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Peter Germann and Peter Holland

Fragmented Ecosystems: People and Forests in the Mountains of Switzerland and New Zealand

The mountain forests of Switzerland and New Zealand have been modified by people, plants, and animals, albeit at different times and in distinctive ways. In both countries, what had been extensive wooded tracts at the start of human settlement were progressively converted by settlers to heterogeneous forest patches surrounded by pasture and other managed systems. Some native species thrived, others became rare, and a relatively small number disappeared. At the same time, exotic plant and animal species became established in remaining areas of forest and have had diverse impacts on the native biota. In both countries, from the 1870s onward, laws were enacted to protect native forest ecosystems. Targeted programs of pest plant and animal control, new regional and national patterns of economic activity, the slow retreat of commercial farming from economically marginal lands, competition from cheap imported wood in Switzerland, and a heightened conservation ethic are expected to facilitate the reestablishment of native forest ecosystems in the mountains of both countries.

Keywords: *Mountain forests; anthropogenic disturbance; introduced species; conservation; ecosystem protection; New Zealand; Switzerland.*

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Introduction

The landscapes of Switzerland and New Zealand show the pervasive impact of people (see overview in Figure 4). In this article, we suggest that increasing public awareness, enlightened legislation, and recent macroeconomic changes could ensure better prospects for the mountain forests of both countries and may even facilitate recovery of their fragmented ecosystems.

Switzerland and New Zealand are mountainous, midlatitude countries that were affected by glaciation during the Pleistocene. The former is part of Europe and has been occupied by people for several thousand years, whereas the latter is a collection of islands in the Southwest Pacific that were first settled about 1000 years ago. Even though plant and animal species native to both countries have become extinct since the beginning of human settlement and many more are currently threatened with extinction, conservationists are now reasonably confident about identifying effective ways to protect native ecosystems. Today, Switzerland faces a major shift in land use. Between 1985 and 1995, the wooded area grew by 5%, from about 1 million to 1.05 million ha, mainly in the mountain regions of the Alps, Pre-Alps, and Jura (Brassel and Brändli 1999). Those statistics indicate a transition from cultural to wild landscapes, with about 40,000 ha of forestland replanted between the 1880s and 1960s (Pfister et al 1987). Much the same is likely in New Zealand and will probably involve greatly expanded commercial forestry in hill and low mountain country.

The Swiss Alps

Early times

Prior to human settlement, forests covered most of Switzerland below the timberline (1700–2400 m). Ott et al (1997) divide the Swiss section of the Alps into 5 forest regions running from southwest to northeast that are characterized by the principal tree species in each (Table 1). Local climates vary considerably with elevation, slope angle, and aspect.

As Welten (1982) suggests, extensive burning and substantial clear-cutting and pasturing at high altitudes began in the early Bronze Age (3800 years BP). Both the area cleared for cultivation and population density peaked about 400 AD, at the end of the Roman period (Klaus et al 2001). Epidemics reduced the human population to about a quarter by the early 7th century, and forest regenerated on previously cleared land. Agriculture was of low intensity and dispersed across the territory, with most domestic animals foraging in the woods (Abel 1978). Population growth eventually led to the expansion of commercial and subsistence agriculture and spurred improvements in food production. Cereal growing intensified during the 10th century, but the amount of meat in the average diet declined as towns and cities grew in size and economic importance during the medieval period (Montanari 1993). Food production occupied about 90% of the population. Forests were a source of timber, fuel, mushrooms, medical herbs, and fruits for the common people as well as meat for those members of the upper class who were permitted to hunt wild game.

Bubonic plague struck in the middle of the 14th century and severely reduced Switzerland's human population. Cattle breeding subsequently improved and larger scale cheese production began (Rösener 1993). Crafts such as blacksmithing, ore smelting, and glass production prospered, increasing the demand for wood for fuel and for use in mining. Forest quality and extent declined due to overuse. Although the authorities issued laws and rules to protect forests and increase their productivity, forest fragmentation and depletion continued into the 19th century (Bavier 1949).

Modern times

A catastrophic flood hit large areas of the northern Alps and Pre-Alps in 1835, followed by a series of minor flood events in the 1840s (Gerber 1989). The Swiss Forest Association (SFA) was founded in 1845, three years before implementation of modern Switzerland's new

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TABLE 1 The five forest climatic regions of Switzerland according to Ott et al (1997).

Northern Alpine Fringe with a modified oceanic climate and foehn conditions in north-facing areas	
Foothills	Mixed broadleaf forests comprising beech (*Fagus sylvatica*), ash (*Fraxinus excelsior*), oak (*Quercus petraea* and *Q. robur*), elm (*Ulmus montana* and *U. campestre*), maple (*Acer platanus* and *A. platanoides*), birch (*Betula pubescens* and *B. pendula*), alder (*Alnus glutinosa*), and hornbeam (*Carpinus betulus*)
Submontane	Beech
Lower montane	Beech
Upper montane	Beech and fir (*Albies alba*)
High montane	Fir and spruce (*Picea abies*)
Subalpine	Spruce
Northern intermediate Alps, with and without beech; the climate varies from modified oceanic to continental	
Foothills	Oak and Scots pine (*Pinus sylvestris*)
Submontane	Beech, with oak and pine on south-facing slopes and fir and spruce on north-facing slopes
Lower montane	Beech
Upper montane	Beech and fir
High montane	Fir and spruce
Subalpine	Spruce
Upper alpine	Larch (*Larix decidua*) and Siberian pine (*Pinus cembra*)
High Alps with continental climate	
Upper montane	Spruce and Scots pine
Subalpine	Spruce
Upper alpine	Larch and Siberian pine
Southern intermediate Alps with climate varying from continental to temperate	
Foothills	Lime (*Tilia cordata* and *T. platyphyllos*), oak, and some chestnut (*Castanea sativa*)
High montane	Fir and spruce
Subalpine	Spruce
Upper alpine	Larch and Siberian pine
Southern Alpine fringes, with and without spruce, with mild and dry winters, humid to wet summers, and annual precipitation exceeding 2000 mm	
Foothills	Oak, chestnut, and some beech
Lower montane	Beech
Upper montane	Fir and beech
High montane	Fir and spruce
Subalpine	Fir and larch

constitution, and hard-liners in that organization aggressively promoted federal forest policy by blaming the fragmented forest cover for floods, mud flows, rockfalls, and avalanches. Based on surveys in devastated alpine regions, the SFA argued that forest regeneration was the best way to prevent further natural hazards in the mountains (Pfister and Brändli 1999). The School of Forestry was the sixth of the original six schools in the emerging Federal Institute of Technology (ETH), Zurich, and its prime aim was to train forest engineers to plan and direct the proposed reforestation projects (Figure 1).

The first Federal Law on Forest Policing was promulgated in 1876. The 1902 amendment protected mountain forests by fostering sustainable management and by requiring a reduction in the area available for

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FIGURE 1 Avalanche fences above Pontresina in the Engadin (Grisons), Switzerland. These iron fences hold snow back, thus protecting against a dangerous mountain hazard.

cattle, sheep, and goat pasturing. It provided the basis for projects partly within the zone where subsidized engineering structures had been set up to provide protection from natural hazards and required replanting of damaged forest areas within 3 years of a natural calamity. Under the undisputed assumptions of a forest's capacity to protect inhabited areas downstream, the law made it possible to subsidize the building of access roads for forest owners as well as the construction of protective structures against avalanches, rockfalls, and soil movement in steep upland catchments. The law required maintenance of totally forested areas and was extremely restrictive with regard to clear-cutting and consequential changes in land use. Consequently, clear-cutting for highways and railroads was undertaken as closely as possible to already cleared areas.

Programs of reforestation followed on land owned by the state or the cantons, providing extra income for people in remote and economically depressed areas (Müller 1990). The local population, however, frequently opposed the enforced reforestation of communal and private lands because of the associated reduction in pastureland and the added burden of protecting young trees. In the Canton of Berne, archival documents reveal that local people opposed about 40% of all reforestation projects; legal disputes often lasted for decades and state subsidies had to be paid back (Kürsteiner 1998; Hunziker 1999). As a clear sign of an increasingly urbanized society, paragraph 699 of the 1902 Civil Code granted public access to forests and pastures and permitted free collection of wild berries and mushrooms, independent of forest ownership.

Urbanization since World War II

Unprecedented urban and suburban sprawl characterized the 1950s and 1960s. There was a massive increase in the number of weekend and vacation homes and development of new infrastructure for tourism in the Alps and Pre-Alps. Planning and zoning laws lagged behind, but strict protection of forests ensured stable structures in an otherwise drastically changing landscape.

The construction and early communications booms required timber for telegraph and telephone poles as well as wood pulp for paper manufacturing. By that time, about 75% of the country's forests were publicly owned. Proceeds from the sale of wood helped keep local taxes low in marginal mountain communities, and small timber processing plants provided work for rural people in remote areas.

During the Cold War, neutral Switzerland developed policies to protect its agricultural sector in order to maintain its capacity to feed the population. Neutrality, restrictions on trade across the Iron Curtain, economic prosperity, and relatively low wages in forestry and agriculture left the primary production sector virtually unchallenged. Forests and forest administration enjoyed almost unlimited popular support from World War II until the 1980s.

Recent developments

Large-scale forest tree dieback (Innes et al 1994), indicated by loss of needles and leaves during the growing season, shocked the Swiss population in the early 1980s. Air pollution was the presumed culprit. Annual surveys

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assessed tree health nationwide, and worst-case scenarios predicted huge forest losses within 10 years. Those predictions proved wrong (Zimmermann 1990), but traditional forestry policies, such as the construction of new access roads or planting spruce (*Picea abies*) at sites optimal for broadleaf trees, became topics of critical public debate. Forest authorities were not prepared to confront the stiff, sometimes aggressive, opposition of ecologists and conservationists.

Market prices for timber and wood pulp declined gradually from the 1950s and quite drastically after the fall of the Iron Curtain because of cheaper imports from East European countries. The demand for fuelwood virtually vanished when developments in technology and logistics ensured efficient wood chip heating systems for larger buildings. In mountain areas today, the proceeds of wood sales barely cover harvesting costs and public funds are increasingly required to renew and maintain forests and their infrastructure.

Since the 1980s, agriculture in mountain areas has been in decline and many farmers now work their land only part time. Woody regrowth can be observed on alpine pastures, and forests are beginning to regenerate on fallow land. Forestry and wood processing industries are deprived of cheap labor during the winter, and in many parts of the country, the cost of harvesting and replanting exceeds the economic return.

The second federal law relating to forest management was implemented in 1993 and promotes a differentiated approach to forests and forestry. It assigns more individual responsibility for forest management to Switzerland's 26 cantons. Moreover, new concepts of forest management are evolving. By concluding contracts with forest owners, a provider of federal subsidies buys specific products, such as protection against hazards or special forest management measures, to ensure the well being of particular plant and wildlife communities.

The top-down system to protect forests that originated in the 19th century, when forests were in poor condition, has been replaced by a flexible management scheme able to meet local requirements and reduce the need for state subsidies. Although locally produced timber is still of high quality, the harvesting of timber has become so expensive that forests are frequently left to grow and take over unused open land. On National Forest Day in 2001, the authorities announced that no less than 10% of the forested area in Switzerland would become forest reserves within 30 years.

The view from the south

New Zealand is an elongated, mountainous archipelago 2000 km southeast of Australia close to the center of the Ocean Hemisphere. Its mountain axis trends southwest–northeast and its dynamic environments reflect the country's geological history, changing biogeographic relations, and occupation first by Polynesian (Maori) and then by European peoples. The Polynesian phase of settlement dates back at least 800 to 1000 years. The European phase began with the arrival of American and West European whalers and sealers in the late 18th century and accelerated after 1840, when organized British colonization began. Since 1000 AD, New Zealand has been transformed from a mostly wooded land, with trees and tall shrubs growing from sea level to treeline, to one where large expanses of native forest are virtually confined to the interior hill and mountain country.

To a biogeographer, the native plants and animals of New Zealand indicate a larger and older world. The country's more than 100 recognizable forest types can be grouped into 3 classes (Cochrane 1973). The kauri (*Agathis australis*) forests of the northern North Island have taxonomic and structural affinities with mountain forests in Melanesia and northern Queensland. The southern beech (*Nothofagus* spp) forests of mostly higher altitudes (Figure 2) in the North and South Islands have their relations scattered across the southern remnants of Gondwana. And the mixed podocarp (members of the Podocarpaceae) and hardwood forests of lower altitudes in both main islands and Stewart Island show a combination of tropical and southern affinities, as botanists such as Hooker (1867) and Cockayne (1919) noted. Like those of Madagascar and Australia, the native forests of New Zealand have been adversely affected by people. They also show the frequently adverse effects of naturalized plants and animals (Holland and Olson 1989) on island ecosystems.

Successive waves of settlers cut trees and cleared forests for habitation, timber, fuel, and food production. The Maori introduced a dozen plant species as well as the Polynesian dog (*Canis familiaris*) and Polynesian rat (*Rattus exulans*), none of which appear to have had a serious impact on native ecosystems. Since 1840, however, European settlers have, by accident or on purpose, brought in numerous plants, animals, pathogens, and diseases, many of which thrive in the widespread habitats of anthropogenic disturbance. There is little evidence for extinction amongst native vascular plants, although several are endangered, but the country faces the imminent loss of several more forest bird species and an unknown, but presumably large, number of invertebrates. In New Zealand, most alien plant and animal species thrive without their normal pest loads, and their growth and spread are consequently rapid. Many exotic woody plant species are used for forestry, shelter, and decoration, but native forests remain important for nature conservation and recreation, as a resource for tourism, in controlling runoff in hill country catchments, and as a source of high-quality furniture and construction wood.

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FIGURE 2 Mountain forest on middle and lower slopes with subalpine communities above treeline and avalanche runs extending through the forest, Lewis Pass, South Island, New Zealand. (Photo by Peter Holland)

The primeval forest

Regional treelines range from about 1400 m in northeastern North Island to 900 m in Fiordland, but during the peak of the Pleistocene glaciations, the treeline was several hundred meters lower (Fleming 1979). The central North Island has experienced frequent volcanic eruptions since the late Tertiary—the last major eruption, centered on Lake Taupo, occurred 2000 years ago—with thick deposits of ash and associated deposits periodically obliterating the area's vegetation cover (Cochrane 1973). New Zealand is home to about 2300 endemic vascular plant species, a fifth of which are also found in Australia (Taylor and Smith 1997). On the other hand, taxonomists report at least 1600 species of lichen and 300 mosses. The country has relatively few native land vertebrates—about 250 species of birds, 2 bats, 3 frogs, a primitive reptile known locally as tuatara (*Sphenodon punctatus*), and several geckos and skinks—but a notably large fauna of invertebrates.

Most New Zealand forests are dominated by evergreen plants, which lack the seasonal aspect that distinguishes the forests of comparable bioclimates in Eastern Asia, Eastern North America, and Western Europe. There is not a spring flush of flowering herbaceous plants; bulb plants, short-lived perennials, and annuals are unusual, and few native herbaceous plants have showy flowers. In the mature kauri (*Agathis australis*) and puriri (*Vitex lucens*) forests of Auckland Province, which Charles Darwin described as "gloomy," and the old podocarp–hardwood forests of both main islands, there are typically 4 or more canopy layers. In the southern beech forests of the South Island hill and low mountain country, 2 or 3 canopy layers are more usual. Seedlings and saplings grow alongside mature trees in the lichen and moss-covered duff of the forest floor, with dense stands of ground ferns and tree ferns growing in glades or alongside streams.

Ferns, epiphytes, and lianes are among the most striking of the native forest plants. Tree ferns (species of *Cyathia* and *Dicksonia*) were prized by the first 3 or 4 generations of European settlers because they survived transplantation to sheltered spots in parks and household gardens. The more fragile ferns that cover trees in moister areas of mountain forests, along with other epi-

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phytes and climbing plants, proved less hardy outside their native habitats.

When organized European settlement began in the 1840s, the inland basins and eastern lowlands of Otago and Canterbury were covered by a mosaic of tall and short tussock grassland, wetland, and shrub communities, but settlers often reported charred logs and in situ root plates of such forest trees as kahikatea (*Dacrycarpus dacrydioides*), rimu (*Dacrydium cupressinum*), and totara (*Podocarpus totara*) in lowland swamps and the tussock covered topsoils of grassy hill country (Molloy et al 1963). The Maori, through their use of fire as an aid for hunting or to promote regrowth of the edible, starchy, below-ground parts of bracken fern (*Pteridium esculentum*), were instrumental in the conversion of drier lowland, interior, and low mountain forests and tall shrub communities throughout the country to shrubby savannas and tussock grasslands.

Environmental transformation

The transformation of New Zealand's low mountain forests by people, plants, and animals began about a millennium ago and has continued episodically ever since. Forests covered at least 85% (23 million ha) of the country on the eve of human settlement but had been reduced by widespread fire and a cooler, drier climate to 53% in 1840 and by fire and tree felling to about 25% today (O'Loughlin and Owens 1987). During the exclusively Polynesian occupation of New Zealand, the pace of forest clearance seems to have peaked between 1350 and 1550 AD, with the greatest environmental impact in the drier eastern and interior lands of both main islands. But there appears to have been relatively little loss of native forest from then until the 1840s, when the pace of clearance again surged (Taylor and Smith 1997). In the 1890s, the area of native forest was reduced from 13 to 9.5 million ha, chiefly for farmland.

Improved pastures of English grasses and fields of crop plants now thrive where extensive lowland forests existed 150 years ago. Extensive tracts of relatively undisturbed forest persist in better watered parts of foothills and mountainous areas that are unsuitable for agriculture: on Stewart Island, in the southwest of the South Island, extensively along the West Coast, in Northwest Nelson, and along the mountain fringes of the North Island. Woody plant regeneration is taking place in economically marginal areas of both main islands.

In 1868, Thomas Potts, who was influenced by the American conservationist George Perkins Marsh, proposed a motion in the House of Commons calling on the government to "ascertain the present condition of the forests of the Colony, with a view to their better conservation." Six years later, Parliament enacted legislation to control forest clearance. But the New Zealand Forests Act of 1874 failed in the face of mounting pressure from settlers for farmland, despite growing public recognition of the 5 "evils of deforestation": uncontrolled runoff and flooding, soil erosion, accumulation of sediment in river valleys, and loss of valuable timber. The Land Act of 1877 gazetted 201,400 ha of native forest as climatic reserves, and since that time, successive administrations have enacted legislation to conserve and manage indigenous forests (McKelvey 1995). It was not until publication of the survey by a British-trained geographer (Cumberland 1944) that the geographic extent of New Zealand's deforestation and consequential erosion problems registered in the public consciousness.

By 1900, there were 2 national parks, both in isolated mountainous areas. Sixty years later, there were 10, also in the mountains and hill country. The New Zealand Forest Service was established in 1920 to manage indigenous and exotic forests on Crown land and paid particular attention to native forest on the 5 million ha of steep land prone to erosion. During the Korean War of the early 1950s, wool prices soared and pressure grew for forested and marginal lands in the Crown estate to be cleared for farming. That marked the last great surge of forest clearance in New Zealand and was the spur for a conservationist movement that shows no sign of abating. Over the second half of the 20th century, the amount of rough-sawn native lumber sold on the local market decreased by 90%. Today, native species provide 5% of the country's commercial lumber, compared with more than half during the 1960s (Taylor and Smith 1997). The Forests Amendment Act of 1993 mandated planning for sustainable forestry, and it is now illegal to replace native forest stands with production forests based on exotic species. The focus of conservational effort has also shifted from the public domain to land in private hands, where the chief threats to native forest ecosystems are posed by fragmentation, invasive plants and animals, and uncontrolled access by people and introduced herbivores.

Conservationists recognize that forest clearance leads to loss of habitat, especially for this country's endangered forest bird species, but the problem has several aspects. Until recently, several organizations promoted the introduction and acclimatization of game animals. Many of those animals have given pleasure to New Zealanders, but several are having catastrophic effects on native plants and animals. At least 8 species of deer (Wodzicki 1950), an Australian opossum (*Trichosurus vulpecula*), several kinds of goats, domestic sheep, and cattle have had a devastating impact on native plant and animal species throughout the country. This has affected biodiversity, reduced recruitment to below replacement values, and damaged mature trees.

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FIGURE 3 Upper reaches of the Rangitata River, South Island, New Zealand, looking westward from Erewhon to the Main Divide and showing mountain forests on steep south-facing slopes, dense shrub communities on steep north-facing slopes, cultivated pastures of introduced species for winter feed on high river terraces, tussock grassland and low shrubby vegetation on fluvio-glacial deposits along the valley floor, scree aprons extending from the mountain slopes to the current river course, and bare flood plain gravels flanking the river. (Photo by Peter Holland)

From the air, an area of native forest may look relatively healthy, but on the ground, it can be another story; the forest floor may have been stripped bare of woody plant seedlings and ground layer plants and the topsoil eroded. There are now more opossums than sheep in New Zealand, and most live in wooded areas.

In recent times, introduced deer that thrive in mountain forests have proven economically valuable and have been shifted to lowland farms, but feral populations still cause serious damage to mountain forests. Opossums are trapped for their skins, but given their vast numbers, wide geographic distribution, and the uncertain international market for their fur, there is little immediate likelihood of them being brought under control let alone exterminated. Poisoning with "1080" (sodium fluoroacetate) is common now that the state has reduced its financial support for programs of pest extermination by trained hunters, but the side effects on other vertebrates and river water quality are leading to a reexamination of its use.

With the exception of vines such as *Clematis vitalba* or plants with fleshy fruits such as *Rubus fruticosus,* healthy mountain forest communities have proven fairly resistant to invasive plant species. Along forest margins in the partial shade of trees and shrubs, there is often a rich mixture of native and alien plants, but we do not know the long-term consequences for native species and ecosystems in these areas.

New forests for old

During the 19th century, a wave of forest clearance swept New Zealand. Whereas the moist west coastal lowlands and foothills had a surfeit of trees, there was a severe shortage of wood for construction, fencing, and fuel east of the Main Divide. Early issues of the Christchurch newspapers carried notices warning people not to fell trees without the landowner's written permission, and commentators of the day noted the scarcity of trees in that city and its dusty environs. Town people and country folk alike were soon planting trees—for shelter from the hot dry winds of spring and early summer or the cold wet winds of winter, for timber and fuel, for food and beautification—but few were native species.

In New Zealand, most native trees grow more slowly than introduced species. Southern beech trees can take between 60 and 120 years to reach maturity, whereas Monterey pine (*Pinus radiata*) can be economically felled for lumber 25 to 35 years after planting. The environmental problems faced by the first 2 generations of European settlers in this wind-swept land were sufficiently pressing to require a prompt solution. The nurserymen of the day tended to promote foreign shelter species in preference to native, and it is only recently that a wide range of native woody plants has been available commercially. The country's parks and private gardens hold healthy specimens of most of the temperate world's main tree species. In just 6 months during 1889,

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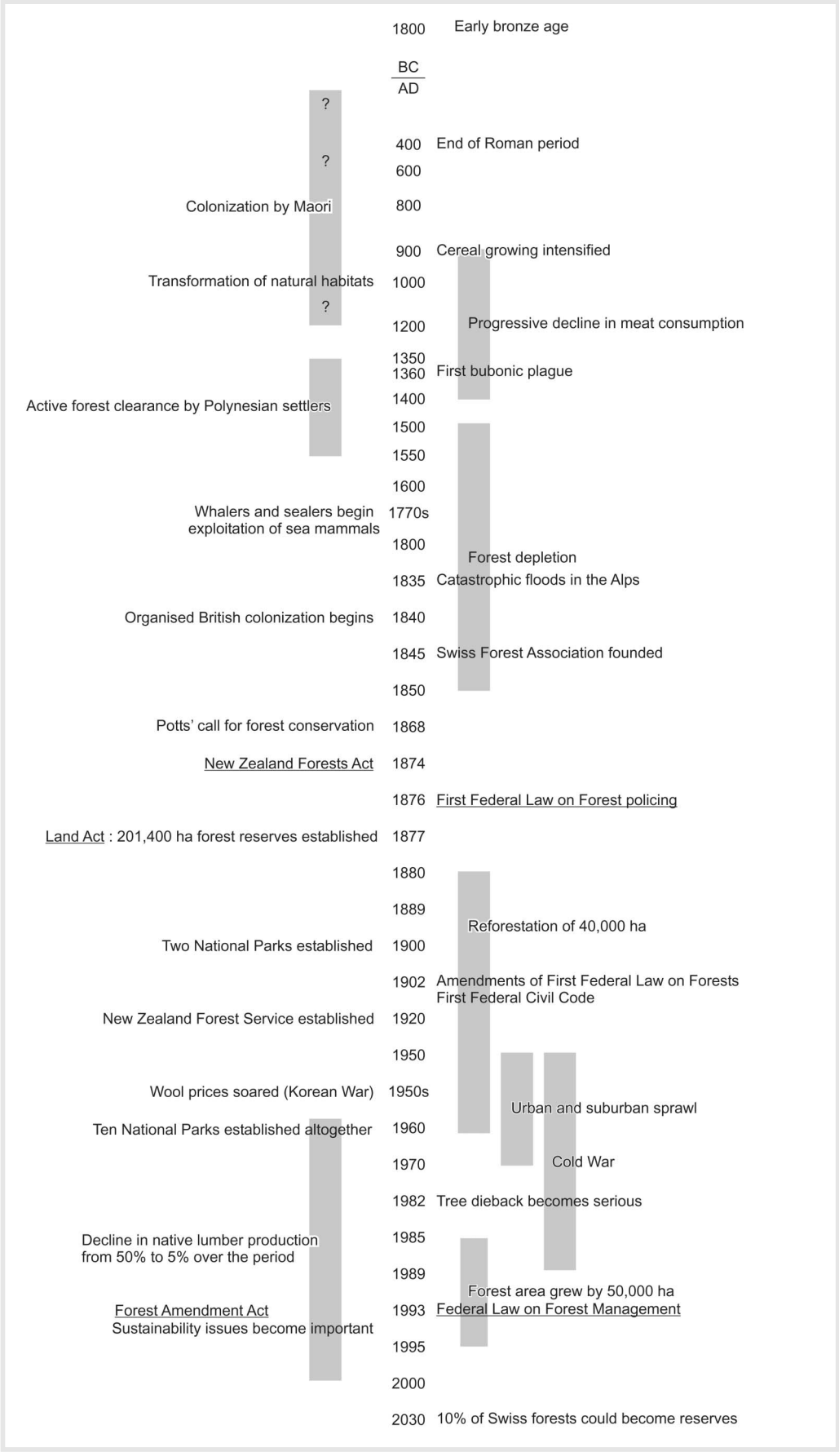


FIGURE 4 Overview of the forest histories of New Zealand (left) and Switzerland (right). (Figure by William Mooney)

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for example, the owner of Raincliff sheep station in the eastern South Island planted 86,176 trees representing more than 40 species on his property. This brought the total to 113,482 trees, whereas in the 1850s, there were only extensive tall tussock grasslands, small patches of valley forest in the foothills, and shrublands in moister areas (from an original memorandum held by the South Canterbury Museum, Timaru). Throughout the country, commercial forestry tends to be based on a few introduced conifers, notably Douglas fir (*Pseudotsuga menziesii*) and Monterey pine. The latter species, which is rare in its native environment, thrives in New Zealand and is the basis for commercial logging operations from the northern tip of the North Island to the far south of the South Island, from sea level to more than 1000 m, and from the coast to the seasonally cold and dry interiors of both main islands.

Commercial forestry has transformed the New Zealand landscape. In the volcanic uplands of the central North Island, what were broad tracts of tussock grass and shrublands on young volcanic ash deposits just 60 years ago are now vast conifer plantations. In places, even native forests have been felled and replaced by single-species stands of conifers. Fast-growing, broadleaf deciduous trees, notably species and cultivars of *Populus* and *Salix,* are occasionally grown for specialty woods and flood control.

Looking over the fence in time and space

The alpine and prealpine forests of Switzerland have undergone several cycles of pressure and relaxation during the period of settlement. The highly esteemed open landscapes of these regions are due to small-scale agriculture, which is now in decline, and forests are beginning to regenerate. Apart from agriculture, however, the planning and management of open landscapes is still in its infancy. At present, it is hard to imagine who, other than farmers, might be able to ensure that open areas are not once again covered by forest.

According to Foster (1999), the New England states of the United States underwent similar changes about a century and a half ago as the American West was being settled by people of European stock. Forests became reestablished on tracts of intensively cultivated farmland, and large native animals returned. Today, moose, black bears, cougars, and coyotes all roam where deer and hares once thrived. Even beavers have returned to habitats that were entirely free of them a hundred years ago.

Similar changes are evident in Switzerland. Lone wolves can be seen hunting unguarded sheep near the upper timberline. Bobcats are disturbing deer to such an extent that hunters feel threatened by them and illegally shoot them as predator animals. The population of wild boars has increased to such an extent that some local authorities encourage the shooting of baby boars. Some naturalists even predict the return of the brown bear to southeastern Switzerland within the next decade. Will intensively cultivated and maintained Swiss landscapes, images of which beautify chocolate boxes and calendars, give way to regenerating native ecosystems on what had been farmland just a few decades earlier?

Most of New Zealand's remaining native forest stands are in hill country and the mountains. For a century, the national economy depended on returns from the export of dairy products, hides, meat, and wool. That is changing as tourism becomes a mainstay of the economy. In its publicity, the country promotes a "clean-green" image, not only for the food products it exports but also for the landscapes it can offer the visitor. Remnant stands of native forest are now significant resources for tourism and provide diverse experiences for visitors. It is widely recognized that a healthy forest cover is equally essential for erosion control and regulation of river runoff, and representative arrays of forest ecosystems are needed to ensure survival of native plant and animal species.

The recent environmental history of New Zealand's forests opened 1000 years ago with extensive coverage below regional treeline by native forest ecosystems. By the late 17th century, lowland forests in the drier interiors and eastern flanks of both main islands had been fragmented and reduced by recurrent fire, with induced tussock and shrub communities taking their place. For almost 150 years after the start of British colonization, vast tracts of lowland forest were cleared for farmland (Figure 3). Today the only extensive native forests remaining are in the steep hill and mountain country. Widespread clearance of native forest has virtually ceased, harvesting of native trees is rigorously controlled, and people are planting native species where once they would have chosen exotics.

Since the late Pliocene, New Zealand has experienced alternating episodes of moist-warm and cool-dry climates, vigorous tectonic activity, and rising and then falling sea levels. Despite those environmental vicissitudes, the native biota, enriched by the steady flow of new arrivals from the north and west, evolved to fill the newly created ecological niches. For a millennium, human settlers have been the novel environmental force acting on native habitats and biota (Figure 4). But what may prove the major cause of persistent ecological disruption has been the rapid influx of exotic plant and animal species, relatively large numbers of which became naturalized and now thrive in the new land. The old food chains are being rearranged and, for the moment at least, many native species seem to be the losers. Because it is hard to envisage a time when the country's native forests will be free of introduced species, the prospects for many New Zealand forest plants and animals are cause for concern.

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