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Burning monkey-puzzle: Native fire ecology and forest management in northern Patagonia

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Abstract. This article outlines the ecological and ethnobotanical characteristics of the monkey-puzzle tree (*Araucaria araucana*), a long-lived conifer of great importance to the indigenous population living in and around its range in the southern Andes. The article also considers the pre-Columbian and historical use of indigenous fire technology. Conclusive evidence of indigenous burning is unavailable. However, our knowledge of native fire ecology elsewhere and our understanding of monkey-puzzle's ecological response to fire suggest that indigenous people probably burned in the past to facilitate the growth of monkey-puzzle trees relative to other species. The obstacles to recovering and redeploying a defunct fire-based production strategy include the vulnerable condition of monkey-puzzle stands after decades of intense logging and burning (by non-indigenous settlers), inadequate access to land and resources by the region's indigenous inhabitants, livestock pressure, depletion of game animals that were once hunted with fire, and reluctance by indigenous people to embrace old production strategies that have been supplanted by new ones based on domesticated animals and crop cultivation. Prescribed burns in selected areas offer an effective way to assess the feasibility of indigenous burning as an alternative to more conventional development initiatives.

Key words: *Araucaria araucana*, Argentina, Chile, Cultural ecology, Fire ecology, Natural resource management, Patagonia

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Introduction

The Andes of southern Chile and Argentina contain one of the world's great stands of temperate forest. This forest, which spans some 20 degrees of latitude, represents one of the highest standing biomasses of any terrestrial ecosystem and exhibits a high level of endemism. For example, standing biomass has been measured at more than 1,000 t/ha, and 34% of the planet's angiosperms are found only in the South American temperate forest (Armesto et al., 1995). Endemic to its northern extremes, the monkey-puzzle tree (*Araucaria araucana*) is a long-lived conifer with exceptional economic and cultural significance. The seed of the monkey-puzzle tree, or *piñon*, has long been a staple food for the Araucanos, an indigenous group of southern Chile and Argentina. The tree has also been prized by the timber industry for its high-quality and valuable wood. Furthermore, the monkey-puzzle tree has been important to national identity in Chile and Argentina. Chilean poet Pablo Neruda (1964) wrote of its majestic qualities in *Oda a la Araucaria Araucana*, and an image of the tree figures as a backdrop in the official seal of Argentina's Neuquén province.

This article considers the recovery and redeployment of defunct native management strategies, which may have incorporated fire to create and maintain stands of monkey-puzzle. The material is based on six months of fieldwork conducted in southern South America. Primary data were collected in two Araucano communities: Ralco Lepoy, a community of 800 inhabitants in the Andes of southern Chile; and Aigo, a community of 650 inhabitants located on the leeward slopes of the Andes in Argentina. These data, which were collected through open-ended interviews and field observations, address the indigenous use of the monkey-puzzle tree. Secondary sources, which were obtained through archival searches in the national and provincial capitals of Chile and Argentina and in

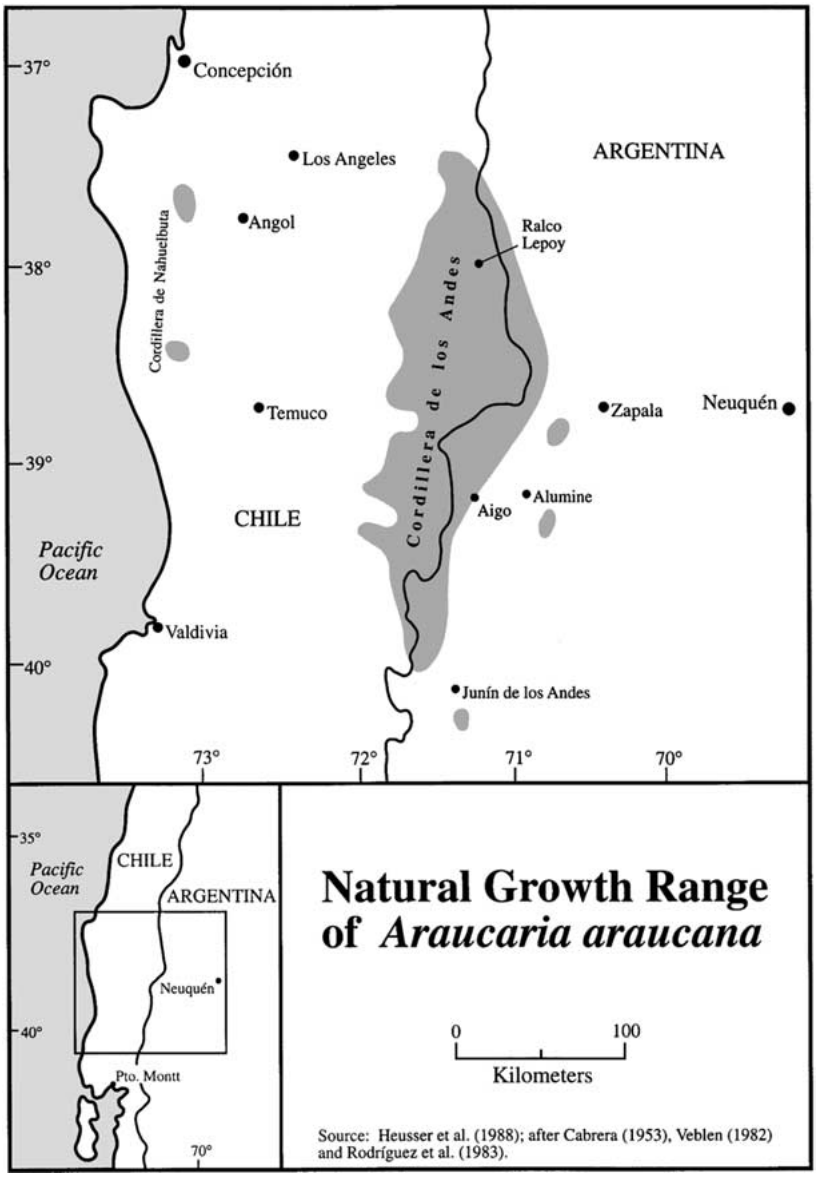

Figure 1. Natural growth range of *Araucaria araucana*.

various libraries in the United States, provide insight into former indigenous management strategies. The article initially describes the natural characteristics of the monkey-puzzle tree and assesses the ethnobotanical importance of the species. It then reviews colonized native ecologies by outlining the historical and political geography of the region's indigenous peoples. The article concludes by examining regional fire history and delineating the difficulties associated with redeploying an extensive fire-based production system. Material presented in this article represents an attempt to add to our understanding of historical and modern forest use in Latin America.

Species range and description

The main natural growth range of the monkey-puzzle tree in Chile is in the high Andes from latitude 37°30′ S to 39°30′ S, with two disjunct populations occurring in the Nahuelbuta Range about 125 km west of the Andean range. In Argentina, monkey-puzzle trees are found in the Andes and Andean pre-cordillera from latitude 37°45′ S to 40°20′ S (Figure 1). The climate in this area can generally be characterized as west coast maritime, with a winter maximum in precipitation. There is a very sharp longitudinal precipitation gradient. The annual precipitation range declines from 4000 mm on the windward Chilean side of the Andes to 1200 mm on leeward slopes in Argentina (Veblen, 1982). Temperature data from ten meteor-

Figure 2. Mature monkey-puzzle trees.

ological stations in the area yield a mean January temperature of 17 °C and a mean July temperature of 4 °C, although monkey-puzzle is capable of withstanding much more pronounced extremes (Montaldo, 1974).

Mature monkey-puzzle trees, which commonly live to be 1300 years old, develop columnar trunks nearly 50 m high and basal diameters of 2.5 m (Figure 2). The juvenile form looks like a pyramid or cone until it begins to lose its lower branches after 100 years. Leaves are perennial, rigid, 2–3 cm long, spiraled, pointed, and shiny, with stomata on each side. Monkey-puzzle trees have a thick, fire-resistant bark, which develops in distinctive polygonal plaques (Angli, 1918). The species has a superficial root system much more massive and extensive than the exposed portion of the plant (Tortorelli, 1942). The monkey-puzzle tree is a dioecious species, with wind being the key agent in fertilization. The male cones are chestnut in color, 8–12 cm long and 4–5 cm in diameter, and contain 10–20 pollen sacks in the center. The female cones are green in color, 20–25 cm long and 15–20 cm in diameter, and contain 120–180 seeds. The seeds resemble light-colored almonds about 4 cm long and 1.5 cm wide. Seed regeneration is generally poor, due to low dispersal rates, short seed viability, a low rate of seed fertility, and many seeds getting caught in the forest understory (Rodríguez et al., 1983).

Monkey-puzzle trees favor equator-facing slopes, being adapted to stronger solar insolation, and west-facing slopes, as a result of their preference for higher humidity. They grow primarily on volcanically derived soils at elevations between 600 and 1800 m. Ideal conditions are generally found between 1300 and 1600 m (Heusser, 1983). Monkey-puzzle grows in both pure and mixed stands. Pure stands, often with little or no understory, are found near timberline or in isolated pockets along the forest-steppe ecotone in Argentina. Mixed stands, which vary considerably according to zone, elevation, and aspect, commonly include the southern beech species of *Nothofagus antartica, Nothofagus pumilio*, or *Nothofagus dombeyi* (Veblen, 1982).

Ethnobotany

The monkey-puzzle tree is an important resource for Araucanos living in and around its main range.[1] Piñones are central to their diet. Interviews with 48 Araucanos in Ralco Lepoy and Aigo revealed that all informants rely on piñones as an important source of food. During the late austral summer and early fall, the Araucanos dedicate much time and energy to the *piñoneo*, or collection of piñones. Piñones are most commonly collected off the ground after being shaken loose from trees by wind, or they are knocked down by two species of parrots that feed in their upper reaches. Monkey-puzzle forests are managed collectively. No family may claim exclusive rights to any part of a forest containing monkey-puzzle trees. Families often go out for several days to collect piñones, sleeping at night in makeshift dwellings or taking refuge in the trunk of a large monkey-puzzle tree previously hollowed out by fire. Those living closer to monkey-

puzzle forests usually go on shorter outings. There is no age or gender division involved in gathering piñones.

Piñones are eaten raw, boiled, or toasted (either directly in the ashes of a fire, in a pot, or on an iron wood stove). They are also used to make a fermented beverage called *chavid*, and often ground into flour to be used as a condiment in soups or to make bread. Piñones may be preserved and stored for year-round use, either by hydration in a pit of cold running water, or by dehydration, most commonly achieved by drying the piñones in the sun or hanging them on necklaces over the family fire. To obtain surplus cash, the Araucanos sell piñones to merchants who visit their communities. Often the piñones are traded for sugar, yerba maté, and other provisions. The terms of trade are never very favorable for the Araucanos. Negotiations occur where the transaction takes place on a one-to-one basis. The Araucanos are at a disadvantage because they have few alternatives regarding where and to whom they can sell piñones. Setting and adhering to a community-wide price might give them some bargaining power, but merchants could counter by threatening to buy piñones from other communities. Merchants resell piñones in lowland towns, and regional and provincial capitals. Some piñones are even sold in the streets of Santiago and Buenos Aires.

Wood from the monkey-puzzle tree is used on rare occasions for house construction. It is more commonly used as fuelwood. The *clavos*, or knarl-like chunks of extremely hard wood found where branches protrude from the trunk, are especially sought after. Clavos burn at very high temperatures for hours, and have even been known to melt iron wood stoves. Some scholars (Angli, 1918; Gusinde, 1936; Hoffman, 1982; Record and Hess, 1943) have suggested that the Araucanos use resin from the monkey-puzzle tree to help wounds heal, for headaches and colds, to treat bruises and ulcers, to set fractures, for lockjaw, and to normalize menstruation, but medicinal use of the resin was not observed during fieldwork, nor was it reported by the Araucanos in interviews.

The Araucanos' relationship with the monkey-puzzle tree goes beyond a subsistence level. The species also provides them with symbolic and spiritual sustenance. The Araucanos perceive the monkey-puzzle forest as an extended family, which they call *lobpewen*. The male tree, *wentrupewen*, and the female tree, *domopewen*, are thought to reproduce through intercourse of their extensive root systems rather than by anemophilous means. Furthermore, the Araucanos respect a pair of deities living in the forest, *pewenucha* and *pewenkuzé*. The will of this couple is believed to influence the reproduction of monkey-puzzle trees (Bengoa, 1985). To ensure a good harvest of piñones, offerings are made during a ritual called *Ngillatun*. The sacred and central area around which this three-day, open-air ceremony takes place contains a monkey-puzzle tree. Piñones are also used in tombs and burials, and monkey-puzzle trees are occasionally planted in indigenous cemeteries. There is also a sacred monkey-puzzle tree in the northern part of its range in Argentina. This tree, called *El Pino del Cajón del Manzano*, is the subject of an annual pilgrimage for many Araucanos (Alvarez, 1980–86).

Sustaining native ecology

Material presented in this article is part of a long-term effort to understand the effects of human activity on the distribution of the monkey-puzzle tree. The conservation history of the species, additional details of Araucano ethnoecology and land tenure in Ralco Lepoy and Aigo, and more general information about forest policy and indigenous resource rights in southern Chile and Argentina are provided elsewhere (Aagesen, forthcoming, 1998a, b). The objective at hand is to evaluate the sustainability of indigenous production strategies, or ecological practices in the area that were colonized by outsiders. But such a quest leads one to wonder whether there is any native ecology to sustain. While the monkey-puzzle tree remains a significant resource for the Araucanos living in and around its main range, their relationship to nature and their livelihood strategies have changed remarkably over the past 500 years. Therefore, contemplating the sustainability of native ecology requires an understanding of the region's historical and political geography.

When the first Spanish conquistadors arrived in Chile in 1537, they found one of the largest South American indigenous societies, the Araucanos, living between the Choapa River and the island of Chiloé (Figure 3). Within this population, there were three groups: the northern Picunche; the central Mapuche; and the southern Huilliche. To the east of the Mapuche, the Spaniards found a mountain people known as the Pehuenche. The lowland Araucanos practiced shifting cultivation, growing maize, potatoes, beans, chili, and quinoa. The Pehuenche were a nomadic and foraging people. The piñon from the monkey-puzzle tree was central to the Pehuenche diet, as was meat obtained by hunting guanaco (*Lama guanicoe*) and ñandú (*Rhea americana*), the former a wild relative of the domesticated llama (*Lama glama*), and the latter a large flightless bird common throughout the windswept Patagonian plains (Olson, 1991).

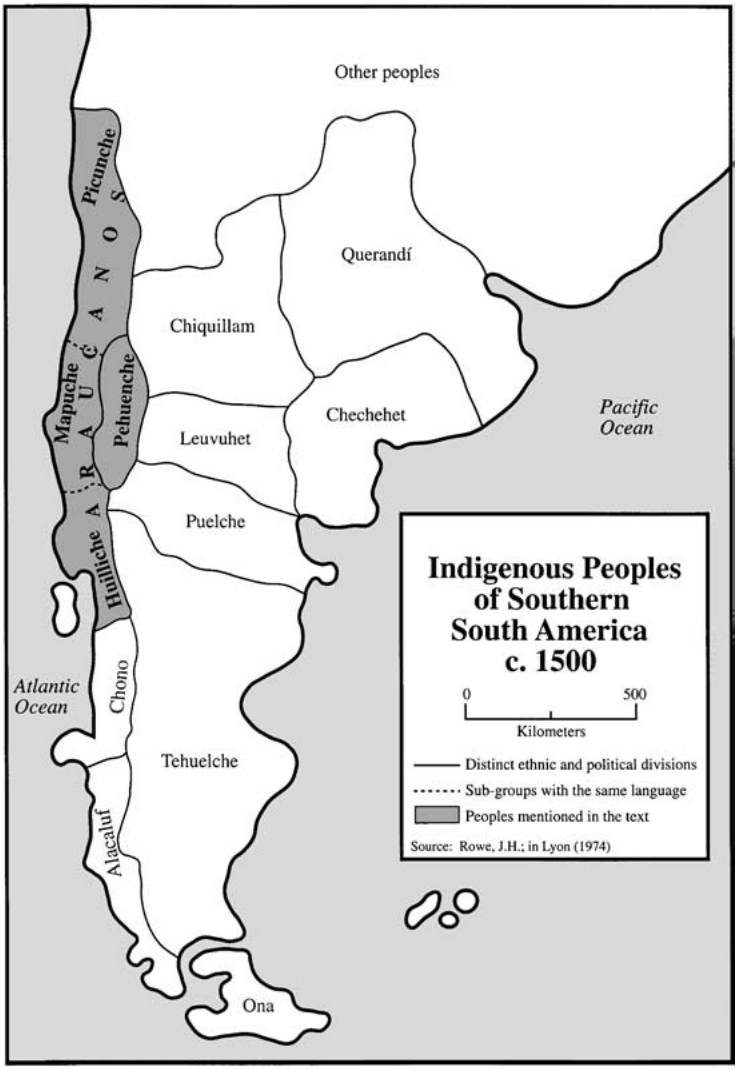

Figure 3. Indigenous peoples of southern South America, c. 1500.

Through a series of wars with the Spaniards, the northern Araucanos, or Picunche, ceased to exist by the early 1600s. This left the entire population of Araucanos south of the Bío-Bío River. Wars continued and many of the lowland Araucanos took to the mountains. Towards the mid-1600s, the Pehuenche fell under the influence of the Araucanos, who moved into the mountains not only as a result of direct conflict with the Spaniards, but also crossed the Andes into Argentina to rustle and trade livestock. The Pehuenche, who often served as intermediaries between the Araucanos and indigenous peoples of the Argentine Pampas, knew the mountain passes well, and the Araucanos needed this knowledge. In due time, through a process referred to as araucanization, the Pehuenche transculturated with the Araucanos. They underwent a series of sociocultural and economic changes, and the Pehuenche language slowly gave way to Mapundungu, the native tongue of the Araucanos. By 1800, the highland indigenous people differed from their lowland counterparts only in body size, numbers, several customs, and the environments in which they lived (Bengoa, 1985).

The Araucanos gained a reputation for being some of the fiercest warriors in the New World. They resisted territorial incursions by mastering the use of the horse, and were able to defend their lands successfully well into the 19th century. Until the early 1880s, penetration of lands south of the Bío-Bío was limited to a handful of settlers and missionaries. At this time, however, the Chilean state, having recently emerged victorious in the War of the Pacific against Peru and Bolivia, made a determined effort to secure territory in southern Chile. The Araucanos could not withstand the force and might of the well-armed Chilean troops, and by 1883 lands south of the Bío-Bío were conquered (Molina and Correa, 1992).

At the same time the Araucanos were being

subdued in southern Chile, the indigenous inhabitants of southern Argentina were experiencing military pressure of their own. It began in 1879 when General Julio Roca led a contingent of 6,000 men from Buenos Aires across the Humid Pampa, through Patagonia, and on to the Andes, waging what is known in Argentine history books as *La conquista del desierto*, or *Desert Conquest*. The Argentine authorities were determined to secure access to the natural resources in southern Argentina and to solidify national sovereignty in the area. Financed by both external and internal interests, Roca and his troops proceeded to decimate native inhabitants. To avoid this systematic extermination, many tried crossing over into Chile, to find the situation only marginally better. In January 1885, the last Araucano group surrendered to the Argentine troops (Curruhuinca, 1986). Authorities on both sides of the Andes had now secured effective control of indigenous peoples in southern South America. Although there is no evidence that the Chilean and Argentine authorities ever collaborated in their respective campaigns against the Araucanos, the principal result was the same. Indigenous people lost vast amounts of territory, along with the accompanying natural resources. Their land was effectively reduced to small patches, and the new territorial organization favored ranchers, settlers, traders, national and regional institutions, and the military (Osidala et al., 1992).

Both the transculturation of the Pehuenche with the Araucanos, completed by the end of the 18th century, and the subsequent incorporation of the Araucanos into Chilean and Argentine societies nearly a century later, modified regional production strategies significantly. Those who currently live in and around the monkey-puzzle forest no longer rely on piñones and game meat to stay alive. In most Araucano highland communities, raising small livestock is an extremely important activity. Goats and sheep are the most common domesticated animals, although some families have cattle, pigs, poultry, and horses. Residents in many communities practice transhumance, a seasonal pattern of livestock migration that involves taking animals to higher alpine meadows and pastures during the summer. Winter dwellings, located as low as 700 m, are left after the shearing season in December. Someone usually stays behind to tend cereal crops such as wheat, rye, barley, and oats.[2] Other family members take to higher lands, in some cases as high as 1300 m, where they live in rustic summer dwellings and stay with their animals until the first snow falls, usually in April or May. Piñones, in effect, are no longer the most important food resource in Araucano communities. They supplement Old World livestock and cereal crops, which have become the greatest sources of food security for the Araucanos. Nor are piñones the most important economic resource in Araucano communities. Temporary wage labor in nearby towns and cities has become the most critical source of economic security in most Araucano households. In many respects, then, a regional native ecology based on collecting piñones and/or hunting game cannot be sustained because it is essentially defunct. But can it be recovered and redeployed?

Recovering and redeploying native ecology

Any consideration of recovering and redeploying defunct native ecological practices in and around South America's monkey-puzzle forest first requires a basic understanding of the region's fire ecology. Naturally occurring fires in the Patagonian Andes are caused by lightening or volcanic activity. Interannual climatic variability strongly influences fire frequency, and years of extreme fire activity are usually associated with dry winters and springs followed by hot summers (Veblen et al., 1999). The monkey-puzzle tree, although not a serotinous (fire-dependent) species, is very well adapted to fire. As mentioned earlier, mature individuals have thick, fire-resistant bark, and they also have protected terminal buds (Veblen et al., 1995). Furthermore, *Nothofagus pumilio* and *Nothofagus dombeyi*, two of the southern beech species that grow in association with the monkey-puzzle tree, are very sensitive to fire. This provides the monkey-puzzle tree with a post-fire competitive advantage when fire strikes stands of either monkey-puzzle and *N. pumilio* or monkey-puzzle and *N. dombeyi*. When fire ignites stands of monkey-puzzle and *Nothofagus antartica*, a third species of southern beech that *is* well adapted to fire, monkey-puzzle will eventually establish dominance. Although *N. antartica* sprouts immediately after a burn and dominates for several decades, monkey-puzzle trees will establish under partial shade. After about 70 years, they will overtake *N. antartica* and grow rapidly. After some 150 years, the monkey-puzzle trees will exclude the senescent *N. antartica* (Veblen et al., 1995).[3]

Given that the monkey-puzzle tree is well adapted to fire, efforts to recover and redeploy native ecological practices must determine the extent to which fire was used by the area's indigenous inhabitants to simulate natural conditions, and thereby increase the distribution and productivity of monkey-puzzle stands. Making this determination is an exceptionally tall task, regardless of whether one considers the pre-Columbian Pehuenche or the Araucanos of about 1800. Virtually no archaeological investigation yielding insight into this question has been conducted, and there is a dearth of written information about early

indigenous production systems because of limited missionary activity and relatively late settlement in the region. Thus, there are few clues in the archaeological and ethnohistorical literature as to whether the area's pre-contact or pre-colonized indigenous inhabitants used fire to create and maintain the monkey-puzzle forest. There is, however, solid evidence that fire was used to hunt game throughout the Patagonian plains and along the forest-steppe ecotone. Since the decline of southern South America's indigenous population during the late 1800s, which effectively ended the use of fire to hunt game, and since policies of fire suppression were enacted during the early 1900s to extinguish blazes caused by pioneer settlers, tree stands along the forest-steppe ecotone have spread slightly east into steppe environments (Kitzberger and Veblen, 1999; Veblen and Lorenz, 1988). But this evidence fails to reveal whether the region's indigenous inhabitants ever used fire to manage the monkey-puzzle tree. One of the earliest written accounts of the area contains no references to the use of fire as a management tool (de la Cruz, 1835). Likewise, there is no mention of fire technology in two comprehensive historical accounts of the Pehuenche (Torrejón and González, 1993; Villalobos, 1989), nor is the use of fire in the southern Andes discussed in a recent reference volume about indigenous South Americans (Wilson, 1999). Two prominent biogeographers, however, have suggested that indigenous groups used to burn the understory of monkey-puzzle stands to facilitate piñon collection (Veblen and Kitzberger, 1997). There is a definite need for coordinated paleoecological, archaeological, and ethnohistorical research to shed light on the region's native fire ecology.

Despite our lack of knowledge about the indigenous use of fire in the temperate forest of the southern Andes, there is ample evidence that fire has been used by indigenous peoples in other parts of the world. In Australia, Aboriginals regularly and systematically used fire to control the distribution, diversity, and relative abundance of plant and animal resources (Preece, 2002; Yubarbuk et al., 2001). In North America, recent studies indicate that Native Americans employed fire technology in diverse habitat types to favor abundant populations of useful plant and animal species. The abundance of red oak (*Quercus rubra*) in south-central Ontario has been attributed to intentional burning that provided the species with a competitive advantage over shade-tolerant trees such as sugar maple (*Acer saccharum*) (Dey and Guyette, 2000). Low-intensity surface fires were also ignited by Native Americans in the Appalachian Mountains to perpetuate oak as a dominant species (Brose et al., 2001). In the coastal ranges of California, indigenous groups used fire to increase seed, bulb, and fruit production (Keeley, 2002). In the Pacific Northwest, a region with climatic and vegetation characteristics similar to those found in parts of the southern Andes, Native Americans used fire to control and maintain ecosystems. This is supported by a combination of paleoecological, archeological, and historical data (Whitlock and Knox, 2002). Overall, these studies reflect a heightened appreciation of the extent to which indigenous peoples used fire to modify or maintain landscapes in a wide range of environments. Lewis (1985: 76), one of the pioneers in the study of North American indigenous fire technology, points out that "with the exception of those societies found in the arctic and in some equatorial forest regions, fires were a significant part of human-environmental relationships for hunting-gathering peoples."

This article does not intend to prove the deliberate burning of monkey-puzzle trees in order to favor their regeneration relative to other species. Again, such proof can only come about after long-term, interdisciplinary research involving paleoecological, archeological, and ethnohistorical inquiry. Given that fire, however, was widely used in other parts of the world and definitely employed to hunt game along the forest-steppe ecotone (by those who would collect piñones during harvest season), and in light of the suggestion by Veblen and Kitzberger (1997) that fire was likely used to facilitate piñon collection, it is entirely conceivable that burning was a strategy used to maintain and even create stands of fire-resistant monkey-puzzle trees. Assuming that fire was once an indigenous resource management tool, one might ask whether it is feasible to redeploy low-intensity, controlled burns in the monkey-puzzle forest.

Clearly, there are numerous impediments to the contemporary use of fire. First, vast stands of monkey-puzzle (as well as other species in southern South America's temperate forest) were burned intentionally by settlers once the region's indigenous population had been conquered. These settlers saw the forest as an enemy, and in their quest to clear land for pasture or cultivation they often eliminated forest cover with the strike of a match (Kozdon, 1958; Weber, 1983). Excessive timber harvest has also been detrimental to the monkey-puzzle tree (Montaldo, 1951; Mutarelli and Orfila, 1970; Puente, 1980; Veblen and Delmastro, 1976). There is legitimate concern that remaining stands of monkey-puzzle might not be able to withstand more fire. Second, the scarcity of indigenous land would make it difficult to redeploy native fire ecology. The Araucanos no longer roam freely throughout the growth range of the monkey-puzzle tree as their predecessors once did. They have been obliged to submit to a reservation system, a considerable portion of land containing stands of monkey-puzzle

is private or protected, and two different countries have jurisdiction over the species. This does not facilitate extensive land use based on prescribed burns. Third, post-fire regeneration of monkey-puzzle stands would likely be inhibited by the widespread presence of livestock in the region. Several researchers point to the negative effects that grazing practices have on monkey-puzzle regeneration. In addition to eating piñones, domesticated animals often crush seedlings and eat seedling leaves that are above the snow during the winter (Mutarelli and Orfila, 1970; Serret, 1984; Tortorelli, 1942). Reducing livestock numbers presents complex sociopolitical challenges, given the economic and cultural importance of livestock to the Araucanos. Fourth, it would be virtually impossible to redeploy fire to hunt game such as guanaco and ñandú. Habitat encroachment has caused a drastic decline of these animals, and one cannot assume that they would please the palate of contemporary Araucanos. Fifth, and finally, the Araucanos themselves may resist the redeployment of indigenous fire technology. Many of them have come to view fire as destructive, given the widespread and uncontrolled burning by settlers and the subsequent emergence of fire suppression policies. Furthermore, the Araucanos have embraced resource management strategies based on livestock and cereal crops largely because of the increased food security they confer. It is quite inconceivable that they would forfeit this security in favor of torching their diminished stands of monkey-puzzle.

Conclusion

The monkey-puzzle tree is one of the most majestic species in the Patagonian Andes. Referred to as the king of non-tropical American trees by the German naturalist E. Poeppig (1836), the species has enormous cultural and economic significance. Scholars know painfully little, however, about the native ecological practices that were used to manage stands of monkey-puzzle. Archaeological investigation is inadequate, and there are no obvious clues in the ethnohistorical literature because the region was poorly chronicled and recently settled. Paleoecological evidence indicates that fire was used along the Patagonian forest-steppe ecotone, but data are insufficient to document the indigenous use of fire within the monkey-puzzle forest. There is clearly a need for long-term, interdisciplinary research to shed light on this question and to bring our knowledge of native fire ecology in the southern Andes on par with our understanding of indigenous burning in other parts of the world, especially Australia and North America. This article makes an explicit call for such research, which has the potential to inform policy discussions about protecting stands of monkey-puzzle and implementing development projects in Araucano communities.

Even if future research establishes that fire was once used to create and maintain stands of monkey-puzzle, the redeployment of native ecology would face formidable obstacles. Stands of monkey-puzzle are vulnerable after years of uncontrolled burning and logging, the area's indigenous residents have lost large quantities of land, domesticated animals inflict widespread damage on native tree species, and game resources such as guanaco and ñandú have been depleted. Furthermore, the Araucanos would not necessarily embrace burning. Through transculturation with and colonization by outsiders, most Araucanos see fire as destructive and have turned away from piñones in favor of other forms of economic and food security, namely livestock, cereal crops, and temporary wage labor. The Araucanos still, however, maintain an important and multi-functional relationship with monkey-puzzle, and are generally interested in measures taken to protect and favor the species. Increased piñon production and collection would allow the Araucanos to reduce alarmingly high stocking rates and decrease their dependence on cereal crops. It would also provide additional economic security through the increased sale of piñones.

Despite the aforementioned obstacles to indigenous burning, it is within the realm of reason to conduct trial burns. The experimental and controlled use of fire in selected areas could facilitate the collection of piñones, and allow forest ecologists to monitor the regeneration of monkey-puzzle relative to other tree species. Measures to increase productivity and security in Araucano communities, however, should in no way exclude the Araucanos. Other data collected during fieldwork, both primary and secondary, suggest that the Araucanos have been marginalized from the formulation of conservation and development policy even though they would welcome opportunities to be more active participants. The Araucanos have a right to be at the forefront of any effort aimed at improving their welfare, regardless of whether this effort involves unorthodox measures such as the recovery and redeployment of past production strategies or more conventional measures based on the introduction of new technologies and resources.

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Notes

1. There are approximately 600,000 Araucanos living in Chile, and some 40,000 in Argentina. Not all of them live in close proximity to the monkey-puzzle tree's main range. The total number of Araucanos in Chile who have a significant relationship to monkey-puzzle is estimated to be 15,000. Approximately 5,000 Araucanos in Argentina consider the monkey-puzzle tree to be an important resource (Olson, 1991; Radovich and Balazote, 1992; Santos, 1991).
2. Such crops are cultivated with introduced technology, namely the steal plow drawn by yoked oxen. Negative environmental consequences include soil erosion, disruption of local hydrology, and increased pressure on forest and forage resources.
3. Overall, the monkey-puzzle tree has an excellent regeneration capacity, even though its seed regeneration is relatively poor. The species does not appear to be, as some have suggested, a relict conifer approaching extinction. In addition to fire-related adaptations, it has developed effective root suckering and stump sprouting mechanisms (Veblen, 1982). Furthermore, the monkey-puzzle tree is able to withstand strong windstorms because of its extensive lateral root system, and is one of the first tree species to colonize rocky sites and areas affected by volcanic eruptions (Veblen et al., 1995).

References

Aagesen, D. L. (forthcoming). "Tradition, timber and territory in the southern Andes: Waging battle over the monkey-puzzle tree." In M. K. Steinberg (ed.), *Forests, Fields, and Fish: Politicized Indigenous Landscapes*. Austin: University of Texas Press.

Aagesen, D. L. (1998a). "On the northern fringe of the South American temperate forest: The history and conservation of the monkey-puzzle tree." *Environmental History* 3(1): 64–85.

Aagesen, D. L. (1998b). "Indigenous resource rights and conservation of the monkey-puzzle tree: A case study from southern Chile." *Economic Botany* 52(2): 146–160.

Alvarez, G. (1980–1986). *Neuquén: su historia, geografía y toponimia*. 6 vols. Neuquén: Gobierno de la Provincia del Neuquén.

Angli, J. (1918). "La *Araucaria araucana* (Mol.) Koch y su resina: Sus relaciones con las demás coníferas." *Boletín de la Academia Nacional de Ciencias* (Córdoba) 23: 1–84.

Armesto, J. J., P. Léon Lobos, and M. K. Arroyo (1995). "Los bosques templados del sur de Chile y Argentina: una isla biogeográfica." In J. J. Armesto, C. Villagran, and M. K. Arroyo (eds.), *Ecología de los bosques nativos de Chile* (pp. 23–28). Santiago: Editorial Universitaria.

Bengoa, J. (1985). *Historia del pueblo mapuche*. Santiago: Ediciones SUR.

Brose, P., T. Schulter, D. Van Lear, and J. Berst (2001). "Bringing fire back: The changing regimes of Appalachian mixed-oak forests." *Journal of Forestry* 99(11): 30–35.

Cabrera, A. L. (1953). "Esquema fitogeográfico de la República Argentina." *Revista del Museo de la Ciudad Eva Perón* 8(33): 87–168.

Curruhuinca, R. (1986). *Sayhueque: el ultimo cacique*. Buenos Aires: Editorial Plus Ultra.

de la Cruz, L. (1835). *Descripción de la naturaleza de los terrenos que se comprenden en los Andes, poseidos por los peguenches, y los demás espacios hasta el Río Chadileubu*. Buenos Aires: Imprenta del Estado.

Dey, D. C. and R. P. Guyette (2000). "Anthropogenic fire history and red oak forests in south-central Ontario." *The Forestry Chronicle* 76(2): 339–347.

Gusinde, M. (1936). "Plantas medicinales que los indios araucanos recomiendan." *Antropos* 5: 851–873.

Heusser, C. J. (1983). "Quaternary history of the monkey-puzzle tree (*Araucaria araucana* (Mol.) C. Koch) in Chile and Argentina." Grant proposal submitted to the National Science Foundation, Environmental Biology Unit, Washington, DC.

Hoffman, A. (1982). *Flora silvestre de Chile: zona austral*. Santiago: Ediciones Fundación Claudio Gay.

Keeley, J. E. (2002). "Native American impacts on fire regimes of the California coastal ranges." *Journal of Biogeography* 29(3): 303–320.

Kitzberger, T. and T. T. Veblen (1999). "Fire-induced changes in northern Patagonian landscapes." *Landscape Ecology* 14: 1–15.

Kozdon, P. (1958). "Las coníferas autóctonas y su progresiva desaparición en la cordillera andina." *Montes* 14(84): 463–472.

Lewis, H. T. (1985). "Why Indians burned: Specific versus general reasons." In *Proceedings – Symposium and Workshop on Wilderness Fire*, November 15–18, 1983, (pp. 75–80). Missoula, Montana: United States Department of Agriculture.

Lyon, P. J. (ed.) (1974). *Native South Americans: Ethnology of the Least Known Continent*. Boston: Little, Brown and Company.

Molina, R. and M. Correa (1992). *Territorio y comunidades pehuenches del Alto Bío-Bío*. Santiago: Comisión Especial de Pueblos Indígenas.

Montaldo, P. R. (1974). "La bioecología de la *Araucaria araucana* (Mol.) C. Koch," Boletín 46/48. Merida, Venezuela: Instituto Forestal Latinoamericano de Investigaciones y Capacitación.

Montaldo, P. R. (1951). *Condiciones ecológicas y dasonómicas de la especie* Araucaria araucana *(Mol.) Koch*. Bachelor's

thesis, Departamento de Ciencias Forestales, Universidad de Chile.

Mutarelli, E. J. and E. R. Orfila (1970). "Ensayo de tratamientos experimentales en bosques de *Araucaria araucana* (Mol.) C. Koch en la zona del Lago Moquehue, Provincia del Neuquén, Argentina." *Revista Forestal Argentina* 14: 109–117.

Neruda, P. (1964). *Nuevas odas elementales*. Buenos Aires: Editorial Losada.

Olson, J. S. (1991). *The Indians of Central and South America: An Ethnohistorical Dictionary*. New York: Greenwood Press.

Osidala, N., R. Romero, and C. Corvalán (1992). "Parque Nacional Lanín: Manejo de los recursos naturales con pobladores." In S. Amend and T. Amend (eds.), *¿Espacios sin habitantes? Parques nacionales de América del Sur* (pp. 57–69). Caracas: Editorial Nueva Sociedad.

Poeppig, E. (1836). *Reise in Chile, Peru und auf dem Amazonen Strome*. Leipzig: N.p. Cited in Patricio R. Montaldo (1974). "La bioecología de la *Araucaria araucana* (Mol.) C. Koch," Boletín 46/48. Merida, Venezuela: Instituto Forestal Latinoamericano de Investigaciones y Capacitación.

Preece, N. (2002). "Aboriginal fires in monsoonal Australia from historical accounts." *Journal of Biogeography* 29(3): 321–336.

Puente, M. (1980). "Utilización de un bosque del tipo araucaria con criterio de permanencia," Boletín Técnico 57. Santiago: Departamento de Ciencias Forestales (Universidad de Chile).

Radovich, J. C. and A. O. Balazote (1992). "El pueblo mapuche en la actualidad." In J. C. Radovich and A. O. Balazote (eds.), *La problemática indígena* (pp. 159–187). Buenos Aires: Centro Editor de América Latina.

Record, S. J. and R. W. Hess (1943). *Timbers of the New World*. New Haven, Connecticut: Yale University Press.

Rodríguez, R., O. Matthei, and M. Quezada (1983). *Flora arbórea de Chile*. Concepción, Chile: Editorial de la Universidad de Concepción.

Santos, J. F. (1991). "La etnía pehuenche y su etorno." Unpublished report prepared for the EULA Project, Concepción, Chile.

Serret, A. (1984). *Regeneración espontánea del pehuen* (Araucaria araucana) *en 4 sitios forestales del Parque Nacional Lanín, Provincia del Neuquén*. Bachelor's thesis, Departamento de Agronomía, Universidad Nacional de Buenos Aires.

Torrejón, F. and T. González (1993). "Los pehuenches: Una vision historica." In F. Faranda and O. Parra (eds.), *La región del Biobío, un espacio y una historia* (pp. 71–125). Santiago: Grafica Andes.

Tortorelli, L. A. (1942). "La explotación racional de los bosques de araucaria del sur." *Servir* 6: 1–53.

Veblen, T. T. (1982). "Regeneration patterns in *Araucaria araucana* forests in Chile." *Journal of Biogeography* 9: 11–28.

Veblen, T. T. and D. C. Lorenz (1988). "Recent vegetation changes along the forest/steppe ecotone of northern Patagonia." *Annals of the Association of American Geographers* 78(1): 93–111.

Veblen, T. T. and R. Delmastro (1976). "Los recursos genéticos de *Araucaria araucana* en Chile." *Información Sobre Recursos Genéticos Forestales* (Food and Agriculture Organization) 5: 2–5.

Veblen, T. T. and T. Kitzberger (1997). "History and ecology of fire in southern Argentina." Paper presented at the II Southern Connection Congress on Southern Temperate Biota and Ecosystems. January 6–11, Valdivia, Chile.

Veblen, T. T., B. R. Burns, T. Kitzberger, and R. Villalba (1995). "The ecology of the conifers of southern South America." In N. J. Enright and R. S. Hill (eds.), *Ecology of the Southern Conifers* (pp. 120–155). Washington, DC: Smithsonian Institution Press.

Veblen, T. T., T. Kitzberger, R. Villalba, and J. Donnegan (1999). "Fire history in northern Patagonia: The roles of humans and climatic variation." *Ecological Monographs* 69(1): 47–60.

Villalobos, S. (1989). *Los pehuenches en la vida fronteriza*. Santiago: Ediciones Universidad Católica de Chile.

Weber, C. (1983). *El patrimonio natural de Chile: Características, importancia y alternativas para su preservación*. Bachelor's thesis, Facultad de Ciencias Agrarias, Veterinarias y Forestales, Universidad de Chile.

Whitlock, C. and M. A. Knox (2002). "Prehistoric burning in the Pacific Northwest: Human versus climatic Influences." In T. R. Vale (ed.), *Fire, Native Peoples, and The Natural Landscape* (pp. 195–231). Washington, DC: Island Press.

Wilson, D. J. (1999). *Indigenous South Americans of the Past and Present: An Ecological Perspective*. Boulder, Colorado: Westview Press.

Yibarbuk, D., P. J. Whitehead, J. Russell-Smith, D. Jackson, C. Godjuwa, A. Fisher, P. Cooke, D. Choquenot, and D. M. J. S. Bowman (2001). "Fire ecology and Aboriginal land management in central Arnhem Land, Northern Australia: A tradition of ecosystem management." *Journal of Biogeography* 28(3): 325–343.

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