DISCUSSIONS

Allozyme variation in *Picea mariana* from Newfoundland[1]: Discussion

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In their recent paper describing the distribution of genetic variation in black spruce (*Picea mariana* (Mill.) B.S.P.) on the island of Newfoundland, Yeh *et el.* (1986) concluded that a center of variability in west-central Newfoundland derived from ancestral populations that persisted on the island during the last (Wisconsin) glaciation. They attributed to Munns (1938) the "theory that part or all of such an area was ice-free during the Wisconsin glaciation." Munns's publication consists of tree distribution maps, long since superseded and not very accurate even when they were published; map 29, for example, wrongly shows black spruce widely distributed in West Virginia, Maryland, and southern New Jersey. This atlas of tree maps has no text apart from a brief introduction that does not mention glaciation, refugia, or Newfoundland, and could not have been the source of the theory referred to by Yeh *et al.* (1986). The other two references cited by these authors in their concluding section, Hultén (1937) and Halliday and Brown (1943), discussed glacial refugia in the context of the time, but Hultén mentioned Newfoundland only peripherally, and Halliday and Brown's description of tree distribution in Canada excluded this island, which was not part of Canada in 1943.

The glacial history of Newfoundland is far better known today than it was in the 1930s and 1940s, but recent reviews of the subject from widely divergent points of view (Brookes 1982; Mayewski *et al.* 1981) underscore the continuing lack of consensus concerning the origin and extent of the island's ice cover during the last glaciation. Prest's (1969) map of Wisconsin glaciation in North America showed Newfoundland completely covered by ice, but this interpretation has lost favor in the past decade. One reason was the influential paper by Grant (1977), which presented new evidence of limited, local glaciation in Newfoundland. Grant's map showed extensive ice-free areas along the coast, including much of the west coast and the Burin Peninsula in the southeast, as well as sizable ice-free enclaves in the west-central interior, where summits like the Topsail Hills and Buchans Plateau may have projected through the ice. Rogerson (1983) further expanded the areas believed to be ice-free in the late Wisconsin, especially on the north and northeast coasts (his Fig. 12, based partly on Grant's map). Between the two extremes of complete ice cover and extensive ice-free areas is Prest's recent (1984) map of glacial limits, showing ice-free enclaves along the coast, including the Burin Peninsula, but not in the interior.

Whatever the true extent of the last glaciation in Newfoundland, there is no evidence that black spruce survived this period in refugia on the island. Pollen records covering the last 3500 years of the Wisconsin have established that tundra vegetation grew on both north and south coasts near the end of the Pleistocene and beginning of the Holocene. At the southern site, near the tip of the Burin Peninsula, Anderson (1983) found an annual deposition rate of up to 30 spruce pollen grains/cm^2 through the late Wisconsin, and he attributed this low level to long-distance transport from New England. At the northern site, on Notre Dame Bay, maximum influx of spruce pollen was about the same as at the Burin site (Macpherson and Anderson 1985). Spruce pollen was not identified to species in these deposits, but at two sites on the Avalon Peninsula, in southeastern Newfoundland, pollen was identified as black spruce. This species reached both sites, more than 60 km apart, 8300–8400 radiocarbon years before present (BP) (Terasmae 1963; Macpherson 1982). At about the same time (8400 years BP) an unidentified spruce reached the northern tip of Newfoundland's Northern Peninsula (J. A. McAndrews, cited by Engstrom and Hansen 1985). These few records of past vegetation are not conclusive, but they provide no support for the hypothesis that black spruce survived in Newfoundland through late-glacial time.

If black spruce did not persist on the island, where did it come from when it appeared on the Avalon Peninsula early in the Holocene (8300–8400 years BP)? The Maritime Provinces to the southwest are the most likely source. Spruce (not identified to species) entered that region from New England as early as 12 000 years BP, and by 10 000 years BP it was widespread in the Maritime Provinces (Mott 1985). Black spruce has small, winged seeds—the smallest of any of the conifers that make up the boreal forests of Newfoundland—and even the 110-km width of Cabot Strait may not have been a major obstacle to its migration across this strait from Cape Breton Island, Nova Scotia, to southern Newfoundland. In the north, Newfoundland is much closer to the mainland; the Strait of Belle Isle, which separates the Northern Peninsula from southeastern Labrador, is less than 20 km wide. White spruce (*Picea glauca* (Moench) Voss) was in southeastern Labrador by 8000 years BP but black spruce did not join it there until after about 6500 years BP (Engstrom and Hansen 1985), nearly 2000 years after its arrival on the Avalon Peninsula.

Is the genetic diversity of black spruce in Newfoundland too great to have been derived from a single introduction early in the Holocene? Yeh *et al.* (1986) did not make up their minds about this. Although they proposed glacial refugia to help account for the differentiation of black spruce in Newfoundland (p. 719), they had earlier (p. 717) concluded that "relatively little genetic differentiation has occurred among *P. mariana* populations in Newfoundland." If the variability of black spruce is too great to originated by migration from the southwest in the early Holocene, its genetic diversity could easily have been augmented in the mid-Holocene by migration from the nearby Labrador mainland.

[1]Paper by F. C. Yeh, M. A. K. Khalil, Y. A. El-Kassaby, and D. C. Trust. 1986. Can. J. For. Res. 16: 713–720.

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On a social discount rate for forestry:[1] Comment

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In his recent article on the social discount rate (SDR) for forestry, Harou (1985) deals with *the* key factor in forest economics. His derivation of SDR from the internal rates of return (IRRs) on acceptable government investments is based on a premise that governments choose investments rationally. This line of reasoning, however, leads into a logical impasse as tersely laid out below.

[1] Governments are deemed to accept public investments whenever their IRR ≥ SDR.

[2] Hence the SDR tends to equality with the lowest IRR among acceptable public investments. (In the absence of [1] and [2], deduction of SDR from IRR of public investments is impossible.)

[3] Public investments for which IRR → SDR have net present worth (NPW) → 0.

[4] Private investments have IRR ≥ private discount rate (PDR) > SDR. (The latter inequality reflects the responsibility of society for the long-term future.)

[5] Investments for which IRR > SDR have NPW > 0.

[6] Hence governments, by taxation or borrowing, are withdrawing funds from private investment with NPW > 0 to invest in public projects with NPW → 0.

[7] Hence governments are not rational in their preference for investments.

[8] Hence a rational discount rate cannot be derived from government choices of acceptable investments.

The possible escape routes from this impasse are as follows.

[9*a*] Although [1], [2], and [3] are true in narrow financial terms, positive externalities increase the *social* IRR of government projects above the financial IRR, such that the social NPWs of marginal public investments are comparable with those of private investments. In this case, however, the SDR is implied, not by the financial IRR but by the (higher but usually undetermined) social IRR.

[9*b*] Premise [4] is untrue; this requires either that SDR ≥ PDR (i.e., society should *not* have a longer term view than do individuals), or

[9*c*] that investors are irrational, accepting investments for which IRR < PDR (i.e., NPW < 0).

[9*d*] Deduction [6] is invalid, funds for public investment being withdrawn wholly from private consumption.

[9*e*] Premise [1] is untrue; governments do not accept all investments for which IRR ≥ SDR, either because they are irrational or

[9*f*] because political constraints on funds do not allow all desirable investments (NPW ≥ 0) to be undertaken. In this case the SDR is lower (by an undefined margin) than the lowest IRR among accepted projects.

Premises [9*b*], [9*c*], and [9*d*] are compatible with an assumption of government rationality, but none of them either

[1]Paper by P. A. Harou. 1985. Can. J. For. Res. 15: 927–934.