Paleoindians and fire during the late Quaternary in southern South America

Paleoindios e incendios durante el Cuaternario tardío en el sur de Sudamérica

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ABSTRACT

Quantities of charcoal in Quaternary deposits in southern South America may serve to establish the presence, age, and migrations of Paleoindians. This concept is based on the proposition that non-human agents, lightning and volcanism, can be discounted as causing fires in non-volcanic sectors of the region. Data derive from records of charcoal examined at two classical, late glacial archeological sites, Monte Verde and Laguna de Tagua Tagua, and at eight additional sites located between subtropical Chile and subantarctic Argentina. The implication of the charcoal is that Paleoindians, while residing in central Chile during the Holocene and during Pleistocene interstades over at least the past 50,000 years, vacated the region at the time of the last glacial maximum (25,000-14,000 yr. BP). Migration in the course of deglaciation reached Tierra del Fuego in the far south before 13,000 yr. BP.

Key words: Charcoal and fossil pollen records, late Quaternary, Paleoindian presence, age, and migration.

RESUMEN

Cantidades de carbón en depósitos del Cuaternario tardío en el sur de Suramérica sirven para establecer presencia, edad y migraciones paleoindias, en base a la proposición de que otros agentes como relámpagos y volcanismo, podrían descartarse como causantes de incendios en sectores sin actividad volcánica, y donde la incidencia de relámpagos es despreciable. Los datos derivan de la documentación de fragmentos microscópicos de carbón examinada en dos sitios arqueológicos tardiglaciales clásicos, Monte Verde y Laguna de Tagua Tagua, y ocho sitios adicionales ubicados entre Chile subtropical y Argentina subantártica. Los datos implican que los paleoindios residieron en Chile central durante el Holoceno y en los interestadiales del Pleistoceno, por lo menos durante los últimos 50.000 años, evacuando la región durante la última glaciación (25.000-14.000 años A.P.). Las migraciones de paleoindios durante el curso de la deglaciación llegarón hasta Tierra del Fuego en el extremo sur, antes de 13.000 años A.P.

Palabras clave: Registros de carbón microscópico y polen fósil, Cuaternario tardío, presencia, edad y migración de paleoindios.

INTRODUCTION

Artifacts of lithic industry found in association with charcoal and bones of Pleistocene mammals in late-glacial cultural deposits at Monte Verde and Laguna de Tagua Tagua (fig. 1), both classic archeological sites, established the early use of fire by Paleoindians hunters in central and southern Chile (Casamiquela *et al.* 1967; Montané 1968; Casamiquela and Dillehay, 1989;M Pino, 1989). Hunting was greatly aided by burning, which provided a means of herding and corralling animal for a kill. Fires intentionally set by Paleoindians on most occasions were probably of limited size; however, with protracted dryness and warmth during summer drought, fires no doubt spread over areas of considerable extent before eventually becoming extinguished.

Lightning and volcanic activity, besides the Paleoindians practice of burning, are additional possible causes of past fires. In southernmost latitudes, however, thunderstorms during which lightning is most likely to occur are, according to Miller (1976), practically unknown, averaging <1 day yr^{-1}; on the west slopes of the Andes, thunderstorms average <4 days yr^{-1}. In this part of South América, the dominating flow of the powerful westerlies negates strong convective air movement required to produce thunderstorms.

Volcanism has the potential of acting as an incendiary (Fuentes and Espinosa, 1986), its region of influence relegated to the proximity of the Andes, were incandescent lava and explosive gases from erupting volcanoes serve as pyric agents. And lightning associated with volcanism (Davis and McNutt 1993) can further increase the

possibility of fire. Volcanic activity, nevertheless, may fail to produce fires, especially where humid conditions prevail. At Cuesta Moraga (Fig. 1), for example, located in an eruptive area centered at Volcán Corcovado in the southern Andes 43°25'S), charcoal is virtually absent in a mire deposit containing tephra layers from at least eight eruptions (Heusser et al. 1992). Moreover, two other deposits studied near 39°S in the region between Volcán Llaima and V. Lanín reveal an inconsistent relationship between layers of tephra and charcoal (Heusser et al. 1988).

On the basis of these and other observations, fire in parts of the region may be unrelated to both volcanism and lightning, making Paleoindians a leading vector of burning. Where data apply at places beyond Andean volcanic centers, exclusive occurrence of man-made fires becomes highly probable. Thus, abundance of charcoal found in non-Andean Quaternary deposits may provide an index of past fires set by Paleoindians. Certainly, its is difficult not to consider this interpretation at places where lightning virtually does not occur and volcanoes are absent as, for example, on Isla Grande de Chiloé and Isla Grande de Tierra del Fuego (Fig. 1), both distantly removed from sites of Andean volcanism.

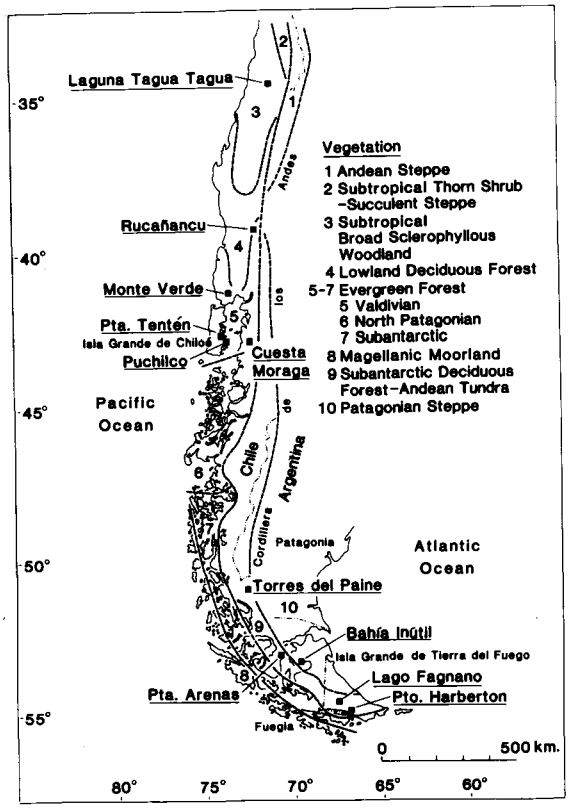

Fig. 1: Late Quaternary site locations of charcoal and fossil pollen records shown in relation to vegetation formations (Schmithüsen 1960; Moore 1974; Pisano 1981) in southern Chile and Argentina.

Ubicación geográfica de los sitios de registros del carbón y polen fósil correspondientes al Quaternario tardío en relación con las formaciones de la vegetación (Schmithüsen 1960; Moore 1974; Pisano 1981) en el sur de Chile y Argentina.

METHODS

Radiocarbon-dated records of charcoal in deposits encompassing as much as 50,000 yr. or more presented in this paper may suffice as indices of the chronology, incidence and overall extent of Paleoindian burning in southern South America during this time period. records selected from ten sites range from Laguna Tagua Tagua in subtropical Chile to Puerto Heberton in subantarctic Argentina (Fig. 1). Two of the sites are directly connected with Paleoindian occupation.

Stratigraphic samples from sections of the deposits were prepared by standard laboratory techniques, which included adding known amounts of exotic spores/ pollen to serve as a reference for measuring the quantities of charcoal (Faegri et al. 1989). Charcoal, consisting of microscopic scorched or blackened, cellular plant remains, as oppose to amorphous mineral particulates, is recorded by its total area (microns^2 cm^{-3}, 7-120 micron range) measured in each sample, except in one instance where numbers of fragments greater than, or equal to, 50 microns cm^{-3} were counted. Accompanying profiles of % fossil pollen/spores, identified from reference material and literature (Heusser 19781; Villagrán 1980), display the principal taxa in the records.

RESULTS

Paleoindian sites

At Monte Verde, (41°30´S, 73°15´W), stratigraphic samples studied are from alluvium unit MV-6 and peat unit MV-5, dated between about 13,500 and 11.000 yr BP (Fig. 2). Cultural remains accorded an age of around 13.000 yr BP (Dillehay 1989), occur in unit MV-5. Charcoal contained in this unit dates approximately the time of human occupation. Climatic warning, creating greater diversity in the *Nothofagus* (southern beech)-dominated arboreal communities at Monte Verde, is suggested by the pollen spectra (Heusser 1989a). Spectra show increasing Myrtaceas (myrtle) succeeding open stands of *Nothofagus* (coígüe), *Drimys winteri* (canelo), Gramineae (grass), and Ericaceae (heath). Peak Myrtaceae was evidently widespread in the late-glacial vegetation at about 12,000 yr BP in this sector of Chile (Heusser 1966), 1990a; Villagrán 1985, 1988).

A second archeological locality, Laguna de Tagua Tagua (34°30´S, 71°10´W), provides lengthy documentation of fire (Fig. 3). Charcoal in a section of the lake bed is found at intervals dating to >45,000 yr BP (Heusser 1983, 1990b). Although Paleoindians occupied this mastodon kill site as early as 11,380 yr BP (Montané

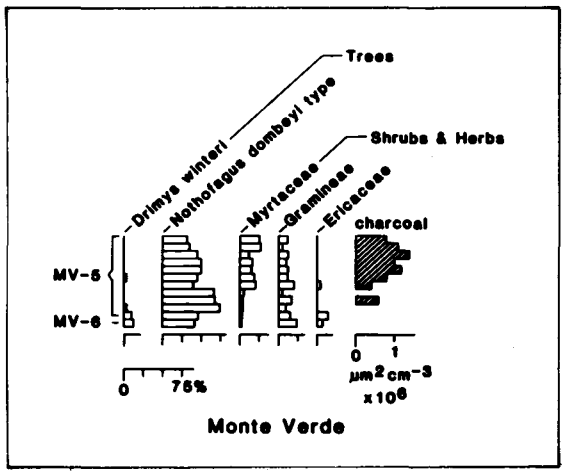

Fig. 2: Records of charcoal and fossil pollen at Monte Verde.

Registros de carbón y polen fósil en Monte Verde.

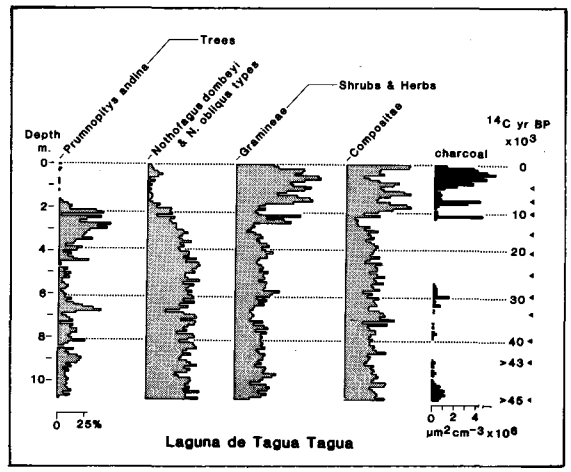

Fig. 3: Charcoal, radiocarbon chronology and fossil pollen in the section of Iscudtrine sediments at Laguna de Tagua Tagua.

Carbón, edad radiocarbónica y polen fósil de la sección de sedimentos lacustres en la Laguna de Tagua Tagua.

1968; Nuñez *et al.* 1993), the older charcoal sequences predating the last glacial maximum (25,000-14,000 yr BP) may also infer Paleoindian antiquity. After 10.000 yr BP, when climate became warmer and summer-dry, the increase in charcoal indicates that burning was apparently practiced on a larger scale than in the late Pleistocene by indigenous groups living in the region. Vegetation of semi-humid, temperate *Nothofagus* - *Prumnopitys* (podocarp) communities about the laguna have shifted to semi-arid, Subtropical Broad Sclerophyllous Woodland, or matorral, containing Gramineae and Compositae (composite) and had become, in turn, more readily combustible.

Chilotan Archipelago

Punta Tentén (42°28´S, 73°45´W), a site on Isla Grande de Chiloé dating from before the last glaciation of the island, is the oldest record of charcoal of this study. Dated at >49,700 yr BP (G. H. Denton, personal communication), charcoal occurs in nine of 19 levels in the section studied (Fig. 4; C. J. Heusser, unpublished data). It is found mainly in association with *Nothofagus* and Gramineae, but also with podocarp [(*Podocarpus nubigena* (manío),

Saxe-gothaea conspicua (manío), and *Lepidothamnus fonckii* (ciprés enano)], the assemblages indicative of open Subantarctic Evergreen Forest and Magellanic Moorland. Its importance, as in the extended record at Laguna de Tagua Tagua, lies in the inference of Paleoindian presence in Chile during an interstade of the Pleistocene.

Charcoal and pollen at Puchilco (42°37´S, 73°37´W), locate in Isla Lemuy in the Chilotan Archipelago, are as much as 11,400 years in age (Fig. 5). Charcoal is relatively unimportant earlier than 10,000 yr BP during the late-glacial, and likewise during the latest millennia of the Holocene (C. J. Heusser, unpublished data). In the climatically moderated early Holocene and later until just after 5000 yr BP, the considerable charcoal implies extensive e burning. North Patagonian Evergreen Forest (Fig. 1) of *Nothofagus dombeyi* type, Myrtaceae, *Podocarpus nubigena*, and *Pseudopanax laetevirens* (sauco del diablo) at Puchilco before 10,000 yr BP was subsequently invaded by *Weinmannia trichosperma* (teniú). After 5000 yr BP, there followed a return of clearly identifiable species of the North Patagonian Forest (*Podocarpus nubigena* and *Pseudopanax laetevirens*) apparently in response to cooler climate. Irregularities in the pollen profiles, notably the profiles of *Nothofagus dombeyi* type, Myrtaceae, and Gramineae during the early middle Holocene, can be attributed largely to conflagrations.

Lake district

Rucañancu (39°33´S, 72°18´W), is situated in the northern part of the lake district close to the contact between Lowland Deciduous and Valdivian Evergreen Forest (Fig. 1). The account of fire (Heusser 1984) is stressed by the increasing amounts of charcoal mostly during the middle and late Holocene (Fig. 6). The increase takes place after 8350 yr BP, coincident with peak Gramineae and achieves a maximum close to about 5000 yr BP, when percentages of *Nothofagus* (*N. obliqua* type at first and later *N. dombeyi* type) are steadily rising. As the trend expressed by the increasingly mesophytic vegetation is toward wetter and cooler climate, under which fire frequency is expected to the relatively low, the data possibly reflect a larger population of hunters and greater use of fire during the interval.

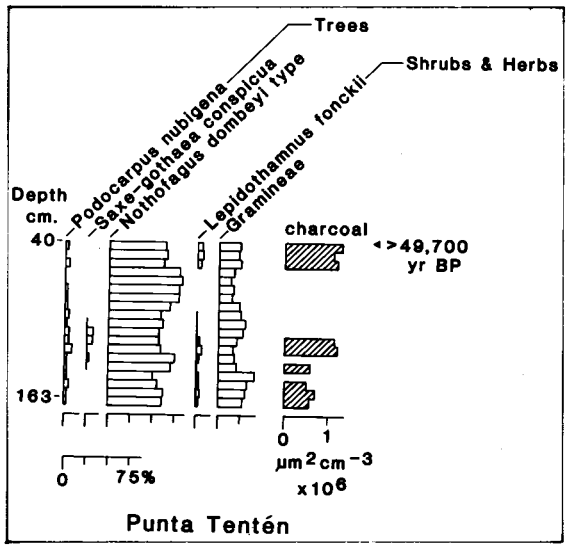

Fig. 4: Charcoal, radiocarbon age and fossil pollen in the section at Punta Tentén.

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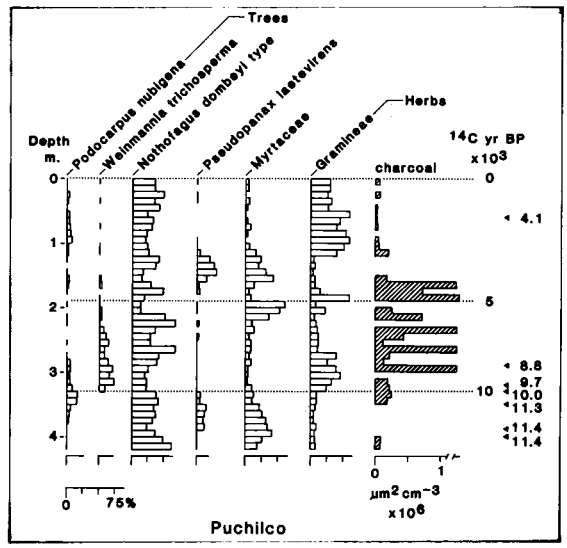

Fig. 5: Charcoal, radiocarbon chronology and fossil pollen in the section of mire at Puchilco.

Carbón, edad radiocarbónica y polen fósil de la sección de turbera en Puchilco.

Southern Patagonia

Two contrasting sites (Fig. 1), one a summer-dry lake in the vicinity of Torres del Paine (50°59′S, 72°40′W), and the other a sphagnous mire on the outskirts of Punta Arenas (53°09′S, 70°57′W), are representative of southern Patagonia (Heusser 1987; C.J. Heusser, unpublished data). The records, spanning the Holocene and part of the late-glacial, are situated in Patagonian Steppe and Subantarctic Deciduous Forest, respectively (Pisano 1973, 1974). At Torres del Paine (Fig. 7), the charcoal sequence begins at the late-glacial - Holocene boundary and exhibits larger concentrations in the early Holocene and during recent millennia. Pollen assemblages are dominated by Gramineae, *Acaena* and Compositae of the Steppe; *Nothofagus* derives from scattered arboreal communities in mesic locations at varying distances beyond the site. At Punta Arenas (Fig. 8), large charcoal concentrations are virtually confined to the early Holocene, at a time when openness of the vegetation, shown mostly by the Gramineae and Filicinae (ferns), preceded the expansion of Subantarctic Deciduous Forest and its displacement of the Steppe.

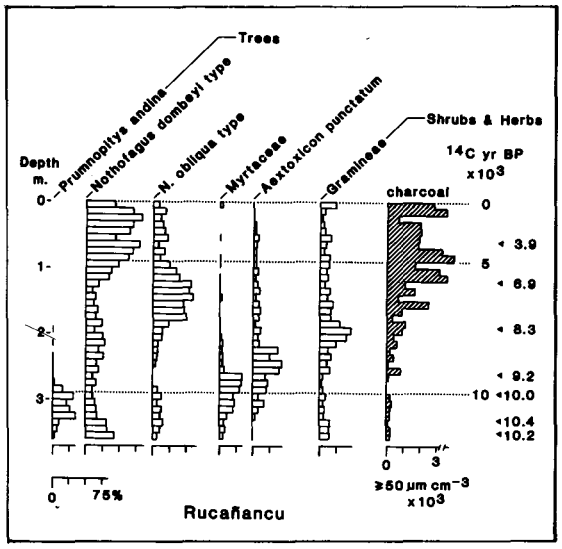

Fig. 6: Charcoal, radiocarbon chronology and fossil pollen in the section of mire at Rucañancu.

Carbón, edad radiocarbónica y polen fósil de la sección del pantano en Rucañancu.

Isla Grande de Tierra del Fuego

Located in Steppe, Bahía Inútil is the first of three selected paleoecological localities studied on Isla Grande de Tierra del Fuego (Fig. 1). The striking amount of charcoal dated at 13,280 yr BP at Bahía Inútil (Heusser *et al.* 1989-1990), occurs in a basal part of the layer of sedge peat, which deposited in a sequence of proglacial lake beds of clay and gravel (Fig. 9). Pollen stratigraphy of the peat shows typical components of the steppe dominated by Gramineae; *Nothofagus* at maxima of 12-18-is the result of long-distance wind transport.

Charcoal concentrations in mires at Lago Fagnano (54°52′S, 67°53′W), in Argentina (Fig. 1) are almost exclusively early Holocene in age (Figs. 10 and 11). This

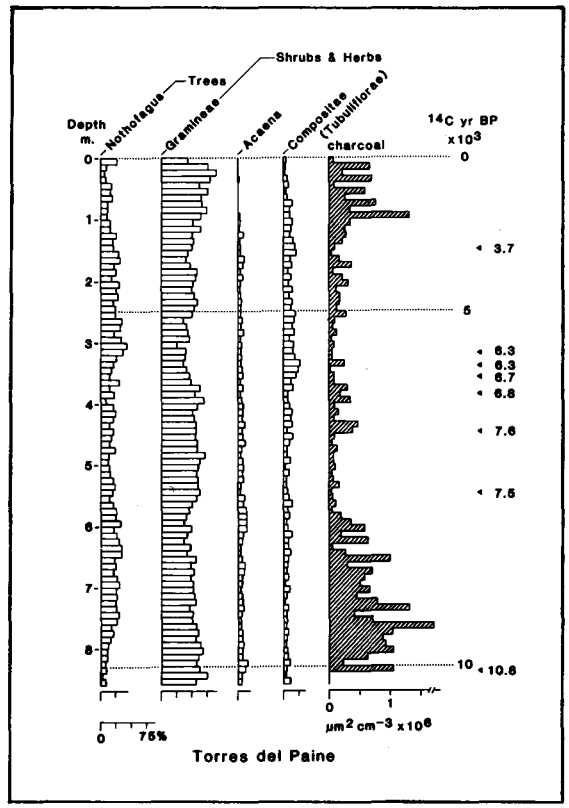

Fig. 7: Charcoal, radiocarbon chronology and fossil pollen in the section of lacustrine sediments at Torres del Paine.

Carbón, edad radiocarbónica y polen fósil de la sección desedimentos lacustres en Torres del Paine.

chronostratigraphic relationship, as previously noted, also applies in the case of the charcoal record of the early Holocene, versus structurally-closed, Subantarctic Deciduous Forest in the late Holocene, is similarly expressed by the pollen/spore stratigraphy at all three sites (Heusser 1990c; Rabassa et al. 1989; C.J. Heusser, unpublished data).

DISCUSSION

Fire during the Quaternary in southern Chile and Argentina was both geographically and temporally diverse, as shown by the recorded charcoal evidence. Although the argument cannot be proven that the cause of extended burning rests largely with Paleoindian activity, the inference seems clear that in non-volcanic regions lacking strong convective air movement necessary to produce lightning, an alternative explanation is not readily to be found accountable for fire. This is particularly the case where charcoal in successive levels in deposits covering many millennia infers uninterrupted burning.

Radiocarbon-rated, infinitely old charcoal is found at lower latitudes in Chile (Laguna de Tagua Tagua and Punta Tentén, Figs 3 and 4). If associated with Paleoindians, it places human habitation in southern South America during interstades in the last ice age; it also supports the possibility of human presence during the hypothesized occupation of Monte Verde at around 33,000 yr BP (Dillehay 1989). At higher latitudes in Fuego-Patagonia, no significant amounts of charcoal are found to be older than 13,280 yr BP (Bahía Inútil, Fig. 9). Among several excavations of cave deposits in Fuego-Patagonia, artifacts of Paleoindian lithic industry are dated no older than 12,600 yr BP (Cardich *et al.* 1973), and charcoal in the caves is as much as 12,390 yr BP (Nami 1987; Massone 1987; Borrero *et al.* 1989). Thus, the age of the Bahía Inútil charcoal,

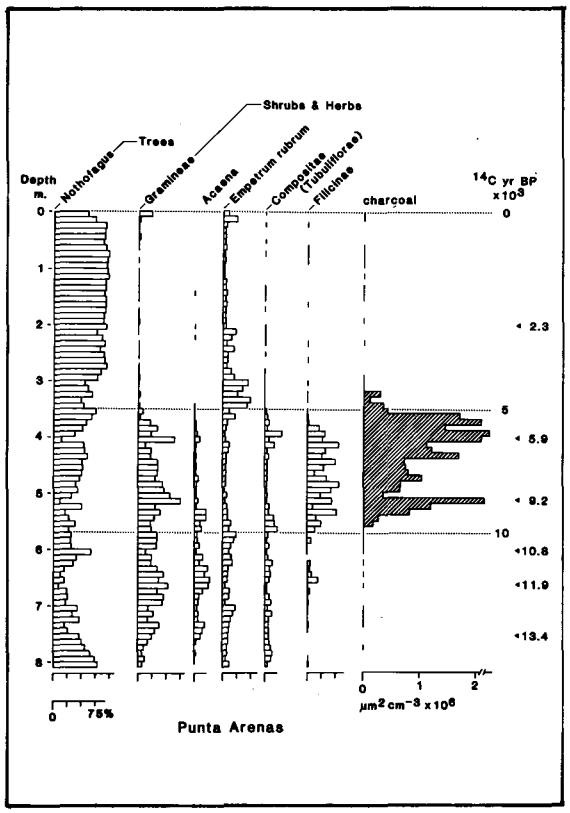

Fig. 8: Charcoal, radiocarbon chronology and fossil pollen and spores in the section of mire at Punta Arenas.

Carbón, edad radiocarbónica y polen y esporas fósiles en la sección de turbera en Punta Arenas.

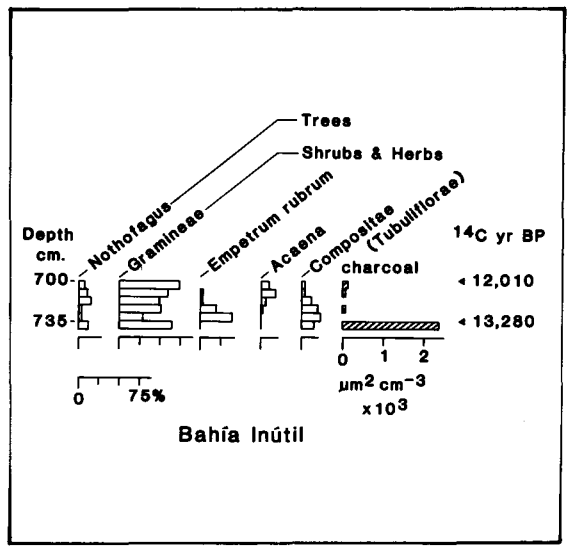

Fig. 9: Charcoal, radiocarbon chronology and fossil pollen in the section of Bahía Inútil.

Carbón, edad radiocarbónica y polen fósil de la sección deBahía Inútil.

approximates the age of 13,000 yr BP for human settlement at Monte Verde (Dillehay 1989).

At the time of the last glacial maximum (25,000 - 14,000 yr BP), cold climate and the expense of ice generated in the southern Andes apparently rendered the region inhospitable for human occupation. Absence of charcoal during this interval at Laguna de Tagua Tagua (Fig. 3) supports the proposition that during glaciation humans had vacated the higher latitudes of South America. Tagua Tagua at times of cold stadial climate was evidently uninhabited, in contrast with the Holocene, when populations apparently expanded. the course of warmer Pleistocene interstadials at Tagua Tagua, the charcoal data imply intermittent occupancy coinciding with a series of human migrations.

Peak amounts of charcoal, registered at different times in the records selected, are suggestive of routes followed by Paleoindians during late-glacial deglaciation and also over the course of postglacial millennia. Sequences from Isla Grande de Tierra del Fuego, beginning with the oldest charcoal from Bahía Inútil dated at 13,280 yr BP (Fig. 9), illustrate this movement. Migration southward, possibly across the Segunda Angostura in the Estrecho de Magallanes when Pleistocene sea level was relatively low, apparently proceeded to Fuegía from Patagonia via the shores of Bahía Inútil (Fig. 1). By 10,000 yr BP, it had continued to the southern sector of Isla Grande, as inferred not alone by the Lago Fagnano and Puerto Heberton charcoal records (Figs. 10 and 11) but also by data from other island sites (Heusser 1989c,

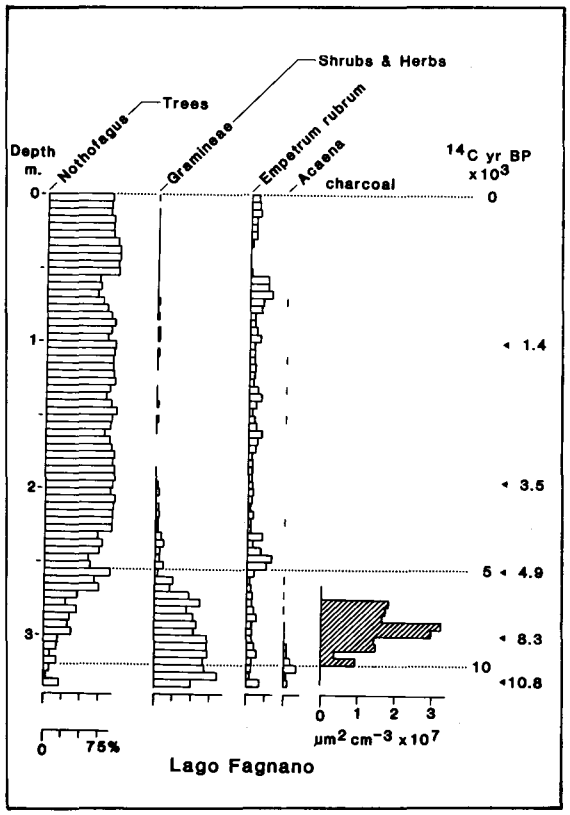

Fig. 10: Charcoal, radiocarbon chronology and fossil pollen in the section of mire near Lago Fagnano.

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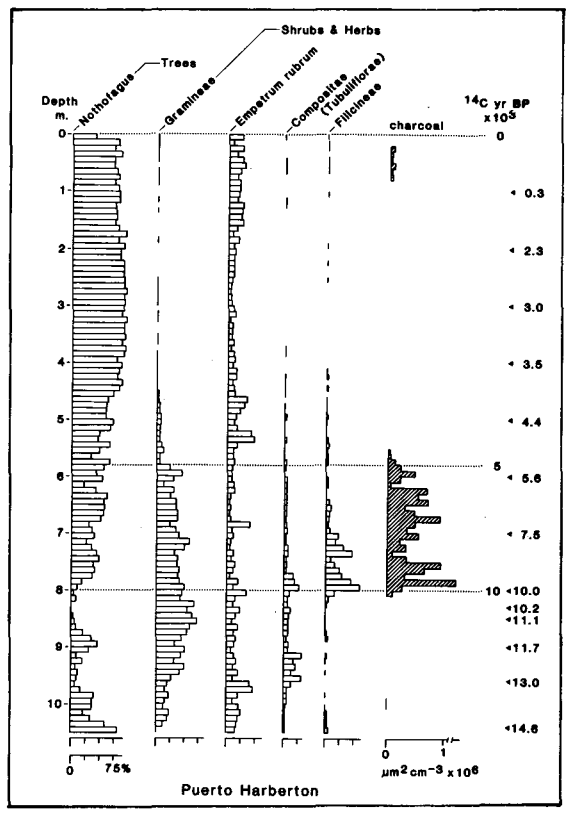

Fig. 11: Charcoal, radiocarbon chronology and fossil pollen in the section of mire at Puerto Heberton.

Carbón, edad radiocarbónica y polen fósil de la sección deturbera en Puerto Heberton.

1990c; Rabassa *et al.* 1989). Later, during more recent millennia, populations apparently occupied the west-central sector and southeastern Atlantic shore of Isla Grande (Heusser 1993; Heusser and Rabassa in press).

Archeological evidence of human occupation dated at 11,880 and 10,280 yr BP at Tres Arroyos (Massone 1987) in the northern part of the island (53°23' S, 68°47' W) is not incompatible with this trend. In the southern part of Isla Grande on Canal Beagle, however, the beginning of the charcoal peak at around 10,000 yr BP predates considerably the known arrival at Túnel (54°49' S, 60°09' W) of the earliest Paleoindian hunters from the interior dated at 7000 yr BP (Orquera and Plana 1987).

In conclusion, charcoal in Quaternary deposits offers a possible means of tracing human presence and migrations in southern South America. Data are most reliable from regions where other causal agents for fire, lightning and volcanic eruptions, can logically be discounted. The charcoal record, in this context, suggests that Paleoindians antiquity in Chile is at least on the order of 50,000 years in age, greatly exceeding the late-glacial chronology established from archeological evidence.

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