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Landscape Approaches to Sustainability—Aspects of Conflict, Integration, and Synergy in National Public Land-Use Interests

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Abstract: Strong land-use pressure challenges sustainable development and calls for landscape approaches that balance economic, ecological, and socio-cultural aspects and interests. In the boreal, sub-alpine, and alpine regions in Sweden, encompassing 32 million ha, many and different land-use interests overlap, which causes risks for conflict, but potentially also suggests integration and synergy opportunities. Based on geographic information system (GIS) analyses of geographically delineated national interests regulated in the Swedish Environmental Code, including, amongst others, Natura 2000, contiguous mountains, recreation, reindeer husbandry, and wind power, and based on forestry as a dominating land use, we found extensive overlap among similar but also between dissimilar types of interest. In some mountain municipalities, our results show that the designated national interest area is four times as large as the available terrestrial area. Moreover, the overlap is much higher in the alpine than in the boreal biome, and there is increasing designation for nature conservation and a decreasing designation for national interests for culture, recreation, and tourism from south to north. We interpret the results with reference to multiple-use needs and opportunities for landscape approaches to sustainable planning. Departing from biodiversity conservation values, we also discuss opportunities to focus planning strategies on assessing synergy, integration, and conflict based on nature-based and place-based land-use characteristics.

Keywords: alpine; boreal; comprehensive planning; environmental code; integrated planning; land-use diversification; multiple use; municipal planning; Sweden

1. Introduction

The landscape approach, although widely embraced and adopted in policy, governance, management, and science, has shown to be difficult to apply in practical sustainability-oriented landscape planning [1–3]. Evidently, there is a lack of comprehensive planning frameworks that are capable of incorporating the multifaceted dimensions of landscapes [4–6]. Nonetheless, a range of high-ambition agendas currently promote sustainable development based on integrated ecological, economical, socio-cultural, and political landscape dimensions. Examples include the statements of the European Landscape Convention [7] and the Intergovernmental Panel on Biodiversity and Ecosystem Services on land degradation and restoration and on the loss of biodiversity and ecosystem services [8]. The landscape dimensions are also embedded in the Aichi targets—in particular, #7 on sustainable management, biodiversity, and conservation, #11 on setting aside a minimum of 17% of terrestrial areas, and #15 on restoring degraded ecosystems [9], as well as generally in the UN Sustainable Development Goals [10]. The need to move forward and implement functional landscape approaches is urgent in order to advance the capacity to reach sustainable development and the use of natural resources and multifaceted values of landscapes and nature.

As a concept, the landscape approach encompasses boundary aspects, such as place-based aspects, multi-functionality, sustainability, co-governance, engaged society, collaborative planning, and inter-disciplinarity [11]. Landscape approaches are seen as a ways forward for, for example, integrating different land-use actors operating at different geographic scales [12,13], supporting ecosystem stewardship [14], and allowing spatial targeting of land-sharing and land-sparing [15,16]. Furthermore, landscape approaches have been assigned with the capacity to combine biophysical data with socio-economic data [17] for developing adaption to climate change [18,19] and for mitigation of the generic impact of the human footprint on nature [20,21].

The human footprint is accelerating and, in many regions, the demands on the land exceed the land availability [22]. Systematic forest harvesting and forest management oriented towards plantation forestry and maximum biomass yield have been identified as potentially degrading and not sustainable [8]. Globally, as well as for the boreal forest biome, industrial forest management transforms intact forest landscapes at critical rates [23–27]. Forest harvesting continues despite governance and management policies that advocate increasing conservation rates and sustainable landscape approaches [28,29], thereby accelerating threats to biodiversity and ecosystem services [30,31]. The combined and cumulative effects of continued landscape transformation [26], land-use intensification [32], and different land use forms overlaid in space and time represent a potential "sledgehammer" [33] effect, where ecosystems and landscapes, due to the extensive human footprint, enter irreversible states from which they cannot recover to earlier states.

Among the forest biomes of the world, boreal forests constitute important natural assets due to their extensive coverage, circumpolar distribution, and their relatively intact nature [25,34–36]. Like in many other more remote hinterland areas, the Swedish northern boreal and mountain region consists of sensitive natural and cultural environments of high ecological significance and also of interest for many different land uses [9,37–40]. There is a negative trend in these areas, however, with key habitats and ecosystem services being lost [41,42]. Systematic forest harvesting for timber, pulpwood, and bioenergy extraction have transformed intact forest landscapes [43], and the pressure from forestry on remaining mature and old forests and other land use types in the alpine and mountain foothills remains high [35,44]. Thus, arguments are raised on the need for additional protection and for landscape restoration in the context of green infrastructure development [45]. The contiguous and extensive remaining belt of intact forest landscapes on the Swedish side of the Scandinavian Mountain range is an international high-value conservation asset per se, but also an ecologically significant transition and gradient into the alpine environments at higher altitudes [44]. Given the high conservation, socio-cultural, and landscape values associated with small-scale agricultural farming and the reindeer husbandry culture of the indigenous Sami people, landscape approaches towards sustainable development require landscape planning with the capacity for spatiotemporal and multi-objective resolution in decision-making [46].

With multiple and divergent land-use claims, cumulative land-use impacts, and a general lack of land area in comparison with the area designated for various land-use purposes, sustainable development is a challenge. The interdependencies among multiple and different landscape values need further attention in practical land-use planning [1], not the least since landscape planning should reflect the policy mix of legal and regulatory instruments [47] associated with the different values. To ensure legitimacy in the planning process and outcome, planning strategies and prerequisites need to be transparent, reasonable, and understandable to land owners and to other stakeholders and right-holders [48]. With the comprehensive planning mandate placed at the municipality level, the 15 Swedish mountain municipalities have a key but difficult role [1,3,40]. With respect to landscape planning, the current comprehensive municipal plans in the Swedish mountain region suffer from being too narrow and too focused primarily on physical planning [3], and thus do not provide enough precision and accuracy for a sustainable landscape approach [9]. Consequently, there is an urgent need to explore routes for further development of comprehensive planning to secure a sustainable provision of landscape values for multiple purposes, which simultaneously give strategic guidance to actual sustainability problem identification and solving. Moreover, there is a need to increase planning capacity for adaptation and mitigation to both expected and unexpected sustainability challenges, e.g., for climate-change-induced land-cover transformation, within already existing legal planning frameworks and for further development of these frameworks.

In this study, we have taken an explorative approach to broad geographic and multiple-scale sustainable landscape planning, departing from the economic, ecological, and sociocultural sustainability dimensions in general and from specific land-use interest and landscape values. In Sweden, national interests (Swedish: "Riksintressen") are legally recognized and defined in the Swedish Environmental Code [49]. These chapters are included in a segment of the Code where possibilities for multiple land-use opportunities are acknowledged and promoted if in accordance with sustainable development of the recognized values. Hence, we explore and move forward sustainable landscape planning based on an already existing legal foundation that currently is in use in comprehensive planning, and that is also associated with a municipal mandate to exercise practical landscape and land-use priority decision-making [3,50]. Since forestry is a dominant form of land use in Sweden in general, and in northern Sweden in particular [26], land where forestry is or can be performed is included as a baseline land use.

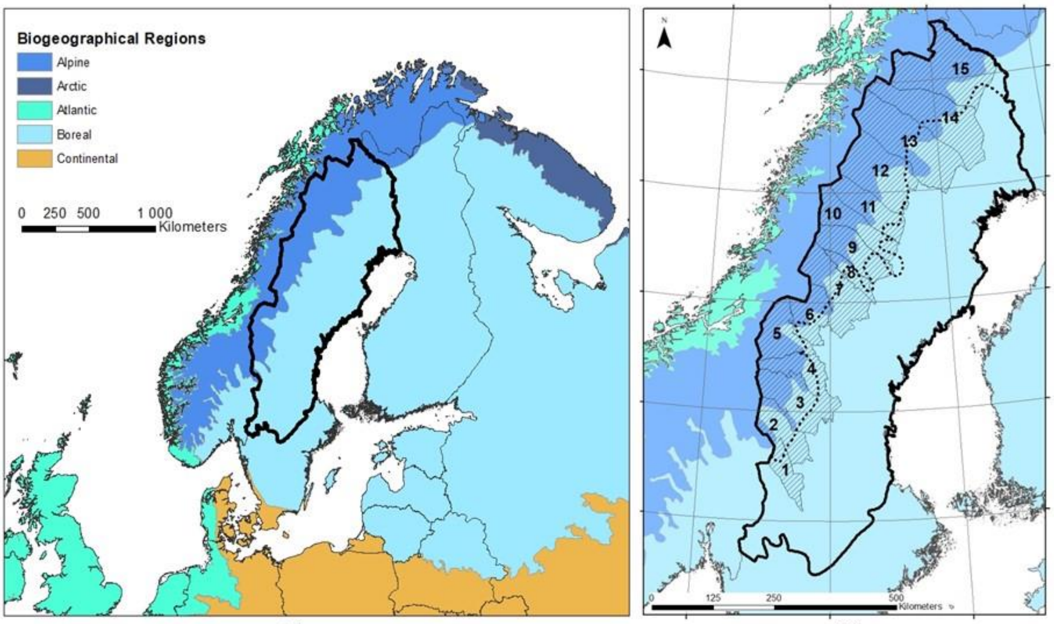
Our study objective was to identify, map, and analyze the geographical distribution and overlap between different legally recognized national interests and forestry land, reflecting the economic, ecological, and socio-cultural sustainability dimensions. Focusing on the Swedish mountain region, we explored how the spatial distribution and overlap vary between the mountain municipalities, across the nine-degree-of-latitude stretch of the Scandinavian Mountain Range, and between the alpine and the boreal forest biomes. Our results are interpreted with reference to multiple interests and multiple uses in the view of ecological, economic, and socio-cultural sustainability dimensions as a groundwork for integrated landscape approaches to sustainable planning. With the conservation of biodiversity as a point of departure, we discuss opportunities to focus planning strategies on assessing synergy, integration, and conflict based on nature-based and place-based land-use attributes.

2. Materials and Methods

2.1. Study Region and Sub-Regions

Our study region covered the northern part of Sweden across nine degrees of latitude (59–69 N°, about 1180 km, Figure 1) and from the Scandinavian mountain range in the west to the Gulf of Bothnia coast in the east, thereby encompassing the alpine and boreal biomes [51] and their transition zone. The Scandinavian mountain range in Sweden, Norway, and Finland, extending south–north from the high arctic Nordkap to the southern boreal Stavanger in Norway, is one of the oldest mountain ranges globally and one of the longest in Europe. The alpine tree line, defined by mountain birch (*Betula pubescens var. tortuosa*), decreases from around 900 m in the south to around 700 m in the north. Heathland, shrub land, barren land, and mires characterize the area above the tree line, with different *Salix* species, heather (*Calluna vulgaris*), graminoids, herbs, and mosses being the dominant vegetation. Coniferous forests (*Pinus sylvetris, Picea abies*) with elements of deciduous forests characterize the foothill boreal forest below the tree line. The Swedish mountain region encompasses 15 different municipalities, pre-dominantly rural with low population density, rich in natural resources, nature conservation, and tourism values, and with the presence of indigenous Sami culture reindeer husbandry as an exceptional characteristic [37,45,52]. The number of residents in the study region is close to

140,000 (just below one person per km^2), with most in the south part; in total, there are three cites with ≥5000 residents and 16 cities with ≥1000 residents [53].



(a) (b)

Figure 1. The study area covers: (**a**) North Sweden, including the entire alpine biome and a very large share of the boreal biome; (**b**): The mountain region with the 15 municipalities (thin black line and shaded surface) in the Swedish territory of the Scandinavian mountain range and north Sweden, divided into the alpine (dark blue) and boreal (light blue) biomes. Mountain municipalities: Malung (1); Älvdalen (2); Härjedalen (3); Berg (4); Åre (5); Krokom (6), Strömsund (7); Dorotea (8); Vilhelmina (9); Storuman (10); Sorsele (11); Arjeplog (12); Jokkmokk (13); Gällivare (14); Kiruna (15).

With a focus on the mountain region, we analyzed the data on four levels (also see Table 2). The first was on the mountain municipality level for the 15 municipalities, from south to north: Malung, Älvdalen, Härjedalen, Berg, Åre, Krokom, Strömsund, Dorotea, Vilhelmina, Storuman, Sorsele, Arjeplog, Jokkmokk, Gällivare, and Kiruna. The second was on the mountain sub-region level, encompassing the southern part with Malung up to the Strömsund municipality in Dalarna and Jämtland counties, the central part with Dorotea up to the Sorsele municipality in Västerbotten county, and the northern part with Arjeplog up to the Kiruna municipality in Norrbotten county. The third was on the mountain region level, covering the combined territory of the 15 mountain municipalities, and the fourth was on the biome level, i.e., the alpine biome and the boreal biome.

2.2. National Interests

In Sweden, National Interests (NIs hereafter) were identified and delineated by the Swedish Parliament and the sector authorities based on the natural, cultural, economic, and societal values associated with certain terrestrial and aquatic geographical areas for the purpose of securing the public interest on such values against private and other conflicting interests [50]. The NIs are geographical areas claimed by the Swedish Parliament and State Authorities including, e.g., the Forest Agency, the Environmental Protection Agency, the Sami parliament, and the Energy Agency, to secure the societal and public rights to access and use those resource values. The NIs cover land owned by different owner categories, including by non-industrial private household owners. The NIs were recognized to secure sustainable use of land and water by protecting those values from measures that caused considerable damage [54]. The rationale behind the initiation of NIs in the national physical planning system was the considerable structural changes since the 1950s, mainly by urban expansion and building of secondary homes in coastal and rural areas. This caused major disturbances on previously un-exploited natural and landscape values [54]. In the Environmental Code, the NI framework is placed within the economy rules (Swedish: "Hushållningsbestämmelserna"), which are specifically oriented towards multiple or combined economic, ecological, and socio-cultural aspects of sustainable use. Thus, these are not placed in the Environmental Code Chapter 7, which exclusively defines a specific natural value, use, or interest, as is the case, for example, for nature reserves. Thereby, the NI framework provides a legal basis for promoting multiple integrated land uses in comprehensive planning as a complement and alternative to promoting a specific, single type of land use. The economy rules include Chapter 3 on general rules and Chapter 4 on specific rules for certain values and purposes. Multiple and integrated aspects are expressed more strongly for those NIs that are regulated in Chapter 3.

In this study, we focused on the NI categories that concern nature, recreation, and cultural values, and those associated with land use in terrestrial areas outside urban settings (Table 1). There are several other types of NIs recognized in the Environmental Code that are not included in this study (see footnote to Table 1). In addition to the NIs, our analyses included forestry land—with forests as the dominant land cover type—and forestry as a dominant land use in the study region. The Environmental Code (Chapter 3) recognizes forestry as an important land use, but does not specify forestry as an NI within certain geographical areas. We classified a total of 11 categories—i.e., 10 different NIs and forestry land—into three classes reflecting economic, ecological, and socio-cultural sustainability dimensions, respectively (Table 1). Thus, the classification was based entirely on the overall sustainability dimension recognized as a public right in the Environmental Code.

Table 1. Classes and categories of national interests and forestry land, with abbreviations applied for the categories in tables and figures and with their definitions according to the Swedish Environmental Code [49].

Class and Category	**Definition**
Nature conservation class	
Nature conservation (NCC)	3:6. Land and water areas, and the physical environment in general, that are important for their natural values in public opinion should, as far as possible, be protected against measures that may substantially harm the natural or cultural environment.
Natura 2000 SCI (Species and Habitat Directive) (NSD)	4:8. Use of land and water in a nature area that has been assigned according to the EU Species and Habitat Directive (2006/105/EG) that, in a substantial way, will impact the environment requires formal permission. Measures that are directly necessary for management and governance of the natural values are allowed.
Natura 2000 SPA (Bird Directive) (NBD)	4:8. Use of land and water in a nature area that has been assigned according to the EU Bird directive (2009/147/EG) that, in a substantial way, will impact the environment requires a formal permission. Measures that are directly necessary for management and governance of the natural values are allowed.
Contiguous mountains (NCM)	4:5. A defined mountain area in which buildings and installations can be approved only if they are needed for reindeer husbandry, local inhabitants, scientific purposes, or for itinerant recreation. Measures not needed for the above purposes are approved only if this is without impact on the natural and semi-natural landscape characteristics of the areas.
Culture, recreation, and tourism class	
Cultural environment (CCE)	3:6. Land and water areas, and the physical environment in general, that are important for their cultural values in public opinion should, as far as possible, be protected against measures that may substantially harm the natural or cultural environment.
Recreation (CRE)	3:6. Land and water areas, and the physical environment in general, that are important for their recreational values in public opinion should, as far as possible, be protected against measures that may substantially harm the natural or cultural environment.
Itinerant recreation and tourism (CRT)	4:2. A defined geographical area in which the tourism and recreation interests, particularly for itinerant recreation, should be especially considered in the approval of exploitive or other impacts and measures on the environment.

Table 1. *Cont.*

Class and Category	Definition
Land use class	
Forestry land (LFO)	3:4. Forestry is of national importance. Forestland that is important for the forest industry should, as far as possible, be protected against measures that may hinder rational forestry.
Reindeer husbandry (LRH)	3:5. Land and water areas that are important to reindeer husbandry should, as far as possible, be protected against measures that may hinder reindeer husbandry. Reindeer husbandry is an allowed land use within the defined reindeer husbandry area [55].
Mining (material, minerals) (LMM)	3:7. Land and water areas that harbor known resources of valuable substances and materials should be protected against measures that may substantially hinder their excavation.
Wind power/energy production (LWP)	3:8. Land and water areas that are particularly suitable for installations for wind energy production should, as far as possible, be protected against measures that may substantially hinder such establishment and use.

Notes: (1) The classification was based entirely on the overall sustainability dimension recognized as a public right in the Environmental Code, i.e., the type of interest that the type of national interest is supposed to deliver. (2) The Swedish Environmental Code also includes other national interests not considered in this study: In Chapter 3 (5–9 §§), hydro-electrical energy production, drinking water supply, energy distribution, communication (physical and digital/electronic), industrial production, waste treatment, nuclear waste storage, commercial fishing, and military and national installations. In Chapter 4 (2–8 §§), water courses protected from hydro-electrical installations, the national city park in Stockholm (Swedish: "Nationalstadsparken"), and coastal and archipelago areas protected from exploitation. (3) Forestry is not recognized as a formal national interest in the Environmental Code, but as a nationally important land use. The data in this category exclude protected forests and other forests with known conservation values using the data on High-Conservation-Value Forests [56].

2.3. Data and Analyses

We downloaded polygons (i.e., vector data) that delineate the spatial distributions of the 11 categories from the public National Geodatabase at the County Administrative Boards (www.lansstyrelsen.se, accessed 13 November 2018), the Geological Survey of Sweden (www.sgu.se, accessed 25 January 2017), and the Environmental Data Portal via the Swedish Environmental Protection Agency [56]. To reduce the risk for erroneous calculation of polygon areas and to reduce delineation overlap, we inspected all polygons visually for false border drawing and corrected obvious errors. All polygon data were merged into one common file, which we used for the intersection analyses. Remaining minor drawing errors were negligible given the size of the study region and sub-regions. To access forestry land potentially available for forestry, we re-classified the Swedish Vegetation map (25 × 25 m, 2002, www.lantmateriet.se) into non-forest and forest pixels, defining all forest types as forest. We then extracted all forest pixels, as well as forestland not in active use for forestry, and converted the map into a shape file, from which we erased protected forest areas and other forest areas with known high nature conservation values using the layer "High-Conservation-Value Forests" [56].

We quantified and summarized the areal (resolution 1 ha) intersection for the polygons belonging to a given category with the polygons of all other NIs using the tool "Tabulate Intersection". We calculated the intersection of the 11 categories on the four geographical levels—each mountain municipality, the alpine biome, the boreal biome, and the entire study area. We demarcated the alpine (alpine and mountain deciduous forest) and boreal biome (northern and middle boreal forest) following the distribution of the vegetation zones [50]. To avoid inaccuracies in polygon overlap due to minor mapping errors, we followed a conservative approach and ignored all intersections <100 ha. Data on the area and proportional overlap between the 10 NI and forestry land for each municipality and for the alpine and boreal biomes, are available as Supplementary Materials to this study.

Finally, to quantify the spatial distribution of co-occurring categories, we generated three "Fishnets" (10 × 10 km)—one for the entire study area, one for the boreal biome, and one for the alpine biome. Based on our merged polygon layer, we counted the number of co-occurring categories within each

Fishnet cell. To account for forestry land specifically, as it is not a formal NI, we performed the same analyses for the 10 NI categories, i.e., without forestry land as the 11th category. We used Arc Map 10.4.1 (ESRI, Redlands, CA, USA) for all spatial analyses.

3. Results

The study region covers close to 32 million ha, of which the terrestrial area is over 29 million ha, from sea level to the highest altitude level in Sweden (Table 2). The mountain municipalities generally cover large geographical areas, ranging from 296 (279 terrestrial) kha (Dorotea, Central) to 2070 (1927) kha (Kiruna, North). The northern sub-region is by far the largest, and covers 46% of the total and terrestrial area in the study region. The alpine biome covers 11,314 (10,354) kha, and the boreal biome 20,410 (18,764) kha.

Table 2. Area (total and terrestrial in 1000 ha) and altitude range (minimum and maximum) for the 15 mountain municipalities (with abbreviations) summarized for the southern, central, and northern sub-regions, for the entire mountain region, for the alpine and boreal biomes, and for the whole study region of northern Sweden.

	Total Area (kha)	Terrestrial Area (kha)	Altitude Range (m)	
MAL; Malung	434	411	266	944
ÄLV; Älvdalen	719	692	199	1197
HÄR; Härjedalen	1192	1134	50	1322
BER; Berg	621	577	275	1789
ÅRE; Åre	830	727	53	1743
KRO; Krokom	689	624	33	1277
STR; Strömsund	1180	1052	189	1390
∑ South	5663	5216	33	1789
DOR; Dorotea	296	279	39	1475
VIL; Vilhelmina	879	812	317	1566
STO; Storuman	828	738	53	1760
SOR; Sorsele	801	744	83	1593
∑ Central	2804	2573	39	1760
ARJ; Arjeplog	1458	1268	42	1810
JOK; Jokkmokk	1947	1775	37	2057
GÄL; Gällivare	1695	1582	13	1810
KIR; Kiruna	2070	1927	45	2098
∑ North	7170	6552	13	2098
∑ Mountain region	15,638	14,342	13	2098
Alpine biome	11,314	10,354	33	2098
Boreal biome	20,410	18,764	0	1020
North Sweden	31,724	29,118	0	2098

Notes: (1) The first set of seven municipalities are within Dalarna and Jämtland counties and are summarized into the southern sub-region. The following set of four municipalities are within Västerbotten county and are summarized into the central sub-region. The final set of four municipalities are within Norrbotten county and are summarized into the northern sub-region. (2) All 15 municipalities are summarized into the mountain region. The mountain region encompasses all of the mountain municipalities, whose territories are situated in both the alpine and the boreal biomes.

Across the study area, the 11 categories cover over 60 million ha, which is more than twice the total terrestrial area (Table 3), and is higher (3.4 times) for the alpine biome than for the boreal (1.4 times). We found evident differences in the appearance of classes and categories across municipalities, south to north within the mountain region, and between the biomes. In the *Nature Conservation* class, "Nature conservation" dominates in 8 out of 15 municipalities and mainly in the south. "Natura 2000 SCI" and "Contiguous mountains" dominate mainly in the north. For the *Culture, Recreation, and Tourism* class, "Itinerant recreation and tourism" dominates in all seven municipalities in the south, and "Recreation" in all eight municipalities in the central and northern sub-regions. For the *Land Use* class, "Forestry land" and "Reindeer husbandry" generally cover large geographical areas, except for the latter being absent in one municipality in the south (Malung), which is outside the reindeer husbandry area (see Table 1). "Mining" and "Wind power" cover, comparably, very small areas, and are even absent in some of the municipalities. On the mountain region level, the *Nature Conservation* class dominates in the south, the *Culture, Recreation, and Tourism* class in the central, and the *Land Use* class in the north. On the biome level, "Recreation" and "Nature conservation" dominate in the alpine biome, with "Contiguous mountains" also covering a large area. "Cultural environment" generally encompasses small areas in both the alpine and the boreal biomes. For the *Land Use* class, "Forestry land" covers 14,528 kha in the boreal biome, which equals 57% of the total area of all categories. The comparable proportion for the alpine biome is 10%, where "Reindeer husbandry" covers a larger (4435 kha; 13%) proportion.

Table 3. Total area (in 1000 ha) of national interest and forestry land for the mountain municipalities, for the entire mountain region (Mtn region) and the mountain region divided into southern, central, and northern sub-regions, for the alpine and boreal biomes, and for the whole study region of northern Sweden (N Sweden).

	Nature Conservation				**Culture, Recreation, Tourism**			**Land Use**				**Sum**
	NNC	**NSD**	**NBD**	**NCM**	**CCE**	**CRE**	**CRT**	**LFO**	**LRH**	**LMM**	**LWP**	
MAL	43	14	4		9	50	96	289			9	514
ÄLV	234	196	187	50	3	198	270	392	117	0	3	1651
HÄR	310	97	70	57	85	233	520	727	322		18	2439
BER	245	27	4	130	101	225	281	333	217		5	1567
ÅRE	389	215	197	250	61	424	712	305	417		1	2970
KRO	169	160	33	115	52	233	316	365	268		2	2970
STR	306	124	94	163	8	306	387	699	427	1	33	2546
DOR	54	63	42	3	0	65	58	167	89			541
VIL	274	307	224	178	25	407	183	387	355	2	11	2354
STO	210	172	164	127	9	370	300	374	314	6	9	2055
SOR	499	411	405	368	43	482	56	271	300		18	2853
ARJ	566	318	22	724	40	1017	238	385	557	0	1	3868
JOK	922	964	218	916	25	1105	156	502	766	1	2	5576
GÄL	578	654	321	632	5	831	72	518	657	24	7	4298
KIR	964	700	181	1149	37	887	224	444	821	23		5431
Mtn region	5762	4421	2165	4862	504	6834	3868	6157	5628	58	118	40,377
South	1694	834	588	765	319	1670	2581	3110	1769	1	70	13,402
Central	1038	953	835	675	78	1325	597	1199	1057	8	37	7802
North	3030	2635	742	3421	106	3840	689	1848	2801	49	10	19,173
Alpine	5330	3915	2066	4811	354	6299	3733	3536	4435	34	55	34,568
Boreal	1794	815	214	50	584	2015	985	14,528	4158	46	285	25,474
N Sweden	7124	4730	2280	4861	938	8314	4718	18,063	8593	80	339	60,042

Note: The value 0 represents occurring areas <500 ha, whereas no value represents no occurring area. See Table 1 for category abbreviations. See Table 2 for municipality abbreviations.

Of the 10 NIs, "Natura 2000 SPA", "Contiguous mountains", "Recreation", and "Itinerant recreation and tourism" have an uneven distribution with an evident dominance in the mountain region and the alpine biome (Figure 2). In addition, "Natura 2000 SCI" and "Nature conservation" are more strongly clustered in the mountain region and the alpine biome, but also occur scattered across the entirety of northern Sweden. "Cultural environment" is more frequently occurring in the southern part, whereas "Reindeer husbandry" uniformly covers the reindeer husbandry area (see Table 1). "Mines" and "Wind power" cover less and more widely dispersed areas; for the latter, with a dominance outside the mountain region and the alpine biome. Some of the NIs, such as "Cultural environment", "Recreation", and "Itinerant recreation and tourism", apparently follow the landscape terrain with parallel river valleys from north-west to south-east.

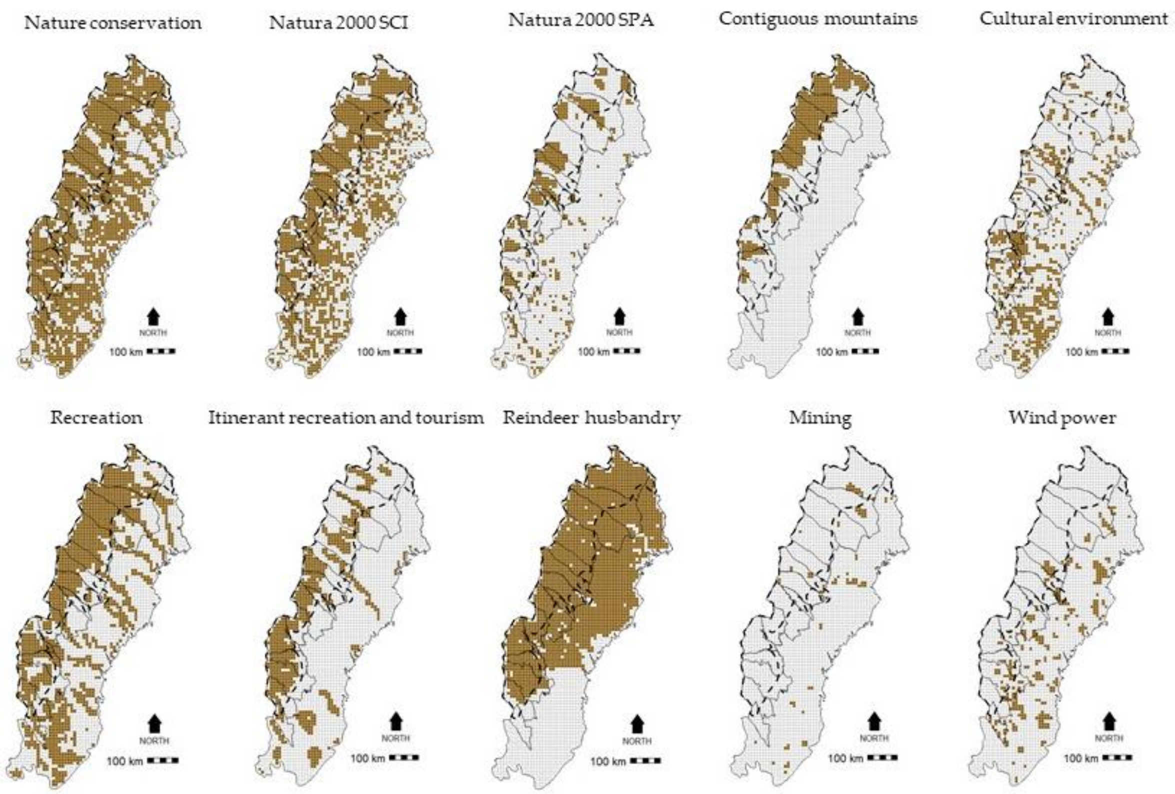


Figure 2. Frequency of occurrence, per 10 × 10 km pixels following the Swedish standard map system, of the 10 national interests in the study. The solid line shows the borders for the mountain municipalities that together represent the mountain region, and the broken line shows the border between the alpine biome to the west and the boreal biome to the east. The marked elongated pattern in the upper central part of the study region, particularly evident for "Itinerant recreation and tourism", is the Vindelälven river valley, which is recognized as a UNESCO Biosphere Reserve.

Our results clearly show that the overlap of NIs and "Forestry land" is extensive across the whole study region, but particularly in the mountain region and in the alpine biome (Figure 3a). A very small fraction of the study region (0.07%, Sorsele municipality) has an overlap of 10 out of the 11 different categories, 31% has an overlap of six or more categories, and 85% an overlap between three and eight categories. Only 2% of the study region has one single category occurring, with these fragments largely confined to the boreal biome and the easternmost parts of the mountain region, and are understood as covered by "Forestry land". In addition, without "Forestry land", the main overlap patterns and hotspots with high overlap frequency remain (Figure 3b).

The NI area and "Forestry land" area generally increase, both with latitude and with increasing municipal territory (Figure 4a). The average category area/terrestrial area ratio is 2.7, but varies substantially among the municipalities. Two municipalities have about four times larger category areas than terrestrial areas (Åre with 4.1 and Sorsele with 3.8), and two have a low ratio (Malung with 1.3 and Dorotea with 1.9). Likewise, the proportion of the *Land Use* class of total category area varies between 21% and 58% (Malung, the only one with more than half of the category area in the *Land Use* class). The proportion of the *Culture, Recreation, and Tourism* class ranges from 20–21% in the northern mountain region to 39–40% in the south. The proportion of the *Nature Conservation* class varies from 12% to 59%. The *Nature Conservation* class covers 50% or more of the total category area in one municipality in the central mountain region and in the three northernmost municipalities, which is mainly a consequence of large areas of "Contiguous mountains" (see Table 3). Thus, our results show a trend of an increasing proportion of the *Nature Conservation* class from the southern to the northern mountain sub-regions (Figure 4b), associated with a trend of decreasing proportion of the *Land Use* class, mainly concerning "Forestry land". For the alpine and boreal biomes, we found an inverse relationship between the proportional distribution of classes of total category area; for the boreal, 75% to 14% to 11%, and for the alpine, 23% to 30% to 47%, for the *Land Use, Culture, Recreation, and Tourism,* and *Nature Conservation* classes, respectively.

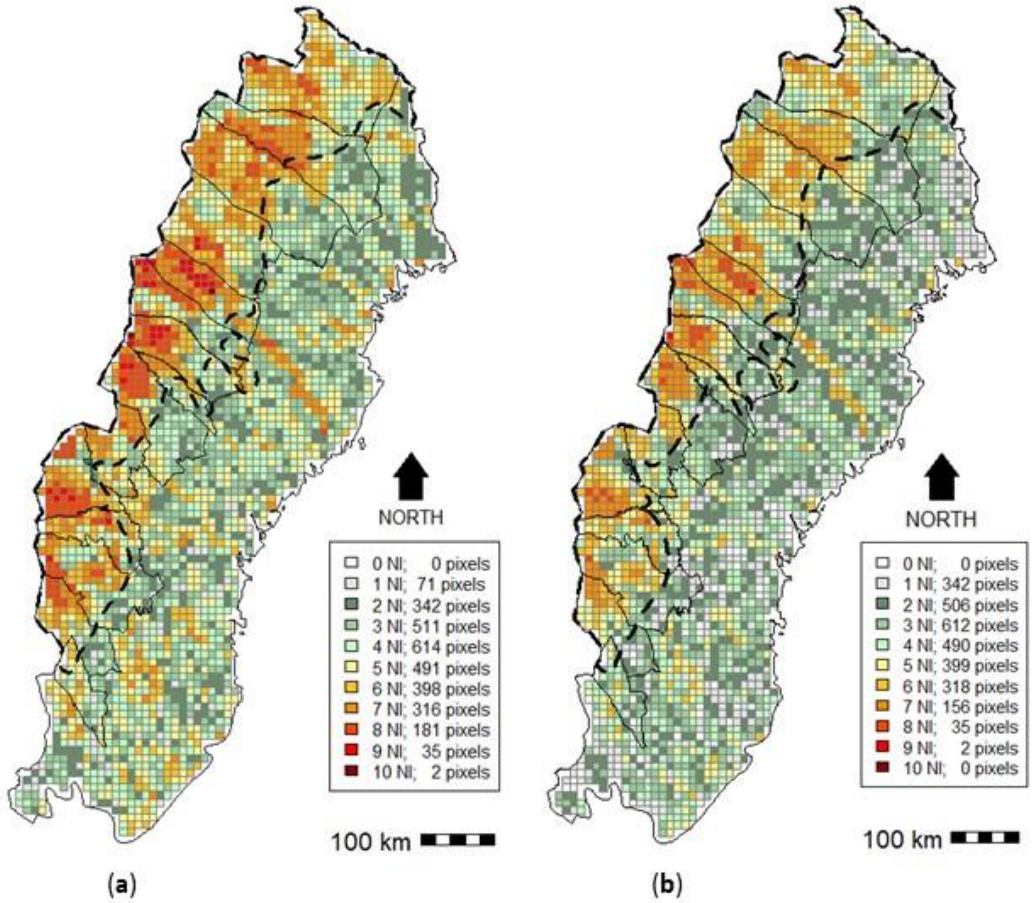


Figure 3. (**a**): Frequency of occurrence of the 10 national interests (NIs) and forestry land per 10 × 10 km pixels; (**b**) frequency of occurrence of the 10 national interests not including forestry land. The solid line shows the borders for the mountain municipalities that together represent the mountain region, and the broken line shows the border between the alpine biome to the west and the boreal biome to the east.

Compared to the other classes, we found that the overlaps are higher among categories within the *Nature Conservation* class in all mountain municipalities except the two southernmost, as well as in the alpine biome (Figure 5a,e). The overlap of the *Culture, Recreation, and Tourism* class in the *Nature Conservation* class is higher than the overlap of the *Land Use* class in the *Nature Conservation* class, particularly in the southern mountain region and the alpine biome (Figure 5b,f). The overlap of the *Land Use* class in the *Culture, Recreation, and Tourism* class is low in the southern, but high in the central and northern mountain sub-regions (in particular, in the Sorsele municipality) and high in the alpine compared with the boreal biome. The overlaps of the *Nature Conservation* class and the *Culture, Recreation, and Tourism* classes in the *Land Use* class are variable, whereas the overlap of the *Nature Conservation* class in the *Culture, Recreation, and Tourism* class is about the same (Figure 5c,g). The overlap in the boreal biome is low (Figure 5d,h).

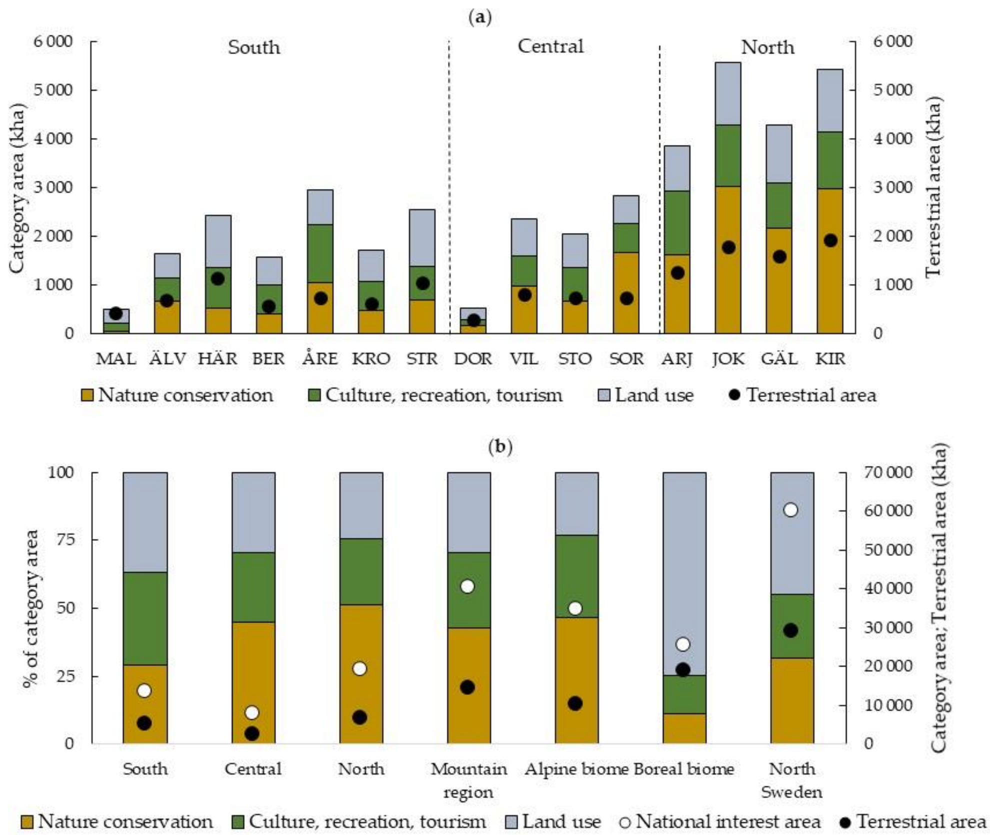


Figure 4. (**a**) National interest and forestry land area (left axis bars) and total terrestrial area (right axis points) in 1000 ha for the Nature Conservation, the Cultural, Recreation, and Tourism, and the Land Use classes for the mountain municipalities with division into southern, central and northern mountain sub-regions. (**b**) Percent class area of national interest area (left axis bars) and total national interest and terrestrial area (right axis points) for the mountain sub-regions, the mountain region, the alpine and boreal biomes, and the entire study region of northern Sweden.

Overlap distributions among the 11 different categories vary substantially between the municipalities (Table 4). The most complex situation (Table 4a) shows that out of 110 possible combinations between the categories, 25 combinations have an overlap ≥ 75%, 28 combinations ≥ 50%, and 42 combinations ≥ 25%. Comparable overlaps in the least complex situation (Table 4c) are 4, 9, and 16 combinations. The most evident trends are overlaps within the *Nature Conservation* class, particularly between "Nature conservation" and "Natura 2000 SPA", and between the *Nature Conservation* class and "Recreation", "Itinerant recreation and tourism", and "Reindeer husbandry" (Table 4a,b). The overlap is also apparent within the *Culture, Recreation, and Tourism* class, between the *Culture, Recreation, and Tourism* class and the *Nature Conservation* class, and in "Reindeer husbandry". Interestingly, "Reindeer husbandry" generally overlaps with both the *Nature Conservation* and *Culture, Recreation, and Tourism* classes, but also with "Forestry land" (Table 4c). Moreover, "Mining" overlaps up to 100% with "Recreation", "Itinerant recreation and tourism", and "Reindeer husbandry". In addition, four more combinations overlap by 99% or 100% between "Natura 2000 SPA", "Contiguous mountains", and "Recreation" (Table 4a).

Compared to the boreal biome, the alpine biome has about twice as many combinations with an overlap ≥ 75% (8 vs. 4), ≥ 50% (24 vs. 13), and ≥ 25% (53 vs. 24) (Table 5). The most evident trends in the alpine biome (Table 5a) are the overlap within the *Nature Conservation* class and the overlap between this class and "Recreation". In the boreal biome (5b), the most evident overlap trends are also within the *Nature Conservation* class and between this class and "Recreation", but also the overlap between the *Culture, Recreation, and Tourism* class and "Forestry land".

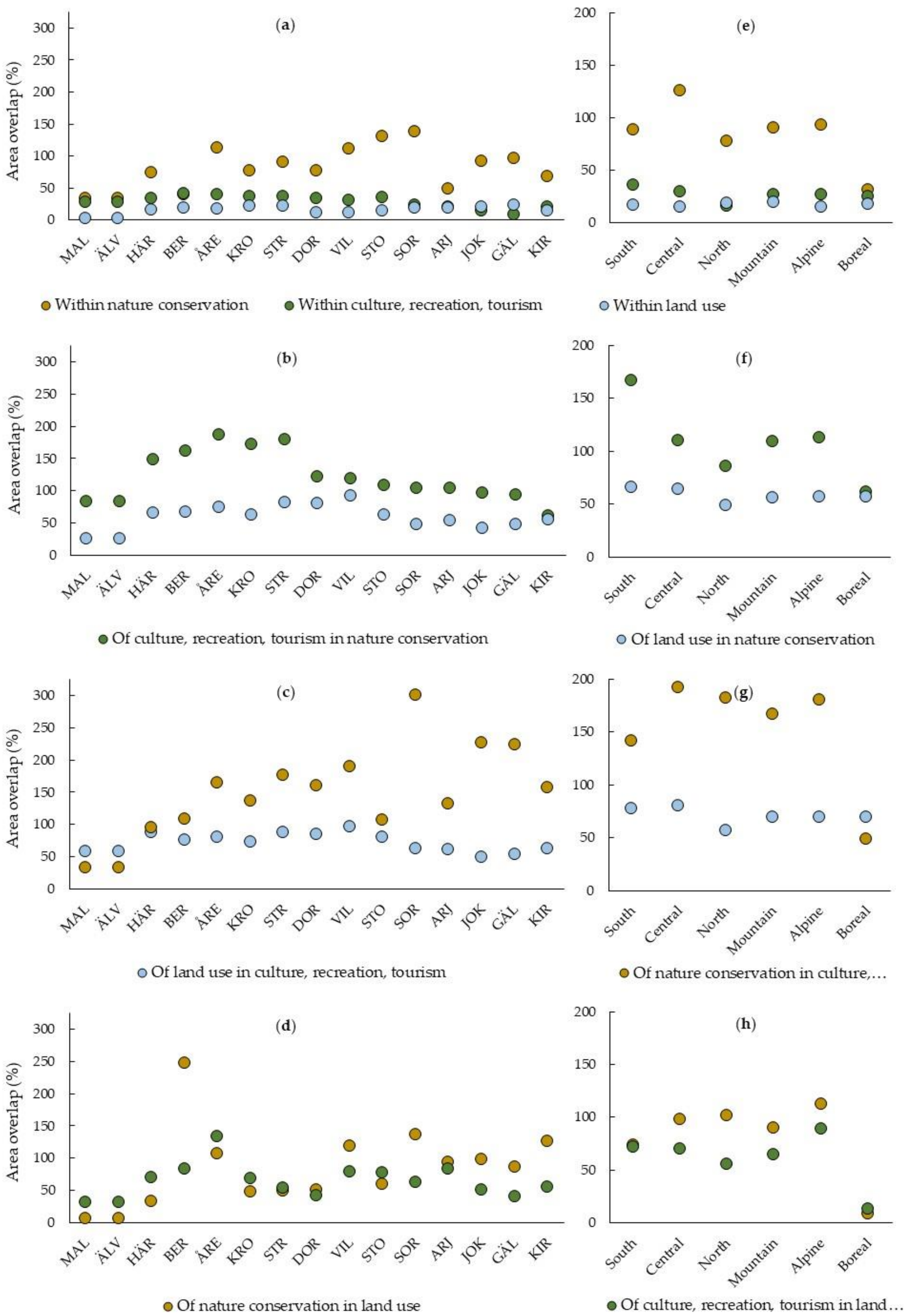


Figure 5. (**a**–**d**) Percent cumulative area overlap of national interests and forestry land for the mountain municipalities; (**e**–**h**) for the southern, central, and northern mountain sub-regions, the mountain region, and the alpine and boreal biomes. (**a**) and (**e**): Overlap within the Nature Conservation, the Cultural, Recreation, and Tourism, and the Land Use classes. (**b**) and (**f**): Overlap of the Cultural, Recreation, and Tourism and Land Use classes in the Nature Conservation class. (**c**) and (**g**): Overlap of the Land Use and the Nature Conservation classes in the Cultural, Recreation, and Tourism class. (**d**) and (**h**): Overlap of the Nature Conservation and the Cultural, Recreation, and Tourism classes in the Land Use class. See Table 2 for municipality abbreviations.

4. Discussion

4.1. Multiple Interests Require Larger Areas Than What Is Available

Highly efficient single-use systems have caused extensive landscape change over vast areas in many regions worldwide; for example, in industrial rotation forestry systems in northern Sweden and elsewhere in forest-rich regions where previously natural and semi-natural intact forest landscapes have been transformed into mono-cultural plantation forests [24,43]. In addition to wood biomass, however, forest ecosystems provide multiple provisioning, regulating, and cultural ecosystem services to various human benefits [38], and it is thus evident that there is commonly more than one type of actual or potential interest and value on the same forestland. Our results clearly show that for northern Sweden, with forestry as a strongly dominating land use, there are also many other types of land uses and interests that are claimed. In the case of the alpine and boreal environments of northern Sweden, reindeer husbandry by indigenous Sami people occurs simultaneously and on the same land as forestry, wind power energy production, and recreation and tourism [37]. Moreover, high ecosystem and landscape conservation values are generally recognized in northern Sweden [9,45]. Many different demands separately claim far larger geographical areas than are available, and many different demands combined and overlapping potentially is a conflict risk [57] as well as a risk for inequitable land sparing due to weak and strong demands [58].

In the case of the national interests (NIs) in Sweden, the area where a certain land use interest has been declared may exceed the actual area where the land use is currently practiced [50]. However, with the recognition in the Environmental Code [49], the land use can claim the right for practice, which can result in an even higher pressure on the available natural and societal capital in the future compared with the present day. Furthermore, this may lead to increased conflicts and even higher future complexity in land-use planning. In Sweden, the municipalities in agreement with the County Administration Boards have the mandate to prioritize one or, if possible given sustainable development, combine more than one type of national interest and state the direction in their comprehensive plan [48]. Our results clearly show that, most often, several and diverging national interests overlap in the same geographical area. With the limited capacity for sustainability-oriented planning prioritization in the municipal comprehensive planning process [3,40], the needed premises for sound decision-making are lacking.

In this study, we selected the NIs that are directed towards nature, recreation, and cultural values and land use on terrestrial lands outside urbanized environments. We also included forestry land as a dominant land use. The total area of these categories greatly exceeds the total available land area; in most municipalities, this between three and four times as large as the terrestrial area. Among the 15 mountain municipalities, there is only one where the claimed area is even close to the actual terrestrial area. This situation is pronounced for the entire mountain region, and particularly for the alpine biome. Despite the overall lower category area relative to terrestrial surface area in the boreal biome, the land-use claim is still, overall, 1.4 times higher than the available area. We also found a clear trend with increasing category area relative to terrestrial area from south to north. Generally, across northern Sweden, and particularly in the mountain region and the alpine biome, there are numerous "hotspots" with multiple claims occurring in the same area. This emphasizes the need for developing landscape-planning routines for actual and forecasted prioritization according to the best solution for a sustainable development.

Table 4. Percent overlap between national interests and forestry land, cumulative overlap per cent (CO), and average overlap (AO) per cent for (**a**) Vilhelmina municipality, which had the highest area overlap sum, (**b**) Härjedalen municipality, which had the median area overlap sum, and (**c**) Malung municipality, which had the lowest area overlap sum. See Table 1 for category abbreviations.

(**a**)	NCC	NSD	NBD	NCM	CCE	CRE	CRT	LFO	LRH	LMM	LWP	CO	AO
NCC		84	81	51	7	79	25	13	73	0	2	415	41
NSD	75		73	46	7	87	34	8	78	0		408	45
NBD	99	100		59	9	88	23	7	83	1		469	52
NCM	78	80	74		13	100	0	11	93			449	56
CCE	79	86	79	89		99	1	17	91			541	60
CRE	53	66	49	44	6		38	23	72	1		351	39
CRT	37	57	28	0	0	85		29	64	1		302	34
LFO	9	6	4	5	1	24	14		20	0	1	84	8
LRH	57	68	53	47	6	83	33	21		1		368	41
LMM	45	45	45			100	100	0	100			435	62
LWP	44				0			45				90	30
(**b**)	NCC	NSD	NBD	NCM	CCE	CRE	CRT	LFO	LRH	LMM	LWP	CO	AO
NCC		30	23	19	7	46	81	29	40		1	275	31
NSD	97		73	52	4	65	81	8	50		0	429	48
NBD	100	100		69	0	83	86	7	52			496	62
NCM	100	87	85		5	95	100	8	52			532	67
CCE	24	4	0	4		27	37	68	27		1	192	21
CRE	62	27	25	23	10		96	37	49		0	329	37
CRT	48	15	12	11	6	43		46	41		0	221	25
LFO	13	1	1	1	8	12	33		21		2	90	10
LRH	39	15	11	9	7	35	66	47			1	230	26
LMM													
LWP	13	0			6	0	2	67	11			100	14
(**c**)	NCC	NSD	NBD	NCM	CCE	CRE	CRT	LFO	LRH	LMM	LWP	CO	AO
NCC		31	8		1	44	35	32				151	25
NSD	93		24		0	50	63	8				238	40
NBD	99	100						4				203	68
NCM													
CCE	3	0				3	1	53			0	60	10
CRE	38	14			0		85	46				183	37
CRT	19	9			0	45		65				134	27
LFO	5	0	0		2	8	21				2	39	6
LRH													
LMM													
LWP					0			74				75	37

(1) Quantiles 0–24% (gray), 25–49% (yellow), 50–74% (orange), and 75–100% (red) overlap, where the value 0 represents overlap <0.5% and where no value represents no overlap.

Table 5. Percent overlap between national interests and forestry land, cumulative overlap per cent (CO), and average overlap (AO) per cent for the alpine (A) and boreal (B) biomes. See Table 1 for category abbreviations.

A	NCC	NSD	NBD	NCM	CCE	CRE	CRT	LFO	LRH	LMM	LWP	CO	AO
NCC		59	38	67	4	81	35	13	46	0	0	343	34
NSD	80		52	66	2	77	46	6	43	0		374	42
NBD	97	99		76	3	87	31	6	51	0		450	50
NCM	74	54	33		2	87	15	9	48	0		321	36
CCE	56	25	15	23		63	42	44	39	2	0	309	31
CRE	69	48	28	66	4		38	16	47	0	0	316	32
CRT	49	30	17	19	4	64		34	43	0	0	260	26
LFO	20	7	4	12	4	29	36		31	0	1	144	14
LRH	55	38	24	53	3	67	36	25		0	0	301	30
LMM	8	4	3	0	17	9	18	47	37			144	16
LWP	34				3	0	1	52	14			104	17
B	**NCC**	**NSD**	**NBD**	**NCM**	**CCE**	**CRE**	**CRT**	**LFO**	**LRH**	**LMM**	**LWP**	**CO**	**AO**
NCC		22	10	1	7	45	16	46	24	0	1	173	17
NSD	49		25	6	2	31	9	12	22	0	0	155	15
NBD	87	97		11	2	56	11	7	26			298	37
NCM	53	91	46			67	1	11	22			290	41
CCE	22	2	1			42	10	57	15	1	0	150	17
CRE	40	13	6	2	12		28	54	15	1	0	150	17
CRT	30	7	2	0	6	57		57	8	0	0	169	17
LFO	6	1	0	0	2	8	4		21	0	2	43	4
LRH	10	4	1	0	2	7	2	72		0	1	101	10
LMM	1	0			6	0	0	58	23		2	90	11
LWP	4	0			0	4	1	80	11	0		100	12

(1) Quantiles 0–24% (gray), 25–49% (yellow), 50–74% (orange), and 75–100% (red) overlap, where the value 0 represents overlap <0.5% and where no value represents no overlap.

4.2. Ecological, Socio-Cultural and Economic Aspects

We clustered the NIs and "Forestry land" into three main classes that basically reflected ecological, socio-cultural, and economic sustainability dimensions. Our classification did not strictly define each type of NI as in one specific class. "Reindeer husbandry", for example, is a land use based on economic incentives, but also represents high social and cultural values as it is an indigenous cultural expression with a very long history. In addition, reindeer grazing maintains the openness of the alpine environment, which is of fundamental value for recreation and tourism activities [59]. We found, however, that the classification assisted the analyses and our interpretations well. We found extensive overlap within each class, particularly within the *Nature Conservation* class and the *Cultural, Recreation, and Tourism* class. We also found clear south-to-north trends in increasing abundance of the *Nature Conservation* class and decreasing abundance of the *Land Use* class, except for "Reindeer husbandry".

The *Nature Conservation* class included four categories. In total, "Nature conservation" covers the largest areas and "Natura 2000 SPA" the smallest. All four categories increase in abundance from south to north, with the exception of "Natura 2000 SPA", which is most abundant in the central part of the mountain region. "Natura 2000 SPA" and "Natura 2000 SCI", which together cover close to 6 million ha of 10.4 million ha (terrestrial area) in the alpine and around 1 million ha of 18.8 million ha in the boreal biome, are oriented more strictly to conservation of species and habitat biodiversity. "Nature conservation" and particularly "Continuous mountains", which together cover about 10 million ha in the alpine and close to 2 million ha in the boreal biome, are more oriented towards general natural and landscape values. Taken together, these four categories cover 19 million ha of the 29 million ha (terrestrial area) in northern Sweden. Obviously, the claimed area for conserving and protecting biodiversity, natural, and landscape values is very high, particularly in the alpine region and in the north. Thus, we found that the actual and relative category area is the highest in the part of the study region where the density of human population and urban centers is the lowest.

The *Culture, Recreation, and Tourism* class included three NI categories; "Cultural environment", "Recreation" and "Itinerant recreation and tourism". The former two NI are oriented towards protecting cultural and natural values for the benefit of human experience, whereas the latter opens up for exploitative measures to facilitate recreation and tourism activities. "Itinerant recreation and tourism" dominates in the south mountain region and in all the 7 south municipalities, which can be understood as an outcome of an urban norm focusing on socio-cultural availability of areas for people in south and central Sweden as well as for international tourists, whereas "Recreation" dominates overall across the mountain region. Together, these three categories cover 14 million ha in north Sweden, whereof over 10 million ha in the alpine region which is very close to equal to the terrestrial area (92%). With reference to the above mentioned clear trend in south to north increasing category-area relative to terrestrial area, the southern municipality of Are diverge from this trend as a consequence, in particular, of exceptionally large areas recognized as "Itinerant recreation and tourism". Given the international high profile in alpine sports and sports and recreation in general in this municipality, this result was expected.

The *Land Use* class included "Forestry land" and three NI categories: "Reindeer husbandry", "Mining", and "Wind power". The two latter cover very small areas overall, whereas the two former cover very large areas in both biomes. In the boreal biome, "Reindeer husbandry" is by far the largest category after "Forestry land". Even though our classification was arbitrary in the sense that the four different types of land use are fundamentally different and most often cannot spatially co-exist, our results highlight the dilemma that these different land-use interests actually frequently overlap geographically. "Mines" and "Wind power" exclude or strongly restrict other types of land use, and cause direct conflicts with "Reindeer husbandry" in areas that are much larger than the actual mine and park sites [52]. "Reindeer husbandry" and "Forestry land" do use the same land, but not without conflicts [57], and these conflicts are expected to become increasingly difficult with a changing climate [37,60].

4.3. Landscape Approaches to Sustainable Planning

For landscape approaches to sustainable planning and given the governmental as well as sector authorities' claim of territory for different land-use purposes, planning in boreal and alpine Sweden has to consider several and sometimes conflicting demands and claims. The geographical extension and distribution of land-use categories presented in this study clearly show the magnitude of this complexity. Places with high frequencies of different NIs are much more common than places with one or few. For the alpine biome, "Natura 2000 SPA", "Natura 2000 SCI", "Nature conservation", "Contiguous mountains", "Cultural environment", and "Recreation" together cover close to 23 million ha. Together, these represent intrinsic species and habitat biodiversity, generic nature and landscape values, and natural and cultural values for the benefit of human experience, and thus cover an area that is 220% and 201% of the available terrestrial and total area, respectively. On the same area, about 4.4 million ha land is claimed for "Reindeer husbandry", and 3.7 million ha land for "Itinerant recreation and tourism", where the latter category allows more extensive exploitation. This adds up to 299% and 273%, respectively. Adding "Forestry land", "Mines", and "Wind power" results in 334% and 306% of the available terrestrial and total area, respectively. Clearly, much more land is demanded and claimed than is available. To ensure sustainable development, a landscape planning approach that takes an integrative approach and that recognizes multiple-use perspectives is hence urgently needed.

The extensive and varying overlap of different land claims causes challenges in planning and prioritization within municipalities, between neighboring municipalities, and generally for the mountain region and alpine biome [3]. Clearly, the situation can be highly complex overall, as in the case of the Vilhelmina municipality, where different types of interests overlap in multiple ways.

The situation can also be less complex with more specific overlap, as in the case of Berg municipality, where there is a very high overlap of the *Nature Conservation* class in the *Land Use* class. Different municipalities thus have very different premises to handle. Given that the municipal comprehensive planning format is static and constructed based on an urban norm [39], a logical interpretation is that the legal NI recognition provides poor planning guidance for solving sustainability issues in rural areas with overlapping and often non-compatible interests.

From a practical planning point of view, it can be questioned whether there is a need to recognize different NIs for similar purposes; for example, both "Nature conservation" and "Contiguous mountains" in the alpine biome. Moreover, NIs in Chapter 3 of the Environmental Code (e.g., "Nature conservation") have less strict regulations and delineations, and open up for combinations of different land uses, given that these result in sustainable use of natural resources, whereas NIs in Chapter 4 (e.g., "Continuous mountains") more strictly define and delineate specific values or a specific segment of values. Fewer and more logically clustered land-use interests would allow a more holistic approach that increases comprehensive planning efficiency and better assists the decision-making process. Potentially, this would also lead to a higher level of coherence with other types of territorial planning; for example, on state-owned land. More detailed information on focal conservation or other values as well as specific governance and management measures can be added in detailed planning and management guidelines for certain areas.

4.4. Synergy, Integration, and Conflict

Given that some types of landscape values and land uses cannot spatially co-exist, the risks for conflict are obvious. However, some types of land uses can indeed co-exist. Given that the land claim exceeds land availability, this calls for identifying integration opportunities and synergetic opportunities—the latter in the sense that the co-existence of different types of land uses may increase the total combined and accumulated values. It can be assumed, for example, that some aspects of nature conservation can be combined with some aspects of recreation and cultural environments, particularly if the conservation values are associated with historic land use and cultural influence. The long history of small-scale farming and the Sami peoples' reindeer husbandry in northern Sweden has added to the landscape and conservation values that are recognized in the current conservation policy [59,61]. Grazing by reindeer and livestock keeps the landscape open, and cutting of grass and sedge for winter fodder on mires and grasslands maintains flora and biodiversity that are associated with disturbance and openness [62]. Another example of a synergy is nature-based recreation and tourism that rely on amenity values originating from experiencing naturalness [61]. In addition, continuous cover and other types of alternative forest management better favor natural and cultural values than the systematic rotation forestry that dominates in boreal forestry [36,63]. By assessing synergy, integration, and conflict across land demands and claims, opportunities and obstacles for multiple uses can be approached.

Instead of focusing on the expected delivered public interest and value that is presumed in the Swedish Environmental Code NI regulations, we propose that a focus on the synergy, integration, and conflict relations between the different recognized values and land claims will provide more useful planning inputs. Such inputs would increase the applicability of the NI regulations in municipal comprehensive planning, but also more broadly in territorial planning that is oriented towards sustainable management and governance.

In Figure 6, we present a framework that, based on aspects of ecosystem functioning and biodiversity, is built on opportunities for assessing synergy, integration, and conflict. Departing from the intrinsic ecosystem functions (biodiversity, habitat) and the nature and landscape supporting these functions, nature-based land use in the form of recreation, tourism, and cultural heritage, forestry, and reindeer husbandry can be exercised without ample impact. When so, synergy and integration between different interests are possible. Developed facilities for recreation, tourism, and intensive forest management can, however, cause ample impact. When so, the opportunities for synergy and integration will decrease or even expire. In Figure 6, we use the ecosystem approach aspect "place-based" [11] to stress that it is the place or site that is the key premise for the land use. For forestry, for example, conflict risks are enhanced with the rotation forestry system that is generally applied, particularly if combined with exotic tree species, modified plant genotypes, draining, and fertilization [26]. Mining excludes other types of land use and causes irreparable damage to nature and landscape values. Wind power causes disturbance to landscape values, biodiversity [50,64], and on other land use, including, in particular, reindeer husbandry [65], but, in comparison with mining, it does allow some other land-use interests to co-exist.

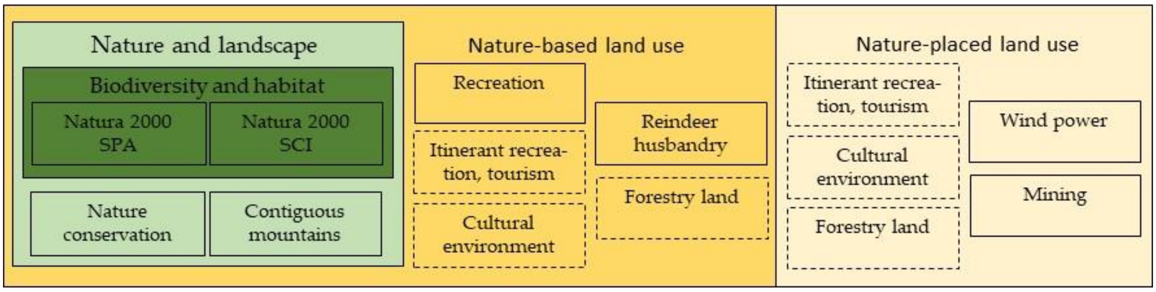


Figure 6. Framework for assessing synergy, integration, and conflict opportunities and risks in sustainable landscape planning based on national interests and forestry land. "Natura 2000 SCI" and "Natura 2000 SPA" are oriented towards protection of biodiversity and habitat values (dark green), whereas "Nature conservation" and "Contiguous mountains" are oriented towards protecting more generic nature and landscape values (light green). "Cultural environment", "Recreation", and "Itinerant recreation and tourism" are land uses that are oriented towards human benefit of natural and cultural values, as well as values associated with historic use and management of nature. "Reindeer husbandry" and "Forestry land" are land uses that are based on nature, landscapes, and ecosystems. If "Cultural environment", "Recreation", "Itinerant recreation and tourism", "Reindeer husbandry", and "Forestry land" imply a close-to-nature type of land use, then these can or potentially can co-exist with interests associated with biodiversity, habitat, nature, and landscape (dark yellow). Thus, as nature-based land uses, opportunities exist for integration and synergy. "Wind power" and "Mining" are land uses placed in nature without interaction with ecosystems and ecosystem processes. In the case of "Mining", opportunities for synergy and integration are poor and conflict risk are evident. In the case of "Wind power", some aspects of integration can be met, whereas conflict risks also are evident. Additionally, with extensive exploitation for "Itinerant recreation and tourism" (e.g., large tourism facilities), "Cultural environment" (environment not based on human interaction with nature), and "Forestry land" (plantation forests), these land uses can also cause conflicts with interests associated with biodiversity, habitat, nature, and landscape, but also with nature-based land use (light yellow). In the case of "Reindeer husbandry" in Sweden, the existing husbandry system is based on annual movement and other traits of the wild reindeer.

5. Conclusions

Identifying conflicts, integration, and synergy between different types of land uses are ways forward for landscape approaches to sustainability. Given the fact that there is an extensive overlap of diverging governmental and sector authorities' land claims, a general interpretation is that single-use and polarizing land-use planning strategies do not reflect the reality in northern Sweden, nor in many other hinterland and natural resource-rich regions with low human population density. The demands on the land substantially exceed the land availability, with overlaps between both similar and related interests and between different and conflicting interests. This complicates landscape approaches [11] and may lead to unsustainable and degrading land use and development [8]. In addition, the pressure for intensified use of natural resources is currently rising; for example, continued intensive forest management is justified as being necessary in the transition towards bio-economy [66,67]. With growing human populations and increasing urbanization, rural and natural resource-rich regions tend to deteriorate by unidirectional outflow of natural capital [22,31,68]. If this movement towards "more of everything" [69] continues unabated, additional threats to landscapes and sustainability will be enforced and ecosystem resilience, as well as sustainability tipping points, may be risked.

Instead, a transition from single- to multiple-use solutions and towards diversification strategies [70] is greatly needed. Opportunities for synergy and interaction among different interests need to be investigated and assessed, and ways forward to avoid and mitigate conflicts need to be explored [71]. In this study, we applied existing legally recognized national interests that claim areas where a certain category of interest is practiced or, as supported by the Environmental Code, can be practiced in the future. Our results clearly show that there is generally a very limited area available for single-use systems. Instead, the extensive overlap of many and different land-use interests calls for an overall strategy towards developing and implementing multiple-use systems that focus on synergy and integration between similar or related interests that can co-exist spatially. If such a strategy is implemented, areas and situations with a high conflict risk can be reduced, and conflict resolution can be directed specifically to those situations where conflicts cannot be avoided. By taking such a landscape approach to multiple uses and diversification in municipal comprehensive planning and other types of territorial planning, focus can be placed on developing adaptation and mitigation towards minimizing the negative impacts of spatially co-occurring natural, landscape, and land-use interests.

Supplementary Materials: The following are available online at http://www.mdpi.com/2071-1050/12/12/5113/s1.

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References

1. Carlsson, J.; Lidestav, G.; Bjärstig, T.; Svensson, J.; Nordström, E.-M. Opportunities for integrated landscape planning—The Broker, the Arena, the Tool. *Landsc. Online* **2017**, *55*, 1–20. [CrossRef]
2. Mansourian, S. Governance and forest landscape restoration: A framework to support decision-making. *J. Nat. Conserv.* **2017**, *37*, 21–30. [CrossRef]
3. Bjärstig, T.; Thellbro, C.; Stjernström, O.; Svensson, J.; Sandström, C.; Sandström, P.; Zachrisson, A. Between protocol and reality–Swedish municipal comprehensive planning. *Eur. Plan. Stud.* **2018**, *26*, 35–54. [CrossRef]
4. Svensson, J.; Sandström, P.; Sandström, C.; Jougda, L.; Baer, K. Sustainable landscape management in Vilhelmina Model Forest. *For. Chron.* **2012**, *88*, 291–297. [CrossRef]
5. Chazdon, R.L.; Brancalion, P.H.S.; Lamb, D.; Laestadius, L.; Calmon, M.; Kumar, C. A policy-driven knowledge agenda for global forest and landscape restoration. *Conserv. Lett.* **2017**, *10*, 125–132. [CrossRef]
6. Spathelf, P.; Stanturf, J.; Kleine, M.; Jandl, R.; Chiatante, D.; Bolte, A. Adaptive measures: Integrating adaptive forest management and forest landscape restoration. *Ann. For. Sci.* **2018**, *75*, 55. [CrossRef]
7. Mikusinski, G.; Blicharska, M.; Antonson, H.; Henningsson, M.; Göransson, G.; Angelstam, P.; Seiler, A. Integrating Ecological, Social and Cultural Dimensions in the Implementation of the Landscape Convention. *Landsc. Res.* **2013**, *38*, 384–393. [CrossRef]
8. IPBES. *Summary for Policymakers of the Assessment Report on Land Degradation and Restoration of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*; Scholes, R., Montanarella, L., Brainich, A., Barger, N., ten Brink, B., Cantele, M., Erasmus, B., Fisher, J., Gardner, T., Holland, T.G., et al., Eds.; IPBES Secretariat: Bonn, Germany, 2018; 44p.

9. Angelstam, P.; Manton, M.; Green, M.; Jonsson, B.G.; Mikusinski, G.; Svensson, J.; Sabatini, F.M. Sweden does not meet agreed national and international forest biodiversity targets: A call for adaptive landscape planning. *Landsc. Urban Plann.* **2020**, *202*, 103838. [CrossRef]
10. Bali Swain, R.; Yang-Wallentin, F. Achieving sustainable development goals: Predicaments and strategies. *Int. J. Sustain. Dev. World Ecol.* **2020**, *27*, 96–106. [CrossRef]
11. Arts, B.; Buizer, M.; Horlings, L.; Ingram, V.; van Oosten, C.; Opdam, P. Landscape Approaches: A State-of-the-Art Review. *Annu. Rev. Environ. Resour.* **2017**, *42*, 439–463. [CrossRef]
12. Cumming, G.S.; Olsson, P.; Chapin, F.S., III; Holling, C.S. Resilience, experimentation, and scale mismatches in social-ecological landscapes. *Landsc. Ecol.* **2012**, *28*, 1139–1150. [CrossRef]
13. Keskitalo, E.C.H.; Horstkotte, T.; Kivinen, S.; Forbes, B.; Käyhkö, J. Generality of mis-fit? The real-life difficulty of matching scales in an interconnected world. *Ambio* **2016**, *45*, 742–752. [CrossRef] [PubMed]
14. Chapin, F.S., III; Carpenter, S.R.; Kofinas, G.P.; Folke, C.; Abel, N.; Clark, W.C.; Olsson, P.; Stafford Smith, D.M.; Walker, B.; Young, O.R.; et al. Ecosystem stewardship: Sustainability strategies for a rapidly changing planet. *Trends Ecol. Evol.* **2010**, *25*, 241–249. [CrossRef] [PubMed]
15. Polasky, S.; Nelson, E.; Camm, J.; Csuti, B.; Fackler, P.; Lonsdorf, E.; Montgomery, C.; White, D.; Arthur, J.; Garber-Yonts, B.; et al. Where to put things? Spatial land management to sustain biodiversity and economic returns. *Biol. Conserv.* **2008**, *14*, 1505–1524. [CrossRef]
16. Fischer, J.; Abson, D.J.; Butsic, V.; Chappell, M.J.; Ekroos, J.; Hanspach, J.; Kuemmerle, T.; Smith, H.G.; von Verden, H. Land Sparing Versus Land Sharing: Moving Forward. *Conserv. Lett.* **2014**, *7*, 149–157. [CrossRef]
17. Lindenmayer, D.B.; Franklin, J.F.; Fischer, J. General management principles and a checklist of strategies to guide forest biodiversity conservation. *Bio. Conserv.* **2006**, *131*, 433–445. [CrossRef]
18. Görg, C. Landscape governance. The "politics of scale" and the "natural" conditions of places. *Geoforum* **2007**, *38*, 954–966. [CrossRef]
19. Heller, N.E.; Zavaleta, E.S. Biodiversity management in the face of climate change: A review of 22 years of recommendations. *Biol. Conserv.* **2009**, *142*, 14–32. [CrossRef]
20. Haddad, N.M.; Brudvig, L.A.; Clobert, J.; Davies, K.F.; Gonzales, A.; Holt, R.D.; Lovejoy, T.E.; Sexton, J.O.; Austin, M.P.; Collins, C.D.; et al. Habitat fragmentation and its lasting impact on Earth's ecosystems. *Sci. Adv.* **2015**, *1*, e1500052. [CrossRef]
21. Jones, K.R.; Venter, O.; Fuller, R.A.; Allan, J.R.; Maxwell, S.L.; Negret, P.J.; Watson, J.E.M. One-third of global protected land is under intense human pressure. *Science* **2018**, *360*, 788–791. [CrossRef]
22. Bar-on, Y.; Phillips, R.; Milo, R. The biomass distribution on earth 2018. *Proc. Natl. Acad. Sci. USA* **2018**, *115*, 6506–6511. [CrossRef] [PubMed]
23. Hansen, M.C.; Potapov, P.V.; Moore, R.; Hancher, M.; Turubanova, S.A.; Tyukavina, A.; Thau, D.; Stehman, S.V.; Goetz, S.J.; Loveland, T.R.; et al. High-resolution global maps of 21st-century forest cover change. *Science* **2013**, *342*, 850–853. [CrossRef] [PubMed]
24. Heino, M.; Kummu, M.; Makkonen, M.; Mulligan, M.; Verburg, P.H.; Jalava, M.; Räsänen, T.A. Forest loss in protected areas and intact forest landscapes: A global analysis. *PLoS ONE* **2015**, *10*, e0138918. [CrossRef] [PubMed]
25. Potapov, P.; Hansen, M.C.; Laestadius, L.; Turubanova, S.; Yaroshenko, A.; Thies, C.; Smith, W.; Zhuravleva, I.; Komarova, A.; Minnemayer, S.; et al. The last frontiers of wilderness: Tracking loss of intact forest landscapes from 2000 to 2013. *Sci. Adv.* **2017**, *3*, e1600821. [CrossRef] [PubMed]
26. Svensson, J.; Andersson, J.; Sandström, P.; Mikusiński, G.; Jonsson, B.G. Landscape trajectory of natural boreal forest loss as an impediment to green infrastructure. *Conserv. Biol.* **2019**, *33*, 152–163. [CrossRef]
27. Rudel, T.K.; Meyfroidt, P.; Chazdon, R.; Bongers, F.; Sloan, S.; Grau, H.R.; van Holt, T.; Schneider, L. Whiter the forest transition? Climate change, policy responses, and redistributed forests in the twenty-first century. *Ambio* **2020**, *49*, 74–84. [CrossRef]
28. Van Teeffelen, A.J.A.; Vos, C.C.; Opdam, P. Species in a dynamic world: Consequences of habitat network dynamics on conservation planning. *Biol. Conserv.* **2012**, *153*, 239–253. [CrossRef]
29. Sverdrup-Thygeson, A.; Sörgard, G.; Rusch, G.M.; Barton, D.N. Spatial overlap between environmental policy instruments and areas of high conservation value in forest. *PLoS ONE* **2014**, *9*, e115001. [CrossRef]

30. Orlikowska, E.; Roberge, J.-M.; Blicharska, M.; Mikusiński, G. Gaps in ecological research on the world's largest internationally coordinated network of protected areas: A review of Natura 2000. *Biol. Conserv.* **2016**, *200*, 216–227. [CrossRef]
31. Watson, J.E.M.; Evans, T.; Venter, O.; Williams, B.; Tulloch, A.; Stewart, C.; Thompson, I.; Ray, J.C.; Murray, K.; Salzar, A.; et al. The exceptional value of intact forest ecosystems. *Nat. Ecol. Evol.* **2018**, *2*, 599–610. [CrossRef]
32. Naumov, V.; Manton, M.; Elbakidze, M.; Rendenieks, Z.; Priedniks, J.; Uhlianets, S.; Yamelynets, T.; Zhivotov, A.; Angelstam, P. How to reconcile wood production and biodiversity conservation? The Pan-European boreal forest history gradient as an "experiment". *J. Environ. Manag.* **2018**, *218*, 1–13. [CrossRef] [PubMed]
33. Barnosky, A.D.; Hadly, E.A.; Bascompte, J.; Berlow, E.L.; Brown, J.H.; Fortelius, M.; Getz, W.M.; Harte, J.; Hastings, A.; Marquest, P.A.; et al. Approaching a state shift in Earth's biosphere. *Nature* **2012**, *486*, 52–58. [CrossRef] [PubMed]
34. Gauthier, S.; Bernier, P.; Kuuluvainen, T.; Shvidenko, A.Z.; Schepaschenko, D.G. Boreal forest health and global change. *Science* **2015**, *349*, 819–822. [CrossRef] [PubMed]
35. Moen, J.; Rist, L.; Bishop, K.; Chapin III, F.S.; Ellison, D.; Kuuluvainen, T.; Petersson, H.; Puettmann, K.J.; Rayners, J.; Warkentin, I.G.; et al. Eye on the Taiga: Removing Global Policy Impediments to Safeguard the Boreal Forest. *Conserv. Lett.* **2014**, *7*, 408–418. [CrossRef]
36. Kuuluvainen, T. Ecosystem management of the boreal forest. *Oxf. Res. Encycl. Environ. Sci.* **2016**. [CrossRef]
37. Pape, R.; Löffler, J. Climate change, land use conflicts, predation and ecological degradation as challenges for reindeer husbandry in northern Europe: What do we really know after half a century of research? *Ambio* **2012**, *41*, 421–434. [CrossRef]
38. Jansson, R.; Nilsson, C.; Keskitalo, E.H.C.; Vlasova, T.; Sutinen, M.-L.; Moen, J.; Chapin III, F.S.; Bråthen, K.A.; Cabeza, M.; Callaghan, T.V.; et al. Future changes in the supply of goods and services from natural ecosystems: Prospects for the European north. *Ecol. Soc.* **2015**, *20*, 32. [CrossRef]
39. Bjärstig, T. Does collaboration lead to sustainability? A study of public–private partnerships in the Swedish mountains. *Sustainability* **2017**, *9*, 1685. [CrossRef]
40. Thellbro, C.; Bjärstig, T.; Eckerberg, K. Drivers for public–private partnerships in sustainable natural resource management—Lessons from the Swedish mountain region. *Sustainability* **2018**, *10*, 3914. [CrossRef]
41. Swedish Environmental Protection Agency. *Naturvårdsverket. Steg på vägen. Fördjupad Utvärdering av Miljömålen*; Swedish Environmental Protection Agency: Stockholm, Sweden, 2012; ISBN 978-91-620-6500-3.
42. Swedish Environmental Protection Agency. *Naturvårdsverket NV 04173-13. Förslag till en Strategi för Miljömålet Storslagen Fjällmilj*; Swedish Environmental Protection Agency: Stockholm, Sweden, 2014.
43. Svensson, J.; Bubnicki, J.W.; Jonsson, B.G.; Andersson, J.; Mikusinksi, G. Conservation significance of intact forest landscapes in the Scandinavian mountains green belt. *Landsc. Ecol.* in review.
44. Jonsson, B.G.; Svensson, J.; Mikusiński, G.; Manton, M.; Angelstam, P. European Union's last intact forest landscape is at a value chain crossroad between multiple use and intensified wood production. *Forests* **2019**, *10*, 564. [CrossRef]
45. European Commission. *Building a Green Infrastructure for Europe*; Publications Office of the European Union: Brussels, Belgium, 2013; 24p. [CrossRef]
46. Neumann, W.; Sandström, C.; Holmgren, L.; Ericsson, G. Defining a Mountain Landscape characterized by grazing using actor perception, governmental strategy, and environmental monitoring data. *J. Mt. Sci.* **2019**, *16*, 1691–1701. [CrossRef]
47. Albert, C.; Fürst, C.; Ring, I.; Sandström, C. Research note: Spatial planning in Europe and Central Asia—Enhancing the consideration of biodiversity and ecosystem services. *Landsc. Urban Plann.* **2020**, *196*, 103741. [CrossRef]
48. Zachrisson, A.; Svensson, J.; Neumann Sivertsson, W.; Bjärstig, T.; Thellbro, C. Comprehensive planning in the 'deep' rural context: Participatory planning to overcome institutional barriers. *J. Environ. Pol. Plann.* in review.
49. Miljöbalk 1998:8080. Miljö- och Energidepartementet/The Ministry of Environment and Energy. Updated to SFS 2020:75. Available online: http://rkrattsbaser.gov.se/sfst?bet=1998:808 (accessed on 9 March 2020).

50. Siyal, S.H.; Mörtberg, U.; Mentis, D.; Welsch, M.; Babelon, I.; Howells, M. Wind energy assessment considering geographic and environmental restrictions in Sweden: A GIS-based approach. *Energy* **2015**, *83*, 447–461. [CrossRef]
51. Gustafsson, L.; Ahlén, I. (Eds.) *Geography of Plants and Animals. National Atlas of Sweden*; SNA Publishing: Stockholm, Sweden, 1996; ISBN 9187760363.
52. Bjärstig, T.; Nygaard, V.; Riseth, J.Å.; Sandström, C. The institutionalisation of Sami interest in municipal comprehensive planning—A comparison between Norway and Sweden. *Int. Indig. Policy J.* **2020**, *11*, 1–24. [CrossRef]
53. SCB. Official Statistics Sweden. Status 2017. 2019. Available online: www.scb.se (accessed on 15 January 2019).
54. SOU. 1971:75. Ministry of Civil Services. Report 1971, Hushållning Med Mark och Vatten: Inventeringar, Planöverväganden om Vissa Naturresurser, Former för Fortlöpande Fysisk Planering, Lagstiftning. Available online: https://lagen.nu/sou/1971:75 (accessed on 9 March 2020).
55. Reindeer Husbandry Act. Ministry of Industry. Rennäringslag SFS 1971:437, 1971; updated to SFS 2018:364. Available online: https://icr.arcticportal.org/sweden?lang=en&start=1 (accessed on 21 November 2018).
56. Swedish EPA. High Conservation Value Forests Database; Miljödataportalen. 2018. Available online: http://mdp.vic-metria.nu/miljodataportalen/ (accessed on 21 November 2018).
57. Widmark, C. Bargaining costs in a common pool resource situation—The case of reindeer husbandry and forestry in northern Sweden. *Can. J. For. Res.* **2019**, *49*, 339–349. [CrossRef]
58. Barinaga-Rementeria, I.; Etxano, I. Weak or Strong Sustainability in Rural Land Use Planning? Assessing Two Case Studies through Multi-Criteria Analysis. *Sustainability* **2020**, *12*, 2422. [CrossRef]
59. Hedblom, M.; Mikusinski, G.; Hedenås, H.; Blicharska, M.; Adler, S.; Knez, I.; Svensson, J.; Sandström, S.; Sandström, P.; Wardle, D. Landscape perception: Linking biophysical monitoring data to perceived landscape properties. *Landsc. Res.* **2020**, *45*, 179–192. [CrossRef]
60. Löf, A. Examining limits and barriers to climate change adaptation in an Indigenous reindeer herding community. *Clim. Dev.* **2013**, *5*, 328–339. [CrossRef]
61. Blicharska, M.; Smithers, R.J.; Hedblom, M.; Hedenås, H.; Mikusinski, M.; Pedersen, E.; Sandström, P.; Svensson, J. Shades of grey challenge practical application of the cultural ecosystem services concept. *Ecosyst. Serv.* **2017**, *23*, 55–70. [CrossRef]
62. Bengtsson, J.; Bullock, J.M.; Egoh, B.; Everson, C.; Everson, T.; O'Connor, T.; O'Farrell, P.J.; Smith, H.; Lindborg, R. Grasslands—More important for ecosystem services than you might think. *Ecosphere* **2019**, *10*, e02582. [CrossRef]
63. Brandt, J.P.; Flannigan, M.D.; Maynard, D.G.; Thompson, I.D.; Volney, W.J.A. An introduction to Canada's boreal zone: Ecosystem processes, health, sustainability, and environmental issues. *Environ. Rev.* **2013**, *21*, 207–226. [CrossRef]
64. Oles, T.; Hammarlund, T. The European Landscape Convention, wind power, and the limits of the local: Notes from Italy and Sweden. *Landsc. Res.* **2011**, *36*, 471–485. [CrossRef]
65. Skarin, A.; Sandström, P.; Alam, M. Out of sight of wind turbines—Reindeer response to wind farms in operation. *Ecol. Evol.* **2018**, *8*, 9906–9919. [CrossRef]
66. D'Amato, D.; Droste, N.; Allen, B.; Kettunen, M.; Lähtinen, K.; Korhonen, J.; Leskinen, P.; Matthies, B.D.; Toppinen, A. Green, circular, bio economy: A comparative analysis of sustainability avenues. *J. Clean. Prod.* **2017**, *168*, 716–734. [CrossRef]
67. Eyvindson, K.; Repo, A.; Mönkkönen, M. Mitigating forest biodiversity and ecosystem service losses in the era of bio-based economy. *For. Policy Econ.* **2018**, *92*, 119–127. [CrossRef]
68. Hill, R.; Adem, C.; Alangui, W.V.; Molnár, Z.; Aumeeruddy-Thomas, Y.; Bridgewater, P.; Tengö, M.; Thaman, R.; Adou Yao, C.T.; Berkes, F.; et al. Working with indigenous, local and scientific knowledge in assessments of nature and nature's linkages with people. *Curr. Opin. Environ. Sustain.* **2020**, *43*, 8–20. [CrossRef]
69. Kröger, M.; Raitio, K. Finnish forest policy in the era of bioeconomy: A pathway to sustainability? *For. Policy Econ.* **2017**, *77*, 6–15. [CrossRef]

70. Felton, A.; Löfroth, T.; Angelstam, P.; Gustafsson, L.; Hjältén, J.; Felton, A.M.; Simonsson, P.; Dahlberg, A.; Lindbladh, M.; Svensson, J.; et al. Keeping pace with forestry: Multi-scale conservation in a changing production forest matrix. *Ambio* **2019**, *49*, 1050–1064. [CrossRef]
71. Nilsson, M.; Griggs, D.; Visbeck, M. Map the interactions between Sustainable Development Goals. *Nature* **2016**, *534*, 320–322. [CrossRef] [PubMed]