

Submitted to Natural Resources Journal
April 1989

NCAR Ms. 0101/89-3

TEMPERATE MOUNTAIN FORESTS: COMMON-POOL RESOURCES WITH
CHANGING, MULTIPLE OUTPUTS FOR CHANGING COMMUNITIES*

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* The author would like to thank Kathy Miller, Ray Prince, Franz Schmithiisen, Anthony Scott, and Roger Sedjo for their helpful comments and suggestions on an earlier draft. This research was supported in part by the Swiss Man and the Biosphere Program, the U.S. National Science Foundation, the University of Colorado, and the Colorado Mountain Club Foundation.

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ABSTRACT

This paper broadens the concept of common-pool resources with reference to a resource supplying many joint products whose relative importance to different communities has changed over time. Case studies refer to forests in the Swiss Alps and Colorado Rocky Mountains. For each region, two levels of analysis are developed. These concentrate on outputs of wood, recreation and protection from natural hazards, and consider: 1) policy development for the two regions and a study area within each; 2) the changing supply of forest outputs from the study areas, within the context of changing policies and demands on the forests.

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INTRODUCTION

One of the principal frameworks for research into resource management systems is based on the concept of common-pool resources (1). This concept is roughly equivalent to, and has been used interchangeably with, those of common-property resources (2) and commons (3). The literature discussing the management of common-pool resources can be traced back to papers considering fisheries in the mid-1950s (4). However, the concept was not widely used until Hardin's "The Tragedy of the Commons" (5) provided considerable impetus. Hardin's theme was that a pasture, available to all members of a community for grazing their livestock would, in the absence of enforced rules defining grazing rights, inevitably become exhausted as a result of population pressure. Though Hardin's concept emphasized only one facet of the management of common-pool resources, and his idea was not new (6), it rapidly gained wide success.

By 1979, Hardin's idea of tragedy was described as "the dominant framework within which social scientists portray environmental and resource issues" (7). It has formed the basis for a vast amount of research and discussion, much of which has questioned its validity for resource management (8). In addition to fisheries and pastures, other resources analysed as common-pool have included forests, parks,

groundwater supplies, public highways, oilfields, and wildlife (9); genetic resources (10); outer space, the oceans, weather and climate, and Antarctica (11); and the radio spectrum and geosynchronous orbits (12).

In the substantial literature on common-pool resources which now exists (13), such resources have generally been treated as having very few outputs (often one) supplied to a well-defined community. An example is provided by the fishery, where one marketable species is the subject of study and the community is that of local fishermen. However, each species of fish occupies a specific niche in an ecosystem - or many ecosystems if it migrates or lives in the littoral zone - so that population changes will necessarily affect other species in the food and decomposition chains (14). Loss of a species, or even a local population, results in the irreversible loss of genetic information. Equally, loss of marketable fish species may well lead to the decline of a fishing village, whose inhabitants will tend to look to the larger national community for assistance for their continued survival.

The treatment of common-pool resources as providing limited outputs to well-defined communities undoubtedly assists in analysis and modelling (15). However, it ignores the fact that no resource should realistically be regarded in isolation. In addition, historical changes in the relative importance of the joint products (16) supplied by a resource are ignored. These may continue to be supplied to an easily-

defined community over long periods of time (17).

Alternatively, the community of users may change over time and vary between outputs. The objective of this paper is to broaden the concept of common-pool resources with reference to a resource which supplies many joint products, whose relative importance to a number of communities has changed over time. The case studies are drawn from the forests of two temperate mountain regions, the Alps and the Rocky Mountains.

JOINT PRODUCTS FROM TEMPERATE MOUNTAIN FORESTS

Temperate mountain forests provide a wide range of outputs, which are summarized in Table 1. These joint products may be classified as private (market), impure public, and pure public goods. Different outputs within this range are defined by two factors: the ability to provide values for them in real or simulated markets, and the size of community which can benefit from their use. However, in reality, the values of forest outputs to different communities should be placed along a continuum, rather than in the discrete categories shown in Table 1.

Many forest outputs are market goods, notably timber and other tree products, such as leaves for forage and Christmas trees. Forage from shrubs, forbs, and grasses can be valued in terms of the value added to grazing herds. Similarly, the water used for irrigation can be valued in terms of the value added through increased crop yields. Game animals and fish

TABLE 1
CLASSIFICATION OF JOINT PRODUCTS OF FORESTS

OUTPUT	TYPE OF GOOD		
	PRIVATE (MARKET)	IMPURE PUBLIC	PURE PUBLIC
ECOSYSTEM DIVERSITY			Option/ existence
FISH	As input to economy (sold)	Recreational use (Club good if permits sold)	
FORAGE	Grazing permits sold on open market	Community use (Local public good)	
GAME	As input to economy (sold)	Recreational use (Club good if permits sold)	
GENETIC DIVERSITY			Option/ existence
HAZARD PROTECTION		Individuals' life, property, safety	Public land, facilities
LANDSCAPE		Limited access viewpoints	Public access viewpoints
RECREATION	Developed: ski areas, private campgrounds etc.	Undeveloped: trails, campsites, picnic areas	
WATER QUALITY	Industrial, municipal, domestic use	Recreational use	Perception
WATER QUANTITY	Industrial, irrigation, municipal use	Recreational use (type of craft)	Perception
WILDERNESS		Perceived environment for recreation	Existence value
WOOD	Sold on market: stumpage fees, market products	Community use (Local public good)	Long-term security of supply

may also be valued in terms of their contribution to the economy as a source of food. Finally, the use of developed recreational facilities, such as ski areas or private campgrounds, takes place within the market economy.

Many of the joint products of forests cannot be valued in the market-place; i.e., they are non-market goods. Some of the outputs mentioned above display non-market characteristics, and their value in real markets may be changed by various types of market intervention (e.g., taxes, subsidies). At the other end of the spectrum from market goods are pure public goods, first defined by Samuelson (18): each individual's consumption of a public good, once made available, has no effect on any other individual's consumption. A number of forest outputs fall into this category. One instance is protection from fires, floods, or avalanches, which provides an example of the fact that the avoidance of a public bad (e.g., destruction of property by an avalanche) is a public good. Another public good is the existence value of a particular forest landscape, wilderness area, or clean, free-flowing stream - the mere knowledge that it exists. In this case, as with the value of preserving a landscape or the gene pool of a forest ecosystem, consumers do not have to be present in either space or time to derive benefits. The preservation of a resource for unknown long-term benefits provides option values (19).

Between market goods and pure public goods are a wide range of other goods, whose characteristics have recently been

summarized by Cornes and Sandier (20). These may be described as impure public goods. The characteristics of such outputs are that their benefits are partially rival and/or partially excludable. The use of forests for recreation and as wilderness provides an example of an impure public good. Up to a certain level of use, the benefits of use are equal for all consumers. However, beyond this level, one or more individuals perceive that congestion is occurring; i.e., the social carrying capacity (21) has been reached. Thus, one person's use affects another's use (rival benefits). To avoid congestion, fees or permits can be used to limit use (excludable benefits). Exclusion may be through a number of means, including direct (e.g., price of permits) and random (e.g., a lottery) methods. Most forest outputs, in some sense, are impure public goods, including water quantity, which may limit the use of a river to certain types of craft; landscapes which can be viewed only from viewpoints with limited access; and hazard protection which benefits individuals' lives, safety, and property rather than public facilities.

Exclusion can also be a function of the scale at which benefits occur, in which case the output is a local public good. One example is the use of a forest for timber by members of a specific community; in contrast to use by the highest bidder in a market situation (i.e., private good). In the latter case, the economic value of this output is determined in the market; in the former, it is very difficult

to put such a value on the output. At the smallest spatial scale, the availability of a public good may be reflected in private values. One example would be a privately-owned hunting and fishing lodge on an unpolluted stream, adjacent to a wilderness area, and protected by public hazard protection programs. The value of this property would clearly reflect the local, joint availability of these public goods.

ANALYTICAL FRAMEWORK

The case studies in this paper are drawn from the forests of the Swiss Alps and the Colorado Rocky Mountains. For each region, two levels of analysis of the supply of joint products from these forests are developed, with particular emphasis on three outputs: wood, recreation, and protection from natural hazards. Each of these was chosen because it falls primarily within one of the three classes shown in Table 1, and was identified in policy and practice as important during the period considered in this study (i.e., as far back as records are available). Wood was chosen as an example of a market good; recreation as an impure public good; and protection (from natural hazards and of watersheds) as a pure public good.

The first level of analysis considers the development of policies both for the forests of the region as a whole and for a study area within each region. The second considers the changing supply of forest outputs from each study area, within

the context of changing policies and demands on the forests. In view of the considerable diversity of physical conditions and human history within each region, the study areas cannot be said to be representative. Each area was chosen because its history displays many characteristics typical of the region and, furthermore, good documentation was available (22).

CASE STUDIES

Swiss Alps.

The Swiss study area is the Aletsch test area, selected for research within the Swiss Man and the Biosphere program. It comprises 12 communes in the Canton of Valais, on the north side of the Rhone, and just west of its headwaters. These communes own 72 percent of the forest area; the remainder is privately owned. Forests were central within the traditional Swiss mountain economy, providing wood for fuel (usually the primary use), construction, and all aspects of agriculture, and fodder for grazing animals.

Sixteenth to nineteenth centuries

The designation of the communal forests early in this millenium clearly identified them as common-pool resources, to which all members of the commune had usufructuary rights. However, from 1515 onwards, communal orders were made to limit the uses of these forests (23). The reason for these, as for

similar orders in other parts of Switzerland, was to ensure a continued supply of wood for the members of the commune, and also to protect settlements and fields from floods, avalanches and rockfall (24). The imposition of these orders showed that members of the local community recognized a need to protect the flows of two local public goods for their use.

The communal orders were not entirely successful in attaining their goals because of inadequate policing (25) and, from the late eighteenth century, increasing demands for wood and charcoal for new industries in towns further down the Rhone. Valais was the first mountain Canton to recognize that forests were common-pool resources not only for individual communes, for whom they supplied wood, but also for the citizens of the Canton as a whole. The outputs in question were wood and protection from natural hazards. The recognition of these values of the forests was exemplified by a series of cantonal laws, passed between 1803 and 1836 (26). These placed limits on wood cutting and sales, and encouraged tree planting, to minimize danger from natural hazards and protect roads (27).

Again, these laws did not attain their goals. In the 1820s and 1830s, many of the Aletsch forests were clearcut, and some parcels of communal forest were sold to private interests (28). From the 1840s, the Swiss Forestry Association (SFA: *Schweizerischer Forstverein*) stressed the national importance of the mountain forests, primarily for protection against natural hazards. These statements were

amplified by the results of severe floods in 1868 (29). In 1874, in a testimony to the effects of the floods and the SFA's lobbying efforts in persuading Swiss citizens of the forests' national importance, the constitution was amended. Superintendence over the mountain forests was transferred from the cantonal governments to the federal government, recognizing that the forests were common-pool resources supplying public goods to the national community. This fact was codified in the 1876 Forest Police Law (*Forstpolizeigesetz*) (30), whose main tenet was that the nation's forested area should not decrease (31). This law, revised somewhat in 1902 (32), remains the basis for the management of the forests of the Swiss Alps.

One of the requirements of the Forest Police Law was that forests should be managed for sustained yields of wood according to plans based on detailed surveys. Plans for the management of the Aletsch forests were made between 1885 and 1895. The sustained yields were set below the volume of recent harvests; in some cases, less than half (33). This disparity suggests that harvests in the 1870s and 1880s had been higher than increment, so that future harvests had to be reduced to permit the forests to supply the public goods recognized in the law.

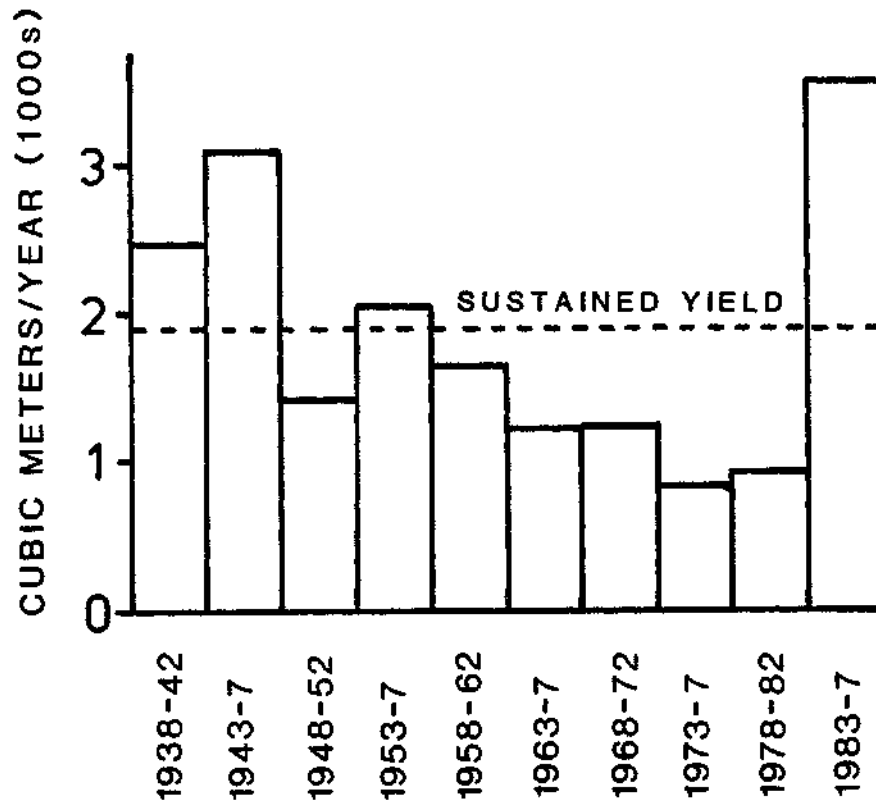
Twentieth century

In the first decades of the twentieth century, although prescribed yields were set for the Aletsch forests, actual harvests were from 5 to 25 percent higher, with logging concentrating on the few areas with good access. While the principal use of the wood was for fuel, most of the harvested trees were of sawtimber size. Almost all of the wood was used locally. This level of harvesting was in contravention of the Forest Police Law, and also the cantonal laws passed pursuant to it (34) but, as in previous centuries, policing was insufficient to stop excessive harvesting. Between 1924 and 1942, new surveys were undertaken, providing the data for management plans in which sustained yields were set even lower than in the previous plans. However, throughout the 1930s and 1940s, high demand led to large harvests to provide wood for sale. Thus, until 1947, harvests were typically higher than the sustained yields (Figure 1). Subsequently, harvests declined until 1970. The next decade was marked by very low harvests; in two-thirds of the communes, there was no logging for at least half of these years (35).

These trends suggest that the concern of the local communities for ensuring the protection of their settlements and infrastructure from natural hazards had been overridden by economic concerns. Until 1950, the primary sector accounted for the majority of employment in the area, as it had for centuries (36). Wood sales were one of the few means of

FIGURE 1

Aletsch Study Area:
Five-year Average Annual Harvests, 1938-1947.



Dotted line shows sustained yield set in 1924-1942 management plans.

SOURCE: M.F. Price, Mountain Forests as Common-property Resources: Management Policies and Their Outcomes in the Colorado Rockies and the Swiss Alps 1988 (unpublished Ph.D. thesis in the library of the university of Colorado, Boulder).

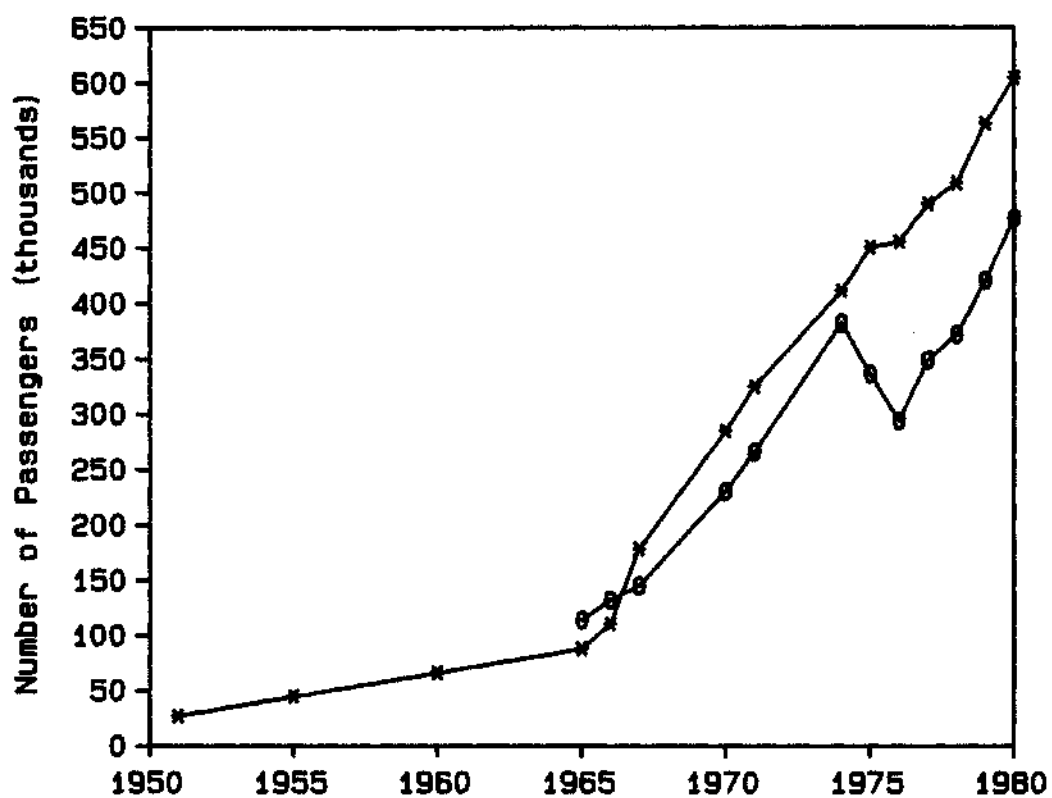
supplementing limited agricultural incomes, particularly as logging mainly took place in winter, the season when agricultural activity was at its lowest level. Subsequently, the basis of the local economy rapidly changed to tourism. The impetus to this change was the construction of cable-cars to the alpine terrace high above the Rhone Valley, which had previously been used only for summer grazing in the traditional pattern of transhumance land use (37).

A substantial tourism infrastructure grew rapidly, as did the number of visitors to the area, both in summer and for the winter skiing season (Figure 2). As elsewhere in Switzerland, little work was done in the forests because greater recompense was available from other activities (particularly in winter), agriculture was declining or being rationalized, alternative sources of fuel had become available, and new transport networks meant that cheaper wood for construction was available from non-local sources (38). For example, many of the "Swiss" chalets in the area were prefabricated in Finland and erected by Finnish workers (39).

The rapid growth of tourism meant that the public goods provided by the forests became even more important. Protection from natural hazards became more significant because of the more dense infrastructure (for recreation, transport, and settlement) exposed to these hazards. Another public good critical to the tourism industry is the alpine landscape, described as the "capital" of tourism by Krippendorf (40), of which forests are an integral part.

FIGURE 2

Aletsch Study Area:
Number of Passengers Carried by Cable-cars



--*-- to Riederalp, 1951-1980

--0-- to Bettmeralp, 1965-1980 (no data 1954-1964).

SOURCE: F. Mattig & H.-P. Zeiter, Der touristische
Wachstumsprozess im MAB-Testgebiet Aletsch (1984).

Undeveloped recreation became more important as tourists used the many trails through the forests for hiking and skiing.

All of these public goods were recognized in the major 1965 revision of the Forest Police Law regulations (41), and also in the 1985 Valais forest law (*Forstgesetz*) (42), which replaced the previous law (43), which had been passed in 1910 and was almost identical to the Forest Police Law. The primary aims of the 1985 law are to preserve the forests, and ensure their maintenance for the safeguarding and improvement of protective and welfare functions. Secondary aims are to increase the potential yield of the forests and encourage their management in the interests of owners and the public; and to maintain and preserve the cultural landscape and a healthy environment.

While these policies clearly recognize that the forests are common-pool resources supplying a wide range of public goods to communities at all levels from the local to the international, they are not yet able to ensure the long-term provision of these goods in the Aletsch area. A total of 62 percent of the area's forests has been classified as important for protection from avalanches, rockfall, erosion, landslides, or flash floods; yet 34 percent is classified as unstable, requiring active management within 20 years. This instability can be traced to the patterns of use in the forests over the past century, which have left the majority of stands dominated by trees of one size class. There is little regeneration, and sawtimber trees, mainly spruces, predominate (44). Spruces at

this stage in their life-cycle are highly susceptible to bark beetles (*Ips typographus*) and disease (45).

As shown in Figure 1, harvests have increased significantly since 1982. The principal reason is that the federal government has provided substantial subsidies for the removal of trees affected by insects, disease, and air pollution (46). This recognition of the forests' protective function has further been shown by government subsidies of over 90 percent for the construction of avalanche control structures in the area (47). One could argue that the public goods supplied by these activities are mainly the concern of the local community. However, the financial condition of the communes is far too weak to permit them to underwrite these activities, and the national and cantonal governments recognize that the dominant tourist economy in the Alps depends strongly on a safe infrastructure and coherent forest cover. Forest management (logging, thinning, and often reforestation) is therefore essential to create a more diverse age structure in the forests, to ensure that all of the public goods provided by these forests, which are now recognized as common-pool resources crucial for the welfare of the nation, and not only local communities.

Colorado Rocky Mountains

The Colorado study area is Summit County. Although this area is on the west slope of the Continental Divide, it contains two large reservoirs which supply water through tunnels to

Colorado's main urban areas, along the foothills of the Rocky Mountains, less than 100 miles distant. The principal settlements in Summit County are small towns which were founded in the mining era, which started in 1859 with the discovery of placer gold. Previously, the area had been used by Ute Indians and, from 1812, by trappers (48).

Nineteenth century

By 1860, with a mining boom underway, Summit County's population had grown to 8,000 (49). At this time, the area's forests were part of the public domain, i.e., open-access resources (*res nullius*) (50). Wood was essential in the mining economy for fuel, construction, and all aspects of mining. The forests were viewed as an inexhaustible resource, essentially as a pure public good, although fires began to deplete their area. Many fires were deliberately set, often to ease access to rock for mining. The first mining boom was over by the mid-1860s; by 1870, the area's population was 258 (51).

In 1878, the federal Free Timber Act (52) was passed. The framers of the act essentially regarded the forests of the public domain as the source of a local public good: wood. The act allowed residents of various western states, including Colorado, to cut dead timber (but not green timber) on mineral lands for building, agricultural, mining, or other domestic purposes. The act was hardly enforced by the few available

agents, and its main effect was to permit unrestrained logging, particularly since 'mineral lands' were never defined (53). Summit County, where a second mining boom began in 1878 with the discovery of gold and silver ore, was a typical example. By 1880, the population had grown to 5,459 (54).

In the early 1880s, two railroads were built into the area. These substantially increased the demand for wood, not only for ties and fuel, but also for export for mining or (as charcoal) smelting to other parts of Colorado. The second boom lasted into the 1890s. Between 1878 and 1902, many fires were recorded in the area. No attempt was made to put them out unless they threatened private property or towns; some were started in order to supply dead trees which could be legally removed under the provisions of the Free Timber Act. Huge volumes of wood were cut for timber and charcoal. By the turn of the century, about half of the area's forests had been logged, burned, or both. The remaining stands of mature timber were near timberline and in the mountains in the north of the area, where there had been no mining and access was limited (55).

The advent of European settlement, often linked to mining booms and railroad construction, occurred throughout the Rocky Mountains with similar results to those in Summit County. The rapid depletion of the public domain forests led to fears at both regional and national levels that the forests might become unable to supply wood in the long term, and also that water supplies might be endangered. When Colorado became a

state in 1876, the constitutional convention recognized that the forests were a common-pool resource supplying the public goods of wood, water for irrigation, and protection against floods (56). However, the legislature did not act on this awareness until 1885 when, at the urging of the newly-founded state forestry association, a Forest Commissioner was appointed and local officials were exhorted to limit the destruction of the forests (57).

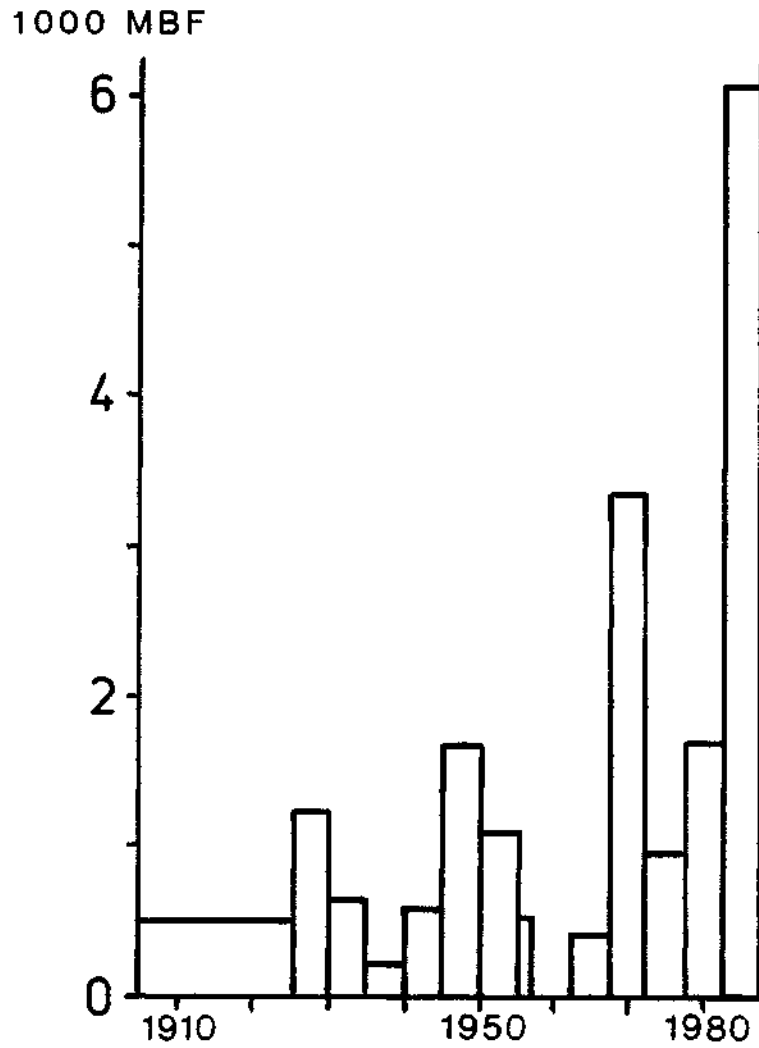
Subsequently, the Colorado legislature provided few words, and scant funds in support of any policies or activities related to forestry. In 1890, the Forest Commissioner resigned, and became a leader in the movement instrumental in forcing national recognition of the importance of the public domain forests for protecting watersheds and wood supplies (58). By the end of the century, the federal Forest Reserve (59) and Organic (60) Acts had been passed, with the intention of providing a basis for the management of these forests. To some extent, these laws owed their passage to political legerdemain (61). However, they had the support of many sections of the American (and Colorado) public, who realized that the public domain forests had to be recognized as common-pool resources providing public goods to the national community.

Twentieth century

Under the provisions of the Organic Act, all of the public domain forests in Colorado were designated National Forests by 1908 (62). Summit County's forests were designated part of the Leadville National Forest in 1905, and transferred to the Arapaho National Forest in 1929. In 1900, the area's population was 2,744 (63); this century's highest level until the early 1970s. Most of the mining camps had disappeared, though some hardrock mining continued, and dredging took place until 1942. The basis of the local economy became ranching, with some logging for local use and, until the railroad closed in 1937, for railroad ties and to supply the mines at Leadville and Climax, to the south of the area.

Figure 3 shows the harvests recorded in the area from 1905 to 1987. Not included in these figures is "free use", the removal of wood for local use, which may have been as high as the recorded harvests until the 1950s. The forests were surveyed in the 1920s, and sustained yields recommended, but harvests stayed well below these levels throughout this period, even during the Second World War, when demands for mining timbers increased and prices were high (64). Forest Service employees spent much of their time constructing trails and roads for fire prevention and control, the primary emphasis of forest management in Colorado (65). Improved access, both within the area and on new roads from outside, also meant that summer recreation became a noticeable use of

FIGURE 3
Summit County Study Area:
Average Annual Harvests, 1905-1987.



SOURCE: M.F. Price, Mountain Forests as Common-property Resources: Management Policies and Their Outcomes in the Colorado Rockies and the Swiss Alps 1988 (unpublished Ph.D. thesis in the library of the university of Colorado, Boulder).

the forests from the 1930s. During this decade, various recreational facilities were built by the Civilian Conservation Corps, who also thinned about 5,000 acres of trees which had regenerated since the mining era (66).

For the first half of this century, the area's forests were regarded by the local community, including Forest Service officials, primarily as a source of one local public good: wood. Forest Service legislation and policies at the national and regional levels recognized the forests' importance as common-pool resources supplying a variety of public goods. First among these were the protection of watersheds and of a secure wood supply; both were primary reasons for the emphasis on fire prevention. While these public goods were identified in legislation, others were mentioned only in policy. Recreation was recognized as a public good provided by the forests in regional policies from at least 1915 (67), and in national policy from 1919. An additional public good provided by the forests was wilderness, first recognized in national-level policies (as Primitive Areas) in 1926 (68). Part of Summit County in the Gore Range, one of the areas essentially unaffected by mining, was established as a Primitive Area in 1933.

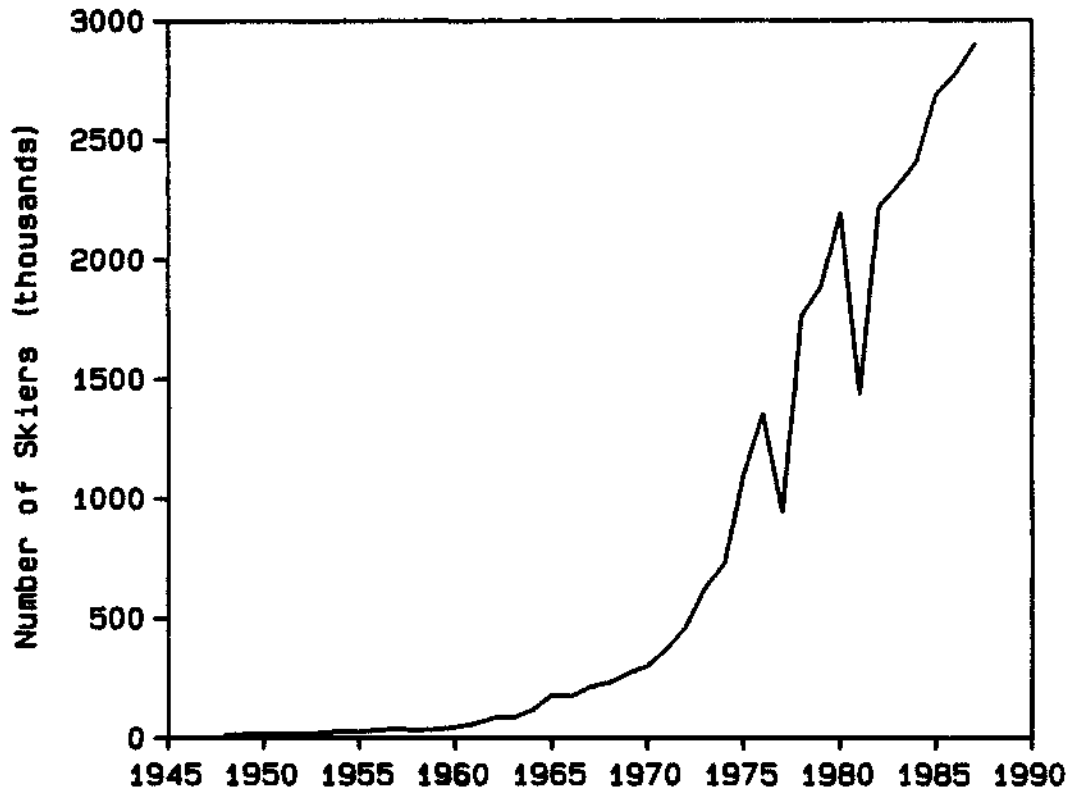
The 1950s can be identified as a turning point for Summit County and its forests, as for much of the Rocky Mountains. Within a few years, Summit County's economy changed from one primarily dependent on ranching, to one based on tourism. One reason for the decline of ranching was that much of the best

agricultural land was flooded by two reservoirs, completed and filled in the early 1940s and 1960s (69). The reservoirs not only depleted the land base, helping to push land prices up, but also provided a significant summer recreational resource. At the same time, the area's excellent potential for downhill skiing was recognized. The first area opened in 1946; there are now four. Figure 4 shows the increase in skier visits until 1987. Summer recreation has shown a similar, though less rapid trend, and winter has become the dominant season. These trends are linked particularly to improved access from Colorado's rapidly growing cities and other 'fueling factors' (70).

Thus, recreation became the main emphasis of forest management in the area, with watershed protection also mentioned in the multiple-use planning undertaken after the passage of the 1960 Multiple-Use Sustained-Yield (MUSY) Act (71). This explicitly recognized that the National Forests should be managed to provide a variety of public goods, including recreation, watershed protection, fish, and wildlife, together with timber and forage. Wilderness was also mentioned in the MUSY Act, but was not a primary concern until the passage of the 1964 Wilderness Act (72). In the 1969 National Environmental Policy Act (73), landscape (i.e., esthetic quality) was also recognized as a significant product of federal lands, including National Forests. With the passage of the 1974 Forest and Rangeland Renewable Resources Planning Act (74) and the 1976 National Forest Management Act

FIGURE 4

Summit County Study Area:
Numbers of Skiers, 1948-1987.



SOURCE: Colorado Ski Country USA, Denver, Colorado.

(75), all of the remaining impure and pure public goods supplied by the National Forests were recognized in federal legislation.

This legislation resulted in a great increase in planning for the forests of Summit County, culminating in the Land and Resource Management Plan for the White River National Forest (76), which has administered the area since 1973. This plan identifies wilderness, undeveloped recreation, and wildlife habitat as the main uses of the forests of the north half of the area. The forests of the south part of the area, which includes the ski areas and settlements, are mainly designated for recreational use. A number of areas are identified for timber harvesting: about 75 percent to control mountain pine beetles (*Dendroctonus ponderosae*) in lodgepole pine stands, the rest mainly in spruce-fir forests to improve forest health and increase diversity.

As shown in Figure 3, timber harvests increased from the late 1960s, though this may be an artifact of the available data, since 'free use' had declined substantially as other sources of fuel and timber for construction became available. Little local timber has been used in the construction boom which took place from the mid-1960s, to supply recreational facilities and housing for a rapidly-growing local population. In the 1970s, the area's population finally exceeded the levels of the nineteenth-century mining booms (77).

There have been a number of reasons for the recent increase in timber harvests (78). In the late 1960s, logging

was undertaken to supply timber for a sawmill north of the area, in line with the Forest Service's community stability policy (79). The clearing of the right-of-way for Interstate Highway 70 and of ski runs also required considerable logging, though much of the wood was burned on-site since no markets could be found. These projects were carefully planned with esthetic criteria in mind, to conform to new agency policies (80). In the 1980s, substantial spraying, thinning, and logging operations took place, in order to bring an epidemic of mountain pine beetles in lodgepole pine stands, which account for half the forests¹ area, under control (81).

This epidemic had been foreseen in the 1960s, and can largely be traced to the results of interactions of people with the forests over the past century. The loss of a large proportion of the forest cover from 1860 to 1900, followed by decades of protection, has resulted in stands with a limited range of age classes and limited regeneration. Such stands account for nearly half of the area's forests; most of the remainder comprises stands with a wide range of age classes, but little regeneration. In general, these are the stands unaffected by the activities of the mining era (82). In the lodgepole pine stands, which occur in both categories, the effect of protection from fire has been the development of large numbers of trees which, because of their stand structure and age, are highly susceptible to insect epidemics and disease (83). Thus, one result of the fire prevention program, intended to provide a public good, may paradoxically

be to increase the likelihood of the public bad it was intended to minimize.

In summary, legislation and policies for the National Forests now recognize that these are common-pool resources supplying a range of public goods to a wide range of communities. These extend from the local to the national, and even international, in the case of recreation, wilderness, and ecosystem and genetic diversity. In Colorado, recreation is recognized as the primary public good provided by the National Forests (84). Summit County's forests are mainly managed for recreation, in terms of supplying recreational facilities and a high-quality landscape, with watershed protection as another important goal. In current planning and management, timber harvesting is principally regarded as a tool to ensure the long-term provision of these public goods; as elsewhere in Colorado, hardly any timber sales make a profit (85).

An alternative management technique is prescribed burning, which is effective for controlling mountain pine beetle populations (86), and often achieves the same results at less cost than timber harvesting (87). Essentially, this would represent the reintroduction of the ecological process which is the principal natural agent of change in Colorado's forests (88). However, opportunities for prescribed burning are currently limited not only by the location of many homes and recreational facilities in the forests, but also by the public perception, fostered by the U.S. Forest Service for decades, that forest fires are bad (89). Nevertheless, this

may well be the most effective technique for ensuring that the area's forests continue to reliably supply a wide range of public goods into the future.

CONCLUSIONS

The case studies presented above show that the forests of the Swiss Alps and Colorado Rocky Mountains are common-pool resources supplying many joint products to a variety of communities. In both regions, two outputs were recognized in early policies: wood, a local public good; and protection, a pure public good. In Colorado, these joint products were recognized from the 1870s; in Switzerland, in local policies from the sixteenth century and in cantonal policies from the early nineteenth century.

One of the primary activities of early foresters in both regions was to emphasize the importance of forest management for supplying public goods, particularly protection of watersheds, to the national community. By the end of the nineteenth century, these activities had resulted in federal legislation which stipulated that the forests should be managed according to the principles of sustained-yield forestry. In effect, the production of sustained yields of timber was regarded as the most efficient method of ensuring the supply of public goods. However, until the 1950s, harvesting levels tended to be based on the needs of local communities rather than the sustained yields derived from

surveys of the forests. Harvesting patterns were very uneven in both space and time, as a result of three interacting factors: demands for wood and other forest products required for primary economies; possibilities for selling wood outside the community; and levels of access to the forests.

After the Second World War, the basis of the economies of the two regions changed rapidly from primary activities to tourism. Populations, which had been declining, began to increase. Yet, although national policies were beginning to recognize that the forests provided many public goods to national communities, forest management activities in mountain areas received less emphasis than in previous decades, and harvests tended to decline. In Summit County, increasing emphasis was placed on planning and other activities related to the growing use of the forests for recreation. In the Aletsch area, the growth of tourism provided new employment, especially in the traditional winter logging season, thus helping to reduce harvests. In both areas, demands for wood also declined because cheaper sources of fuel and construction materials became available. These trends apply not only to the study areas, but to the regions as a whole (90).

By the 1980s, legislation for the forests of both regions recognized their importance to national, and even international, communities. Legislation in the United States recognized a wider range of public goods than in Switzerland, including ecosystem and genetic diversity, which are supplied not only to current, but to future generations. At the same

time, the long-term ability of the forests to supply all of the expected joint products began to be limited, as a result of the legacy of human interactions with the forests. Forests in both regions had a large proportion of stands composed of trees of few species, with a narrow range of age-classes. The trees were also in the stage of their life-cycles when they were becoming increasingly susceptible to insect infestation and disease.

While these problems had often been predicted for decades, neither local (in Switzerland) or national communities (i.e., federal governments) had been willing to invest in the management activities necessary to increase the forests' diversity, in order to decrease their susceptibility to natural and anthropogenic stresses and ensure their ability to supply the expected public goods. When insect epidemics began, however, federal governments acted relatively quickly to limit their effects. To date, these actions have mainly been prophylactic; a legislated or policy basis for the forest management activities necessary to ensure the long-term provision of all of the public goods identified in legislation still does not exist in either region.

In Colorado, the necessary evolution of policy may require a considerable reorientation of the legislation and policies driving the management of the National Forests (91), together with an increased emphasis on prescribed burning as a management tool. In Switzerland, a new forest law (92) is likely to be passed in the early 1990s. This will recognize

that a minimal level of management in the mountain forests is necessary if they are to continue to provide all of the joint products expected by local and national communities. In sum, it is crucial that local communities support the management of adjacent forests. While these are important to national communities, the future of local communities is most closely tied to the future of these forests. Future legislation and policies for their management should recognize that these forests provide a wide range of public goods and that, since their structure has been strongly influenced by human activities, continued human intervention in natural ecological processes is essential for the forests to continue to provide these joint products.

FOOTNOTES

1. Ostrom, Issues of Definition and Theory: Some Conclusions and Hypotheses, Proceedings of the Conference on Common-property Management (Board of Science and Technology for International Development, 1986), at 604, defines a common-pool resource as "a natural or man-made facility that produces a flow of use units per unit of time (or several flows of different types of use units) where exclusion from the resource is difficult or costly to achieve and the resource can potentially be utilized by more than one individual or agent simultaneously or sequentially."
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