Centre for Economic Development, Transport and the Environment

REPORT 72 | 2014

TRIWA III-Forestry Task

Water protection in regeneration cutting and site preparation areas

Guidelines and practices in the field

MARIANA JUSSILA | PETRI LILJANIEMI | LAURI KARVONEN | MAGNUS JOHANSSON

TRIWA III-Forestry Task

Water protection in regeneration cutting and site preparation areas

Guidelines and practices in the field

MARIANA JUSSILA
PETRI LILJANIEMI
LAURI KARVONEN
MAGNUS JOHANSSON

REPORT 72 | 2014

TRIWA III-FORESTRY TASK
WATER PROTECTION IN REGENERATION CUTTING AND SITE PREPARATION AREAS
GUIDELINES AND PRACTICES IN THE FIELD

Centre for Economic Development, Transport and the Environment for Lapland

Layout: Ritva-Liisa Hakala
Cover photo: Riparian buffer zone; Mariana Jussila
Maps: Riku Elo
Pictures: Hannu Lehtomaa

ISBN 978-952-314-094-3 (PDF)

ISSN-L 2242-2846
ISSN 2242-2854 (web)

URN:ISBN:978-952-314-094-3

www.doria.fi/ely-keskus

Table of Contents

1 Introduction

In terms of space, forestry has the greatest human impact affecting surface waters in Northern Scandinavia, and is a prominent source of diffuse pollution in the Torne river basin. Among the forestry activities, draining of peatlands, site preparation and clear-cuttings have had the most pronounced impacts on sediment, nutrient, and the metal loading of surface waters. Contemporary forestry aims to reduce this risk by using various water protection measures, such as riparian buffer strips and sedimentation pool designs. Although the first Swedish and Finnish guidelines and recommendations for water protection measures in forestry were published in the 1980s, it has taken some time to realize these recommendations in the field.

The TRIWA III -project gave us the opportunity to compare forestry methods between Sweden and Finland, and through field inspections understand how water protection is taken into account in forestry practices on the both sides of the border river. The project also increases the consensus between the forestry sector authorities in both countries and, hopefully, will lead to greater cooperation across the border regarding these issues. Forestry has great importance for business, export, employment and prosperity on either side of the River Torne valley. Contemporary markets and customers have begun to demand certificated, quality-assured and environmentally acceptable products. Therefore, modern forestry also aims to enhance water protection and facilitate environmentally sustainable development.

The project supports the implementation of the European Union's Water Framework Directive in Sweden and Finland. The directive demands cooperation between the EU-countries with transboundary watersheds. Finland and Sweden decided in 2010 to consolidate the national programmes of measures and water management plans concerning the Torne River international watershed. The goal of cooperative activities is to harmonize the classification of the ecological status of common water bodies, and also to reach a consensus regarding the measures used to maintain and enhance the status of the surface waters (e.g. water protection measures in forestry).

Within earlier Intereg projects (TRIWA I and II), the County Administrative Board of Norrbotten and the Centre for Economic Development, Transport and the Environment for Lapland have compared national guidelines and developed propositions for shared criteria for quality elements and national practices.

The forestry task of the TRIWA III -project continues this work by laying the foundation for common practices in water protection measures in the forestry sector. The other tasks of the project deal with the inventory of the impacts of forestry on rivers in the Torne watershed, the evaluation of the needs and costs of river restoration on these waters and development of detailed restoration plans for pilot areas. The results of the tasks are presented in separate reports.

2 Background

2.1 History of forestry in River Torne valley

The forests of the Torne river valley have been utilized since the nineteenth century. In those days, cuttings were mainly different kinds of selection fellings. Timber was at first used for tar production, house- and shipbuilding and household needs, but from the late 1800s it was increasingly used for the needs of rising sawmill industry. The sawmill industry peaked in the turn of the century, when there were 21 larger sawmills specializing in export in the Swedish County of Norrbotten, and several large sawmills in Northern Finland. Uncontrolled cuttings led to overexploitation of woodlands in the southern regions of the Torne Valley. Exploitative forestry was hindered in Sweden and Finland during late 1800's and early 1900's with several laws and decrees, which controlled the extent and age of harvested woodland and obligated forest owners to ensure the regeneration of the forest.

Although the First World War ceased the export of timber leading to temporary regression of sawmill industry, the demand of timber grew fast during the following decades because two pulp mills were founded in Kemi in Finland (the first in 1919 and the second in 1930). Furthermore, several big sawmills were founded in Northern Finland and Sweden during the first decades of the 1900s. Timber for these mills was transported mainly by floating, and therefore the river channels of River Torne and its tributaries were cleared for log floating on both sides of the border. When the demand for smaller diameter round wood increased with the pulp mill industry, small headwater rivers were also cleared. Floating ended finally in the 1970s, and after that channels were restored by removing the floating structures (dams, flow-directing embankments). These first restorations were conducted in a rough manner, and there is a need for further habitat restoration in the tributaries.

Selection cuttings with dimension felling were common until the 1940–1950s. This often led to forests with residual character dominated by birch and spruce. After the Second World War, large-scale clear cuttings and so called seed tree cuttings (a cutting method encouraging natural regeneration) became the main cutting methods, especially in state-owned forests of Northern Finland. Cutting areas were burnt in order to achieve better germination of seeds and better initial development of the young seedlings. Site preparation was not widely used. If burning was not successful enough, hoe patches were dug and planted or seeded using manpower. Prescribed burning and man-made patching were used until mechanized site preparation methods were developed at the beginning of the 1960s. Forest ploughs pulled by bulldozers and different kinds of scarifiers pulled by forest tractor become the most common methods of site preparation. Ploughing, which is a very heavy method, was used especially in spruce-dominated sites, which had a thick humus layer and which were usually also paludified. These sites were usually planted. The lighter methods such as harrowing came back again in the 1980s when regeneration cuttings moved increasingly to pine-dominated forests which were seeded or regenerated naturally with a help of the seed trees. Nowadays, harrowing is the most common site preparation method on sites with a thin humus layer. In Sweden, the light methods are predominately used. Ploughing of Finnish state-owned forests ceased in 1994 because of landscape conservation and water protection. However, in private forests the method is still in use to some extent. After abandoning the ploughing, Metsähallitus started the development of lighter soil preparation methods based on excavators. Also, other forest companies have participated in the development work. Today there are different kind of screefing and mounding methods that can be done by excavators. Generally speaking, excavators are nowadays used on sites which have a thick humus layer and where there is need to make mounds for planting. These areas may also require mounding with ditches in order to conduct excess water away from the regeneration site.

The oldest draining of peatland for enhancing forest growth in Finnish Lapland dates back to the 1930s. These drainages were made using manual labour and can be found, for instance, in Näätävuoma in Ylitornio and in Teuravuoma in Kolari. In Sweden, the draining of peatlands was already actively pursued in the 1930s. In Finland, drainage for forestry purposes on a large scale began in the 1960s, and at that time drainage was carried out on 3 000–4 000 hectares per year in the Torne river valley. In 1970s the guidelines changed, and criteria for choosing only the economically best objects for drainage were emphasized. Also, water protection issues were increasingly taken into. In Finnish state-owned forests the last drainages of virgin peatlands were carried out in 1992. Since then only maintenance ditching of old drained areas have been carried out. At present, the criteria of the Finnish Forest Certification System do not allow the drainage of pristine peatland areas for forestry purposes. This applies to both private and state-owned forests. Draining of virgin peatlands has also ceased in Sweden.

The first guidelines dealing with water protection in the forest management of state-owned forests in Finland were published in 1984. Guidelines introduced for the first time different kind of water protection measures for the drainage of peatland forest. Since those days, guidelines have been updated several times during the 1990s and 2000s both in Finland and Sweden. The present water protection guidelines have instructions for every contemporary forestry measure (including ditching, soil preparation and logging) that can have harmful impacts on the surface or ground water.

2.2 Impacts of forestry on surface waters

Agriculture and forestry are the main sources of diffuse pollution in the Scandinavian countries. Although forestry's share of the diffuse nutrient loading is clearly smaller than loading from agriculture, the land area used for forestry is many times larger. Therefore, forestry can be considered the widest-scale direct human impact affecting water quality in Finland and Sweden. Furthermore, forestry is often the only significant source of diffuse pollution in headwater catchments.

Forestry practices affect the hydrological and chemical properties of surface waters. Regeneration cutting of forests raises the groundwater table, thus increasing the volume of annual runoff and leaching of nutrients, metals, dissolved organic matter and suspended solid compounds. Site preparation enhances the leaching and erosion by breaking up the top layer of soil. Heavy site preparation (e.g. ploughing or furrowing) and ditching may cause serious erosion, especially if they penetrate the mineral land beneath the organic layer (the effects of ditching are discussed on separate report). Heavy tillage also affects the timing and intensity of seasonal floods, usually shortening the duration of the flood by reducing the retaining capacity of soil. Serious erosion may also originate from the use of water crossings (fording places) and forest road construction.

The main effects of forestry measures on surface waters are sedimentation of the substrate, eutrophication by increased nutrient loading and, in some cases, acidification. In northern waters, erosion-induced sedimentation of river and lake beds is often the most notable impact of forestry. Especially in small headwater rivers and streams, the sedimentation of substrate may permanently alter the habitat structure and ecological community. Sedimentation of spawning grounds can cause serious deterioration in valuable migratory fish-stocks (e.g. Salmon (*Salmo salar*) and trout (*Salmo trutta*)). At erosion-sensitive sites, sedimentation and leaking of suspended solids may continue for decades after tillage or road construction. The increased load of humus substances may cause changes on the water colour and lightning conditions especially in small forest lakes.

Eutrophication alters species composition by increasing the number of species that favour nutrient-rich conditions. The invasion of eutrophication-tolerant species takes place at the expense of sensitive species, and often leads to the reduction of biodiversity and potent changes in habitat characteristics. In the nutrient poor conditions of Northern watersheds, the changes caused by increased nutrient load can be dramatic, but are often limited to a relatively short period of time. Usually, increased loading continues for a couple of years after the forestry measures. Fertilization of the forest floor may prolong the impacts, but this forestry practice is seldom used in Northern Scandinavia. Furthermore, current forestry guidelines restrict the use of artificial nutrients in the vicinity of surface waters (a buffer zone with the width of more than 30–50 metres is recommended for fertilization of shore terraces).

Forestry measures can reduce the pH of water in acidification-sensitive areas, such as sulphate soils found in the coastal area of Ostrobothnia. Cases of harmful changes in acidity are usually connected to ditching of forest land, and these events are quite rare in the River Torne watershed. Forestry measures also increase the concentrations of metals on water (for instance, iron (Fe), nickel (Ni), mercury (Hg)), but serious consequences to ecology of surface waters are usually connected to acidic conditions. In Lapland, increased metal concentrations may cause problems in connection with other harmful effects (mainly sedimentation), but are rarely the driving force in the deterioration of aquatic environments.

2.3 Legislation

According to the *Swedish Forestry Act*, a forest owner must submit a felling license (Avverkningsanmälan) for harvesting an area larger than 0,5 ha. If the area intended for harvest is located in a mountainous area, a separate harvest permit is needed. The forest owner has to state whether he is planning to use cultured seedlings or natural regeneration. Permission is needed if forest regeneration is conducted using introduced, exotic species.

After regeneration cutting (i.e. harvesting), the owner has to secure the regeneration by performing the necessary measures within three years if he intends to use planting. With natural regeneration, the owner has 7 years (Southern Sweden) or 10 years (Northern Sweden) in which to achieve the necessary regeneration approved by the Swedish Forest Agency. The owner also has to state which method of soil preparation will be used and on how large an area the site preparation is to be used.

The forest owner has to state the type and extent of the environmental protection measures employed in the forestry measure area (protective zones in proximity to water, ancient trees, solitary or in group, etc.). Protection of the natural environment and cultural heritage are both regulated by the Paragraph 30 of the Forestry act.

Upon submission of the felling licence the owner has the opportunity to state whether there is a need to perform 'protective' ditching on the site. Furthermore, the owner presents an estimate concerning the environmental effects according to the Environmental Act (Chapter 12 Paragraph 6). The owner has to submit a map of the harvest area. The map is the basis for assessments carried out by the Swedish Forestry Agency in order to confirm the validity of the parameters that the forest owner has stated in his licence.

The legislation is quite similar in Finland: the Forestry Act obliges the land owner to make a statement concerning utilization of his forest, and when he intends to cut his forest. This statement must be made at least 10 days before the cutting takes place (Forest Act 14 §). The statement is submitted to Metsäkeskus (The Finnish Forest Centre). In Finland, Metsäkeskus ensures that the forest act is complied with. In his statement, the land owner must specify, whether planned forestry measure involves improvement cutting or regeneration cutting. In the case of regeneration cutting, the owner is obliged to ensure the regeneration of the forest. This means that, after the regeneration cutting, the area must have viable new growth within the time period defined in the Forest Act. The Forestry Act also defines the measures that the owner must carry out in order to accomplish the new growth (Forestry Act 8 §).

According to the Finnish Forestry Act, regeneration of forest can be achieved by planting using cultured seedlings or seeds, or by natural regeneration. Regeneration and the new growth must be secured by clearing the shading undergrowth, preventing the growth of grass, preparing the soil and controlling the water balance.

These measures must be conducted within three years of the cutting. Metsäkeskus oversees that the regeneration is carried out according to plan and is sufficient for establishing new growth. Supervision is based on the information given in the statement of utilization of forest (characteristics of vegetation and soil, planned site preparation method, regeneration method, etc.). If the regeneration measures are not adequate, Metsäkeskus can demand changes to the regeneration plans.

The Finnish Forestry Act defines valuable habitats, that are important for the conservation of biological diversity (Forestry Act 10§). These habitats are pristine or close to their natural state, and have characteristic, distinguishable features. Furthermore, these areas are usually quite small. Habitats conserved by the Forestry Act include small waterbodies, fertile peatland types and groves. Valuable small waterbodies feature springs, streamlets, rivulets and small ponds (with an area of less than 0,5 ha) and their neighbouring areas. The vicinity of small waterbodies is conserved by the Forestry Act, whereas the stream channels or other water areas are protected by the Water Act. As a principle, these habitats must not be altered, although there are some regional exceptions concerning the regulations.

The alteration of larger waterbodies (streams, rivers and lakes) is prohibited by the Water Act. Spoiling or deteriorating of surface- or groundwater is prohibited by the Environmental Protection Act. If planned measures are likely to have adverse impacts as defined in these Acts, an environmental permit or water permit must be applied for. Forestry measures are not usually subject to license in Finland.

Figure 1. Regeneration cutting area. Photo: Timo Tahvonen

3 Description of forestry measures

3.1 Regeneration cutting

Several different methods of regeneration cutting are used in Sweden and Finland. The most common method in Sweden is a clear-cut harvesting of a site followed by site treatment and planting to secure the regeneration of forest on the site. Other methods included are based on natural regeneration. These methods include the use of seed trees (usually used with pine) or different kinds of stand regeneration where self-seeded saplings are used as a basis for regenerating the site. The former method generally includes the site preparation. The latter method is suitable especially for spruce on moist and wet sites, where spruce can grow under the screen of birch. These sites are usually left without soil preparation. In Finland both regeneration methods – artificial regeneration based on planting or sowing and natural regeneration based on seed-trees – are widely used. In all methods the environmentally, conservationally and culturally valuable features of a site are left outside harvesting.

3.2 Site preparation

When choosing site preparation methods connected with forest regeneration, special attention must be paid to the soil properties, topography and location in relation to watercourses. The site preparation method must be chosen so that it alters the structure of the soil as little as possible. Thus, environmental impacts are also minimized. However, the method used must be effective enough to ensure regeneration.

Successful regeneration usually requires site preparation so that plants or seeds will not have too much competition from other vegetation. Soil preparation also improves the soil properties by raising the temperature of the soil and by enhancing the availability of nutrients. The type of treatment depends on soil type and the hydrological conditions of the site. Generally speaking, the drier the site, the lighter the method that should be used. For sites located on slopes with dry or dryish, permeable soils, preparation methods that

Figure 2. Mounding with ditches (using ditch breaks). Photo: Jukka Vähätaini

only expose the mineral soil are adequate (screefing, light harrowing). On more fertile, paludified or poorly permeable soils, heavier mound-making methods such as ploughing and mounding should be used.

In Sweden, intermittent soil treatment, most commonly mounding, is used where the soil does not need much agitation, and is often used under seed trees of pine to increase growth points on natural regeneration sites. The mounding method and intensity can also be varied, having a small mound of over-turned turf on drier sites, whilst on wetter sites with soils larger mounds can be made with e.g. an excavator.

In Finland, harrowing is a widely used soil preparation method. This method is used on natural regeneration sites and also sites cultivated by seeding. On the planting sites, different kinds of mounding are used, produced by special mounding devices or by excavators. In private forests, ploughing is possible method and it has been used especially in Lapland. In some cases on the paludified sites drainage is needed and it is combined with soil preparation.

3.3 Water crossings

In Sweden, a new policy was recently agreed by the whole forestry industry. It accentuates the importance of avoiding serious soil damage when forestry machinery is used. Similar practices have been in used in Finland for the last decade, and recommendations are stated in the newest guidelines.

Harvester and forwarder routes should be planned with consideration for soil, water, historical and cultural monuments before a measure is implemented. Driving in streams or rivers, on lake shores, through springs or wetter areas and over large fallen trees should be avoided. Further, driving in direct proximity to areas having conservational or other value should be avoided. Damage to the shore area should be minimized by driving as far from the water as possible.

If it is unavoidable to drive close to water or other places with a risk of erosion, the ground should be reinforced. Finnish guidelines promote the use of winter roads in areas, where the permafrost prevents erosion during winter. This applies especially to Northern Finland. The reach of the harvester should be utilized fully, and timber should be stacked away from the water so that the forwarder does not have to drive close to the water or to historical and cultural monuments.

Crossing of streams must be avoided whenever possible, and the possibilities of extending the logging road or building a permanent bridge over the stream should be considered. When crossing a watercourse is unavoidable, it should be done at the most suitable place using available technical appliances (e. g. portable bridges, causeways made out of round wood, wooden bridges; the method depends on the size and properties of the stream) preferably without the machinery coming into contact with the water.

It is important that the edges of the stream are stabilized so as to avoid damage that can cause silting. Ramps for the bridge should be protected with timber mats, causeways or by using harvest residue. However, use of round wood or harvest residue should not be the first option for crossing streams or functioning trench systems. Damage should be avoided using as simple a means as possible, for example, portable bridges. Round wood put into a ditch or stream must be removed after use in order to prevent flooding. Damage to trench systems should be prevented so as to protect watercourses downstream and to maintain the draining function of the ditches.

Technical appliances such as. bridges can be left in place and kept accessible to facilitate crossing for later measures (e.g. soil treatment and collection of harvest residue) unless they create damming and/or flooding.

3.4 Protective drainage ditches

Protective ditching is carried out on productive sites so as to prevent the groundwater from rising after e.g. a final felling. The measure is supposed to replace the water up-take of the harvested trees. Establishing protective ditches are meant to facilitate regeneration on that specific site. A suitable depth for protective ditches normally a span between 0,4 and 0,6 metres. In Sweden, the measure has to be reported to the Swedish Forest Agency.

In Finland, drainage of the regeneration area can be carried out if it is obvious that a rise in groundwater level will threaten the development and success of the young seedlings. In these cases, the Forest Act states that protective drainage must be carried out on the peatland after regeneration cutting. On the mineral soils, the drainage is usually linked with the soil preparation carried out by excavator. During the soil preparation, shallow ditches (0,3–0,5 m) are dug to get rid of the extra surface water in the cases when the basic drainage is not needed. If the ground water level has to be lowered permanently, the deeper ditches (0,6–0,8 m) must be excavated. According the Forest Act, the basic drainage is not needed on mineral soils, but the forest owner can do it, if he thinks the measure is necessary from his point of view. However, if the drainage area is large, the forest owner must – according the Water Act – make a preliminary announcement of the measure to the regional Ely-centre.

Figure 3. Temporary bridge. Photo: Börje Pettersson

Figure 4. Buffer zone between stream and regeneration area. Photo: Jukka Vähätaini

4 Description of water protection methods

4.1 Area characteristics and water protection

The properties of the catchment area, especially areas in the vicinity of the shore, dictate the intensity of water protection methods needed in the forestry measure area. The slope of the shore, as well as the size, gradient and soil type of the catchment govern the erosion sensitivity of the compartment (the forest stand where the measures take place). Erosion-sensitive areas require more extensive water protection methods, such as wider buffer zones, less intensive site preparation and active control of sediment loading.

Several Finnish forestry actors have published guidelines and recommendations for water protection. Among others, Metsähallitus, Metsäkeskus, Forestry Development Centre Tapio and private actors (e.g. UPM) have given their own guidelines to be followed in harvesting and other forestry measures. Although there are differences in their recommendations, they all follow the general guidelines given in national and international forestry certificates and directives. The chapters that follow deal with recommendations on a general, national level.

4.2 Buffer zones

The buffer zone or buffer area is a protective forest belt left between the forestry measure area and surface water formation (stream, river, lake, pond, spring etc.). The buffer should act as a filter and stop the leaking of solid substances and nutrients before they reach the water area. The buffer is preferably left uncut and without site preparation, but there is variability in national and organizational recommendations, and thinning and even clear-cut may be allowed. The buffer zone is the most important and most widely used water protection method in connection with regeneration cutting and site preparation.

Finnish recommendations generally state that the minimum width of buffer should be five metres (e.g. The Finnish Forest Certification criteria). This applies to larger lakes and rivers, and impacted smaller water bodies with an altered natural state. Erosion sensitivity (soil type and gradient) and landscape characteristics dictate the width of the buffer, which usually varies from the minimum up to 30 metres. The buffer width should follow the shapes and properties of terrain. Wider buffers are also used with valuable, pristine small waters (Forest act 10 §: streams, ponds, springs, etc.). If the aim is to keep the microclimate of such a habitat intact, the width of the buffer should correspond to the height of the dominant trees of the area. In practice, this means a buffer width of 15–30 metres.

Wider buffer areas are generally recommended for compartments with site preparation. When dealing with lightly prepared, flat areas 5–30 metre wide buffer is recommended, depending on the guidelines. For sites with heavier scarification methods, erosive soil and steeper slopes, Metsähallitus recommends that the buffer width should be at least 20–30 metres. Recommended buffer widths for the private sector are often less stringent compared to guidelines for state-owned forests, and minimum width of 5 metres may also in be applied areas with site preparation.

Finnish practices concerning the forestry measures inside a buffer area also vary between the actors. In state-owned land governed by Metsähallitus, measures are generally not carried out in the buffer zone. Private actors and Metsäkeskus allow thinning and selective felling within buffer.

4.3 Site preparation

As with buffer width, erosion sensitivity dictates the selected site preparation methods. In both countries, methods include lighter measures such as mounding, harrowing and screefing, and heavier methods such as mounding with ditches and ploughing. In Sweden, the heavier methods are not widely recommended. Lighter methods are used in dry, water-penetrating terrains, whereas heavier site preparation is needed in wet areas with a need for drainage.

Figure 5. Harrowing along the contour lines. Photo: Jukka Vähätaini

Prescribed burning is also used as a site preparation method, but at present it is carried out in relatively limited fashion in Northern Scandinavia. Additionally, fertilization of forest soil may be carried out, but it is a rare and marginal measure in northern areas, and therefore does not cause notable problem in the River Torne basin.

In forest compartments with steeper slopes, the site preparation must be done following the contour lines. In eroding slopes, the grooves and furrows on surface soil should not be continuous. If mounding with ditches is used, breaks in ditches should be provided in order to enhance the retention of suspended solids. Mechanic site preparation is avoided in areas with valuable ground-water deposits.

If the draining of the area demands the discharge of excess water, additional water protection methods are needed to control the leaking of harmful substances and suspended solids. These methods are usually combined with implementation of heavy scarification. In Finland, the same water protection methods are also widely used in maintenance ditching operations. Maintenance ditching is dealt with in a separate report.

4.4 Sedimentation control methods

In wet forestlands it may be necessary to drain the excess water away from the measure area in order to enhance the regeneration of the stand. The water protection methods used to prevent leaking of substances and sedimentation of surface waters below the drained area are similar to those used in connection with maintenance ditching and forest road construction. Methods include sedimentation pits, pockets and basins, and overland flow areas constructed on and below the drainage ditches.

If possible, eroding solids should be stopped in the measure area. In addition to using less erosive site preparation methods such as discontinuous harrowing and mounding with ditch breaks, sedimentation pits and pockets can be dug in drainage ditches. Sedimentation pits and pockets are deeper, slower-flowing sections of the ditch, which allow suspended particles to settle down and sediment. According to Finnish guidelines, sedimentation pits should be 1–1,5 metres deeper than the normal ditch. Thus the volume of the single sedimentation pit is approximately 1–2 m^3. In the drainage area sedimentation pits are usually dug at 100–200 metre intervals. The term sedimentation pocket is used for laterally wider depressions of the ditch.

Sediment basins are larger pools with a retention time of at least one hour in order to enable efficient sedimentation. They are mostly used in connection with maintenance ditching. The dimensions of the sediment basin depend on the size and gradient of the catchment area. Finnish recommendations state that the catchment area of each sediment basin should be no bigger than 30–40 hectares. The preferable size is 10–15 hectares. Recommendations also suggest that the basin's surface area should be 3–8 m^2/hectare of catchment area and the sediment storing capacity 2–5 m^3/hectare of catchment area. In erosion sensitive areas the upper range of recommendations should be used. Sedimentation basins require maintenance, and they should be emptied before the next flood season, if over the half of sediment capacity is filled, and erosion is likely to continue. When performing efficiently, a sediment basin may remove 30–50 % of suspended matter loading.

Overland flow areas are unditched areas below drainage ditches where the runoff water is divided evenly, usually through a perpendicular distribution ditch. If an unditched area is unavailable for overland flow, old ditches can be dammed and filled, but this method is not widely used and is mostly applied in connection with catchment area restoration projects. The area of overland flow should be at least 1–2 % of the size of the catchment area. The most effective terrain for overland flows is treeless peatland with thick peat layer. The most efficient overland flows may remove 70–100 % of the suspended matter and 20–30 % of organic matter. Nutrient loads are also effectively reduced (retentions of 45–95 % of inorganic nitrogen and up to 60 % of total phosphorus are reported), but the efficiency in nutrient removal is highly case-specific. Overland flow areas have also been observed to release nutrients, especially immediately after the construction of the area, when the water balance of the area is changing. As with sediment basins, the size of the catchment area above the overland flow should not exceed 30 hectares.

The most effective water protection solutions are combinations of the above-mentioned methods. A sedimentation basin located above the overland flow area removes nutrients and solids efficiently. Basins and overland flows can also be constructed in the middle parts of the catchment area, if suitable unproductive wetland depressions are available.

Figure 6. Sedimentation pool. Photo: Timo Tahvonen

5 Survey methods

5.1 Screening and selection of inspection areas

The selection of the inspection sites (sites with regeneration cutting and site preparation) was carried out by using the GIS-based forestry measure registers of Skogsstyrelsen, Metsähallitus and Metsäkeskus. GIS-systems contain updated and detailed information about the properties and growing stock of the forestry stand compartments. In addition, every compartment has information on all the measures carried out in the past and also the exact year when these measures have taken place (for instance regeneration cutting and site preparation measures). In Skogsstyrelsen and Metsähallitus GIS-analyses, tools were used in order to focus the inspections on the sites and measures which probably could have had direct impact on tributaries of the Torne River. In the analyses a virtual 50 metre buffer zone was made to surround the streams and rivers less than 10 metres wide. All the regeneration cutting areas with shore areas inside virtual buffer zone were picked for further selection. In Metsäkeskus the virtual buffer was not used, but the selection was made “manually” by going through all register-entries for regeneration cuttings conducted in 2004–2009, and picking out areas in close proximity to small rivers. Additional selection criteria demanded that the area of the stand compartment should be at least one hectare and regeneration cutting had been carried out during the years 2004–2009. This time period was chosen so as to ensure that site preparation had been carried out. Both in Finland and Sweden, the Forestry Act obligates that regeneration measures (including site preparation) should be conducted within three years of felling.

In 2011 the inspections were focused on areas which had been cut during 2004–2008. In Finland, these sites were located in the municipalities of Tornio, Ylitornio ja Pello, and in Sweden municipalities included Haparanda, Övertorneå and Pajala. In the second field season of the study (2012), inventories were made in the municipalities of Kolari and Muonio (Finland) and Övertorneå, Pajala and Kiruna (Sweden), and the sites also included areas which had been cut in 2009. The inspections were carried out in late summer and autumn, with the assumption that compulsory site preparations should already have been implemented.

5.2 Description of field inspections

Detailed field inspections were carried out after the screening and selection of the regeneration and site preparation areas. Prior to field inspection, maps, aerial photographs and registers were used in order to assess the coordinate position of the site, the surface area of the stand, the length of waterfront and the implementation date of regeneration cutting and site preparation. A common field protocol was developed and tested in field conditions before the first field season (Appendix 1a and 1b).

Most variables and characteristics were estimated visually in situ by walking across the inspection area and along the buffer zone on the waterfront. Impacts of erosion were observed from the stream channel and adjacent shore area. The following sections describe the methods and classifications used for inspected background characteristics and water protection measures.

5.2.1 General characteristics

General characteristics of the inspection sites (stands, compartments) present the properties of terrain, soil and riparian area (Table 1). Evaluated variables are described and discussed in the chapters that follow.

Area of the stand was estimated from the map. Swedish compartments were generally larger than Finnish stands. Swedish state-owned areas were on average at least twice the size of the compartments of other actors.

Effective riparian area describes the share of run-off area affecting the surface water (stream, river). The effective area was estimated by locating the watershed dividing the direction of run-off. The area sloping towards the stream was regarded as the effective area. The effective area was generally the largest in Finnish private forests. This may reflect the over-all characteristics of these areas: Finnish private lands are mostly located on flat lowlands in Southern parts of the River Torne valley.

Table 1. General characteristics of the inspection areas.

	Sweden		Finland	
	Private	State	Private	State
Area of the stand (mean ha.)	7,5	15,3	5,2	5,3
Effective riparian area (% of total area)	61	55	84	67
Length of waterfront (mean m)	295	382	292	276
Slope (% of stands)				
1: 0–5%	69	62	73	54
2: 5–20%	24	32	26	37
3: > 20%	7	6	1	9
Soil type (% of stands)				
1: Fine	53	36	37	48
2: Medium	44	59	60	49
3: Coarse	3	5	3	3
Thickness of peat layer (% of stands)				
1: 0–30 cm	100	100	97	94
2: 30–60 cm	0	0	3	6
3: > 60 cm	0	0	0	0
”Moisture types” on stand (% of total area)				
1: Dry	8	7	23	48
2: Fresh	51	63	58	43
3: Moist	41	30	19	9
Water level in stream (% of stands)				
1: Low	23	15	0	3
2: Normal	37	21	31	49
3: High and flooded	40	64	69	48
Stands without site preparation (% of stands)	29	23	11	3

Length of waterfront indicates the total length of stream bordering the inspected compartment. The total length of buffer zone was in some cases shorter than waterfront length, because the shape of the stand did not always follow the shoreline, and sections of the waterfront may not belong to the compartment with forestry measures.

Slope means the gradient of the effective area. It was divided into three classes, which represent the angle of the slope. The low gradients are more frequently observed on Finnish private lands.

Soil type describes the degree of coarseness of the soil particles and conveys the erosion sensitivity of the area. The variable was divided into three classes (“Fine” for fine sand, silt and clay, “Medium” for gravel and coarse sand, and “Coarse” for coarse gravel and stones). The fine, eroding soil types were more frequently represented on Swedish private lands and Finnish state-owned areas.

Thickness of peat layer was also divided into three thickness classes. Differences between countries and actors were small; inspected areas were usually located on forest land with a relatively thin peat layer. Additionally, inspected compartments were also divided roughly into “peatland” and “mineral land” classes (thickness of peat layer over/under 30 cm). This division proved to be uninformative, since almost all inspection sites were on “mineral land”.

Moisture types portraits the moistness of the compartment (i.e. level of groundwater in relation to surface of the soil). Moisture class also corresponds roughly with different forest types in the following manner:

- **Dry:** Ground water level more than 2 metres deep; Dry forest types
- **Fresh:** Ground water level less than 2 metres deep; Fresh forest types
- **Moist:** Ground water on surface; Wet forest types and forest wetlands

The visual estimation was made on the "effective riparian area" of the compartment and the percentage coverage of every moisture type was registered. In Finland, dry moisture type land covered notably higher share of the inspected areas than in Sweden. The highest share of dry land was observed in Finnish state-owned measure areas. This reflects the fact that Finnish state-owned forests are mostly located in northern areas which are more barren and drier than more fertile southern forests.

Water level in stream indicated the discharge conditions, which have an impact on the observations in inspections. High and flooded conditions may hinder the visibility of stream substrate, making it hard to detect sedimentation and other symptoms of erosion and forestry measure impacts. On the other hand, high discharge and precipitation may make erosion clearly visible in the inspected land area. Water level was classified as "low", normal" or "high" by comparing the present situation to the level of the established shore line. In general, Finnish inspections were made rather more often during high or flooded discharge conditions.

The inspections revealed that in some areas site preparation had not been carried out. In some cases the regeneration cutting of the stand was done so recently that the contractor had not yet had time to carry out the operation, but in some cases the site preparation had clearly been neglected. **Sites without site preparation** were more common in Swedish forests.

5.3 Inspected variables

The field inspections were focused on the estimation of effectiveness and sufficiency of the water protection methods used. Several variables describing the attributes of water protection measures and forestry measures impacts on surface waters were evaluated and documented in field protocols developed for the project's inspections. Field protocol is presented in Appendix 1.

5.3.1 Buffer characteristics

Buffer characteristics defined variables affecting the buffer's efficiency in removing suspended solids and nutrients from runoff water. These characteristics included the mean width of the buffer (in metres), length of the buffer and the length of the narrow buffer (buffers narrower than recommended five metres). The share of different forestry measures in the buffer area was also estimated (uncut, thinned and clear-cut). The properties of the buffer were estimated visually in the field by crossing the buffer on random locations. The shorelines with a narrow or heavily cut buffer zone were inspected in a more systematic manner.

Finally, the overall functioning (i.e. efficiency in stopping the leakage into the stream) of the buffer was estimated on scale from 1 to 3. The "functioning classes" were:

1. **Good** (No erosion or leakage)
2. **Moderate** (Some erosion visible on stream channel and shore area)
3. **Poor** (Clear erosion and damage to stream)

Observed problems were described in comments (for instance, "buffer too narrow", "buffer damaged by vehicles", "old ditches causing flow-through", etc.). Implemented forestry measures on the buffer (1: Uncut, 2: Thinned, 3: Clear-cut) were estimated as the different methods' coverage (%) of the total area of the buffer.

Also shading of the riparian trees on the stream channel (i.e. the share of channel area covered by foliage) was originally registered, but after the first field season it was obvious that the results were not comparable between the countries due to differences in estimation methods. Therefore, the systematic estimation of the shading was dropped from field inspection routines, and the results are not dealt with further.

5.3.2 Water crossings

Existing water crossings (fords, temporary bridges, forest roads) and possible impacts were estimated in situ and described as free text. The gravity of impacts was assessed using following impact classes:

Figure 7. Erosion caused by water crossing. Photo: Timo Tahvonen

1. **None or little** (e.g. clean stream substrate or only irregular small patches of sand or silt on the bottom)
2. **Moderate** (clear sedimentation, sand and silt regularly between stones)
3. **Strong** (heavy sedimentation, sand or silt covers large parts of the stream bottom)

5.3.3 Site preparation

The used site preparation methods were expressed as coverage (%) of the total measure area (site preparation was called “Scarification” in field protocol (Appendix 1)). Preparation methods were as follows:

1. None
2. Harrowing
3. Screefing
4. Mounding (with shallow ditches, <50 cm)
5. Mounding (with deep ditches, >50 cm)
6. Mounding without ditches
7. Ploughing

The distance of the site preparation area from the shore was estimated visually, and possible impacts were described in comment field of the protocol. The suitability of the site preparation method used in contrast to the erosion sensitivity (slope, soil type of the compartment) was judged by the using following categories:

1. Suitable
2. Too heavy
3. Too light

The direction and continuity of the grooves and ditches were described using four categories:

1. Parallel to shore
2. Parallel to shore with ditch breaks
3. Towards to shore
4. Towards to shore with ditch breaks

Figure 8. Ploughing along contour lines. Photo: Jukka Vähätaini

5.3.4 Protective drainage ditches

If protective drainage was carried out, the mean depth of ditches was estimated and possible impacts described. The general direction of ditches was documented in the field (1: parallel to shore, 2: towards to shore, 3: straight to water). The impacts were evaluated the using the impact classes applied with the water crossings.

5.3.5 Water protection methods

The applied water protection methods were listed and additional measures were recommended, if deemed necessary. Water protection methods used and recommended included buffer zones, sedimentation pits and ponds, ditch breaks and dams and overland flows.

5.3.6 Quality of water protection

The final assessment of the quality of water protection measures is a synthesis of all the measures employed in the inspection area, and gives a general evaluation of overall level of water protection in the area. Quality was estimated using a three level classification (1: Good, 2: Satisfactory, 3: Poor).

6 Results and discussion

The inspections were carried out in late summer – autumn in 2011–2012. The total number of inspected areas was 462. In Sweden, the majority (two thirds) of the sites inspected were privately owned, whereas in Finland the areas inspected were quite evenly divided between private and state-owned areas (Table 2). There's a difference in the definition of state-owned areas between the two countries. In Finland, the state-owned forests are compulsorily owned by state and governed by Metsähallitus. In Sweden, communal forests (i.e. forests owned by municipalities, church etc.) are also included the in "state-owned" category.

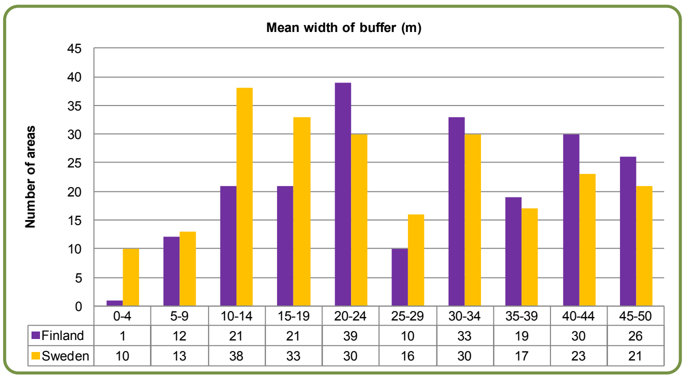


Figure 9. Mean width of buffer zone (metres) in Finland and Sweden.

Table 2. Number of inspected regeneration cutting-site preparation areas.

Sweden (Skogsstyrelsen), total of 241 areas	
Private 160	**State** (and communal) 81
Finland (Metsäkeskus, Metsähallitus), total of 221 areas	
Private 103	**State** 118

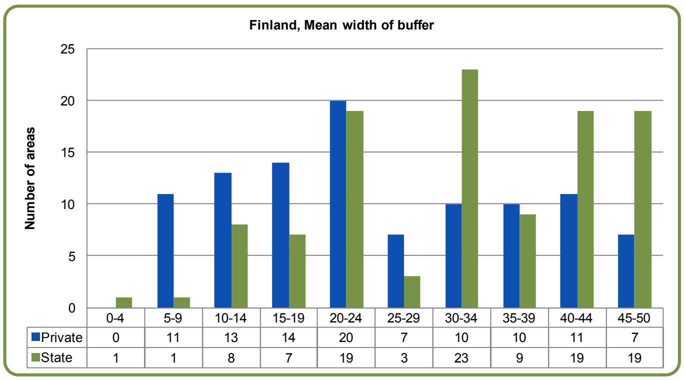


Figure 10. Mean buffer widths (metres) in private and state-owned forestry areas in Finland.

6.1 Buffer characteristics

Mean width of buffer zone

The average width of the buffer zones was estimated with an accuracy of one metre, but in Figure 9 the observations have been divided into five metre intervals to make it easier to overview. The majority of buffer zones in Sweden were about 10–14 metres wide, while in Finland the most common width was 20–24 metres. At several sites the buffer width varied also for natural reasons because of unproductive flooding areas and wetlands located between the stream and forestry measure area. In Finland, the zones were in general wider in the state owned forests than in the private ones, which is clearly shown in Figure 10.

In Sweden, the protective zones were in general somewhat narrower on woodland owned by private and communal actors (Figure 11).

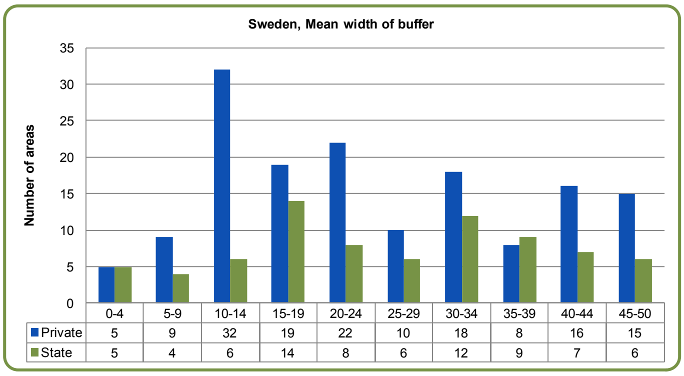


Figure 11. Mean buffer widths (metres) in private and state-owned forestry areas in Sweden.

Table 3. The share of narrow buffer (<5 metres) of the total length and total number of inspected buffers.

	Total lenght (m)	Narrow buffer lenght (m)	%
Finland	55 470	1 480	2,7
Sweden	75 436	6 834	9,1
	Total n of areas	**Narrow buffers (n)**	**%**
Finland	221	14	6,3
Sweden	241	109	45,2

Share of narrow buffers

Most policies state that the width of the buffer zone is not allowed to fall short of 5 metres. The number and combined length of the buffers narrower than five metres was related to total number and length of inspected buffers (Table 3). Unexpectedly the share of narrow buffers was notably higher in Sweden, where almost half of the inspected buffer zones were partly too narrow. Remarkable for many of the Swedish sites is that they do fall short of 5 metres on parts of the protective zones.

Functioning of the buffers

Protective buffer zones were in general functioning adequately and stopped visible erosion efficiently. Although the share of "poorly" functioning buffers was somewhat higher in Sweden, the share of "good" buffers was 80 % in both countries (Pictures 12 and 13). The differences in buffer efficiency between private and state-owned forest were small in both Sweden and Finland.

Forestry measures on buffer zone

The majority of the zones had been left uncut and untreated (Table 4). At several sites only part of the buffer had been thinned or cut, while other sections were left untreated. In Sweden, it seems to be more common to completely harvest the zones (6,3 % of zones clear-cut), while in Finland it is more common to use thinning on buffer zones (9,2 %).

Although the differences between the state and private sector were small, there was a slight difference between Finnish state and private forests with regard to thinning, where it was more common to thin the protective zones in privately-owned forests (13,3 %

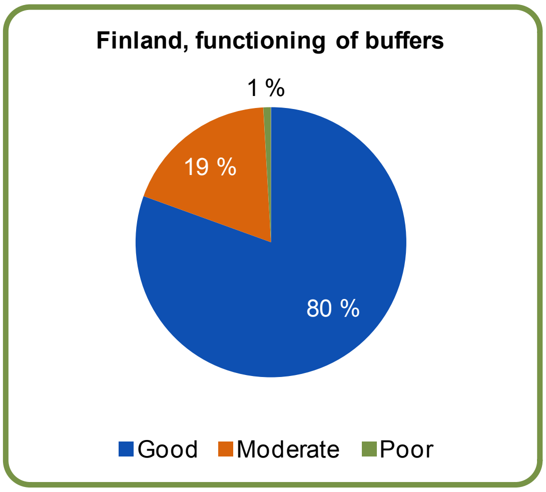


Figure 12. Functionality and efficiency of buffer zones in Finland.

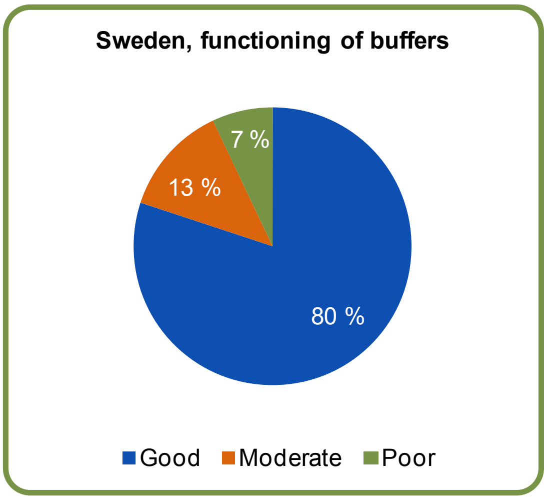


Figure 13. Functionality and efficiency of buffer zones in Sweden.

Table 4. Implemented forestry measures on buffer zones (% of the buffer area).

	Uncut	Thinned	Clear-cut
Finland	89,0	9,2	1,8
Sweden	89,4	4,3	6,3

Table 5. Implemented forestry measures on buffers divided between forest owners (% of the buffer areas).

	Uncut	Thinned	Clear-cut
Finland			
Private	86,3	13,3	0,4
State	91,3	5,6	3,1
Sweden			
Private	89,4	4,6	6,0
State	89,6	3,6	6,8

Table 6. The frequency of buffers with forestry measures divided by country and by forest ownership

	Total numbers of buffers	Buffers with measures	%
Finland	**221**	**30**	**13,6**
Private	103	15	14,6
State	118	15	12,7
Sweden	**241**	**48**	**19,9**
Private	160	31	19,4
State	81	17	21,0

Table 7. The share of regeneration cutting areas with water crossings (% of all inspected sites).

Finland	**48 %**
Private	30 %
State	64 %
Sweden	**47 %**
Private	43 %
State	56 %

Table 8. The share of different impact classes in private and state-owned forests in Sweden and Finland (% of impacted sites).

	None or little	Moderate	Strong
Finland			
Private	89	11	0
State	95	5	0
Sweden			
Private	73	14	13
State	70	25	5

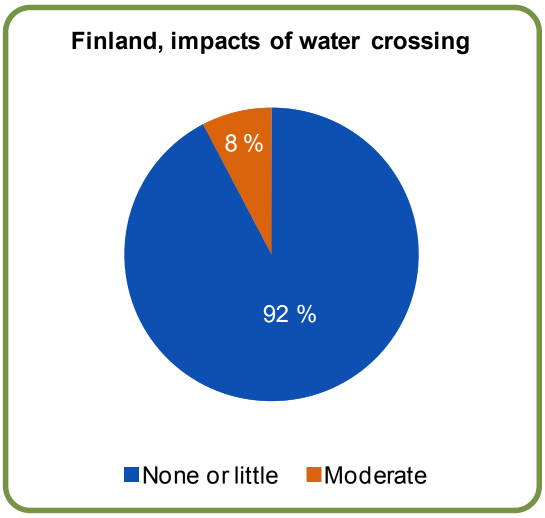


Figure 14. Impacts caused by water crossings in Finland (% of impacted sites).

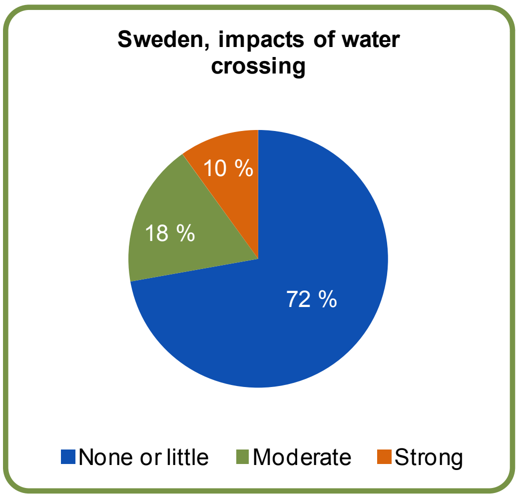


Figure 15. Impacts caused by water crossings in Sweden (% of impacted sites).

compared to 5,6 %) (Table 5). It should be borne in mind that thinning of zones did not necessarily lead to "poor" water protection status, because careful thinning can sometimes actually increase natural values on the site (e.g. the felling of spruce to the advantage of hardwood). However, if the logging is carried out in the buffer zone, from the water protection point of view the logging waste should be removed from the zone in order to prevent the leaching of the nutrients. Removal of the logging waste was not evaluated in the inspections.

When the total number of inspected buffer areas with forestry measures is compared between countries, it seems that measures are more frequently carried out in Swedish buffers. Difference between state and private sector is small in both countries (Table 6).

6.2 Water crossings

Approximately half of all inspected regeneration cutting sites had water crossings (bridges, fords, driving tracks etc.). The share of areas with water crossings did not differ between countries. Differences between state and private sector were also quite similar, as water crossings were more commonly used in state-owned forests in both countries (Table 7).

However, estimated impacts of water crossings differed between the countries; in Sweden "strong" and "moderate" impacts were observed in 10 % and 18 % of the inspection sites. "Strong" impacts were more common on privately owned woodland (in 13 % of inspection sites) (Figure 15, Table 8). In Finland there were no areas with "strong" impact, and "moderate" impacts covered only 8 % of sites (Figure 14, Table 8).

The reason for this significant difference between the countries raised several hypotheses. First, could the subjective, visual estimation method cause the difference? The field method was "calibrated" in two common field excursions, so the possible difference in the methods of field personnel should not affect the estimation severely. Second, it was assumed that the Finnish forest road network may be denser compared to Sweden, and therefore there would be less need to cross the streams with heavy machinery. This assumption does not seem very likely, because the share of sites with water crossings was virtually identical in both countries (Table 7).

The third and most plausible reason for the heavier impacts in Sweden concerns national forestry practices. In both countries, the guidelines state the need to use temporary bridges, when crossing a stream is deemed necessary. Furthermore, the banks of the stream should be reinforced using round wood or logging residue. At the sites visited in Sweden, temporary bridges had not frequently been used. In Finland, the temporary bridges and bank reinforcements were commonly used, and winter roads were often used for timber transport. Moreover, it is more common in Finland to use winter roads to perform soil treatment in wintertime. That is the case especially when the site preparation areas are situated far away behind difficult terrain such as sinking wetlands. In Sweden, it has been noted that the machines for soil treatment are the ones doing the most damage when crossing streams.

Sometimes round wood has been laid in the stream in the direction of the flow of water and left in the water after leaving the site. This was regarded as a negative matter in the evaluation of the impacts.

6.3 Site preparation

Compared to Sweden, more radical site preparation methods (ploughing and mounding with ditches) are used in Finland (Figures 16 and 17). In Sweden, light preparation methods, such as mounding without ditches, are preferred. The mounding devices used also differ: in Finland, mounding is usually carried out using excavators, but a special mounding device pulled by the forest tractor is in use in Sweden. There is a prominent difference in the implementation of obligated site preparation between countries. In Sweden, as many as 27 % of the sites cut for regeneration had not been subjected to soil treatment despite the fact that it was reported in the felling license.

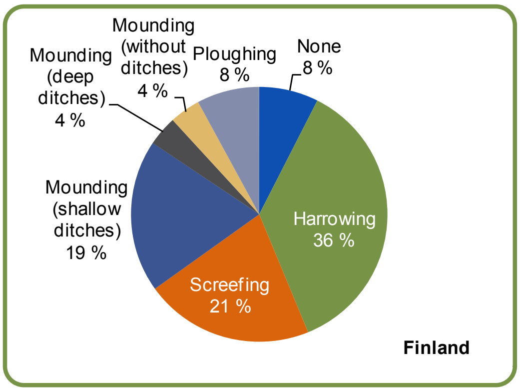


Figure 16. Site preparation methods in Finland.

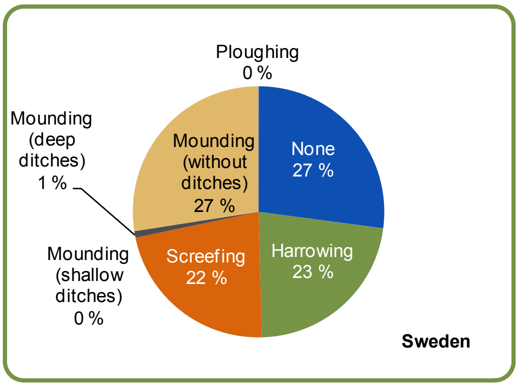


Figure 17. Site preparation methods in Sweden.

Differences between soil treatment methods between forest owners are not very prominent (Table 9 and 10). One notable difference is that ploughing has been used frequently in Finnish privately owned woodland and not used at all on state-owned woodland. In Sweden, it is slightly more common to use harrowing on privately owned woodland, whereas screefing is more popular in state-owned forests.

The direction of scarification in relation to stream or lake should preferably be parallel to the shoreline, but on flat land with minimal slope it may be necessary to enhance the drainage by directing water flow towards the shore. Site preparation towards the shore is most common in Finnish private forests (Figure 18, Figure 19). This may be explained by soil and terrain properties: Compared to state lands, Finnish privately-owned forests are mostly located in the less-eroding flatlands in the southern parts of the Torne river valley (see Table 1 on general characteristics). Since the general differences in slope and soil type are quite small between the count-

Table 9. Site preparation in state-owned and private forests in Finland.

Finland	None	Harrowing	Screefing	Mounding (shallow ditches)	Mounding (deep ditches)	Mounding (without ditches)	Ploughing
Private	12	35	15	13	8	0	17
State	4	37	27	24	0,3	7	0

Table 10. Site preparation in state-owned and private forests in Sweden.

Sweden	None	Harrowing	Screefing	Mounding (shallow ditches)	Mounding (deep ditches)	Mounding (without ditches)	Ploughing
Private	30	25	18	0	1,3	26	0
State	22	17	31	0	0	30	0

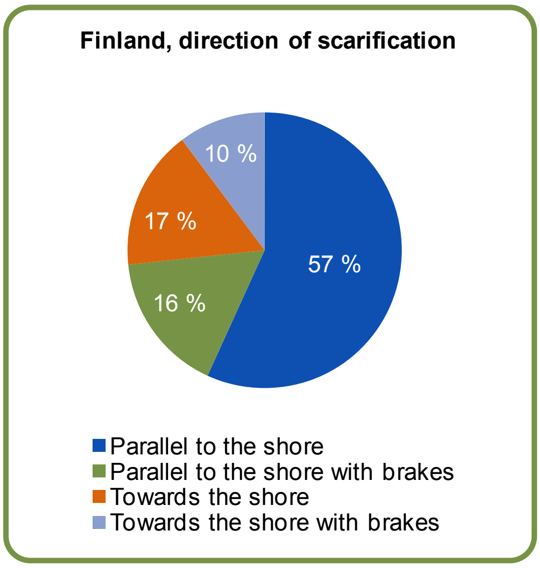


Figure 18. The implementation of scarification in Finland.

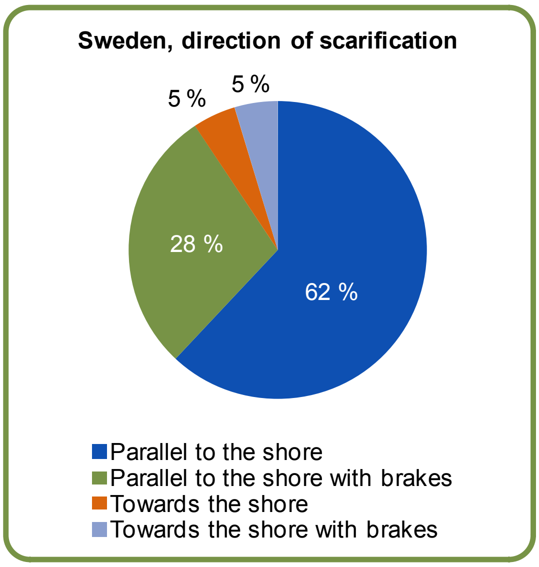


Figure 19. The implementation of scarification in Sweden.

ries (most inspected sites are located on areas with gentle slope and soil with fine to medium particle size), it seems that the guideline of carrying out scarification parallel to the shoreline is more scrupulously followed in Sweden.

Suitability of the site preparation method used was evaluated using expert judgement and taking into account soil and terrain properties. When assessing the suitability of the method, mainly the silvicultural point of view was considered. There is a significant difference between the countries (Figure 20 and 21). In Finland, the measures implemented are mostly deemed to be suitable for the site, whereas one quarter of Swedish sites were regarded as too lightly prepared. This result coincides with the large share of unprepared sites (27 %). These sites have mostly been assessed as being in need of heavier tilling. There is no notable difference between the state and private sectors in either country.

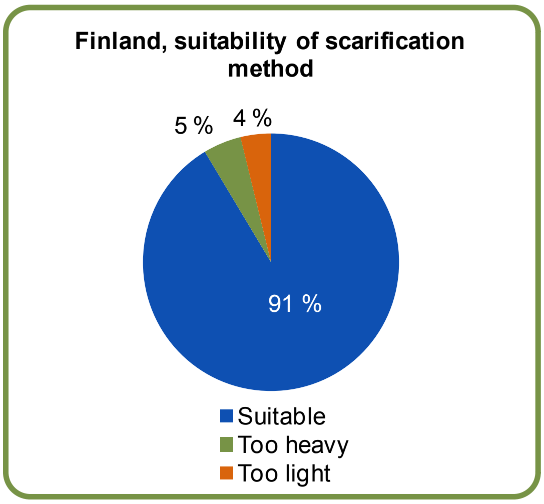


Figure 20. Assessed suitability of site preparation methods in Finland.

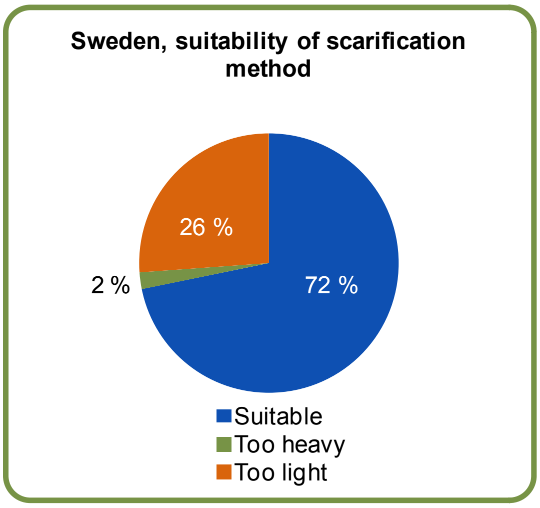


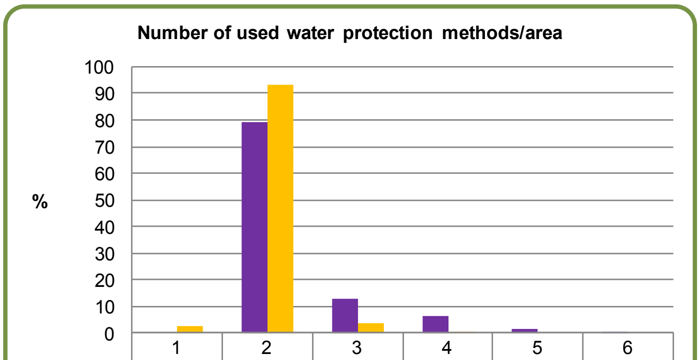
Figure 21. Assessed suitability of site preparation methods in Sweden.

Table 11. Number of sites with protective ditching in Finland and Sweden.

	State	Private	Total
Finland	27	16	43
Sweden	1	14	15

6.4 Protective drainage ditches

Protective ditching is more common in Finland, in Sweden it is rarely carried out (Table 11). In Finland it is more frequently used on state-owned land than on private land. Impacts were mainly assessed as “Small” in Finland, whereas “Moderate” and “Strong” impacts were estimated on half of Swedish sites. Keeping in mind the small role of protective ditching in Sweden, the overall impacts of the measure can be considered to be generally small.



	1	2	3	4	5	6
Finland	0,0	79,2	12,7	6,3	1,4	0,5
Sweden	2,5	93,4	3,7	0,4	0,0	0,0

Figure 22. Number of water protection methods/area used in Finland and Sweden.

6.5 Water protection methods

A buffer zone was the most common water protection method in inspected areas, and mostly the only one, especially in Sweden (Figure 22). Other structures, such as sedimentation pits and pockets and overland flows were used occasionally. Variability in the protection methods used was more common in Finland, where up to five different water protection methods were used in the same regeneration area.

6.6 Quality of water protection

The final assessment of the quality of water protection is a general evaluation of overall level of measures in the inspection area and sums up all the aspects of interest. The proportion of sites assessed as “moderate” and “poor” was clearly higher in Sweden. In Finnish areas “poor” classifications were lacking altogether (Figure 23, Figure 24).

The differences between forest owners were not very noticeable. “Satisfactory” classifications were more numerous in the Finnish private sector, when compared to state-owned forests. In Sweden, the “poor” grades are distributed quite evenly between the sectors (Table 12).

Although the subjective nature of the inspection methods may have had an influence on the evaluation of the general status of water protection, there seems to be a real difference between the countries. Care was taken to “calibrate” the methods with common field excursions in order to ensure the comparability of results between countries and actors. The observed short-comings of Swedish water protection measures seem to arise from problems with water crossings, and an unexpectedly large proportion of narrow buffers.

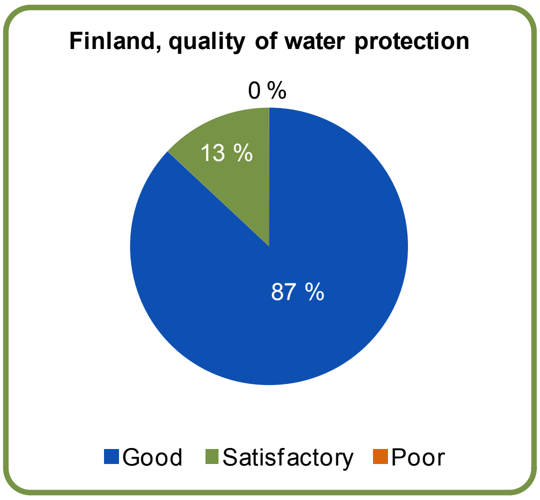


Figure 23. Classification of general status of water protection in inspected areas in Finland.

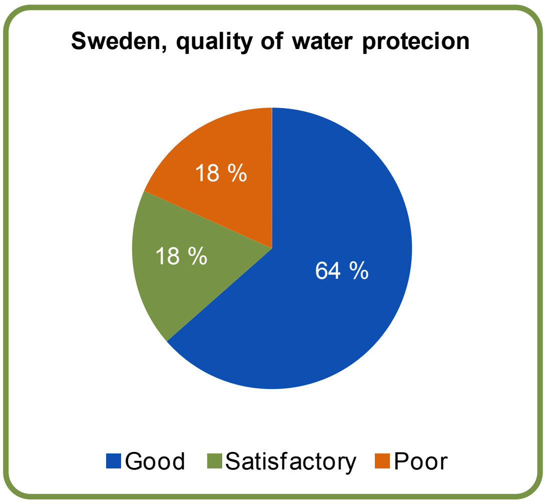


Figure 24. Classification of general status of water protection in inspected areas in Sweden.

Table 12. Classification of general status of water protection divided by forest owner.

	Good	Satisfactory	Poor
Finland			
Private	81	19	0
State	93	7	0
Sweden			
Private	67	14	19
State	57	26	17

7 Summary in english

In terms of space forestry has the greatest human impact affecting surface waters in Northern Scandinavia, and is a prominent source of diffuse pollution in the Torne river basin. Among the forestry activities, draining of peatlands, site preparation and clear-cuttings have had the most pronounced impacts on sediment, nutrient, and the metal loading of surface waters. Contemporary forestry aims to reduce this risk by using various water protection measures, such as riparian buffer strips and sedimentation pool designs. Although the first Swedish and Finnish guidelines and recommendations for water protection measures in forestry were published in the 1980s, it has taken some time to realize these recommendations in the field. TRIWA III -project gave us the opportunity to compare forestry methods between Sweden and Finland, and through field inspections to understand how water protection is taken into account in forestry practices on either side of the border river.

The protective buffer areas left on the shoreline of streams were generally wider in Finnish areas with regeneration cutting and site preparation. Further, buffer strips were frequently wider in forests owned by the Finnish state (Metsähallitus) when compared to the private sector. The share of buffers narrower than the recommended minimum width of five metres was notably higher in Sweden, whereas the minimum was generally followed in Finland. Overall effectiveness of buffers in preventing erosion and sediment leakage was good in both countries, although the number of poorly functioning buffers was higher in Sweden. The majority of buffers (c. 90 %) were left uncut, even though guidelines in both countries allow careful thinning and harvesting of the buffer area.

Water crossings (i.e. bridges, fords, driving tracks) in streams proved to be very problematic for water protection in Sweden. The recommendations in both countries encourage forestry actors to use temporary bridges and to reinforce shore banks at crossing sites, but these guidelines were often not complied with in Swedish forestry areas, either in public and private sectors. In Finland, guidelines were more scrupulously followed, and temporary bridges and bank reinforcements were routinely used. Furthermore, in Finland the transport of logs and even site preparation were conducted using winter roads when possible. Use of winter roads for forwarders and site preparation equipment efficiently prevents the creation of eroding driving tracks. These differences in national customs lead to significant differences in observed impacts (erosion and sedimentation of streams) between the countries. Moderate or strong impacts were observed on 18 % of inspected sites in Sweden, whereas in Finland only moderate erosion was detected on 8 % of inspection areas.

Site preparation practices differed somewhat between countries. Heavier methods, such as ploughing and mounding using deep ditches were preferred in Finnish privately-owned forests. This may be explained by the fact that private forests are mostly located in flat lowlands in the southern parts of the Torne river valley. The need for more effective drainage in these areas may also explain why, in Finland, the scarification grooves are more often directed towards the shore instead of following the contour lines, which is the method preferred in Sweden. In Sweden, site preparation had not been carried out in a quarter of inspected sites, although the measures should be conducted within three years of regeneration cutting. This can partly be explained by more frequent use of prescribed burning as a regeneration method in Sweden.

Protective buffer zone was the most common and often the only water protection measure applied in inspection areas. In Finland, the variety of methods used was somewhat more diverse than in Sweden, and ditch breaks, sedimentation pits and -pools were used in erosion-sensitive areas. The overall status of water protection in the field was mainly good in both countries, but the observed short-comings with water crossings and buffer widths raised the share of sites with a “poor” level of water protection in Sweden. The result of TRIWA III’s inspection shows that guidelines and recommendations concerning forestry’s water protection are nowadays mainly followed in practice on both sides of border. However, there is still room for improvement, and constant quality control is needed to maintain the good quality level.

Keywords: Forestry, Water protection, Buffer zone, Erosion

8 Summary in swedish

Skogsbruk har utan tvekan den största påverkan på ytvatten i norra Skandinavien och är den mest framträdande källan av diffus miljöpåverkan i Torne älvens vattenavrinningsområde. Exempel på sådana skogsbruksaktivitet som har den mest uttalade påverkan på sedimentering, näringsläckage och metallutlakning i ytvatten är dikning av våtmarker, gallring, föryngringsavverkningar och markberedning av föryngringsytor. Dagens skogsbruk vill minska risken genom olika vattenskyddsmetoder som exempelvis genom skyddszoner mot vatten och genom olika sätt att förhindra sedimentering som gropar, bassänger eller översilningsområden. Trots att det både i Finland och Sverige finns olika policys och rekommendationer för hänsyn till vatten som redan publicerades på sent 80– eller tidigt 90-tal så har det tagit tid att förverkliga dem ute i fält. Triwa III har gett oss tillfälle att jämföra olika skogliga metoder mellan Finland och Sverige genom att i fält besöka olika föryngringsytor och se hur skogsbruket på bägge sidor älven tar hänsyn till vatten.

Skyddszonerna som lämnades kvar på strandkanterna mot bäckarna var generellt sett bredare på de finska ytorna, med föryngringsmetoden markberedning och plantering, än vad de svenska var. Dessutom var de bredare på statligt ägd mark än privat. Andelen ytor med skyddszoner smalare än fem meter var fler i Sverige än i Finland. I Finland följdes regeln om att inte ha smalare skyddszon än fem meter mycket bra. Skyddszoner för att förhindra erosion och sedimentering var i bägge länderna mycket bra, trots att antalet ytor med betyget dålig funktion av zon var mycket högre i Sverige. Majoriteten av skyddszoner (ca 90 %) var orörda, trots att det är tillåtet i bägge länderna med försiktig gallring och avverkning i skyddszonen.

Överfarter (exempelvis broar, traktorvägar, skotarvägar mm) över bäckar visade sig vara ett stort problem för hänsyn till vatten i Sverige. Rekommendationerna i båda länderna uppmanar skogsbruket att använda sig av tillfälliga broar samt risa och kavla på- och avfarter. I Sverige har man inte på de inventerade ytorna använt sig av dessa rekommendationer, varken inom det privata eller det övrigt ägda skogsbruket. I Finland har man följt rekommendationerna och tillfälliga broar och riskavling har använts rutinmässigt. I Finland används även vintervägarna till att transportera virke och markberedare (det markbereds även vintertid på svårtillgängliga områden) så att markberedaren inte lika ofta behöver passera vattendrag under barmark som det ofta görs i Sverige med spårbildning och sedimentation som följd. De här nationella skillnaderna ger signifikanta skillnader i observerad påverkan på vattendrag, genom sedimentering och erosion, mellan länderna. Betyget, måttlig eller dåligt, var i Sverige observerade på 18 procent av de inventerade ytorna medan det i Finland endast var måttlig erosion på 8 procent av de inventerade ytorna.

Det skiljer mellan länderna i vilka metoder av markbehandling man väljer. I Finland använder man sig av generellt sett kraftigare metoder som plöjning och högläggning med djupa diken som inte förekommer i Sverige. Dessa metoder var vanligare inom de finska privatägda skogsbruket. Det kan troligen förklaras genom att privatskogsbruket i Finland har sina marker inom låglänta och icke erosionskänsliga marker i den södra delen av Tornedalen. Behovet av kraftigare dränering av markerna förklarar kanske varför det även är vanligare med markberedningsfåror som går mot vattendraget istället för parallellt mot vattendraget som är vanligare i Sverige. I Sverige visade det sig att en fjärdedel av ytorna inte var markberedda och föryngrade trots att Skogsvårdslagen kräver att de ska vara föryngrat efter tre år. I Sverige förekom även bränning som markbehandlingsmetod på de inventerade ytorna

Skyddszon mot vatten var den vanligaste och oftast den enda vattenskyddsåtgärden som användes på de inventerade ytorna. I Finland använde man sig av fler och varierande vattenskyddsmetoder än i Sverige som dikesavbrott, sedimenteringsgropar och bassänger som användes i erosionskänsliga områden. Det slutliga omdömet var i huvudsak bra i bägge länderna. De ytor som gav dåligt slutomdöme i Sverige var de med för smala skyddszoner och dåliga överfarter.

Resultatet av Triwa III´s inventeringar visar att policys och rekommendationer av skogsbrukets hänsyn till vatten ofta följs i praktiken på bägge sidor om gränsen. Det finns dock utrymme för förbättringar och ständiga kvalitetskontroller är nödvändiga för att bibehålla en hög nivå.

Nyckelord: Skogsbruk, vattenskydd, Skyddszon, Erosion

9 Summary in finnish

Metsätalous on pinta-alaltaan suurin Pohjois-Skandinavian pintavesiin vaikuttavista ihmistoiminnan muodoista, ja merkittävä hajakuormituksen lähde myös Tornionjoen valuma-alueella. Metsätaloustoimista suometsien ojituksilla, maanmuokkauksella ja avohakkuilla on ollut voimakkaimmat vaikutukset vesien kiintoaine-, ravinne- ja metallikuormitukseen. Nykyisin metsätaloudessa pyritään aktiivisesti vähentämään vesistöihin kohdistuvia paineita esimerkiksi suojavyöhykkeiden ja erilaisten eroosion hallintakeinojen avulla. Ensimmäiset ruotsalaiset ja suomalaiset kansalliset metsätalouden vesiensuojeluohjeet- ja suositukset julkaistiin 1980-luvulla, mutta ohjeiden saattaminen käytäntöön on vienyt aikaa. TRIWA III -projekti tarjosi meille mahdollisuuden vertailla Suomen ja Ruotsin metsätalouskäytäntöjä, ja selvittää maastotarkastuksien avulla, kuinka vesiensuojelu otetaan metsätaloudessa huomioon rajajoen molemmin puolin.

Projektin tulosten perusteella virtavesien varsille jätetyt suojavyöhykkeet olivat yleensä leveämpiä suomalaisilla uudistushakkuu- ja maanmuokkauskuvioilla. Suojavyöhykkeet olivat myös leveämpiä Metsähallituksen hallinnoimissa valtion metsissä yksityiseen sektoriin verrattuna. Suositusten mukaista minimileveyttä (5 metriä) kapeampien suojavyöhykkeiden osuus oli huomattavan korkea Ruotsissa, kun taas Suomessa suosituksen minimileveyttä pääosin noudatettiin. Suojavyöhykkeiden tehokkuus eroosion ja kiintoainekuorman ehkäisemisessä oli kummassakin maassa hyvä, joskin huonosti toimivien vyöhykkeiden määrä oli korkeampi Ruotsissa. Suurin osa suojavyöhykkeistä (n. 90 %) oli jätetty hakkaamatta, vaikka kansalliset ohjeistot sallivatkin varovaisesti tehdyn harvennus- ja uudistushakkuun.

Virtavesien ylitykset (sillat, kahlaamot, ajourat) osoittautuivat vesiensuojelullisesti ongelmallisiksi Ruotsissa. Kummankin maan vesiensuojeluohjeet suosittelevat tilapäisten siltojen käyttöä ja rantapenkkojen vahvistamista purojen ja jokien ylityksen yhteydessä. Ruotsissa nämä ohjeet oli usein jätetty huomiotta sekä valtion, että yksityisten omistamissa metsissä. Suomessa ohjeistoa noudatettiin tunnollisemmin, ja tilapäisiä siltoja käytettiin rutiininomaisesti. Lisäksi puunajo ja mahdollisuuksien mukaan myös maanmuokkaus pyrittiin Suomessa toteuttamaan talviteitä siirtymiseen käyttäen. Erot kansallisissa käytännöissä ilmenivät merkittävänä maiden välisenä erona havaittujen vaikutusten (eroosio ja jokipohjien sedimentoituminen) voimakkuudessa. Kohtalaisia tai voimakkaita vaikutuksia havaittiin Ruotsissa 18 %:lla tarkastuspaikoista, kun taas Suomessa vain kohtalaisia vaikutuksia oli havaittavissa kahdeksalla prosentilla tarkastuskohteista.

Käytetyt maanmuokkausmenetelmät erosivat jonkin verran maiden ja omistajatahojen välillä. Suomen yksityismailla suosittiin raskaampia menetelmiä, kuten metsäaurausta ja ojitusmätästystä. Tämä saattaa selittyä sillä, että suurin osa Tornionjokilaakson yksityisistä metsämaista sijaitsee tasaisilla alamailla alueen eteläosissa. Näiden alueiden suurempi kuivatustarve selittää luultavasti myös sen, miksi muokkausvaot ja -ojat suunnattiin Suomessa Ruotsia useammin kohtisuoraan ranta-aluetta kohti, kun taas korkeuskäyrien suuntaista muokkausta suositellaan kansallisissa ohjeistoissa. Ruotsissa maanmuokkaus oli tekemättä neljänneksellä tarkastuskohteista, vaikka lain mukaan metsänuudistamistoimenpiteet tulisi toteuttaa kolmen vuoden sisällä uudistushakkuusta.

Suojavyöhykkeet olivat yleisin ja yleensä ainoa tarkastusalueilla käytetty vesiensuojelumenetelmä. Suomessa käytettyjen menetelmien valikoima oli Ruotsia hieman laajempi, ja eroosioherkillä alueilla oli käytetty ojakatkoja ja kaivettu lietekuoppia ja -altaita. Kokonaisuutena toteutuksen taso oli kummassakin maassa hyvä, mutta Ruotsissa havaitut puutteet ylityspaikkojen ja suojavyöhykkeen minimileveyden osalta nostivat vesiensuojelultaan huonoiksi arvioitujen tarkastuspaikkojen määrää. TRIWA III -hankkeen hakkuualuetarkastusten tulokset osoittavat, että metsätalouden vesiensuojelulle laaditut ohjeet ja suositukset otetaan pääosin huomioon hakkuita ja maanmuokkauksia suunniteltaessa ja toteutettaessa. Suunnitelmia ja toteutusta voidaan kuitenkin vielä parantaa, ja metsätalouden vesiensuojelun hyvän tason ylläpito edellyttää toimijoiden säännöllisesti toteuttamaa laadunvalvontaa.

Avainsanat: metsätalous, vesiensuojelu, suojavyöhyke, eroosio

Acknowledgements

We are grateful to everyone who worked on the project; their contribution made this effort possible. Most people were involved in the forestry task throughout the duration of the project. The field work was carried out by Mariana Jussila, Maria Johansson, Jukka Vähätaini, Timo Tahvonen and Johanna Räty. Their efforts during the field seasons in 2011–2012 produced a good and solid data for the analysis of the results. The analysis and reporting was conducted by Mariana Jussila, Petri Liljaniemi, Lauri Karvonen and Magnus Johansson. The text and images were processed by Ritva-Liisa Hakala and Hannu Lehtomaa. Coordination of funding in partner organizations was managed by Magnus Johansson (County Administrative Board of Norrbotten), Marko Kangas (Centre for Economic Development, Transport and the Environment for Lapland), Lauri Karvonen (Metsähallitus) and for Suomen Metsäkeskus by Ari Keski-Mölö and Ulla Huusko. Thank You!

Literature

Cederstam, B. 1978. Norrbotten - Landet annorlunda. Skogsvårdsstyrelsen Norrbottens län.

Eriksson, I. 2013. Skogshistoriska sällskapets årsskrift 2013. Danagård LiTHO Ödeshög.

Joensuu, S., Kauppila, M., Lindén, M. & Tenhola, T. (eds.) 2013: Hyvän metsänhoidon suositukset- Vesiensuojelu (Guidelines to good forestry. Water Protection). Metsätalouden kehittämiskeskus Tapion julkaisuja, 78 s. Metsäkustannus oy. ISBN 978-952-6612-05-8.

Korhonen, K-M., Laamanen, R. & Savonmäki, S. (eds.) 1998: Environmental Guidelines to Practical Forest Management. – Forest and Park Service 1998. Oy Edita Ab, Helsinki. ISBN 952-446-102-1.

Päivinen, J., Björkqvist, N., Karvonen, L., Kaukonen, M., Korhonen, K-M., Kuokkanen, P., Lehtonen, H. & Tolonen, A. (eds.) 2011: Metsähallituksen metsätalouden ympäristöopas (Environmental guidelines for forestry in Metsähallitus). Metsähallituksen metsätalouden julkaisuja 67. 162 s. ISBN 978-952-446-924-1.

Appendix

Appendix 1a. Field Protocol for Regeneration cutting and site preparation area inspections, page 1.

TRIWA III Inspection of clear-felling and scarification areas

Country	Land owner (1, 2)
Date	Inspector
Name/Code of the stand	
Area (ha)	Municipality
Year of clear-felling	Year of scarification
Effective area (% of tot. Area)	

General characteristics

Length of waterfront (m)	Slope (1-3)		
Peatland/Mineral	Soil type (1-3)		
Thickness of peat layer (1-3)	Moisture (%) 1:	2:	3:
Water level in stream (1-3)			

Buffer characteristics

Mean width (m)	Length (m)			
Length of buffer < 5m wide (m)	Shading (0-3)			
Functioning of buffer (1-3)	Measures on buffer	1.	2.	3.
	%			
Description of causes of problems:				

Water crossings (forest roads, fords)

Impacts (1-3)
Description of construction and impacts

Scarification

Methods (1-7)				Distance from the shore (m)
%				
Suitability of the method (1-3)	Direction (1-4)			
Description of the impacts:				

Protective drainage ditches

Depth (m)	Direction (1-3)
Description of the impacts:	Impact (1-3)

Appendix 1b. Field Protocol for Regeneration cutting and site preparation area inspections, page 2.

Water protection measures

Implemented measures
Recommended measures

Final assessment

Quality of water protection measures (1-3)

Comments

REPORT 72 | 2014
TRIWA III-FORESTRY TASK
WATER PROTECTION IN REGENERATION CUTTING AND SITE PREPARATION AREAS
GUIDELINES AND PRACTICES IN THE FIELD

Centre for Economic Development, Transport and the Environment for Lapland

ISBN 978-952-314-094-3 (PDF)

ISSN-L 2242-2846
ISSN 2242-2854 (web)

URN URN:ISBN:978-952-314-094-3

www.doria.fi/ely-keskus | www.ely-keskus.fi

Länsstyrelsen Norrbotten

METSÄHALLITUS
FORSTSTYRELSEN

SKOGSSTYRELSEN
SWEDISH FOREST AGENCY

metsäkeskus
skogscentralen

Gränslösa möjligheter

EUROPEISKA UNIONEN
Europeiska regionala utvecklingsfonden

INTERREG
IV A NORD