From Floods to Reforestation: The Forest Transition in Switzerland

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ABSTRACT

The forest area in Switzerland has been expanding for more than one hundred years, after a long period of contraction culminating in an apparently accelerated phase of deforestation in the first half of the 19th century. The nature and causes of this transition from net deforestation to net reforestation are considered. It is concluded that the perception of a resource crisis played a key role, but also that various passive factors facilitated an end of deforestation and the beginning of reforestation. The question of the comparability of the Swiss case to that of modern developing countries currently experiencing rapid deforestation is considered.

KEYWORDS

Forest transition, deforestation, reforestation, resource crisis, forest sustainability, Switzerland

INTRODUCTION

The Intergovernmental Panel on Forests, in its recent report to the UN Commission on Sustainable Development, recommended that countries should carry out a comprehensive analysis of the 'historical perspective of the causes of deforestation' (IPF, 1997). In several European countries, however, deforestation has given way to reforestation as the dominant feature of forest trends in the 20th century: this change is defined as the forest transition. In the current quest for sustainability, it can be argued that analyses of the causes of this forest transition are potentially at least as valuable as those of deforestation alone.

In this paper, the case of Switzerland is examined. By the mid-19th century, forests had shrunk to around 15 per cent of the land area: they have now expanded

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to occupy almost 30 per cent of that area. It is argued that this transition is linked to a combination of factors, some of which are permissive or passive, while others are more active. In effect, a crisis, operating against a background which 'permitted' forest expansion, served as a trigger for reforestation. The lesson from the Swiss case is that a jolt into forest sustainability is more likely than a smooth, crisis-free passage.

BACKGROUND

Limitations of historical data

A full and reliable set of time-series data on long-term forest trends in Switzerland simply does not exist. It is only from the middle of the 19th century that reliable data become available. From then on, forest expansion is the dominant national trend, even if its course cannot be charted in precise detail. The long history of deforestation and forest contraction prior to the 19th century cannot be charted in quantitative terms, such is the paucity of reliable data. There is little doubt that forests shrank over a long period, but the precise form of the curve of forest area against time is unknown.

In relation to other European countries, Switzerland has a number of distinctive features. The fact that its boundaries have been stable since the early part of the 19th century should in theory facilitate the compilation of data on national land-use trends. In this respect it contrasts with neighbouring countries such as France and Germany. On the other hand, the modern Confederation came into being only in 1848. Prior to that date, land-use data are available for some cantons, but problems of inconsistency of categories and dates have confounded attempts to assemble a long-term data series at the federal level.

The earliest attempt to assemble data from the cantons was in 1842/3 (Weisz, 1953). A few years later a survey between 1845 and 1848 covered 22 cantons and included both state and private forests (Franscini, 1852). Several decades were to elapse before regular and systematic collection of statistics began. The compilation of annual national statistics dates from the 1890s, and the federal statistical agency began to report detailed forest statistics in 1908 (Decoppet, 1908).

As in many other countries, the interpretation of historical data is complicated by the procedures employed in their collection, by the use of non-standard statistical units, and by definitions of land-use categories (including forests in particular). Some of these complications persist until the present, although they have in general tended to become less serious in recent times. In some of the early federal forest statistics, for example, private forest is excluded. In general the early forest statistics focused on production forests within the public sector, since they were concerned mainly with wood production and trade (e.g. Decoppet,

1908). There are some exceptions which did include private-sector forests (e.g. Decoppet, 1912), but in general only estimates can be made for the private sector (and hence for the total forest area), at least until more recently (Schuler, 1983). Areal units such as *poses* and *jucharten* differed in size from one canton to another, making conversion to common metric units (which became widely used from 1875) difficult. Problems also extend to definitions, as well as to scope and statistical units. One example is 'wooded pasture': some cantons included this category in their land-use data, while others did not. Decoppet (1908) warns about such inconsistencies in the data in early forest statistics. Overall, there is little doubt that data have become more comprehensive as well as more reliable in recent times. It is possible that some of the apparent increase in forest area stems from fuller statistical coverage, but most of the expansion appears to have been real rather than merely a function of better statistics. Unfortunately, the key period in the national forest transition (i.e. in the 'turn round' from net deforestation to net reforestation) is not well documented statistically.

The long trend of deforestation

While forest trends prior to the mid-19th century cannot be charted in detail, it is clear that deforestation was the dominant process, although its rate almost certainly fluctuated. The first major phase of deforestation was probably associated with the settlement of the 'Alemanni' around the 5th century (Schuler, 1988). The Pre-Alps are believed to have been little affected at this time, but they did not escape a second phase of clearance which took place in the Medieval period. The foundation of settlements with 'clear-cutting' names (e.g. Rüti, Grüt, and Schwand) is dated to this period (Schuler, 1988). Extensive areas had already been deforested in the lowlands by the 12th and 13th centuries (Hauser, 1964). With an increasing population and expanding agriculture, alpine forests were partially cleared for and by grazing, and the timber line was lowered by 200-300m. As in neighbouring countries, this phase was brought to a halt by the outbreak of the Black Death and the ensuing decline in population (McEvedy and Jones, 1978). Some recovery of forest area is likely to have resulted from the consequent abandonment of land. From the 16th century, however, some 250 years of exploitation left a serious mark on the state of the forest (Auer, 1956). More rapid population growth from the late 18th century was probably accompanied by accelerated deforestation, especially as early industrialisation was increasing demand for charcoal (Schuler, 1988). Deforestation now extended far up the alpine valleys and into the mountains. Overall, a close inverse relationship probably existed between population and forest trends in the period leading up to the 19th century. By the early 19th century, the proportion of the national land area remaining under forest cover had almost certainly fallen to under 20 per cent.

Forest trends in the 19th and 20th centuries

During this period, the character of forest trends and their relationship to population trends underwent a reversal. The last century and half has been characterised by an approximate doubling of the forest area and a trebling of population. Figure 1 summarises these forest trends. It indicates a degree of consistency in the estimates from around 1860, even if complete unanimity is lacking. While some data are available for earlier years (notably in Franscini, 1852), they relate to only part of the country. For that area, the forest extent was approximately 0.4 million ha. These data do, however, contain some interesting detail: for example the private woodlands of the Berne Canton were said to be shrinking at an annual rate of 540 poses, against a total area of 240,000 poses (1 pose = 0.36 ha).

A steady expansion has characterised the last hundred years and more, with the brief exception of the years of World War II. The precise date of the forest transition cannot be established in detail, because of the inadequacy of statistical data for the period prior to the mid-19th century. What is clear, from photographic and cartographic evidence as well as from statistical sources, is that forest expansion has been both sustained and substantial. Many areas formerly deforested are now reforested, and it may be speculated that the forest area is now as large as it was four or five centuries ago. Having continued for well over a century, this expansionary trend cannot be dismissed either as a statistical quirk or a short-term phenomenon. What are the causes of this dramatic reversal?

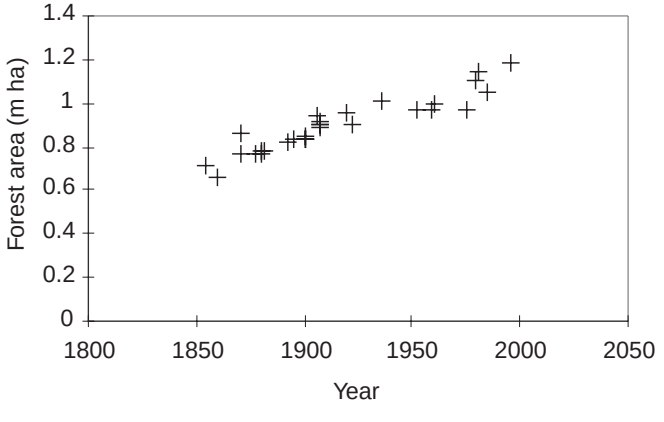

FIGURE 1. Apparent trend in forest area in Switzerland since c. 1850.

Source: compiled from data in Brugger (1968), Decoppet (1912), FAOSTATS (various years), Landolt (1862), Mazzuchi (1965), Inspection Fédérale des Forêts, Chasse et Pêche, Schweizerische Forstatistik (various years), Statistischen Bureau (various years), Société Suisse des Forestiers (1862), Swiss Federal Institute (1990), Union Suisse des Paysans (1936).

THE CAUSES OF THE FOREST TRANSITION IN SWITZERLAND

The driving forces of land-use trends in general are poorly understood. It is widely assumed that candidate drivers such as demographic trends and economic development are significant, but their precise mechanisms are not well understood. Nor is the relationship between proximate and underlying factors or causes easy to disentangle. If these conclusions apply to land-use trends in general, their validity in relation to *reversals* in trends is likely to be even greater. For example, if population growth can be invoked as a driver of deforestation, how can the association between reforestation and population increase over the last century and half be explained? Clearly, a change in the nature of the relationship must have taken place: indeed the relationship appears to have been inverted. With that inversion there may also have been a significant change in the relationship between correlation and causality. Population growth can be plausibly postulated as a driver of deforestation, but it is difficult to see how that role can come to an end, and even more difficult to envisage how it can 'cause' reforestation.

Forest trends can be conceptualised as reflecting the relative strengths of factors favouring deforestation and reforestation. When the latter equal the former, a 'natural' forest transition occurs. By the time such a transition was reached, however, the forest might have almost completely disappeared, in Switzerland and in several other European countries. In practice, an earlier transition was induced or facilitated by state regulation (in the widest sense, including controls on deforestation and incentives for reforestation). Several conditions need to be satisfied, however, if regulation is to be effective. Clearly it needs to be introduced in the first place, and its effectiveness will depend on its design and on the relationship between the power with which it is implemented and the resistance which it encounters, including the relative strength of factors favourable to deforestation and reforestation. Thus effectiveness will depend, to some extent at least, on power relationships.

The thesis developed in this paper is that perception of crises played a significant role in triggering the forest transition. Crises can be viewed as active factors: in the Swiss case they included both general issues of wood shortage and particular events such as floods. Fundamental questions arise about the extent to which perceived crises are real and the diagnoses of their causes are accurate. Questions also arise about the way in which crises are subsequently highlighted in order to promote regulation of the forest and its use. At the same time, however, a halt to deforestation and the onset of forest expansion in Switzerland were facilitated or made possible by changing socio-economic conditions. These conditions can be regarded as permissive or passive factors. Both the perception of the crisis and the changing socio-economic conditions were located in a changing climate of thought and attitudes, and a changing political climate.

ACTIVE FACTOR: THE CRISES

The late 18th and early 19th centuries were a period of increasing pressure on the forest resource. The rate of population growth accelerated, and the early stages of industrialisation added new demands for wood and charcoal. Deforestation appears to have accelerated, though there is inadequate statistical coverage for the country as a whole to provide a sound basis for a detailed quantification of the trend.

Malthus, in the second edition of his famous essay (1803), remarked on the relatively low rate of population growth in Switzerland in the 18th century, compared with neighbouring countries, and commented on the 'want of fruitfulness of Swiss women' (p. 204). He concluded that a low birth rate was a response to a low death rate, which in turn reflected the prudence, cleanliness and general healthiness of the country. He also saw it as the result of self-regulation in the context of low resource potential of a mountainous country with limited agricultural land (he observed that 'the peasant sometimes makes hay with crampons on his feet' (p. 212). At the very moment when he was writing, however, the growth rate was accelerating. The population of alpine Switzerland grew from 408,000 in 1700 to 466,000 in 1800 and to 614,000 in 1850, at an average annual rate of 0.13 per cent between 1700 and 1800 and 0.55 per cent thereafter. In non-alpine Switzerland, the corresponding rate between 1800 and 1850 was 0.75 per cent (Viazzo, 1989).

During the early 19th century, population growth in the highlands in particular was accompanied by environmental degradation as well as by pauperisation (Pfister and Messerli, 1990). In Valais, for example, it was suggested a goat consumed 20 francs worth of wood to produce 10 centimes worth of milk (Loup, 1960). One of the factors behind the acceleration of population growth was the introduction and widespread use of the potato. Its higher productivity per unit area, compared with cereal crops, in effect meant that the carrying capacity of the land increased as a result of this innovation, at least in terms of food production. While emigration functioned to some extent as a safety valve, resident populations were nevertheless characterised by growth. In the absence of a commensurate change in land management, however, environmental stress resulted. The productivity of pastures and hay-making capacity did not increase commensurately (at least in the upland areas), and cows were partly replaced by goats. Their activities, combined with the growing fuel demands of the expanding population, caused serious degradation of mountain forests (Pfister, 1983).

As has been indicated, it is not possible to reconstruct the forest curve in detail for the period around 1800. It is highly probable, however, that the rate of deforestation increased as population grew. The process also extended into new areas in the mountain forests in the headwaters of the valleys.

In essence, the existing systems of management could not cope with the pressure of population growth and increasing demand for wood. Most of the forest was under communal ownership, and traditionally, the cutting of wood for fuel and construction was strictly limited by a complex series of communal mechanisms. Amongst them was the control of wood cutting by elected village councils: the emphasis was on restricting resource use to the rate of forest growth, maintaining the protective function of the forest, and providing equitable shares of the annual cut to each household (Netting, 1972; 1981). Such a system might prove effective and successful during times of relatively stable population, but with rapid population growth the stresses imposed by demand for forest resources became too great for this type of communal regulation to control. In short, a fuel shortage or energy crisis was being experienced by the middle of the 19th century (e.g. Marek, 1994).

Superimposed on this long-term or chronic stress on the forest resource were particular or specific crises relating to events that could be linked to the use of the forest resource and to the protective role of the forest. Prominent among such events were damaging floods, which occurred particularly in the 1830s and again in the 1850s. The Swiss Forestry Society drew attention to a perceived links between the occurrence of floods and the state of the forest. In 1856, it petitioned the federal government, through its president, Professor Elias Landolt, to look into the condition of the forests. Soon afterwards, a major survey of forest condition was commissioned, to be carried out under the supervision of Landolt. The survey report concluded that deforestation caused irregular river discharge, that the treeline had been lowered and resistance to avalanches and rockfalls consequently had been reduced, and that forest removals were greater than increments (Landolt, 1862). The wider conclusion was that alpine deforestation but not just a local problem but one which affected the whole nation. The implication was that improved forest management was essential. Further floods in 1868, in which 50 deaths occurred, served to emphasise the apparent link between deforestation and floods. The result was that over the next few years, federal initiatives emerged in reforestation and in the strengthened regulation of existing forests. These initiatives culminated in the Forest Police Law of 1876 (e.g. IFF, 1976). Under that law, which applied to the Alpine and pre-Alpine forests, reduction in the forest area was prohibited. A permit was required before felling could occur, and felled areas had to be replanted or a compensatory area in the vicinity afforested. Rights of traditional uses were made subject to regulation. The cantons or federal government could require afforestation of bare land in order to create protective forest, and private land could be appropriated for this purpose. In short, the state was now intervening in forest management.

The crisis in context

While the floods of the 1830s and 1850s are well documented, the question of whether damaging natural events significantly increased in intensity or frequency during the mid-19th century is another matter. So also is that of whether the floods were causally linked to deforestation. One analysis of floods between 1400 and 1900 suggested that the pattern was random (Röthlisberger and Keller, 1992), but other views also exist (see, for example, Pfister, 1999 and Pfister and Brändli, 1996). In addition, it was perhaps more of an assumption than a proven fact that deforestation was a cause of flooding and other natural disasters and that reforestation would be a solution. In a sense both questions – whether flooding was on the increase and if so, whether deforestation was the cause – are largely irrelevant for our present purposes. The importance lay in the prevailing perceptions. Landolt was able to highlight a perceived crisis of floods and an assumed link with deforestation as a means of boosting a federal apparatus for forest regulation. Public debate was stimulated and political support secured. The dominant social construction of forest and flood was now that of the forester-scientist, who by mobilising favourable public opinion and political support could steer the state into initiatives of reforestation and stricter regulation. The result, of course, was a better funded and more prestigious forest service.

The context in space: Neither Landolt nor the beginnings of Swiss reforestation operated in national isolation. Clear parallels are evident in neighbouring countries, and especially in France, both in terms of perceived links between deforestation and flood and in terms of state-assisted reforestation. In 1797, Jean Fabre, engineer of bridges and highways in the *département* of Var, published a pioneering study of alpine torrents. He identified deforestation as the primary factor contributing to flood damage, and advocated tree planting and protection of remaining woods (for example against damage by goats) as a means of minimising damage (Brown, 1876). Many years were to pass before Fabre's influence took effect, but severe floods in 1840 were followed by the publication of Surell's *Etude sur les Torrents des Hautes-Alpes,* in 1841. It again highlighted a perceived interaction between floods and forests, and became an influential classic. Twenty years later, at almost exactly the time of the publication of Landolt's report in Switzerland, a programme of restoration of mountain terrain, involving reforestation, began in the French Alps. New forest laws were also enacted, in similar vein, in neighbouring alpine areas such as Bavaria.

The context in time: Timing may have been significant. According to Corvol (1987), various natural disasters such as the eruption of Vesuvius had conditioned people (or at least opinion formers) in the first half of the 19th century to the notion of the terrors of an 'angry nature', responding to its human maltreatment. .She likened contemporary concern about a deforested future to fears of nuclear war in the 1980s : it was 'the great fear of the 19th century' (p. 74, trs). Fear of flood was superimposed on chronic concern about wood shortages. The

effect of the Surell report was to promote a sense of crisis or fear of catastrophe. But there is also another temporal factor. The concept of the forest as a means of protection against natural hazards had a long history in Switzerland, and regulatory measures geared to this concept had been attempted for several centuries. It is true that the protection forest was seen initially as a means of defence against avalanches (e.g. Price, 1988) and later, against soil erosion (e.g. Société suisse des forestiers, 1862), rather than primarily in relation to floods. Perhaps it was less important that the focus of protection had now altered and that these measures had met with limited success than that neither the concept nor the measures represented a completely new innovation. Furthermore, the writings of Landolt and others on the subject of the protective function of the forest had a great influence on the Swiss people (Hagen, 1974), as well as a political influence which led to the first federal forest law (Ott, 1974).

Equally significant is the evidence for the perception of a worsening situation throughout much of the 19th century. The Landolt report was by no means the first indication of concern about the state of the forest resource. Table 1 summarises the succession of regulatory measures employed in the protection forest above the village of Andermatt (Canton Uri). There, regulation geared to protection against avalanches had been attempted since the 14th century: the table shows the frequent implementation of new measures – presumably reflecting stress on the resource – in the 19th century.

Year	Measure
1803	Fine for removal of forest products raised to 40 florins
1820	Goats banned from forest
1841	Children banned from forest: fines for grazing of animals
1846	Forest guard appointed
1864	Commune constructs avalanche defence walls
1873	Commune votes to spend 6000 francs on forest improvement

TABLE 1. Andermatt forest regulation

Source: based on Coaz (1875)

A clear trend of increasing regulatory effort can be discerned in relation to Swiss forests over a longer period of several centuries. From the 14th century onwards, regulation at the communal level sought to control some or all uses in communal forests, and in some cases wardens were employed to enforce orders.

By the 16th century, the scope of local regulations had expanded to control the sale and export of wood as well as the consumption of forest products (Price, 1988). In the face of growing stress on forest resources, such measures proved inadequate, and regulation at the scale of the canton began to be attempted in the early 19th century. The influence of German forestry was apparent here: scientific and technical advances in silviculture fostered renewed attempts at regulating the use of the forest resource (Hagen, 1974). In Graubünden, for example, the first cantonal inspector of forest was engaged in 1836 (following the floods of 1834), and the first cantonal ordinance was introduced in 1839 (Rageth, 1983). In some other cantons, parallel developments occurred later: the Canton of Freiburg, for example, established its first forest law in 1850 (Müller, 1990a).

At the time of the foundation of the Confederation in 1848, the constitution ascribed competence over forestry matters to the cantons. In 1876, however, the first federal forestry law was enacted, marking a new level of regulation. It was now being realised that deforestation in the mountains could endanger the lowlands (Schuler, 1993). In other words, there was a perception that deforestation in one area could have effects in distant areas, and thus federal intervention was justified.

One of the features of the forest transition in Switzerland, as in neighbouring countries such as France, is that an increasing polarisation occurred between forest and farmland: whereas the traditional use of the forest included activities such as grazing and the collection of fodder, this agricultural role was increasingly excluded as the role of the forest increasingly focused on timber production and environmental protection. In parts of the country (especially in the lowlands), this separation had already occurred by the time of the Confederation (Hauser, 1964), and it now extended into the mountains.

In general, implementation of the measures set out in the federal law of 1876 was left to the cantons, but the broad rules and general principles were set at the federal level. Influence could also be exerted from that level. In the Canton of Freiburg, for example, little forest was left by around 1870 (Müller, 1990a) Despite several federal promptings from the late 1870s onwards, the head forest official was slow to act. During the 1870s and 1880s some local people had petitioned the cantonal government to acquire land for reforestation, for both environmental protection and wood production. Further floods in 1888 strengthened the calls, and in 1889, federal pressure was applied. Thereafter a number of afforestation projects were launched (Müller, 1990b).

Overall, therefore, the scale of regulation increased from the commune to the federal level, and the scope widened to include reforestation as well as control of deforestation, and to encompass other forest products as well as wood.

The wider context: A further dimension is provided by the advent of 'scientific' forestry, and the ascendancy of rationalism. Towards the end of the 18th century, 'economic patriots' with Physiocratic views began to show interest in the notion

of better-managed forests and revitalised forestry, but their aspirations were frustrated by a lack of trained personnel (Schuler, 1984). In the early 19th century, however, influences from French and German forestry schools began to penetrate the country and to stimulate and inform new types of regulation. At the same time, the belief in the French Alps that a feckless and ignorant peasantry was inimical to the forest resource (e.g. Lovie, 1981) is echoed also in Switzerland. For example, Elisée Reclus (1887) observed that 'in some cantons, and more especially in Valais and Ticino, the trees have been cut down without the least thought of the future, and the disastrous consequences of such wanton destruction have not failed to appear in the deterioration of the climate and an increase in the destructive action of mountain torrents. The forests no longer deserve that name'. (p. 476). In his view, 'environmental anarchy' prevailed. And by the end of the century, Romantic notions were complementing Enlightenment attitudes. In particular, mountain and forest were perceived as symbolic of Swiss identity, and both symbolism and identity were strongly associated with the building of the nation during the 19th century (Walter, 1984; 1989; 1991). Threats to the forest, therefore, were to be taken seriously for emotional as well as for physical reasons.

PASSIVE FACTORS

Reference to 'the wider context' brings us to the arena in which different factors intersect to give rise to conditions favouring, or at least making possible, the end of deforestation and the beginning of reforestation. As Schuler (1980) observes, the passage to a regulated forest economy became possible only when agriculture and the economy in general began to modernise. To attribute the forest transition solely to Landolt and subsequent federal initiatives would be at best a gross oversimplification. Numerous attempts had been made to regulate forest use and to control deforestation, from the 13th century onwards in at least one canton (Valais: Price 1988) and from the 14th century in others (Schwyz, Uri: Coaz, 1875; Fraser, 1974). Furthermore, forests were amongst the subjects discussed at supra-cantonal meetings that occurred regularly from the 16th century onwards (Schuler, 1980). The continuing decline of the forest area testifies to the general failure of cantonal and supra-cantonal measures to protect forests from the pressures to which they were subjected, even if they had been successful in some local areas. To attribute the Swiss forest transition simply to the mid-19th century floods and ensuing measures, therefore, would be to beg the question of why these measures turned out to be effective when their predecessors had largely failed. Perhaps the answer is that a number of circumstances were more favourable by the 19th century than they had been previously. These circumstances embrace both institutional factors and socio-economic and technical trends.

Institutional factors

As has been indicated, forest regulation prior to the 19th century was pitched at the level of the commune and canton. The intervention of the cantons implies a perceived failure on the part of the communes to ensure that their forest management had no wider effects. The establishment of the Confederation in the mid-19th century, in turn, introduced a new dimension. It marked a milestone in the evolution of the modern nation-state, and in Switzerland as in neighbouring countries, the new state assumed the right to intervene in the management of the forest resource. Individuals such as Landolt had access to the state apparatus, and the corollary was that the 'scientific-rational' construction of the forest and the forest-flood relationship was privileged above others. Furthermore, these actors did not operate simply as individuals: in 1843, the *Schweizerischer Forstverein* (Swiss Forestry Society) was founded, with the primary objective of conserving forests. It proceeded to operate as an influential association for the promotion of forest management (Zon and Sparhawk, 1923). Shortly after the Confederation was established, a Department of Forestry was created (in 1850). In 1855, training in forest management began to be provided at the Federal Polytechnic School. Then in 1856, the Swiss Forestry Society was given funding for forest research, and work began on the causes of flooding. In short, therefore, several institutional developments had occurred before the 1860s, involving both the state and civil society. Collectively, they helped to ensure that the infrastructural pre-conditions for the passage to a more sustainable form of forest resource management were satisfied.

Agricultural and demographic change

In theory, an increasingly close adjustment between agriculture and land quality can indirectly lead to a forest transition. With closer adjustment, a given volume of food can be produced from a smaller area of land. Poorer and more marginal areas of land are thus released from agriculture, and become available for reforestation by natural regeneration or planting (Mather and Needle, 1998). A rural exodus, involving the migration of farm populations to the cities, could accentuate the effects of this process, through land abandonment. Improved agricultural techniques in some areas proved to be more rewarding on better agricultural land, thus in effect widening the productivity gap between better and poorer areas and accentuating the marginality of poorer areas and encouraging a rural exodus. Therefore reforestation and rural depopulation might be linked, indirectly and passively but in a sense also causally. In some neighbouring countries such as France, the rural exodus in peripheral regions assumed major proportions in the second half of the 19th century, and there close statistical relationships exist between reforestation and rural depopulation.

In Switzerland, the picture is more complicated for a number of reasons, including the patterns of agricultural change and industrialisation. Up to the end of the 18th century, a large degree of self-sufficiency existed in food production in alpine Switzerland (Pfister and Messerli, 1990). Thereafter, a shift developed away from subsistence towards a market orientation and specialisation on dairy products. This shift was accompanied by an increasing emphasis on grazing, both indirectly through the production of hay and on the use of high pastures. Complete abandonment of land previously used for the cultivation of grain or potatoes was therefore less likely: it could simply be used as pasture land, and hence natural regeneration of woodland could be impeded. Also during the 19th century, the industrial revolution was not accompanied by rapid urban growth, as in most other European countries. Instead, industrialisation in Switzerland had a rural emphasis (Biucchi, 1976). Indeed to some extent the growth of industry reflected a movement of industrial workers into the countryside, rather than a migration of rural population into the cities. For example, Pelet (1985) suggests that ironworking activities moved from urban centres in the 18th century, as forests became exhausted, into the deeper countryside, where more forest remained. Some of the artisans turned to part-time farming to secure or supplement their food supply. Industrial change therefore tended to buffer agriculture against land abandonment or dramatic land-use change. Population growth and industrial development in the early part of the 19th century may have intensified the pressures on the forest. Later in the century, extensive land abandonment in remote and peripheral areas, such as occurred with the rural exodus in France as peasants moved to the cities, was more limited in Switzerland.

This does not, however, mean that land abandonment was unknown, and it became more widespread in the early 20th century (Hauser, 1975). In areas such as Emmental, for example, agricultural change contributed to significant expansion of the forest area (Gerber, 1989). During the 19th century a shift from alpine dairying to dairying in the valleys, combined with a more general trend of declining intensity in marginal areas, allowed forest expansion through natural regeneration. More generally, the agricultural population (as opposed to the rural population in general) was clearly in decline from the second half of the 19th century. While a dramatic rural exodus may not have occurred, the absolute and relative numbers of people dependent on agriculture did decline, and in turn obstacles to the reforestation of land previously used for agriculture were weakened. In short, an inverse relationship can be seen to exist between forest cover and the size of the agricultural population (Figure 2).

Agricultural and demographic change may have been less dramatic than in some neighbouring countries, but during the second half of the 19th century these trends facilitated reforestation, whereas at the beginning of that century they were more likely to give rise to deforestation. The existence of these trends

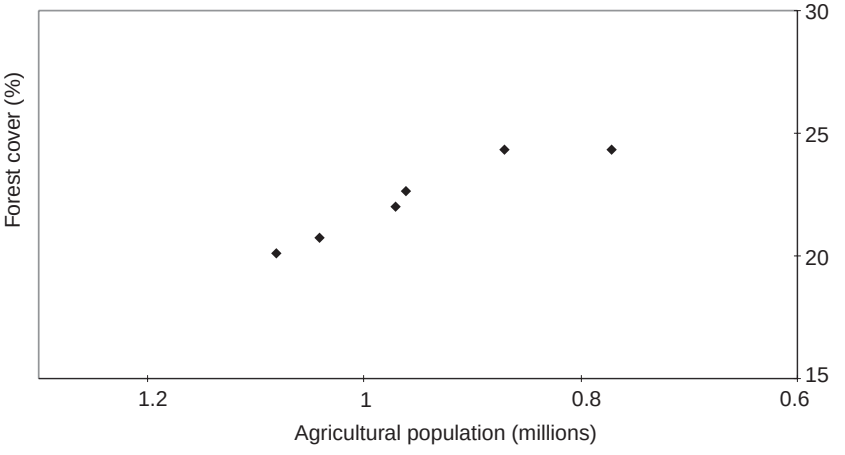

FIGURE 2. Trends in forest area and agricultural population in Switzerland. Source: compiled from data in Brugger (1968)

during the second half of the 19th century may help to explain the muted tone of resistance to new regulatory measures such as the Forest Law of 1876.

Technical change: wood and fuel

The Landolt Report concluded that annual wood removals exceeded annual increments by a margin of around 30 per cent. If this pattern had been established over a period of decades, as seems likely, the effect would to have been to reduce the forest extent. A large part of the removals was for fuel, both domestic and industrial. Socio-economic trends and industrial growth both meant increasing demand, and lower temperatures over the previous century may have increased fuelwood requirements (e.g. Pfister, 1990; 1994; Pfister and Messerli, 1990). By the end of the 19th century, however, the pressure of demand for fuelwood (and for timber) had weakened. Alternative sources of timber and energy had become available as a result of the development of a transport network.

From the early 19th century, some cantons were importing more wood than they were exporting. For example Neuchâtel around 1840 imported 141,000 *cubes* from France, and exported 18,000 (Société suisse des forestiers 1862). By mid-century, the same pattern was probably true of the country as a whole. Detailed statistics on imports and exports become available only from 1885, but change was rapid from then onwards. The ratio of wood imports to exports was 1.1 in 1885 but had widened to 6.2 by 1907 and trends in charcoal imports were even more striking (Table 2).

Date		construction wood*	fuelwood*	total*	charcoal†
1885/6	imports	100,000	150,000	250,000	5601
	exports	180,000	40,000	220,000	3138
1906/7	imports	480,000	210,000	690,000	11100
	exports	80,000	33,000	113,000	961

* cubic metres † tonnes

TABLE 2. Wood and charcoal imports and exports.
Source: based on Decoppet (1912)

In relation to woodfuel, trends in population and pressure on the Swiss forest were now being decoupled. In other words, these changes in the sourcing of energy resources were a passive factor which may have facilitated the forest transition. It should be borne in mind, however, that imports are more likely to have been used in urban areas than in the remoter countryside, where pressure on the forest may have been maintained to a greater degree.

If this is true of woodfuel, it is even more significant in relation to fossil-fuel resources. From around 1850, coal began to be used – and imported – in significant quantities. Table 3 summarises the energy revolution that occurred in the second half of the 19th century.

	1851		1910	
	TJ	%	TJ	%
Wood	18920	88	17190	16
Peat	2050	9	0	0
Coal	664	3	83570	78
Petroleum	0	0	740	1
Water power	90	<1	5270	5
Total	21724	100	106770	100
Per capita	9.03*		28.45*	

TJ – terajoule * Gigajoule

TABLE 3. Primary energy balance in Switzerland 1851–1910.
Source: based on Marek (1994)

Clearly, during the second half of the 19th century Switzerland moved from the wood age to the fossil-fuel age. The drivers of this transition are as hard to isolate as are those of the forest transition, but fears of a wood shortage (i.e. an energy crisis) almost certainly played their part in Switzerland as in other countries such as Britain. The absolute reduction in consumption of woodfuel is modest (9 per cent) and in itself may seem rather implausible as a major factor in 'driving' the forest transition although it would have facilitated that transition. More important, perhaps, is the indirect role of the energy transition in facilitating new forms of employment and lifestyles that were not dependent on resources drawn from the immediate locality. In other words, the trend summarised in Table 3 may be significant as a proxy for economic, social and political change, as well as serving as an indicator of technological change. Sablonier (1995) has shown how changes in the forest in central Switzerland as long ago as the 14th century were very closely associated with economic, political and social change in rural communities. It is not surprising, therefore, that the complex of changes associated with 'development' and with the transition to the fossil-fuel age should have significant effects in forests of the country as a whole.

Imports of both woodfuel and coal were facilitated by the expansion of the railway system. Between the opening of the first Swiss railway line in 1844 and 1850, only 24 km of line had been laid. By 1860, however, that figure had risen to over 1000 km, and by the end of the century to over 3000 km (Statistischen Bureau, 1900). Imports doubled between 1860 and 1870, and trebled by two years later (Société suisse des forestiers, 1874). The growth of the transport network and the rise in imports of both wood and coal are closely correlated.. Arguably, therefore, the incorporation of the country (and in particular of its alpine part) into a wider economy and the contemporaneous change in the sourcing of energy resources played important, if passive, parts in making forest expansion possible or at least easier than it might otherwise have been.

DISCUSSION

This point serves as a reminder of the contingent nature of factors relating to trends in land use and land cover. A similar expansion of the railway system in the late 19th century in southern Italy presaged a phase of deforestation, as previously inaccessible forests could now be commercially logged (McNeill, 1992). Similarly, the incorporation of the peripheral Chaqueña Region of northern Argentina into a wider economy was manifested by the growth of a railway network and was followed by serious depletion of the forest resource (Aguerre and Denegri, 1996). In general, it seems that extensive forest resources are exposed to exploitation by such incorporation, whereas pressures on scarcer forest resources may be alleviated. The result, however, may also be closely linked to the effectiveness and determination with which regulatory measures (and incentives for forest expansion) are implemented. With downward trends

in agricultural populations and the increasing availability of fuels other than local wood, such measures are more easily applied than in situations where these conditions are not present. In alternative terms, the degree of coercion required to halt deforestation and to initiate reforestation is likely to be greater in the absence of the operation of these passive factors.

Equally, however, the will to introduce regulation (in the form of forest laws and incentives for reforestation or better management) is likely to depend on a complex set of circumstances, including both societal and personal dimensions as well as the occurrence of triggers such as floods. As Sheail (1997) has remarked in relation to World War II and its dramatic effects in relation to land use in Britain, a crisis does not automatically translate into action. Instead, strong personalities are needed: a crisis may provide an opportunity, but it does not in itself inevitably lead to remedial action. In the case of Switzerland, Elias Landolt played a crucial part in highlighting the perceived disbenefits resulting from the state of Swiss forests in the mid-19th century, and succeeded in eliciting a federal government response in terms of more stringent regulation and stronger incentives. Landolt, however, made his contribution at a time when both government and civil society offered conditions that were probably more favourable for the acceptance of his views that at any previous time in history. The state was now prepared to intervene in environmental management (and if necessary in effect to restrict the property rights of individual forest owners (e.g. Stoltz, 1988)), while the growth of civil society (and of the Swiss Forestry Society in particular) provided channels to link the views of individuals such as Landolt with government. Furthermore, positive perceptions of the forest provided a favourable climate for policies of forest protection and expansion.

Ideally, a reductionist approach would be adopted which would seek to separate explanation of the legislation and explanation of the forest transition. As has been demonstrated for pre-19th century Switzerland, the introduction of legislative and other measures certainly did not always mean an end to deforestation. In practice, however, the causes of legislation and of the forest transition are so intimately intertwined in 19th century Switzerland that it is perhaps as pointless as it is difficult to attempt such separation. It is possible that an upward trend was already becoming apparent before the passing of the Forest Police Law in 1876, but the inadequacy of the statistical record is such that uncertainty exists. Such uncertainty, however, does not apply to the post-1876 period: as has been indicated, the trend thereafter was one of sustained expansion of the forest area. Ironically, the set of circumstances that gave rise to deforestation and to the passing of the law were perhaps already beginning to change towards another set that facilitated reforestation. At the same time, the direct effect of the 1876 law in terms of afforestation appears to have been limited: between 1872 and 1909, a total of just under 10,000 ha were afforested (Statistischen Bureau, 1910).

In the second half of the 19th century, a variety of factors coincided in time to give rise to a new forest regime which not only effectively halted further diminution of the forest resources, but initiated its prolonged expansion. In effect

a transition to sustainable management of the forest resource was effected. Its determinants encompass various factors, some of which could be regarded as active, and some passive or permissive. The occurrence of floods, purportedly linked to deforestation, was a trigger successfully activated by an influential individual in a setting in which socio-economic and technical factors, as well as the political and philosophical climate, were more favourable for reforestation than they had been in previous eras. Nor does the case of Switzerland seem exceptional in an European context: clear similarities exist with other European countries such as Denmark (Mather et al, 1998) and France (Mather et al, 1999).

In at least some respects, comparisons can also be made with some developing countries, both in terms of deforestation and in responses to it. Pfister (1983) explicitly likens conditions in highland Switzerland in the early 19th century to those in parts of the developing world today, while Marek (1994) notes that per capita energy consumption in Switzerland in 1851 was comparable with that in recent times in countries such as India and Bolivia. In Thailand and the Philippines, recent flood and landslides have been attributed to deforestation, which has proceeded with intensity and rapidity in the last few decades. In these countries, reactions have now set in: civil society has evolved, environmental NGOs have developed, and regulatory measures have been introduced and strengthened. There is some evidence to suggest that some land cleared for agriculture is now being abandoned as a rural exodus occurs, and that secondary forest is becoming re-established. In other words, there is some evidence to suggest that similar courses may be followed. Differences will undoubtedly exist between modern developing countries and European countries where the forest transition was effected in the 19th century: perhaps Switzerland was in a better economic position to import fossil fuels in the mid 19th century than many developing countries are today. At the same time, however, there would seem to be a number of commonalities. These include a serious drawing down of the forest resource followed by an acute crisis in the form of floods and fuel shortages, and also the operation, in various ways and intensities, of passive factors such as change in rural population and fuel sources. These also include the evolution of powerful nation states and governments prepared to intervene in environmental management, and the emergence of influential urban-based middle classes with positive perceptions of the forest. Bürgi (1994) outlines the replacement of the traditional form of forest utilisation in one area of Swiss forest by modern forestry in the second half of the 19th century. In microcosm, this trend reflects what was happening over much of Europe during the 19th century. Disequilibrium had set in: traditional forms of management could not safeguard the forest in a modernising country, and a phase of depletion ('crisis') persisted until there was modernisation of management – not only in silvicultural techniques but in terms of infrastructure and climate of thought.

The case of Switzerland, like those of a number of other countries, suggests that reforestation can be the correlate of development: growth in national population and affluence does not necessarily mean continued deforestation, while the cluster of economic, social, political and technological trends associated with 'development' can apparently facilitate reforestation. On the other hand, the Swiss case, like those of other European countries, suggests that a smooth transition to sustainable forest management (at a time when substantial forest areas remain), is less likely than a jolt at a time when the national forest resource has been seriously degraded. Schuler (1993) has referred to how the principle of sustained yield was formally adopted in federal legislation for mountain forests (1876) and then for the whole country when the 1902 Forest Police Law extended federal supervision to all Swiss forests. Sustained yield is, of course, not synonymous with sustained management, but perhaps here we have, in a nutshell, an example of how the trajectory to sustainability may be bumpy rather than smooth.

Thus it would suggest that a stimulus of serious resource problems is required for the threshold of sustainable management to be crossed. The forest transition as experienced in Switzerland fits comfortably within Whitaker's (1941) 'depletion-melioration' model, which appeared – significantly – just after the Dust Bowl episode in the United States. Whitaker in turn was influenced by Friedrich's (1904) concept of *Raubwirtschaft* and theory of 'creative destruction': the crisis resulting from destructive exploitation was the stimulus for the introduction of new regimes of resource management. Without such a stimulus or trigger, a transition will at best be delayed. It might eventually happen spontaneously, if a rural exodus develops and abandoned agricultural land becomes reforested. By then, however, most of the forest would probably have disappeared. Unfortunately, there is little evidence to suggest that we have progressed significantly from the 19th century and the days of Friedrich: each country, it seems, has itself to experience some form of forest resource crisis before it can effect a transition to the sustainable management of its forest resource. If the forest transition is a major hinge of environmental history, it is one which is both complex and, in terms of its timing, unpredictable. While the operation of certain passive factors can be predicted at least in part, the active factors involving crises and personalities are largely unpredictable. Forest transitions similar to those experienced in countries such as Switzerland in the 19th century may be expected to occur – eventually – in parts of the developing world currently experiencing deforestation. It is difficult, however, to predict when they will occur, but unfortunately it is likely that they will follow from crisis, hazard and hardship. The historical evidence does not suggest that the path to sustainability of forest resource management will be a smooth one.

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REFERENCES

Aguerre, M. and Denegri, G (1996) 'Deforestation in the Chaqueña region in Argentina', in Palo, M. and Mery, G (eds.) *Sustainable Forestry Challenges for Developing Countries* (Dordrecht, Kluwer), pp. 275–87

Auer, C. (1956) Die volkswirtschaftliche Bedeutung des Gerbirgeswalds, *Schweizerische Zeitschrift für Forstwesen* 107: 319–26.

Biucchi, B. M. (1976) 'The Industrial Revolution in Switzerland 1700–1914', in Cipolla, C.M (ed.) *The Emergence of Industrial Societies* (Brighton, Harvester), pp. 627–55.

Brown, J.C. (1876) *Reboisement in France* (London, King).

Brugger, H. (1968) *Manual statistique de l'agriculture suisse* (Berne, Imprimerie Fédérative).

Bürgi, M. (1994) Fruhere Nutzungsformen im Sigriswiler Wald, *Schweizerische Zeitschrift für Forstwesen* 145: 669–76.

Coaz, F. (1875) Le remboisement de la vallée d'Urseren dans le Canton d'Uri, *Journal suisse d'économie forestière*, Année 1875, 60–73.

Corvol, A. (1987) L'arbre et la nature (XVIIe-XXe siècle), *Histoire, Economie et Société* 6: 67-82.

Decoppet, M. (1908) Vorläufige Zusammenstellung der Produktion der öffentl. Waldungen Jahrgang 1907, *Schweizerische Forstatistik* (vol. 1) (Zurich, Meier).

Decoppet, M. (1912) Produktion und Verbrauch von Nutzholz : A Einleitung: Einige statistische Angaben über die forstlichen Verhältnisse der Schweiz, *Schweizerische Forstatistik* (vol. 3) (Zurich, Füssli).

FAO (annual) FAOSTATS (Rome, FAO).

Franscini, S. (1852) *Statistique de la Suisee*: livre premier – le pays (Lausanne, Michod).

Fraser, C. (1974) Avalanches: lessons in defence and control, *Unasylva* 26 (105): 23–9.

Friedrich, E. (1904) Wesen und Geographische Verbreitung der Raubwirtschaft, *Petermanns Mitteilungen* 50: 68–79 and 92–5.

Gerber, B (1989) Waldflächenveränderungen und Hochwasserbedrohung im Einzugsgebeit der Emme, *Geographica Bernensia* G33 1–8.

Hagen, C. (1974) Die Wohlfarts- und Erholungfunktionen des Waldes in der Praxis und Gesetzgebung des 19.Jahrhunderts, *Schweizerische Zeitschrift für Forstwesen* 125: 11–24.

Hauser, A. (1964) Wald und Forst in der Gründungszeit der Eidgenossenschaft, *Schweizerische Zeitschrift für Forstwesen* 115: 637–58.

Hauser, A. (1975) Brachland oder Würstung? Zur begrifflichen und historischen Abklärung des Brachlandproblems, *Schweizerische Zeitschrift für Forstwesen* 126: 1–12.

Inspection Fédérale des Forêts (1976) *100 ans de protection de la forêt* (Berne, IFF).

Inspection Fédérale des Forêts, Chasse et Pêche (various years) *Statistique Forestière Suisse* (Berne,. Bureau Fédérale de Statistique).

Intergovernmental Panel on Forests (1997) *Report of the Ad Hoc Intergovernmental Panel on Forests* (New York, UN Commission on Sustainable Development)

Landolt, E. (1862) *Bericht an den hohen schweizerischen Bundesrath über die Untersuchung der schweiz Hochgebirgswaldungen vorgenommen in den Jahren 1858, 1859 und 1860* (Bern).

Loup, J. (1960) L'exploitation de la fôret de des produits de cueillette en Valais, *Revue de Géographie Alpine* 48: 179–202.

Lovie, J. (1981) Les ressources forestières de la Savoie pendant les premières années du régime français (1860-1875), *Revue de Géographie Alpine* 49: 742–59.

Malthus, T.R. (1803) 'An essay on the principle of population', in Wrigley, E.A. and Souden, D. (eds) *The works of Thomas Robert Malthus*, volume 2 (London, Pickering), pp 202–15.

Marek, D. (1994) 'Der Weg zum fossilen Enerfgiesystem, Ressourcengeschichte der Kohle am Beispiel der Schweiz 1850-1910', in Abelshauser, W (ed.) *Umweltgeschichte; Umweltverträgliches Wirschaften in historischer Perspektive*, Gottingen pp. 57–75.

Mather, A.S. and Needle, C.L. (1998) The forest transition: a theoretical basis, *Area* 30: 117–24.

Mather, A.S., Needle, C.L. and Coull, J.R. (1998) From resource crisis to sustainability: the forest transition in Denmark, *International Journal of Sustainable Development and World Ecology* 5: 182–93.

Mather, A.S., Fairbairn, J. and Needle, C.L. (1999) The course and drivers of the forest transition: the case of France, *Journal of Rural Studies* 15: 65–90.

Mazzuchi, B. (1965) 'Conservation et extension de la surface forestière', in *Aus der Tätigkeit der Eidgenössiischen Inspektion für Forstwesen, Jagd und Fischerei* (Bern, Eidg Departement des Innern), pp. 14–19.

McEvedy, C and Jones, R. (1978) *Atlas of World Population History* (London, Allen Lane).

McNeill, J.R. (1992) *The Mountains of the Mediterranean World: An Environmental History* (Cambridge: Cambridge University Press).

Müller, U. (1990a) 'The afforestations of the Canton of Freiburg in the Senseoberland between 1889 and 1989 as an example of an active land use policy', in M.C. Whitby and P.J. Dawson (eds) *Land Use for Agriculture, Forestry and Rural Development*, Proceedings of the 20th Symposium of the European Association of Agricultural Economics, pp. 235–42.

Müller, U. (1990b) *Schutzwaldaufforstungen des Staates Freiburg im Senseoberland* (Freiburg, Kanton Freiburg).

Netting, R.M. (1972) Of men and meadows: strategies of alpine land use, *Anthropological Quarterly* 45: 132–44.

Netting, R.M. (1981) *Balancing on an Alp* (Cambridge, Cambridge University Press).

Ott, E. (1974) Auswirkungen des ersten Eidgenössichen Forstgesetzes vom Jahre 1876 auf den waldbaulichen Zustand unserer Gebirgswälder, *Schweizerische Zeitschrift für Forstwesen* 125: 895–905.

Pelet, P.-L. (1985) La metallurgie aux champs – le myth de la ferme-atelier, *Schweizerische Zeitschrift für Geschichte* 35: 157–63.

Pfister, C. (1983) Changes in stability and carrying capacity of lowland and highland agro-systems in Switzerland in the historical past, *Mountain Research and Development* 3: 291–7.

Pfister, C. (1990) 'Food supply in the Swiss canton of Bern, 1850', in L.F. Newman (ed.) *Hunger in History: Food Shortage, Poverty and Deprivation* (Oxford, Blackwell), pp. 281–303.

Pfister, C. (1994) 'Switzerland: the time of icy winters and chilly springs', in Frenzel, B. (ed.) *Climatic trends and anomalies in Europe 1675–1715: high resolution spatio-temporal reconstructions from direct meteorological observations and proxy data* (Stuttgart, Fischer).

Pfister, C (1999) *Wetternachhersage: 500 Jahre Klimavariationen und Naturkatastrophen 1496–1995* (Bern, Verlag Paul Haupt).

Pfister, C. and Messerli, P. (1990) 'Switzerland', in B.L. Turner II et al. (eds) *The Earth as Transformed by Human Action* (Cambridge, Cambridge University Press), pp. 641–52.

Pfister, C. and Brändli, D. (1996) 'Überschwemmungen im Flachland – eine Folge von Abholzungen im Gebirge? Zur Durchsetzung eines neuen Erklärungsmuster im 19. Jahrhundert,' in R. Kaufmann-Hayoz (ed.), *Bedingungen umweltverantwortliches Handeln von Individuen, Proceedings des Symposiums Umweltverantwortlicehs Handeln* Bern, pp. 50–55.

Price, M.F. (1988) Legislation and policy for forests in the Swiss Alps, *Land Use Policy* 5: 314–28.

Rageth, B. (1983) Die Forstdienstorganisation im Kanton Graubünden, *Schweizerische Zeitschrift für Forstwesen* 134: 509-516

Reclus, E. (1887) *The Universal Geography Vol. II, France and Switzerland* (London, Virtue)

Röthlisberger, G. and Keller, H.M. (1992) 'Historische hochwasser in der Schweiz – ursachen und jahreszeitliche verteiliung', VHB International Symposium (Bern, Interpraevent), pp. 105–16.

Sablonier, R. (1995) Waldschutz, Naturgefahren und Waldmitzung in der mittelalterlichen Innerschweiz, *Schweizerische Zeitschrift für Forstwesen* 146: 581–96.

Schuler, A. (1980) Wald- und Holzwirtschaftspolitik der alten Eidgenossenschaft, *Beiheft zu den Zeitschriften des Schweizerischen Forstvereins* No. 68.

Schuler A. (1983) Der Privatwald in der Forstgeschichte, *Schweizerische Zeitschrift für Forstwesen* 134: 687–701.

Schuler, A. (1984) 'Sustained-yield forestry and forest functions, as seen by Swiss foresters in the nineteenth century', in H.K. Steen (ed.) *History of Sustained-yield Forestry* (Santa Cruz, Forest History Society), pp 192–201.

Schuler, A. (1988) 'Forest area and forest utilisation in the Swiss pre-alpine region', in F. Salbitano (ed.) *Human Influences on Forest Ecosystems Development in Europe* (Bologna, Pitagora), pp. 121–7.

Schuler, A. (1993) Das Prinzip der Nachhaltigkeit und der Aufbau der Schweizerischen Forstwirtschaft, *IUFRO Proceedings of Subject Group S6.07 (Forestry History)*, Vienna (also *Schweizerische Zeitschrift für Forstwesen* 144: 263–9.

Sheail, J. (1997) Scott revisited: post-war agriculture, planning and the British countryside, *Journal of Rural Studies* 13: 387–98.

Société suisse des forestiers (1862) Procès-verbal des sources de la société des forestiers suisses à Neuchâtel 17/18 juin 1861, *Journal suisse d'économie forestière*, année 1862 (2): 19–34.

Société suisse des forestiers (1874) Société sur la recherche de houille, *Journal suisse d'économie forestière*, année 1874 (8): 146.

Statistischen Bureau (annual) *Statistisches Jahrbuch der Schweiz* (Bern, Stämpfli & Cie).

Stoltz, P. (1988) Epochen der Waldgeschichte und Entwicklung der eidgenossischen Forstpolitik umwelt-okonomisch betrachtet, *Schweizerische Zeitschrift für Forstwesen* 139: 211–23.

Swiss Federal Institute for Forest Research (1990) *Inventaire forestier national suisse: résultats du premier inventaire 1982-1986*, Berichet 305 (Birmednsdorf, FIFR).

Union Suisse des Paysans (1936) *La sylviculture suisse* (Brougg, Secrétariat des Paysans Suisses).

Viazzo, P.R. (1989) *Upland communities: environment, population and social structure in the Alps since the sixteenth century* (Cambridge, Cambridge University Press).

Walter, F. (1984) Perceptions des paysages, action sur l'espace: la Suisse au XVIIIe siècle, *Annales: Economies, Sociétés, Civilisations* 39: 3–29.

Walter, F. (1989) Attitudes towards the environment in Switzerland 1880–1914, *Journal of Historical Geography* 15: 287–99.

Walter, F. (1991) La montagne des suisses: invention et usage d'une representation paysagère, *Etudes Rurales* 121: 91–107.

Weisz, L. (1953) Ergebnisse einer schweizerischen Forstenquete vor 110 Jahren, *Schweizerische Zeitschrift für Forstwesen* 104: 309–20.

Whitaker, J.R. (1941) World view of destruction and conservation of natural resources, *Annals of the Association of American Geographers* 30: 143–62.

Zon, R. and Sparhawk, W.W. (1923) *Forest Resources of the World* (New York, McGraw-Hill).