



## Article

# Desirable Effects from Disturbance Ecology—A Paradox within Conservation Management

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**Abstract:** The importance of natural disturbances for biodiversity is well-documented in the disturbance ecology literature. Natural disturbances such as fire, wind, and flooding strongly influence ecosystems by creating short and long-term ecological processes. Conservation management of protected areas should consider the importance of natural disturbances since natural shifts in ecosystems are, in a long-term perspective, necessary to maintain high biodiversity. The purpose of this study is to explore how and if natural disturbances are incorporated in the management of Swedish national parks and to identify possible examples of barriers for this incorporation. The design of the study is a multiple comparative case study based on a document study and completed with qualitative interviews. The cases consist of propositions and management plans for 15 Swedish national parks established between 1962 and 2018. The document analysis generated four main categories: historic/future and positive/negative perceptions of natural disturbances. The results indicate that there are positive perceptions concerning the inclusion of disturbance ecology in the management of national parks. However, there are also obstacles and challenges around natural disturbances within Swedish national parks. These obstacles are, in some cases, explained by practical implications such as the closeness to surrounding societies and in others explained by paradoxes such as visitors' perceptions of national parks and the wilderness.

**Keywords:** natural disturbances; conservation management; disturbance ecology; national parks; paradox



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## 1. Introduction—Natural Disturbances and Conservation Strategies

Natural disturbances such as fire, wind, flooding, pests, and volcanos strongly influence forest ecosystems by creating spatial patterns of structures, compositions of dead and alive trees, and both short and long-term ecological processes [1]. These disturbances change the physical environment, the availability of resources, and can disrupt an ecosystem's structure, population, and community. Disturbances can vary with respect to the size of the disturbed area, intensity (e.g., wind speed) and severity (e.g., the disturbance's effect on ecosystems), which will affect the number of residuals (organisms) that survive the disturbance event [2]. For instance, fire has the ability to increase the diversity of both flora and fauna species due to mixed-severity regimes in both temporal and spatial variability [3]. Another example is that disturbances could contribute to national parks' adaptation to climate change and increased temperatures [4]. The importance of natural disturbances for biodiversity is well-documented in the disturbance ecology literature [5–8], often with a more specific demarcation such as the contribution of fire to forest development [3,9–12]. At the same time, natural disturbances are complex and difficult to define due to hierarchical

relations and interactions with other small or large-scale disturbances [13]. Natural disturbances might generate compound disturbances caused by the same type of disturbance within a limited time, or different types of disturbances such as fire and subsequent bark beetle infestation [13]. There is also a perspective concerning how individual species might gain from a combination of different disturbances such as flood, fire and ice [14], fire and flood [15], and fire and drought [16].

The conservation management of protected areas should consider the importance of natural disturbances since natural shifts in ecosystems due to disturbances (even abrupt and unpredictable changes with large impacts) are in a long-term perspective necessary for maintaining a high biodiversity. However, practical aspects connected to economic and social consequences may hinder the possibilities to let natural disturbances operate unmolested and, as a result, the intention of establishing these reserves may be defeated [7].

National parks should be managed in order to preserve their natural conditions. However national parks, reserves, and wilderness areas throughout the world are missing defined terms for quantitative standards of naturalness [17]. By allowing ecosystems to respond to change without human intervention, which maintains forest structure and function, it is possible to conserve rich values of wilderness in protected areas [18,19]. Instead of defining absolute disturbance regimes, it is more important to accept unavoidable natural changes in ecological systems. Hence management planning should incorporate non-equilibrium perspectives and consider the context of natural disturbances [7]. There is a need for policy makers and planners to understand natural disturbances' dynamic and, in motivated cases, re-establish natural disturbances in order to increase resilience in environmental systems [2]. Disturbances might contribute to tree species' diversity, which would indicate that the diversity created by disturbances should be considered by forest managers [20]. Decisions have to be made whether or not to intervene in the active management measures of protected areas. To not intervene means that protected areas should not be manipulated or controlled whilst active measurements are made to alter ecosystems' development through either one-time actions or ongoing actions [18].

Today, 14.9% of the world's land and 7.3% of the ocean is, to some extent, protected [21]. It has been suggested on the 15th meeting of the Conference of Parties to the CBD, and Action Target 2 of the draft post-2020 Global Biodiversity Framework, that protected areas should, by 2030, cover 30% of the planet's land and water area [22]. Due to the importance of natural disturbances within protected areas, this study explores if and how the conservation management of Swedish national parks incorporates disturbance ecology. If disturbance ecology might not be possible to integrate, then the obstacles preventing integration are visualized.

### *1.1. Obstacles to Allow or Introduce Natural Disturbances into Protected Areas*

Management strategies and goals do not always reflect a planned and large-scale approach for protected areas and how these fit within a larger system such as the regional landscape [18,23]. The reason may be personal preferences, a lack of coordination and available resources, or even neglect [18]. There might also be changes made by humans causing wide effects on the landscape, for instance when flooding is regulated by dams. Regulations in water levels will disrupt important interactions with native species and natural processes which negatively affect riparian and aquatic organisms, e.g., by increasing the cover of plant species that otherwise would be removed by the flood [24].

The goal might be to let fire burn as "freely" as possible within national parks but considerations should be made to the fire intensity to avoid intense crown fires caused by unnatural fuel build up [25]. Increased fire trends in subalpine forests in California have shown that the forests' function, structure, and composition may change [26]. Moreover, the soil quality might be reduced from wildfire and require a longer recovery time, which affects vegetation recovery [27]. How landscapes respond to disturbances might vary due to historic place-specific management. A practical obstacle to the incorporation of natural disturbances might be to fully understand these varieties [28].

Disturbance events in nature do have both immediate and lasting effects which significantly affect the population dynamics of many species. Disturbances in nature can either follow a periodic pattern of time, such as spring floods, or not follow a pattern of time [29]. It is difficult to determine if and when (e.g., whether forest fires should be allowed in conservation management to increase or protect species diversity) [30]. Natural disturbances caused by variations in flow volume, water movement, floods, and drought have an important influence on ecological functions and structures. Floods may regulate the catchment area's diversity by restoring or strengthening the continuity between upstream and downstream, whilst droughts can generate a lag effect on diversity [6]. The effects of natural disturbances on ecosystems can vary depending on the intensity of the disturbance, the populations' carrying capacity, the threshold of the populations' extinction, the time between the disturbances, etc. Due to this, optimal management plans are difficult to design [29]. For instance, if natural flood variations cannot be restored it is possible to use management to mimic some of the processes to gain ecological benefits, such as clearing of vegetation from river banks [24]. However, there are uncertainties regarding how to mimic in a way that sustains aquatic biodiversity [31]. Incorporating disturbances into management strategies requires difficult considerations. For example, how will the ecosystem respond to the disturbance? Which was the original disturbance regime to mimic? Should there be alterations to the disturbance? There might be negative effects from new disturbances when they differ from how the area has been affected by disturbances historically. In areas of low frequency and intensity fires, there is an increased potential for invasion by fire-tolerant non-native species when fire-sensitive native species are affected by fire [32].

Even if conservation management plans based on natural disturbance regimes have shown to increase biodiversity, there are challenges to implement mimics of these disturbances. The challenges are both ecological, such as the uncertainty of ecological changes after a disturbance due to climate change, and socioeconomic, such as how the timber harvest might be affected [11]. Socioecological challenges have been discussed by Long [11] as the more important obstacle, and this goes in line with concerns of possible conflicts between production forestry and conservation. This conflict is caused by a failure by the market economy to put a value on other forest products than fibre, which has made it difficult to assess the economic consequences of more conservation-oriented forest management [33].

### 1.2. Aim and the Swedish Context

Mimicking natural disturbance regimes is an ecological tool for managing landscape biodiversity in Nordic boreal forests. One reason behind this is to create environments for disturbance-dependent species. To base local management strategies on the many differences associated with natural disturbances requires an understanding of disturbance variations, considering type, occurrence rate, and severity, in addition to regional differences due to ecological, climatic, and topographic conditions [33]. This can be illustrated by two studies from southern Sweden. The first one highlights the difficulties of deciding about nature conservation strategies based on limited knowledge of the landscape's history [34]. The second one is a study from oak-rich forests in southern Sweden and focuses on how beetles respond to either partial cutting or leaving conservation forests for free development, and the difficulties involved in giving advice on how to maintain these forests due to both different response from different beetle species and how big the cut area is [35]. According to Österlin, et al. [36], the protected areas in mountain regions in northern Sweden have a management objective dominated by the "wilderness" discourse. Since protected areas described as wilderness are defined as being untouched by humans, the management of environmental values through wilderness discourse basically involves leaving the area for free development [36].

Protected areas in Sweden, as in other parts of Europe, are sometimes described as primeval forests (i.e., forests without human impact) with high conservation values

generated by natural disturbances and internal dynamics [37]. However, it has been shown that there are extremely few areas not influenced by historic human activities such as clearcutting and sweat burn [37], which also contribute to the difficulties of mimicking historic disturbances. A study of Sweden's boreal swamp forests showed that the most important contributor to the high diversity of lichen and fungal species has been historic natural and man-made fires. Interestingly, no relationship was found between species diversity and forests with long-standing continuity. One explanation is the amount of dead wood generated by fire. Felled trees, or dead wood, become important habitats for several species. Some species require these felled trees to be affected by fire [38].

There have been studies in Sweden about natural disturbances' contribution to biodiversity wherein the studied disturbances have been regarding fires [37–40], storms [35], and multiple other disturbances [41]. The important role of natural disturbances in forests' development and biodiversity is agreed upon for Swedish north boreal forests [39], mixed forests [40], riparian forests [42], deciduous forests [34], and the North Fennoscandia mountain forest [41,43,44].

Of seven possible permanent and formal protection of water and land in Sweden, national park status is the strongest legal protection an area can receive [45]. Almost 15% (8,690,671 hectares) of Sweden's land and fresh water area is covered by some kind of legal protection. National parks are the third most common form of protected nature, covering 1.6% (743,235 hectares) of Sweden's fresh water and land area [46]. There is long-term planning to create new and expand existing national parks. This would result in an increase of 1,200,000 hectares, and the amount of protected area in Sweden would increase from 15 to 35% [47]. This, together with the "wilderness" discourse and the importance of natural disturbances for environmental areas, makes the management of protected areas highly desirable to understand. One important difference between national parks and modern forestry is that modern forestry focuses on the production of timber [33], whilst national parks should be managed according to their environmental and biological values [48]. Conservation management is responsible for how the national parks are managed and, to the best extent possible, how their natural values are preserved [48]. This study will use public policy documents to represent conservation managers' perspectives on both natural disturbances and conservation management. The purpose of this study is to explore if and how natural disturbances are incorporated into the management of Swedish national parks and to identify possible challenges or examples of barriers for this incorporation.

## 2. Materials and Methods

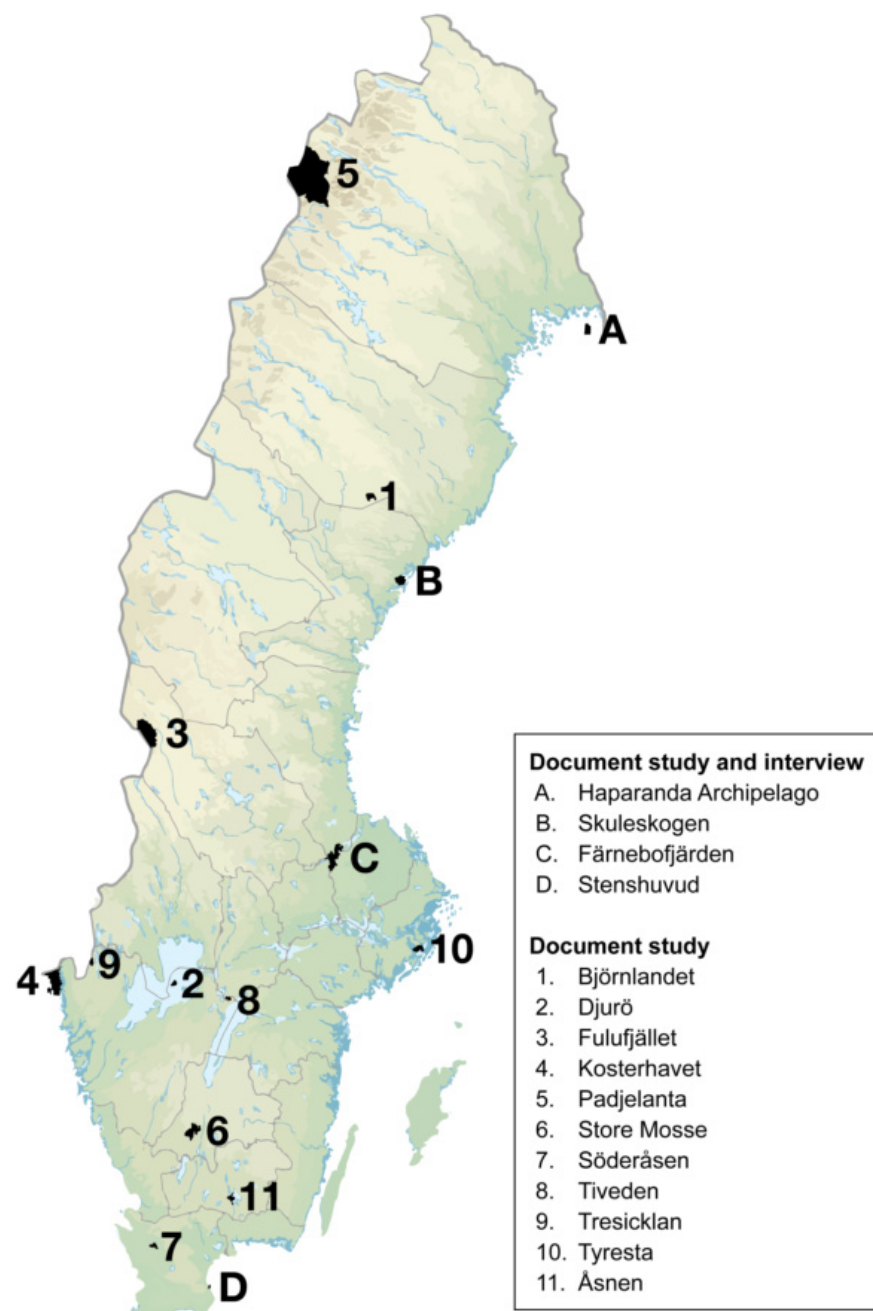
This is a multiple comparative case study based in a document study and completed with qualitative interviews [49].

### 2.1. Document Study

The database Protected Nature (Translation from the Swedish name of the database "Skyddad natur" <https://skyddadnatur.naturvardsverket.se/> accessed on 13 May 2020) provided by the Swedish Environmental Protection Agency was used for an overview of the National Parks in Sweden. In total there are 30 National Parks established from 1909 to 2018. Half of them were established between 1962 and 2018, and these are the ones included in this study: Björnlandet, Djurö, Fulufjället, Färnebofjärden Haparanda Archipelago, Kosterhavet, Padjelanta, Skuleskogen, Stenshuvud, Store Mosse, Söderåsen, Tiveden, Tresticklan, Tyresta, and Åsnen (Figure 1). This selection of the 15 parks established since 1962 is motivated by forestry development, location of national parks, and environmental protection development. During the mid-20th century, Swedish modern forestry, or intensive forestry practices to maximize timber and pulpwood production, was developed [33]. The first national parks, created in 1909, had a clear focus on state-owned mountain areas in northern Sweden. Still today there are larger parks in the northern part of Sweden, even if nowadays they are more spread out to represent Sweden's variety of nature [36]. Another important change that contributed to the modern development of

forests and their protection is that Swedish environmental policies were put in place by implementing three important environmental laws: the Nature Conservation Act (1964), the Environment Protection Act (1969), and the Hazardous Products Act (1973) [50].

Political propositions which preceded the decisions for establishing and management plans (hereafter referred to as MP) for the 15 Swedish National Parks constitute the basis for this study. The MPs contain the objectives of the park (and how to reach them), the values to preserve, and the history of the park. For three national parks (Björnlandet, Skuleskogen, and Tiveden), the park area has successively been extended, and in these cases both the propositions were included. For the three extended parks, and Färnebofjärden, there were two MPs. For Store Mosse there were three, all of which are included in the study. In total, there are 37 documents included in the study.



**Figure 1.** Map over Sweden and location of, in the study, included national parks. For ABCD, there has been both document studies and one interview for each park. See Table 1 for the categorization of ABCD. For 1–11, there has been document studies.

**Table 1.** The document analysis identified four main categories which represent the perception of natural disturbances from conservation managers' perspective. Documents from the analysis may possibly belong to several categories. For instance, the same document can be categorized for both historic and future disturbances. The next step were interviews (one for each category). The table also gives an overview of which category the interviewed represented, as well as which national park.

	Positive	Negative
Historic Natural Disturbance	I. Occurred historic natural disturbances which have contributed to the national park area. Interviewed National Park: Haparanda Archipelago	II. Not occurred historic natural disturbance which have been negative for the national park area. Interviewed National Park: Färnebofjärden.
Possible Future Natural Disturbance	III. Possible future natural disturbances expected to contribute to the national park area. Interviewed National Park: Skuleskogen.	IV. Possible future natural disturbances should be avoided. Interviewed National Park: Stenshuvud.

### 2.1.1. Document Analysis

The document analysis followed an inductive approach in order to capture both similarities and differences in how natural disturbances are perceived from a conservation management perspective. The approach also made it possible to identify themes and categories which helped formulate potential explanations [51]. The themes categorize if and how natural disturbances are described, which disturbances are mentioned, if the disturbance is historic or a possible future event, and if the disturbances are viewed as positive or negative for the national park area.

Disturbances might be generated by human interference [13], but this is not within the scope of this study. Only natural disturbances mentioned in the propositions and MPs are included. A distinction is made between historic and future natural disturbances. Historic disturbances are those that have already occurred when this study was conducted. Future hazards refer to disturbance events described in the MPs as possible but which have not yet occurred (at the time when the MP was established). This distinction is made since historic disturbances are not possible to manage. Instead, historic disturbances might be possible to assess from the perspective that the effects are possible to experience in the national park. Future disturbances, on the other hand, might be possible to manage and are possible to assess based on expectations from the disturbance.

The definition of positive is when natural disturbances, both historic and future, are described as contributors to the park area in some way. For instance, by creating structures such as felled trees and habitats for fauna species, thereby helping trees to rejuvenate, the ingrowth of spruce that otherwise out concurs other tree species is avoided; by creating habitats for fauna species there is an increase in biodiversity. Positive also represents the ability of disturbances to create areas that give the impression of wilderness and a primeval appearance [5–8,18,19].

The definition of negative varies depending on if it is a historic or future disturbance. A negative future disturbance is when natural disturbances are described as being avoided, for instance by putting out spontaneous fire. From a historic perspective, it is negative when natural disturbances have not occurred and therefore have not generated the effects seen from positive historic disturbances (Table 1) [7,18]. Natural hazards not mentioned in propositions or MPs are not included or defined as positive or negative.

This categorization makes it possible for a distinction between when nature can develop from its own premises, and when active management strategies are decided for nature, which in turn makes it possible to identify obstacles towards natural disturbances.

### 2.2. Interviews

In addition to the document study, four complementary interviews with one representative from particular national parks (Haparanda Archipelago, Färnebofjärden, Skulesko-

gen, and Stenshuvud) were performed. The aim of the interviews was based on the initial document study. The parks selected for interviewing represent one of each of the four main themes (see Table 1 for which national park represents which theme) and are spread north–south in Sweden. One way of selecting cases is to contrast between them. These contrasts also enable making comparisons of the data generated by the selected cases [49]. By selecting one representative from the four themes, the interviews add further information on how managers perceive natural disturbances and possible obstacles for disturbances in conservation management.

The interviews were semi-structured and followed an interview guide (Appendix A). They focused on how the conservation managers perceive natural disturbances, if they are incorporating disturbances in their work and, if not, why they are not. The initial questions had a historic perspective about natural disturbances, followed by a future perspective and how possible disturbances are perceived. The transcribed text was analysed in the same way as the document analysis described in Section 2.1.1.

### 3. Results—Historic Perspective on Natural Disturbances within Swedish National Parks from a Conservation Management Perspective

The results from both the document study and the interviews are presented with the categorizing themes in Table 1 (I–IV) as a basis. The first section of the result contains the historic part and how (or not) occurred natural disturbances have contributed to the park area (Table 2). The second section contains the future part and how possible natural disturbances are perceived as positive or negative.

**Table 2.** Overview of the national parks' MPs and propositions and how they experience historic natural disturbances. P (positive) = occurred historic natural disturbances are seen as positive for the park area. N (negative) = not occurred historic natural disturbances are seen as negative for the park area. The categorization from Table 1 (I–IV) is included. Documents from a national park that do not include any of this information in either MPs or propositions are from here excluded [52–62].

National Park Established (Extended)	Proposition Management Plan	Fire	Flood	Storm	Cloudburst	Snow Damage	Drought	Pests	Category (Table 1)
Björnlandet 1991 (2017)	Proposition 1990/91:31 [53]	-	-	-	-	-	-	-	-
	Proposition 2016/17:97 [63]	P, N	P	-	-	-	-	-	I, II
	Management plan Björnlandet [64]	P	-	-	-	-	-	-	I
	Management plan Björnlandet [65]	P, N	P	-	-	-	-	-	I, II
Fulufjället 2002	Proposition 2001/02:116 [66]	-	-	-	P	-	-	-	I
	Management plan Fulufjället [67]	P	-	-	P	-	-	-	I
Färnebofjärden 1998	Proposition 1997/98:91 [68]	-	P	-	-	-	-	-	I
	Management plan Färnebofjärden [69]	P	P	P	-	-	-	-	I
	Management plan Färnebofjärden [70]	P, N	P, N	P	-	-	-	-	I, II
Haparanda Archipelago 1994	Proposition 1993/94:254 [71]	-	-	P	-	-	-	-	I
	Management plan Haparanda Archipelago [72]	-	-	P	-	-	-	-	I
Skuleskogen 1984 (2009)	Proposition 1978/79:217 [73]	-	-	-	-	-	-	-	-
	Proposition 2008/09:98 [55]	-	-	-	-	-	-	-	-
	Management plan Skuleskogen [74]	P, N	-	P	-	P	-	-	I, II
	Management plan Skuleskogen [75]	P, N	-	-	-	-	-	-	I, II
Store Mosse 1982	Proposition 1980/81:100 [76]	-	-	-	-	-	-	-	-
	Management plan Store Mosse [77]	-	-	-	-	-	-	-	-
	Management plan Store Mosse [78]	-	-	-	-	-	-	-	-
	Management plan Store Mosse [79]	P, N	P, N	P	-	-	P	P	I, II
Tiveden 1983 (2017)	Proposition 1978/79:217 [73]	-	-	-	-	-	-	-	-
	Proposition 2016/17:96 [80]	P, N	-	-	-	-	-	-	I, II
	Management plan Tiveden [81]	P	-	-	-	-	-	-	I
	Management plan Tiveden [82]	P, N	-	P	-	-	-	-	I, II
Tresticklan 1996	Proposition 1994/95:162 [83]	P	-	-	-	-	-	-	I
	Management plan Tresticklan [84]	P	-	-	-	-	-	-	I
Tyresta 1993	Proposition 1992/93:205 [85]	P	-	-	-	-	-	-	I
	Management plan Tyresta [86]	P	-	P	-	-	-	-	I
Åsnen 2018	Proposition 2017/18:87 [87]	-	-	-	-	-	-	-	-
	Management plan Åsnen [88]	P, N	P, N	P	-	-	P	P	I, II

### 3.1. Benefits around Occurred Historic Natural Disturbance (Category I)

Of the fifteen studied national parks in Sweden, there are propositions and MPs for ten parks (Björnlandet, Fulufjället, Färnebofjärden, Haparanda Archipelago, Skuleskogen, Store Mosse, Tiveden, Tresticklan, Tyresta, and Åsnen) which mention historic natural disturbances as positive for the parks' area.

One recurrent theme is that spontaneous historic fires are seen as positive events because they contribute to biodiversity and help shape the biological values found today in the parks [64,65,69,70,79–82,86,88]. For example, the important natural features and highly biological values characterizing Tiveden National Park, are described as a result from 86 different spontaneous forest fires occurring between 1371 and 1853 [80–82]. Major parts of the park are still influenced by historic fires, which is rare for the southern part of Sweden [80].

Spontaneous historic fires and other types of natural historic disturbances are viewed as positive due to their contribution to the character in the national park such as primeval forests and wilderness [65,67,69,70,74,79,88]. For example, in 1997 Fulufjället National Park a cloudburst of 400 millimetres of rain in a couple of hours made the watercourse Tangån have a water-flow of 300 cubic metres per second, compared to its normal 1 or 5 cubic metres per second [67]. Heavy streams were generated which removed sand, stone, and ten thousand cubic metres of trees. The felled trees from the expanded river were piled up in enormous build-ups and the removed land material created new landscape formations. This event created a changed scenery in the landscape and is described as one of nature's newly created attractions [66,67].

### 3.2. Not Occurred Historic Natural Disturbances (Category II)

The theme which corresponds to six of the studied national parks (Björnlandet, Färnebofjärden, Skuleskogen, Store Mosse, Tiveden, and Åsnen) are previously not occurred historic natural disturbances which have had an expressed negative effect on the parks' area. The reason is that disturbances necessary to increase biodiversity are missing [63,65,70,74,75,79,82,88]. For example, unusual insect species have decreased in population over the years due to overgrowth caused by lack of historic fires. Other fire-favoured species need areas affected by fire in order to develop and survive [83]. Another consequence from the lack of historic disturbances is the ingrowth of spruce. In Färnebofjärden National Park, loss of regular floods have made it possible for spruce to outconcur giant oak [70].

Five national parks (Djurö, Kosterhavet, Padjelanta, Stenshuvud, and Söderåsen) do not mention historic natural disturbances as important contributors, nor a lack of historic disturbances as problematic for the national park areas. No information explaining why this is the case are to be found within MPs or propositions. However, the representative for Stenshuvud explained that the park area is without natural fire dynamics since most of the forest in the park are deciduous forest which will not burn. Additionally, the landscape is culturally influenced and fire has not been used in the landscape. The representative for Haparanda Archipelago clarified that the lack of fires should not be negative for the park area since the fire frequency is significantly lower on islands (sometimes as low as once every thousand year). The fire frequency might be affected by humans, but then it is not natural. The islands in Haparanda Archipelago National Park are getting more overgrown. However, the overgrowth is a consequence of isostatic land uplift which is a natural process for these islands.

### Obstacles around Historic Natural Disturbances-Human Interference

Why historic natural disturbances have ceased in five national parks can be explained as a result from human interference (Björnlandet, Färnebofjärden, Skuleskogen, Store Mosse, Tiveden, Åsnen). Regular forest fires stopped within national park areas as a consequence of modern forestry [80] which, when the forest increased in economic importance, made humans handle fire with great caution [74,75]; spontaneous fires out outside the



park had to be put out [65,88]. Natural flooding and variations in water levels stopped or changed as a consequence of human interventions of water regulations [88], the lowering of lakes for agricultural area [79], and hydroelectric power in the Dala River [70].

#### 4. Results—Future Perspective on Natural Disturbances within Swedish National Parks from a Conservation Management Perspective

The second section present the future perspective of natural disturbances and conservation management. In Table 3 is an overview of those national parks' MPs mentioning future natural disturbances as positive or as something negative. The MPs contain more thorough information about the natural disturbance spontaneous fires compared to other disturbances such as storm and flood. Therefore, the perspective of future disturbance in MPs do focus on spontaneous fire and interviews complete with information about other types of natural disturbances.

**Table 3.** Overview of the national parks' MPs and how they experience possible future hazards. P (positive) = possible future disturbances are seen as positive contributors to the park area. N (negative) = possible future disturbances are seen as negative contributors to the park area. The categorization from Table 1 (I–IV) is included. X = MPs that consider conservation burning as a management tool. MPs from a national park that do not include any of this information are from here excluded [52,56,61,72].

National Park Established (Extended)	Management Plan	Fire	Flood	Storm	Cloudburst	Snow Damage	Drought	Pests	Category (Table 1)	Conservation Burning
Björnlandet 1991 (2017)	Management plan Björnlandet [64]	N	-	-	-	-	-	-	IV	-
	Management plan Björnlandet [65]	P	P	P	-	P	-	-	III	X
Fulufjället 2002	Management plan Fulufjället [67]	P	-	-	-	-	-	-	III	X
Färnebofjärden 1998	Management plan Färnebofjärden [69]	P	P	-	-	-	-	-	III	-
	Management plan Färnebofjärden [70]	P	P	P	-	P	-	-	III	X
Kosterhavet 2009	Management plan Kosterhavet [54]	-	-	-	-	-	-	-	-	X
Skuleskogen 1984 (2009)	Management plan Skuleskogen [74]	N	-	-	-	-	-	-	IV	-
	Management plan Skuleskogen [75]	P	P	P	-	P	-	-	III	X
Stenshuvud 1986	Management plan Stenshuvud [58]	-	-	-	-	-	-	-	-	-
	Management plan Stenshuvud [59]	N	-	-	-	-	-	-	IV	-
Store Mosse 1982	Management plan Store Mosse [77]	-	-	-	-	-	-	-	-	-
	Management plan Store Mosse [78]	-	-	-	-	-	-	-	-	-
	Management plan Store Mosse [79]	P	P	P	-	-	P	P	III	X
Tiveden 1983 (2017)	Management plan Tiveden [81]	N	-	-	-	-	-	-	IV	-
	Management plan Tiveden [82]	P	-	-	-	-	-	-	III	X
Tresticklan 1996	Management plan Tresticklan [84]	N	-	-	-	-	-	-	IV	X
Tyresta 1993	Management plan Tyresta [86]	N	-	-	-	-	-	-	IV	-
Åsnen 2018	Management plan Åsnen [88]	P <sup>1</sup>	P	P	-	-	P	P	III	X

<sup>1</sup> Major impact might cause negative damage onto other values. It is not mentioned what these other values might be.

##### 4.1. Possible Benefits around Future Natural Disturbances (Category III)

Six national parks (Björnlandet, Färnebofjärden, Skuleskogen, Stenshuvud, Store Mosse, and Tiveden) have revised their MPs. For three of them there is a shift in how future fires are perceived. While in previous MPs fires should be put out [64,74,81], in the new updated MPs there are some possibilities for allowing fires [65,75,82].

For seven national parks' MPs (Björnlandet, Fulufjället, Färnebofjärden, Skuleskogen, Store Mosse, Tiveden, and Åsnen), all of which are the actual MPs, a recurring theme is that future spontaneous fires are seen as positive contributors to the park areas. There are two perspectives to be distinguished on how fires will contribute to the park areas: the biological perspective [65,67,69,70,75] and development towards primeval forest [79,82,88]. For example, one management goal for Björnlandet National Park is to let fires occur regularly, since historic forest fires have had a role to shape the vegetation and fires are necessary to create needed structures and functions for ecosystems [65]. The management

for Store Mosse National Park also has a goal for spontaneous fires to be part of the park. Fires and letting time pass will contribute to development towards primeval forests [79].

Another example of the biological perspective and possible benefits from natural disturbances is mentioned by the representative for Färnebofjärden. Massive tree felling caused by a storm is one way to create dead wood which benefits insects. The park managers want there to be more dead wood. However, visitors might see it as “messy”. “How a forest is appreciated depends on what kind of eyes are looking. Some might find a production forest with moss and trees standing 10–15 m in between to be really beautiful, like a cleaned park. Whilst if you have another set of eyes you will see it is quite dead”.

Even if future natural disturbances are considered positive for the national parks, there are limitations. These limitations can be separated in two categories. The first is that the park itself is too “valuable” [65,67,75,79,82,86]. For instance, some might say that the park should be appreciated for how it is right now and there is a wish to not interfere with it. The second is that the surroundings would be at risk [64,70,79,84,86]. For instance, there is a risk of fire spreading to surrounding forests. For further explanations, see Sections 4.1.1 and 4.1.2.

#### 4.1.1. Obstacles around Future Natural Disturbances—The Park Itself Is Too “Valuable” (Category IV)

Obstacles for the national parks to experience future spontaneous fires can be explained by the prerequisite to not interfere with the current state of the park. The reasons are biological [65,67,79,82,86], recreational interests [67,86], and high season for visits [75]. For example, in Tiveden National Park spontaneous fires should be limited in areas that historically have had little or no impact from fire, wetland, watercourse close land, and areas with old coarse trees [82]. For Skuleskogen National Park, considerations of whether a spontaneous fire should be put out immediately or not might be that the season for spontaneous fire often coincides with the high season for visits [75]. A biological perspective is also mentioned by the representative for Stenshuvud, who says that, so far, no major disturbances such as a severe storm have occurred in the park area. Storm-felled trees result in dead wood, which is needed in the park. However, it would be preferable if the trees fell more spread out instead of a hectare felled at the same place. If the latter is the case, natural values and location decide if the felled trees can stay or not. For example, if the trees fell in a nice forest grove they might have to be removed.

#### 4.1.2. Obstacles around Future Natural Disturbances—The Surroundings Would Be at Risk (Category IV)

The second category of obstacles for the national parks to experience future spontaneous fires are settlements and human activities outside and in close proximity to the park’s borders [64,70,79,84,86]. For example MP for Björnlandet [64] and Tresticklan [84] state that spontaneous fires within the park area is impossible to allow as, the area is too small and the risk of surrounding forests too great. The MP for Haparanda Archipelago [72] does not mention anything about future possible fires. The representative for Haparanda Archipelago agreed that fires should be put out to avoid spreading and would thereby protect natural and cultural environments and property and lives.

A slightly more permissive view is found within the MP for Färnebofjärden [70] and Store Mosse [79], where spontaneous fires should be evaluated and might be left to spread if there is no danger to public safety, private property, or any threat to the area’s values and facilities. The representative for Färnebofjärden explained that even if the management of the park do want there to be fires in the park, this is not possible due to the surrounding area. One event that exemplifies this was when there was a fire on one of the smaller islands in the park and the managers suggested it to self-extinguish, but the fire department could not guarantee that the fire would not spread to main land. The representative for Skuleskogen told a similar example of a spontaneous fire at a peninsula. The local fire department did not ask the park managers if it was possible to let the fire self-extinguish, which it would due to natural fire obstacles such as a pond, and allow for subsequent positive ecological benefits. Instead, the fire was put out by the fire department.

Regarding future storm and storm felled trees, both representatives for Skuleskogen and Färnebofjärden reasoned about the possible consequences of major outbreak of pests such as the spruce bark beetle. Due to national park regulations, it is neither possible to remove felled trees as a preventive measure nor handle an outbreak in some way. An outbreak of pests within the park could spread to other forest owners bordering to the park, which is a worry from a manager's perspective.

In Färnebofjärden National Park there is not enough flooding due to hydroelectric power in Dala River. Major future flooding would be desirable and contribute to the biological development in the park area. The issue for future flooding is the surrounding buildings. About 10 years ago an ice block in the River Dala made the water level rise half a meter above the already high water level. The fire department walled-in areas that needed protection, for instance the Gysinge factory. The rising water was considered a threat likely to cause severe damage to nearby buildings which caused discussions about blowing up the ice. Luckily, the block released by itself and the water level dropped.

#### 4.2. Possible Benefits around the Mimic of Natural Disturbances by Using Conservation Burning

The same seven national parks (Björnlandet, Fulufjället, Färnebofjärden, Skuleskogen, Store Mosse, Tiveden, Åsnen) as presented in Section 4.1 share the theme that future spontaneous fires are seen as positive, and are using conservation burning as a management tool (Table 3). The same two perspectives as for spontaneous fires and how fire will contribute to the park area are also here distinguished for the same parks, namely the biological perspective [65,67,70,75,88] and development towards primeval forest [79,82,88]. The only exception is that Åsnen National Park is included in both perspectives.

For example, Färnebofjärden National Park recognises conservation burning as an important tool to promote natural values associated with a fire-affected forest, such as pine, deciduous trees, biodiversity, and structures generated by fire, which is a prerequisite for achieving the aim of the park [70].

Two national parks (Kosterhavet and Tresticklan) do not describe future disturbances as positive but are still considering conservation burning as a management tool. For example, in some areas in Kosterhavet National Park it is possible to burn last year's grass, heather, and juniper bushes [54].

The interviewees for Färnebofjärden, Skuleskogen and Stenshuvud mention the benefit of conservation burning to decide where and when to burn. For example, in Färnebofjärden National Park inventories have been made to decide locations that will benefit the most from fire, and locations that should not burn due to biologically valuable environments. According to the representative for Färnebofjärden and Stenshuvud, conservation burning is possible to regulate in intensity and decide how burnt the area should be. It is even possible to control the height of the flames and use it as a thinning tool to remove spruce and keep pine. The Stenshuvud representative mentions that conservation burning is cost-effective and makes it possible to remove grass from remote locations. If a mower was used instead, the transportation would destroy other environmental values in the park. "The fire is very useful for us but one must be careful". The heat from the fire helps fire-dependent species and is important to benefit the biodiversity within the parks.

Even if conservation burning is considered a management tool, there are limitations for how conservation burning should be used. The category distinguished here is the same as for one of the categories to limit future spontaneous fires, i.e., the park itself is too "valuable" [65,70,75,79,82].

#### Obstacles around the Mimic of Natural Disturbances by Using Conservation Burning—The Park Itself Is Too "Valuable"

Obstacles for using conservation burning as management tool can be explained by the prerequisite to not interfere with the current state of the park. The reasons are biological [65,70,79,82], the cultural environment [70], and the high season for visits [75]. For example, during conservation burning consideration and protection should be made to cultural valuable environments, such as old deciduous trees and pine. The intensity of the

fire should be regulated to enable limited damage from the flames and make it possible for pine to not be destroyed [70].

The obstacle to not interfere with the current state of the national parks are explained in three of the interviews (Färnebofjärden, Haparanda, and Skuleskogen). Both in Haparanda Archipelago and Skuleskogen National Parks there has not been any conservation burning made. One of the reasons is the public reactions for burning, since the optimal time is the same as when there is a lot of activities in the forests (such as birds nesting and hatching eggs). In Skuleskogen National Park there are plans for a small conservation burning of 2–3 hectares due to a fire-dependent beetle only existing in a few places in Sweden. Since the area is limited, it should be fine, but making a major conservation burning like in other parts of Sweden might not be desirable due to negative public reactions. Visitors may perceive a burned area as black, dead, and scary. Färnebofjärden National Park is using conservation burning. During summer 2020, an area of 300 hectares of forest and bog were burned. The public tended to get worried and were irritated by the smoke, making SOS alarm calls. Before a burning, the public receives information through post, radio and signs to reduce worries and increase the understanding of why conservation burnings are needed.

#### 4.3. Free Development

Six of the studied national parks (Djurö, Haparanda Archipelago, Stenshuvud, Söderåsen, Tresticklan, and Tyresta) are united in the theme of free development without any active management for some areas in their parks. These six parks do not mention the lack of historic natural disturbances as problematic (Table 2). No information explaining why are to be found in the MPs or propositions. Also, neither of these parks consider future natural disturbances to be positive; there is no information to be found within the MPs about future natural disturbances (Table 3).

The interviews indicate that there are problems with letting national parks develop freely. In Färnebofjärden National Park there has been a shifted position from the previous MP of letting the park develop freely with reduced management, to the current MP of active management, such as burning and removing spruce. The reason for this shift is that, since 1920, flooding from the lower Dala River has decreased considering the flooding's water level, return period, and duration time as a consequence of hydroelectric power production. There are several red-listen species in the park (example the beetle *Ceruchus chrysomelinus*, white-tailed eagle, and white-backed woodpecker), species that basically only exist there. If the park was left for free development, important values from the park would disappear since they and their habitats depend on the natural water variations from before the hydroelectric power development. When the park was left for free development, spruce were growing and threatened to out concur other species and make the forests darker, indicating that there was a need for active managements. The shift is explained with "... we (humans) already have changed the prerequisites. Then we have to save what is possible to save".

## 5. Discussion

The purpose here has been to investigate how conservation managers perceive natural disturbances and to identify examples of barriers towards allowing for disturbances in conservation management. To understand how conservation managers perceive natural disturbances and if it is possible for natural disturbances to interact with the area of national parks make an important contribution for future management. There are both global [22] and Swedish [47] goals to increase the amount of protected areas, which should be managed according to the preservation of current values as well as future ones. A common overarching goal for national parks globally is that they should be managed to preserve natural conditions (exceptions, such as preserving historical values, do occur) [17]. The primary objective for national parks is, as stated by IUCN, "To protect natural biodiversity along with its underlying ecological structure and supporting environmental processes ... " (<https://www.iucn.org/theme/protected-areas/about/protected-areas-categories/>

[category-ii-national-park](#) accessed on 15 February 2021) This study has identified obstacles around necessary environmental processes which interfere with this objective. Even if some of the national park managers perceive natural disturbances and environmental processes as positive, it is not entirely their decision to make. The paradox for conservation managers is to manage national parks while at the same time care for the surrounding society's wishes, two goals which may be in conflict.

Arts, et al. [89] reason that the interpretation of wilderness is a result of one's relation to land, making a plurality of wildernesses possible. For there to be a relationship between western societies and the wilderness, the paradox of wilderness, such as its plurality, has to be acknowledged. For instance, environmental restoration should not be reduced to an extreme: "... an approach that creates a fully autonomous wilderness which could be typified as hell-like, may not be supported by a wider public." [89]. A possible conflict is landscape management and the perception of landscape values [90]. The argument for why natural disturbances are seen as negative are the park areas' closeness to people and societies, as well as peoples' perception and attitude towards these disturbances. An obstacle for letting Swedish national parks experience natural disturbances and conservation burning are public reactions due to the parks' own value. What that value might be depends on one's expectation for the national park, for example recreation interests [67,86]. Since disturbances are an important component in ecological integrity, visitors in protected areas need to be aware of and understand these functions [91].

National parks in Sweden constitute a relatively small area [46] which may hinder wilderness achievable. National parks are not isolated islands possible to manage optimally for preserving natural values on this particular limited area. National parks interact with the landscape outside of the park and will get affected by both modern forestry and the reduced amount of forest fires. Furthermore, national parks are part of the society even if they physically might be distance. How people perceive a national park perhaps should not be interfering with the management of it. However, as shown here, peoples' perception are an obstacle. One explanation might be the direct link between visiting protected areas and individuals' mental wellbeing, which could contribute to the economic value of conserving protected areas [92]. If protected areas such as national parks are perceived as not appreciated, then they might not be visited, be visited less, or even generate a negative experience for the visitor.

Swedish authorities, like the County Administrative Board, tend to work with slices of land instead of looking at the whole picture for landscape care. For instance, flooding of a meadow that is part of nature conservation project is considered by them to be something "disruptive" [90]. Conservation management through free development without active management might seem as a way to achieve primeval areas and wildernesses. However, when human have changed the prerequisites for natural disturbances the development of these areas will also change. An example of the difficulties national park managers have to handle is to mimic the effect of a natural disturbances that have been lost due to human interference. Färnebofjärden National Park uses active management to mimic the effect of floods in order to help oak trees located next to the river withstand the competition from spruce. This finding goes in line with Hobbs and Huenneke [32] and the need of active management to replace the natural disturbance regimes, since human interference and landscape fragmentation have modified the physical environments. Active management is difficult to use in a way that benefits the trees without hurting them [93] and it is difficult to determine the effect on surrounding species [94].

Not only do conservation managers have to consider the conflict between biological values and interests from society, there are also other values within the national park to manage, such as cultural values, which may be in conflict. For example one reason to put out spontaneous fire in the Haparanda Archipelago is to protect cultural environments. The finding that cultural preservation is an obstacle for natural disturbances contradicts Österlin, Schlyter and Stjernquist [36], who say that the primary target for national park management is to conserve and protect wilderness, even at the expense of cultural preservation.

If future natural disturbances are perceived as positive or negative, they might be related to aspects of control. A potential explanation as to why future fires are well-described in some MPs and perceived as negative in others is the possibility of controlling them. When there is a fire, the risk of spreading, severity of the fire, and possibility of putting it out or letting it self-extinguish are evaluated and sometimes followed by action. Other types of future natural disturbances mentioned in the MPs but less described are storms, cloudburst, snow damage, drought, and pests. These are not possible to manage and will occur despite what the MP say. They are all perceived as future positive events where they are mentioned. Future floods are the only disturbance possible to control due to human interference such as lowered lakes, water regulations, and hydroelectric power. Floods are also perceived as positive.

Fire within an ecosystem affected by human impact, and which therefore has unnatural structures, can with the help of time restore the ecosystems' function and structure to a more natural state [17]. The paradox here is more complex when adding the time perspective. Features of protected areas are generated by historic natural disturbances. Future recreational values such as the experience of primeval forests might be lost if the disturbances needed are hindered today due to short-term interests. Consequences from a short-term perspective might be an explanation to shifts in how future fires are perceived. For three national parks (Björnlandet, Skuleskogen, and Tiveden) there is a shift from future fires first being perceived as negative to later perceived as positive. These parks were established in the 80s and 90s, with updated MPs about 25 years later. Arguments for their foundation were formulated based on protection of their environmental values which have been created through historic development and disturbances. All three of the parks mention a lack of historic fires as negative for the park area. Example of reasons for fires to be positive are the biological development, creation of structures, and functions for ecosystems and the important contributions from historical forest fires [65]. It is possible that the lack of natural disturbances in a longer-term perspective were perceived as negative when the effect of lost disturbances successively became visible. This might also explain the shift to include conservation burning as a management tool in the updated MPs.

Identified obstacles for future natural disturbances could in a long-term perspective generate new types of negative aspects for the national parks. According to Buma, Schultz and Leverkus [4] natural disturbances have the potential to create opportunities for adaptation towards climate change within social and ecological systems. After a natural disturbance such as fire, the environmental area will develop according to new premises, such as increased temperatures. Disturbances could contribute to national parks' adaptation to climate change and therefore continue to be worth protecting. However, the identified obstacles related to short-term interests might hinder these opportunities.

#### *Method Discussion*

A multiple case study makes it possible for comparisons between the cases and to study causal mechanisms [49]. The main strength with this study is that it is reflecting half of the national parks in Sweden and is based on multiple cases.

The document analysis, which is the main part of the presented result, consists of propositions for establishing the 15 national parks, and expanding three parks. Also, MPs are included (both the original and occurring updated versions). In total, 37 documents have been analysed. The initial document study of the multiple cases generated four main themes: historic/future and positive/negative perception of natural disturbances. These themes have been possible to compare and to identify obstacles for why natural disturbances not might be possible within the park areas.

By starting with the document study, it was possible to prepare the interviews thoroughly and to create questions based on what was lacking in the documents or what needed to be further explained. They also gave the perspective on how the parks actually work with their conservation management in the present day.

The first national parks to be established in Sweden in 1909 had a clear bias towards northern mountain areas. This study use national parks established between 1962 and 2018 to include parks that represents more modern times. By doing so, most of the parks included in the document study are located in the middle and south part of Sweden. This distortion has been countered by the interviews representing national parks spread out from north to south, which give more in depth interview information. The four interviews bring another dimension to the data collected from the document analysis and to the four themes. For instance, they provide examples of other disturbances than fire, which is lacking in the documents (e.g., the importance of storm and snow damages). The interviews also turned out to be supplementary concerning information about conservation burning. The interviews show that there is saturation in data in some respects. For instance, they all describe the practical implications of national parks being located next to societies and forestry.

The information from the interviews was possible to validate by comparing it with propositions and MPs, as well as by asking about both historic and future events [51].

The document analysis show that there are four main themes (historic/future and positive/negative), with the natural disturbance either belonging to one or several of these categories or not. This indicate that the 15 studied parks are covered by the main themes. The results from this study describe how and if the conservation management of the 15 national parks in Sweden, established between 1962 and 2018, are including disturbance ecology.

As seen in the results, the document study and the interviews are consistent in their perception about natural disturbances. However, the interviews show that there are nuances and give more thorough explanations as to why natural disturbances are perceived as either positive or negative.

The purpose of national parks to preserve natural conditions [17], the importance of disturbance ecology, and the here-identified obstacles and paradoxes can be possible indicators of challenges met in protected areas outside of Sweden. This multiple case study, based on a document analysis and completed with interviews, has been from a conservation manager's perspective. It is possible that the perspective from another stakeholder might have generated another result.

## 6. Conclusions

From a conservation manager's perspective, there are positive aspects of including disturbance ecology in the management of national parks. The disturbances can be either natural or mimic. Both historic and future natural disturbances are in some cases considered positive and of importance for national park areas. This study has identified obstacles around natural disturbances within Swedish national parks. They are, in some cases, explained by practical implications and, in others, explained by paradoxes. Conservation managers have to consider conflicting interests between biological values, interaction with the landscape outside of the national park, interests from society, short and long-term perspectives, cultural values, and control. Negative perceptions and obstacles of future disturbances derive from two aspects, namely that the park itself is too "valuable" or that its surroundings would be at risk.

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## Appendix A. Interview Guide

### Historic perspective

- Has there been known natural hazards within the National Park area?
  - What type?
  - How was the area affected?
  - Was this before the National Park was established?
  - Has there been a hazard after the National Park was established?
  - Was it managed? If so, how (clearance, fire extinguishing etc.)?
  - What was the reason for the chosen management?

### Future perspective

- Which natural hazards are possible to occur within the park area? What are the possible consequences?
- Has there been a risk assessment made? Is it possible to take part of?
  - When making a risk assessment, is the local population taken into account? How? Why?
  - What is the risk/what can be lost due to natural hazard?
  - Is the risk considered a problem? Why?
- Has there been preparedness made in case of a hazard? Examples?
  - Why has there been preparedness made? What is it that you want to protect?
  - Are there contingency plans? Other types of preparing work in case of natural hazard?
- Ask about fire, flood, storm, pests, snow damage and drought.
- If there is no risk assessment made, might there be a worry about natural hazards?
  - What is the worry about/what might be lost?
  - Has there been measurements in case of a hazard? Examples?
    - Why has there been preparedness made? What is it that you want to protect?
    - Are there contingency plans? Other types of preparing work in case of natural hazard?
- Are there local extinguishing plans?
- Is conservation burning used?
  - Is it used differently within the park area?
  - Compared to a spontaneous fire, is there a difference? Examples?
  - What is the reason for using conservation burning?
- Why is conservation burning not used?
- When making a conservation burning, is the local population taken into account?
  - How?
  - Why?



- Are there environmental values that could benefit from a natural hazard? Examples?
- Are there environmental values that could be lost due to lost natural hazards?

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