Soc. Am. Foresters* 7: 184-186.
- LITTLE, E. L., JR. 1949. Important forest trees of the United States. *In: Trees*. U. S. Dept. Agr., Yearb. Agr. 1949. Pp. 763-814.
- MASTERS, M. T. 1901. Hybrid conifers. *Jour. Roy. Hort. Soc.* 26: 97-110.
- MUNNS, E. N. 1938. The distribution of important forest trees of the United States. U. S. Dept. Agr., Misc. Publ. 287. 176 pp.
- PINCHOT, G. 1972. Breaking new ground. [new ed.] 522 pp. Univ. Wash. Press, Seattle & London.
- PIPER, C. V. 1906. Flora of the state of Washington. 637 pp. Contr. U. S. Natl. Herb. 11.
- SARGENT, C. S. 1898. The silva of North America. Vol. 12. Coniferae (*Abietinae* after *Pinus*). 144 pp. Houghton, Mifflin & Co., Boston & New York.
- SMEDMAN, L. Å., K. SNAJBERK, E. ZAVARIN, & T. R. MON. 1969. Oxygenated monoterpenoids and sesquiterpenoid hydrocarbons of the cortical turpentine from different *Abies* species. *Phytochem.* 8: 1471-1479.
- SUDWORTH, G. B. 1908. Forest trees of the Pacific slope. 441 pp. U. S. Dept. Agr. Forest Serv. Washington.
- SUTTON, S. B. 1970. Charles Sprague Sargent and the Arnold Arboretum. 382 pp. Harvard Univ. Press, Cambridge.
- U. S. COURT OF APPEALS, 4th CIRCUIT. 1975. Forest Service violation of the Organic Act of 1897. Decision No. 74-1387. 29 pp.
- U. S. GEOL. SURVEY. 1900. Olympic Forest Reserve, Washington. 21st Annual Rep. (Part 5) 1899-1900. Pp. 145-208.
- U. S. SENATE. 1897. Establishment of forest reservations. 55th Cong. Proc. 1st Sess. P. 36 in Doc. 21.
- WOLFE, L. M., ed. 1938. John of the mountains. The unpublished journals of John Muir. 459 pp. Houghton Mifflin Co., Boston.
- ZAVARIN, E., K. SNAJBERK, & W. B. CRITCHFIELD. 1973. Monoterpene variability of *Abies amabilis* cortical oleoresin. *Biochem. Syst.* 1: 87-93.

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