The Swiss experience in forest sustainability and adaptation

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Natural regeneration in this close-to-nature Swiss lowland forest will ensure that, when mature trees are felled, younger trees are ready to take their place

Close-to-nature forest management has been practised in Switzerland for more than 100 years and could be crucial for minimizing risk in the face of climate change.

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Forests in Switzerland have been managed for thousands of years; for example, there is evidence of well-ordered oak forest management 5 000 years ago in the early Bronze Age (Gassmann, 2007). Since the fourteenth century, documents written by local communities provide evidence of their efforts to secure the protective functions of forests, wood supply and other forest services. Forests have long provided villagers with energy for cooking and heating, construction wood, fodder, autumn leaves and moss for fertilizing fields, food such as mushrooms and berries, medicines, and much more. Thus, the forests of Switzerland, even in the most remote valleys, have been used – more or less intensively – for centuries.

For centuries, too, the cities of the lowlands relied heavily on wood. Around 1800, the forests near urban centres began to show signs of resource exhaustion and conflicts arose over their use. Clearfelling in the mountains for wood-hungry cities or for export contributed significantly to the catastrophic floods of the 1860s, which had widespread effects on the lowlands and cities.

A serious endeavour in forestry was required. This article describes the

development of forestry in Switzerland, which at the beginning followed methods developed in Germany and then branched off to a close-to-nature approach to forestry, which today is employed throughout Switzerland.

THE MODERN BEGINNING OF SUSTAINABLE FORESTRY

Many of today's forests were established in the context of the devastation arising from the quest for energy and raw materials; in that sense, wood scarcity and catastrophe are the parents of the mature forests in Switzerland today. The classical German forestry model that was developed in Prussia and Saxony in the middle of the eighteenth century initially had a strong influence on the development of Swiss forestry. In the mid-1800s forest use was oriented toward a constant wood harvest – in other words, a sustainable harvest – as advocated by Hans Carl von Carlowitz in 1713 (Schmithüsen, 2013). If the forest was "capital", only the growth – "interest" – was to be harvested. To regulate the harvest, tree populations were organized like a chessboard. Each year a square would be clearfelled and afterwards reforested, often with a single tree species. The goal of German forestry and thus Swiss forestry in that period was to produce as much wood as possible in the short term. Spruce (*Picea abies*) and pine (*Pinus silvestris*) were the chosen species in this model.

Prior to enactment of the first national Swiss forest law, significant areas of broadleaved species near cities were clearfelled and the roots dug up for firewood. Such clearing was often followed by several years of agriculture, mostly potato production, after which spruce or other conifers were planted, often in monocultures, following the German model. Exotic species from North America such as Douglas fir (*Pseudotsuga menziesii*) and Weymouth pine (*Pinus strobus*) were also used. Even today, there are stands that bear the mark of this history.

THE NATIONAL FOREST LAW

Diverse developments in the economic context of forests played an important role in the realization of the sustainability concept in Swiss forests. The construction of railways in the 1850s was decisive because it allowed the importation of coal, fertilizers and food. The age of coal enabled industrialization. The first train entered Bern in 1858, and within two years coal had become cheaper than firewood in the city.

These developments in the energy and economic sectors reduced pressure on forests and their many products and made possible the introduction and implementation of the first national Swiss forest law in 1876. It is a myth, therefore, that this law alone saved Swiss forests, as argued by some (Küchli, 1997), although it has been hugely influential. It was conceived as a

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Foresters discuss the use of a soil penetrometer. Soil fertility has improved tremendously under close-to-nature forest management

framework law, and with several revisions it is still in force today. The law maintained the existing forest ownership structure but in the interest of the whole – including future generations – it introduced strict controls on management by public and private owners. From the beginning, the federal government provided the cantons (analogous to provinces or states in other federal systems) with financial support to enable them to employ forest officials. The most important article of the national forest law pertains to forest area, which may not decrease in size unless it is in the overarching public interest, for example the construction of a railway line. If an area of forest is cleared, an equivalent area elsewhere must be afforested. This rule, which still applies today, is the reason that the cultivated landscape of Switzerland, with its typical pattern of forested and open land, has remained practically unchanged for a century and a half (Küchli, 1997).

By the 1880s, nature had begun to work its wonders: bit by bit, the trees and forests made their way back on degraded land. In remote areas, trees naturally repopulated landscapes, while, in the lowlands, trees were often planted. Even in those times, the pros and cons of planted versus naturally regenerated trees were the subjects of difficult discussions among foresters. In 1868, for example, one forester expressed the fear that if foresters did not plant, they would be laughed at, and people would say, "if nature can do everything by itself in the forest, we don't need any foresters" (Küchli, 1994). For the early Swiss foresters it was important to produce quick results, just as it is today in many forestry projects, especially in developing countries.

But nature was not always benevolent. The mistakes of the young forestry profession, such as inappropriately planted exotic species or spruce monocultures, were exposed pitilessly by infestations of insects and disease. Swiss foresters began to understand that the closer to nature were their forests, for example in their structure and species composition, the better the trees would withstand storms and disease in the course of their long lives.

HENRY BIOLLEY AND THE BEGINNINGS OF CLOSE-TO-NATURE FORESTRY

At the end of the nineteenth century, in the forests of Couvet near Neuchâtel, the Swiss forester Henry Biolley refined the single tree selection method. For many centuries in those forests, a limited number of trees in a given area were harvested according to the specific use to which they were put – for example, strong trunks for construction and young firs for beanpoles. Over time, this felling of single trees or small groups of trees had a marked impact on the structure of the forest: large firs grew next to small spruces, and vice versa. Using this traditional forest-related knowledge, Biolley developed a vision of a "family forest" in which fir, beech and maple would cohabit in a multistoried mixture, from saplings to large trees.

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In Switzerland, if a forest is cleared to make way for a new development in the overarching public interest, an equivalent area must be afforested

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Spruce logs lie stacked in a Swiss alpine forest, ready for transport to the mill for the production of high-value products

Biolley described this form of forest management, which today we call close-to-nature forestry, as experimental because it was flexible and oriented to the situation rather than following a fixed plan. Of course, an experiment without oversight can fail. To record the effects of his approach, Biolley set in place a tree measurement procedure that had been invented by the Frenchman Adolphe Gurnaud and presented at the World Expo in Paris in 1879. In refining Gurnaud's method, which enabled the measurement of tree growth in stands of trees with differing diameters, Biolley laid an important foundation for the liberation of foresters away from the chessboard approach towards a more subtle approach that allowed uneven-aged stands.

For Biolley, irregularity was a characteristic of nature, whose laws should be followed as closely as possible. He was one of the first of his profession to consider the forest as an organism. He recognized the potential of natural regeneration, and in this he made his mark on Swiss forestry. Similar developments were also occurring in German forestry: in 1922, Alfred Möller presented his treatise called *The permanent forest* in which he described a forest featuring trees of differing ages and species and in which the self-regulation mechanisms of nature were applied in order to achieve silvicultural goals. His approach greatly stimulated discussion on close-to-nature approaches.

Minimizing risk

By about 1900, therefore, Swiss foresters had learned to appreciate the natural regeneration potential of trees, and the short historical phase of plantation forestry with clearfelling was abandoned in most places. Trees were harvested in small groups or as single stems, and natural regeneration became predominant. This did not, however, preclude enrichment planting with favoured tree species, such as spruce or beech (for centuries, beech had been cut for firewood and therefore was no longer or was only sparsely present in many areas). All these developments can best be understood under the overarching goal of minimizing risks through an adaptive silviculture. The chessboard approach involved considerable economic and environmental risk: single species – sometimes of unknown provenance – planted over large areas were prone to storm damage, pest outbreaks (such as bark beetles) and other risks. Close-to-nature forestry was increasingly seen as a way of controlling and gradually diminishing such risks with simple silvicultural measures.

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The timber cut in this alpine forest is extracted using cables to minimize soil disturbance and the risk of avalanche

FROM QUANTITATIVE TO QUALITATIVE SUSTAINABILITY

Biological and ecological knowledge in European forests increased considerably in the first half of the twentieth century. The soil was no longer thought of as a dead substrate but as a richly populated root space. Insights into the nature of tree diseases showed that pathogens multiplied particularly in weakened host plants, and chemical treatments were not the answer.

Under the coordinated leadership of Hans Leibundgut, professor of silviculture from 1940 to 1979 at the Swiss Federal Polytechnical School in Zurich, these and many other findings from close-to-nature forestry were consolidated and adapted to the peculiarities of Swiss forests. The overall objective of the approach is a forest ecosystem that is stable in the face of external disturbances such as storms, or which recovers quickly after such events. The influence of those who use the forest should be as low as possible and should be aligned with natural processes. In Leibundgut's time, forest management ceased to be geared towards producing as much wood as possible; the emphasis shifted instead toward the management of ecosystems to provide a wide range of products – such as high-value timber – and services such as catchment protection, biodiversity conservation, clean air and recreation (Leibundgut, 1975).

The results of the concepts and methods that were initiated by Henry Biolley and further developed and consolidated in Leibundgut's time are best explained by an examination of the forests where the process began. In 1890, Biolley measured all trees in the forests of Couvet greater than 17.5 cm in diameter, and his seven successors continued that practice, which has been maintained up to today. There may be no other forest in the world that has been measured so consistently and managed according to the same principles for so long. The collected data contain a wealth of unique information. Well over 1 000 m^3 of wood per hectare have been harvested on the exposed northern flank of the forest since 1890 – an average of about 10 m^3 per hectare per year. Compared with the state of the forest in 1890, the structure and composition are now greatly improved – there is more standing volume and many more high-value stems. Today,

one-fifth of the trees are broadleaved; in Biolley's time, those species had practically disappeared.

For these changes to have taken place, several framework conditions were necessary. Biolley found a forest area with secure tenure and a forest structure with good preconditions for the application of his tenets. His successors worked strictly in the same direction. Fellings were carried out by well-trained forest workers, and over time a relatively dense network of forest roads developed to allow access to the dispersed felled trees. It has always been possible to sell these trees at a healthy profit, or, in times of low prices, to at least cover costs. Finally, the community of Couvet – the forest owners – have always stood by their forests and supported the efforts of the forest stewards.

The fundamental principles of close-to-nature forest management such as that implemented in Couvet could be applied in many other European forests as well as elsewhere, including the tropics (see box). Organizations such as Pro Silva Europe[1] are continuing to develop close-to-nature principles, including through a broad, country-spanning exchange of information. There is continuous development towards attaining mixed stands composed mainly of tree species that would grow naturally at a given location. In Switzerland, regeneration today is left mainly to nature (and therefore costs very little). This is shown in Swiss planting statistics: between 1980 and 2011, the annual quantity of planted trees declined from 7.5 million to 1 million seedlings. As long as a stand develops naturally in the direction of the management goal, no interventions are made. A similar approach is used as stands grow: natural and no-cost processes are taken advantage of, and minimal, directed, cost-effective interventions are carried out only when necessary.

[1] www.prosilvaeurope.org.

A KEY TO COMBATING CLIMATE CHANGE

The median air temperature of Switzerland has increased by 1.5 °C since 1970. This means that even if the international community can agree on measures to limit the global temperature rise to no more than 2 °C (a target agreed at the Conference of the Parties to the United Nations Framework Convention on Climate Change in Copenhagen in 2009), climate change in Switzerland will still be significant. If international negotiations fail and we have business as usual, an increase in the summer temperature of up to 4.8 °C is expected in the Swiss Alps by 2100 (The CH2011 Initiative, 2011). Significantly less rainfall is also projected.

Extreme events such as storms, heat waves, droughts and disturbances from pests could have major impacts on forests. Two events in the last decade provide a taste of things to come: a storm (called "Lothar") in 1999, and the 2003 summer heat wave. These two extreme events, and the resultant bark beetle infestations, were responsible for the loss of more than 8 million m^3 of spruce in Switzerland; many of the killed trees were remnants of the plantation period of a century ago. A changed climate directly affects tree growth, mortality and regeneration and in the long term would fundamentally alter many forests. Climate change will negatively affect many forest functions and services that are taken for granted today.

Close-to-nature approaches in the tropics

Close-to-nature forest management is a promising concept for tropical forests, and a variety of interesting parallels and connections exist between Europe and the tropics. At the end of the nineteenth century, Alfred Möller worked in the Brazilian rainforest, and his ecological research there was one of the key experiences that eventually led to his close-to-nature forest management concept (Bruenig, 2009). Forests can be managed according to the same fundamental principles applied in Europe and elsewhere.

Evidence of close-to-nature principles being applied in tropical forests can be found in many parts of the Amazon. Only recently has science begun to decipher traces that indigenous populations have left of their strong impact on forest landscapes. The distribution of Brazil nut trees (*Bertholletia excelsa*) is closely linked to the traditional forest-related knowledge of local peoples (Brazil nuts, also known as Para nuts, are long, oily nuts that these days can be found in almost any nut snack mix). Brazil nut trees are found in Amazonian forests individually and also in groups of dozens of individuals per hectare. Such large stands can only develop in clearings because *Bertholletia excelsa* is a light-demanding species in its early years. It is probable that, today, the larger groups of these trees are growing in what were once areas cultivated by indigenous people for cassava. Presumably the farmers planted the trees before they let natural tree succession take over again.

Very similar management practices can be observed in peoples such as the Dayak on the island of Borneo. The Dayak enrich small areas of cleared forest after dry rice cultivation with fruit trees or trees that produce resin or other tradable products. The area is then taken over by natural forest. The cycle repeats itself after decades or centuries. Huge tracts of rainforest that are considered to be untouched – that is, primary forest – are, in fact, traditional cultural landscapes. Since time immemorial, such landscapes have been managed according to what we could call close-to-nature principles.

The feasibility of close-to-nature forest management in tropical rainforests has been demonstrated by extensive scientific research (Bruenig, 2009). Clear tenure and use rights are a crucial precondition for the local populations to apply their rich forest-related knowledge and management experience.

It is not yet possible to determine the best forest management strategies in the face of climate change. Close-to-nature managed forests, however, offer *a priori* a good basis on which to start because they are resilient and have high adaptive capacity. Their resilience is based on their diversified structure and stability, and their adaptive capacity stems from their broad genetic diversity, which is a precondition for species to adapt to changing climatic conditions. The large number of trees that establish through natural regeneration means that there is an ongoing process of genetic recombination and consequently high genetic diversity in close-to-nature forests. This effect is even more pronounced in forests in which many old trees stand together in mixed structures, because regeneration is occurring constantly and involves diverse mother trees.

When ecological conditions change, the presence of diverse genotypes is a prerequisite for producing offspring that are able to adapt to new environmental conditions. Of the many saplings that regenerate naturally, the best adapted will survive. In contrast, nursery-reared plants are produced under artificial conditions that may favour less-adapted individuals and clones. From this we may conclude that natural regeneration ensures better adaptive capacity than planting (Pro Silva Europe, 2012). This is not to preclude plantations of exotic tree species that demonstrate the capacity to cope with changing climate conditions. Nevertheless, the planting of such species should be done cautiously and whenever possible within a matrix of natural stands.

The great uncertainty about the impact and speed of climate change requires an effective distribution of risk, which is best enabled by forests that are diversified in species and structure. Risk minimization is exactly what close-to-nature forest management has been attempting for more than a century. ◆

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