Major forest companies and owner associations interpretation of policies and certification programs regarding riparian buffer zones

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Major forest companies and owner associations interpretation of policies and certification programs regarding riparian buffer zones

Större skogsaktörers tolkningar av policy och certifieringsprgram gällande kantzoner till vattendrag

Eric Lundström

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Abstract

Human intervention in forests such as clearcut forestry have a negative impact on water quality and biodiversity. To maintain water quality and its biological values a commonly used method is to leave trees and shrubs closest to the water, in so called a buffer zone. For riparian buffers to maximize their crucial services, buffer zone widths of at least 30 m have been recommended by research. However, in Sweden, riparian buffers are much thinner, especially along small streams, which rarely have buffers over 5 m. To comprehend the underlying factors for the miss match, the focus of this thesis was to analyze both the Swedish buffer zone policy and how major forestry actors had interoperated the policy. The analysis of the actor's interoperations was done through analyze the actor's internal guidelines for buffer zone management. The result indicates that the prevailing policy mix in Sweden, allows actors the flexibility to interpret the policy in accordance with their specific objectives, rather than aligning with evidence-based research. The analysis of the actor's interoperations supports the results of the policy analysis but do also show that the interoperations of the buffer zone policy vary between actors, while some actors do not establish internal guidelines, which can explain the variation in buffer zone implementation in Sweden.

Keywords: Buffer zone, Water quality, Buffer zone policy, Forestry, Policy Interpretation

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1. Introduction

In forestry, protection of the riparian, stream-side forest in a "buffer zone" has become an accepted method to reduce the impact of adjacent forest harvest on waterways (Ring et al., 2018; Thorell & Götmark, 2005). The riparian forest is defined as the vegetation closest to the streamside while the buffer zone is a defined distance from the streamside where human interventions are restricted to protect the functions of the riparian forest (Naiman & Decamps, 1997). By creating a buffer zone, six vital functions of the riparian forest can be preserved, including, stabilizing the banks to reduce sediment and nitrate transport (Haycock & Pinay, 1993; Lowrance, 1992; Peterjohn & Correll, 1984), preserving biodiversity through maintaining the connectivity for species and supplying deadwood (Marczak et al., 2010; Meyer et al., 2007; Stokland, 2012), maintaining water temperature through shading (Gomi et al., 2006), providing food for aquatic organisms through litter (Berggren et al., 2009) and conserving important soil chemical processes (Gundersen et al., 2010). Those functions have been recognized by the Swedish Forestry Agency (SFA) through policy as a foundation of preserving water and must therefore be taken into consideration when carrying out forestry actions (Andersson et al., 2013)

Unfortunately, there is still a gap between scientific research and the implementation of riparian buffers in practice in the forestry context. Research shows that to maintain all of the riparian buffer zone functions at pre-harvest levels, a width of 30 m is recommended (Sweeney & Newbold, 2014). Some functions can be preserved with narrower buffers, such as sediment transport, but the risk of not supporting all functions increases. However, research state that the function of biodiversity is not supported by buffers with a width of around 10 m (Broadmeadow & Nisbet, 2004; Kuglerová et al., 2023; Sweeney & Newbold, 2014). Recent studies have shown that the average riparian buffer zones of Swedish production forests are much thinner than the width recommended by scientific literature. However, there is a variation between natural streams, modified streams, and lakes, where lakes often have buffer zones of around 10 m, while streams, both natural and modified, have between 4.0 m and 6.6 m (Kuglerová et al., 2020; Ring et al., 2022). This has also been recognized by SFA which documented that one-third of all waters in Swedish forest landscapes lacked buffer zones (Skogsstyrelsen, 2022b). And there is some evidence to show that the majority of larger streams do have buffer zones, while smaller streams are far less protected (Hasselquist et al., 2020; Kuglerová et al., 2020). Nevertheless, the majority of Sweden's waterways are headwaters, smaller streams and mires that connect to larger waterways (Bishop

et al., 2008). Those small waterways are both important for biodiversity and water quality when they host habitats for endemic species and are connected to larger lakes, streams and rivers (Bishop et al., 2008).

In Sweden, there is a long history of modifying natural streams and smaller waterways, which could also contribute to why not all waters are protected (Hasselquist et al., 2020). In research from Laudon et al. (2022) they found that 67% of all waterways in Sweden are human-made, out of a total of one million kilometers. This can be both ditches and natural waterways that are modified (deepened and straightened). The Swedish policy does not clarify which waterways should have buffer zones. Still, there is a divided opinion between researchers, bureaucrats and commercial forestry representatives on how and if ditches should be protected (Mancheva, 2021). Consequently, just a small fraction of ditches are currently protected with an average of buffer width of only 1,5 m (Ring et al., 2022).

The attainment of management goals for natural resources is dependent on the so-called "policy mixes" put in place (Rogge & Reichardt, 2016) and the lack of protection of waterways, both natural and modified, could be explained, at least in part, by Sweden's soft forestry policy approach. The compulsory Swedish Forestry Act functions as a minimum requirement while more specific guidelines are non-legislative policy instruments (Hasselquist et al., 2020). A result of this soft forestry policy is that the protection of the environment is very dependent on voluntary measures. The Forestry Act states that a riparian buffer must be present and that it should maintain the ecological functions of the riparian zone. However, it does not describe details of how riparian buffer zones should be designed (including minimal buffer width). The Strategic Objectives (SOs and in Swedish, *skogssektorns gemensamma målbilder*) (Andersson et al., 2013) for nature considerations are considered by the forestry actors and SFA as an important instrument for guiding how forestry protects natural values during their work (Mancheva, 2021). The SOs for riparian buffer zones defines the buffer zone functions and to some extent how to operate in practice to preserve them but leave room for own interpretation. For example, the way the policies are written (including SOs) it is unclear which waterways (natural, modified or created) should have buffer zones or how wide the buffer zone should be in order to maintain all buffer zone functions. Moreover, they are only recommendations without any specific targets that can be measured and monitored over time, leaving practitioners to decide where and how in the landscape to place buffers. This likely leads to large differences in the amounts of productive forest conserved within riparian buffers and in turn the level of protection that our water resources are given.

2. Aim

This thesis aims to better understand why there is a gap between scientific research that points towards the ecological importance of wide buffers and the implementation of riparian buffers in Swedish forestry practice. I will identify and summarize how the major Swedish forest actors interpret policies and certification programs that should be applied to the management of riparian buffers. Further, I will explain how the currently applied policy mix affects the implementation of riparian buffers in practice. I ask the following research questions:

1. How is the policy mix affecting the implementation of riparian buffer zones?
2. How does the interpretation of policies and certification programs differ between different forest management actors, i.e., companies and owner associations?
3. Do the forestry actors specify how wide buffer zones should be and are stream size or degree of naturalness (i.e., ditches or straightened streams) a consideration when determining how and when to leave a riparian buffer, if yes how?

3. Background

Sweden introduced its first Forestry Act in 1903, which made it compulsory to replant forests after clear-cutting. Today's soft forestry policy can be traced back to this act, which set the foundation for the "freedom under responsibility" on which today's Forestry Act leans. This implies that the forest owner can set their own goals for their forest if they follow the minimum requirements regarding replanting and environmental protection (Ekelund & Hamilton, 2001). The Swedish environmental laws were revised in the 1990's thereby also the forestry regulations through the 1993 Swedish Forestry Act. With the revised Forestry Act, production goals became equal to environmental goals, which means that it is just as important that forest owners get revenue from their forests as it is to preserve healthy nature for the future (Ekelund & Hamilton, 2001). During this time the Swedish environmental goals were also introduced and which today is an important framework for the Swedish environment work (Naturvårdsverket, 2022).

As a result of societal demands in late 1990, the Forest Stewardship Council (FSC) and Program for Endorsement of Forest Certification (PEFC) were introduced in Sweden. The certification programs were quickly accepted by Swedish forest owners in an effort to try to maintain market shares in Europe, which during that time had a strong environmental movement (Hasselquist et al., 2020). Both certification programs have higher requirements than the law in Sweden and have therefore been described as a type of "market-based regulation" (Cashore et al., 2004) due to the voluntary participation and the potential great impact on forest practices.

The regulations to preserve water quality got strengthened with the EU Water Framework Directive in 2000 (WFD, 2000). The WFD aims to achieve "good chemical and ecological status" for all waters by establishing a management system for water basins, streamlining legislation and management of waters. However, the WFD does not explicitly mention buffer zones (EC, 2000) and fails to establish rules and recommendations for buffer zones (Urbanič et al., 2022). Within the WFD, buffer zones are perceived as a tool to protect waters rather than a feature to be protected (Rodríguez-González et al., 2022). SFA got the responsibility to ensure that the legal requirements of the WFD connected to forestry are followed. The SFA

presented the first action program for implementing the WFD in 2008 (Hasselquist et al., 2020). Soon after, in 2010 SFA included water quality into the Forestry Act through new recommendations that were based on already used practices, such as the riparian buffer zones (Hasselquist et al., 2020).

In follow-up work done by the SFA in the early 2000s, it became clear that the Swedish state and forestry actors did not share the same view on environmental consideration (Skogsindustirerna, 2016). To bring the parties' views closer together, a working group was established consisting of representatives from the SFA, forestry stakeholders and non-profit organizations, the result was the SOs. The SOs are recommendatory policies, however, they are to a larger degree implemented when the FSC states that they must be followed (FSC, 2019). Regarding buffer zones, the SOs set up guidelines for how to manage buffer zones to maintain their functions (Skogsindustirerna, 2016), but do not state in which level the functions should be maintained. The forestry sector has, based on the SOs and research, among others, created an educational hub (Skogsskötselskolan, 2023) that is mandatory for all employees and entrepreneurs working for most of the larger forestry actors to complete. This is seen as an attempt to standardize and ensure good forestry practices.

4. Material and method

4.1 Approach

This study employed a dual analytical approach, that included two distinct, yet complementary analyses. Firstly, to explain which underlying effect the policy has on buffer zone implementation, a policy analysis was carried out. The policy analysis was based on Rogge & Reichardt (2016) theoretical framework for analyses of complex policy mixes. Secondly, an analysis of the internal guidelines of forestry actors was conducted based on a qualitative questionnaire to explore how Swedish buffer zone policy are influencing these actors and subsequently impact the implementation of buffer zones.

4.2 Theoretical framework

The theoretical framework used in the policy analysis is based on the work of Rogge & Reichardt (2016). Using their theoretical framework allows for a systematic analysis of the different components in a policy mix. According to Rogge & Reichardt (2016) each policy mix has its *Policy characteristics,* that include the policy process and the policy *Elements* (Figure 1). First, the *policy characteristics* describe the *policy mix*. Example of *characteristics* is how comprehensive the mix is, the credibility (i.e, how much it is believed to succeed related to its purpose) and the coherence of the process that relates to how synergistic and systematic the policy process was. The *characteristics* can help to describe the performance of a policy mix and how effective it is. Secondly, the *Policy process* includes policy-making and implementation and involves political problem-solving. Finally, the third component is the *Elements which* include the policy strategy that sets the objectives and the principal plan for how to reach the objectives. The *Elements* also include the instrument mix that includes all policy instruments used to reach the objectives, such as the SOs. Since the focus of this study is on the internal guidelines of forestry actors and how they interpret and implement EU and national policies to reach their goals, the *Policy processes get* irrelevant to the aim of this study. The

aim mainly concerns the *Elements,* and it will therefore be further described and operationalized further.

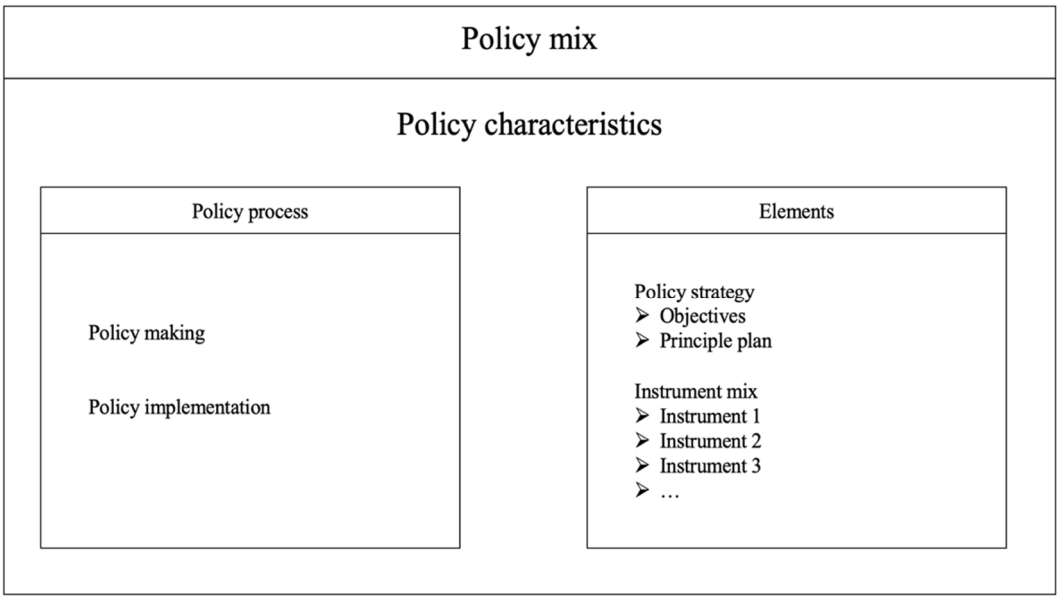


Figure 1. Description of the Policy mix concept developed by Rogge & Reichardt (2016) with its three components. The Policy characteristics help to describe the performance of a Policy Mix. The Policy Process describes the making and implementation of the Policy Mix. The Elements include the overarching Policy Strategy with the objectives and the principle plan for how to reach them. The Elements also include the instrument mix that describes the instrument used to implement the policy (e.g., fines).

The *Elements* can be divided into an overarching policy strategy and *Instrument mix*. The overarching policy strategy which consists of two components, the *Objectives* and the *Principle plan*. The *Objectives* can be associated with the long-term goal that the policy aims to reach. The *Objectives* tend to have multiple aims such as environmental outcomes, economic growth, job-generating objectives, etc. (Rogge & Reichardt, 2016). In some cases, the different objectives can conflict with each other such as economic and ecological objectives (Cashore et al., 2004). The second component of the overarching *Policy strategy* is the *Principle plans* that governments intend to use to reach the *Objectives*, this includes framework conventions, guidelines, strategic action plans and roadmaps (Rogge & Reichardt, 2016).

The second component of the *Elements* is the *Instrument mix* that consists of *policy instruments*, or "tools" used to achieve the *Objectives*. The *Instruments* can be divided into three types: economic (taxes, subsidies, market design, etc.), regulation (laws, rules, recommendations, etc.) and information instruments. While the regulation instruments can be seen as the foundation of the *Policy mix*, the economic and information instruments complement regulations by guiding and regulating stakeholder actions. When instruments are combined, we get the instrumental mix (Rogge & Reichardt, 2016).

In this study, the SOs are considered as the *policy strategy* which provides the objectives, and the principle plans for achieving those objectives. Since forests are softly regulated in Sweden and the bulk of responsibility for management practices lies with forest owners (Appelstrand, 2007), the instrument mix will be analyzed by looking into the forestry act (Skogsstyrelsen, 2022a), certification schemes (FSC, 2019; PEFC, 2017) and the SOs (Andersson et al., 2013). In that manner, the study will analyze how the *Policy mix* (*Policy strategy* and *Instrument mix*) have affected the implementation of riparian zones in Swedish forests.

4.3 Policy analysis

One of the objectives of this study was to analyze how the Policy mix affects the implementation of riparian buffer zones. This analysis was based on policy documents, legal texts, expert knowledge, and scientific literature. The starting point for the data collection was to identify these policy documents, legal texts and scientific literature connected to forest buffer zones on both the EU level and the national level. By using word search in google scholar I was able to identify relevant scientific literature that contributed to my analysis. To find policy documents and legal text, expert knowledge within the subject was used combined with an extended internet search.

The policy analysis was based on (Rogge & Reichardt, 2016) policy analysis framework that was produced to analyze complex and dynamic policy mixes that apply to a field of transition, such as the green transition. I used this framework to analyze buffer zone policy due to its ability to categorize and map the different *Elements* in the policy mix. In the progress of my research, I recognized that some parts of the framework were of no use to answer the aim. For example, how the policy is created and how it is implemented are not as relevant as the *Elements,* which can explain some of the underlying factors of the implementation of buffer zones. Therefore, I choose to only focus on the *Elements* of the policy mix. The *Elements* provided the conditions to analyze what in the policy mix is affecting the implementation of the buffer zones.

4.4 Analysis of Internal Guidelines

More than 50% of Sweden's forests are owned by private owners, and an additional 25% by privately owned companies (Helander, 2015). Many private owners belong to one of three major owner associations. I selected participants based on the criterion that the actor possesses a significant share of the management of Sweden's forests. Unlike individual forest owners and smaller forestry actors, the larger

forestry actors administer a substantial portion of Sweden's forests with shared guidelines, making them an excellent group to study. A criterion to contribute to this study was that the forestry actor either owns a large proportion of Sweden's forests distributed in several regions or sells services to individual forest owners to help them manage their forests in several regions. Some of the participating actors (e.g., privately owned forestry companies) both own forests and sell their forestry services to individual forest owners or other actors that own forests e.g., municipalities among others. Therefore, major forest companies, organizations that own larger amounts of forests, and owner associations were contacted.

A total of twelve actors were invited to participate in this research, with eight providing responses. The non-participating actors responded either that they had time constraints or did not respond when contacted. To get as many participating actors as possible and to create an objective study all answers in this study are anonymous. All collected data were coded and if the actor was cited in the text no names were used. All actor's guidelines are written in Swedish, so all direct citations were translated into English by me.

To address my research objective concerning the interpretation of buffer zone policy among forestry actors, internal guidelines were deemed the most appropriate data source. The assumption was that all actors had internal guidelines and that, in a clear and structured way, explains how the actors interpreted the SOs. In the progress of the data collection, it became clear that not all actors had internal guidelines. Even though half of the actors lacked internal guidelines, I continued with the analysis as it still contributed to addressing my questions. However, I then chose to also investigate how, or which material the actors without guidelines used. All data was collected through email correspondence with the actors (2023-02).

A structured questionnaire was developed to collect standardized data. Based on both ecological factors and the SOs, 31 questions were written with multiple-choice answers to make quantitative analyses possible (Appendix 1). To get an overarching perspective over forestry actors' interpretations of buffer zone policy the quantitative perspective seemed to best fulfill the aims of my study. These questionnaire questions were then answered based on the forestry actor's internal guidelines by me. If a question could not be answered from the guidelines, I followed up the question via email to directly ask the forestry actor. While I waited for responses from the actors, I realized that the quantitative method sometimes missed certain formulations that the actors had made in the guidelines. Therefore, when I present the results in the text, some further qualitative formulation from the internal guidelines is included to give the overall perspective.

5. Results and discussion

5.1 Elements connected to buffer legislation

EU legislation typically sets an overarching framework for the policy *Elements* (de Boon et al., 2021). However the EU has failed to integrate specific legislation on buffer zones into policies (Urbanič et al., 2022), thus, EU legislation has not directly affected Swedish national forest buffer zone policy to a greater extent. The following policy analysis will therefore focus on Swedish national policy and will describe the *Elements* that include the *Policy strategy* that sets the objectives and the *Principle plan* for how to reach the objectives.

5.1.1 Policy strategy for riparian buffer management

At the Swedish national policy level, the overarching framework is set by the Swedish environment goals (Naturvårdsverket, 2022) and the forestry act (Skogsstyrelsen, 2022a). The Swedish environmental goals set the national overarching goals for the environmental policy with its 17 goals, 9 of which can be connected to the functions of the riparian forest and buffer zones. The forestry act can be described as having dual, and often conflicting objectives; the environment and the production goals (Skogsstyrelsen, 2022a). The environment goal aims to secure the forest's natural production and to secure the biodiversity of the forests meanwhile the production goal aims to secure good financial returns and give the forest owner the freedom to choose how to manage their forest. However, these goals are not directly mentioning buffer zones and are centered more generally on water quality and biodiversity and can therefore not be seen to set the *Policy strategy*. The *Policy strategy* is thereby set through the recommendatory SOs (Andersson et al., 2013).

5.1.2 Objectives and Principle plan for riparian buffer management

The *Policy strategy* includes the *objectives* and the *Principle plan* (*Figure 2).* The *Objectives* of the *Policy mix* encompass two outcomes: to achieve good water quality and preserve biodiversity, through maintaining the six functions (Andersson et al., 2013).

The *Principle plan* provides guide lines for how buffer zones should be handled, and which measures are appropriate in different situations (Andersson et al., 2013). An essential consideration has to be given to the fact that the principle plan is also influenced by the forestry act through the "freedom under responsibility". This emphasizes that forest owners retain the autonomy to make informed decisions regarding the establishment of buffer zones, including the characteristics of the buffer zone and on which waterways establish it. Thus, even if the SOs set the principle plan, there is no incentive to comply. The *policy mix* can therefore be described as soft and non-legislative which allows forestry actors to make their interoperations. A study from Khanna, (2001) shows that soft, non-legislative policy within environment protection policy tends to allow actors, such as forestry actors to shape policy in their favor. This is one explanation for why there is a difference between implemented buffer zone and recommended buffer zones. Due to that, the economic value of the forest is a bigger driver for forest owners than nature consideration (Rivière, 2016). The *Policy mix, therefore,* allows actors to design buffer zones that do not support all functions. For example, design buffer zones that are way under 30 meters, which is the width that is established by research to be the minimum to preserve all functions in pre-harvest level (Sweeney & Newbold, 2014).

Sweden is however not unique with the voluntary approach, but it varies which approach other countries take. Finland and Sweden have the voluntary approach where the buffer zone design is much up to the forest owner. There are however countries, such as Latvia and Estonia that implements a hard policy that for example the buffer width is fixed and the management of the buffer are highly regulated (Ring et al., 2017).

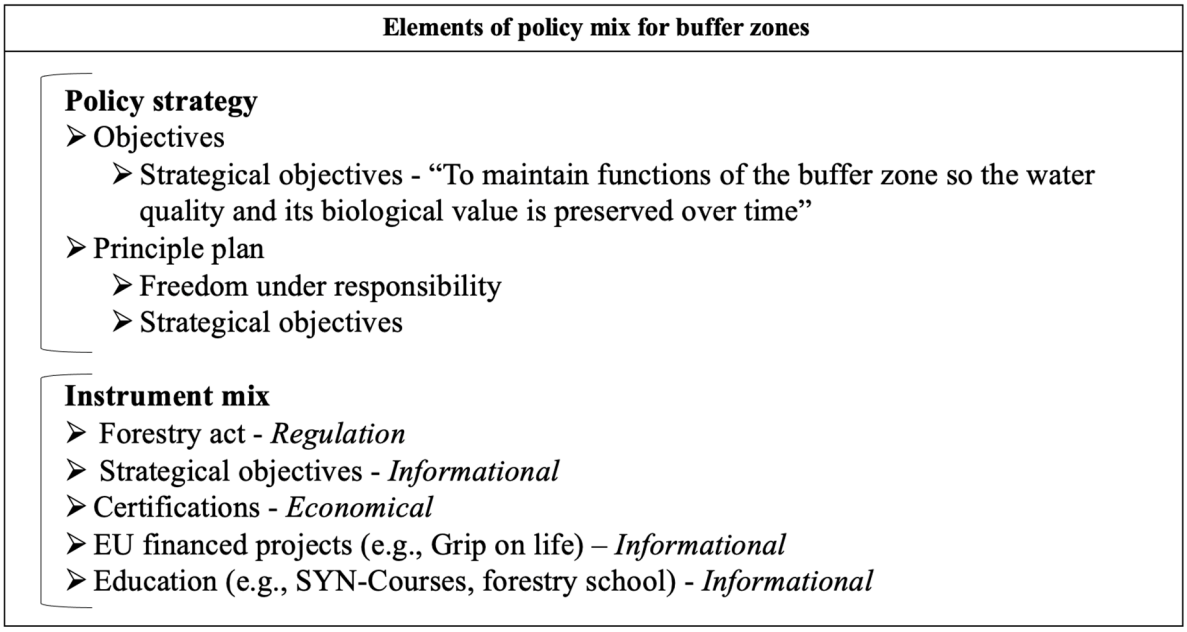


Figure 2. Description of the Elements in the policy mix in the context of Swedish buffer zone policy based on the framework for policy analysis.

5.1.3 Instrument mix for riparian buffer management

The analysis of the Swedish buffer zone policy shows that there is a handful of *Instruments* that affect buffer zones, but most of the instruments are informational (Figure 2). The only regulatory instrument connected to forest buffer zones is the forestry act. The aforementioned act (Skogsstyrelsen, 2022a) references buffer zones; however, the effectiveness of the act as an instrument for implementing buffer zones is debatable, primarily due to its inherent limitations in terms of guidance and legal authority. The act does not provide a comprehensive framework for the implementation of buffer zones, nor does it establish any explicit consequences if buffer zones are not established. As a result, the act's ability to serve as an effective tool for the establishment and enforcement of buffer zones is questionable. However, the act establishes the definition of a buffer zone (a predetermined width closest to the waterway that is left without management) and its purpose. Which sets the foundation for SFA to give further instructions. The regulation can therefore be described as a soft regulation when it is recommendatory and non-binding (Torenvlied & Akkerman, 2004).

The Certifications schemes (i.e. FSC and PEFC) in Sweden can be seen as economic instruments (Figure 2). This is due to timber having a higher market value if it is certified and the forestry actor can lose the certification, and thus, the extra value of the timber if the rules are not followed. However, the PEFC (2017) does not define recommendations or rules about buffer zones. FCS (2019) states that the SOs regarding the consideration to water should be followed but does not provide

additional guidance. There is however evidence that certification schemes can be a policy instrument that has a positive effect on preserving buffer zone functions. Results from Jyväsjärvi et al. (2020) show that the Finnish FSC, which requires 15 m buffers, leads to the buffer zone functions almost being preserved in pre-clearcut levels. The Finnish PEFC do also have a minimum width requirement, but only 5 m buffers, in that case, the buffers do not establish efficient protection of the waterways and do not support the conservation of biodiversity. Regardless that the FCS protects the waterways better is it far less applied than the PEFC in Finland. Both Finland and Sweden do rely upon to a large extent on voluntary measures (Ring et al., 2017), thus Finland's buffer zones give better protection of the buffer zone functions with an average width of 15 m compared to Sweden's 4 m (Jyväsjärvi et al., 2020; Kuglerová et al., 2020).

The purpose of the information instruments is that they should guide the forestry actors to manage the riparian forests leading to reaching the *Objectives*. The foundation of the informational instruments could be seen as the SOs. This is due to, among other things, both the certification schemes mentioning the SOs, as guidelines that should be implemented and that some education material within the forestry sector is based on the SOs (Skogsskötselskolan, 2023). The SOs do state recommendations for how to achieve the objectives. It gives some examples of measures that can be carried out to contribute to water quality. However, as mentioned above they are only guidelines that use in some cases vague language that is open to interpretation. For example, it states to preserve biodiversity, "the buffer zone should in most cases be left without forestry, alternatively nature conservation management should be carried out" (Skogsstyrelsen, 2014). In addition, it states that selective logging can be applied but that all broadleafs should be left within 10 m (Skogsstyrelsen, 2014). Making it clear how to preserve broadleaf species but does not give further recommendations on how to maintain remaining biodiversity. Putting a lot of pressure on the ecology knowledge of the person planning the forest operations. As the result shows further down, the forestry actor does not state any clearer instructions in their internal guidelines for biodiversity.

5.2 Internal guidelines

The analysis of the forestry actor's internal guidelines shows that not all actors define how their employees should interpret current policy regarding buffer zones. A total of eight forestry actors accepted to participate in the study. Five privately owned companies, one owner association and two actors defined as others. Others are actors that don't fit in the privately owned companies or the owner association, but have an impact on larger proportion of Sweden's Forests. Half of the

participants (5) had internal guidelines which should serve as support for personnel that plan or perform forestry actions. The guidelines included more in-depth instruction on how the actors should handle riparian buffer zones. The opinion of the forestry actors that had no internal guidelines was either that the SOs were sufficient to guide their employees to ensure a satisfying result or that they have courses that capture the interpretations and practical use of the SOs. The courses are among others, Skogsskötselskolan (2023), SYN-courses (Skogsbrukets yrkesnämnd, 2023), or internal training.

More than half of the forestry actors had internal guidelines (5/8, Figure 3). One actor categorized as "other" had internal guidelines and four of the privately owned forest companies had them. The owner association that participated in the study did not have internal guidelines (Figure 3). In addition, all the actors that had internal guidelines for riparian buffer zones had guidelines aiming toward final felling, while two of the actors had also specific guidelines for thinning and pre-commercial thinning operations.

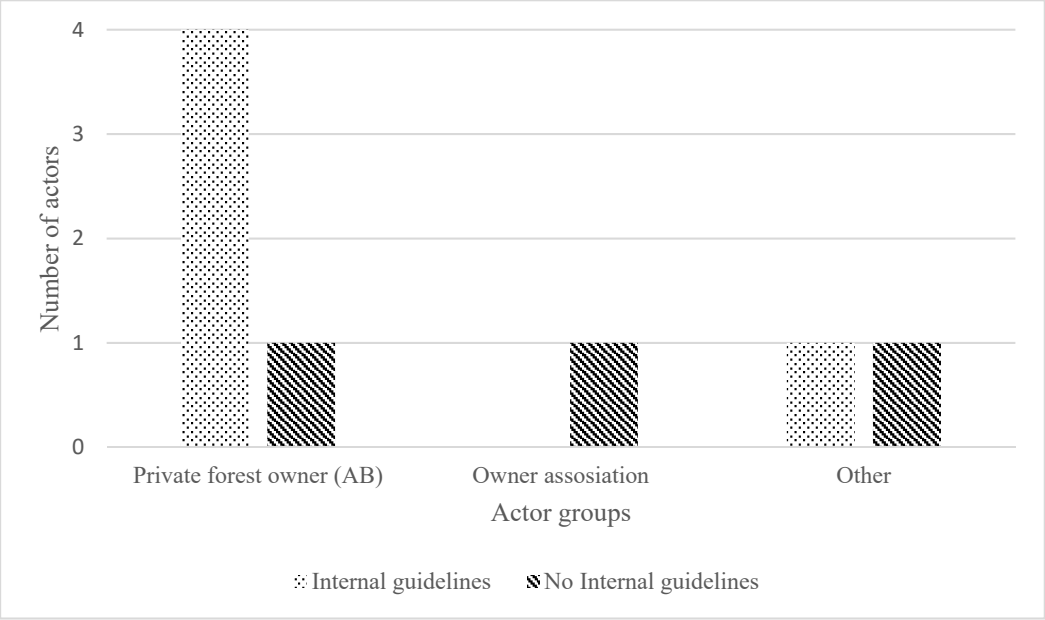


Figure 3. The number of actors with internal guidelines, divided into three groups.

5.3 The content of the internal guidelines

There are no clear results that the internal guidelines are more detailed than the SOs. However, when the guidelines are divided up into categories based on the buffer zone functions the result shows that some actors have more detailed guidelines than the SOs. All actors have the same recommendations as the SOs regarding biodiversity and food for living organisms. Regarding both the functions "stabilize stream banks to prevent erosion and sediment transport" and "create and protect

deadwood", two of the actors had more detailed instructions than the SOs. Further, some guidelines give more detailed recommendations when it comes to the function of shading and filtering (Figure 4).

All participating forestry actors bases their actions and got support from the SOs. Almost all the actors (3) that had internal guidelines had referred to or did use pictures from the SOs. One of the participants specifically mentioned the buffer zones' six ecological functions in the internal guidelines while the rest addressed methods to promote the functions without mentioning them. This shows evidence that the SOs in some way work as an *informative policy instrument* when the information is adapted into the forestry actors' internal guidelines. As Rogge & Reichardt (2016) describes the informative instrument's purpose is to educate the target group. Due to the construction of the *Policy mix*, the SOs works as both a *Policy instrument* and describes the *Principle plan*, this also gives indications that the principle plan to some extent is adapted by the forestry actors. However, the indication that the SOs are adapted by the forestry actors does not mean the same as that they are adapted in a way that improves the functions of the buffer zones.

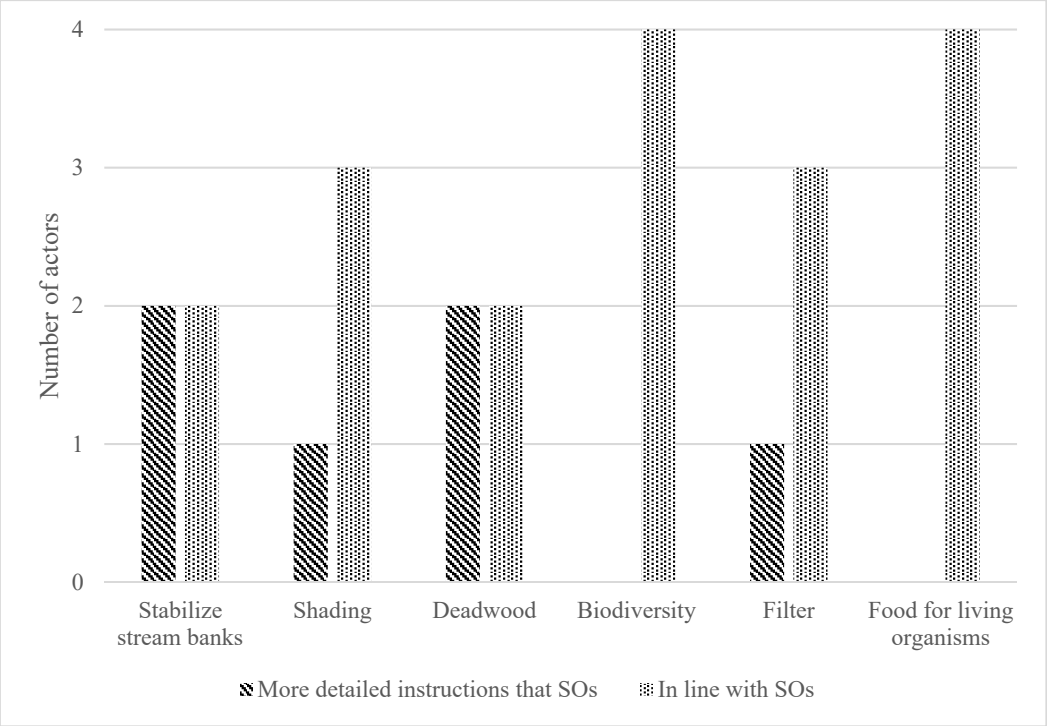


Figure 4. The forestry actor's internal guidelines that are either in line with the SOs or are more detailed. The guidelines are divided up in six categories, based on the six functions.

5.4 Buffer zone width

By analyzing the internal guidelines, the result shows that three of the eight actors did further specify how to construct the buffer zones. One of the actors used the same phrasing as the SOs, the buffer zone should aim to support the six functions but do not have a predetermined or minimum width except when it comes to buffer zones by lakes, then the buffer zone should instead be adapted after the groundwater discharge areas (GWD) and be at least five meters wide. Another actor did define that all riparian buffer zones should be adapted after the GWD and should also be at least 10 meters wide. A third actor defined that the riparian buffer zone should be at least five meters wide regardless of the type of water (Table 1). Research shows that the buffer zone should be between 3 – 30 m to effectively maintain the functions connected to buffer width (Gundersen et al., 2010). However, 3 m should not be applied as a rule when other research shows that 5 m does not give efficient protection of the functions (Jyväsjärvi et al., 2020). Another paper argues that the recreational and socioeconomic values are lost, especially by lakes, when you can see through the buffer zone (Buttle, 2002). However, researchers agree to maintain all functions especially biodiversity, the buffer width should be at least 30 m, preferably wider than 40 m (Marczak et al., 2010; Selonen & Kotiaho, 2013; Sweeney & Newbold, 2014). A study based in Canada by Buttle (2002) argues for location-adapted buffer zones based on slope conditions and GWDs to maintain certain biodiversity, with a buffer width well over Sweden's today's average buffer width. Though with Sweden's *Policy mix* that is based on voluntary measures, buffers that invade too much on the economic aspect can be hard to implement. However, research from (Tiwari et al., 2016) shows that buffer zones adapted after GWD with their model, are cheaper per hectare to establish than fixed buffers.

Table 1. Definitions from the participation actors internal guidelines regarding the width of the buffer zones.

Quetion	Actor 1	Actor 2	Actor 3	Actor 4	Actor 5	Actor 6	Actor 7	Actor 8
How wide should the riparian buffer zone be for watercourses?	At least 5 meter	No minimum but adapted after the six functions	It is not defined	It is not defined	Adapted to the GWD but at minimum 10 meter	It is not defined	It is not defined	It is not defined
How wide should the riparian buffer zone be for lakes?	At least 5 meter	Adapted to the GW discarge but at minimum 5 meter	It is not defined	It is not defined	Adapted to the GWD but at minimum 10 meter	It is not defined	It is not defined	It is not defined

5.5 Prevention of sediment transport and conserving important soil chemical processes

Regarding driving within the buffer zone, with a harvester or a forwarder, the SOs states that driving within 10 meters of the edge of the water is not allowed because

of the increasing risk of sediment transport and chemical leakage. One of the participating actors had added in their internal guideline that “all driving within 10 m should normally be avoided”. In addition, no actor included other measures to prevent sediment transport other than driving routines (Figure 5). The prevention of transport of fine sediment from forestry is important to prevent due to among others protecting spawning areas for Solomonid species when the sediment deteriorates the spawning areas (Lisle & Lewis, 1992). It is also important to reduce de risk of polluting the water with mercury and when there can be high concentrations of mercury and methyl mercury in moist soils and have a potentially negative effect when it carries up the food web to humans(Cain, 2011; Naiman & Decamps, 1997). The risk of sediment transport and chemical leakage is reduced by not driving in within the buffer zone (Andersson et al., 2013).

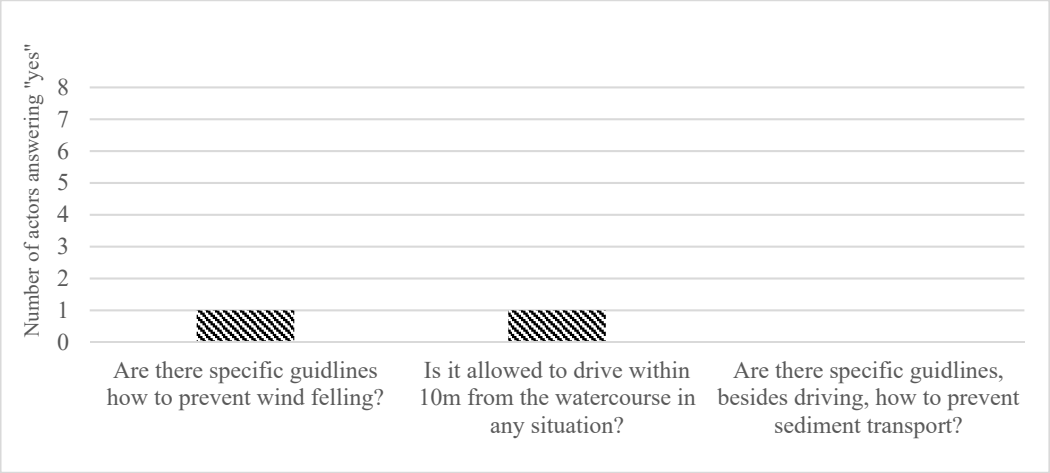


Figure 5. Description of the number of actors that answered yes in questions connected to sediment transport.

5.6 Type of waterway – buffer zone establishment

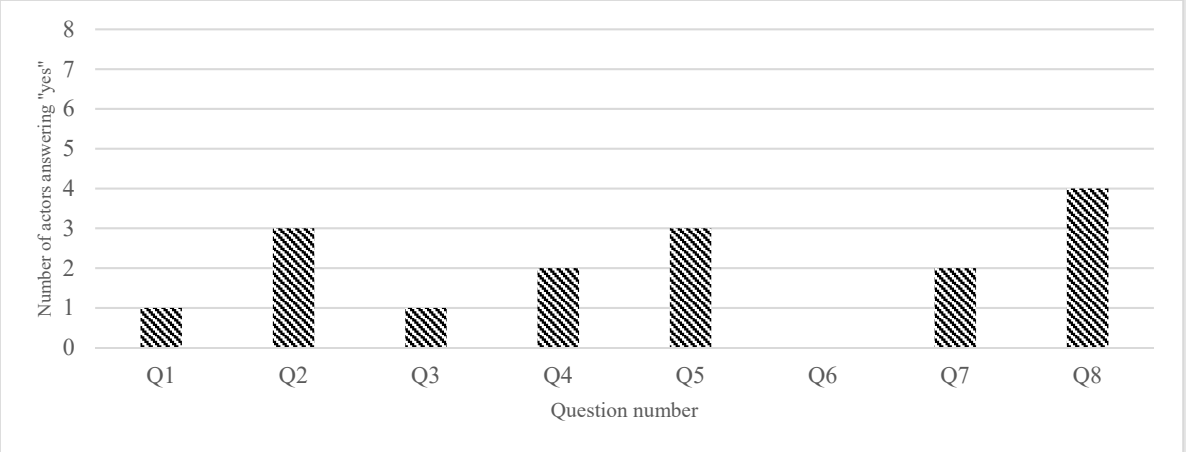
Three of the participating actors included further instructions than the SOs regarding which waterways buffer zones should be established. Two of them were similar and very specific stating that “all waterways except ditches should have a buffer zone”. One of the remaining actors stated that “all waterways with yearly water flow should have a buffer zone”. Both the SOs (Skogsstyrelsen, 2014) and Bishop et al. (2008) state, that it is especially important to protect waterways with seasonal waterflow due to the endemic species that migrate from the groundwater to waterways with seasonal waterflow. Despite the importance of those small streams with seasonal water flow, evidence shows that larger streams receive better protection in Sweden (Kuglerová et al., 2020). Neither of the internal guidelines highlights the importance of the small streams. This phenomenon explains that seasonal waterways can be hard to spot if the planning does not occur when the

waterway has water flow. Ågren et al. (2015) did also show that many small waterways with seasonal water flow are left out of maps, something that can explain the difference.

None of the internal guidelines described how to determine if it the waterway is a ditch or a modified stream. However, one actor, which did not have internal guidelines but I asked in a follow-up email, stated that determining the naturalness of a waterway is a complicated task. They stated that they typically assess, based on a larger area i.e., on a map, whether the "ditch" upstream or downstream follows such terrain that it could be a straightened stream. In addition, the actor also stated that they are not implementing buffer zones on ditches. This is in line with recent research from Ring et al. (2022) that argues that it can be hard to evaluate the origin of the waterway without assessing longer distances, both up and downstream.

5.7 Biodiversity, Deadwood and Shading

The SOs state that biodiversity is preserved by leaving sensitive biotopes completely untouched or by carrying out conservation management. They also mention that by leaving all broadleaved trees in conifer-dominated buffer zones, biological diversity should be promoted as well as preserving and supplying dead wood in the buffer zones (Skogsstyrelsen, 2014). All the actors were in line with the SOs that all broadleaved trees should be left in the buffer zones (Figure 6, Q8). Regarding dead wood, all actors stated that it should be left untouched. Two of the actors gave specific instructions on how to create dead wood (Figure 6, Q7). For example, one actor stated that “if selective cutting is going to be done in the buffer zone some larger tree should be left lying over the stream”. There are many endangered species connected to deadwood, and it is therefore important to create and protect deadwood (Cain, 2011).



Q1- Are there specific instructions for how to maintain shading?	Q5 - Are there specific guidelines how to handle riparian buffer zones with mixed species?
Q2- Are there specific guidelines how to handle riparian buffer zones dominated by spruce?	Q6 - Is it allowed to cut down broadleaf trees in the buffer zone?
Q3 - Are there specific guidelines how to handle riparian buffer zones dominated by pine?	Q7 - Are there instructions to create deadwood?
Q4 - Are there specific guidelines how to handle riparian buffer zones dominated broad leaf?	Q8 - Are there instructions to protectiong dead wood

Figure 6. Description of how many forestry actors that answered yes on questions regarding forest composition and deadwood through their internal guidelines.

The internal guidelines showed that some actors have included specific guidelines to handle specific tree species mix in the buffer zones (Figure 6). All actors are in line with the current policy that all broadleafs should be spared in the buffer zone, due to both lack of broadleafs in Swedish forest (Lindbladh et al., 2014) and that the litter from the broadleaf trees are a high-quality food for water living organisms (Hisabae et al., 2011). One actor had specific instructions on how to handle forests dominated by spruce, pine, broadleaf, and mixt buffer zones. A total of three actors had specific instructions for how to handle mixed species and buffer zones dominated by spruce (Figure 6). These three actors agreed that spruce-dominated buffer zones needed to be restored due to the high risk of wind felling. However, all three have different methods to do this. One actor recommended considering removing the whole buffer zone to start over and "restore" the species composition, which contradicts with all the buffer zone functions. The second actor recommended removing the spruce in sections over time to keep some function of the riparian forest, which is a method that is supported by ecology research (Kreutzweiser et al., 2012). The third actor recommend removing most of the spruce trees in the buffer zone but leaving high stumps cut just below the first green branch and placing some trees over the stream to maintain shading, if the shading was not satisfying, the planner should consider leaving larger storm proof tree groups. The SOs states that satisfying shading for smaller waterways is 50 – 70%

(Andersson et al., 2013), but none of the internal guidelines gives indications that this should be taken into consideration. Shading is important from an ecological point of view, light increase the primary production that can create unique and more diverse habitats which can increase the biodiversity (Keeton et al., 2007). But also, shading affects the temperature in the water, which connects to species richness, when the species richness increases with the temperature to a certain threshold to then decrease when the temperature is too great (Cain, 2011). It is therefore important to maintain the shading in the perfect threshold.

6. Conclusions and Recommendations

6.1 Conclutions

I found that the current *Policy mix* allows for a lot of variation in how riparian buffer zones are implemented in practice. The *Policy mix* sets a foundation with *Objectives* to protect the riparian forest functions. Due to soft recommendatory *Policy instruments*, the *Policy mix* allows the forestry actors to use it in its own favor, which leads to conflict between implemented buffer zones and with both research and the *Policy objective*. Some actors have established written guidelines meanwhile others argue that standardized education for staff regarding buffer zone implementation and interpretation of policy is sufficient. This soft policy allows for a variation of implementation recommendations between actors, some actors have given more detailed instructions when it comes to preserving single functions while most of the instructions are in line with the SOs. However, due to my result, I was not able to draw any conclusions on whether the interpretations differ between different types of actors, as the number of participating owner associations was too low to obtain a scientific result. However, interoperations between individual actors differ, and some actors have not established internal guidelines for how to interpret buffer zone policy. Based on the foundation of the Forestry Act's principle of "freedom under responsibility," the actor can decide if they want to weigh their buffer zone management towards the environmental goal or the production goal. This could explain the variation in buffer zone implementation in Sweden.

Only half of the participating actors had internal guidelines regarding buffer zone implementation and management. Some of these actors had specified a minimum buffer width and which waterways should have buffer zones. Two actors have stated a minimum width, that the buffer zone should be, meanwhile one stated that it should be adapted after GWD and to maintain the six functions, neither of the guideline were in line with evidence-based research to maintain all six functions. Regarding which waterways should have buffers the guidelines also split. That majority implemented buffers on all waterways except ditches meanwhile one actor implemented it on waterways with yearly water flow. A conclusion is that none of

the above-mentioned instructions are preserving all six functions of the riparian forest according to prevailing ecology research.

6.2 Recommendations

With knowledge of the *Policy mix* and evidence from other countries, my policy recommendation is to include buffer zone recommendations in the certification schemes. With the close relationship between buffer zone width and the preservation of the functions of the buffer zones, the focus should be to increase Sweden's average buffer zone width. With Sweden's deep-rooted tradition of the forest owners' right to decide over their own forest, a system is needed that accommodates that aspect. Therefore, the right way to go is to introduce minimum width into the certification system, such as Finland has. It is though important to base the minimum width on evidence-based research in order to maintain the buffer zone functions at a level that supports Sweden's *Objectives* regarding the protection of water and biodiversity. The certification schemes allow for optional implementation of the instructions but give economic consequences if not followed, thus the importance of wider buffer zones is highlighted. However, there is a risk that the usage of certification schemes decreases with increased strictness. It is therefore important to investigate this question further, how it could influence the usage of the certification schemes.

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9. Appendixes

Appendix 1 – Questionnaire sheet

Question	Answer
The forestry actor is a:	- Private owned AB - Owner association - Other
Is the actor certified with FSC	- Yes - No
Is the actor certified with PEFC	- Yes - No
Are the internal guideline mentioning the six functions of riparian buffer zones?	- Yes - No
Are pictures from "SOs" used in the internal guidelines?	- Yes - No
Do the forestry actor have internal guidelines for considerations to lakes and watercourses?	- Yes - No
Are there specific guidelines for pre-commercial thinning?	- Yes - No
Are there specific guidelines for thinning?	- Yes - No
Are there specific guidelines for harvest?	- Yes - No

Which watercourses should have a riparian buffer zone?	- All watercourses and lakes (ditches included) - Everyone that have waterflow all year - Only natural watercourses (straitened included) - Only natural watercourses (straitened excluded) - All except ditches
How wide should the riparian buffer zone be for small watercourses?	- 0 -5 meter5 - 10 meter - 10 - 15 meter15+ meter - No minimum but adapted after the six functions - Adapted to the GWD but at minimum 5 meter - Adapted to the GWD but at minimum 10 meter - Width not prescribedIt is not defined
How wide should the riparian buffer zone be for large watercourses?	- 0 -5 meter5 - 10 meter - 10 - 15 meter15+ meter - No minimum but adapted after the six functions - Adapted to the GWD but at minimum 5 meter - Adapted to the GWD but at minimum 10 meter - Width not prescribedIt is not defined
How wide should the riparian buffer zone be for lakes?	- 0 -5 meter5 - 10 meter - 10 - 15 meter15+ meter - No minimum but adapted after the six functions - Adapted to the GWD but at minimum 5 meter - Adapted to the GWD but at minimum 10 meter - Width not prescribedIt is not defined
Are there specific instructions for how to maintain shading?	- Yes - No
If yes, what shade is considered good enough?	- 0-50% - 50-70% - 50-100%

Are there specific guidelines how to prevent wind felling?	- Yes - No
Are there specific guidelines how to handle riparian buffer zones dominated by spruce?	- Yes - No
Are there specific guidelines how to handle riparian buffer zones dominated by pine?	- Yes - No
Are there specific guidelines how to handle riparian buffer zones dominated broad leaf?	- Yes - No
Are there specific guidelines how to handle riparian buffer zones with mixed species?	- Yes - No
If the riparian buffer zone consists of unstable spruce, can you cut down the entire riparian zone for restoration purposes?	- Yes - No
Is it allowed to drive within 10m from the watercourse in any situation?	- Yes - No
Is it allowed to drive in GWD?	- Yes - No
Is it allowed to cut down broadleaf trees in the buffer zone?	- Yes - No
If yes, how far from the stream?	- 0 - 5 meter - 5 - 10 meter - 10 - 15 meter - 15 + meter
Should all broadleaves and bushes be left in the riparian buffer zone when the stand is pre commercial thinned?	- Yes - No
Are there instructions to create deadwood?	- Yes - No
Are there instructions to protect dead wood?	- Yes - No
Are there specific guidelines how to preserve biodiversity in the instructions?	- Yes - No

If yes, biodiversity of what organisms?	- All - Vegetation - Insects - Bryophytes - Vertebrates - Invertebrate - Birds

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Alteration of the forest structure in historically impacted Nothofagus spp. forests on the Brunswick peninsula.
Recommendations for their protection and management.

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The evaluation of novelty kilns: drying msasa wood at a small scale sawmill in Mozambique

2022:12 Författare: Andreas Karlstrand
Samband mellan föryngringsresultatet år 5 och kvalitetsklassning av markberedning och planteringsåtgärder på SCA:s fasta provytor i norra Sverige.

2023:01 Författare: Tyra Tornberg
Forest regeneration and edge effects – An ecophysiological analysis after gap-cutting

2023:02 Författare: Erik Wickberg
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2023:03 Författare: Carl Åhlund
Kvävegödslingens effekter på bladyta och trädkronor i tallbestånd

2023:04 Författare: Johan Engström
Increased carbon sequestration of actively restored tropical forests in Sabah, Malaysia
A comparison of natural regeneration and active restoration

2023:05 Författare: Magdalena Fassl
Tree-growth and climate-growth relationships of Scots pine and downy birch in a natural forest in northern Sweden

2023:06 Författare: Ruben Baan Hofman
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An observational study into the effects of forest management on understory vegetation communities along boreal headwaters

2023:07 Författare: Nils Helge Havertz
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Svenska sågverk och sågverksarbetare i norra Ryssland 1898–1925

2023:10 Författare: Elijah Ourth
Consequences of Alternative Forest Management in Different Widths of Riparian Buffer Zones: A GIS Analysis

2023:11 Författare: Eric Lundström
Major forest companies and owner associations interpretation of policies and certification programs regarding riparian buffer zones