Floating Timber in Northern Sweden: The Construction of Floatways and Transformation of Rivers

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ABSTRACT

The development of the export-oriented forest industry played an essential role in the industrialisation of Sweden at the end of the nineteenth century. A very important factor was the available watercourses: these could be used to transport timber from inland forests to the sawmills on the coast. The aim of this study is to analyse the transformation of one river in boreal Sweden, the Vindelälven, during 1820–1945, caused by the introduction of large scale floating of timber. The most prominent feature of this development was the exploitation of a landscape without any industrial infrastructure. Production volumes and the scale of production within the forest industry increased radically from the mid–nineteenth century and transformed the landscape of both the forests and the rivers. The transformation of this natural watercourse, by building different kinds of floatway structures and dramatically changing the flow of water, can be divided into four characteristic periods: i) 1820–1850, ii) 1850–1900, iii) 1900–1945, and iv) from 1945 to the end of the log driving era in Vindelälven in 1976. The many different activities and the lengthy time period have resulted in a fundamental transformation of the river and its ecological characteristics, and have therefore left an almost indelible imprint on the river Vindelälven.

KEY WORDS

Timber floating, forest history, Northern Sweden, rivers, floatways.

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INTRODUCTION

The development of the export-oriented forest industry, involving the establishment of numerous sawmills and also later pulp mills, played a very important role in the industrialisation of Sweden at the end of the nineteenth century.[2] The increasing international demand for sawn wood and square timber in the industrially developing countries of Western Europe gave rise to the exploitation of the forest resources in northern Scandinavia.[3] Among the important factors were technological developments – for example, steam-powered sawmills and telegraphs – together with several institutional changes, and the introduction of liberal economic ideas that prompted the export of timber from northern Sweden. Another very important factor concerned the watercourses: these could potentially be used to transport the timber from inland to the coast. One very important consequence of the Scandinavian timber frontier was therefore the construction of floatways for floating timber.

The socio-economic situation in the agrarian society during this period must also be considered. When the timber frontier moved northward and inland, the logging integrated the farmers into a market economy and supplied them with a new source of income. In this region a wage income was important, because the topography, climate and lack of a larger local market made agriculture difficult to manage profitably. Alongside small-scale farming, lumbering and timber-floating became essential for people's subsistence. The forest workers were mostly farmers, crofters or tenants and their work was conducted within a normal annual cycle (forestry in winter, timber floating in spring, harvesting in summer and floatway construction in autumn), depicting a so-called 'combination of trade'.[4]

The use and improvement of the natural watercourses for log transportation were based on several fundamental conditions. First, the topography and climate made the rivers in northern Sweden well suited for timber floating: a gentle slope from the Fennoscandian mountains (0.9–2.1 metres per kilometre), a dense network of smaller streams and creeks of different sizes, and a climate which ensured a useful flood during the spring.[5] However, the rivers and streams had to be improved to facilitate the floating of timber. It was, therefore, a question of seeking control over nature.

On the tributaries log driving occurred only under specific conditions and circumstances. For instance, the lack of water after the floods subsided required various improvements to be made, including floatway structures, splash dams, box booms, flumes etc., to regulate the streams and guide the logs in order to avoid logjams.

On the rivers higher waterfalls and rapids made timber floating hazardous and difficult because of the risk of huge logjams that could prove costly and dangerous to break up. In eddies and branch channels the logs could get stuck.

Therefore, it was important to build a number of different constructions, especially stone piers, to regulate the rapids and achieve a canalisation effect – making them narrower and deeper – again with a view to avoiding boulders and other obstacles that could create large logjams. It is important also to consider the physical environment that characterised this particular type of work. Since it was carried out near rapids and waterfalls and at times when the water temperature was low, the work of timber floating was very risky and sometimes deadly. For example, when breaking up logjams with explosives and rowing their boats down the roaring falls the workers were often in great danger.[6]

Production volumes and the scale of production within the forest industry changed radically from the mid-nineteenth century and transformed the landscape of both the forests and the rivers.[7] The fundamental transformation of the north Swedish forest ecosystems began, from fire-regenerated uneven-aged old-growth forests successively towards single species and even-aged production forests.[8] Because the floatways had to reach the new logging areas, the length of the floatways in Northern Sweden grew rapidly, especially between 1860 and 1890 (from about 1,000 km to near 20,000 km). Investment in floatways proved more economical than the alternative, i.e. railways; compared with log driving, the cost of transporting timber via railways was nearly eight times higher during the first decade of the twentieth century.[9]

The expansion of timber floating in boreal Sweden can be divided into three broad phases: the first phase coincided with the early forest exploitation of the late nineteenth century[10] and was characterised by the clearing of the rivers and the establishment of a network of floatways; the second phase, between 1900 and 1950, can be described as a phase of expansion within the existing limits;[11] the third phase, between 1950 and 1980, was one of decline, when fewer rivers were used and land transport took over.[12]

In other parts of the northern hemisphere similar timber frontier movements and subsequent creation of floatways have occurred in the nineteenth and twentieth century. There are many similarities in the nineteenth century forest exploitation of north-eastern United States and northern Sweden. In both cases this was characterised by penetration of the timber frontier into unexploited forests, especially the old pine forests (primarily composed of *Pinus strobus* and *Pinus sylvestris*) containing large diameter timber.[13] In both countries the same logging and timber floating techniques were used, especially in timber floating, stream clearing and artificial constructions, for example splash dams and flumes, and the practice of breaking logjams was very similar.[14]

Aims of the study

The principal aim of this study was to analyse the transformation of one river, between two clearly defined points in time in boreal Sweden, from the early nineteenth to the late twentieth century, caused by the introduction of large scale floating of timber. The data gathered are used to discuss the different phases of the transformation of the river and the ecological consequences.

MATERIALS AND METHODS

Sources for the study

The primary sources used in this study are mainly taken from the Umeå Floating Association archive at Folkrörelsearkivet in Umeå, Sweden. The data has been collected from the archive of Floatway documents, including Investigation journals, Construction journals and maps. Other primary sources and data are taken from The Royal Swedish Stream-Clearing Committee archive at Riksarkivet in Stockholm, Sweden and The Administration of Road- and Water- Constructions, Bureau of Harbours archive, including Investigation journals, maps and protocols from the same archive (Table 1). The primary data have been used to calculate and analyse changes in the river as well as to describe the general development of timber floating in this region.

A. *The Administration of Road- and Waterconstructions, Bureau of Harbours archive*, Riksarkivet, Stockholm.

1. F.I.e: 28 (2048). *Investigation journal;* Regulation of Umeå and Vindeln River, including; *Investigation map,* nr 67 Umeå and Vindeln River, 1816.

B. *The Royal Swedish Stream-Clearing Committee archive*, Riksarkivet, Stockholm.

1. A.I. *Protocol,* Vol. 2 (1819), 17 (1826).
2. GI.c. *General Ledger,* Vol. 2 folio 2, 10, 16 (1819-1825).

C. *The Umeå River Drive Association archive,* Folkrorelsearkivet, Umea.

1. *F.Xl.Floatway Documents,* including *Investigation journals,* 1855, 1867, 1880, 1888 and 1905.
2. G.VI. *Journal of Constructions,* 1916–1946.
3. G.XI. *General Ledger,* 1947–1976.
4. J.I. *Maps,* 1894, 1927, 1928 and 1945.

TABLE 1. Unpublished historical records used to collect the data.

The study area

The study area comprises the course of the Vindelälven river in northern Sweden (64° 21' – 66° 16'). The river runs westwards from the Fennoscandian mountain range in the east towards the Baltic Sea. The length of the river is approximately 400 km. One area has been studied in detail. It is situated between two waterfalls, Renforsen and Degerforsen, and lies in the vicinity of the village of Vindeln, about 60 km from the coast (Figure 1).

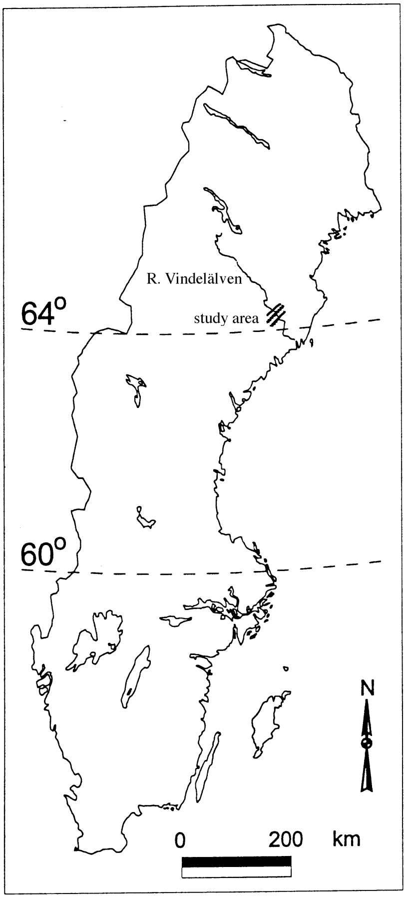

FIGURE 1. Map of Sweden with the river Vindelälven and the study area (hatched).

RESULTS

General history of the area

The Vindelälven river valley has been used and populated by humans for a very long time. Neolithic settlements as well as early historic Sami and agricultural settlements have been discovered at a number of different locations along the river. However, it was not until the eighteenth and nineteenth centuries that agricultural colonisation and a change in land use began on a larger scale. Even at that time the population density in the region was lower than one person per square kilometre and cultivated farmland comprised less than one per cent of the total land area.[15] Around 1850 logging reached the region.[16] The initial logging was high grade and aimed at the largest Scots pines. The logs, saw timber and square-cut timber, were transported on horse sleds from the forest and then floated on the river to water-powered sawmills near the coast. Also, pine-tar was produced and wooden tar barrels were floated to the harbour in Umeå to be exported. Logging on a larger scale did not occur until the 1880s, when the Swedish Forest Service began to offer substantial timber contracts to private sawmills.[17] At the beginning of the twentieth century, forest management and its prerequisites, forest inventories, were implemented in the region. Also at that time other products such as smaller saw-timber logs and pulpwood were cut in the forests.

Creating a floatway in Vindelälven – the transformation of a river.

The first real attempt to make Vindelälven suitable for timber floating was made by the Royal Stream-Clearing Committee, which was formed in 1815. The purpose of the committee was to investigate the rivers of northern Sweden and facilitate the transportation and floating of timber. During the 1820s the first operations started in Vindelälven. The most important work involved clearing stones in the rapids to avoid logjams and the construction of roads on land beside the most hazardous waterfalls. At the end of the 1820s the Stream-Clearing Committee defined about 140 km of Vindelälven as cleared and suitable for floating timber.[18]

In the 1850s, when the timber frontier had advanced to this area, more intensive work was initiated to facilitate the floating of timber. In Vindelälven this work was carried out by the owners of sawmills located near the coast. These efforts were technologically and economically much more intensive than the work carried out by the Royal Stream-Clearing Committee. From this point on, as a result of the increase in stream clearing and the building of a variety of floatway structures, the network of floatways started to cover almost the entire drainage area. At the end of the century practically the whole river and its floatable tributaries were used for floating timber, with a total length of around 1,000 km.[19]

At the turn of the nineteenth century log driving and floatways in Sweden encountered fresh problems, principally the growing quantities of timber and the increase in the variety of products transported. This created a need for more and better floatway structures. During this period (1900–1950) major improvements were made in Vindelälven, including splash dams in the tributaries, a greater number of larger stone piers along the rapids and more effective booms. The length of the floatways did not continue to grow at the same pace: at the beginning of the 1930s the total length of floatways in Vindelälven (river plus tributaries) was nearly 1,600 km (Table 2). This phase continued until the decline of timber floating during the post-war period.[20]

From the beginning of the 1950s, trucks began to take over as the main means of transporting logs in Vindelälven. Pressure mounted as a result of the restructuring of the timber transport market and can be ascribed to direct competition from lorry transport companies, especially when it was difficult to float timber on the tributaries (Figure 2). New techniques in road construction (with the use of excavators) and the development of large, well-equipped lorries with loading cranes made this change possible.

Total length:	452km
Floatway length (year 1930):	
Main course:	357km
Tributaries:	1223km
Height of fall:	760m
Total drainage area:	12,629km^2
Mean waterflow at mouth:	184m^3/s
Maximum recorded flow:	1,787 m^3/s

Other: One of four rivers in northern Sweden that is declared a National River and protected from regulation by hydroelectric power plants.

TABLE 2. Basic data for Vindelälven.

Source: The Umeå River Drive Association archive. F.XI:60. *Flottledshandlingar. Uman-Vindeln vol. III.* Bergström, S, *Sveriges hydrologi — grundläggande hydrologiska förhållanden.* SMHI/Svenska Hydrologiska Rådet. Norrköping 1993. Avrinningsområden i Sverige. Del 2. Vattendrag till Bottenhavet. SMHI/svenskt Vattenarkiv Norrköping 1998.

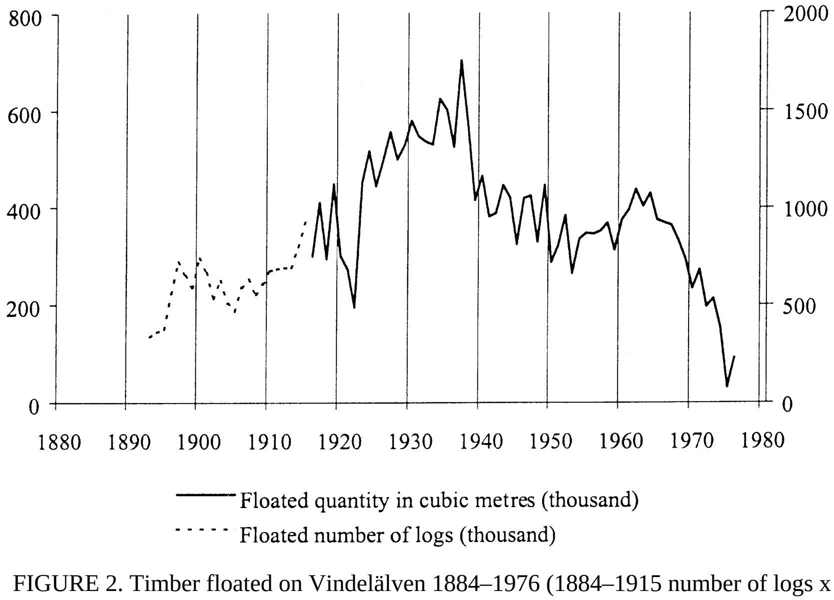

FIGURE 2. Timber floated on Vindelälven 1884–1976 (1884–1915 number of logs x 1000, 1916–1976 volume x 1000 m^3). Left y axis: m^3; right y axis: number of logs.

Source: Törnlund 1999.

This new situation resulted in a challenging transformation process, characterised by repeated attempts to rationalise timber floating. One of the most effective methods, due to new technology in the construction industry, was the introduction of bulldozers, which were used to clear out the floatways, and especially the tributaries. Bulldozers were a cheap and fast method of clearing out the streams and building jetties to regulate the water flow. This was fairly successful in the short term, but ultimately timber floating gave way to land transport, firstly on the tributaries and later on the main watercourses. 1976 saw the last year of timber floating in Vindelälven.[21]

Clearing the rapids and building floatway structures – a detailed analysis of the transformation of Renforsen and Degerforsen, 1850–1945

The area studied in detail comprises two waterfalls and the stretch of river between them. The two falls, Renforsen and Degerforsen, lie in the vicinity of the village of Vindeln, about 60 km from the coast. The total length of the rapids is about 1,100 m and the total drop nearly 24 m. The normal mean waterflow in these rapids is ca. 175 m^3s^{-1}.[22]

Floatway structures	**Length (metres)**						
	1855	**1867**	**1880**	**1888**	**1905**	**1925**	**1945**
Twin-faced box booms[a]	247	770	912	901	977	917	309
Stone pier					19	139	590
Guiding booms[b]							208
Total length:	*247*	*770*	*912*	*901*	*996*	*1056*	*1167*[c]
Quantity of stone used (m^3):		*4056*					*8000*[d]

TABLE 3. Length (in metres) of different floatway structures in the rapids of Deger- and Renforsen, Vindelålven 1855–1945.

Source: Table 1.

[a] Timbered guiding boom with stone filling.

[b] According to the English translation this kind of floatway structure means a particular construction with a concrete face, fastened to posts on foundation stones. This type of structure should not be confused with simpler constructions of guiding booms, for example holding booms of aligned logs, link-jointed with link-locks and sometimes held by fixed moorings.

[c] Including 60 m of canalisation.

[d] Approximate.

FIGURE 3. Log drivers in Vindelälven in 1947, rowing their boats in the stream and, in background, working to remove a log jam.

FIGURE 4. Log drivers in work to remove a logjam in Renforsen and Degerforsen (1952).

The building and transformation of this natural watercourse (Table 3) can further be studied by dividing its history into four periods, all of which have their own characteristics, namely: the shortest period 1820–1850; the periods between 1850–1900 and 1900–1945; and, finally, the period after 1945 to the end of the log driving era in Vindelälven (1976).

Period 1. 1820–1850: The first clearings on the river

During this period the Royal Stream-Clearing Committee started to clear the two rapids. Only clearing, using black powder and stone burning in order to crack large boulders, was practised and no buildings of any kind were constructed. However, a small road was built beside the rapids in order to make the transport by river of tar-barrows less difficult and hazardous.[23] The exact quantities of stones and rocks that were cleared cannot be deduced from historical records.

Period 2. 1850–1900: The first constructions on the river

During this time most of the river structures were timbered boxes filled with stones (natural and/or blast stones). The most common type was a twin-faced box boom. The stone filling was taken primarily from the river.[24] Dead standing pine trees were mainly used for this kind of floatway structure since they had no other commercial use. They were well suited for construction purposes due to the natural impregnation of resins caused by the slow death of the trees.[25]

The primary function of this floatway structure was to prevent the logs from drifting into side branches, (see *area A* in Figure 5 below). Most common was the twin-faced box boom over the inflow and into the smaller side branch, supplemented with a holding boom (strip boom) in front of it. Some of the constructions were designed to regulate the current on the rapids and achieve a canalisation effect – making them narrower and deeper – in order to by-pass the areas that could cause large logjams, which was the case with constructions on the *Storholmen* (see no. 1 in Figure 5)**,** just beside *Renforsen*. Here, in *area A*, a pair of two-sided box booms, linked together, was also constructed to protect the inflow and a flume leading to a water-mill.

Another function was to avoid the logs entering and getting stuck in a back-eddy, as in *Mariedalsgrenen*, (see no. 3, *area B* in Figure 5). To prevent the logs from being washed over the small island, *Sågholmen* (see no. 4 in Figure 5), situated almost in the middle of the rapids in *Degerforsen*, a twin-faced box boom was constructed in front of the island in the shape of a plough. Finally, a twin-faced box boom was built to protect the inflow to the water-driven sawmill on the side of the rapids.

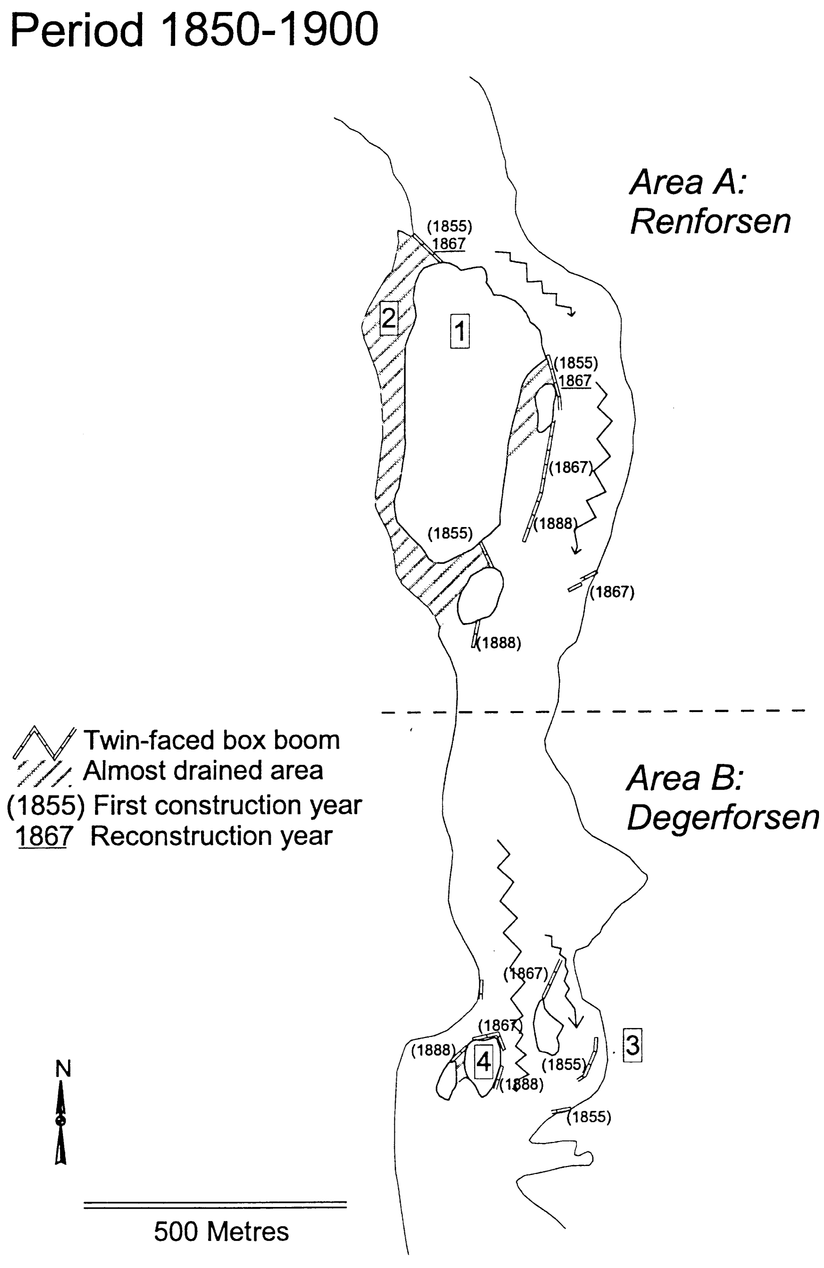

FIGURE 5. The location of the floatway structures in Renforsen and Degerforsen, 1850–1900.

Period 3. 1900–1945. The transformation reaches its peak.

During this period the most dramatic changes in the river took place. Firstly, many of the existing floatway structures were extended. Secondly, building materials and the construction techniques were also greatly improved compared to the previous period. In addition, the use of explosives increased dramatically (Figure 7).

In *area A* (Figure 6), for example, a branch of the river**,** *Lillån***,** was closed off with a stone jetty (wall) at the end of the1920s (see no. 2 in Figure 6). To compensate for the effect of the damming work on farm property upstream from the rapids, the largest of the waterfalls was widened using explosives to increase the flow of water. The resulting stones were laid to construct a stone jetty (130 m long, including approx. 800 m^3 blast stone.). Stone walls and/or guiding booms with concrete aprons fastened to posts on foundation stones replaced some of the existing two-sided box booms in this area. During the recession in the 1930s, the unemployed undertook this type of work and were paid by the government. Renforsen had, for example, narrowed to approximately half its width by this time due to canalisation carried out since the early nineteenth century.

In *area B* (Figure 6), one of the most radical changes took place at the end of the 1920s. Extensive blasting work was carried out and a canal was built through one of the small islands in order to change the direction of the watercourse and avoid the logs being driven into the back-eddy. A guiding boom with a concrete face was then constructed in order to lock the old inflow, while some years previously the old plough-shaped, stone-filled timber box boom on another small island (*Sågholmen,* see no. 4 in Figure 6) was replaced by a jetty constructed of concrete and stone, carefully sculpted by stonemasons (Figure 8).

Another construction was the almost 220 metre long stone jetty that was built at the beginning of the 1930s to prevent the logs from being driven into another back-eddy, just above the small island, which had been canalised. This stone jetty in fact replaced an older twin-faced box boom, probably built at the beginning of the twentieth century (first mentioned in the records in 1905, also see Figure 7).

Period 4. 1945–1976: The decline in log driving and construction of floatway structures.

During this period the quantity of logs floated in Vindelälven started to decline. The construction work in *Ren-* and *Degerforsen* were therefore limited. In the middle of the 1950s a 50-metre long concrete guiding boom was built, just below and on the south side of *Renforsen.* Some clearing using bulldozers was carried out in the calm areas of the watercourse (Figure 9).

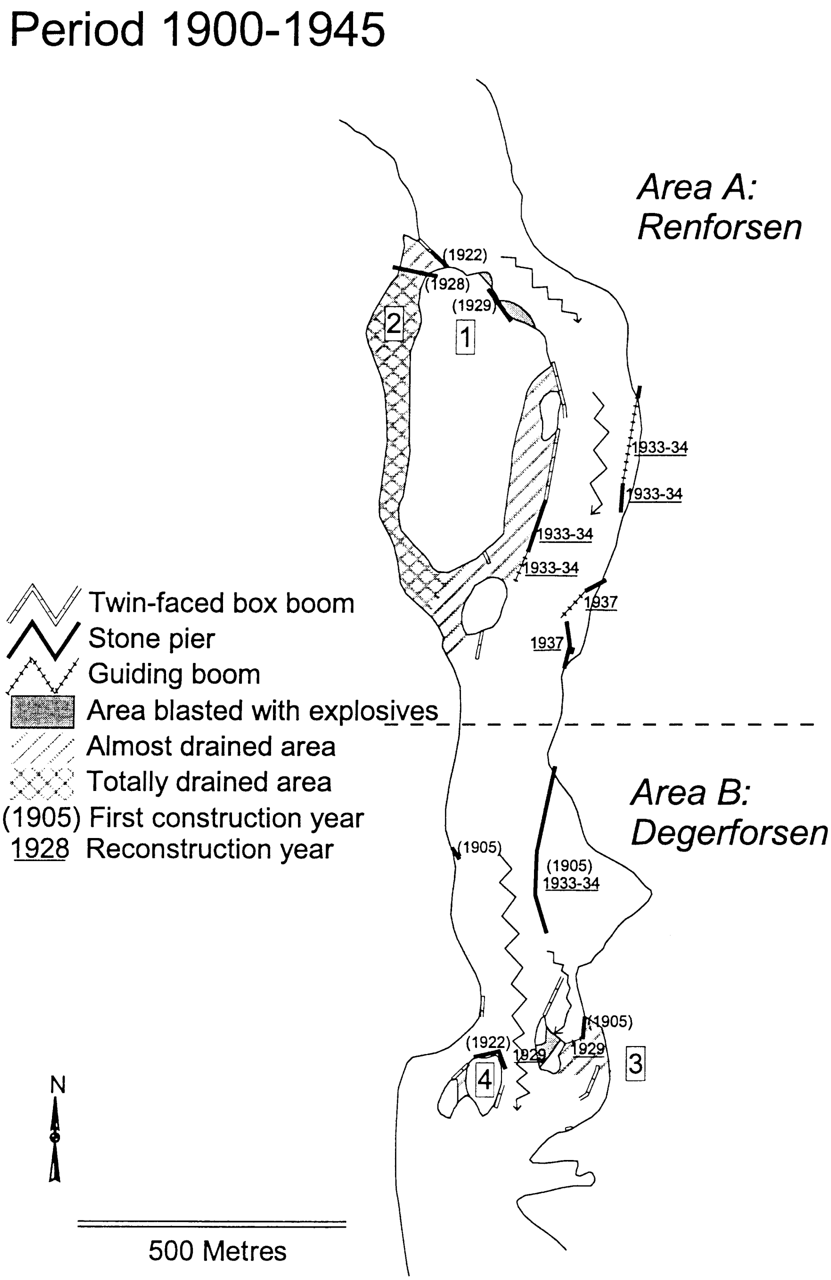

FIGURE 6. The location of former and new floatway structures in Renforsen and Degerforsen, 1900–1945.

FIGURE 7. Clearing the rapids and building of a twin-faced box boom, probably at the turn of the century (1900), in *Degerforsen* and the eddy just above *Kallholmen.*

FIGURE 8. Log jam in the front of the well sculpted, plough-shaped, stone jetty at *Sågholmen, Degerforsen* (1957).

FIGURE 9. Stream-clearing with a Caterpillar, downstream *Sågholmen, Degerforsen,* in the 1950s.

DISCUSSION

A river as a transportation device – economic and institutional changes for the development and decline in log driving

Forest industries, saw- and pulp-mills, played an important role in the industrialisation of Sweden during the second half of the nineteenth century. The northern part of Sweden was suddenly drawn into an international economy. However, it was still basically an agrarian economy and while Sweden as a whole industrialised, the rural and agrarian population declined in the south while it continued to grow in the north.[26]

This forested backwater of industrialised Sweden was dominated by an industrial structure supplying raw materials, primarily timber. The workers comprised farmers or farm workers and loggers/log drivers. The work was carried out within a normal annual cycle: building floatway structures in the fall, forestry in the winter, timber floating in spring and harvesting in summer.[27]

The most prominent feature of this development was the exploitation of a landscape without any industrial transport infrastructure, which could link the natural resource, i.e. the forest, to the fast growing forest industry. The existing transport system was primarily related to an agrarian infrastructure, and consisted mostly of paths and small narrow roads.[28]

Besides the heightened demand for transport, the great increase in total floatway length after the 1860s was also linked to legislative matters, namely the 1880 timber floating law, which was the first piece of national legislation regulating the floating of timber.[29]

This law included two cornerstones which greatly affected further development. First, timber floating and the building of floatway structures had priority use of the watercourses, providing this gave the nation and/or the local communities possibilities for economic growth. This gave the logging companies important advantages over the local salmon fishing, for example. The second cornerstone prescribed that timber floating and investment in floatway structures had to be organised and administered by a Floating Association. This was largely an upshot of the situation that existed during the early logging era of the 1850s, when the logging companies tried to control the system of log driving by exerting monopolistic rights to use the watercourses and build floatway structures. Vindelälven was no exception.[30]

All the interested parties who used the floatways had to be members of this association, and their influence on decisions and share of payment for the transport and investment costs was dependent on how much timber they each floated. In Vindelälven this legislation prompted the creation of the floating association in 1889. One driving force behind the 1880 law was the State; which owned large areas of forest in the northern interior, and it became in the national interest to break up these monopoly interests created by the early logging companies. This legislation was especially important in Vindelälven, because the State was the biggest landowner in the upper areas of this river valley.[31] However, this kind of institutional framework and legislation was not unique to Sweden. For example, in other Scandinavian countries, Norway[32] and Finland,[33] and in the United States,[34] this kind of arrangement was essential for the development of the forest industry and log driving.

This legislative and institutional form of managing water resources was again redefined at the turn of the century. During this time the Swedish hydroelectric industry began to grow, as part of the national industrialisation programme. Yet again, the legislature had to face fresh problems and circumstances because the hydroelectric industry in Sweden came into conflict with the interests of the logging industry. In essence this reflected the conflicting requirements on the watercourse of *pro-dammers* and *anti-dammers*. The hydroelectric industry wanted to store the water and the latter wanted to make use of the spring floodwaters.[35]

In 1918 a new water law was introduced which can be seen as a consensus law as it regulated the relationship between the already existing logging and the up-and-coming hydroelectric industries. This law and its resolutions therefore gave the logging industry opportunities for the continued use of the watercourses for their own purposes, a condition that prevailed until the end of log driving in the 1980s.[36] In this regard Vindelälven is a fairly rare exception, because the river was never exploited for the use of hydroelectric power plants. Therefore, in Vindelälven the construction of floatway structures continued until the middle of the twentieth century without the need for negotiation with the hydroelectric industry about the use of the water resources.

To ease the developing conflict with the hydroelectric industry, successively larger quantities of timber required increased investment in improved floatway structures. Competition in the international timber market had increased, especially from Finland and Russia. As an effect of the exploitation of forests that had continued for about fifty years, the supply of larger pine trees had fallen and timber with a lower diameter was used. This, together with the expansion of pulp mills that could use smaller trees (both pine and spruce), meant there was a greater risk of the timber sinking. Attention now focused on the rationalisation of this transport system and, compared with the previous period of industrial development (1850–1900) this period (1900–1950) focused on improvements in quality. Our area of investigation shows a good example of this. In both Ren- and Degerforsen the best floatway constructions were built and the most intensive canalisation was carried out during the period 1900–1950.

At this time in many other areas there was a general shift from timber floating to land transport (railways). This was the case for example in the Great Lakes area in North America.[37] Here, the decline of timber floating occurred much earlier than in Sweden. The difference of seventy years between Michigan, USA, and our area of investigation in Northern Sweden may be attributed to two factors, namely the availability and accessibility of timber and the market price of timber. In Michigan the forests were denser and the trees larger than in northern Sweden. Also, stump prices were higher (relatively) in Michigan. This could be seen as a motivation and an economic spur to the more rapid switch from timber floating to land transport.[38]

Finally, from the middle of the 1950s timber trucks began to take over as the main form of log transportation and the third and final phase of the log driving era in Sweden began. New techniques in road construction and the development of large, well-equipped lorries made this changeover possible. Technological developments resulted in an increase in land transportation. This new situation also affected the relationship between log driving and the hydroelectric industry, as there was now an alternative to timber floating. The increasing national demand for electricity production during the postwar period resulted in a higher value being placed on the water resource and the negotiations between the two parties hardened.

After a period of gradual growth in the use of trucks in timber transportation, and after the decline in log driving by river, the new water law of 1983 stated that the floatways could be declared closed if they presented an obstruction to an enterprise of greater public importance than log floating. However, by this time most of the log driving had already disappeared in Sweden.[39]

Ecological consequences of floating and river constructions

The changes brought about by the construction of an efficient floatway have left an almost indelible imprint on the river Vindelälven. Before the floating of timber began, the river was only marginally influenced by human activities. Small water-powered sawmills and grain-mills on tributaries and stationary fish-traps were common but they did not change the flow of water or the basic ecological qualities of a wild river. The creation of a floatway, the many different activities connected with this and the lengthy time period involved have resulted in a fundamental transformation of the river structure and ecological characteristics. Some activities have had a clear and direct impact on the river. Stone jetties, for example, are easily identified today and can usually also be dated. By studying a succession of such constructions it is possible to approximate how the channel has been narrowed and when and how eddies and side-branches of the river have been cut off.

The area between Renforsen and Degerforsen under investigation shows clearly how the rapids have been narrowed by canalisation. For example, the broadest part of Renforsen was approximately 200 metres wide before the floating began and was narrowed to only half of that in the course of a hundred years. Two large tributaries have also been cut off. The best example of this is the closing of Lillån, which affected a stretch of about 600 metres long by 50 metres wide of this natural tributary. However, the stone wall that cut off this tributary was blown up by explosives in the spring of 1995. That year the spring flood was very high and in order to protect houses near the river-banks above Renforsen and Degerforsen, which otherwise would be susceptible to overflow caused by the damming effect of the stone wall, it was necessary to re-open this tributary.

Other changes are subtler, for example the removal of larger stones and boulders from the rapids. This has been an ongoing process right through from the beginning of the construction of the floatway until the very end. This means that successively less pronounced obstacles have been removed, since the most problematic ones were removed first wherever possible. However, there have also been technological changes, from the early burning of stones[40] to the use of explosives and Caterpillars in the twentieth century. These changes have had a profound effect on the river ecosystem overall and particularly on the fish populations. Brown trout (*Salmo trutta*), Atlantic salmon (*Salmo salar*), grayling (*Thymallus thymallus*) and several other important species of fish as well as the whole food chain are negatively influenced by the same measures that have favoured the floating of timber.[41] For example, the removal of larger stones and boulders from the river removes niches for the stream-dwelling fish and insects, while cutting off eddies limits the habitats for smaller fish and the removal of dead trees from the watercourse limits primary production in the ecosystem.[42] However, since the changes have been gradual and no systematic surveys of fish populations have been carried out it is very difficult to make a quantitative estimate of their impact. All these ecological changes connected to the creation of a floatway must be acknowledged and understood today when the river Vindelälven is considered as one of Sweden's few remaining wild rivers. Future restoration of its ecological qualitites must be based on actual knowledge of this transformation, while acknowledging that physical remnants of the creation of a floatway also have a cultural historical value and to some extent need to be protected.

NOTES

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[1] Corresponding author
[2] Söderlund 1951, Schön 2000.
[3] Björklund 1984, Östlund 1993, Östlund et al. 1997.
[4] Lundgren 1984, Bäcklund 1988, Törnlund 2000b.
[5] Andersson 1907.
[6] Törnlund 2000b.
[7] Östlund, et al 1997, Östlund and Zackrisson 2000.
[8] Axelsson and Östlund 2001.
[9] Törnlund 2000b.
[10] Östlund et al. 1997, Östlund 2000.
[11] Winberg 1944, Törnlund 1999.
[12] Hultland 1962, Törnlund, 2000b.
[13] Williams, 1989, Östlund 1993.
[14] Rector 1953, Dinsdale 1965, Smith 1972, Twining 1983, Rosander 1988, Törnlund 2000b.
[15] Östlund et al. 1997.
[16] Björklund 1984, Östlund et al. 1997.
[17] Holmgren 1959.
[18] Törnlund 1999.
[19] Törnlund 1999.
[20] Törnlund 1999, Östlund 2000, Törnlund 2000a.
[21] Törnlund 2000a, Törnlund 2000b.
[22] *Förteckning över Sveriges vattenfall utgiven av Kungl. Vattenfallsstyrelsen och Hydrologiska Byrån*. 28 Vindelälven.1917, Bergström 1993.
[23] The Royal Swedish Stream-Clearing Committee archive. A.I. *Protocol*, Vol. 2, 1819.
[24] Törnlund 1999.
[25] Östlund 1993.

[26] Lundgren 1984, Bäcklund, 1988.
[27] Lundgren 1984, Bäcklund 1988.
[28] Ericsson 2001.
[29] Winberg 1944, Törnlund 2000b.
[30] Törnlund 1999.
[31] Törnlund 1999, Östlund 2000.
[32] Vestheim 1998.
[33] Meinander 1950, Snellman 2000.
[34] Rector 1953, Williams 1989.
[35] Jakobsson 1996, Jakobsson 2000.
[36] Lundgren 1987, Jakobsson 2000.
[37] Rector 1953, Twining 1983.
[38] Törnlund 2000b.
[39] Lundgren 1987, Jakobsson 2000.
[40] See Östlund 2000.
[41] Cf. Näslund 2000.
[42] Cf. Östlund 2000, Näslund 2000.

REFERENCES

Andersson, G. 1907. 'Timmertransporter på de svenska vattendragen och dess geografiska förutsättningar'. *Ymer* 4: 315–74.

Avrinningsområden i Sverige. Del 2. Vattendrag till Bottenhavet. 1998. SMHI/Svenskt Vattenarkiv. Norrköping: CA-tryck AB.

Axelsson, A-L, and Östlund, L. 2001. 'Retrospective gap analysis in a Swedish boreal forest landscape using historical data'. *Forest Ecology and Management:* 147: 109–122.

Bergström, Sten 1993. *Sveriges hydrologi – grundläggande hydrologiska förhållanden.* SMHI/Svenska Hydrologiska Rådet. Norrköping: CA-tryck AB.

Björklund, J. 1984. 'From the Gulf of Bothnia to the White Sea'. *The Scandinavian Economic History Review* 1: 17–41.

Bäcklund, Dan 1988. *I industrisamhällets utkant.* Ph. D. Diss, Umeå Studies in Economic History 8. Umeå.

Dinsdale, E M. 1965. 'Spatial Patterns of Technological Change: the Lumber Industry of Northern New York'. *Economic Geography* 41: 258–65.

Ericsson, Tysk Staffan. 2001. *Culture within Nature. Key areas for interpreting forest history in boreal Sweden.* Ph.D. Diss, Umeå.

Förteckning över Sveriges vattenfall utgiven av Kungl. Vattenfallsstyrelsen och Hydrologiska Byrån. 1917. 28 Vindelälven.

Holmgren, A. 1959. 'Skogarna och deras vård i övre Norrland intill år 1930'. In Arpi, G. *Sveriges skogar under 100 år. Del II.* Stockholm: Ivar Haeggströms Boktryckeri AB.

Hultland, Gunnar 1962. *Virkestransporter i Kalix älvdal 1951–1960.* Geographica 27. Ph.D. diss, Uppsala.

Jakobsson, Eva 1996. *Industrialisering av älvar. Studier kring svensk vattenkraftsutbyggnad 1900–1918.* Ph.D. Diss, Göteborg.

Jakobsson, E. 2000. 'Flottning – konflikter och politik om vatten'. In *Flottning. Vattendragen, arbetet, berättelserna.* ed. Törnlund, E,. Östlund, L. Skrifter om skogs- och lantbrukshistoria 14. Stockholm: Nordiska museets förlag.

Lundgren, N-G 1984. *Skogs för export*. Ph. D. Diss, Umeå Studies in Economic History 6. Umeå.

Lundgren, N-G 1987. *Kampen om naturresurserna: ekonomisk utveckling och institutionell förändring i Lule älvdal under 700 år.* Stockholm: SNS Förlag.

Meinander, Nils 1950. *Virkeshushållning och sågverksrörelse i Torne, Kemi och Simo älvdalar intill första världskriget*. Ph.D. Diss, Helsingfors.

Näslund, I. 2000. 'Flottningen och fisket'. In *Flottning. Vattendragen, arbetet, berättelserna.* ed. Törnlund, E,. Östlund, L. Skrifter om skogs- och lantbrukshistoria 14. Stockholm: Nordiska museets förlag.

Östlund, Lars. 1993. *Exploitation and structural changes in the north Swedish boreal forest 1800–1992.* Ph.D. Diss, Umeå.

Östlund, L, Zackrisson, O, Axelsson, A-L. 1997. 'The history and transformation of a Scandinavian boreal forest landscape since the 19th century'. *Canadian Journal of Forrest Research* 27: 1198–1206.

Östlund, L. 2000. 'Den tidiga flottningen i ett vattendrag i mellersta Norrland'. In *Flottning. Vattendragen, arbetet, berättelserna.* ed. Törnlund, E,. Östlund, L. Skrifter om skogs- och lantbrukshistoria 14. Stockholm: Nordiska museets förlag.

Östlund, L, Zackrisson O. 2000. 'The Forest History of Boreal Sweden: a Multidisciplinary Approach'. In *Methods and Approaches in Forest History,* ed. M. Agnoletti and S. Anderson. IUFRO Research Series 3. Cambridge: Cambridge University Press.

Rector, W G. 1953. *Log Transportation in the Lake States Lumber Industry 1840–1918. The movement of logs and its relationship to land settlement, waterway development, railroad construction, lumber productions and prices.* American Waterways Series No. 4, Glendale, California: Arthur H. Clark.

Rosander, Göran. 1988. 'Skogsarbetaren och hans verktyg'. *Kungliga Skogs- och Lantbruksakademiens Tidsskrift* 127: 145–62.

Schön, Lennart. 2000. *En modern svensk ekonomisk historia. Tillväxt och omvandling under två sekel.* Stockholm: SNS Förlag.

Smith, D C. 1972, *A History of Lumbering in Maine 1861–1960.* Ph.D. diss, University of Maine Studies No. 93. Orono, Maine: University of Maine Press.

Snellman, H. 2000. 'Flottningen i Kemi älv i Finland'. In *Flottning. Vattendragen, arbetet, berättelserna*. ed. Törnlund, E, Östlund, L, Skrifter om skogs- och lantbrukshistoria 14. Stockholm: Nordiska museets förlag.

Söderlund, Einar 1951. *Svensk trävaruexport under hundra år.* Uppsala: Almqvist and Wiksells.

Twining, C E. 1983. 'The Lumbering Frontier' in *The Great Lakes Forest. An Environmental and Social History*. ed. Flader, S L. Minneapolis: University of Minnesota Press.

Törnlund, E. 1999. *Flottning, flottledsbyggnader och förändringar i vattenmiljön. Fallstudie för sträckan Storgräsforsen – Storsandforsen i Vindelälven 1850–1970*. Umeå Papers in Economic History 21. Umeå.

Törnlund, E. 2000a.'Flottningen under efterkrigstiden – om arbetskraft, rationalisering och avveckling'. In *Flottning. Vattendragen, arbetet, berättelserna.* ed. Törnlund, E. and Östlund, L. Skrifter om skogs- och lantbrukshistoria 14. Stockholm: Nordiska museets förlag.

Törnlund, Erik 2000b. *Skog, vatten och arbete. Aspekter på flottningens avveckling efter Ume- och Vindelälvarna 1945–80.* Licentiate Thesis. Umeå.
Vestheim, Öjvind 1998. *Flötning gjennom århundrer. Flötningas historie i Glomma- og Mjösvassdragen.* Elverum.
Williams, Michael 1989. *Americans and Their Forests. A historical geography.* Cambridge: Cambridge University Press.
Winberg, Isak 1944. *Flottning i Sveriges allmänna flottleder till omkr. år 1935.* Ph.D. Diss, Stockholm.