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A case study of forest change in the Swiss lowlands

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Abstract

This paper presents a regional case study of forest development and the history of forest use and management in the north-eastern lowlands of Switzerland during the 19th and 20th centuries. The analysis draws on historical documents related to forestry to consider the following aspects of forest change: forest types, growing stock, trees species composition and non-timber forest uses. Based on the data presented, three overlapping periods of forest use and management can be discerned. The 'period of traditional multiple use' lasted until the second half of the 19th century. From the mid 19th to the mid 20th century, a 'period of primacy of timber production' occurred. During the 20th century, the 'period of modern multi-impact management' has developed. For these three periods, groups of main actors, their needs and interests, and how they were causing the changes in the aspects under study were defined This procedure of definin periods and the respective groups of main actors is a critical link between landscape ecology and history, as changes in demands of the society can be directly linked with changes in land-use and land-cover.

Introduction

Changes in land-use and land-cover are key factors for global environmental change (Turner et al. 1995). Therefore it is important to know how these processes can be controlled at the local and regional scale. Long-term research can provide a temporal context in which global environmental change becomes visible (Magnuson 1995). Case studies may demonstrate differences in past and present land-use and land-cover, evaluate the key factors for these differences and determine the likely driving forces of the processes shaping the landscape. Driving forces of landscape change can be either physical, as for example elevation, soil type (Auclair 1976), natural disturbance and forest development (Foster et al. 1992), or they can be anthropogenic, such as property ownership (Schenk 1996; Turner et al. 1996), human activity in general (Foster et al. 1992), laws and legal policies (Kwasniak 1996), and land-management schemes (Bürgi in press).

Hobbs (1997) pointed out that in many landscape ecological studies processes are often afforded less attention than landscape patterns or may be altogether ignored. To study processes mainly driven by anthropogenic factors, an intense dialogue with historical disciplines is of great importance (Russell 1997), but it rarely takes place. Thus the question arises of how the integration of the different disciplines working in the f eld of historical changes of the landscape can be made easier and more fruitful.

This paper is based on a regional case study of forest change in the Swiss lowlands during the 19th and 20th centuries (Bürgi 1998a). In this study a method was developed to compile regional time series of forest changes based on local forest management plans irregularly distributed over time. Thus, the study is transdisciplinary, as ecological questions were studied by examination of historical documents. Such an approach allows us to interpret environmental changes that result from changes in human needs. Therefore, changes in demands of the society can be linked with

changes in land-use and land-cover and anthropogenic factors as driving forces of landscape changes can be better understood in their historical context.

Study area

The study area of approx. 34 000 ha is situated in the northern part of the Canton of Zürich, in the north-eastern lowlands of Switzerland (Figure 1). Today, about 12 000 ha are covered by forest, with about one-third of the forest privately owned. The other two thirds consist of about 70 public forests, covering an area of about 7500 ha. Most of this public land (ca. 7100 ha) is owned by the 47 local communities. There are four state forests owned by the Canton of Zürich covering about 430 ha. The cantonal forestry officials are in charge of the management of all public forests, i.e., the state and the community forests. The natural vegetation is primarily beech (*Fagus sylvatica*) in mesic beech-wood communities (Galio odorati-Fagetum) (Ellenberg and Klötzli 1972). In some more exposed sites, pine (*Pinus sylvestris*) and oak-hornbeam (*Quercus spp./Carpinus betulus*) forests occur naturally. However, the actual species composition is heavily altered due to the long history of human activity.

Material and methods

In Switzerland modern forestry began about 1800 (Schuler 1985). The first duty of forestry officials was to put the forests 'in order' and to introduce forest management. The main planning tools in forestry are forest management plans. After evaluating possible source-types for this study, these forest management plans were selected as primary sources of information. Since 1820, about 590 forest management plans have been issued for the public forests in the study area, primarily for planning periods of 10 to 20 years (Staatsarchiv Zürich ZAK III-IV 88/07 and 90/21, and plans in the archives of the local forestry offices). These plans were originally compiled to ensure a sustainable forest yield. Each plan refers to the forests of one owner, usually a community or the canton. The plans were written by forest engineers, typically those in charge of the forests. The earliest plans, the so-called 'Visitationsberichte', or visiting reports written in 1823, included a description of the forest, a short report about its use and management, and guidelines for future management. After about 1850 the plans became more comprehensive and increasingly included tabulated information describing the stands or the planned felling quantity. Since about 1920, standing timber inventories by full calipering have been part of these plans. These inventories provide precise information on the growing stock, number of stems and dominant tree species in every stand and forest.

Forest management plans, therefore, contain both quantitative and qualitative information. In order to analyse the quantitative information, regional time series for the different aspects of forest change (i.e. forest types, growing stock, tree species) were compiled by summing time series for individual forests. As the management plans are irregularly distributed over time, data points in the time series for individual forests were interpolated to the middle of each decade, assuming a linear development. In order to weight more heavily the data from the forest management plans, they were used instead of the interpolated value if the year of the respective plan was less than three years away from a middle of a decade. The data for all individual forests were summed up to calculate the regional time series. Data for growing stock and tree species since 1920 were taken directly from the management plans. Because only a few plans included data on trees < 16 cm diameter, these data were excluded from all analysis.

Data about forest types were taken from the stand descriptions. As the terms used in the plans changed over the period under study, all stands were reclassified into three categories, based on the stand descriptions: simple coppice, coppice-with-standards and high forests. Coppice forests are cut with a rotation period of 20 to 40 years and they regenerate by stump sprouts. The timber harvested is mostly used as fir wood. In the coppice-with-standards forests, the understory of stump sprouts is covered by an overstory of large trees, the so-called standards (Mayer 1992), used as construction timber. Unlike these two forms of forests, high forests mainly consist of tall trees of seedling origin. The wood from high forests provides a variety of products, but in general the proportion of commercial timber is higher than in the different forms of coppice forests. Additional details of this classificatio process are given in Bürgi (in press). The procedure used to interpolate the classified data and sum the time series for the individual forests was the same as described above for growing stock and tree species.

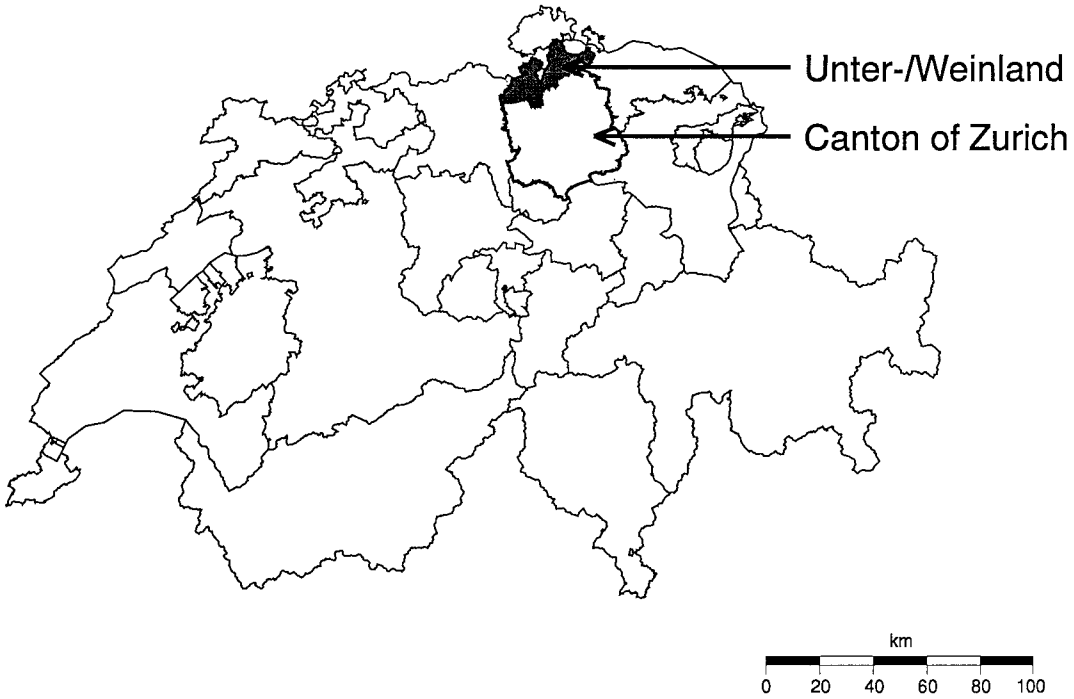

Figure 1. The study area (Unter-/Weinland) includes the northern part of the Canton of Zürich, Switzerland (source of boundaries: BFS GEOSTAT/L + T).

The qualitative data included in the management plans was more diff cult to evaluate since the plans are off cial papers written for community authorities and senior forestry off cials. Thus, they are to some extent biased by the interests of the authors and and the intended readers. The concerns and interests of local people entitled to rights of supply from the forests are not represented in the management plans. Such a governmental viewpoint is a typical bias for many written sources used in forest history (Schenk 1996). Therefore a source-critical approach in evaluating the management plans is very important. This is especially true for information about the non-timber forest uses such as wood pasture or litter-collecting. In certain periods such uses were very important for poorer people, although forestry off cials typically refer to these uses as 'Nebennutzungen', or minor forest uses, because their main interest was in timber production. Nevertheless, in combining information taken from the forest management plans with information extracted from other sources, the changing importance of these non-timber uses can be estimated.

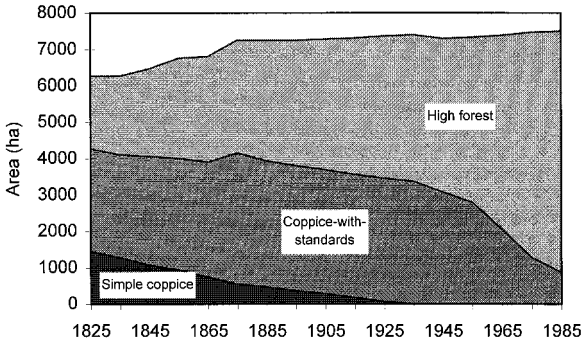

Figure 2. Forest types in the public forests of the Unterland and Weinland, 1825–1985.

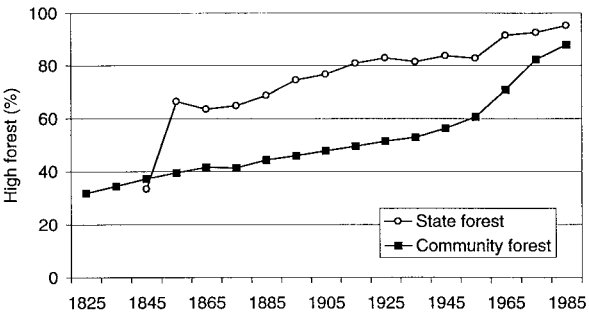

Figure 3. Percentage of high forest stands in state forests and community forests in the Unterland and Weinland, 1825–1985.

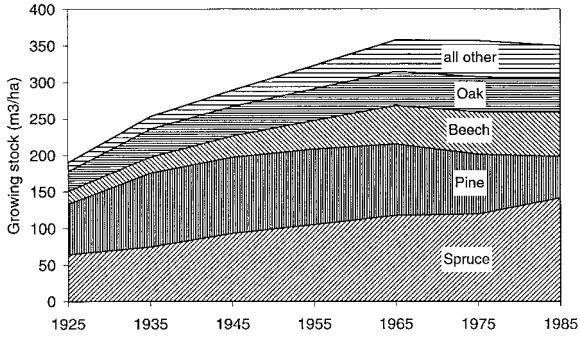

Figure 4. Growing stock and species composition in the public forests of the Unterland and Weinland, 1925–1985

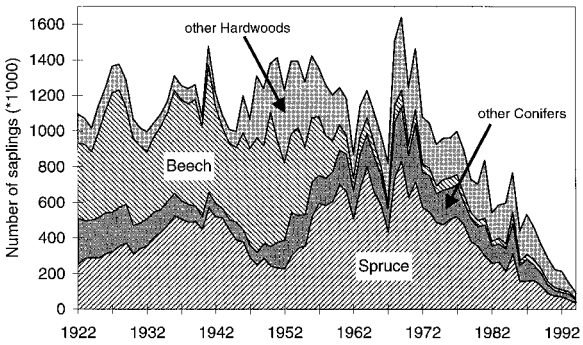

Figure 5. Number of saplings used in plantations in the community forests of the Canton of Zürich, 1922-1994 (data: SFS).

Results

Development of forest types 1825–1985

The total area of public forests remained relatively constant from 1825 to 1985 (Figure 2). In 1825, 4270 ha or more than two-thirds of the forest area supported simple coppice (23%) or coppice-with-standards (45%). Simple coppice was almost completely eliminated during the nineteenth century, whereas until the 1930s, 45% of the forest area remained as coppice-with-standards. Between 1955 and 1975 more than half of the remaining stands of coppice-with-standards were converted into high forests, and today, coppice-with-standards comprise only about 866 ha or 12% of the forest. However, active coppicing began to decline in the 1920s, and the last regular coppice clearing was conducted in 1958 (forest management plan from Andelfingen 1964). Thus, the stands identified as coppice-with-standards in the second half of the twentieth century were gradually becoming high forests.

The rate of development of high forest differed among forests owned by the communities and state forests managed directly by the forestry officials (Figure 3). Forests owned by the canton were transformed earlier to high forests than forests owned by the communities.

The management plans also distinguished among several different types of high forests. In 1825, about 400 ha were covered by oak forests, with lesser amounts of beech forests (Bürgi 1997). Most of these stands were replaced by coniferous stands of pine and spruce. Today, high forests mostly consist of mixed stands of hardwoods and conifers.

Growing stock and species composition 1925–1985

Forest management plans since the 1920s indicate development of growing stock and species composition for the public forests (Figure 4). From 1925 to 1965 growing stock per area increased by 90% from 188 m^3/ha to 358 m^3/ha. Since 1965, the total volume has remained stable. The four most important tree species are spruce (*Picea excelsa*), pine (*Pinus sylvestris*), beech (*Fagus sylvatica*), and oak (*Quercus robur, Quercus petraea*). Until 1945 pine was the most important tree species regarding growing stock, but since then it has decreased. In 1985, pine average growing stock was 57 m^3/ha, compared to 104 m^3/ha at its peak in 1945. Since 1925 spruce and beech have increased in growing stock. Spruce increased from 64 m^3/ha to 141 m^3/ha, and beech increased from only 18 m^3/ha in 1925 to 61 m^3/ha in 1985. Oak showed an increase in growing stock between 1925 (25 m^3/ha) and 1975 (48 m^3/ha), followed by a slight decline to 45 m^3/ha.

Species composition of these forests is heavily influenced by the species used in artificial regeneration. Forest management plans sometimes included data about planned plantations, but rarely indicated what was actually planted. Pine-seeding probably was preferred in the first half of the 19th century, whereas plantation of spruce was more common in the second half. Since 1922, the annual Swiss statistics about forests (SFS) include data about the species planted in every canton. Thus, the data given in Figure 5 refer to all community forests of the Canton of Zürich. Still, the general trends are very likely the same as in the Unterland and Weinland. In the first half of the 20th century, beech was the most important species used in plantations. In the 1960s and 1970s, plantation of spruce regained importance, but after that

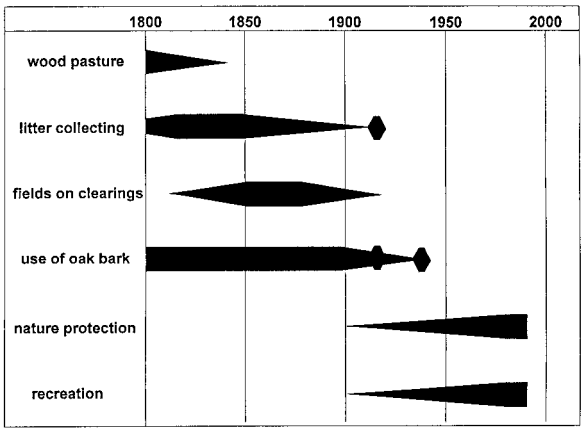

Figure 6. Non-timber forest uses in the public forests of the Unterland and Weinland since 1800. The thickness of the lines are a relative measure of the intensity of the use.

the total amount of planting decreased sharply, as natural regeneration became more popular. Today, the proportion of artif cial regeneration is low (Bürgi 1998a).

Non-timber forest uses since 1800

Forest development in central Europe has been heavily influence by forest uses such as wood-pasture or litter collecting. However, because historical documents are often lacking, it is rarely possible to quantify these uses. As mentioned above, forest management plans contain some information about these uses, but being written from a governmental viewpoint, they do not give the full picture. Nevertheless, in combination with information taken from other sources such as local histories and publications it is possible to draw a conceptual diagram depicting their relative importance (Figure 6).

In the 19th century, the most important non-timber forest uses were wood-pasture, litter-collecting, agricultural use of the clear cuts and the use of oak bark for tanning. Wood-pasture was discontinued after the f rst half of the 19th century due to changes in agricultural practice. Indoor feeding of cattle during the summer and an increased productivity of the meadows were part of the 'agricultural revolution' towards the end of the 18th and the beginning of the 19th century (Pf ster and Messerli 1990) that allowed the abandonment of wood-pasture. As indoor feeding became common practice, the demand for litter increased. In the 19th century, the collecting of dry leaves, needles, small twigs, and mosses was common in the canton of Zürich (Landolt 1872). The forest management plans indicate that forestry off cials tried to stop litter-collecting, because it led to an impoverishment of the soils. In the 20th century, this use was no longer common, but in times of scarcity, as during World War I, litter was again collected in some of the forests of the study area.

Agricultural use of clear cut high forests and coppice-stands that were cleared for conversion into high forest was also quite common in the 19th century. Agricultural use of clearings increased after crops failed in 1816 due to the so-called 'year without a summer' (Harington 1992) and due to the potato disease in 1845 (Fritzsche et al. 1994). The demand for these fiel s in the forests gradually declined in the second half of the 19th century. The last agricultural use of a clearing mentioned in the management plans for the study area took place in 1912 (forest management plan for Hüntwangen 1927).

Unlike the uses mentioned so far, the commercial use of oak bark was apparently never opposed by the forestry off cials as selling the bark for tanning purposes led to additional income. Unfortunately the market price f uctuated strongly. The use of oak bark was generally abandoned at the beginning of the 20th century, although it was temporarily reinstated during both World Wars.

During the 20th century new demands became important, such as nature protection and recreation (Figure 6). These demands are expressed by various interest groups rarely mentioned in the management plans. The impact of these new demands probably remained small until after World War II.

Discussion

Development of forest types 1825–1985

In comparison with other European regions, it is striking that the total forested area in the Unterland and Weinland remained relatively constant in the 19th and 20th century. The pattern of forests and open landscape in the Swiss lowlands probably has not changed greatly since late medieval times. This is partly because these densely populated regions also relied for wood on the forests of the wooded Pre-Alps and Alps (Schuler 1992).

The development of forest types (Figure 2) shows a decline of simple coppice and coppice-with-standards. In both forest types f rewood was the primary product. Because the consumption of fossil fuels was still

insignif cant in the mid 19th century (Marek 1994), this decline in coppice cannot be seen as the result of a decline in the demand for f rewood. More likely, the area of high forests was expanded due to a growing demand for commercial timber produced in such stands. Marek (1994) too, interpreted the steadily growing production of commercial timber during the f rst half of the 19th century as a consequence of the increasing commercialisation of forestry. In the 19th century, state forests owned by the government were transformed earlier from coppice forests to high forests than community forests (Figure 3). Communities eventually gave up coppice management in their forests when the demand for f rewood declined in the f rst part of the 20th century. As the 1926 annual report of the cantonal forest administration (OFA) states:
'The transformation into high forests is increasing constantly. Coal, cooking gas and electricity are reducing uses of the less valuable types of wood from the understorey of the coppice-with-standards forests.'

As the classificati n used to compile the time series shown in Figure 2 and 3 is based on the structure of the stands and not on management objectives, the graph shows this increase in high forest management with a time lag of about 30 years, after World War II. This is about the time it takes for a coppice-with-standard stand to lose its typical two-story structure and look more like a high forest.

To understand the difference in rate of transformation between forests owned by the canton and forests owned by the communites, differences in timber requirements among these groups must be considered. As the yields in the forests owned by the canton did not have to meet the requirements of the local people entitled to use fir wood, commercial timber production could more easily be promoted in the state forests. The annual reports of the cantonal forest administration (OFA) repeatedly show that although community official were also interested in commercial timber production, their forests had to fulfil the traditional obligation to supply locals with fir wood (details in Bürgi in press).

Growing stock and species composition 1925–1985

The strong increase in average growing stock in the 20th century (Figure 4) partly resulted from a decrease in demand for non-timber forest products (e.g., f rewood, litter). As the average growing stock in high forests is higher than in the different coppice forests, the shift in forest types also contributed to this increase in growing stock.

The shift in species composition reflect changes in forestry practices. In the 19th century, the increase in high forests was closely connected to an increase in coniferous species. The peak in growing stock of pine in 1945 is a result of the pine-seeding in the f rst half of the 19th century. The growing f gures for spruce are a result of spruce being preferred in artif cial regeneration in the second half of the 19th century.

During the 20th century, the signif cance of modern multi-impact management has grown. The introduction of the so-called near-to-nature silviculture at the turn of the century (Schuler 1998) can be seen as a starting point for this development. It is one of the aims of near-to-nature silviculture to promote the tree species that would naturally occur in a region. Thus, forestry off cials tried to increase the proportion of deciduous species, especially beech (Figure 5). The increase in growing stock of beech throughout the 20th century is a direct result of this change in forestry. In the 1960s and 1970s, plantation of spruce regained importance, but after that the total amount of planting decreased sharply, as natural regeneration became more popular. As today, the proportion of artif cial regeneration is comparatively low (Bürgi 1998a), a further increase of beech is expected. The relative abundance of spruce will also probably increase, as stands planted in the 1960s and 1970s mature.

Non-timber forest uses since 1800

Traditionally, local people had rights to graze their cattle (wood pasture) and to collect litter (Figure 6). Whereas forestry off cials were anxious to stop most so-called 'minor' forest uses, they nevertheless promoted the agricultural use of clearings. These field were rented to locals for limited times. After a farming interval of 2 or 3 years, these areas had to be re-planted artif cially. Since the ground was completely cleared for tillage, no regrowth through shoots was possible after f eld abandonment, promoting artif cial regeneration (by seed and planting of conifer saplings). As artif cial regeneration was a core element of modern forestry, forestry off cials f rst tolerated and even supported this system of clearcut, agricultural use and artif cial regeneration (Bürgi 1998a). After the outbreak of the potato disease in the Canton of Zürich in 1845 (Fritzsche et al. 1994), the agricultural use of clearings increased because soils in forest clear-

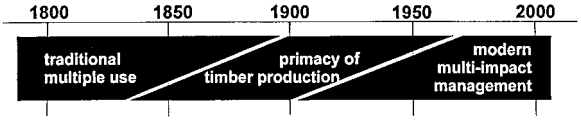

Figure 7. Periods of forest use and management in public forests of the Unterland and Weinland. Note that the periods overlap.

ings were not infected. In the second half of the 19th century however, forestry official became aware that trees planted or sown on these temporary fields grew more slowly than on sites not used for agriculture (e.g., forest management plan for Eglisau 1897).

The commercial exploitation of oak bark was another traditional use that provided income from the forests and was therefore promoted by forestry officials. The introducton of quebracho wood and artificial tanning products brought an end to the use of oak bark at the beginning of the 20th century, although it was temporarily reinstated during both World Wars.

After World War II, all of the so-called minor forest uses were abandoned. With the exception of collecting oak bark, all of these uses had been elements of the agricultural production of their time. In the second half of the 20th century, the agricultural advances increasingly differentiated the open land managed by farmers from the forested land managed by foresters. This segregation has had consequences for landscape and biodiversity, as habitats formerly created by traditional agricultural activities in the forests disappeared (Bürgi 1998b).

Nature protection, recreation and outdoor sports became popular during the 20th century, leading to new demands by the respective interest groups. These changes coincide with an increase in public support for natural regeneration versus plantation management, and have contributed to the increase in beech in the 20th century. Additional sources about the increase in leasure time and the activities of groups propagating nature conservation could give a more precise picture of how these new demands influenced forest development in the 20th century.

Synthesis 1: Periods of forest use and management

Based on the data presented, three overlapping periods of forest use and management were identified (Figure 7). The 'period of traditional multiple use' lasted until the second half of the 19th century, when the so called minor forest uses were still common and of importance for local people. From the mid-19th to mid-20th century, a 'period of primacy of timber production' occurred that is characterized by a decline in the minor forest uses and an increased emphasis on maximizing timber production. During the 20th century, the period of 'modern multi-impact management' has developed as the significance of forest uses other than material extraction has steadily grown. New demands formulated by different interest groups have increasing influenc on forest use and management.

Synthesis 2: Main actors in forest use and management

Three different groups of actors influencing forest changes can be distinguished: Forestry officials, as they played a crucial role in fulfilling the demands put on the forests by society, community officials, as they were the owners of most of the public forests under study, and the population in general. The respective needs and interests of these three groups changed over time (Table 1).

The forestry officials were among the main actors in all three periods. In a study of the 18th century they would not yet be considered relevant, because in Switzerland forestry proper only began around 1800 (Schuler 1985). During the second half of the 19th century the production of commercial timber for the market increased with growing demand. The forestry officials' interest in timber production did not always correspond with the intentions of the community officials (Bürgi in press). This is documented by differences in the development of forest types between the state forests and community forests. Community officials maintained their influence in all three periods as most of the forests under study were community forests. To asses their influence on forest change more throughly, different sources would have to be evaluated (Table 1).

Other groups of actors include local people in the first period and special interest groups in the third period, both being a subset of the population in general. In the period of traditional multiple use local people entitled to rights of supply influence forest management. Furthermore, trespassers were often mentioned in the management plans while forest products were still of great importance for the population. The development of agriculture and the growing independence from local resources through the availability of cheaper alternatives to the so called minor-forest-uses (partly due to the newly-built railways which made imports easier) lessened agricultural interest in the forest after around 1850.

Table 1. Main actors of forest change in the three periods of forest use and management

Period of traditional multiple use	
Who is acting?	A. forestry offi ials B. community off cials C. local people entitled with rights of supply, trespassers
What are their needs/interests?	A. put forests 'in order', introduce modern forestry, improve timber production, raise income from oak bark and agricultural use B. fuelwood, commercial timber, income for the community C. fuelwood, wood pasture, litter, f eld fruits
How do they act?	A. classify the forests and regulate the management B. (sources not appropriate) C. collecting, pasture, agriculture
Period of primacy of timber production	
Who is acting?	A. forestry offi ials B. community off cials
What are their needs/interests?	A. commercial timber production, high forests, sustainable management B. commercial timber, income for the community
How do they act?	A. convert coppice-forests into high-forests, introduce artificia regeneration B. (sources not appropriate)
Period of modern multi-impact management	
Who is acting?	A. forestry offi ials B. community off cials C. interest groups
What are their needs/interests?	A. near-to-nature silviculture, integrate economy and ecology B. income for the community C. nature protection, recreation
How do they act?	A. convert coppice-forests into high-forests, favour natural regeneration B. (sources not appropriate) C. (sources not appropriate)

In the 20th century people become less dependent on the local resources, and nature protection or recreational activities increase in importance but are expressed by special interest groups rather than by individuals. This shows a tendency to form institutions in which needs can be articulated and people can get organised. Whereas the ideas and requests promoted by these special interest groups have apparently inf uenced forest management in the period of modern multi-impact management, the forest management plans used in this study do not adequately describe these impacts.

Conclusions

The data presented here demonstrate how the forests in the Zürcher Unterland and Weinland changed in the 19th and 20th centuries in stand composition and management, documented in forest management plans. By combining such quantitative data with qualitative information on human activities and demands over time, it as been possible to def ne periods of forest use and management. Through use of such an approach, changes in demands of the society can be linked with changes in land-use and land-cover. The results reveal a multitude of forces driving land-use changes and afford insight into the context in which decisions

about land-use are made. The question 'Why does the landscape change?' is complex, demanding that we evaluate not only changes in the aspect of landscape under study, but also the human actors and their changing needs. Therefore new methods of integrating data of different quality must be developed, as historical information rarely f ts the standarts of natural sciences, but provides critical insight into the driving forces of landscape changes.

Acknowledgements

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Sources used

Forest management plans are available in Staatsarchiv Zürich ZAK III-IV 88/07 and 90/21, and the archives of the local forestry offi es OFA:

Jahresberichte des Oberforstamtes des Kantons Zürich. Included in Regierungsrätliche Rechenschaftsberichte, available in Staatsarchiv Zürich.

SFS:

1908–1930: Schweizerische Forststatistik. Zürich, Meier.

1930–1974: Schweizerische Forststatistik. Bern, Eidgenössisches Statistisches Amt.

1975–1984: Jahrbuch der schweizerischen Wald- und Holzwirtschaft, Forststatistik.

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