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Forest Restoration: Do Site Selection and Restoration Practices Follow Ecological Criteria? A Case Study in Sweden

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Abstract: The speed with which restoration will, or can, be accomplished depends on the initial state and location of the sites. However, many factors can undermine the process of choosing sites that are deemed the best ecological choice for restoration. Little attention has been paid to whether site selection follows ecological criteria and how this may affect restoration success. We used habitat inventory data to investigate whether ecological criteria for site selection and restoration have been followed, focusing on restoration for the white-backed woodpecker (*Dendrocopos leucotos* B.) in Sweden. In our study region, which is situated in an intensively managed forest landscape with dense and young stands dominated by two coniferous species, purely ecological criteria would entail that sites that are targeted for restoration would (1) initially be composed of older and more deciduous trees than the surrounding landscape, and (2) be at a scale relevant for the species. Furthermore, restoration should lead to sites becoming less dense and less dominated by coniferous trees after restoration, which we investigated as an assessment of restoration progress. To contextualize the results, we interviewed people involved in the restoration efforts on site. We show that although the first criterion for ecological site selection was largely met, the second was not. More research is needed to assess the motivations of actors taking part in restoration efforts, as well as how they interlink with public efforts. This would allow us to identify possible synergies that can benefit restoration efforts.

Keywords: *Dendrocopos leucotos*; forest restoration; forestry; site selection; project management; public-private partnerships

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1. Introduction

As a reaction to recent and anticipated future declines in species populations, and following a general concern about ecosystem health, attempts to restore (parts of) ecosystems are increasingly common [1,2]. The main aim of restoration is to recover a self-sustaining ecosystem which is resilient to normal stress and disturbance levels and interacts with contiguous ecosystems [3]. The SER International Primer on Ecological Restoration [3] provides nine attributes to determine if restoration has been accomplished successfully, but what is not mentioned is that the initial state of the sites chosen for restoration may determine how fast and perhaps also if restoration goals will be, or are, accomplished. It is unequivocal that a site near the desired state will reach a restored ecosystem state more quickly than a site that is not. When the aim is to reintroduce and preserve a specialist species, the target species' ecological requirements are central to the selection of restoration sites. However, a stakeholder may have several motivations for choosing a site, including ecological, logistic, and economic.

Although several papers have examined how to select sites for restoration based on ecological factors [4,5], little attention has been paid to whether site selection has followed ecological criteria and how this affects restoration success. Insights into how restoration sites were selected can be gained either through studying the action plan or evaluation plan or from conversations with people that were involved in the project [6,7]. However, conclusions drawn from such studies are only reliable to a limited extent, in part because there is a tendency to overestimate ecological results if collaboration and organization worked well [8]. Further evaluation of whether the ecologically best sites were chosen for restoration and whether restoration has been, or will be, accomplished can be achieved through on-the-ground monitoring of the sites before and during restoration. Unfortunately, such evaluations are often incomplete, unavailable, or nonexistent [9,10]. Additionally, it is not always logistically feasible to conduct field studies that yield accurate and sufficient data on the habitat composition and structure of sites selected for restoration and the surrounding area.

Although the white-backed woodpecker (WBW, *Dendrocopos leucotos* B.) is globally of 'least concern,' the population is in decline [11], and in Sweden its status is 'critically endangered' [12]. Since the beginning of the 20th century, its distribution range in Sweden has decreased by over 90%. This loss has been attributed to forestry practices that have reduced deciduous woodland and old and dead trees, and subsequently the WBW's main food source: wood-boring and bark-living insects [12–14]. Efforts to restore the WBW population were initiated in the 1970s by the Swedish University of Agricultural Sciences, followed by the Swedish Society for Nature Conservation. National coordination was formalized through an advisory action plan for the WBW, adopted in 2005, where public and private actors (the Swedish Environmental Protection Agency, county administrative boards, NGOs, forest companies, and landowners) work together [15]. Private companies have undertaken most of the WBW habitat restoration, and in 1993 a large forest company committed to setting aside and restoring 10,000 ha of forest [15]. Also, in other countries in the region, conservation efforts are targeted at the WBW where efforts consist of protecting the remaining breeding sites, providing food during the winter, and managing protected areas specifically for the WBW [16,17]. Adopted management strategies have included (1) the removal of spruce to create well-lit deciduous forest habitat, and (2) the creation of decaying and dead birch wood [16]. These management strategies are, however, not always effective [17].

The habitat requirements for the WBW comprise old-growth deciduous forests with plentiful dead and decaying wood [15,18]. In Sweden, it is estimated that a pair of WBWs needs 50 to 100 ha of deciduous forest to survive [13] and 10 to 20 m^3 ha^{-1} of dead deciduous wood [18]. Furthermore, 10% to 17% of a forested landscape (tens of km^2) needs to be suitable habitat [19]. This means that a pair of woodpeckers requires at least 50 ha of deciduous forest within a 294 to 500 ha area of forested landscape (50 ha is 10% of 500 ha and 17% of 294 ha) to survive. However, the goal in the project plan was to have 100 ha with a high proportion of deciduous trees (> 75%) within 500 ha of forest [15].

Because the WBW is extremely rare in Sweden (there was only one breeding pair in the country in 2013 [20] and three or four in 2016 [21]), considerations for the regions where sites might be restored were based upon the presence of relatively high amounts of deciduous forest compared to other parts of Sweden, so sites that were already relatively close to ideal. WBW had been released in Sweden since the 1990s already [21], so restored sites could serve as new release sites. Restoration was thus focused on the counties of Värmland and Dalsland in southwestern Sweden because they were seen as the most ecologically promising to be able to contain a healthy population of WBW in the relatively near future [15]. We assumed that the best way to protect the WBW is to choose sites for restoration that are close to ideal ecological conditions, so that sites might reach ideal conditions more quickly and not take years or decades, which may be too late for protecting the WBW. So, if site selection within these counties was solely based on the species' ecological requirements, then selected restoration sites would contain more deciduous trees and more older trees than the surrounding landscape. Furthermore, one would expect that restoration should remove coniferous trees, create less dense forests with plenty of dead deciduous wood (both standing and lying), and that it should match a scale relevant to the WBW.

Our study addresses the issue of whether site selection meets ecological criteria by using a case study to determine whether site selection for the restoration of a locally red-listed species, the WBW, was based on its habitat needs. We focused on a large, long-running restoration effort in Sweden that aims to restore forest ecosystems that have long since been intensively managed and are now dominated by relatively young and dense stands of Scots pine (*Pinus sylvestris* L.) and Norway spruce (*Picea abies* L.) that have little amounts of dead wood [22]. The aim of the restoration is to allow re-colonization of a healthy population of WBW. Bell et al. [23] previously collected environmental data from nine restoration sites restored as part of this project as well as from nine nearby commercially managed reference sites. They found that the restored sites contained larger volumes of coarse, woody debris than commercially managed forests. Furthermore, the majority of man-made snags and downed logs were birch (*Betula* spp.) and most spruce trees were removed, which led to less dense stands dominated by broadleaved trees. We used forest inventory data to evaluate the ecological appropriateness of a large number of restoration sites, which were selected by a forest company for restoration targeted at the WBW. We assessed (1) the current suitability of the region for the WBW, (2) whether restoration sites contained older trees and more deciduous trees than the surrounding landscape before restoration, (3) the progress that had been made in creating a less dense forest that is less dominated by coniferous trees, and (4) whether the restoration occurred at a scale appropriate for the WBW. In parallel with this study and to contextualize the results, we interviewed people involved in the WBW restoration efforts on site in Värmland in September 2013. The seven interviewees were key individuals involved in the WBW work (one forest owner and representatives of two forest companies, the county administrative board and the Swedish Forest Agency).

2. Materials and Methods

We obtained locations of forest stands restored for WBWs in the county of Värmland from one of the Swedish forest companies involved in WBW restoration, a company which is the main restoration actor in this county (Figure 1) [15]. Unfortunately, we were unable to obtain locations of restored stands not managed by this forest company. Therefore, our study focused solely on whether ecological criteria for stand selection were met by this forest company. The forest company identified a total of 595 stands (~2300 ha) that were restored between 1995 and 2011. Because forest inventory data were only available for the years 2000, 2005, and 2010, the forest composition analyses were based on the 405 sites that were restored between 2001 and 2009 (~1530 ha).

Many of the stands were directly adjacent to, or very close to, another stand, and approximately one third of the stands were <0.001 ha (10 m^2) and connected to or encompassed by a larger stand. These 'slivers' were probably caused by location corrections or additions to previously restored stands by the forest company. Therefore, we aggregated these stands for the forest composition analyses using ArcGIS 10. Determination of which stands were aggregated were based on numbers presented by Aulén [11] and Carlson [19], from which we concluded that a pair of WBWs needs approximately 50 ha of deciduous forest within a 500 ha area of forested landscape (i.e., 10% deciduous forest within a forested landscape) to survive. Using the radius of a 500 ha circle (~1.26 km), we created a buffer zone of 1.26 km around each of the restored stands to represent the forested landscape required by a pair of WBWs. When a restored stand was situated within the buffer zone of one or more other restored stands, these stands were aggregated. This resulted in 63 groups of aggregated stands, encompassing all 405 sites that were restored between 2001 and 2009. Henceforth, we called these groups 'restoration sites' or 'restored sites', depending on if they were pre-restoration or post-restoration. We also amalgamated the buffer zones around the stands so that each restored site had an accompanying buffer zone of 1.26 km in width. In total, 89% of the land within these buffer zones was classified as 'tree cover' by the Global Land Cover 2000 Project (GLC 2000), of which 45% was owned by the forest company (data were obtained from the forest company) and 8% was protected area with various levels of conservation and protection.

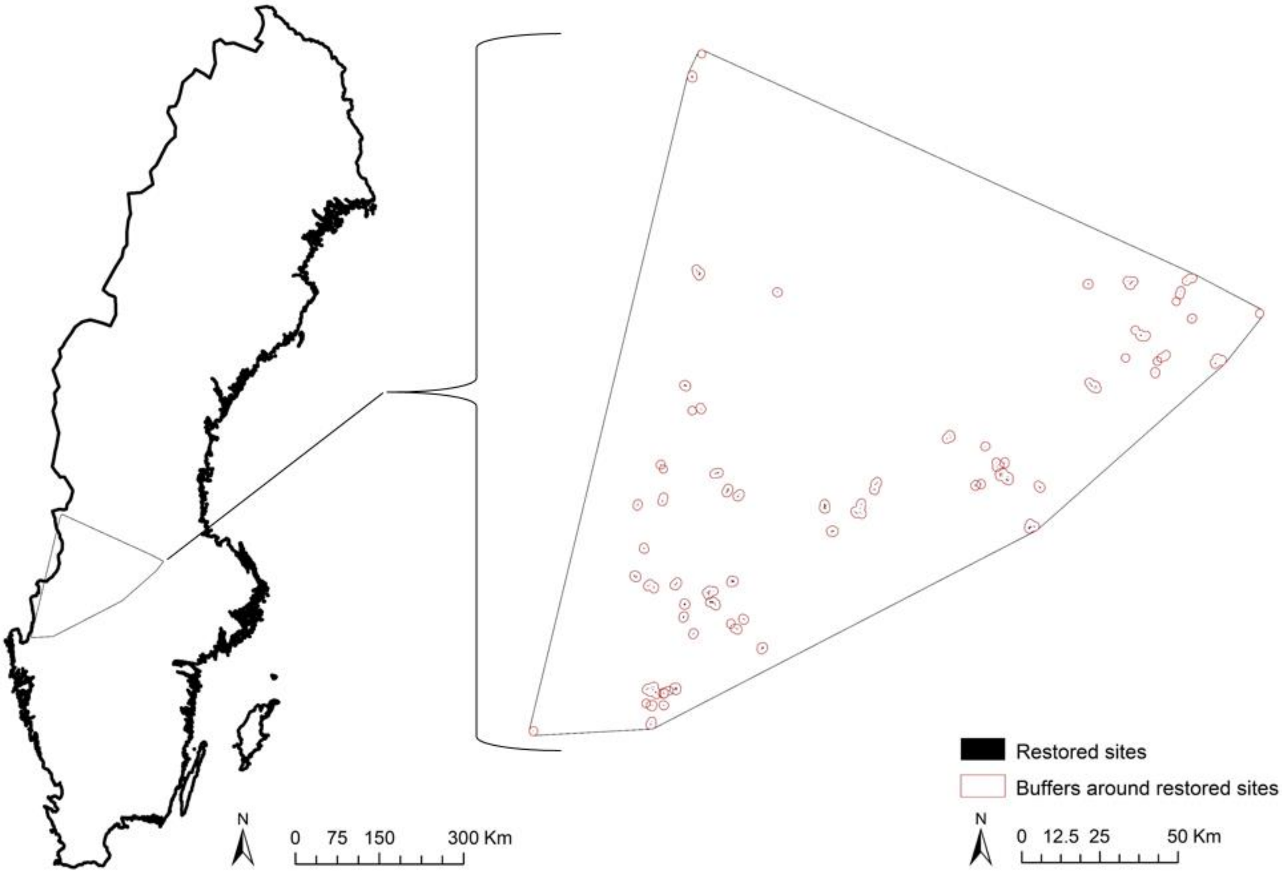

Figure 1. The location of the restored sites and their buffers (see main text) within Sweden used for the study.

For the analyses we created five different geographic categories: first, the restored sites (category 1: R (Table 1)) and their accompanying buffer zones (category 2: B) as described above. We created a convex hull polygon enveloping all restored sites to geographically define the study region (category 3: A). In order to compare the forest composition of stands selected for restoration with those not selected for restoration, we obtained data from the forest company on the location of all the land they owned in the study region. This land defines category 4 (FC). Additionally, to gauge the current suitability of already established protected areas (category 5: P) in the study region for the WBW, we obtained data on their locations from the World Database on Protected Areas (WDPA: http://www.wdpa.org/, updated annually, accessed on 1 February 2013). Category 5 is defined by all land in the study region classified by the WDPA as protected, excluding 'natural landmarks' as they consisted of lone trees, boulders, etc. (Table 1).

Table 1. Definitions of categories used for the analyses.

Code	Category	Definition
A	Study region	The entire study region defined by a convex hull polygon enveloping all restored sites.
B	Buffer zones around sites selected for restoration	Buffer zones of approximately 500 ha around sites selected for restoration, to represent the minimum area of forested landscape required for a pair of white-backed woodpeckers to survive.
FC	Forest company owned land	All forested land owned by the forest company, including restoration sites.
P	Protected areas	Areas with different levels of protection, from national parks to nature reserves. These areas were not specifically managed to suit the white-backed woodpecker.
R	Restoration sites	The sites, owned by the forest company, that were selected for restoration and have been restored between 2000 and 2010 for the white-backed woodpecker and aggregated based on distance from each other (see the main text).

We used forest inventory data from 2000 and 2010 to determine whether restoration sites contained older trees and more deciduous trees than the surrounding landscape before restoration (2000) and whether restoration sites had lower tree densities and were less dominated by coniferous trees after restoration (2010). These forest data were obtained from the Swedish forestry inventory conducted by the Department of Forest Resource Management of the Swedish University of Agricultural Sciences (http://skogskarta.slu.se, accessed 1 February 2013). The datasets contain information on age and biomass of common tree species at a 25 × 25 m resolution. The data used were the mean ages of all living tree species and the volume of individual living tree species: European beech (*Fagus sylvatica* L.), lodgepole pine (*Pinus contorta Douglas ex Loudon*), Norway spruce (denoted as 'spruce'), pedunculate oak (*Quercus robur* L. denoted as 'oak'), Scots pine, silver birch (*Betula pendula* Roth, denoted as 'birch'), and of 'other deciduous trees' (e.g., common alder (*Alnus glutinosa* L.) and Eurasian aspen (*Populus tremula* L.)). Unfortunately, data on the volume of dead deciduous wood present were not available on a detailed scale and could thus not be taken into account. Means of tree ages were calculated for each restored site, buffer zone, forested area owned by the forest company, protected area, and for the entire study region.

To determine whether the restoration occurred at a scale appropriate for the WBW we assessed if, in the study region, there were areas in which a 100 ha area (i.e., 20%) of a 500 ha forest had a high percentage of deciduous trees (>75%), a goal set by the project plan [13]. To assess whether this was accomplished or not, we overlayed the study region with a 500 × 500 ha grid and counted all the grid cells in which this criterium was fulfilled. Further, we made a density map showing the percentage of deciduous trees in each 25 × 25 m grid to visualize areas with a high proportion of deciduous trees in the study region. In addition, we measured the size of restored sites and assessed the proximity to one another; a few large, or many small, restored sites that are near each other may, together, reach the required 100 ha containing a high percentage of deciduous trees within a 500 ha forest.

ArcGIS 10 was used for data organization and for the analyses. Statistical analyses were performed in R 3.5.0 [24]; paired t-tests were used to compare each restoration site with its respective buffer and restoration sites at two different time periods. Welch t-tests were used to study differences between other categories, for example between restored sites and protected areas.

3. Results

3.1. Forest Composition before Restoration

Concerning the current suitability of the region for the WBW; the forest survey data analyses showed that before restoration the volume of deciduous trees in the study region was not very high, with an average of 16 m^3f/ha (cubic meter standing forest volume per hectare) in 2000, of which ~75% consisted of birch (Figure 2). There were no European beech in the region. In comparison, there was a high volume of coniferous trees in the study region, with an average of 111 m^3f/ha, of which ~54% was spruce and ~45% was Scots pine (Figure 2).

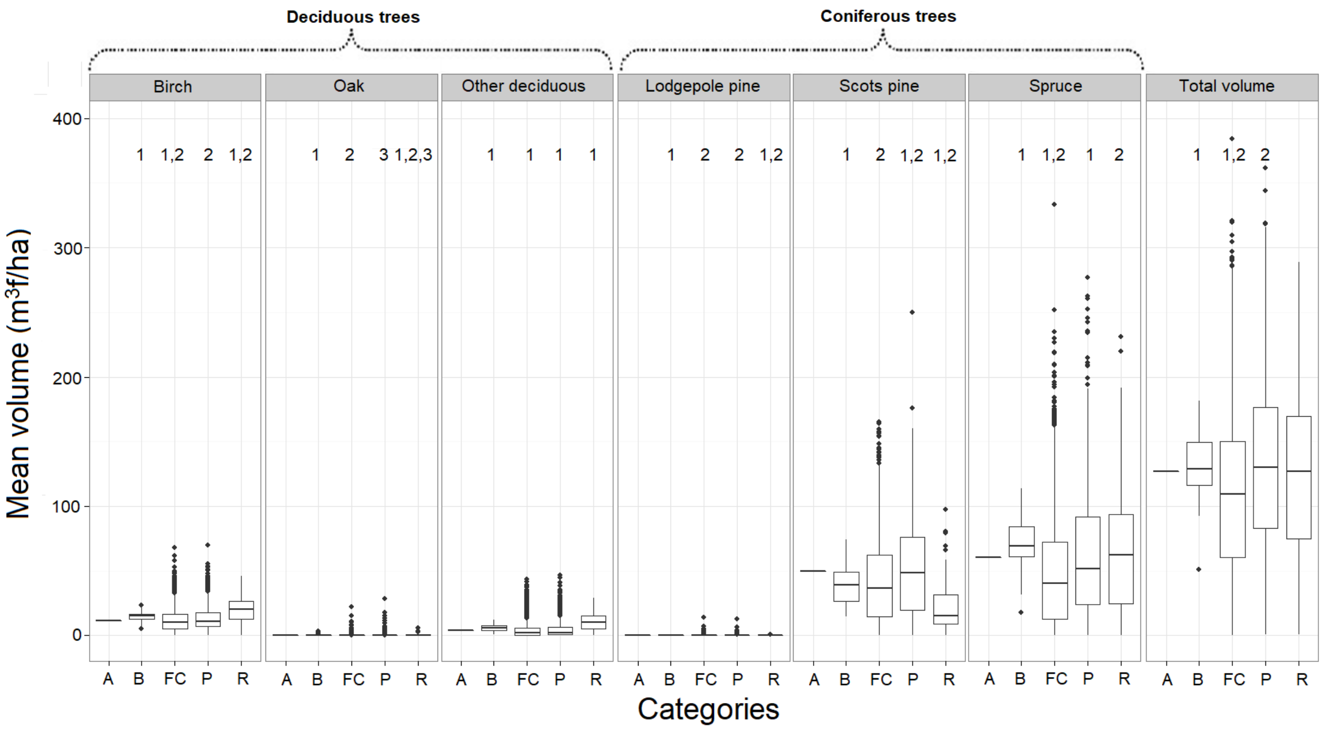

Figure 2. Boxplots of the mean volume in m^3f/ha (cubic meter standing volume per hectare) in 2000, per A: entire study region, B: buffer zones around sites selected for restoration, FC: forest company owned land, P: protected areas, R: sites selected for restoration. Equal numbers displayed above bars denote significance between categories ($p \leq 0.050$).

Concerning whether restoration sites contained older trees and more deciduous trees than the surrounding landscape before restoration; we found that before restoration the volume of all deciduous tree species was, on average, higher in the sites selected for restoration than in their accompanying buffer zones (oak: $t_{62} = 3.270$, $p = 0.002$, birch: $t_{62} = 5.117$, $p < 0.001$, 'other': $t_{62} = 6.395$, $p < 0.001$). However, in 22% of the cases, the mean volume of birch was lower in the restoration site than in its buffer zone. This was also the case in 25% and 19% of the sites for 'other deciduous trees' and oak, respectively. Prior to restoration, the average volume of deciduous trees was higher in sites selected for restoration (owned by the forest company) compared to the average of all areas owned by the forest company (oak: $t_{64} = 3.328$, $p < 0.001$, birch: $t_{65} = 6.368$, $p < 0.001$, 'other': $t_{65} = 6.799$, $p < 0.001$). But numerous stands owned by the forest company that were not selected for restoration had a higher average volume of deciduous trees than the restoration sites (21% of the stands for birch, 4% for 'other deciduous trees,' and <1% for oak). The average volume of all deciduous tree species in restoration sites was higher than the average for the study region (Figure 2).

The mean volumes of coniferous species before restoration were significantly lower in the sites selected for restoration than in the buffer zones, except for spruce (lodgepole pine: $t_{62} = -4.528$, $p < 0.001$, spruce: $t_{62} = -0.168$, $p = 0.867$, Scots pine: $t_{62} = -6.075$, $p < 0.001$).

The volume of spruce was higher in 41% of restoration sites than in their respective buffer zones prior to restoration. This was also the case for Scots pine and for lodgepole pine in 16% and 37% of the sites, respectively. The mean value of the two pine species was significantly lower in the restoration sites than in all the areas owned by the forest company (lodgepole pine: $t_{100} = -5.613$, $p < 0.001$, Scots pine: $t_{71} = -6.612$, $p < 0.001$). However, the average volume of spruce was significantly higher in the restoration sites than in all the other areas owned by the forest company ($t_{65} = 2.894$, $p = 0.005$). Prior to restoration, the mean age of the tree stands, including both coniferous and deciduous trees, in the restoration sites was significantly lower than in the buffer zones ($t_{62} = 2.476$, $p = 0.016$, Figure 3) but similar to that in the areas owned by the forest company ($t_{100} = 1.715$, $p = 0.090$).

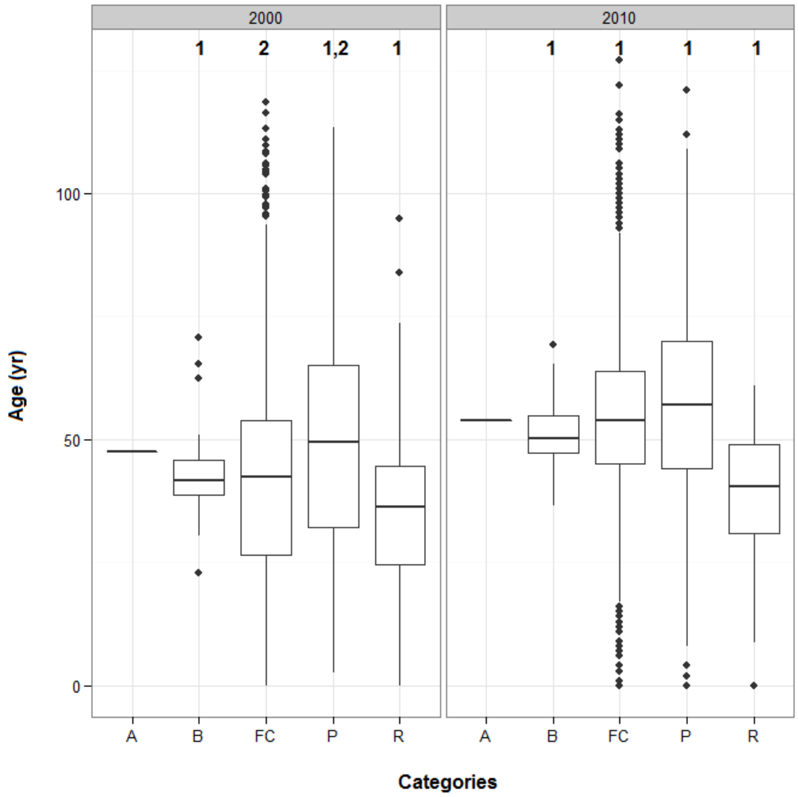

Figure 3. Boxplots of the mean age (in years) of the stands per A: entire study area, B: buffer zones around sites selected for restoration, FC: forest company owned land, P: protected areas, R: sites selected for restoration. Equal numbers displayed above bars denote significance between categories ($p \leq 0.050$).

3.2. Forest Composition after Restoration

Concerning the progress that had been made in creating a less dense forest that is less dominated by coniferous trees; we found that after restoration the average volume of 'other deciduous trees' (t62 = 4.930, $p < 0.001$) and oak (t62 = 4.244, $p < 0.001$) in the restored sites was significantly lower than before restoration (Figure 4). There was no significant change in birch (t62 = 1.088, $p = 0.281$), but the average volume of spruce significantly decreased (t62 = 2.350, $p = 0.022$). The volume of the two pine species significantly increased between the years 2000 and 2010 in restored sites (lodgepole pine: t62 = −2.165, $p = 0.034$, Scots pine: t62 = −3.863, $p < 0.001$). The total volume of trees in the sites did not significantly change (t62 = 1.111, $p = 0.271$). Three sites had been clear-cut between the years 2000 and 2010.

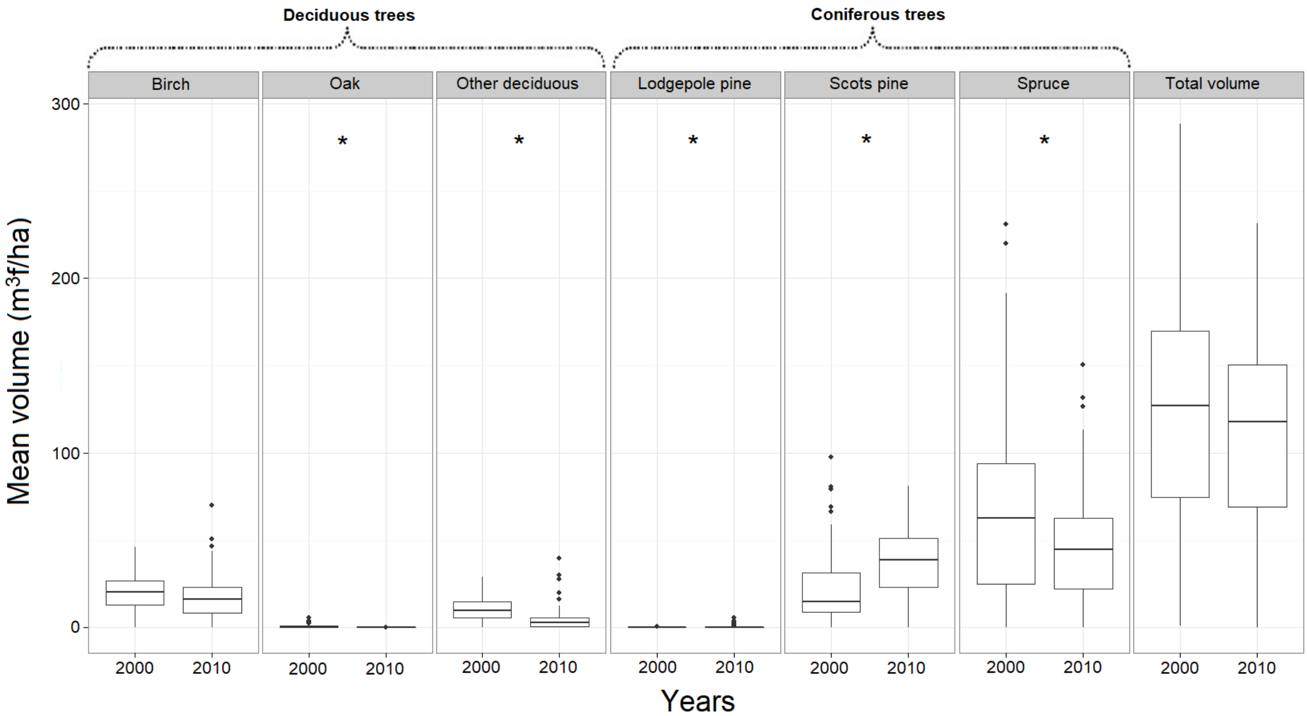

Figure 4. Boxplots of the mean volume in m^{3}f/ha (cubic meter standing volume per hectare) in the sites selected for restoration for each of the tree species and all of the species combined, compared between the years 2000 and 2010. * denotes significant differences ($p \leq 0.050$).

Focusing on the proportion of each tree species present in the restored sites, we found that spruce was, on average, the most dominant species both before and after restoration. However, after restoration the proportion of spruce in the restored sites was 8 percentage points lower than before restoration (t62 = 2.430, $p = 0.016$). The proportion of all deciduous species decreased as well: oak by 1 percentage point (t62 = 3.629, $p = 0.001$), birch by 4 percentage points (t62 = 2.822, $p = 0.006$), and 'other deciduous trees' by 7 percentage points (t62 = 5.360, $p < 0.001$). The two pine species became more dominant after restoration: lodgepole pine by <1 percentage points (t62 = −8.317, $p < 0.001$) and Scots pine by 19 percentage points (t62 = −2.484, $p = 0.016$).

Comparing the state of the restored sites in 2010 with that of the protected areas in the same year to assess the suitability of already established protected areas for the WBW (Figure 5), we found that the mean volumes of 'other deciduous trees' (t64 = 2.550, $p = 0.013$) and oak (t83 = 2.948, $p = 0.004$) were significantly higher in the restored sites than in the protected areas, whereas the mean volumes of spruce (t73 = −4.237, $p < 0.001$) and Scots pine (t77 = −9.061, $p < 0.001$) were significantly lower. Furthermore, the mean age of the tree stands was significantly higher in the protected areas than in the restored sites (t74 = 9.527, $p < 0.001$, Figure 3).

3.3. Landscape Analysis

Concerning whether the restoration occurred at a scale appropriate for the WBW; the analyses showed that in 2010, only 1% of the forested area in the study region had a high percentage of deciduous trees. Overlaying the study region with a 500 × 500 ha grid, none of the grid cells contained 20% high-deciduous forest, but there were three grid cells containing 10%. On average, 1% (se < 0.1%) of each 500 ha grid cell had a high percentage of deciduous trees. A density map, based on the percentage of deciduous trees in each 25 × 25 m grid, revealed that the area of the study region with the highest density of stands that had a high proportion of deciduous trees contained 11% high-deciduous forest (Figure 6). Figure 7 shows a scatterplot plotting each restored site by size, proximity to the nearest other restored site, and percentage of the site, including its buffer (representing 500ha), containing high-deciduous forest before restoration. The graph also shows which sites contain trees with an average age of 60 or older, determined by Virkkala et al. [13] as a threshold for forest age preferred by WBW. Based on this graph, it is clear that although several sites contain high-deciduous forest, are near other restored sites, or are of considerable size, for many sites this is not necessarily the case.

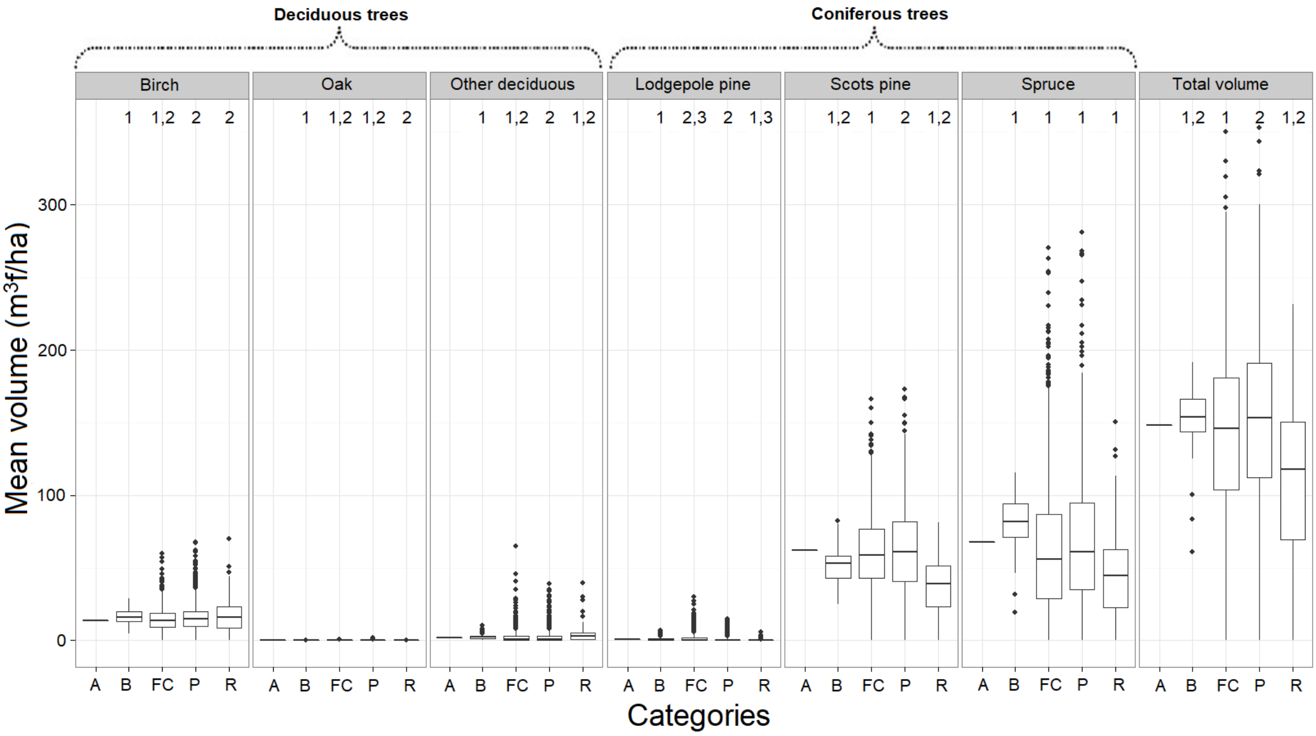

Figure 5. Boxplots of the mean volume in m3f/ha (cubic meter standing volume per hectare) in 2010, per A: entire study region, B: buffer zones around restored sites, FC: forest company owned land, P: protected areas, R: restored sites. Equal numbers displayed above bars denote significance between categories ($p \leq 0.050$).

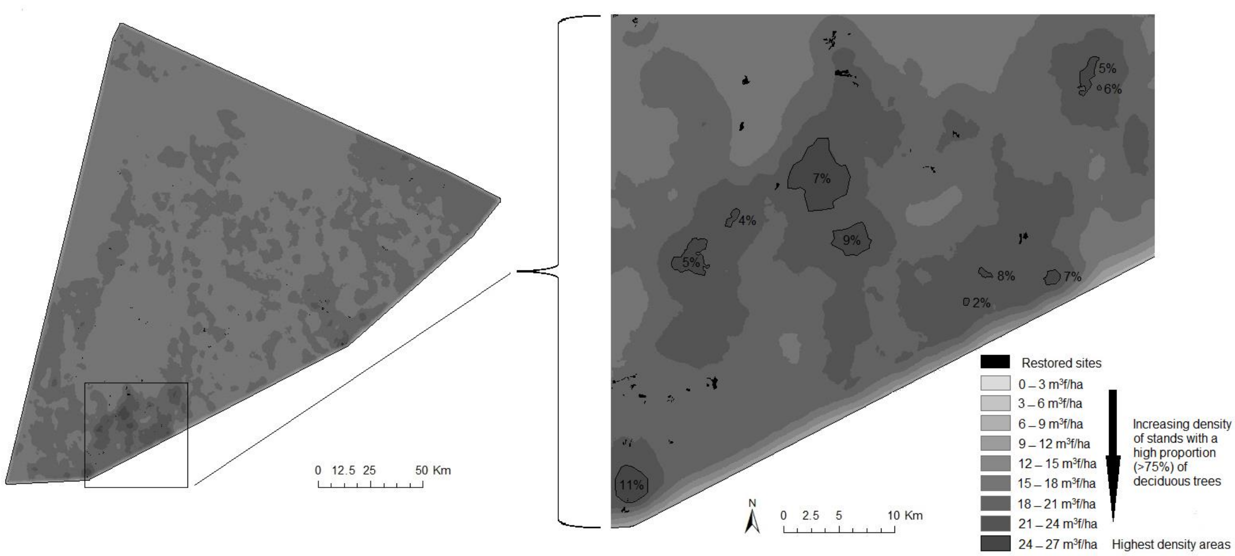

Figure 6. Density map showing (1) the areas with the highest density of stands with a high percentage of deciduous trees (>75%) and (2) locations of the restored sites for the entire study area and a portion of the study region with highest densities. The % values show the percentage of high-deciduous forest per 500 ha in that specific area.

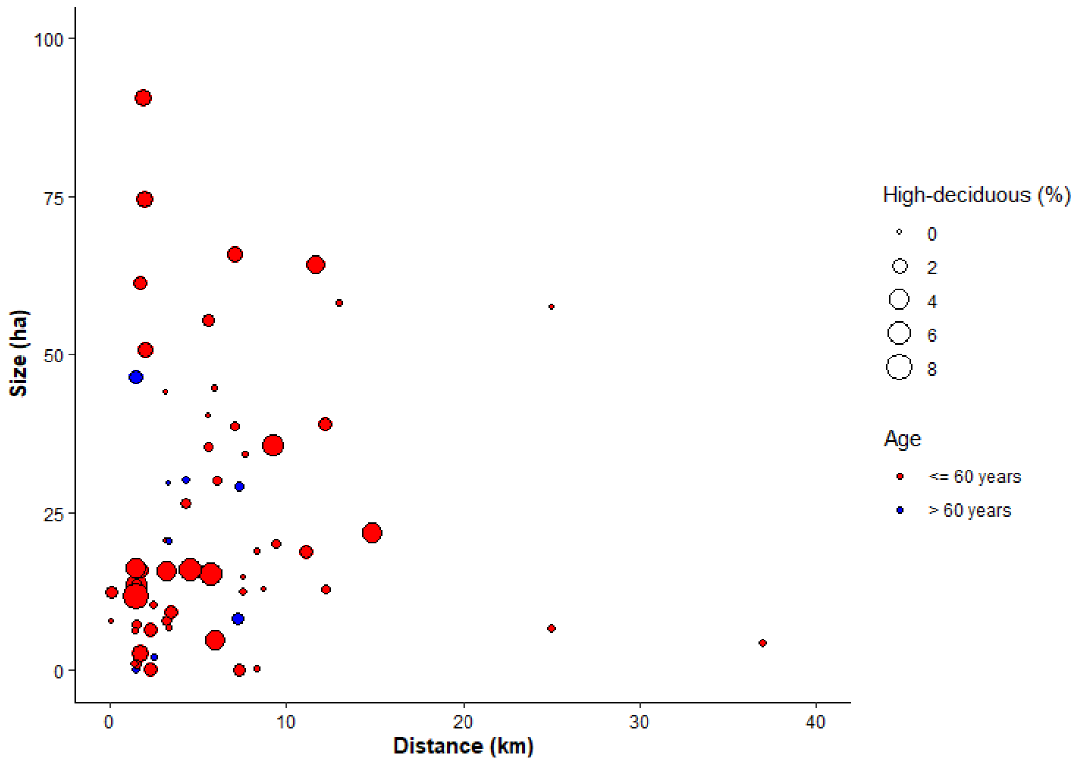

Figure 7. Scatterplot showing, for each restored site, the size, distance to the nearest other restored site, and the percentage of the site, including its buffer (representing 500 ha), containing high-deciduous forest before restoration. Blue dots indicate sites whose trees were, on average, older than 60 years. Red dots represent younger sites.

4. Discussion

In our case study, the ecologically best sites for restoration, meaning those sites that are likely to reach ideal conditions for the WBW the fastest, should (1) contain older and more deciduous trees than the surrounding landscape at the start of the project, and (2) be at a scale relevant for the WBW. Furthermore, restored sites should have lower tree density and be less dominated by coniferous trees after restoration if they are to sustain a healthy population of WBW. We found that, instead of being older, the stands in restoration sites were younger than in their accompanying buffer zones, the protected areas, and the study region as a whole, in addition to many other stands owned by the forest company. Although data on the average age per tree species were not available, the higher average age in non-restored sites was likely caused by old spruce and Scots pine trees (nearly) ready for harvesting. Because the elimination of coniferous trees may be beneficial to the WBW, it might have been advantageous to also restore some of these older sites because the forest company would make a profit, which could help pay for restoration practices. However, the average volume of all deciduous species was higher in the restored sites than in other areas owned by the forest company before restoration, but there were a number of areas with high average volumes of deciduous trees in sites owned by the forest company that were not selected for restoration. The interviews we conducted revealed that the motive of the company to take part in the WBW habitat restoration was to improve the company's environmental profile; the WBW would make their environmental efforts more concrete and 'marketable'. The company ecologist suggested in the interviews setting aside one hundred areas consisting of 100 ha each, a figure that was easy to market and showed that the company was serious about the campaign, for fifty years through voluntary nature protection agreements with the Swedish Forest Agency. The interviews further revealed that the sites were chosen primarily to ensure connectivity with former WBW habitats, and this geographical focus meant that the sites were mostly dominated by spruce. This plan was not successful because moose (*Alces alces* L.) ate the new shoots and because the restoration measures were not always conducted properly by the entrepreneurs, according to the interviews.

Prior to restoration, a considerable proportion of the restored sites had lower volumes of deciduous tree species than their buffer zones. Only about half of the land in the buffer zones was owned by the forest company, suggesting that coordination between different landowners might be advantageous in order to avoid fragmentation of suitable habitat. Unfortunately, detailed data on the volume of dead deciduous wood were not available; because the availability of ample dead deciduous wood (10 to 20 m^3 ha^{-1} [14]) is an important requirement for the WBW, the lack of these data may have affected the analyses to some extent. However, the average initial levels of dead deciduous wood were 0.9 m^3 ha^{-1} [25] in Värmland, the county in which the study region was located, and 1.8 m^3 ha^{-1} [25] in the whole of Sweden. Even if the initial levels of dead deciduous wood were locally higher than the average, we think it likely that initial levels were not high enough to meet the 10 to 20 m^3 ha^{-1} [18] required by the WBW. We therefore do not think site selection was driven by the initial level of dead deciduous wood, especially since the main objective of the restoration project was the creation of high levels of dead wood [15], which can be realized relatively easy and quick [26]. We therefore think that the potential effect on the analyses remains low.

In terms of creating less dense forest and eliminating coniferous trees to create forest dominated by deciduous trees, it appears that not much progress has been made during the course of the study. This lack of progress was confirmed in an interview with a forest company representative. It was also corroborated by a study from Blicharska et al. [27] who, amongst others, conducted interviews with actors involved in the WBW restoration in Sweden. Their findings revealed that the achievement of the targets set in the action plan was, during 2005–2008, much lower than planned. This was partly explained by lack of knowledge, data, experienced workers, and administrative flexibility [27]. However, the possible regeneration of deciduous trees after restoration has not been accounted for in our study since we used forest inventory data. Observations on site should take place to inventory saplings of deciduous trees. Interviews we conducted, however, also revealed that moose ate the new shoots, so regeneration of deciduous trees likely remained low. A study by Hämäläinen et al. [17] on how to maintain deciduous trees in territories of WBW found that in eastern Finland, the removal of spruce did benefit the regeneration of aspen, but not of birch. They therefore concluded that additional measures targeted at benefitting birch may be needed if we are to have successful populations of WBW [17].

The total volume of standing wood did not significantly change over the years, even though some restored sites were clear-cut. In addition, the volume of both pine species significantly increased rather than decreased. The proportion of spruce did decrease, but only by eight percentage points. This can be explained by the forest company's lack of focus on the restoration during the time period studied because the land containing restoration sites was sold in 2004. As per the interviews, once a new forest company took over, the work was slowed further, as it had to start anew in organizing its environmental work. We can only speculate about whether there were additional unspoken reasons, such as logistical problems or that the coniferous trees that needed to be removed had not yet reached the age at which they are economically suitable for harvesting, that contributed to the lack of restoration results. Modelling studies reveal that set goals may, however, be reached if appropriate management strategies are chosen, the continuity of the management is safeguarded, and the scale of management is appropriate [26,28].

Based on forest inventory data in 2010, not enough suitable forest is available for the WBW to sustain a healthy population in the study region. The aim stipulated in the project plan for the WBW was to have 100 ha of forest with a high percentage of deciduous trees (> 75%) per 500 ha [13]. We were unable to identify a forested landscape (500 ha) with such a large area of stands with a high proportion of deciduous trees based on the forest inventory data. There were a number of landscapes with about 50 suitable hectares, which may be sufficient to sustain a pair of WBWs according to Aulén [13] and Carlson [19].

However, more restored sites are needed to sustain a healthy population of WBWs. For example, common management practices, such as thinning and clear-cutting, are ongoing in the immediate surroundings of many of the restored sites. It is conceivable that restored sites might become isolated islands. Restoring at an inappropriate scale may be a waste of time, effort, and economic resources when the habitat requirements of the species are not met. The forest company's plan was to connect former WBW habitats by corridors. Unfortunately, as stated above, the interviews revealed that restoration was impeded by the land sale and many mistakes were made by subcontractors, negatively affecting the outcomes.

Trees take a long time to grow. The initial lack of sufficient deciduous trees in the study region, especially old ones, severely limits the possibility of creating suitable WBW habitat quickly. It is highly likely that habitat suiting the WBW to such an extent that the species can maintain itself will not be available in the study region for several decades, especially because existing protected areas did not specifically target the WBW's habitat needs [15] and did not provide optimal habitat for the species. However, the question is whether the current restoration plans will still be in effect and prioritized in a future society with different views, opinions, and economic situations. Although the action plan contains a long-term goal of restoring through the year 2070 [15], the trend has already shifted from mandatory to voluntary set-aside of forest land within the action plan's time frame as per the interviews. For the success of the WBW project, continuity is important because the ecosystem in the restored sites is currently not self-sustaining. For example, spruce from managed forest adjacent to restored sites regenerates at restored sites. If the project plans and goals are abandoned within the next few decades, the forest will likely revert to its pre-restoration state.

Reliable land cover and habitat inventory data can provide information about spatial and temporal habitat composition and can therefore guide restoration projects in selecting appropriate sites to restore [4,29]. The analysis of the forest inventory data suggests that restoration site selection by the forest company was not optimal, given the age and initial tree species composition. However, interpretation and analysis of forest inventory data is based on the assumption that they are reliable. There may be some uncertainty and unreliability in the forest inventory data we used due to miscalculations and misidentification. Therefore, due to a lack of ground truthing, the results should be interpreted with caution. Based on our results, the major driver in the site selection was the plan to connect former WBW habitats through corridors. Restoration was delayed because of the land sale and because of mistakes by the subcontractors conducting the actual restoration measures, because, as revealed by the interviews, coordination with the Forest Agency and follow-up by the forest company was insufficient. Whether and how fast ecological restoration will occur depends not only on initial plans and restoration activities, but also on what is organizationally feasible. This factor was also pointed out in the only external evaluation of the WBW project that we are aware of [30], suggesting that coordination between different stakeholders could be improved. Because of data limitations, our study only examined site selection by one of the forest companies involved. In order to draw conclusions as to why site selection and distribution were not optimal with regard to the target species' habitat needs, both quantitative and qualitative data from other stakeholders are needed. The results raise questions about whether, and when, organizational, and/or possibly economic and logistical factors overran ecological concerns in practice. A study by Steinwall [31] suggests there have been conflicts surrounding the action plans for the WBW restoration, which may have had ecological consequences. Therefore, more studies are needed to look into the motivations of private companies that take part in restoration efforts, with the potential of finding possible synergies that could reinforce restoration efforts. This study was a first step towards finding evaluation measures to assess the ecological appropriateness of restoration site selection, which may aid restoration projects worldwide.

5. Conclusions

From our study we can draw up the following implications for practice; (1) Reliable habitat inventory data may be useful for large scale follow-up of restoration practices; (2) habitat requirements of target species need to be taken into account during site selection; (3) site selection needs to be coordinated between restoration experts, authorities, and land owners; (4) evaluations of restoration activities are needed to ensure actual restoration matches goals and habitat needs and; (5) more awareness is needed about what motivates landowners and private companies involved in restoration in order to promote coordination.

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Data Availability Statement: Restrictions apply to the availability of data concerning the locations of forest stands restored for white-backed woodpeckers. These data were obtained from a private forest company and are available from the authors only with the permission of the private forest company. Data on the location of protected areas are freely available from the World Database on Protected Areas (WDPA: http://www.wdpa.org/ accessed on 1 February 2013). Forest inventory data are freely available from the Swedish University of Agricultural Sciences (http://skogskarta.slu.se accessed on 1 February 2013). No new data were created or analyzed in this study.

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