Master of Forestry, Final Thesis Report

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A comparison between the forestry sector in New Brunswick (Canada) and Hesse (Germany)

by

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Abstract

This report provides an in-depth comparison of forestry and forests in the province of New Brunswick (Canada) and the state of Hesse (Germany). The first two sections describe the general situation and circumstances of forests and forestry in New Brunswick and Hesse, respectively, and the third section aims to compare the two forestry sectors to each other in more detail. The comparison shows several significant differences between the two forestry sectors in regard to forest management, forest governance, and factors influencing the economics of the respective forestry sectors. However, often it was not possible to find directly comparable data for Hesse and New Brunswick, which has several reasons. Therefore, the comparisons made in this report are of a relative nature, to see how much of an impact the forestry sector has on the economy and the people living in New Brunswick and Hesse.

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List of Abbreviations

AAC	Annual Allowable Cut
ATV	All-Terrain Vehicle
BMEL	Bundesministerium für Ernährung und Landwirtschaft (German Federal Ministry of Food and Agriculture)
BMELV	Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz (German Federal Ministry of Food, Agriculture and Consumer Protection)
BWI III	Bundeswaldinventur 3 (National Forest Inventory 3)
CCFM	Canadian Council of Forest Ministers
CFB	Canadian Forces Base
CFS	Canadian Forest Service
CLFA	Crown Lands and Forests Act
CSA	Canadian Standards Association
CWA	Clean Water Act (New Brunswick)
DBH	Diameter at Breast Hight
DFWR	Deutscher Forstwirtschaftsrat e.V. (German Forestry Council)
DNR	New Brunswick Department for Natural Resources
EEA	European Economic Area
ESM	European Single Market
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FENA	HessenForst Servicezentrum Forsteinrichtung und Naturschutz
FMU	Forest Management Unit
FPA	Forest Products Act (New Brunswick)
FPAC	Forest Product Association of Canada
FPMB	Forest Product Marketing Board (New Brunswick)
FSC	Forest Stewardship Council
FTC	Forestry and Timber Cluster

GAC	Global Affairs Canada
GDP	Gross Domestic Product
GNB	Government of New Brunswick
GVA	Gross Value Added
HLNUG	Hessisches Landesamt für Naturschutz, Umwelt und Geologie (Hessian State Agency for Nature Conservation, Environment and Geology)
HMUKLV	Hessisches Ministerium für Umwelt, Klimaschutz, Landwirtschaft und Verbraucherschutz (Hessian Ministry for the Environment, Climate Protection, Agriculture and Consumer Protection)
HMWEVW	Hessisches Ministerium für Wirtschaft, Energie, Verkehr und Wohnen (Hessian Ministry for the Economy, Energy, Transport and Housing)
HWaldG	Hessisches Wald Gesetz (Hessian Forest Act)
JDI	J.D Irving, Limited
NB	New Brunswick
NBFPC	New Brunswick Forest Products Commission
NBFWO	New Brunswick Federation of Woodlot Owners
NRC	Natural Resources Canada
NRED	NB Department of Natural Resources and Energy Development
NRTEE	National Round Table on the Environment & the Economy (Canada)
NSDNR	Nova Scotia Department of Natural Resources
NW-FVA	Nordwestdeutsche Forstliche Versuchsanstalt (Northwest German Forest Research Institute)
PEFC	Programme for the Endorsement of Forest Certification
RiBeS	Richtlinie für die Bewirtschaftung des Staatswaldes (Guidelines for the management of the state forest)
RP	Regierungspräsidium (provincial government)
RVR	Rahmenvereinbarung für den Rohholzhandel in Deutschland (Framework Convention for the Raw Timber Trade in Germany)
SCF	The State of Canada's Forests Annual Report

SFE	State Forest Enterprise
SFI	Sustainable Forestry Initiative
SFM	Sustainable Forest Management
TC	Transportation Certificate (New Brunswick)
UNCED	United Nations Conference on Environment and Development

1. Introduction

Germany and Canada are well known for their forestry sector. However, while Canada and Germany are both a federal country, there are several significant differences between Canada and Germany in terms of forests and the way they are managed. Since Canada is the second-largest country in the world, there are many different types of forests and significant differences in forest management within Canada. Due to Germany's comparably small size, the differences between forests and forest management within Germany are by far not as significant as those in Canada. Nevertheless, essential differences within Germany exist, which is why neither Canadian nor German forests and forestry can be described and compared in a simple manner. To narrow down the focus of the report and to ensure better comparability, the province of New Brunswick (Canada) and the Federal State of Hesse (Germany) were selected for comparison concerning their forestry sector.

Both in Hesse and New Brunswick (NB), forests play an essential role, not only for the economy but also for recreation, biodiversity, protection functions, climate change adaptation/mitigation, and human wellbeing in general. Even though there are several differences between Hesse and New Brunswick, for example, in terms of the use of the forests, silviculture, nature conservation, forest composition, tree species, or forest infrastructure, there are also some commonalities. Furthermore, such as Hesse, New Brunswick, is facing multiple challenges in the future, especially in terms of climate change. For example, two of the most economically important tree species in their

respective region, i.e., balsam fir in New Brunswick (ERD 2019) and Norway spruce in Hesse, are at risk as a result of a changing climate.

This report aims to present an overview and a comparison between Hesse (Germany) and New Brunswick (Canada) regarding their forestry sector. Hesse is under the German federal governance system, and Germany is a member of the European Union, the forestry sector in Hesse should be subjected to more regulations than the one of New Brunswick, which is only under the Canadian federal governance system. It will, therefore, be interesting to assess the effects that the different regulations have on the forestry sectors in Hesse and in New Brunswick. Also, the difference in the forest governance systems can have different benefits to the public. We hypothesize that (1) although the Hessian forestry sector is much more regulated than that in New Brunswick, the economic conditions for Hessian forestry are nevertheless more favorable than in New Brunswick. Another hypothesis, which is connected to the first one, is that (2) forest management done by a public agency (State Forest Service or Provincial Department) is more beneficial to the public than forest management done by industrial companies.

To provide a better understanding of the circumstances and realities of the forestry sector in Hesse and New Brunswick, this report is structured into three main parts. The first part will describe the forestry sector in New Brunswick with a foundation in providing general information on forests and the forestry sector in Canada. The second part will be dedicated to the forestry sector in Hesse with a foundation in providing general information on the forests and forestry sector in Germany. In the third part, we will compare the New Brunswick and Hesse forestry sectors. Such comparison is

supposed to be made easier by applying the same general structure for the first two chapters. However, the general chapter structure can deviate slightly to accommodate some significant differences between both regions. The third part will sum up the findings of the first two parts and compares these findings with each other. After pointing out the major differences, this report will try to provide explanations as to why these differences exist and what are the underlying reasons. Those reasons can be of different nature, some are obvious, and others are more complicated. Furthermore, it discusses the regulations for forestry in Hesse and New Brunswick and their impacts on the sector.

This report is based on published literature, data, and other information material, which was gathered from a variety of sources. Primary information sources for New Brunswick and Canada included public authorities and information platforms like Statistics Canada, the Canadian Forest Service, the Government of New Brunswick and the New Brunswick Department for Natural Resources and Energy Development. For Germany and Hesse, the primary information sources included the State Forest Enterprise HessenForst, the Hessian Ministry for the Environment, Climate Protection, Agriculture and Consumer Protection (HMUELV), the Northwestern German Forest Research Institute (NW-FVA) and the Thünen Institute. We also used scientific papers, newspaper articles, and websites. The information that was gathered and screened was used to provide an overview of the forestry sector in New Brunswick and Hesse, which will now be presented.

2. The Forestry Sector in New Brunswick

2.1. Introduction

This section will begin by providing a brief overview of Canadian forest resources that will include a few interesting statistics and facts about the forests in Canada, which are meant to lay the groundwork for the following sections of this part. This part will be followed by a more detailed description of the New Brunswick (NB) forestry sector, including forest resources, forest industry, its socio-economic impacts, forest ownership, regulations, certification, climate change implications, and a few topics specific for New Brunswick.

Canada is widely known for its immense forest resources. Approximately 35 % of Canada's land area is covered with forests (NRC and CFS 2018). With nearly 347 million ha of forests, Canada has the third-largest forest area in the world following the Russian Federation and Brazil (FAO 2015). Furthermore, Canada is the second-largest country in the world, comprising an area of more than 998 million ha. Despite Canada's size, the population is relatively small, with just about 35.15 million people living in Canada (Statistics Canada 2017). Not surprisingly, the population density is very low, with only 3.9 people per km^2. On the other hand, the forest area per capita is relatively high, with about 9.74 ha per person (Table 1) (NRC and CFS 2018). However, the population is not evenly distributed as the major part of Canadians live in the biggest urban centers close to the U.S. border.

Table 1 General and forest-related statistics for New Brunswick and Canada

Region	New Brunswick	Canada
Total area [ha]	7,344,000	998,467,000
Population [N]	747,101	36,963,854
Population density [people/km^2]	10.5	3.90
Forest area [ha]	6,100,000	347,069,000
Forest cover [%]	85	35
Forest area per Capita [ha/person]	8.10	9.74

In terms of forest ownership, by far the largest share of forests in Canada are under public ownership (89.5 %), which is also referred to as Crown Forests or Crown Land. Given the federal nature of the Canadian governance system, these Crown Forests are under the provincial/territorial jurisdiction, but not under the federal jurisdiction. Private owners in Canada own only 6.2 % of the forests, and the federal government owns 1.6 %, and 0.3 % are municipally owned forests (NRC and CFS 2018).

As stated earlier, Canada is one of the largest countries in the world and is comprised of ten provinces and three territories. It has six standard time zones, 15 terrestrial ecozones (Marshall et al. 1999), and stretches over 5,514 km from east to west (Statistics Canada 2011a). Canada is known as being a diverse country not only in landscapes but also in cultures in each province. Not surprisingly, there are significant differences between the 13 Canadian provinces and territories concerning their forestry sector. However, this report will focus on the forestry sector of the Province of New Brunswick.

New Brunswick is situated on the Atlantic east coast of Canada and is the biggest of the three Maritime provinces, which also include Nova Scotia and Prince Edward Island. However, compared to the other Canadian provinces, New Brunswick is a very small

province with a land area of approximately 7.344 million ha (GNB 2019b). About 747,101 people live in New Brunswick (Statistics Canada 2017), with the three biggest cities being Saint John, Moncton, and Fredericton (Provincial capital). Even though New Brunswick's population is relatively low, the population density of 10.5 people per km^2, which is the fourths highest among the Canadian provinces and territories, is considered to be relatively high (Statistics Canada 2011b). Those are just a few well-known characteristics unique to New Brunswick compared to the rest of Canada. There are still several other fascinating differences in New Brunswick, which will be highlighted in more detail in the following sections.

Perhaps one of the most interesting and important facts presented in this report is that New Brunswick has the highest percentage of forest coverage compared to all Canadian provinces. Approximately 6.1 million ha of New Brunswick are covered with forests, which accounts to about 83-85 % of forest coverage (Erdle and Ward 2008; Nadeau et al. 2012; NRED 2018; Ward 2018), Nova Scotia, which is a neighboring Maritime province, follows in second place with about 75.8 % (NSDNR 2017) forest coverage. Due to New Brunswick's relatively high population density, its forest area per capita of 8.1 ha per capita is below the Canadian average of 9.7 ha per capita. New Brunswick has a highly diverse distribution of forest ownership with a very high percentage of privately-owned forests of about 50 % of which, 20 % are industrial freeholds, and 30 % are non-industrial private woodlot owners (Erdle and Ward 2008; Nadeau et al. 2012).

Undoubtedly, with such large forest areas, forests are essential to the province of New Brunswick and play a significant role in contributing to New Brunswick's economy. Forestry is, in fact, New Brunswick's largest industry, and as such, the province relies more on the resources of this renewable industry than any other Canadian province (Floyd et al. 2012; NRED 2018). The Forest industry is particularly important in rural New Brunswick, where the economy is still very much dependent on the use of renewable and non-renewable natural resources (Floyd et al. 2012).

The following section of this chapter will describe and provide a broad overview of the forestry sector of the Province of New Brunswick. This overview will cover topics such as forest types and main tree species, forest ownership, governance, forest management, forest certification, and socioeconomic aspects of the forestry sector.

2.2. Forest Types and Tree Species

The forests in New Brunswick belong, for the most part, to the Acadian Forest Region (Mosseler et al. 2003; Erdle and Ward 2008; Environment Canada 2013), as well as a small part of north-western New Brunswick, to the Great Lakes-St. Lawrence Forest Region (Figure 1). In Canada, the Acadian Forest is confined to Nova Scotia, Prince Edward Island, and a significant part of New Brunswick (Loo and Ives 2003; Erdle and Ward 2008; Environment Canada 2013).

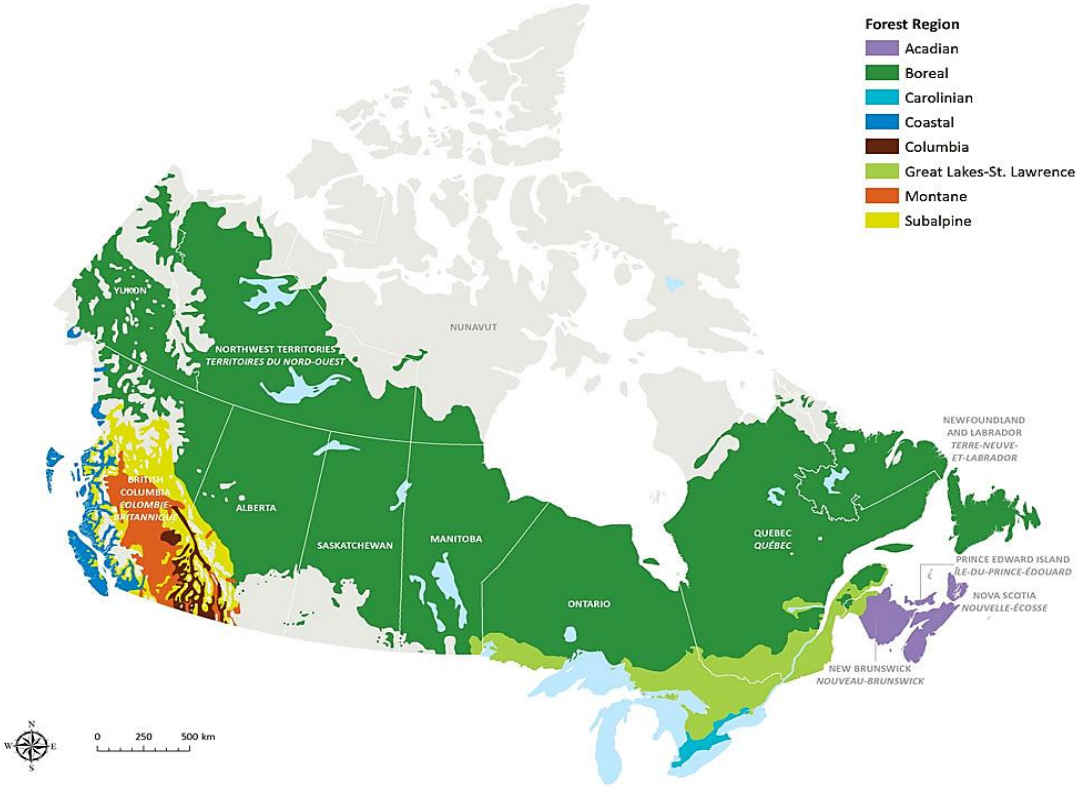

Figure 1 Canada's forest regions (Bonomo 2018)

The Acadian forest is a unique type of forest only found on the Canadian east coast in the Maritime provinces. It is a transitional zone, situated between the boreal forest in the north and the deciduous forest in the south and west of New Brunswick (Loo and Ives 2003; Mosseler et al. 2003; Jäger 2014). Natural forest types in the Acadian Forest

Region include rich tolerant hardwood, spruce-fir forest, and several coniferous, deciduous, and mixed intermediate types (Erdle and Ward 2008). In terms of tree species, red spruce, balsam fir, yellow birch, and sugar maple are commonly found here and are considered characteristic species of the Acadian Forest Region (Table 2) (Loo and Ives 2003; Mosseler et al. 2003). Additionally, black spruce, white and grey birch, red oak, white elm, black ash, American beech, red maple, trembling aspen, and balsam poplar are also widely distributed.

Table 2 Main tree species in New Brunswick, Ward 2018

	Tree Species	**Scientific Name**	**Areal Percentage (%)**
Coniferous	**All coniferous**		**65**
	Balsam Fir	*Abies balsamea*	21
	Black Spruce	*Picea mariana*	15
	Red Spruce	*Picea rubens*	10
	White Spruce	*Picea glauca*	5
	White Pine	*Pinus strobus*	3
	Jack Pine	*Pinus banksiana*	2
	Eastern white cedar	*Thuja occidentalis*	6
Broadleaf	**All broadleaf**		**35**
	Red Maple	*Acer rubrum*	9
	Poplar	*Populus spp.*	8
	White Birch	*Betula papyrifera*	6
	Sugar Maple	*Acer saccharum*	6
	Yellow Birch	*Betula alleghaniensis*	4

Even though 85 % of New Brunswick's land surface is covered with forest, there is almost no patch of forest to be found, which is not or was not influenced by human activities over the past four centuries. These activities had a significant impact and resulted in general in a shift in successional status and age distribution of forests, with an increased frequency of relatively young, often even-aged, early successional forest types (Loo and Ives 2003) like for instance intolerant hardwood stands.

Overall, about 65 % of New Brunswick's forest area is comprised of coniferous- and about 35 % of deciduous- tree species (Table 2). The stand composition is just as diverse as the tree species composition, with 51 % of the stands being softwood stands, 21 % being mixed-wood stands (Hardwood-Softwood and Softwood-Hardwood), and the remaining 28 % being hardwood stands (Ward 2018). About 12 % of the hardwood stands are intolerant hardwood stands, which is an early successional forest type, that is composed of species like trembling aspen, red maple, white birch, and grey birch. However, tolerant hardwood- (2.95 %), tolerant hardwood mix- (1.03 %) or tolerant softwood- (1.56 %) stands, which can be considered closer to a natural Acadian forest, are far less abundant (Ward 2018).

As stated before, the Acadian forest region has a high diversity of tree species (more that 27 tree species) which include: balsam fir (*Abies balsamea*), sugar maple (*Acer saccharum*), red maple (*Acer rubrum*), silver maple (*Acer saccharinum*), yellow birch (*Betula alleghaniensis*), white birch (*Betula papyrifera*), grey birch (*Betula populifolia*), American beech (*Fagus grandifolia*), white ash (*Fraxinus Americana*), red ash (*Fraxinus pennsylvanica*), black ash (*Fraxinus nigra*), butternut (*Juglans cinereal*), American larch

(Tamarack) (*Larix laricina*), Ironwood (*Ostrya virginiana*), red spruce (*Picea rubens*), black spruce (*Picea mariana*), white spruce (*Picea glauca*), white pine (*Pinus strobus*), red pine (*Pinus resinosa*), jack pine (*Pinus banksiana*), balsam poplar (*Populus balsamifera*), trembling aspen (*Populus tremuloides*), red oak (*Quercus rubra*), bur oak (*Quercus macrocarpa*), eastern white cedar (*Thuja occidentalis*), eastern hemlock (*Tsuga canadensis*) and American elm (*Ulmus Americana*) (Loo and Ives 2003). Up to 20 of those tree species are commercial species with differing abundance (Erdle and Ward 2008).

However, the main commercial tree species are balsam fir, black spruce, and red spruce for the coniferous tree species (softwoods) and red maple, poplar, white birch, sugar maple and yellow birch for the deciduous tree species (hardwoods) (CCFM 2018c). Despite this diversity, currently, the most common tree species in New Brunswick are balsam fir (21 %), black spruce (15 %), red spruce (10 %), and red maple (9 %) (Ward 2018).

The average increment of merchantable timber in New Brunswick's forests is about 1.8 m^3/ha. This value is the highest compared to other eastern Canadian provinces, including Ontario (0.6 m^3/ha), Quebec (0.8 m^3/ha), and Nova Scotia (0.9 m^3/ha). The biomass growth, though, is only measured for accessible forest lands (Gardner Pinfold 2018). However, the net merchantable volume growth of wood with a diameter of larger than 8 cm for softwood plantations accounts for about 8 m^3/ha (Jäger 2014). Typical plantations species are black spruce, white spruce, balsam fir, or jack pine.

2.3. Forest Ownership

Across Canada, 89.5 % of the forests are publicly owned by the provincial governments (Crown Land); the federal government owns 1.6 % of forests, and 6.2 % are privately owned. The remaining 2.4 % is composed of 2.0 % aboriginal ownership and 0.4 % other types of forest ownership (NRC 2015; NRC and CFS 2018). However, Aboriginal and Other ownership are subdivisions to federal ownership type, which means that in total, the federal government of Canada owns about 4 % of Canada's forests (Table 3) (NRC 2015).

Table 3 Forest ownership in Canada and New Brunswick, Source: GNB, NRC and CFS 2018

	New Brunswick	**Canada**
Ownership type	**Share [%]**	**Share [%]**
Provincial (Crown Land)	48	89.5
Private	50*[1]	6.2
Municipal	-	0.3
Federal	2	1.6
Aboriginal	-	2.0
Other*[2]	-	0.4
Total	100	100

*[1] 20 % industrial freeholds and 30 % non-industrial private woodlot owners
*[2] Missing, unknown or other ownership

However, in New Brunswick, 48 % of the forests are publicly owned, and 50 % are privately owned (Table 3). Furthermore, the share of 50 % of private forests can be subdivided into 20 % industrial freeholds and 30 % non-industrial private woodlot owners (Table 3) (Erdle and Ward 2008; Floyd et al. 2012; Nadeau et al. 2012; CBJ 2018; ERD 2019). Industrial freeholds, as the name suggests, are owned by large industrial forestry companies. Those companies are, for instance, well-known corporations such as

J.D. Irving, Limited. The fourth type of forest ownership is forests owned by the federal government of Canada, which accounts for about 2 % of New Brunswick's forests (Nadeau et al. 2012). These areas include military areas (CFB Gagetown), National Parks (Fundy- and Kouchibouguac- National Park), First Nation reserve lands, or research forests (Acadia Research Forest) (Figure 2) (NRC 2015).

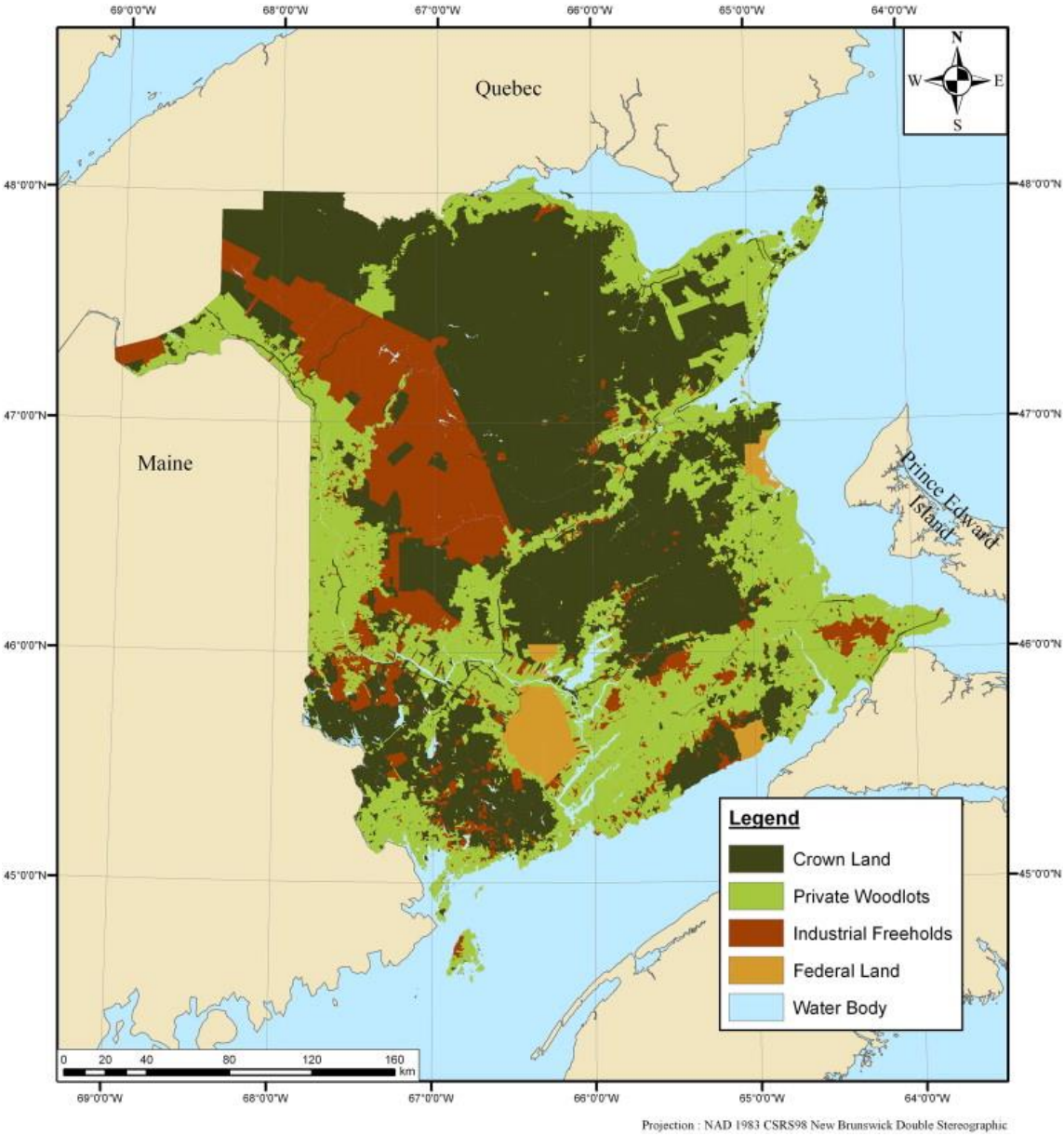

Figure 2 Forest ownership in New Brunswick (Bouchard et al. 2013)

In New Brunswick, large adjacent blocks of forest are assigned to a specific ownership type. The biggest industrial freeholds are found in the northwestern part of New Brunswick, with significant areas of crown land bordering to the east. Private woodlots are typically found along New Brunswick's coast, adjacent to the border of Maine (USA) and alongside rivers (Figure 2). The areas, private woodlots are situated in, are often more productive soils which are close to industries, infrastructure, and communities (NRTEE 1997).

With a share of about 50 % in private forests, New Brunswick has a significantly larger share of privately-owned forests than almost any other Canadian province, except for Nova Scotia, where private forests account for about 59.4 % of the forest area (NSDNR 2017). The total combined area of private forests in New Brunswick accounts for about three million hectares. Approximately 1.2 million hectares of which are comprised of industrial freeholds and 1.8 million hectares are non-industrial private woodlots. The average size of a private woodlot in New Brunswick accounts for about 45.5 ha (Chaini and Johnston 2012). There are some 41,900 non-industrial private woodlot owners in New Brunswick, which accordingly own nearly 30 % of New Brunswick's forests. That is very important to note since private woodlot owners are much less restricted in the way they manage their forests compared to Crown forests. Private woodlots are mostly unregulated by the Crown (Province). The only and most crucial regulation private woodlot owners have to adhere to is the New Brunswick Clean Water Act (CWA 1989), which concerns riparian buffers, water crossings, and lands within designated drinking water supply areas (Floyd et al. 2012; Roach and Berch 2014).

2.4. Forest Governance, Management Legislation and Regulations

When talking about forest governance, forest management legislation and regulations, the different types of forest ownership must be distinguished, since those imply different ways of management and regulations. As stated earlier, the four forest ownership types in New Brunswick are Crown forests, private woodlots, industrial freeholds, and federal lands. The following section is structured accordingly to the forest ownership types.

2.4.1. Provincial (Crown Forests)

Crown land includes all the land that is owned by the province of New Brunswick (CL&FA 1980). Crown lands are managed by different New Brunswick departments. In the case of forested land, the Department of Natural Resources and Energy Development (NRED) is responsible for management (GNB 2019a).

Since Crown lands are public, theoretically, the occasional use of this land does not require a formal authorization by the Province. Occasional uses include activities such as hiking, biking, picnicking, geocaching, canoeing, and overnight camping (GNB 2019a). However, extended use of Crown lands and development activities require formal authorization that is issued in the form of a license such as the timber license. Activities that require authorization include, for instance, commercial and industrial activities such as forestry operations and maple syrup production (GNB 2019a).

Several New Brunswick acts and regulations are governing Crown forests in New Brunswick, such as the Crown Lands and Forests Act, the Forest Fires Act, the Forest Products Act, the Clean Water Act, and the Transportation of Primary Forest Products

Act. The Crown Lands and Forests Act is the legal foundation of crown forest management in the Province of New Brunswick (CL&FA 1980; CCFM 2018c). It divides the Crown Land (public forests) into ten timber licenses (forest management units) (Martin 2003; GNB 2019c). These licenses are granted to the licensees, which are usually big industrial forestry companies such as J.D. Irving Ltd., Fornebu Lumber Company Inc., AV Group, and the Twin Rivers Paper Company (Table 4) (GNB 2019c). Furthermore, each of these companies has an assigned number of sub-licensees, which often operate smaller forest-based mills (Martin 2003; NRED 2017). Currently, four companies are managing the nine largest, out of a total of ten, Crown Timber Licenses. The remaining and smallest license (5 Kent) is managed by the Department for Natural Resources (DNR) – Kent License Management Team (GNB 2019c). Altogether, the ten Crown Timber Licenses comprise an area of 3,272,505 ha (Table 4), which makes up for about 48% of New Brunswick's forest area (Table 3).

Table 4 Crown Timber Licenses and Licensees in New Brunswick (GNB 2019c)

Company (Licensee)	License	Administrative Unit	Area (ha)	% of total
AV Cell Inc.	1 Upsalquitch	1 Upsalquitch	421,350	13
Fornebu Lumber Company Inc.	2 Nepisiguit	3 Nepisiguit-Miramichi	257,024	29
	3 Lower Miramichi		310,599	
	4 Upper Miramichi		381,293	
DNR – Kent License Management Team	5 Kent	5 Kent	70,815	2
J.D. Irving Ltd.	6 Queens-Charlotte	7 Queens-Charlotte-Fundy	622,332	32
	7 Fundy		424,308	
AV Nackawic Inc.	8 York	8 York	257,605	8
Twin Rivers Paper Company*	9 Carleton	9 Carleton-Restigouche Tobique	130,896	16
	10 Restigouche-Tobique		396,283	
		Total	3,727,505	100

*License Holder: Twin Rivers Paper Company; License manager: Acadian Timber

Crown Timber Licenses are always linked to specific management objectives, which must be implemented by the licensee and are subject to regular audits. These forest management goals, objectives, and standards are set out by the government of New Brunswick and are administered by the Department of Natural Resources and Energy Development (NRED). The NRED is responsible for periodically monitoring and controlling the activities and performance of the licensees (Martin 2003; NRED 2014).

Licenses are granted for a period of up to 25 years. As a result, a management plan must be implemented. This plan describes the objectives for which the Crown Lands and its resources will be used by the licensee and its sub-licensees, which must be named in the

plan (CL&FA 1980; Martin 2003; NRED 2017). It also describes how the licensee will manage Crown Lands concerning silviculture, timber harvesting, fire protection, road construction and maintenance, forest recreation, fish and wildlife habitat, watershed protection, general land management, and other matters prescribed by regulation (CL&FA 1980). To guarantee compliance with the management plan, the licensee's forest management performance is evaluated by the NRED and third-party auditors at five-year intervals (CL&FA 1980; CCFM 2018c). As a tool to evaluate the compliance of the licensees with forest management acts, regulations, and standards, the NRED uses a Result Bases Forestry system. That system is described in detail in the Forest Management Manual for New Brunswick Crown Lands (NRED 2014).

2.4.2. Private Woodlots

Private woodlots are defined as all forest land except forest land owned by the Crown; forest land owned by a person whose principal business is the operation of a wood processing facility, unless the primary function of the wood processing facility is the production of wood chips and biomass at or on the harvest site, and forest land consisting of an aggregate area of at least 100,000 ha which is owned by the same person or persons (FPA 2012).

As already stated earlier, private woodlots are mostly unregulated by the Province (Floyd et al. 2012; Roach and Berch 2014). Accordingly, private woodlot owners are free to manage their woodlots as they deem appropriate. However, even though in New Brunswick harvest levels from private woodlots are not regulated, the Province defines

an annual allowable cut (AAC), which is supposed to serve as a guideline for a sustainable level of harvesting (Chaini and Johnston 2012). The only regulation private woodlot owners must adhere to is the Clean Water Act (CWA 1989; CCFM 2018c; ERD 2019). This act concerns riparian buffers, water crossings, and lands within designated drinking water supply areas, in which restrictions for private woodlot owners occur (Floyd et al. 2012). Another legislation concerning private woodlots is the Transportation of Primary Forest Products Act (ERD 2019), which is explained in more detail in the timber processing legislation and regulations section. It requires a Transportation Certificate (TC) for wood transports from private woodlots.

There are approximately 41,900 non-industrial private woodlot owners in New Brunswick. Each one of those can choose to be a member of one of seven Forest Product Marketing Boards (FPMB), which cover the whole province. Each FPMB covers a specific area (Figure 3). As a result, private woodlot owners can only be members of the FPMB, which serves the area they live in. The names of the FPMB are as follows: Madawaska Forest Products Marketing Board (MAD), North Shore Forest Products Marketing Board (N-S), Northumberland Woodlot Owners Association (NTH), South Eastern New Brunswick Forest Products Marketing Board (SENB), Southern New Brunswick Forest Products Marketing Board (SNB), York Sunbury Charlotte Forest Products Marketing Board (YSC) and Carleton-Victoria Wood Producers Association (C-V) (Figure 3) (GNB 2018b; NBFWO 2019).

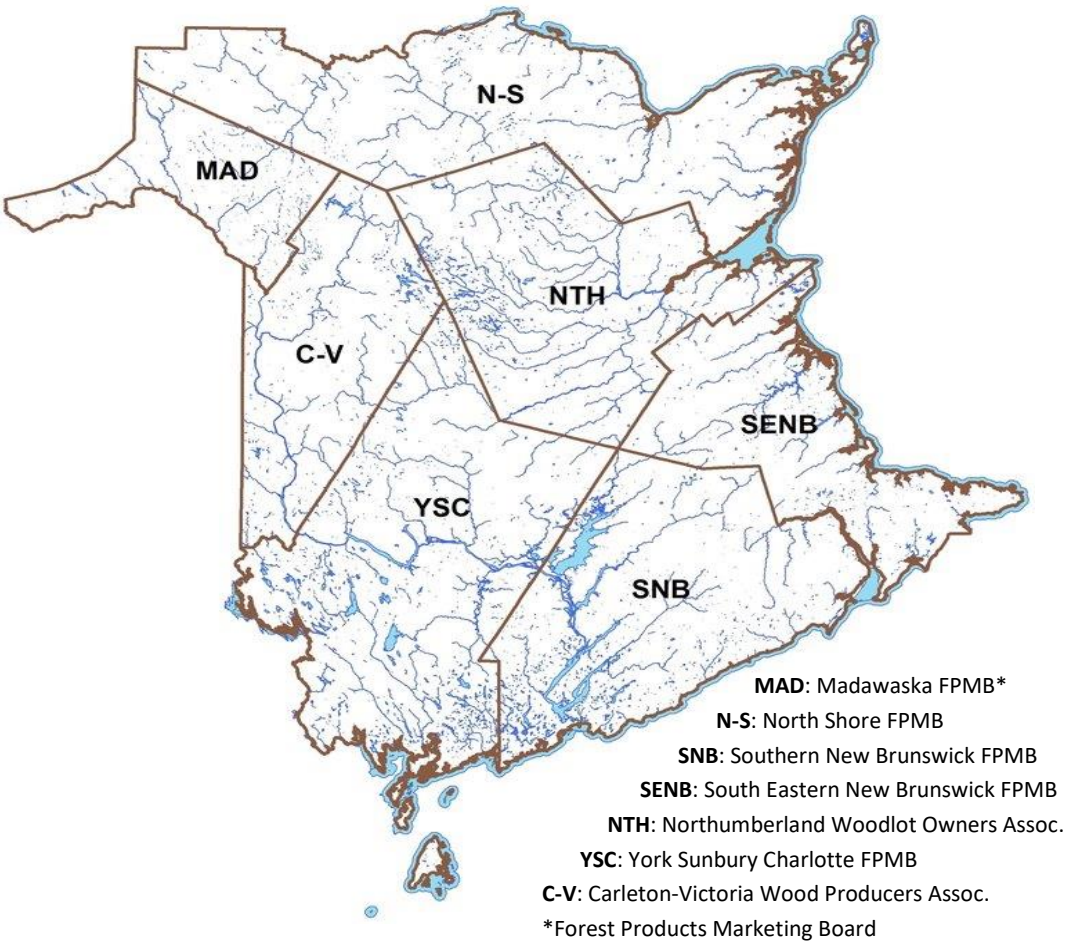

Figure 3 Forest Product Marketing Boards of New Brunswick (NBFWO 2019)

The FPMBs offer different services to their members like the development of management plans, timber cruises, renewal of boundary lines, advice on stumpage agreements, absentee owner programs, or cutting and selling advice for veneer logs. They are also involved in the delivery of the New Brunswick Silviculture Program, which is funded by the Province and provides funding for different silvicultural treatments aimed at improving private woodlots (ERD 2019). These treatments include, for instance, planting, thinning, alternative harvesting methods, or the preparation of management plans (YSC 2019).

Additionally, there is the New Brunswick Federation of Woodlot Owners (NBFWO), which is a federation of private woodlot owner associations across the province. The previously mentioned forest product marketing boards are members of the NBFWO. That means that a private woodlot owner who is a member of a regional marketing board is also a member of the NBFWO. The NBFWO acts as a liaison between the provincial government and the seven marketing boards (NBFWO n.d.).

2.4.3. Industrial Freeholds

Industrial freeholds are private forests owned by large industrial forestry companies. However, the largest forestry company in New Brunswick, which is J.D. Irving, Ltd., owns the most significant share of industrial freeholds. Their freeholds comprise an area of about 728,000 ha (KPMG PRI 2017), which is almost two-thirds of New Brunswick's 1.2 million ha of industrial freeholds and about 12 % of the total forest area. Other industrial freehold owners are the AV Group, H.J. Crabbe and Sons Ltd., Fornebu Lumber Company Inc., and Acadian Timber Limited Partnership.

Industrial freehold forests are managed on a commercial scale, and most companies have their forests certified to at least one of the recognized third-party sustainable forest management (SFM) certification programs like the Sustainable Forestry Initiative (SFI), Canadian Standards Association (CSA) or Forest Stewardship Council (FSC). Just like the private woodlot owners, they must only conform to the Clean Water Act. Furthermore, the NRED Minister occasionally requests information about the management strategy for Industrial Freehold forest operations.

2.4.4. Federal Land

About 2 % of New Brunswick's forests are owned by the Government of Canada (Martin 2003; Nadeau et al. 2012). These forests are located in national parks, military areas, First Nations reserve lands, and research forests (NRC 2015; CCFM 2018a).

Forestry operations are very limited on federal lands, and they only place small amounts of timber into the supply chain. Regarding forestry operations, those are governed by the Canadian Forestry Act (Forestry Act 1985) and accompanying timber regulations, or by legislation enabling forest harvesting on reserve lands (NRC 2020). Provincial legislation applies as well, except when it is overwritten by federal legislations. Forest management plans that include information and statements about inventories, harvesting, silviculture, and other related activities are always required (CCFM 2018a).

2.5. Timber Processing Legislation and Regulations

In regards to Crown lands, the Forest Management Manual for New Brunswick Crown Lands (NRED 2014) outlines the management requirements that guide the planning and operations of the Crown Timber Licensees. Furthermore, under the Crown Lands and Forests Act, all wood processing facilities in the Province of New Brunswick are required to report the volumes of timber and timber sources to the NRED, whatever the wood sources, i.e., Crown lands, private woodlots, industrial freeholds, or imported wood. This allows tracking all roundwood and biomass harvested and consumed in New Brunswick. Timber from all sources is scaled according to the New Brunswick Scalers Act and New

Brunswick Scaling manual (GNB 2012). The NRED is responsible for the oversight of scaling, reporting, and wood tracking on Crown lands (GNB 2012).

Another relevant legislation is the New Brunswick Transportation of Primary Forest Products Act. It requires that all wood products that are transported in the Province of New Brunswick have a Transportation Certificate (TC). Transportation Certificates must indicate the source, date and time loaded, product, species, destination, license plate number, name and signature of the vehicle operator, offload date, and receiver signature. This regulation is also relevant to wood products from private lands (private woodlots and industrial freeholds). The Forest Products Marketing Boards administer the Transportation Certificate system for wood from private woodlots, and legislation is enforced by the New Brunswick Department of Justice and Public Safety (CCFM 2018c).

Furthermore, Crown and private woodlot TC's are subject to audits by NRED and the New Brunswick Forest Products Commission (NBFPC). This Commission is an independent body that oversees the marketing relationships involving the forest industries (pulp mills and sawmills), Forest Products Marketing Boards (private woodlot owners and producers), and the provincial government (NBFPC 2015, 2016a).

2.6. Forest Certification

The Province of New Brunswick requires that Crown forests managed by Crown Timber Licensees are certified under at least one of the following third-party forest certification systems: Sustainable Forestry Initiative (SFI), Canadian Standards Association (CSA) or Forest Stewardship Council (FSC) (Wyatt and Bourgoin 2010; GNB 2014). Currently, a total of 4,234,837 ha of New Brunswick's forests, which account for about 69 % of the whole forest area, is certified under SFI. That includes all the Crown lands, which are managed by the Licensees, which account for an area of about 3.2 million ha. Furthermore, most of the industrial freeholds forests, which account for an additional one million ha, are certified under SFI as well (CCFM 2018c; FPAC 2019) (Figure 4).

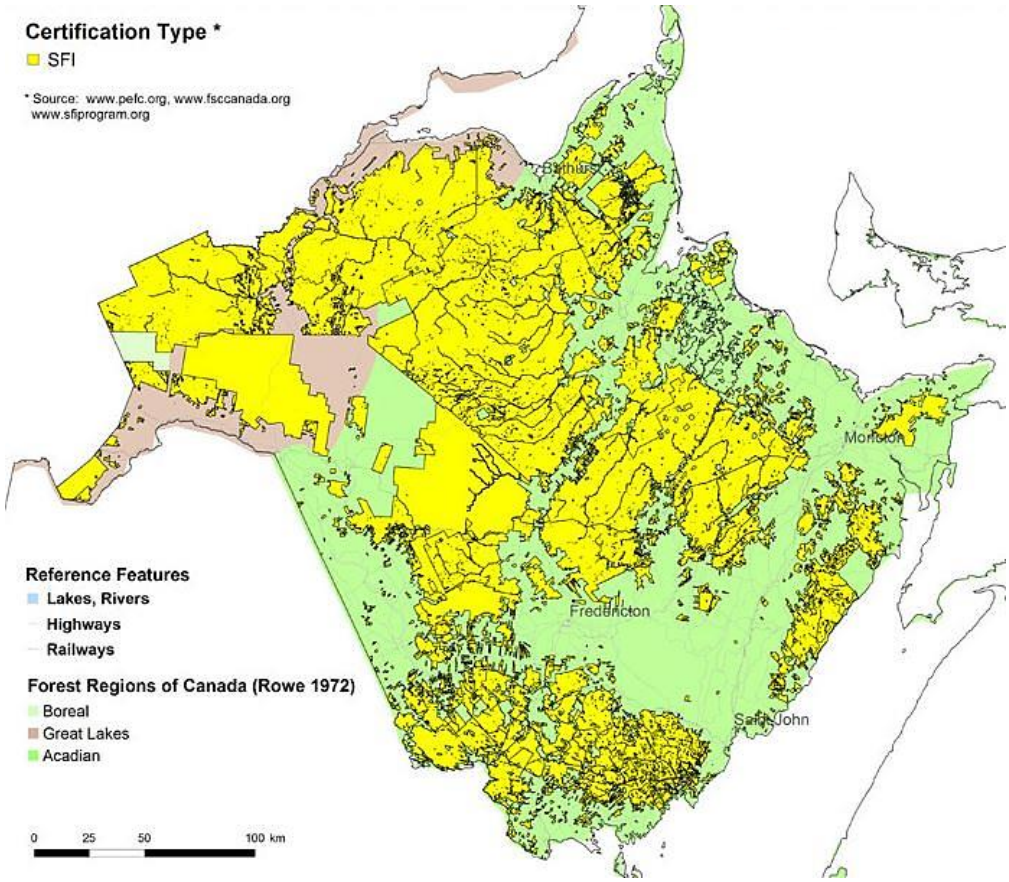

Figure 4 SFI Certification areas in New Brunswick (FPAC 2018)

However, certification on private woodlots is rare (Wyatt and Bourgoin 2010). Furthermore, it is difficult to find any data about certification on private woodlots. Reasons for the lack of certification in private woodlots could be a lack of knowledge, unwillingness to pay, or uncertainty about the usefulness of certification (Vlosky 2000).

2.7. Economic Impact of the Forestry Sector

Canada-wide, nearly 80 % of forest industry employment is concentrated in three provinces: Quebec (31 %), British Columbia (29 %), and Ontario (21 %). However, compared to other provinces, the forest industry represents a larger percentage of New Brunswick's total workforce of about 3.5 %, followed by British Columbia (2.3 %) and Quebec (1.6 %) (NRC & CFS 2019). Forestry is, in fact, New Brunswick's largest industry and as a result, the Province relies more on the resources of this renewable industry than any other Canadian province (Floyd et al. 2012; NRED 2018). Moreover, the forest industry is particularly crucial in rural New Brunswick, where the economy is mainly dependent on the use of renewable and non-renewable natural resources (NBCLTF 2011; Floyd et al. 2012). That is especially true for the counties located in northern New Brunswick, such as Restigouche County, Madawaska County, Northumberland County, and Victoria County (Figure 5). Specifically, these counties are highly dependent on the forestry sector in terms of income and employment (Gardner Pinfold 2018). For instance, Restigouche County has 34.9 % of all county wages and salaries and 68.3 % of all full-

time jobs depending on the forestry sector. That makes it the most forest industry-dependent county of all fifteen of the New Brunswick counties (Gardner Pinfold 2018).

Figure 5 New Brunswick counties; Source: Government of New Brunswick

There is no question that the forestry sector is one of the most prominent drivers of New Brunswick's economy as well as a significant source for jobs in the province. It provides approximately 24,000 jobs (Direct, Indirect and Induced) (Table 5), which means that about 1 in every 14 jobs is linked to forestry (CBJ 2018; Gardner Pinfold 2018). Furthermore, the forest sector salaries are higher than the average incomes of all other census divisions (NBCLTF 2011; Gardner Pinfold 2018). With an average yearly salary of about $54,000, they are almost twice the provincial average, which is currently $29,000

(Gardner Pinfold 2018). However, even though forestry jobs are good-paying jobs, the industry is struggling to find workers to fill vacancies, partially because the Province has an aging workforce. For example, workers are needed on the forestry operations side, which have jobs like logging truck drivers or mechanized forest equipment operators (CBJ 2018). The sector is comprised of about 605 firms, which include forestry and logging companies, support activities for forestry, as well as wood-, pulp-, and paper manufacturing. The largest share of these companies is made up of 405 forestry and logging companies, which include 23 timber tract operations, 9 forest nurseries, 160 non-contract logging firms, and 213 contract logging firms (Gardner Pinfold 2018). In addition to those forestry and logging companies, another approximate 2,500 companies are connected within the supply chain. In total, about 8 % of New Brunswick's businesses are linked to the forestry sector (Gardner Pinfold 2018).

Table 5 shows the direct, indirect, and induced economic impacts of the New Brunswick forestry sector for the year 2016. Direct economic impacts refer to the manufacturing firms, while indirect economic impacts are generated by logging and support activities. The induced impacts are generated from the spending of salaries by those employed in direct and indirect activities (Gardner Pinfold 2018). In 2016, the forestry sector contributed nearly 1.7 billion dollars to New Brunswick's Gross Domestic Product (GDP), which is about 30.4 billion dollars. That means that the forestry sector contributed approximately 5.6 % to the total GDP of New Brunswick (Gardner Pinfold 2018; Statistics Canada 2019). Furthermore, about 1.2 billion dollars of income were generated within the sector (Gardner Pinfold 2018). Despite a severe slump in the industry, which was due

to the 2007/2008 financial crisis, today the sector is back to 90 % of the original harvest levels of 2006, while Nova Scotia is only back to 72 % (Gardner Pinfold 2018).

Table 5 Direct, indirect, and induced economic impacts of the New Brunswick forestry sector for the year 2016, Source: modified after Gardner Pinfold 2018

	Direct	Indirect	Induced	Total
Output	3,244,876	2,136,872	485,746	5,867,494
GDP	698,582	698,103	290,595	1,687,279
Income	529,229	526,768	122,115	1,178,112
Employment*	9,725	11,061	3,081	23,867
Provincial taxes	16,508	33,005	59,152	108,664
Federal taxes	4,126	8,248	26,765	39,139

2.8. Forest Product Markets and Issues

Across Canada, New Brunswick is the most export-dependent province. About 84 % of its forest products are exported into other countries (CBJ 2018). Not surprisingly, the United States of America (U.S.) are the most important export country for New Brunswick and Canada. In 2016, 78 % of all New Brunswick forest product exports went to the U.S., followed by India (7 %), China (2 %), South and Central America (2 %), and the European Union (2 %). In the recent past, New Brunswick aimed to diversify its markets and lower the strong dependence on the U.S. as its main export market. The U.S. share was reduced by 8 %, between 2005 and 2016 thanks the development of new market opportunities like China or increased exports to India (from 2 % to 7 %) (Gardner Pinfold 2018). Interestingly, while the market shares of China and India increased, the market share of the EU decreased from 4 % in 2005 to 2 % in 2016 (Gardner Pinfold

2018). However, with 78 % of New Brunswick's forest products going to the U.S., it is still very much dependent on the U.S. market. Therefore, conflicts like the ongoing Canada-U.S. Softwood lumber dispute, which will be explained in more detail in the following, can pose severe threats to New Brunswick's economy.

The Canada- U.S. softwood lumber dispute is one of the largest and most enduring trade disputes between Canada and the U.S (GAC 2020b). During the past three decades, the U.S. lumber industry has repeatedly attempted to obtain U.S. government restrictions on the import of Canadian softwood lumber through the use of U.S. countervailing duty and anti-dumping laws (GAC 2017). These laws allow the levying of import duties, in this case, countervailing duties, in situations where a U.S. industry is allegedly damaged by subsidies in the exporting country. In the case of dumping, which is when a U.S. industry is allegedly harmed by imported products that are sold at rates lower than the production cost or lower than prices on the domestic market, anti-dumping duties are applied (GAC 2020b).

Anti-dumping duties and countervailing duties on Canadian softwood lumber were introduced because the U.S. industry assumed the provincial stumpage rates, the price that licensees pay to harvest timber on crown land, to be a contestable subsidy. Furthermore, certain provincial funding programs like the free of charge provision of planting material and the reimbursement of planting costs for licensees were considered to be contestable subsidies to Canadian softwood lumber producers (GAC 2020a).

In 2006 an agreement with the U.S. was reached, the so-called 2006 Softwood Lumber Agreement. The agreement provided a certain degree of stability and predictability for

the U.S. as well as for the Canadian industry (GAC 2017; Casey 2019). Because the U.S. agreed that the Atlantic provinces, including New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador were paying market prices on their timber, these provinces were excluded from the countervailing duty investigations and did not have to pay anti-dumping and countervailing duty. However, the 2006 Softwood Lumber Agreement expired in 2015 and with it also New Brunswick's exemption from export taxes and quotas. Since November 2017, softwood lumber products from New Brunswick were not anymore excluded from anti-dumping and countervailing duties on exports to the U.S. (Casey 2019; GAC 2020a). These extra costs obviously have a negative influence on New Brunswick's economy, and for instance, mill closures could be a possible outcome (Casey 2019). The current U.S. anti-dumping and countervailing duty rates came into effect on January 3rd, 2018 and are summarized in Table 6. For the start of the investigation, four major Canadian producers were selected to serve as samples for the countervailing duty and anti-dumping cases. For that reason, these companies (Canfor Corporation, Resolute Forest Products, Tolko Marketing Sales Ltd., and West Fraser Mills Ltd.) have company-specific rates. For the rest, the "All other" rates apply, meaning that New Brunswick based companies must pay 20.52 % in combined duty rates. The remaining company, J.D. Irving Ltd. (JDI), which is based in Saint John New Brunswick, however, is a special case. JDI was individually investigated as well because they voluntarily took part in the countervailing duty investigation and, for that reason, received a company-specific countervailing duty rate of only 3.34 % (GAC 2020a), which is significantly less than the other rates. It could be argued, that if J.D. Irving Ltd. only

pays a combined duty rate of 9.38 %, the same should apply to companies in the whole province of New Brunswick since they pay the same stumpage fees and receive the same silvicultural support from the New Brunswick Department for Natural Resources.

Table 6 U.S. anti-dumping and countervailing duty rates (%) as of January 3rd, 2018
Source: Global Affairs Canada (GAC)

Company	Headquarters	Anti-dumping Duty Rate (%)	Countervailing Duty Rate (%)	Combined Duty Rate (%)
Canfor Corporation	Vancouver, BC	7.28	13.24	20.52
Resolute Forest Products	Montreal, QC	3.20	14.70	17.90
Tolko Marketing Sales Ltd.	Vernon, BC	7.22	14.85	22.07
West Fraser Mills Ltd.	Vancouver, BC	5.57	17.99	23.56
J.D. Irving Ltd.	Saint John, NB	6.04	3.34	9.38
All Others	N.A.	6.04	14.19	20.23

2.9. First Nations and Aboriginal Harvesting Agreements

New Brunswick is home to fifteen First Nation Communities, which are scattered across the province. By the end of 2019, approximately 16,509 First Nations people were living in New Brunswick. Far more than half of them (9,889 people) are living on reserve lands, and the remaining 6,620 people live off-reserve (GNB 2020). The First Nations people can be subdivided into two main nations, which are the Mi'kmaq and the Maliseet Nation. There is also a Passamaquoddy band close to St Stephen.

In order to generate employment and provide economic development opportunities, five percent of the Annual Allowable Cut (AAC) of the crown lands is allocated to the First

Nations communities since 1998, (Martin 2003; CBJ 2018). Commercial harvesting agreements between the New Brunswick Department of Natural Resources and Energy Development and the fifteen First Nations communities are set up every year. Those agreements specify the amounts of timber and royalties allocated to each First Nations community (NRED 2019). The communities can decide by themselves what to do with their 5 % share. They can either choose to harvest the wood by themselves and offer it on the market, or they can hire third-party contractors to do the harvesting for them. Either way, forestry is seen as a good way to foster capacity building in First Nations communities (Martin 2003; CBJ 2018).

2.10. Implications of Climate Change and Other Disturbances

Like many other Canadian provinces, New Brunswick is very likely to experience climatic changes in the future, which will affect its vegetation, and most importantly in this context, its tree species and forest composition. Forests are influenced in multiple ways, with some of them being positive and others being negative. Depending on projections and different climate change scenarios, the outcomes vary. However, stand yields are expected to change, influenced by both positive and negative factors such as a prolonged growing season or by increased droughts. Disturbances like wildfires, pests and diseases are likely to increase. Furthermore, changed regeneration patterns due to disturbances could result in different species compositions (Erdle and Ward 2008).

Until 2100, northward shifts of 250-600 km for several tree species are expected. Of concern, especially for the forestry industry, is balsam fir (*Abies balsamea*). This species,

which is one of the most economically important tree species in New Brunswick, is expected to be at high risk (ERD 2019) and to disappear from large parts of the Province and move northward to northeastern Quebec and Labrador (Johnston et al. 2009). Furthermore, the climate zone suitable for yellow birch (*Betula alleghaniensis*), which is a common deciduous tree species in New Brunswick, is expected to shift northeastwards into central Quebec (Johnston et al. 2009). Those are just two examples of how changes in climate could affect the forests of New Brunswick. These changes will appear gradually over time. There will undoubtedly be tree species that will become less abundant, while others will thrive. For instance, tolerant hardwood species, white pine, and red spruce are expected to be favored under the anticipated climatic changes (Erdle and Ward 2008). Strategies for coping with these issues could involve forest management approaches that favor the regeneration of better-suited species. That could be accomplished, either by choosing appropriate harvest prescriptions to regenerate them naturally or by selecting appropriate species and genotypes to regenerate forests through planting (Erdle and Ward 2008).

Besides climate change, there are also other biotic and abiotic disturbances influencing New Brunswick's forests. One of the most important forest pests in New Brunswick and Canada is the spruce budworm (*Choristoneura fumiferana* (Clem.)), which, despite its name, affects mainly balsam fir but also spruce species (white, red and black spruce). The spruce budworm is native to New Brunswick, and its populations fluctuate from year to year (Zelazny 2007). However, on average, every 35 years, spruce budworm populations increase to epidemic levels (Royama et al. 2017) and lead to major

defoliation of spruce-fir forests, which can lead to tree mortality and consequently to severe economic losses. Spruce budworm outbreaks typically last for about 10 to 15 years (Royama 1984; MacLean and Ostaff 1989). There are different ways of dealing with outbreaks, which include, for instance, spraying insecticides to prevent defoliation to keep trees alive, salvage harvesting of dead trees, or planting non-vulnerable species like jack pine or hardwood species (MacLean et al. 2002).

3. The Forestry Sector in Hesse

3.1. Introduction

This section will start by providing a brief overview of German and European forest resources, followed by a more detailed summary of the Hessian forestry sector that includes a description of the forest resources, forest industry, forest ownership, regulations, forest functions, certification, disturbances, and socio-economic impacts. Such as for the NB forestry sector, the groundwork for the following sections of this report will be based on statistics about the German and the Hessian forestry sectors.

With about 83 million inhabitants, Germany is the most populated country in the European Union (EU) (Destatis 2020). It is also one of the most densely populated countries in Europe, with a population density of about 237 people per km^2 (Table 7).

Across the world, Germany is well known for its forests and its forestry. Roughly 32 % of Germany's land area is covered with forests (Thünen-Institute 2012d), which accounts for about 11.4 million ha (Thünen-Institute 2012a) (Table 6). Germany has the 7th largest forest area in Europe right after Sweden (28.1 M ha), Finland (22.2 M ha), Spain (18.4 M ha), France (16.7 M ha), Norway (12.1 M ha) and Turkey (11.9 M ha) (Forest Europe 2015). Even though Germany has only the 7th largest forest area, it has the highest growing stock (336 m^3/ha) and the highest increment of all 27 EU countries (Eurostat 2011; Thünen-Institute 2012f; Cook 2018). The average increment in German forests is about 11.2 m^3 per hectare and year (BMEL 2017a). The forest area per capita in Germany accounts for approximately 0.14 hectares per person (Table 7).

In terms of forest ownership, about 48.0 % of Germany's forests are owned by private owners, 29.0 % are State Forests (owned by the individual federal states), 19.4 % are communal forests, and about 3.5 % is owned by the Federal Republic of Germany (Thünen-Institute 2012c) (Table 7).

Table 7 General statistics for Hesse and Germany; Source: Destatis, BWI 3

Region	Hesse	Germany
Total area [ha]	2,115,680	35,738,600
Population	6,265,809	83,149,300
Population density [people/km^2]	297.0	237.0
Forest area [ha]	894,180	11,419,124
Forest cover [%]	42	32
Forest area per Capita [ha/person]	0.14	0.14

As all these numbers suggest, forests play an important role in Germany. Not only for economic reasons but also and possibly even more so for their regulating and cultural ecosystem services. The German forestry sector works in a sustainable and multifunctional way to fulfill the whole array of forest functions. Furthermore, the concept of close-to-nature forest management is increasingly being applied in German forests (BMEL 2017b)

In the following, a more detailed summary of the forestry sector in Hesse will be presented. The State of Hesse is situated in west-central Germany and borders six German states (Länder) (Lower Saxony, Thuringia, Bavaria, Baden-Württemberg, Rhineland-Palatinate, and North Rhine-Westphalia). With an area of about 2.1 million hectares, Hesse is the seventh-largest state in Germany. Hesse is also the seventh-most densely populated state, with an average of 297 people per km^2 and about 6.3 million

people living in Hesse. However, approximately half of the Hessian population, about three million people, live in the southern part in the Rhine-Main-Region surrounding the largest city of Hesse, Frankfurt (European Commission 2015). Not surprisingly, the Rhine-Main-Region is also the least forested part of Hesse, with a forest cover as low as 26 % (Figure 6). Forest cover percentages of 50 % and more can be found in rural areas like the Hessian uplands, which include the Northern Hessian Slate Mountains or the rural areas of Spessart and Odenwald (HMUKLV 2012, 2015). Rural and intermediate areas in Hesse account for about 74 % of the Hessian state area. Accordingly, only about 26 % are categorized as urban areas, which can mainly be found in the Rhine-Main-Region (European Commission 2015) (Figure 6).

Together with the state of Rhineland-Palatinate, Hesse has the highest percentage of forest cover among the German federal states (Thünen-Institute 2012c; BMEL 2017a; HessenForst 2018). About 894,180 ha of the area of Hesse is covered with forests, which accounts for approximately 42 % of its surface area (Thünen-Institute 2012a; European Commission 2015; SDW 2018). The forest area per capita in Hesse accounts for approximately 0.14 hectares per person, which is about the same as for the whole of Germany (Table 7).

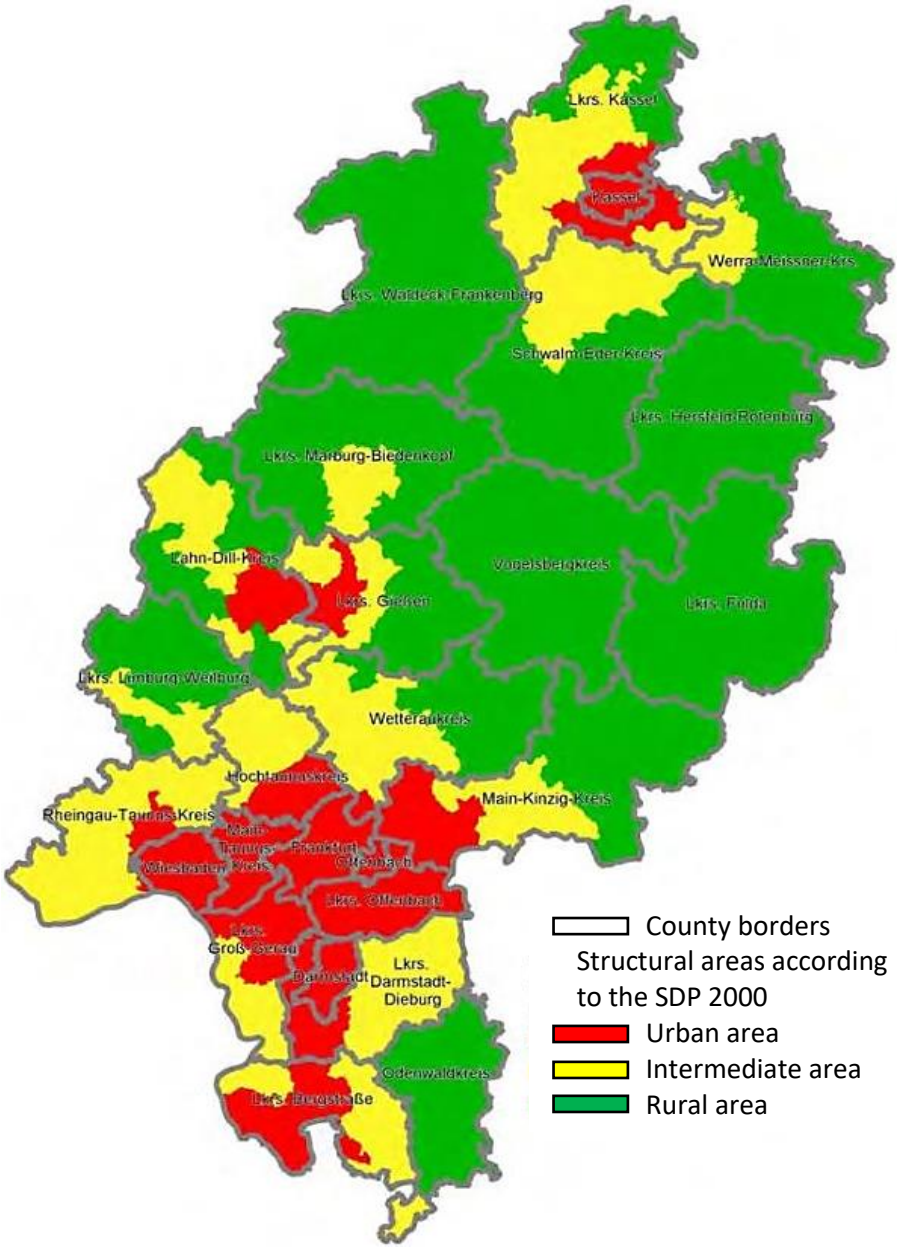

Figure 6 Zonings in Hesse according to the State Development Plan (SDP)
Modified after: HMWEVW

Forests can be found in the entire state of Hesse, covering the whole ecological amplitude. They occur on an altitude between 90 m to 950 m, featuring an annual average temperature between 5-10 °C. However, the average temperatures during the vegetation period, which is from May to September, are between 12.5 °C and 17 °C. The average precipitation ranges between 600 mm and 1300 mm per year. The parental

material of Hessian soils is mostly sandstone, quartz rock, and slate, which most often results in brown earth soil types (HMUKLV 2012).

In terms of the importance of the earlier described forest functions, Hesse is no different from the rest of Germany. The state of Hesse is using a multi-functional forest management approach to provide social, economic, and environmental benefits at the same time on the same site. Due to the high population density, especially in the southern part of Hesse, recreational and protective functions are of utmost importance and are an important goal of forest management. Furthermore, about 40 % of the Hessian State Forests are protected areas within the European Union Natura-2000 protected areas network (Wilke 2010; HessenForst 2011; HLNUG 2012).

The Hessian State Forest sustainably produces the resource wood, has a high significance as a place of recreation and education, serves as a retreat for plants and animals, improves the climate, is a workplace for numerous people, especially in rural areas, and provides income for the state budget.

3.2. Forests and Tree Species

Compared to the German average of 43.4 % for deciduous and 54.2 % for coniferous-tree species, Hesse is a particularly deciduous tree species-rich state (Table 8). In Hesse, about 57.5 % of the trees are deciduous (hardwood), and only about 39.9 % are coniferous (softwood) tree species (Thünen-Institute 2012b). While the share of 57.5 % of deciduous tree species is high, there are several other German federal states just like North Rhine-Westphalia (55.1 %), Rhineland-Palatinate (58.7 %) or Schleswig-Holstein

(63.9 %) which have similar or even higher proportions of deciduous tree species (Thünen-Institute 2012b). By far, the four most important tree species in Germany are Norway spruce (*Picea abies*), Scots pine (*Pinus* sylvestris), European beech (F*agus sylvatica*) and oaks ((either pedunculate (*Quercus robur*) or sessile oak (*Quercus petraea*)) (Thünen-Institute 2012b). Norway spruce has not only the highest share of forest area (25.4 %) of all tree species in Germany but also the highest standing stock. From an economic point of view, Norway spruce is currently the most important tree species in Germany, with about 52 % of all timber produced being Norway spruce. The German forestry sector heavily relies on softwood and especially on Norway spruce. However, that is supposed to change in the future, since Germany is currently in a transformation process intending to grow larger shares of mixed deciduous forests which are more desirable form a silvicultural and ecological point of view and are also considered to be more resilient and resistant to climate change impacts. As a result, two major tasks for the future will be to find suitable substitutes for Norway spruce and to develop new and innovative marketable hardwood products (BMEL 2017b).

Table 8 Percentage of tree species areas in 2012, Source: BWI 3

	Tree Species	Scientific Name	Hesse	Germany
Coniferous	**All coniferous**		**39.3**	**54.2**
	Norway Spruce	*Picea abies*	21.7	25.4
	Scots Pine	*Pinus sylvestris*	9.3	22.3
	Silver Fir	*Abies alba*	0.1	1.7
	Douglas Fir	*Peseudotsuga menziesii*	3.6	2.0
	European Larch	*Larix decidua*	4.6	2.8
Broadleaf	**All broadleaf**		**57.5**	**43.4**
	European Beech	*Fagus sylvatica*	30.1	15.4
	Oak	*Quercus spp.*	13.2	10.4
	Pendunculate	*Quercus robur*	,,	,,
	Sessile	*Quercus petrea*	,,	,,
	other deciduous trees with a long-life expectancy		7.0	7.1
	other deciduous trees with a short-life expectancy		7.2	10.5

However, in Hesse, the most common tree species is European beech (*Fagus sylvatica*) (30.1 %), which is almost twice as much as the German average (15.4 %) and way higher than in any other German state (Thünen-Institute 2012b) (Figure 7). In fact, beech forests are the potential natural vegetation for most of central Europe with Germany and accordingly Hesse as the center of its distribution area (Wagner M et al. 2015). Without human influence, European beech would occupy approximately 90 % of the area in the state of Hesse (HMUKLV 2014).

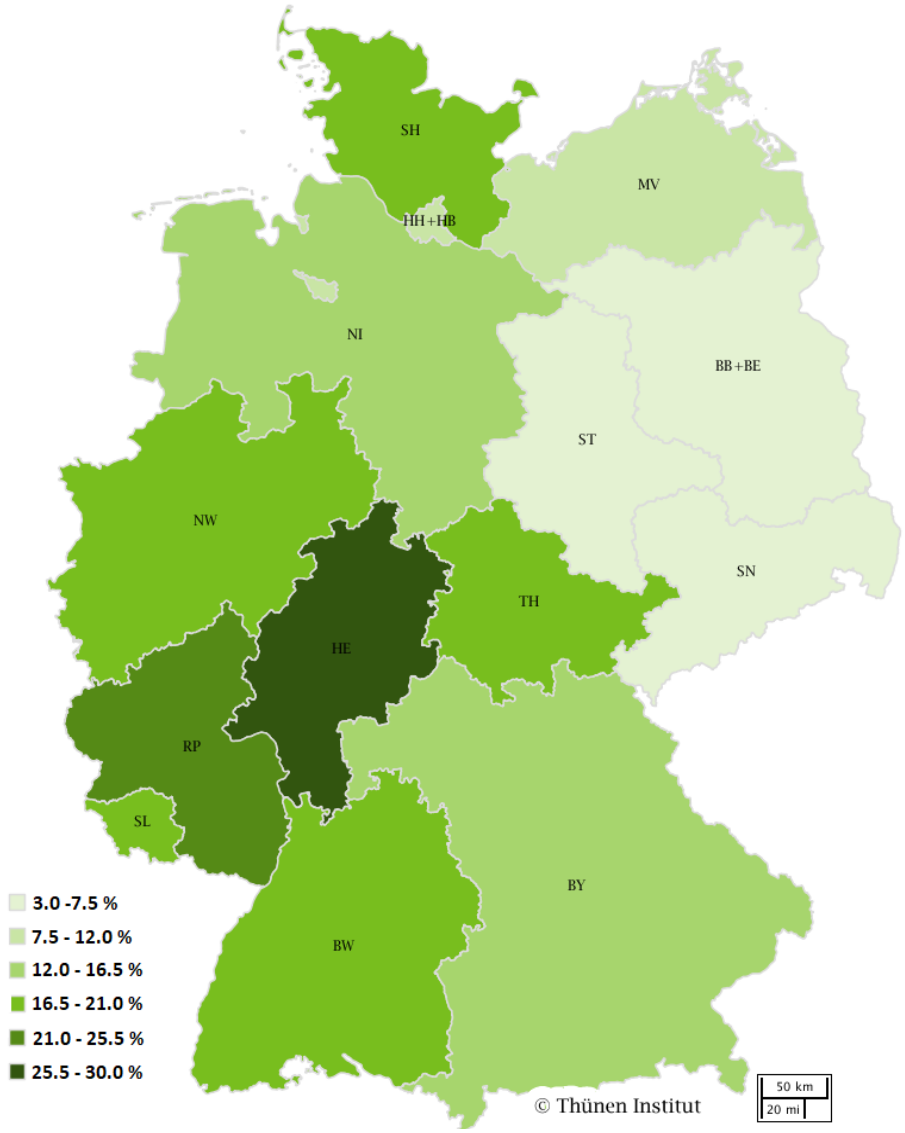

Figure 7 Share of European Beech in German federal states in 2012 in percent of forest area. Hesse is the dark green colored state. Source: Third National Forest Inventory (BWI III)

Apart from European beech, the other main tree species in Hesse are Norway spruce, Scots pine, pedunculate oak, and sessile oak. As already stated earlier, Norway spruce with a share of 25.4 % of the forest area, is the most common tree species in Germany, and the second most common tree species in Hesse with a share of 21.7 % right after European beech. Besides the main tree species, there are several other deciduous tree species which are summarized under other deciduous trees with long life and short life

expectancy in Table 8. These include species such as silver birch (*Betula pendula*), field maple (*Acer campestre*), Norway maple (*Acer platanoides*), sycamore maple (*Acer pseudoplatanus*), European ash (*Fraxinus excelsior*), European hornbeam (*Carpinus betulus*), red oak (*Quercus rubra*), black poplar (*Populus nigra*), small-leaved lime (*Tilia cordata*), large-leafed lime (*Tilia platyphyllos*), European aspen (*Populus tremula*), white willow (*Salix alba*), goat willow (*Salix caprea*), Scots elm (*Ulmus glabra*), European white elm (*Ulmus laevis*), mountain ash (*Sorbus aucuparia*) and wild cherry (*Prunus avium*). All of those together make up for about 14.2 % of the area, with the most common ones being silver birch, sycamore maple, European ash, and European hornbeam (HMUKLV 2014).

In general, Hessian forests are progressing towards an increased share of deciduous tree species. Reasons for that are, for instance, the heavy windstorms Kyrill in 2007, Emma in 2008, Xynthia in 2010, and Friederike in 2018, and severe bark beetle infestations (i.e., in 2018 and 2019) which led to significant area losses, especially in Norway spruce and Scots pine stands. Furthermore, they gave rare species like Sycamore maple, European ash, or European white elm, the chance to increase their areas. However, many deciduous tree species are also affected by disturbances, such as pests and diseases or drought (NW-FVA 2019). These area losses are not as significant due to their lower shares of the forest area and because they are usually not grown in monocultures like it is often the case for Norway spruce. To deal with disturbances and to lower the risk for storm damage, bark beetle infestations, other pests and diseases, and to account for future climate change impacts, the share of mixed-species deciduous forests is supposed to

increase. That action is part of the Hessian close-to-nature and multipurpose forestry approach (Schulzke and Stoll 2007; HMUKLV 2012, 2018).

The mean increment of all tree species in Hesse is 10.9 m^3/ha/year. The highest increments are obtained for Douglas fir (19.1 m^3/ha/year), Norway spruce (16.6 m^3/ha/year), European beech (10.1 m^3/ha/year), and European larch (10.1 m^3/ha/year). Across all ownership types, the growing stock in Hessian forests accounts for just about 341 m^3/ha (HMUKLV 2014), which is slightly more than the German average of 336 m^3/ha (Thünen-Institute 2012e).

3.3. Forest Ownership

Forest ownership and distribution in Hesse are highly diverse and scattered across the Hessian state (Table 9). In general, it can be distinguished between four different ownership types, which are private, communal, state, and federal forests. The biggest forest owner in Hesse is the state of Hesse itself, which owns about 38.2 % (341,516 ha) of the forests. Compared to the German average of 29 %, Hesse has a particularly high share of State Forests (Thünen-Institute 2012c). Furthermore, the Hessian State Forest is behind Bavaria, the second largest state-owned forest in Germany. However, it is only less than half of the size of the Bavarian State Forest, which comprises an area of about 777,670 ha (Thünen-Institute 2012c) (Table 9).

Table 9 Forest ownership types and distribution in Germany and Hesse; Source: BWI 3

	Hesse		Germany	
Ownership type	**Area [ha]**	**Share [%]**	**Area [ha]**	**Share [%]**
Public (State Forest)	341,516	38.2	3,309,537	29.0
Private	218,746	24.5	5,485,679	48.0
Communal	324,320	36.3	2,220,445	19.4
Federal	9,598	1.1	403,464	3.5
Total	894,180	100	11,419,124	100

Regarding management, the Hessian state-owned forests are exclusively managed by the State Forest Enterprise (SFE) "HessenForst", which is the operational wing of the Hessian State Forest authority.

Just like the State Forest, the share of communal forests, which is approximately 36.3 % (324,320 ha) (Figure 8), is very different from the German average of approximately 19.4 % (Table 9) (Thünen-Institute 2012c). The communal forests are owned by 418 Hessian communities and cities, which also means that only eight Hessian municipalities do not own any forests (Scheele and Backhaus 2000). Communal forests include, for example, forests owned by public entities like cities, towns, or universities (§3 BWaldG, §2 HWaldG).

The share of private forests, however, is with 24.5 % (218,746 ha) (Figure 8), only about half of the German average of 48 % (Table 9) (Thünen-Institute 2012c). Roughly 50 % of the private forest area, approximately 110,000 ha, is owned by more than 60,000 individual private owners (HMUKLV 2015). About 47,000 of those are small scale forest owners, which own parcels of forest with an average size of less than 3 ha (HMUKLV

2012). A third of those small-scale forest owners are farmers who own small parcels of forest and make use of them, especially in winter, when their agriculture is less

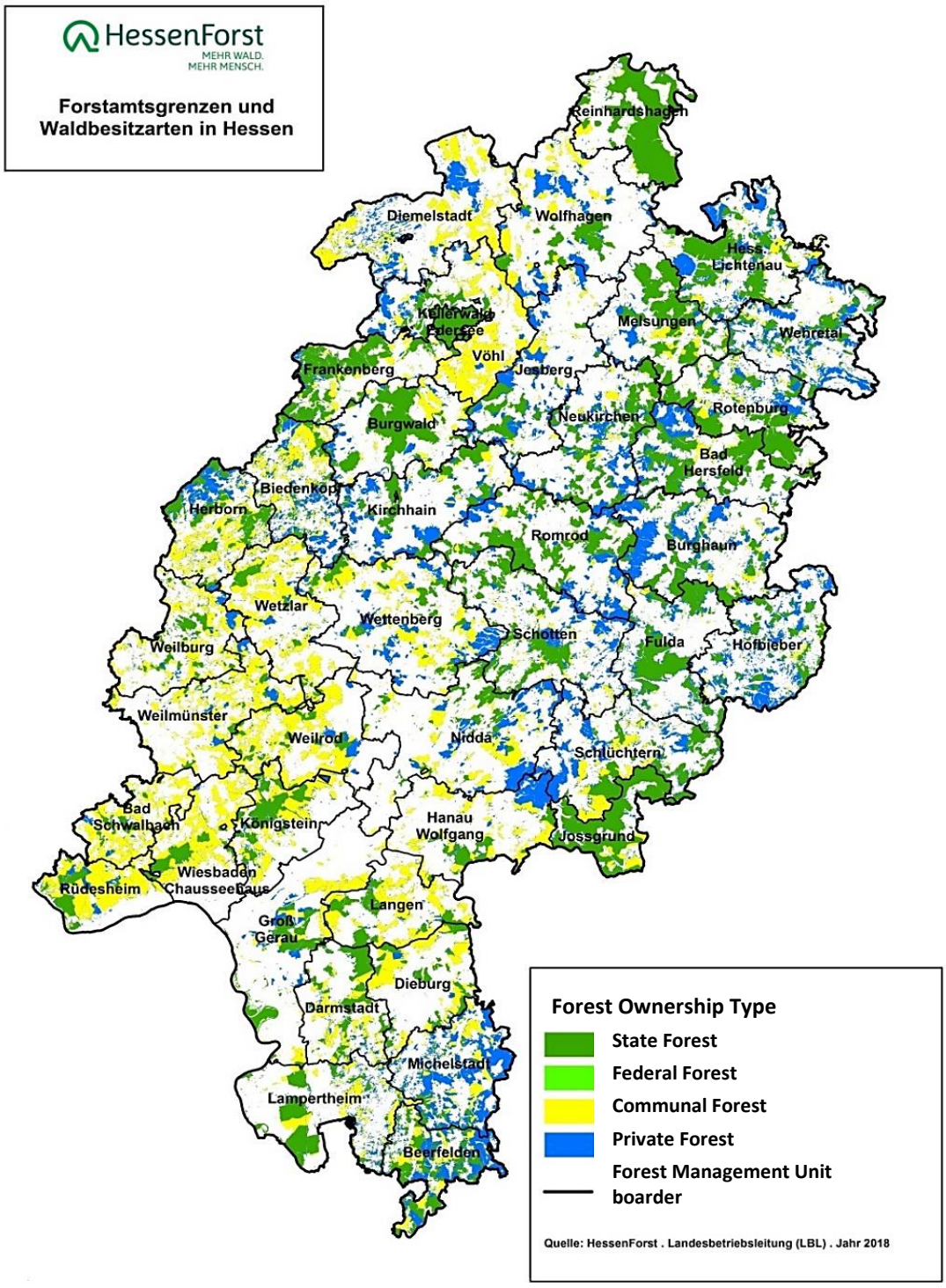

Figure 8 Forest Management Units and forest ownership distribution in Hesse (HMUKLV 2019) modified after: RiBeS 2018

labor-intensive. This high number of small-scale forest owners is, amongst other things, caused by an old inheritance system of partible inheritance, where each heir gets an equal part of the inheritance. Another 14,000 individuals own parcels of forest with an average size of about 80 ha and only 170 individuals own forest parcels with an average size of 420 ha (HMUKLV 2012). The largest private forests in Germany are usually owned by aristocratic families, like the Thurn und Taxis family, which owns about 20,000 ha, i.e., the largest private forest in Germany (Wald-Prinz.de 2019).

However, large scale private forest owners comprise only a small amount of forest owners. By far the highest amount of private forest owners are small-scale forest owners, which causes issues like problems with wood mobilization, absent forest owners, and accordance with management obligations. However, one of the tasks of the State Forest Enterprise is to deal with these issues and to support private and communal forest owners in forest management, which will be described in more detail in the following section.

The fourth type of ownership is the federal forests, which are owned by the Federal Republic of Germany. Federal forests make up only about 1.1 % (9,598 ha) of the Hessian forests (Table 9) (Thünen-Institute 2012c). Most of those forests are situated in military areas, alongside highways and big rivers like the Rhine or the Main river. The primary functions or purposes of those forests are often protection functions, for example, from noise or dust from military practice sites or highways.

3.4. Forest Governance, Management Legislation and Regulations

When talking about forest governance, forest management legislation and regulations, the different types of forest ownership should be distinguished, since those often imply slightly different ways of management, regulations, and more or less important functions. The four forest ownership types in Hesse are state, private, communal, and federal forests. However, this chapter will focus mostly on State Forests, since they make up the largest share of forests in Hesse and because the State Forest Enterprise plays a major role in managing Hessian forests. Furthermore, the Hessian Forest Act and the Federal Forest Act apply to all types of forest ownership. In total, about 78 % of the total forest area in Hesse is managed by the State Forest Enterprise "HessenForst", which emphasizes its importance. As a matter of fact, HessenForst manages 100 % of the State Forest as well as 86 % of the communal forests and 35 % of private forests (HessenForst 2018). However, that is likely to change in the future. The reasons for that change will be explained in more detail in section 3.4.4 about the State Forest Service HessenForst.

Before taking a closer look at Hessian forest governance, management legislation, and regulations, it is important to start on the federal or even at the EU-Level since those policies lay the groundwork and heavily influence Hessian regulations and legislations. On the EU-Level, several policies, such as the Biodiversity Strategy and the decisions on climate policy, biomass, and renewable energies, have direct impacts on German and Hessian forest policy and management (BMEL 2017b). Another policy affecting forests in Germany is the Natura 2000 Network of protected areas, which is an instrument for implementing the goals of the EU Council Directive 92/43/EEC on the Conservation of

natural habitats and of wild fauna and flora or more commonly known as the Habitat directive (European Commission 2019). Approximately 24 % of Germany's forest areas are included in the Natura 2000 network (BMEL 2017b). However, there is no formal common European forestry policy, such as for the agriculture and fisheries sectors. The EU Commission's Standing Forestry Committee is the central advisory body for the coordination of the EU member states when it comes to forest policies. The central EU guideline concerning forests is the EU Forest Strategy of September 2013 (BMEL 2017b).

The most important forestry regulations on the German federal level can be found in the Federal Forest Act, which is described in more detail in the following section. Other important federal regulations that affect forests are the Act on Forest Reproductive Material, the Act on the Joint Task for the Improvement of Agricultural Structures and Coastal Protection, the Timber Trade Safeguard Act, the Compensation for Forest Damage Act, the Federal Hunting Act, and the Federal Nature Conservation Act (BMEL 2017b).

3.4.1. Federal Forest Act

In Germany, the legal provisions on forests, known as the Forest law, are determined by the Federal Forest Act (1975), which had its last revision in 2017. The Federal Forest Act itself is part of the environmental law. Just like the environmental law, the Federal Forest Act is considered to be a framework law, which means that the basic principles are laid down there, but for some parts of the law, the States can make their own more detailed regulations. However, for other parts of the law, such as the regulations on forestry, competing legislation can occur, meaning the States may issue their individual

regulations, but these are repealed as soon as the federal government makes corresponding regulations (BMEL 2017b).

The Federal Forest Act was enacted in particular to preserve the forest for its economic benefits (provisioning ecosystem good and service) and its importance to the environment, in particular for the continuous performance of the natural balance, the climate, the water regime, air purification, soil fertility, the appearance of the landscape, agriculture and infrastructure and the recreation of the population (protective and recreational functions), and, if necessary, to increase the forest area and ensure its sound management in a sustainable manner, to promote forestry and to achieve a balance between the general public interest and the interests of the forest owners (German Federal Parliament 1975).

3.4.2. Hessian Forest Act

In Hesse, there have been forestry regulations for more than 70 years. The Hessian Forest Act of 1954 was the cornerstone, and it had a fundamental revision back in 1978. Since then, society has changed, people's demands upon the forest have changed, climate change has become evident, and biodiversity and sustainability are more important than ever. As a result, a fundamental revision of the forestry regulations in Hesse has been carried out and adopted in 2013.

The completely revised Hessian Forest Act is more modern and explicit than the earlier versions and clearly states the objectives for the conservation and management of Hessian forests. Within the framework of sustainable forest management, all functions

of the forest are supposed to be implemented. According to this Act, it is a clearly stated goal to promote forestry and to achieve a balance between the interests of the general public and the interests of the forest owners. Paragraph 3 of the Hessian Forest Act requires all types of forest ownership to ensure competent, orderly, and sustainable forest management in order to preserve the forest's productive-, protective-, climate protection-, and recreational functions (§3 HWaldG - Grundpflichten).

The requirements for sound forest management [German: ordnungsgemäße Forstwirtschaft] are clearly stated in the law and are listed below (HMUKLV 2015).

Characteristics of sound forest management as stated in the Hessian Forest Act are in particular as follows:

1. The long-term and sustainable character of forest production,
2. The conservation of forest ecosystems as a habitat for species-rich plant and animal life by establishing healthy, stable, and diverse forests,
3. The avoidance of clearcutting of areas larger than one hectare,
4. The selection of site-adapted tree species, using suitable seed and planting material while maintaining genetic diversity,
5. The site-adapted use of fertilizers to maintain and improve soil fertility,
6. The use of the potential offered by integrated plant protection, avoiding the use of herbicides and pesticides as far as possible,
7. A gentle approach to measures of maintenance, utilization, regeneration, and transport,

8. The application of adapted forest management methods that are not harmful to forest stands and soil,
9. The demand-oriented development of forests while protecting the landscape, forest stands and soil,
10. The functional design of forest edges, which also takes into consideration the interests of species protection, landscape conservation, and agriculture and
11. The promotion of game densities adapted to forest stands and their regeneration, and measures to prevent damage caused by game populations (Hessischer Landtag 2013)

Some other important regulations include, for instance, article eight, the statutory duty for orderly forest management [German: planmäßige Forstwirtschaft], which is described as a kind of management that is based on an operating plan to ensure sound forest management and sustainability. According to that regulation, every forest owner with a combined forest area of 100 ha or more is obligated to define their forest management objectives in an operating plan. Operating plans are made up for ten years to account for a changing environment and changing societal needs. For State Forests, those plans are prepared by the State Forest Enterprise (HessenForst). For communal and private forests, operating plans are prepared, whether by the SFE or any other authorized expert or forestry technician (Hessischer Landtag 2013).

Another fundamental regulation is the right to enter forests. According to that regulation, every person has the right to enter the forest for leisure and recreation purposes, regardless of the type of forest ownership. There are only a few exemptions.

It is, for instance, not allowed to enter the forest with motor-driven vehicles for leisure and recreation (§ 15 HWaldG – Betreten des Waldes, Reiten und Fahren).

3.4.3. State Forest Administration

The forest administration in Hesse operates on three levels, which consist of the supreme, the superior, and the lower forest authorities. The supreme forest authority in Hesse is the Ministry of Environment, Energy, Agriculture and Consumer protection (HMUELV), which is situated in Wiesbaden, the state capital. The superior forest authorities are the three provincial governments [German: Regierungspräsidien] with their departments for forest affairs in the cities of Kassel, Gießen, and Darmstadt. The lower forest authorities are composed of the 41 Forest Management Units (FMU) of the State Forest Enterprise HessenForst (HMUKLV 2012; Hessischer Landtag 2013).

One of the main tasks of the superior and, accordingly, the supreme forest authorities, is the supervision of forest management. Communal and private forest owners with a combined forest area (operating area) of 100 ha or more, are subject to forest supervision if their forests are not managed by the SFE. The practice of forest supervision by the superior forest authorities aims to ensure and monitor compliance with forest laws and regulations. That includes compliance with the basic obligations of forest owners, which are the management of forests to the benefit of the general public and the fulfillment of protective, productive, climate protection- and recreational functions (RP Kassel 2016; RP Darmstadt 2019).

Under § 5 of the Hessian Forest Act, forestry enterprises with an operating area of 100 ha or more must prepare operating plans. Those plans are set up for a time frame of 10

years and are mandatory for all types of forest ownership. The operating plans build the foundation for forest management (i.e. harvesting, regeneration, forest functions) and must be renewed on a ten-year basis (RP Kassel 2016; RP Darmstadt 2019).

3.4.4. State Forest Enterprise HessenForst

The State Forest Enterprise HessenForst, which is the operational wing of the Hessian State Forest authorities, plays a fundamental role in managing Hessian forests. It assumes the rights and duties of the State of Hesse as a forest owner, carries out forest management and technical services for communal and private forests, contributes to forest sciences research and scientific cooperation, conducts forest-related education and supports the forest authorities so that they can carry out their tasks (Hessischer Landtag 2013; HMUKLV 2015). Furthermore, the SFE is responsible for hunting and the management of the game populations in the State Forests (HMUKLV 2012).

As mentioned earlier, about 78 % of the total forest area of Hesse is managed by the SFE, which includes major parts of communal (86 %) and large parts of private forests (35 %) (HessenForst 2018). The forest management provided by the SFE for communal and private forests includes forestry services such as tree labeling, harvesting, technical support, forestry consulting and the sale of the timber. To guarantee appropriate and competent forest management and other services to private and communal forests and the general public, the SFE has a state-wide field structure. This Hessian-wide structure is comprised of 41 Forest Management Units, each having 10-12 forest engineer districts.

Each of the FMUs, on average, manages an area of about 18,000-20,000 ha of forest (HMUKLV 2012).

All forests, including private and communal, that are managed by the SFE are managed in accordance to the Agenda 21, the forest principles of UNCED in Rio 1992, the Ministerial Conference on Protection of Forests in Europe (Forest Europe), the Agenda 2000 of the European Commission, the Federal Forest Act, and the Hessian Forest Act (HMUKLV 2012).

However, how HessenForst is managing communal and private forests is likely to change in the future. In particular, changes need to be made to the practice of joint marketing of roundwood from communal, private, and State Forests. A process to find solutions for that issue started in 2018 and is still in progress (HessenForst 2018). The background for this change is a proceeding against the State of Baden-Württemberg and its joint marketing of round timber, which was initiated by the Federal Cartel Authority [German: Bundeskartellamt] back in 2012. Sawmills and the timber industry complained about the joint marketing of round timber by the State Forest company Forst BW. Forst BW markets timber from public, communal, and private forests, which overall accounts for about 60 % of the volume of the total round timber sold in Baden-Württemberg. The prices for timber from all types of forest ownership, the customers, and the conditions for sales were negotiated and determined by Forst BW. However, this kind of practice is, according to the Bundeskartellamt, prohibited under the competition law (BKartA 2015).

Although this case was being filed against Baden-Württemberg, it sets an example and thus will impact the State Forest services of other German states as well. As stated

earlier, HessenForst is already in the process of making changes to its management practices for communal and private forests. These changes include, for instance, that HessenForst is no longer selling wood from private and communal forests being larger than 100 ha (Spriestersbach 11/14/2018; Schulze 2018).

3.5. Timber Processing Legislation and Regulations

For measuring and rating timber in Germany, and accordingly in Hesse, the Framework Convention for the Raw Timber Trade in Germany (RVR) is used. This set of rules is a private-law regulation that has been internally agreed within the industry and is intended to make the German raw timber market more transparent and efficient. The RVR came into force in 2015 and replaced the Gesetzliche Handelsklassensortierung für Rohholz (Forst-HKS) from 1969, which was a federal act governing measurement and rating/classification of timber.

3.6. Forest Functions

The forest in Hesse fulfills a multitude of functions, which are named and described in the Hessian Forest Act. In the Federal and the Hessian Forest Act, the term “forest functions” is still being used. These terms are outdated, and in science forests functions are referred to as ecosystem goods and services (Millennium Ecosystem Assessment 2005). Nevertheless, the term forest functions is still being used in this report, according to the regulations described here. The functions are divided into four main groups: protective functions, productive functions, climate protection functions, and recreational functions. All those functions are supposed to be fulfilled simultaneously on

every site by applying an orderly and sustainable forest management approach. In the case of conflicting goals, biodiversity, climate protection, and other protective functions take precedence over productive and recreational functions (HMUKLV 2018).

The mapping of forest functions is part of the development of mid-term (10 years) forest management plans. This task is carried out by the Institute for Forest Inventory and Planning (FENA), which is a division of the State Forest Enterprise (HMUKLV 2012). Since the State of Hesse is densely populated, and every forest owner is obligated to manage their forests also to benefit the public, the different forest functions are of high importance (Volz 2001). In terms of public benefit, recreational and protective functions stand out, which is especially true for densely populated areas like the Rhine-Main-Region, where the recreational functions might even be the most important ones (DFWR 2016; BMEL 2019). However, the provision of recreational and protective functions creates certain costs. On the one hand, these costs can arise due to active management to create, for instance, a higher recreational value of the forest. On the other hand, costs can also occur in the form of opportunity costs and a decrease in timber harvest (Rosenkranz and Seintsch 2015; BMEL 2017a).

3.7. Forest Certification

Hesse has about 894,180 ha of forest, from which major parts are certified under at least one of the large third-party forest certification schemes (Table 10). The main third-party forest certification schemes in Hesse are FSC (Forest Stewardship Council) and PEFC (Programme for the Endorsement of Forest Certification Schemes). Since 2018, 100 %

(341,516 ha) of the Hessian State Forest (public forests), which is more than 38 % of the total forest area, are certified under FSC. The certification process started in 2014 with nine out of a total of 41 Forest Management Units (FMU, Forstämter) and was finished in 2018 with all 41 FMUs (HMUKLV 2019). The FSC standards are intended to increase the ecological value of the Hessian State Forest, make it more resistant and to lower the risk of disturbances in the future. For instance, the use of any pesticides (i.e. Glyphosate) is generally prohibited. Furthermore, ten percent of the certified area must be set aside for conservation purposes and therefore excluded from any forest management activities (Wilhelm et al. 2018). Concerning tree species selection, FSC is guided by the naturally occurring forest communities. Hesse is very strongly influenced by the occurrence of forest communities with European beech (*Fagus sylvatica*) as the main tree species, which is supposed to increase. However, coniferous species such as Norway spruce (*Picea abies*) or Douglas fir (*Pseudotsuga menziesii*), will be reduced in some places (HMUKLV 2019).

Table 10 Forest certification in Hesse, Source: PEFC Deutschland 2019, HMUKLV 2019

Third-party certification scheme	Area [ha]	Percentage of the total forest area [%]
PEFC	783,496	87.62
FSC	341,516	38.19
Both PEFC and FSC	324,359	36.27
Total area certified	783,496	87.62

Another relevant third-party forest certification scheme is PEFC, under which an even greater portion of the forests in Hesse is certified. In 2019, the PEFC certified forest area in Hesse accounted for approximately 783,496 ha, which is about 88 % of the total forest

area (PEFC Deutschland 2019). Hesse has the highest share of PEFC certified forests amongst all German states (HMUKLV 2019). PEFC follows a different approach than FSC, which includes, for example, the possibility to certify whole regions under PEFC. Hesse is such a PEFC region. This concept is comprised of two stages. In the first stage, the whole region is reviewed for sustainable forest management, and once that is approved, individual forest owners can join the regional certification (HMUKLV 2019). Especially for Hesse with its diverse and scattered forest ownership pattern, this kind of certification approach makes sense and makes it easier for small private owners to get certified. In total, 691 forest enterprises and associations in Hesse are certified under PEFC (HMUKLV 2019; PEFC Deutschland 2019).

While FSC certified forests can mainly be found in the State Forest (public), FSC certification is much less common in private and municipal forests. In contrast, PEFC certified forests in Hesse do include not only State Forests but also large parts of private and communal forests. For instance, 28 % of the PEFC certified forests in Hesse are communal forests, 13 % are private, and another 16 % are forests owned by forestry cooperatives (PEFC Deutschland 2019).

3.8. Economic Impact of the Forestry Sector in Hesse

The forestry sector plays a considerable role in the Hessian economy. Between 2009 and 2017 on average about 2.2 % of all jobs in Hesse were within the so-called “Cluster Forst und Holz” (forestry and timber cluster (FTC)), and it contributed approximately 1.4 % to the Hessian states gross value added (GVA) (Jaensch and Harsche 2007; Harsche et al. 2013; Becher 2016) (Table 11).

Table 11 Employment and gross value-added data for Hesse between 2009 and 2016, Source: Becher 2016; Weimar 2017.

Year	Total		Forestry and Timber Cluster in Hesse			
	Number of employees	Gross value added (million €)	Number of employees	Number of employees [% of total]	Gross value added (million €)	Gross value added [% of total]
2009	3,174,100	196,920	72,972	2.30	2,969	1.51
2010	3,178,800	204,422	71,404	2.25	2,728	1.33
2011	3,219,500	211,607	71,985	2.24	3,041	1.44
2012	3,256,600	213,887	72,547	2.23	3,104	1.45
2013	3,271,400	219,363	71,151	2.17	3,064	1.40
2014	3,306,800	228,405	70,056	2.12	3,049	1.33
2015	3,341,500	235,635	68,603	2.05	3,092	1.31
2016	3,384,700	246,121	72,778	2.15	3,397	1.38
2017	3,445,610	253,277	71,839	2.08	3,031	1.20

When only looking at the quantitative data, the importance of the cluster seems to be not very remarkable, but that is without considering its climate protection and resource efficiency functions. Furthermore, the economic importance of the forestry and timber cluster is particularly crucial in rural and structurally lagging regions to provide employment and additional income opportunities (BMEL 2019; Becher and Weimar 2020). Many small-scale private forest owners are farmers, which use their forests to generate an additional income, especially in winter. They, for instance, might also use their forests to produce stakes to fence their meadows. In Hesse, those rural areas often coincide with the regions featuring the highest forest coverages like the Northern Hessian Slate Mountains or the rural areas of Spessart and Odenwald (HMUKLV 2012).

When talking about the forestry and timber cluster, the first thing that comes to mind is the traditional forestry industry and sawmills. However, the forestry industry has several downstream industries, which include the woodworking industry (sawmills, wood-based materials industry), the wood processing industry (furniture, packaging, etc.), the carpentry trade, the paper industry, the publishing, and printing industry and the energetic use of wood. In addition, the FTC also includes the timber trade and its suppliers. In Germany, about 1.1 million people are employed in the forestry and timber cluster (Jaensch and Harsche 2007; Becher 2016; Weimar 2017). In fact, there are more people employed in the forestry and timber cluster than in the German automobile industry.

In 2016 the Hessian forestry and timber cluster was comprised of 8,061 companies, generated a turnover of 10.79 billion Euro, contributed about 3.4 billion Euro to the Hessian GVA, and employed 72,778 people (Table 12). However, it should be noted that the publishing and printing industry alone makes up for approximately 36 % of the GVA and employees of the forestry and timber cluster and generates about 20 % of the turnover (green marked cells in Table 12). The FTC includes industries of all three economic sectors (primary sector: raw materials, secondary sector: manufacturing and tertiary sector: services). Forestry, which produces and harvests the wood, is the only industry in the FTC belonging to the primary sector (Destatis 2008), while most of the other industries belong to the secondary manufacturing and processing sector. Nevertheless, even though the forestry sector produces and provides the raw wood material for all downstream industries, it only contributes a relatively small share to the

FTC regarding the number of companies, turnover, gross value added, and the number of employees (Table 12).

Table 12 Forestry and timber cluster data in Hesse for the 2016 year, highest numbers in green, modified after (Becher 2016)

Economic sectors	Companies	Turnover (Tsd. €)	Gross value added (Tsd.€)	Number of employees
Forestry	**1,366**	**413,775**	**235,036**	**6,165**
Forestry	1,060	344,503	195,122	4,942
Forestry services	306	69,273	39,914	1,223
Woodworking industry	**262**	**587,614**	**105,241**	**1,953**
Sawmill industry	234	502,993	89,123	1,800
Wood-based materials industry	28	84,621	16,117	153
wood processing industry	**1,674**	**2,057,926**	**638,345**	**13,740**
furniture industry	726	965,358	307,958	6,597
Wood packaging industry	71	266,876	69,555	1,457
Industrial timber construction	690	676,153	215,122	4,571
Other wood processing	187	149,539	45,710	1,115
Wood in the construction industry	**2,791**	**1,189,750**	**456,689**	**15,117**
Carpenter	753	353,224	132,121	3,784
Joinery	1,898	710,941	291,929	10,328
Prefabricated wood construction	140	125,584	32,640	1,005
Paper industry	**183**	**2,553,261**	**651,045**	**8,455**
Wood and pulp production	8	43,527	13,823	46
Paper production	46	982,348	208,911	1,963
Paper processing	129	1,527,386	428,310	6,446
Publishing and printing industry	**1,632**	**3,222,556**	**1,209,292**	**26,543**
Publishing industry	655	1,875,654	723,024	14,529
Printing industry	977	1,346,902	486,267	12,014
Timber trade	**153**	**767,219**	**100,903**	**805**
timber trade with raw and sawn timber	60	569,307	64,699	290
Wholesale of other intermediate wood products and wooden building components	93	197,912	36,204	515
Total forestry and timber cluster	**8,061**	**10,792,101**	**3,396,550**	**72,778**

As stated earlier, forest ownership in Hesse is not evenly distributed in terms of ownership type as well as spatial distribution. The importance of the State Forest is

particularly evident in northern Hesse, while in central Hesse, the share of private forests is relatively high by Hessian standards. However, higher shares of private forests create certain issues, for instance, heterogeneous market partners and absentee forest owners, which can cause problems for timber mobilization (Harsche et al. 2013). To address the issues of small-scale private forest ownership, to overcome structural disadvantages, and to ensure sustainable forest management, the Hessian state supports and encourages the formation of private forest owner associations (HMUKLV 2012). The support of private forest owner associations and forest enterprise associations is also part of the Hessian State Forest Act (Hessischer Landtag 2013).

3.9. Forest Product Markets and Issues

Since Hesse is a federal state of Germany, and Germany is a member of the European Union, Hesse has access to the European Single Market (ESM). The ESM is comprised of the 27 member states of the EU and grants all members access to the so-called "four freedoms," which are the freedom of movement of goods, capital, services, and labor (European Commission 2018). Furthermore, the ESM was extended under the European Economic Area Agreement (EEA) and through bilateral agreements to the countries Iceland, Liechtenstein, Norway, Switzerland, and the United Kingdom. The EU is the largest economy in the world, about 500 million people live in the EU, and approximately 75 % of the EU's trade is within the ESM (European Commission 2018).

Not surprisingly, a large share of Hessian exports, about 60 %, is within the ESM (Hessisches Statistisches Landesamt 2019a). As stated before, the ESM guarantees the

freedom of movement of goods, capital, services, and labor. For Hessian forest sector companies, that means that they do not have to pay duties on exports within the ESM (European Commission 2018). The total value of hessian exports in 2018 accounted for about 64.5 billion €, and approximately 39.5 billion € of those were within the European economic area. About two billion € of the total export value was generated with products from the forestry and timber cluster, meaning that the forestry and timber cluster contributes about 3.12 % of the total hessian export value (Hessisches Statistisches Landesamt 2019b).

Roundwood is an export good, that mostly stays with the EU, one of the reasons for that being that roundwood transport and shipping are comparably expensive. The most important export countries for hessian roundwood are Italy, Austria, and Denmark. Italy and Denmark each have a share of about 20 % of the export volume and Denmark accounts for about 15 % (Jaensch and Harsche 2007). Therefore, these three countries receive about 55 % of the total roundwood exports from Hesse.

Besides the EU, other important export markets for Hessian roundwood are eastern and southeastern Asian countries like Japan, South Korea, Taiwan, China, and Indonesia. However, China is the most important export market outside the EU for Hesse. China is responsible for about 20 % and up to 40 % of the export value of Hessian roundwood (Jaensch and Harsche 2007).

At present, the most significant issues for the forestry sector and the timber market in Hesse are windthrows, droughts, and bark beetle infestations. Those issues especially affect softwood species like Norway spruce and Scots pine and lead to high amounts of

salvage cutting. These high amounts of softwood timber are flooding the markets and can lead to price drops of up to 50 % or even more (Naumann 2019). The harvesting costs of the salvage-cuts often even exceed the revenues from selling the timber. Furthermore, it is difficult to sell the timber at all due to the high amount of timber since the offer exceeds the demand.

3.10. Disturbances and Climate Change Implications

Large scale disturbances and disturbances, in general, became more abundant in the recent past and are expected to become more frequent due to climate change (Grundmann 2012). There is a multitude of different causes, such as pests and diseases, windthrows, droughts, and combinations of all the above. The year 2018 has been one of the worst years for Hessian forests since the end of world war two. It was the warmest and sunniest year since the beginning of meteorological records. Also, it was one of the driest years, featuring about 26.9 % less precipitation compared to the average of the climatological normal of the period from 1961- 1990 (HessenForst 2019a). Just like 2018, the year 2019 has been too dry and too warm as well. Right after each other, the combination of those two years had devastating consequences for Hessian forests. Reasons for that were that the forests were still weakened from drought, storm, and bark beetle calamities and that the groundwater levels had not recovered from the year 2018 (NW-FVA 2019).

Such weather conditions provide favorable conditions for the mass reproduction of bark beetles, which prefer dry and warm weather (NW-FVA 2018). In 2018, three generations of bark beetles were able to develop, which led to massive damages in tree populations,

especially in Norway spruce, which was also profoundly affected by windthrow (HessenForst 2019b). For instance, in the FMU of Hofbieber in eastern Hesse, 61 % of all timber cut in 2018 was due to salvage cutting. With about 86 % of salvage cutting in Norway spruce and 96 % in European ash, those two species were most affected by disturbances in 2018 (HessenForst 2019a). For the entire Hessian State Forest, the amounts of salvage cutting in the year 2018 were even higher than in the example before. Overall, about 72 % of all timber harvested in 2018 was the result of salvage cutting, including 93 % of salvage cut for Norway spruce (HessenForst 2018).

The two main bark beetle species in Germany and respectively in Hesse are the European spruce bark beetle (*Ips typographus*) and the six toothed spruce bark beetle (*Pityogenes chalcographus*). A third important bark beetle species in Hesse is the large larch bark beetle (*Ips cembrae*), which affects European larch (*Larix decidua*) (NW-FVA 2018), which has a share of almost 5 % in Hessian forests. In coniferous tree species like Norway spruce and European larch, bark beetle calamities were the leading causes for damages and subsequent salvage cutting. As stated earlier, these calamities were facilitated by droughts and windthrows (NW-FVA 2019). When looking at the overall change in tree species shares, it becomes evident that in particular coniferous tree species, like spruce, pine, and larch exhibit decreasing proportions (Figure 9) (HMUKLV 2014).

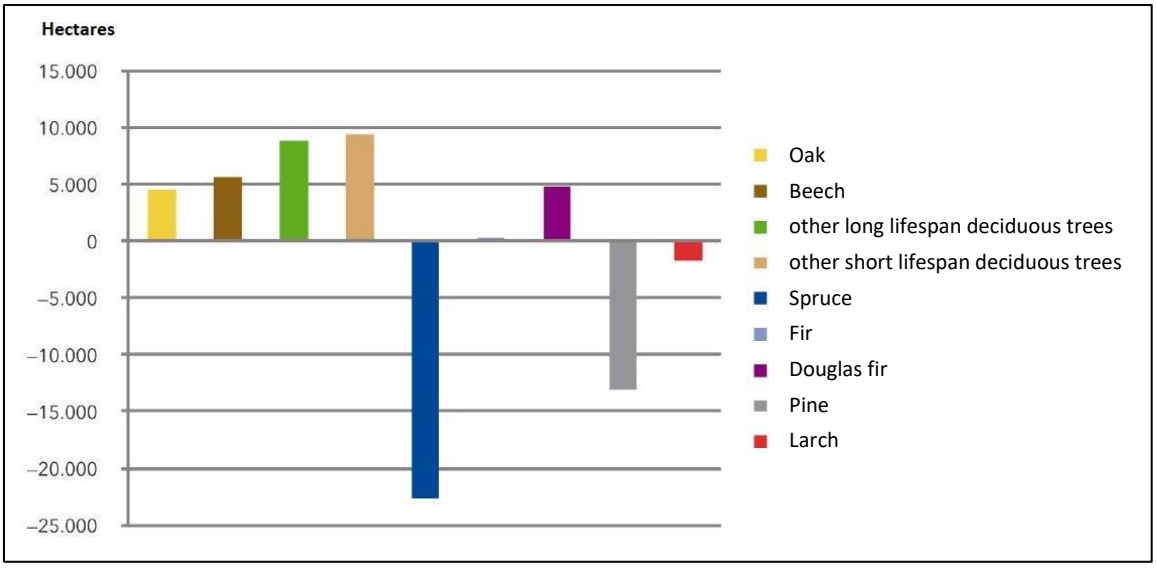

Figure 9 Change in areas from 2002 to 2012 for the main tree species in Hessian forests. Source: (HMUKLV 2014)

However, not only coniferous tree species are affected by disturbances. Many deciduous species are suffering too. Deciduous species are much less affected by windthrow and bark beetles than coniferous species are, but there are other pests and diseases and climatic influences that affect them. European Ash, for instance, is highly affected by the ash dieback, which is caused by a fungus (*Hymenoscyphus fraxineus*) introduced from East Asia (NW-FVA 2018, 2019). Even European Beech, which is the main tree species in Hessian forests, and which is considered to be stable concerning changing climatic factors, showed first signs of stress. That includes, for instance, the development of much smaller than usual leaves, which is an indicator of water stress (NW-FVA 2019).

Summing up the forest condition in 2019, the overall mortality rate has increased to 2.3 %, which is seven times more than the long-term average. Furthermore, approximately 6 % of all forest stands had to be salvage cut after windthrow and bark beetle infestation. As a result, the forest condition and the vitality status of Hessian

forests in 2019 are the worst since the beginning of the forest condition surveys in 1984 (NW-FVA 2019).

To lower the risks for forests stands to be severely affected by disturbances and to increase their resistance and resilience, the goal is to develop forests in the direction of species-rich mixed forests as well as to lower the shares of coniferous species (HMUKLV 2018). However, the Hessian State Forest Enterprise, sawmills, and large parts of the forest economy in Hesse depend on softwood, which is mainly sourced from Norway spruce (HMUKLV 2018). To still be able to provide the timber industry with softwood and, at the same time, decrease the share of Norway spruce, alternative tree species must be found. Since the climate, in general, is predicted to become warmer and dryer in Germany and, respectively, in Hesse, possible alternative tree species must be able to deal with that type of new climatic conditions. Possible alternatives for Norway spruce, which are currently under debate, are, for instance, silver fir (*Abies alba*) or Douglas fir (*Pseudotsuga menziesii*) (Grundmann 2012; HessenForst 2019c) because they are more tolerant to warm and dry climate (Vitali et al. 2017). Possible alternatives for deciduous tree species are, for example, Mediterranean oak species like Turkey oak (*Quercus cerris*), pubescent oak (*Quercus pubescens*) (Thurm et al. 2018) or evergreen oak (*Quercus ilex*) (Koller et al. 2014). Some rare native species, such as the wild service tree (*Sorbus torminalis*), are also under consideration (HessenForst 2019c). Other non-native species options are black locust (*Robinia pseudoacacia*) (Thurm et al. 2018) or red oak (*Quercus rubra*) (Fiebiger et al. 2008; HessenForst 2019c).

4. Comparison between the NB and Hesse Forestry Sectors

4.1. Introduction and General Findings

After introducing details about the forestry sectors in Hesse and New Brunswick, the third part of this report compares the two sectors, attempts to find differences and similarities, and aims to investigate the earlier stated hypothesis of this report. The structure of this final part is, to some extent, similar to the structure of the two previous parts. However, when trying to explain the differences and similarities and why they exist, topics often overlap or are closely connected. For that reason, some new topics like societal differences, uses, values and forest functions were introduced in the final part of this report. Furthermore, like the previous parts, the third part starts by providing a big picture when comparing general information about Canada, Germany, New Brunswick, and Hesse and follows by taking a closer look into the differences.

As shown in Table 13, the federal state of Hesse has an area of about 2.1 million ha (Destatis 2019), while New Brunswick comprises an area of about 7.3 million ha (GNB 2019b), which means that New Brunswick is about 3.5 times bigger than Hesse. New Brunswick, as well as Hesse, are the provinces with the highest percentage of forest cover in Canada and respectively in Germany. While about 85 % of the province of New Brunswick is covered by forest (Nadeau et al. 2012; Ward 2018), compared to the 35 % national average of Canada, in Hesse the forest cover accounts to approximately 42 %, compared to 32 % national average of Germany (Thünen-Institute 2012d). That means New Brunswick's forest cover in percent of the total area is more than twice as big as

that of Hesse. However, in absolute numbers, the difference is even more significant since New Brunswick has 6.1 million ha of forest, compared to only about 0.89 million ha in Hesse.

Table 13 Comparison between New Brunswick, Hesse, Canada, and Germany for various area and population statistics

	NB	Hessen	Canada	Germany
Total Area [ha]	7,290,700	2,115,680	998,467,000	35,738,600
Population [N]	760,744	6,265,809	36,963,854	82,792,351
Population density [ppl./km^2]	10.50	297.00	3.90	232.00
Forest cover [%]	85	42	35	32
Forest area [ha]	6,100,000	894,180	347,069,000	11,419,124
Forest area per capita [ha/pers.]	8.02	0.14	9.74	0.14

In terms of population size and density, the differences are large as well, yet for these figures, Hesse features much higher values than New Brunswick. There are approximately 6.2 million people living in Hesse, resulting in a population density of about 297 people/km^2 (Destatis 2019). Therefore it is nearly 28 times more densely populated than New Brunswick with only 10.5 people/km^2 (Statistics Canada 2017) and a population of just about 0.76 million people (NRC and CFS 2018). Not surprisingly, the forest area per capita in New Brunswick, which accounts for 8.02 ha per person, is about 57 times higher than that of Hesse, which accounts for only about 0.14 ha per person. This short comparison of some general data already shows some big differences, as well as illustrates the scale and importance of forests both in New Brunswick and Hesse.

Besides the large differences in area extent, population size, and forest area, another significant difference between New Brunswick and Hesse is their economic performance relative to Canada and, respectively, Germany. New Brunswick is a long-standing "have-not" province, which is characterized by below-average employment levels and below-average per capita income (Wallace 2012). Furthermore, it is heavily dependent on federal transfer payments from the equalization support program (Wallace 2012). As of 2019, New Brunswick is officially Canadas poorest province, receiving the highest equalization amounts per person below all Canadian provinces (Jones 2019). Hesse, on the other hand, ranks within the top five out of the 16 German federal states in terms of total GDP, GDP per capita, GDP per market income earner and also has one of the lowest unemployment rates in Germany (Statistische Ämter des Bundes und der Länder 2020).

However, the role that forestry plays for New Brunswick's and the Hessian economy is very different in terms of employment, income, exports, and the overall performance of their economies. Not surprisingly, New Brunswick's economy depends much more on forests and natural resources than the Hessian economy does. However, that does not mean that forests are less important in Hesse than they are in New Brunswick. Regarding importance, it is merely a matter of which forest functions are in focus. While in New Brunswick, the production function is more prominent, in Hesse, recreation and protection functions are of higher importance. These differences and the reasons for that will be discussed in more detail in the following parts.

4.2. Societal Differences, Uses, Values and Forest Functions

People across the world have different relationships to the forests in the countries they live in. They might use them for recreation, economic purposes, as a resource or for subsistence. These forest functions and uses differ in terms of their importance to the local populations. That, of course, applies to New Brunswick as well as it applies to Hesse.

As stated earlier, in New Brunswick, 85 % of the province is covered with forest; the population density is as low as 10.5 people per km^2, and the forest area per capita accounts for 8.02 ha per person. In comparison, in Hesse, only 42 % of the state is covered with forest, the population density of 297 people per km^2 is about 28 times higher than in New Brunswick, and the forest area per capita accounts for only about 0.14 ha per person. Of course, these significant differences also imply a difference in the understanding of forests, forest management, the ways of using forests, and the importance of forests to the local population. Further differences occur as a result of the respective forest laws in Hesse and New Brunswick. For example, those laws stipulate the right to enter forests, which is a prerequisite to use the forest for recreation in the first place. In addition, they also mandate which activities are permitted in forests and which are forbidden.

An excellent example to illustrate the differences between regulations are the attitudes and regulations towards clear cuts, which are perceived or accepted very differently by people living in Hesse and New Brunswick. According to the Hessian Forest Act, clear cuts of more than one hectare in size should be avoided (Section 4, Paragraph 2, HWaldG). In New Brunswick, however, clear cuts of up to 100 ha of coherent clear-cut area are

allowed by law (Martin 2003; Jäger 2014). About 75 % to 80 % of harvests that occur on Crown land are clear-cuts, and only 20 % to 25 % are non-clear-cut harvesting systems (Auditor General of New Brunswick 2015; Ward 2018). Even though the average clear-cut size on Crown land amounts to about 35 ha, and the upper limit of 100 ha of clear-cut is rare, it is still a significant difference in comparison to Hesse. Regarding clear-cuts, it is often argued that they simply mimic the natural disturbance type of the forests found in New Brunswick. However, when removing significant parts of vegetation from a forest site, high amounts of nutrients are removed as well, and the site is left vulnerable to erosion.

Furthermore, the type of natural regeneration occurring on a clear-cut site is very different from what is considered to be Acadian forest type species. The conditions found on a clear-cut area favor shade-intolerant hardwood and softwood species (pioneer and light-loving species) and threaten shade -tolerant species like sugar maple, eastern hemlock, American beech, red spruce, and yellow birch (Mosseler et al. 2003; Auditor General of New Brunswick 2015). In addition, forests dominated by tree species mixtures of shade-tolerant tree species usually regenerate in small gaps, caused by single fallen trees or groups of trees, which is the natural disturbance type in Acadian forests. That stands in stark contrast to major stand-replacing disturbances found in boreal forests (Mosseler et al. 2003), which is the kind of disturbance clear cuts cause in New Brunswick, even though New Brunswick's forests are not boreal forests.

In Hesse, clear-cuts are avoided in general, and special permission is required for a clear-cut of more than one hectare in size (HWaldG). Nevertheless, for certain situations, like

bark beetle infested Norway spruce stands or for conservation purposes, clear-cuts are necessary and cannot be avoided. However, when clearcutting is performed, the chances are high that members of the public will react with protests and petitions against clear-cuts as well as the parties responsible for initiating them (Bethmann and Wurster 2016).

A public uproar was caused after a five-hectare clear-cut in the Hessian Nationalpark Kellerwald-Edersee occurred, performed by the State Forest Enterprise HessenForst (Brandau 11/24/2015). In that case, five hectares of spruce monoculture were removed on a mountaintop for conservation purposes. Multiple complaints and letters to the editor ensued. It is not surprising that clear-cuts are perceived in such a negative way by the people in Hesse, compared to New Brunswick, since Hesse is way more densely populated. The higher population density in Hesse also means that the recreational use of forests is much higher, and therefore changes to forests do not go unnoticed by people living in the surrounding areas.

On the other hand, in New Brunswick forested lands are vast, the population density is low, road infrastructure in much less dense and entry to large parts of the forests (private forests) is prohibited. As a result, people in New Brunswick might feel less disturbed by clear-cuts since the areas where they occur are typically not areas with high recreational value or densely populated areas. Besides that, people who grew up in Canada and respectively in New Brunswick are used to the sight of a clear-cut area. However, that does not mean that everyone in New Brunswick likes or does not mind clear-cuts. Growing opposition, concerns, and a change of mind concerning issues like clearcutting

are beginning to be seen, which will be discussed later in this section (Nadeau et al. 2008).

Another glaring difference between Hesse and New Brunswick is that in Hesse, forests are open to the public. Therefore, everyone is permitted to enter any forest and use it for recreation, regardless of the ownership type of the forest (§ 15 HWaldG). Forests in Hesse are usually easily accessible and offer an extensive network of forest roads, trails, and other infrastructure for public use (HMUKLV 2012). The average forest road density in Hesse, for forest road categories 1 and 2 (forest roads suitable for logging trucks) combined, accounts for about 38 running meters per hectare (Bittlingmaier 2015). Permitted recreational uses include cycling, hiking, or riding horses on forest roads. However, there are a few exemptions. It is prohibited to enter the forest with motor-driven vehicles for leisure and recreation (§ 15 HWaldG).

However, in New Brunswick, the situation is a different. While forests in New Brunswick are an important place for recreation too, the recreational pressure on most forests is much lower than in Hesse. Since about 50 % of New Brunswick's forests are under private ownership, the access to those forests is restricted. In such cases, entry to private property, including forests, is prohibited without permission from the owner. Recreational activities in forests are also more focused on parks, like provincial or national parks, private woodlots (used by the owners) or purpose build trail systems for hiking, biking, skiing, snowmobiling or riding All-terrain vehicles (ATVs) (Nadeau et al. 2008). Furthermore, it is important to note that, for instance, visiting a National Park in Canada requires the purchase of a day pass or camping reservation in order to access

parks. In contrast, the public may enter national parks in Germany without paying an entrance fee.

When it comes to recreational use and permission to enter forests, in theory, the situation on Crown lands is more like Hesse. Anyone is allowed to enter Crown land to use it for recreation like hiking or biking; in addition, overnight camping and driving motorized vehicles like ATVs or snowmobiles are allowed as well (GNB 2018a, 2019a), which is not permitted in Hessian forests. Just like in Hesse, in New Brunswick, there has been an ongoing shift in the opinion and demands of the general public in the direction of environmental values of forests.

The public demands more biodiversity, aesthetic values, or protection functions like air and water purification. These values are getting more important and are often favored by the public before economic and other utilitarian values (Nadeau et al. 2008). In a survey on public views on forest management in New Brunswick published by Nadeau et al. (2008), more than 1500 New Brunswickers took part and completed the survey. The results of this survey were meant to provide a better understanding of which values and uses are important to the public and what their opinion is on forest management. One finding of the survey was that about 94 % of New Brunswick residents visit forests during the year, spent time on their woodlots, in cottages, or go camping. Furthermore, more than 95 % of the respondents stated that they take part in forest-related activities and even more that they make use of non-timber forest products like maple syrup or fiddleheads (Nadeau et al. 2008). In terms of forest values, the participants ranked the protection of water, air and soil in the first place, followed by the provision of habitat for

a variety of animals. The forest as a source of economic wealth and jobs was ranked third, followed by recreation and relaxation in the fourth place. In the last place was the use of forests as a source of meat, firewood, berries, and other non-timber forest products (Nadeau et al. 2008). Additional findings of the survey illustrated multiple concerns of the public mostly regarding environmental protection and, in this context, concerns about practices like clearcutting or the use of pesticides in forests (Nadeau et al. 2008).

People also seemed to be dissatisfied with forest management, especially on industrial freeholds. However, industrial freeholds are managed by the same companies that manage most of the Crown forests, which could imply a similar dissatisfaction with forest management on Crown land. Compared to private woodlots, the level of dissatisfaction for Crown land management was almost twice as high but still slightly lower than for industrial freeholds (Nadeau et al. 2008). A reason for the high amount of dissatisfaction with industrial freehold management could be that there are only little insights into their forest management and their finances since those companies are private companies that are not required to report on their finances and management. Taking all these findings into account, it appears evident that there is a demand for change. Given that this survey is more than ten years old, it seems likely that the attitudes around the use of forests, values, and functions have amplified since then, which could be connected to more awareness of the effects of climate change around the world and in Canada.

There have been similar studies in Germany to determine the preferences and attitudes of the general German public regarding forests, its uses, functions, and associated values.

In 2016 the Federal Ministry of Food and Agriculture (BMEL) conducted a survey regarding the attitudes of Germans around forests and forestry. It was published in the 2017 Report on Forests of the Federal Government of Germany. A similar survey by the federal government had already been conducted in 2009, which stated that the use of forests for recreational activities of the population increased in recent years and that this trend will continue in the future (BMELV 2009). The results of the 2017 survey confirmed the forecast and found that for 90 % of Germans, forests are an important place to experience and observe nature. 77 % stated that they make use of forests for exercise, recreation, and leisure time. Furthermore, 93 % of the respondents stated that they visit forests regularly throughout the year, which resulted in an average of 28 forest visits per person and year. The most popular activities for forest visits were hiking and going for walks in the forest (BMEL 2017a). This survey was performed for all of Germany and not specifically for Hesse. Although there are slight differences between the German federal states, it can be assumed that the results of the survey provide reasonable estimates for the situation in Hessian forests too.

The results of these surveys and studies for New Brunswick, Germany, and respectively Hesse, suggest that forests are an essential part of people's lives and that New Brunswickers, as well as Hessian citizens, make use of forests regularly. The extent of possible uses is different for the two and is specified in the respective forest laws. Furthermore, given that more than 90 % of the people in Germany and New Brunswick stated that they visit forests on a regular basis, the recreational pressure on forests in Hesse can be expected to be much higher than in New Brunswick. That is simply a result

of population size and density and the areal extent of forests available for recreational purposes. The value of forest area per capita, which accounts for 0.14 ha per capita in Hesse compared to 8.02 ha per capita in New Brunswick, which is about 57 times higher than in Hesse, makes that clear as well.

After confirming that forests are an essential space for recreation for the respective populations and that people demand an increase in environmental or ecosystem services like water and air purification, the next questions would be: Who is providing these services? What do they cost? What kind of costs arise from providing recreation and protection functions? And who is paying for it?

The provision of forest functions and ecosystem services are associated with costs for forest owners. These services are provided both through active management as well as through intentional operational omissions, such as not making use of old-growth and deadwood or to not plant certain tree species like Norway spruce, which then leads to direct management costs or opportunity costs. These measures are placing a burden on the forestry industry because only a part of the protection and recreation services are provided as a by-product of wood production without any additional expense or reduced income (BMEL 2017a). Furthermore, recreational uses can cause an increased risk of forest fires, a higher amount of waste, or erosion damage, which then can lead to increased costs for the forest owner (BMEL 2017a). While protective and recreational functions are essential and therefore have a high value, it is challenging to determine the exact value, especially in monetary terms. However, measures to provide recreation and protection functions decrease the management possibilities for forest owners and lower

the economic outcome from their forests. In a study about economic burdens for the German forestry due to protection and recreation functions of forests, Dög et al. (2016), calculated a total economic burden for the year 2011 of 45.03 €/ha for private forest enterprises and 52.03 €/ha for communal forests greater than 200 ha. When comparing the costs for the provision of protection and recreation functions to the net revenues of private forests (188 €/ha) and communal forests (124 €/ha) in the year 2011, it becomes apparent that these costs have a significant impact on the rentability (BMEL 2017a). For private forests, the costs account for about 24 % of the net revenue and in communal forests, even for about 42 %. State forests were not examined in this study. However, the economic burden for State Forests can be assumed to be similar to that of communal forests or probably even higher, since State Forests have the highest obligation for the common good and the provision of protective and recreational functions.

In New Brunswick, these costs do not occur for private forest owners (industrial freeholds and private woodlots) since they have no obligation to manage their forests with respect to the common good. Compared to Hesse, that means that private forest owners in New Brunswick have less of a financial burden. Certainly, there are trail systems and recreational activities in private forests in New Brunswick. However, private forest owners can charge an entry fee from forest visitors, which they can then use to offset their spending to provide this service. In Hesse, forest owners do not have any means to charge forest visitors for the services they provide.

4.3. Forest Ownership, Related Responsibilities and Issues

As shown in Table 14, in Hesse, the share for public forests (38.2%) is high compared to the German average (29 %). By contrast, the percentage of the province-owned forest (48 %) in New Brunswick is considered to be low compared to the Canadian average (89.5 %) as most forests are owned by the Crown in Canada (i.e., provinces and territories) (Table 14). In British Columbia, for instance, 95 % of all forests are owned by the Province, and only 5 % are private forests (CCFM 2018b). The high amount of provincial or territorial forests in Canada and the way in which Crown forests are managed lead to significant problems concerning softwood lumber exports to the United States of America. That dispute is still ongoing and one of the biggest concerns for the Canadian forestry sector at the time. For an overview and an explanation concerning the Canada- U.S. softwood lumber dispute, see section 2.8.

Table 14 Proportions of forest ownership types in % of forest area

Forest ownership [%]	New Brunswick	Hessen	Canada	Germany
Provincial/State	48	38.2	89.5	29
Private	50*	24.5	6.2	48
Federal	2	1.1	1.6	3.5
Communal	0	36.3	0.3	19.4

*20 % industrial freeholds and 30 % non-industrial private woodlot owners

With respect to forest ownership, not only do the proportions of ownership types differ but also the kinds of forest ownership, differ between NB and Hesse. For example, there is no such thing as communal forests in New Brunswick. Also, the scale of forest areas owned by single private owners and the total number of private forest owners are largely

different. An excellent example of this is the largest forestry company in New Brunswick, J.D. Irving, Limited, which owns about 728,000 ha of industrial freeholds and manages another 1,038,000 ha of Crown forests. In comparison, the largest private forest owner in Germany is the Turn und Taxis family which owns about 20,000 ha of forest, or for Hesse the forest community of the Riedesel Freiherren zu Eisenbach GbR (Waldgesellschaft der Riedesel Freiherren zu Eisenbach GbR), which manages about 14,000 ha of forest (Wald-Prinz.de 2019). Furthermore, even the largest forest owner in Hesse, which is the Hessian state, only owns about 342,516 ha (Thünen-Institute 2012c).

The above comparisons aim to illustrate the considerable differences between Hesse and New Brunswick, especially for private ownership. However, these differences have implications on the management of forests. As stated in Sections 2.4.2 and 2.4.3, private woodlots and industrial freeholds are mostly unregulated by the Crown. Accordingly, they are free to manage their forests as they deem appropriate, with the exception that they must adhere to the NB Clean Water Act. However, this degree of freedom means that private forest owners in New Brunswick have no obligation to manage their forests with special consideration to the common good, as is the case in Hesse. As already stated earlier, private forest owners in New Brunswick can also restrict people from entering their property, which is not possible for any forest owner in Hesse.

Considering the lack of regulation and responsibilities for private forest owners in New Brunswick, compared to Hesse, it could be argued that private forest owners in New Brunswick have more possibilities to manage their forests in a way that is more financially beneficial for them. However, similarly to Hesse, there are certain issues with

timber sales from private woodlots. In Hesse, issues concerning timber sales and timber mobilization often arise due to the small size of private woodlots, which is a competitive disadvantage because the amounts of timber harvested and sold are small, and forestry operations are expensive. Another common issue in Hesse is the lack of interest or loss of connection of small-scale private forest owners regarding their woodlots. These issues are recognized by the Hessian State, which is why one of the tasks of the State Forest Enterprise HessenForst is to promote the establishment of forest owner/company associations. In New Brunswick, however, the size of private woodlots, which is about 45.5 ha on average (Chaini and Johnston 2012), is less of an issue. The biggest challenge for private woodlot owners in New Brunswick is to receive a reasonable price for their timber. The Crown Lands and Forests Act states that Crown timber licensees are supposed to have a proportionate timber supply from all ownership types and are first to buy timber from private woodlots and then source their remaining need of wood supply from Crown lands. However, in practice, that is not the case, since licensees cover their wood supply mostly with Crown timber and timber from industrial freeholds and use private woodlot timber supply to cover their remaining needs. That practice does not comply with the Crown Lands and Timber Act and can be considered unfair against private woodlot owners. Furthermore, it leaves private woodlot owners in a problematic and unfair bargaining situation and makes it difficult for them to receive fair prices (Auditor General of New Brunswick 2015).

4.4. Forest Management

The ways in which forests are managed in New Brunswick and Hesse differ significantly from each other. On the one hand, this is due to the climate-related shorter vegetation period, lower site factors, and the associated lower increment in New Brunswick's forests, compared to Hesse. On the other hand, it depends significantly on who owns and manages the forests and who is setting the rules and objectives.

In Hesse, even though only about 38.2 % are public forests, approximately 78 % of all forests are managed by the State Forest Enterprise "HessenForst" (HessenForst 2018). All forests that are managed by the SFE, regardless whether private, municipal or public forests, are managed in accordance to the Agenda 21, the forest principles of UNCED in Rio 1992, the Ministerial Conference on Protection of Forests in Europe (Forest Europe), the Agenda 2000 of the European Commission, the Federal Forest Act and the Hessian Forest Act (HMUKLV 2012), to ensure an appropriate, competent and sustainable forest management. HessenForst, as a State Forestry Enterprise, is committed to the common good by law (§ 18 & §27 HWaldG). Therefore, not only economical, but also recreational and protective functions of forests play an essential role in its management, and often even have priority over economic goals.

To ensure the fulfillment of all kinds of forest functions, the Hessian State Forest is about to change in the future. One of the goals is to increase the share of deciduous tree species like beech or oak from 54 % to 58 % and to lower the share of coniferous species like spruce or pine by the year 2050 (HMUKLV 2018). The overall management follows a close-to-nature silviculture approach, which includes single tree harvesting of high-

quality logs, Future-Tree (Z-Baum) selection systems, or the preferred use of natural regeneration of native and site-adapted species.

Concerning dimensions, the diameters of trees at harvest are, in general, higher in Hesse than they are in New Brunswick. The production goal in terms of diameter for assortments of logs from different tree species typically ranges from diameter classes 3 to 6 (Table 15) (HessenForst 2016). To determine the diameter class of a log, it is measured in the middle, and the diameter is reduced by a certain amount to account for the bark (DFWR and DHWR 2015). Measurements of standing trees are usually done at breast height (DBH), meaning that a tree with the diameter class 6 can have a DBH with bark of more than 70 cm.

Table 15 Diameter classes and measurements for different tree species in Hesse. Source: (DFWR and DHWR 2015; HessenForst 2016)

Diameter in the middle of the log without bark [cm]	Diameter class	Tree species
Up to 9	0	
10 - 14	1a	
15 - 19	1b	
20 - 24	2a	
25 - 29	2b	
30 - 34	3a	Spruce, Birch
35 - 39	3b	Pine, Birch
40 - 49	4	Pine, Maple, Ash, Cherry, Alder
50 - 59	5	Beech, Larch
60 - 69	6	Oak, Douglas fir
70 - 79	7	
from 80	8	

However, in New Brunswick, the vast majority of softwood and hardwood assortments falls under diameter class 2 (20 -29 cm) (Jäger 2014). For this kind of assortment, for even-aged, mature and over-mature stands, clearcutting is still the most commonly used harvesting method. The average clear-cut size on Crown land accounts for about 35 ha, yet clear-cuts of up to 100 ha in size are permitted (Martin 2003). The main uses for the harvested timber are pulp and paper and softwood lumber.

In contrast to Hesse, in New Brunswick, 48 % are public forests, and 50 % are private forests (20 % industrial freeholds and 30 % non-industrial private woodlot owners) (ERD 2019). Besides the different shares of ownership types, a significant difference is that communal forests do not exist in New Brunswick. Furthermore, New Brunswick does not have a State Forest enterprise like in Hesse to manage the Crown (public) forests.

Instead, the provincial government, and respectively the New Brunswick Department for Natural Resources and Energy Development (NRED), has a licensing system in place to manage Crown forests. Within the system, the Crown forests are split into ten Crown timber licenses, which are then managed by the so-called licensees for a duration of 25 years. Crown timber licensees are large industrial companies, like J.D. Irving, Ltd., or Fornebu Lumber Company Inc., which operate their own wood processing facilities. The provincial government of New Brunswick defines the management goals for the Crown timber licenses and agrees on a management plan with each of the licensees. Every five years, the management of the licensees is monitored by the provincial government to ensure compliance with the prior set management goals. Furthermore, yearly operating plans must be set out, and the active forestry operations in the field are monitored by

the Department for Natural Resources and Energy Development of the provincial government. In addition, all Crown timber licenses must be certified under at least one of the established certification systems CSA, FSC or SFI. For every Crown timber license, an annual allowable cut (AAC) is defined in the management plan. For all timber harvested on Crown land, the licensee must pay a stumpage fee (royalty) to the province. Stumpage is the value of the standing timber on someone's land and, therefore, the amount of money offered to the landowner for harvesting the timber. The Crown Lands and Forests Act states that royalty rates for stumpage on Crown lands should be based on a fair market value of the standing timber (NBFPC 2016b). Since natural resources are the sole responsibility of the provinces (NRC 2020), royalty rates are different in every Canadian province, and they have significant impacts on the forest industry and timber trade, especially on softwood lumber exports to the United States.

As stated earlier, the licensees must pay stumpage fees to the province for the wood they harvest. In return, the licensee is provided free of charge with planting material like seedlings from the provincial tree nursery for reforestation or enrichment planting. Furthermore, the occurring planting costs for the licensee are reimbursed by the Province. In addition, the licensee receives financial support from the province for juvenile spacing and care and pre-commercial thinning if budget funds are available. The costs for forest protection measures (forest fire and pest control) are often funded and shared by the licensee and the provincial government (Jäger 2014).

However, the funding licensees receive, how royalty rates are determined, and the amount of royalties the licensees pay to the province of New Brunswick can create significant problems concerning wood exports and trade. The issue of the Canada- U.S. Softwood Lumber Dispute was already described in more detail in Section 2.8.

4.5. Forest Governance and Regulations

When it comes to forest governance and regulations, Hesse and New Brunswick are very different from each other in many ways. For instance, forestry in Hesse is more regulated and restricted than in New Brunswick, not only on the Hessian level but also on a German and the EU level. There is a multitude of regulations and policies influencing and governing forestry in Hesse, for instance, the Hessian Forest Act, the Federal Forest Act, or the habitat directive of the European Union. In New Brunswick, however, natural resources and, respectively, forests are the sole responsibility of the province, and thus only provincial laws affect forestry in New Brunswick.

In New Brunswick, the supreme forest authority is the New Brunswick Department for Natural Resources and Energy Development (NRED), and there are no subordinate superior and lower forest authorities as in Hesse. The NRED is directly responsible for the oversight of Crown forest management, which is done through the earlier described Crown timber license system. That also means that there are no further hierarchical levels between the supreme forest authority (NRED) and the companies that manage New Brunswick's forests (licensees). However, this very direct connection between the

NRED and the licensees could possibly mean that the licensees could directly influence the decision-making of the NRED.

When looking at forest authorities, the NRED could be best compared to the Hessian Ministry for the Environment, Climate Protection, Agriculture and Consumer Protection (HMUKLV), since that entity is the supreme forest authority in Hesse and it acts on the highest governmental level of the Hessian State. However, a difference is that the NRED does not have to adhere to any higher authority, such as the federal government of Canada, when it comes to natural resources like forests. In Hesse, on the other side, the Hessian Forest Act is based upon the Federal Forest Act, which restricts the scope of action of the Hessian government. The Hessian forest authorities are composed in a system of three tiers, the supreme, superior, and lower forest authorities. The lower forest authorities in Hesse are the forest management units of the State Forest enterprise HessenForst, which manages the State Forests and major parts of private and communal forests (HessenForst 2018). In that sense, HessenForst does the job that, in New Brunswick, is carried out by industrial forestry companies such as J.D. Irving, Limited, or Fornebu Lumber Company Inc., which are private companies. Since, for instance, J.D. Irving, Limited is a private, family-run business and not a publicly traded company, it is not possible to get insights into its finances. That and the lack of transparency can be considered problematic since the company is managing public (Crown) forests, which are meant to serve the public.

The fact that private industrial companies manage New Brunswick's forests sets New Brunswick apart from Hesse. Of course, these companies develop management plans

which must be approved by the NRED; however, they are still private sector companies whose main goal is to make a profit, and which are less restricted by common good obligations than HessenForst. The reason why private companies manage Crown forests in New Brunswick is that they were thought to have the infrastructure, staff, and technical expertise already in place and because they are more adaptive to changes and new forest management techniques than a government department would be. Due to that, Crown forest management by private companies is supposed to be more cost-effective (Auditor General of New Brunswick 2015).

Furthermore, the few big industrial forestry companies in New Brunswick are a major source of jobs, especially in structurally lagging, rural areas. They also contribute significantly to the provincial GDP (Gardner Pinfold 2018). The jobs that these companies provide are significant to the Province of New Brunswick because New Brunswick has one of the highest unemployment rates in Canada, and every single job supports a household. For those reasons, these companies are very powerful. In some instances, it seems that their influence on the NREDs policies, strategies, and regulations is significant. For example, in 2012, the NRED announced a new forest management strategy, which included the maintenance of the allowable softwood harvest levels and a decrease in allowable hardwood harvest levels. Furthermore, a reduction of clear-cut harvesting was intended. However, in 2014 the strategy was changed for the third time, and the new version included an increase of the allowable softwood harvest levels and the maintenance of the allowable hardwood harvest levels (Auditor General of New Brunswick 2015), which is basically the opposite of what was intended earlier and of

what the public demands. The Auditor General of New Brunswick (2015) also found that that NRED, in consultation with stakeholders, drafted a set of silvicultural standards to maintain the integrity of the Acadian forest. That could, for instance, include a decrease in clear-cut harvesting. However, this set of standards never came into effect because the forestry industry lobbied against it to prevent its implementation (Auditor General of New Brunswick 2015).

When looking at the forestry industry sector and New Brunswick's economy as a whole, it is inevitable to take a closer look at the Irving Group of companies, including J.D. Irving Ltd., Irving Oil Ltd., and Ocean Capital because these companies have a major influence on New Brunswick's economy. All these companies are privately owned and family-run.

Everyone in the Province New Brunswick knows the Irving name. The Irving Group of Companies is a major conglomerate that operates in a wide range of sectors across the province of New Brunswick and northeastern North America. It owns and operates by far largest forestry company, which is managing and operating logging operations, pulp and paper mills, and sawmills and is producing paper-based products. Furthermore, it owns and runs Canada's largest oil refinery; it has extensive long-distance transportation facilities like railroad lines and trucking companies, owns the fourth-largest French fries producer in North America and also a big shipbuilding company which built major parts of the Canadian naval fleet. Also, the company owns a fleet of cargo ships, a major towing company, an office products wholesaler, a whole chain of home improvement stores, a manufacturer of ready-made and custom homes, a big crane company, a large construction company, and local sports teams. Irving also owns almost all New Brunswick

newspapers and dailies and therefore has close to a monopoly of the media in New Brunswick. That list is not complete, and there is way more business the company owns and operates (Jobb 2008; Julian H. Walker 2010; Couture 2013). Furthermore, all those companies show a high degree in vertical integration. There is much controversy about that topic in New Brunswick, and it is far too complex to go into depth in this report. This report will only provide a brief overview of J.D. Irving, Limited (JDI).

The most relevant company to the forest sector within the Irving Group of Companies is J.D. Irving Ltd, which is sometimes also described as “the woods” side of the business and which was already mentioned earlier in other sections of this report. JDI owns or manages more than 2 million hectares of forest land in New Brunswick, Nova Scotia, and Maine (U.S.). The most significant part of the 2 million hectares is located in New Brunswick, where they manage Crown License number 7, which by itself accounts for more than one million hectares and about 32 % of all Crown forests (Table 4) (GNB 2019c). Furthermore, they own large industrial freeholds (private forest land) in New Brunswick, which comprise an area of more than 700,000 hectares. Combined, they own or manage more than 1.76 million hectares of forest in the Province of New Brunswick, which is about 29 % of all forests and approximately 24 % of New Brunswick’s total area (KPMG PRI 2017; FPAC 2019).

Moreover, JDI owns 50,000 hectares in Nova Scotia and another 505,000 hectares of freehold land in Maine, which makes them the biggest private forest owner in Maine. In addition, the company is also a sub-licensee to Crown timber licenses number 1, 3, 5, 8, and 9. To sum all these numbers up, JDI owns 1,283,000 hectares of industrial freeholds

and manages 1,038,000 hectares of Crown land, meaning that the company in total manages forest on an area of 2,321,000 hectares (Table 16) (KPMG PRI 2017). That is, without a doubt, a vast number, especially when compared to the state of Hesse, which has only about 0.89 million hectares of forests in total.

Table 16 Forest ownership and Crown Timber Licenses of J.D. Irving, Ltd, Source: KPMG PRI 2017

Province/State	**Industrial freehold [ha]**	**Crown License [ha]**	**Total [ha]**
New Brunswick	728,000	1,038,000	1,766,000
Nova Scotia	50,000	N.A.	50,000
Maine (U.S)	505,000	N.A.	505,000
Total [ha]	**1,283,000**	**1,038,000**	**2,321,000**

Considering the size of the company's forest operations and the influence on New Brunswick's economy, it could be argued that its practices pose a distortion of competition in the province. Yet, there were no countermeasures taken to resolve that situation and to improve competition.

4.6. Economic impact of the forestry sector

In both Hesse and New Brunswick, the forestry sector has economic importance, besides having several other important functions. However, the forestry sector has a more prominent role in New Brunswick than it does in Hesse, especially in terms of exports, jobs, and its contribution to the economy as a whole. That is not surprising since 85 % of New Brunswick is covered with forests compared to only about 42 % in Hesse. Apart from that, forestry and related or connected industries, both in Hessen and in New Brunswick, play an essential role, especially in rural areas. The forestry industry is a major employer in these areas.

For this report, economic data was gathered from reports and statistical data sets on the forest industry in New Brunswick and Hesse. The reports and other data used for this comparison were mostly sourced from public authorities like the provincial government of New Brunswick, Statistics Canada, and regarding Hesse from the Thünen-Institute or the Hessian Ministry for the Environment, Climate protection, Agriculture and Consumer protection.

The data available for New Brunswick is often not directly comparable to the data available for Hesse. That is because different economic indicators are used, and the models to calculate them differ from those used in Hesse. Another issue is the definition of the forestry sector. German and Hessian statistics are calculated for the so-called “Cluster Forst und Holz” (Forestry and Timber Cluster). That definition includes several industries, including the publishing and printing industry, parts of the construction industry, or the furniture industry (Table 11). However, data for the forest industry in New Brunswick does not include

publishing and printing, the furniture industry, or construction for the direct and indirect impacts. That makes the numbers difficult to directly compare to each other, mainly since the before named industries contribute large shares for all indicators in Hesse (Table 12). The comparisons made in this report are of a relative nature, to see how much of an impact the forestry sector has on the economy and the people in New Brunswick and Hesse.

In order to compare employment, numbers of companies, GVA/GDP and other economic figures, the industries not included in the figures for New Brunswick were subtracted from the figures from the forestry and timber cluster in Hesse. The numbers presented in Table 17 represent the total values for the forestry and timber cluster in Hesse, starting with the total (A), followed by the total less publishing and printing (B) and finally the total less furniture industry, wood in the construction industry and publishing and printing (C).

Table 17 Forestry and timber cluster data table for the year 2016 in Hesse showing the three different totals, modified after (Becher 2016)

Economic sectors	Companies	Turnover (Tsd. €)	Gross value added (Tsd.€)	Number of employees
(A) Total forestry and timber cluster	**8,061**	**10,792,101**	**3,396,550**	**72,778**
(B) Less publishing and printing	**6,429**	**7,569,545**	**2,187,258**	**46,235**
(C) Less furniture industry, wood in the construction industry and publishing and printing	**2,912**	**5,414,437**	**1,422,612**	**24,521**

For New Brunswick, this report distinguishes between two total values, which are presented in Table 18. For comparison, the total of direct, indirect, and induced impacts (D) and the total for direct plus indirect impacts (E) are used.

Table 18 New Brunswick forest sector impacts in 2016, Source: modified after Gardner Pinfold, 2018

	Direct	Indirect	Induced	(D) Total	(E) Direct + Indirect
Output*	3,244,876	2,136,872	485,746	5,867,494	5,381,748
GDP*	698,582	698,103	290,595	1,687,279	1,396,685
Income*	529,229	526,768	122,115	1,178,112	1,055,997
Employment	9,725	11,061	3,081	23,867	20,786
Provincial taxes*	16,508	33,005	59,152	108,664	49,513
Federal taxes*	4,126	8,248	26,765	39,139	12,374

* values in thousand Canadian dollars

Table 19 summarizes the results from a comparison of the forestry sector employment in New Brunswick and Hesse, using the before described categories (Hesse: A, B, C; NB: D, E) and compares them to the total numbers of employees in the respective study areas. When looking at the total values and shares calculated for forestry employment in Table 19, it becomes apparent that the total values for categories A, B, and C (Hesse) vary significantly from each other. That is because the excluded sectors, like publishing and printing (B), contribute very high numbers in employment to the whole forestry and timber cluster in Hesse. The differences for categories D and E for New Brunswick, however, are not as significant, compared to Hesse.

Table 19 Comparison total employment with employment in the forestry sector and shares of the different alternatives in NB and Hesse; Source: Statistics Canada, Hessisches Statistisches Landesamt, Thünen-Institute, Gardner Pinfold

Region	Category*	Total employment	Forestry sector employment	share [%]
Hesse	A	3,384,700	72,778	2.15
	B	3,384,700	46,521	1.37
	C	3,384,700	24,521	0.72
New Brunswick	D	351,600	23,867	6.79
	E	351,600	20,786	5.91

**(A) total forestry and timber cluster, (B) total less publishing and printing, (C) total less furniture industry, wood in the construction industry and publishing and printing, (D) total, (E) total less induced impacts*

As mentioned earlier, the forestry sector is more prominent and a more important source of jobs in New Brunswick than it is in Hesse. The percentage of jobs in the forestry and timber cluster, compared to the total number of jobs in Hesse, ranges from 0.72 % (C) to 2.15 % (A), depending on the category used. In New Brunswick, however, between 5.91 % (E) to 6.79 % (D) of the jobs are within the forestry sector (Table 19). That means that even when taking the whole forestry and timber cluster (A) in Hesse into account, there are still about three times fewer people employed in forestry as a percentage of the total amount of employment. About 1 in every 14 jobs in New Brunswick is linked to forestry, which is a lot, especially when compared to Hesse (Table 19).

The two categories, best comparable to each other, are category C for Hesse and category E for New Brunswick since they include the most similar set of different industries. When looking at that comparison, the differences in employment become

very large, meaning that forestry employment is about 8.3 times higher in New Brunswick, than it is in Hesse (Table 19). That again understates the significance that the forestry sector has in New Brunswick. Furthermore, it is important to notice that a few big industrial forestry companies in New Brunswick provide large amounts of jobs.

Another interesting measure to look at is the Gross Domestic Product (GDP) or the Gross Value Added (GVA). However, in New Brunswick, the GDP is used to describe the sector's performance, while in Hesse, the GVA is used to describe the performance of the forestry and timber cluster. These two measures are not directly comparable to each other since they are calculated differently. Unfortunately, it was not possible to find GVA or GDP values for both Hesse and New Brunswick. However, they are still similar and can be used for New Brunswick and Hesse to describe their contribution to the respective economies.

In New Brunswick, the forestry sector contributed about 1.7 billion dollars to New Brunswick's Gross Domestic Product in 2016. In that year, New Brunswick's GDP accounted for about 30.4 billion dollars. That means that the forestry sector contributed approximately 5.6 % to the total GDP of New Brunswick (Gardner Pinfold 2018; Statistics Canada 2019). In Hesse, the forestry sector contributes significantly less to the economy. As already stated earlier, in Hesse, the gross value added (GVA) is used to describe the economic performance of the forestry and timber cluster. The total GVA of the Hessian economy in 2016 accounted for about 246.121 billion €, of which 3.397 billion € were contributed by the whole forestry and timber cluster (Category A of Table 19) (Becher 2016; Weimar 2017). That means that the forestry and timber cluster contributed about 1.38 % to the total GVA of Hesse.

Compared to New Brunswick, the contribution of the forestry sector is, therefore, about four times lower.

4.7. Market situation

As mentioned earlier, New Brunswick is the most export-dependent province in Canada. Not surprisingly, the US, as the world's largest economy, is also the most important trade partner for Canada and, respectively, for New Brunswick. Approximately 78 % of all New Brunswick forest product exports were exported into the United States in 2016. In the past decade, New Brunswick put in efforts to reduce the high dependence on the U.S market. These efforts resulted in a reduction of the share of exports to the U.S. from 86 % in 2005 to 78 % in 2016 (Gardner Pinfold 2018). However, with 78 % of New Brunswick's forest products going to the U.S., the dependence is still significant. In comparison, other export countries play only a minor role at present, but especially the Chinese and Indian market shares increased since 2005 from 0 % to 2 % (China) and from 2 % to 7 % (India). On the other hand, forest products exports to the European Union decreased from 4 % to 2 % in the same period of time (Gardner Pinfold 2018).

There are several reasons as to why the diversification of export markets for New Brunswick's forest products is essential. However, probably the most important reason is the Canada-U.S. softwood lumber dispute, which heavily affects New Brunswick's forestry sector. Since 2017, New Brunswick is no longer excluded from anti-dumping and countervailing duties on softwood lumber exports to the United States (Casey 2019; GAC 2020a). The respective duties to be paid on softwood lumber exports are listed in

Table 6. For most of New Brunswick's softwood lumber exporters, the combined anti-dumping and countervailing duties account for 20.23 % (GAC 2020a).

Interestingly, J.D. Irving, Limited, received a company-specific rate and only has to pay a combined duty rate of 9.38 %, which is less than half of what everyone else pays (GAC 2020a). In a study about the economic impacts of the New Brunswick forest sector performed by Gardner Pinfold (2018), forest sector companies were asked about issues and challenges. The topmost issue all companies named was the Canada-U.S. softwood lumber dispute. Even companies which are not softwood lumber producers named this topic as one of their main concerns, because there are multiple knock-on effects, affecting them as well (Gardner Pinfold 2018).

In Hesse, the situation is very different from New Brunswick. Hesse is a federal state of Germany, which is a member state of the European Union. Therefore, Hesse has access to the European Single Market (ESM). The ESM is comprised of the 27 EU member states and has been extended to Iceland, Liechtenstein, and Norway under the European Economic Area Agreement (EEA) and through bilateral agreements with Switzerland and the United Kingdom. The ESM guarantees the "four freedoms," which are freedom of movement of goods, capital, services, and labor. That means there are no duties to be paid on exports of any goods within the ESM (European Commission 2018). Not surprisingly, most of the Hessian exports are within the ESM. In 2018 more than 60 % of the Hessian exports stayed within ESM (Hessisches Statistisches Landesamt 2019a). The total value of hessian exports in 2018 accounted for about 64.5 billion €, and approximately 39.5 billion € of those were within the European economic area. About

two billion € of the total export value was generated with products from the forestry and timber cluster, meaning that the forestry and timber cluster contributes about 3.12 % of the total hessian export value (Hessisches Statistisches Landesamt 2019b).

The vast majority of roundwood exports stay with the EU. One reason for that is that roundwood transport and shipping are comparably expensive. The most important export countries for hessian roundwood are Italy, Austria, and Denmark. Italy and Denmark each have a share of about 20 % of the export volume and Denmark accounts for about 15 % (Jaensch and Harsche 2007). Therefore, these three countries receive about 55 % of the total roundwood exports from Hesse.

Other important export markets for Hessian roundwood are eastern and southeastern Asian countries like Japan, South Korea, Taiwan, China, and Indonesia. Of those countries, China is the most important export market for Hesse. China is responsible for about 20 % and up to 40 % of the export value of Hessian roundwood (Jaensch and Harsche 2007).

When comparing Hesse with New Brunswick, it becomes apparent that Hesse is much less dependent on one single country for its forest product exports than New Brunswick. For once, that is simply because of its geographical location, having many more neighboring countries and close by countries like France, Austria, Switzerland, the Netherlands, Belgium, Luxemburg, Denmark, Czech Republic, or Poland. Furthermore, there are no duties to be paid on exports within the European economic area. That is a significant advantage, especially when compared to 20.23 % anti-dumping and countervailing duties New Brunswick softwood lumber exporters have to pay for exports

to the United States. The 20.23 % of duties that have to be paid on softwood lumber exports to the U.S. place a significant financial burden on New Brunswick's forestry sector and is potentially threatening the existence of several companies. In that sense, the market situation for Hesse in the European Single Market is much safer and more predictable, since free trade is guaranteed. Regarding that, it can also be said that the EU adds more restrictions for the forestry sector in Hesse, for instance, through the habitat directive. However, being a member state of the EU also grants access to the European Single Market, which is an advantage.

5. Conclusions

This thesis provided a variety of information on different topics regarding forests and forestry in Hesse and New Brunswick in order to gain a better understanding of how the two systems work independently, what the major differences are and how that affects each region. As became apparent in sections two and three, there are several significant differences between Hesse and New Brunswick. For one, there are considerable differences in terms of land area, forest area, forest cover percentage, population, and population density (Table 1). Furthermore, climate, length of the growing season, forest types, shares of deciduous and coniferous species, and increment differ significantly. These distinctions also affect the manner in which forests in Hesse and New Brunswick are managed.

This thesis hypothesizes that (1) although the Hessian forestry sector is much more regulated than that in New Brunswick, the economic conditions for Hessian forestry are nevertheless more favorable than in New Brunswick. The second hypothesis, which is connected to the first one, assumes that (2) forest management done by a public agency (State Forest Service or Provincial Department) is more beneficial to the public than forest management done by industrial companies.

These hypotheses cannot be answered easily, and as it is often the case in forestry, it depends on a number of factors and variables. When discussing whether or not certain factors are more beneficial, it is important to note that it largely depends on perception and goals. For example, just because something is beneficial to the industry does not

necessarily mean it is as beneficial for the general public. It is evident that at times there is a trade-off between economic interests and positive public attitudes towards such forest functions or uses. Forests are usually subject to a variety of uses by a multitude of stakeholders. Those stakeholders have different expectations and needs when it comes to forest use.

In most cases, the most crucial forest function for the industry is the production function (provisioning ecosystem service) of forests; however, the general public puts more emphasis on forest functions like recreation and protection functions (Regulating and cultural ecosystem goods and services) (Nadeau et al. 2008). In order to satisfy the needs of the public and the industry, forests in Hesse and New Brunswick are managed for certain functions. Due to significantly different local economic and environmental conditions in New Brunswick and Hesse, the respective forest management emphasizes different forest functions.

Both regions have a high percentage of forest cover, especially when compared to the national averages of Canada and Germany (Table 13). Therefore, the forest industry in both Hesse and New Brunswick provides a vital contribution to their respective economies. Especially in rural areas, forestry provides a significant number of jobs to the local populations, which is true for Hesse as well as for New Brunswick. However, the economic impact and importance of the forestry sector are much more significant in New Brunswick for a number of reasons. One reason for that is the high percentage of forest cover in New Brunswick of about 85 %. Furthermore, the province strongly depends on natural resources as one of their main sources of economic value and is the poorest

Canadian province (NBCLTF 2011; Floyd et al. 2012; Jones 2019). The natural resources sector contributes to about 4.3 % of New Brunswick's gross domestic product (NBjobs 2019).

Hesse, on the other hand, does not rely as heavily on its natural resources (primary sector) for its economy, but rather on the service sector (tertiary sector), which contributes about 74.9 % to the Hessian gross value added (GVA). The primary sector is composed of agriculture, forestry, and fishing, and only contributes approximately 0.3 % to the Hessian gross value added (Hessisches Statistisches Landesamt 2016).

However, that does not mean that forests and forestry are not important in Hesse. The difference to New Brunswick is that recreation and protection functions are more crucial, or at least as important as the production function, while in New Brunswick, the production function seems to get more weight.

That being said, there is a multitude of factors influencing forestry in Hesse, meaning that the forestry sector is more regulated in Hesse than it is in New Brunswick (Sections 2.4 & 3.4). This high amount of regulation has effects on the economic situation of the forestry sector. In New Brunswick, natural resources are the sole responsibility of the province and, in the case of forests, of the New Brunswick Department for Natural Resources and Energy Development (NRED). Federal laws do not affect forest management in the province of New Brunswick, and there is no supranational organization like the EU, which could add further regulation. It could be argued that these regulations make decision making more straightforward and more adapted to New Brunswick’s needs.

Furthermore, as mentioned before, the big industrial forestry companies in New Brunswick are very powerful and have a major influence on politics. That is because they provide a high amount of jobs and contribute significantly to New Brunswick's economic performance (Gardner Pinfold 2018). Due to their authority, it appears that they can influence government forest policies and regulations through their strong lobbying efforts (Auditor General of New Brunswick 2015). In New Brunswick, forest management strategies often seem to be in favor of the forest industry. For example, planned reductions in clear-cut harvest levels are not being pursued, allowable softwood harvest levels are being increased instead of being maintained, and allowable hardwood harvest levels are being maintained instead of decreased, in order to increase the wood supply (Auditor General of New Brunswick 2015). Measures like increasing the allowable harvest levels and, therefore, the wood supply are meant to increase the forestry industry's competitiveness. In that sense, it could be argued that the working environment for the forestry industry in New Brunswick is probably more industry-friendly than it is in Hesse.

However, the measures that aim to improve the forest industry's economic situation are not as beneficial to the public or the environment. Of course, the forest industry provides a significant amount of jobs to the people of New Brunswick and stimulates the economy, which is essential. However, as stated earlier in section 4.2, the general public, both in Hesse and in New Brunswick, demands for more environmental sustainability and recreational values, rather than the prioritized production of timber and the associated economic benefits (Nadeau et al. 2008; BMEL 2017a). Furthermore, there are

growing concerns regarding clear-cut harvesting and pesticide use (Nadeau et al. 2008). Nevertheless, clear-cutting was still found to be the most common timber harvesting system used in New Brunswick, regardless of announcements of the provincial government to decrease clear-cut harvesting. Clear-cutting is the cheapest and most efficient way of harvesting timber, but it comes with high ecological and social costs. That is because it leaves the harvest sites vulnerable to erosion, drains nutrients, negatively affects biodiversity, and diminishes the possibility of other uses and income sources like hunting or tourism.

In Hesse, clear-cutting of more than one hectare in size is avoided, and express permission is required for clear-cuts of more than one hectare. The most common harvesting systems in Hesse are single-tree and selective harvesting systems, which maintain the canopy and result in small gaps, which then allow regeneration. Compared to clear-cutting, a single tree harvesting system is more expensive, more dangerous for the forest workers, needs highly qualified workers, and requires more detailed planning. However, with single-tree and selective harvesting, there is less damage to forest soils, it is more aesthetically pleasing, causes less erosion, all while the production capacity of the forest site is maintained. Both systems have their advantages and disadvantages. Nevertheless, the higher associated costs for single tree and selective harvesting systems lower the revenues and, therefore, possibly make forestry operations in Hesse economically less viable than in New Brunswick. However, that is just an assumption, since there was no data found to prove that argument.

Another difference that was found to impact the economic outcome of the forestry sector is the provision of recreational and protective functions of forests. Paragraph 15 of the Hessian Forest Act states that everyone is permitted to enter the forest for recreation, irrespective of the ownership type of the forest. With that comes a high amount of forest visitors in private, communal, and State Forests. The high recreation pressure on forests creates costs for the forest owners, whether through active management or intended operational omissions. The amount of costs to the forest owners can be significant since these costs can account for between 24 % and 42 % of the net revenue depending on the ownership type (Dög et al. 2016). As stated earlier, the study of Dög et al. (2016) was focused on Germany as a whole and did not differentiate between the individual German Federal States. Therefore, no specific data for Hesse is available. However, since the data mentioned before is an average for all of Germany, it can be assumed that in Hesse, these numbers are at least similar. Even though the data is not available for Hesse in particular, it still points out the financial burden that the provision of regulating and cultural ecosystem goods and services puts on forest owners in Germany. For New Brunswick, it was not possible to find comparable data. However, the before stated costs do not occur for private woodlot and industrial freehold forest owners in New Brunswick, because access to private forest property is restricted. That difference alone might be the most significant factor influencing the economic outcomes of the forestry sector when comparing New Brunswick and Hesse.

Since 2018, 100 % of the Hessian State Forest are FSC and PEFC certified. Furthermore, about 87 % of all forests in Hesse are certified under PEFC (HMUKLV 2019). Especially the

FSC certification adds several new restrictions, like an increase of protected forest area (no harvesting and other uses) to 10 % of the State Forest, restrictions regarding tree species choice, and a decrease in softwood species. Just like for New Brunswick, softwood species are essential for the forest industry in Hesse too, in particular for sawmills. Furthermore, the restrictions for tree species choice, limit the ability to prepare and adapt the Hessian forest with regards to climate change. Consequently, the FSC certification causes higher expenditures, limits timber harvesting, and therefore lowers the revenue from forests.

Considering all of the restrictions and regulations mentioned above, it seems that the higher amount of regulations for the Hessian forestry sector lowers the economic outcome of the forestry sector in Hesse compared to New Brunswick. Therefore, the first hypothesis of this thesis appears to be wrong; in fact, the opposite seems to be more likely.

However, on the one hand, the restrictions and regulations negatively affect the economic outcome of the forestry sector in Hesse compared to New Brunswick. Nevertheless, on the other hand, the same restrictions and regulations benefit the public, since they improve the provision of protection and recreation functions (Regulating and cultural ecosystem goods and services) of the forests in Hesse. Therefore, the second hypothesis that assumed that forest management led by a public agency (State Forest Service or Provincial Department) is more beneficial to the public and the environment vs. forest management influenced by industrial companies who prioritize profit appears to be the case.

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