Education and advice contribute to increased density of broadleaved conservation trees, but not saplings, in young forest in Sweden

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ABSTRACT

The effectiveness of different conservation policies is debated, but the policies are rarely evaluated quantitatively. A voluntary or ‘soft’ policy based mainly on education provides information about ecosystems and effects of land use, to encourage conservation action. Swedish forestry relies mainly on soft policy, with substantial resources for education and advice to more than 200,000 forest owners, while legal regulation is weak. Increased retention of broadleaved trees at clear-cutting, with environmental benefits in the conifer-dominated forestry, is important in the policy. We used the Swedish National Forest Inventory to analyse this policy for young forests in southern Sweden. Between 1983–1987 and 1998–2002 the policy had no positive effect on saplings (1.3 m tall to 4.9 cm dbh) of birch, oak, beech and other species that mostly decreased in density, due to planting of conifers and browsing by ungulates. However, broadleaved conservation trees (≥15 cm dbh) increased in density, e.g. to about one oak and six birches per ha in young coniferous forest in 1998–2002. The relative increase in density was higher for large (≥20 cm dbh) than for small trees (15–20 cm dbh). The density of conservation trees was higher on forestland of high than of low productivity. Thus, the soft conservation policy did not influence regeneration of saplings in this type of forestry system, but large broadleaved trees were increasingly saved at ‘clear-cuttings’. Advice and educational programmes probably contributed to this result. A continued increase in conservation trees at harvest may require economical support to forest owners.

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1. Introduction

The importance of sustainable land use is increasingly emphasized. Knowledge is scant or lacking, however, on the effectiveness of different environmental policies and strategies (Robinson, 2006). Wynne (1998) discussed four alternative or complementary policy tools: (1) education (motivation through understanding), (2) exhortation/persuasion (persuasion through advocacy), (3) economic instruments (persuasion through money) and (4) legal instruments (control by law). These alternatives have advantages and disadvantages (Wynne, 1998) but for forestry there are few empirical studies evaluating what can be achieved by any single policy (see, e.g. Lämas and Fries, 1995; Knight et al., 2006; Robinson, 2006). Here we analyse voluntary, or what we will refer to as ‘soft’ government conservation policy for forestry, with respect to its effect on densities of trees and saplings for conservation purposes (soft includes Wynne’s policy tools type 1 and 2, but also aspects of type 4, depending on how laws are implemented, see below).

In Sweden, Europe and elsewhere, even-aged conifer stands are managed in a form of forestry where clear-cutting and plantations predominate. Such forestry has disadvantages, e.g. low species diversity in stands (Hunter, 1999; Nilsson et al., 2001), acidification of soils, and susceptibility to wind throw, forest pests, and global warming (Sverdrup and Stjernquist, 2002; Götmark et al., 2005a). In the temperate zone of southern Sweden, a ‘natural’ forest would contain a high proportion (probably >50%) of broadleaved deciduous trees (Lindbladh et al., 2000), while currently more than 80% of the forest wood biomass in the area consists of conifers. In this study, we investigate the environmental considerations in Swedish forestry, based on a conservation policy from the 1980s to about 2000 that encouraged increased retention of broadleaved trees.

We focus on young forests after ‘clear-cutting’ and the early regeneration stages (see below) that could have been influenced by the policy. Using long-term systematically collected data from the Swedish National Forest Inventory (NFI), we compare densities of trees and saplings of broadleaved trees before and after the new policy had been implemented. Saved trees were related to land...
productivity, and analysed by size classes. We did not analyse dead wood, another important component for biodiversity (e.g. Hunter, 1999), and the focus of earlier studies (e.g. Fridman and Walheim, 2000; SYF, 2007). Live trees are of interest for several reasons, and saving them is more costly than saving dead wood. Forest certification schemes (Leslie, 2004) are not considered here, as they were not common among the forest owners in the study area at the time (see Section 5). We first describe the soft policy in Swedish forestry to show its extensive approach and its parts.

2. Background: development of a soft governmental policy in Swedish forestry

Forestry based on conifers has long tradition in Sweden (more than 100 years). Starting in the 1950s, a combination of reduction of broadleaves, conifer plantations, even-aged stands, and clear-cutting was strongly implemented (Ekelund and Hamilton, 2001). After public debate about such forestry in the 1970s (Eckerberg, 1988; Ekelund and Hamilton, 2001), the Forestry Act of 1979 stated that landscape (i.e. aesthetic) and biodiversity values must be considered, by retention of single trees, small groups of trees, and dead wood at harvest. Eckerberg (1988) investigated this law and found that in most stands studied old and dead trees valuable for flora and fauna were usually felled, while some trees close to roads and inhabited areas were not felled, i.e. mainly aesthetic aspects were considered.

From the early 1980s onwards, the negative effects of short-rotation conifer forestry for wildlife led to focus on remnant seminatural habitats or stands (Bush, 2005). In the 1990s, the state financed a large inventory on private land of woodland key habitats, WKHs (SFA, 1999a; Götmark and Thorell, 2003). Currently, there are 52,000 WKHs, on average 3 ha in size (SYF, 2007), and defined as having biodiversity value and potential for red-listed species. Also, state-financed education for environmental considerations in forestry started, for forest officials, forest owners and forest workers, organized by the forestry boards. Between 1986 and 1988, many of them joined classes on general forest ecology and ‘site adapted forestry’ (Lundmark, 1987, 1989). Then began a huge education effort: between 1989 and 1993 about 100,000 persons participated in more than 4300 classes based on the book ‘Richer forest’ (SFA, 1990), which was considered a great success (Klasson et al., 1992). Of more than 65,000 persons, 75% were private forest owners; and of all forest workers in the country at least 70–80% participated in the education, as did officials in the major companies. From 1991, staff from the forestry boards participated in university courses at 10 sites in Sweden to enhance their skills in conservation aspects, education that was considered successful (Andersson and Danielsson, 1997). Later, each of the 63 board districts had at least one official responsible for the conservation work. The education efforts included nature conservation and considerations, as well as silviculture based on conifers and to some extent broadleaves.

From 1994, a new Forestry Act stated that forestland “shall be managed in such a way as to provide a valuable yield and at the same time preserve biodiversity”. Thus, there are two equal goals: wood production and biodiversity (Lämås and Fries, 1995; Bush, 2005). In what follows, we focus on environmental considerations on land used for forestry. Forest protection through national parks and nature reserves is based on the Environmental Code and other authorities (SEPA, Swedish Environmental Protection Agency and the County Administrations). Less than 3% of the productive forestland (wood volume production >1 m³ per ha per year) in the study area is under such legal protection. Therefore, environmental considerations on the remaining 97% of forestland are of interest for conservation work.

The Forestry Act of 1994 includes recommendations, as follows. (1) Small stands of 0.5–1 ha may be set aside for conservation purposes. However, this and other advice below are not applicable if “the interventions seriously interfere with on-going land use”, which is forestry. In such cases protection and economic compensation to forest owner are possible, e.g. through SEPA. (2) On land producing <1 m³ wood per ha per year, e.g. wetland or land dominated by bedrock, and larger than 0.1 ha, no trees or only occasional trees can be cut. (3) Buffer zones/stripes (width not specified) with trees and bushes bordering, e.g. streams, wetland, bedrock, and agricultural land, shall be retained during cutting. (4) At cutting, valuable bushes and trees, and groups of trees, shall be retained for biodiversity and cultural values (number or density of trees not specified). Most of these recommendations were included already in the 1979 Forestry Act.

When cutting forest stands >0.5 ha (i.e. at clear-cutting or nearly so, usually of several ha), forest owners need to apply for permission from forestry boards, and to specify environmental considerations on forms (Uliczka, 2003). Board officials may inspect stands before cutting, for advice to the forest owner, but rarely after cutting. Very few cases of insufficient considerations have been taken to court. In southern Sweden, when forestry boards assessed a sample of stands before and after cutting, they found that in 25% of cases studied (N >100), the considerations taken were insufficient or less than would be required by the Forestry Act. The saved trees were more often related to aesthetic aspects or to low-productive land than to biodiversity aspects (de Jong, 1998).

Skogs-Eko, a quarterly magazine from the SFA, contains much forestry and conservation information and is distributed free to about 270,000 Swedish forest owners. A new education campaign, “Greener Forest” (SFA, 1999b) between 1999 and 2001 also included conservation material, and in total 350,000 participants (121,000 persons from the forestry sector). We conclude that for a 21-year period (1979–2000) the Swedish approach to conservation on land used for forestry represents soft policy, relying mainly on information, education, and advice to forest owners. Essentially, the Forestry Act is not used for the kind of legal control described by Wynne (1998), but for ‘legal advice’. General statements and recommendations in Forestry Acts are not the same as control, and need to be evaluated in each individual case study.

3. Materials and methods

3.1. Study area and tree species

The study area in southern Sweden (Fig. 1) comprises about 125,000 km². It is a transition zone between the boreal forest in the central and northern parts of Sweden and the temperate forest of continental Europe (Gustafsson and Ahlén, 1996; Nilsson, 1997). The study area is often divided into biogeographic parts, but to obtain large samples we pooled these parts. The study area coincides with the approximate northern limit of the distribution of oak and several other broadleaved (hardwood) trees.

The area is lowland less than 300 m above sea level, glaciated about 10,000 years ago, mostly with till on granite or gneiss. The bedrock is sometimes exposed, in a mosaic landscape of forest, small fields, lakes, and wetlands. Some larger agricultural areas contain more fertile soils. For climate data, see maps at www.smhi.se (Swedish Meteorological and Hydrological Institute). Several thousand years ago, oaks (Quercus robur, Quercus petraea), small-leaved lime (Tilia cordata), hazel (Corylus avellana) and other species dominated the forests, but human influence favoured conifers, especially after 1850 (Lindblad et al., 2000). Presently, most of the forest in the study area is less than 50 years old (SYF, 2007). About 10% of the forest is more than 100 years. Based on total estimated wood volume, Table 1 gives volume percentages for tree species in the study area. Norway spruce and Scots pine predominate, while birches, aspen and oaks are the most common
deciduous broadleaved trees (for Latin names, see Table 1). The forest is mostly private and about 200,000 forest owners own 70% of the total forestland (SYF, 2007). Companies, state, church, municipalities, and others own the remaining forest.

In Swedish forest legislation, 13 species of broadleaved hardwood trees are ‘noble’ (historical term) and considered important for wood production (Löf, 2001) and especially for biodiversity values (Gustafsson and Ahlén, 1996; Nilsson et al., 2001). Four of the noble species are very rare. Nine noble species are more common: oaks (two species), beech, common ash, wych elm, small-leaved lime, Norway maple, hornbeam, and cherry/gean (see Table 1). In the NFI, records were available for oaks (two ecologically and morphologically similar species, pooled) and for beech, while Fraxinus, Tilia and Ulmus are pooled in the NFI as ‘other noble trees’. The two species of birch, which are also relatively similar, were pooled. We analysed birches, oaks, beech, ‘other noble’, ‘other broadleaves’ and conifers as explained below (see also Table 1).

We included forest producing $\geq 1$ m$^3$ wood per ha per year (Swedish definition of ‘forestland’). This means that we excluded, e.g., the low-productive xeric and wet forest types. Forestland in national parks and nature reserves was also excluded (covering less than 3% of the forestland in study area). We analysed densities of saplings of broadleaves (1.3 m tall to 4.9 cm dbh, i.e. diameter at 1.3 m), of interest for forest regeneration. We also analysed densities of trees 15 cm or more in dbh (below referred to as ‘trees’) to focus on conservation trees retained at harvest (SFA, 2002; SYF, 2007, p. 95). These trees may also be used as seed/shelter trees in forestry (see below). For trees, ‘other noble trees’ were relatively few and not meaningful to analyse statistically. We analysed trees of birches, oaks, beech, and ‘other broadleaves’ (including ‘other noble’ but dominated by aspen and alder; Table 1). Also coniferous trees (pooled) were analysed, for comparisons with broadleaved trees.

3.2. The Swedish National Forest Inventory (NFI) and data analyses

The NFI was established in 1923 and the present design introduced in 1983 (Ranneby et al., 1987). Tree, stand, site, and management history data are recorded by field teams (Lindroth, 1995). The inventory covers the whole of Sweden with a stratified systematic cluster sample using partial replacement. Field work is performed on circular plots (with radius 10 or 7 m depending on plot type) clustered in a ‘tract’ of square or rectangular shape. Certain measurements, such as forest type, height and canopy closure are made with plot radius of 20 m. The permanent plots are inventoried in 5–10 year intervals. In general, for acceptable precision, estimates require data from a 5-year period.

The analyses are based on all NFI data from plots in the study area during two periods, 1983–1987 (referred to below as ‘1985’) and 1998–2002 (referred to as ‘2000’). Between 1956 and 1984,
retention of trees at stand harvest decreased markedly in Sweden, from on average about 35 m$^3$ to 5 m$^3$ of wood per ha [SFA, 2002, pp. 49–50, based on NFI data]. Therefore, 1983–1987 is a suitable reference period for analyses of the effects of the soft policy. Algorithms for estimation and for standard error of estimates are described in Fridman and Walheim (2000). The total number of plots was lower in 2000 than in 1985 due to financial limitations, but there were many plots in total (Table 2). For the two periods pooled, the total numbers of saplings analysed were 173,540 birches, 17,707 oaks, 4369 beech and 4698 other noble species; the total numbers of trees were 25,287 birches, 5005 oaks, 3729 beech and 12,725 other broadleaves.

We used NFI data for saplings and trees from young (low) forest, <7 m in height, implying that mean forest height in the sample was much lower. Due to young age of forest, all trees 15 cm or more in dbh were considered as conservation trees, retained after the harvest. For a detailed study of regeneration ecology of broadleaved saplings in the study area, based on the NFI, see Götmark et al. (2005a). Forest types were based on the dominating tree species, and defined by proportion of the basal area (see Table 2). The area and number of plots of forest types dominated by broadleaves were small compared to coniferous forest types (Table 2) and therefore the number of plots of forest types dominated by broadleaves was defined as follows. (1) Light browsing (growth form not obviously affected), (2) moderate browsing (growth form weakly to moderately affected), (3) heavy browsing (growth form heavily affected) (see Hörnberg, 2001 for detailed description). NFI data from young (<7 m) forest was used, and we analysed (1) birch and (2) other broadleaves (ash, aspen, oak, rowan, and Salix spp.). We pooled all forest types in these analyses.

Since the NFI is based on sampling with partial replacement, the estimates are quite complex (see Fridman and Walheim, 2000). Although systematic sampling is used in the NFI, for this study standard error (S.E.) was estimated assuming random sampling of

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### Table 2

Number of plots used from the National Forest Inventory (NFI); for plot sizes, see text (smaller samples 1998–2002 due to financial limitations for NFI in Sweden)

<table>
<thead>
<tr>
<th>Forest type</th>
<th>No. of plots in young (&lt;7 m) forest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spruce</td>
<td>2836</td>
</tr>
<tr>
<td>Pine</td>
<td>1918</td>
</tr>
<tr>
<td>Spruce/pine</td>
<td>266</td>
</tr>
<tr>
<td>Mixed conifer/broadleaved</td>
<td>75</td>
</tr>
<tr>
<td>Birch</td>
<td>134</td>
</tr>
<tr>
<td>Noble</td>
<td>15</td>
</tr>
<tr>
<td>Other broadleaved</td>
<td>57</td>
</tr>
</tbody>
</table>

* Spruce, pine and spruce/pine: basal area of species >60% of total basal area; birch, noble, and other broadleaved: basal area of species >70% of total basal area; mixed coniferous/broadleaved is remaining forest. In addition for ‘noble’ forest: at least 50% of the total volume must consists of oaks, beech, common ash, lime, Norway maple, hornbeam, wych elm or cherry (official definition).
tracts (which may overestimate the true S.E.). Confidence intervals (95%) for estimates were based on S.E. and significance of differences ($P < 0.05$) was based on the confidence intervals. Below, for some estimates we do not give confidence intervals, as they are time-consuming to construct and as we judged they were not needed (for Figs. 3, 5, and 6 we judged that it was sufficient to show trends).

4. Results

4.1. Densities of broadleaved saplings and trees

In 1985 and 2000, coniferous forest dominated the stands, 87 and 84%, respectively (Table 3) and young forest made up 21–22% of all forest (Table 3). For young forest, Table 4 summarizes changes in sapling densities of broadleaves in spruce forest and the broad-leaved forest types (pooled); the densities generally decreased, more or less, from 1985 to 2000, except for other noble species and oaks in young broadleaved forest (increases). For the oaks and beech, we found statistically significant decline in sapling density in spruce and mixed coniferous forest, while (non-significant) declines were recorded for birches in several forest types (see Fig. 2 for densities and data for each forest type). For oaks and beech, we estimated that the total sapling populations in young forest decreased by about 50% from 1985 to 2000.

Planting of seedlings was the major form of forest regeneration in both 1985 and 2000. Of the total estimated planted area, broadleaves were used for 0.2% (100 ha) in 1985 and 1.6% (700 ha) in 2000; and conifers on 99.6 and 98.4%, respectively (non-significant changes). Browsing by ungulates increased in young forest between 1984 and 2001 (Fig. 3). Browsing was generally

![Fig. 3. Changes in estimated proportion of forestland with no browsing and three levels of browsing intensity, based on assessment of accumulated browsing in each plot. Data for young forest and 1983–2002, shown as 3-year running averages (no records taken in plots 1988–1992), with all forest types pooled.](image)

![Fig. 4. Tree densities (stems per ha; $\geq 15$ cm dbh, diameter at 1.3 m) of oaks, beeches, birches, and other broadleaves 1985 (1983–1987) and 2000 (1998–2002) in conifer-dominated and broadleaved-dominated young forest (mean tree height <7 m). Different letters over bars indicate statistically significant differences between years (periods), based on 95% confidence intervals. Note that ‘other broadleaves’ include other noble trees as well as species such as aspen.](image)

Table 3

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway spruce</td>
<td>45</td>
<td>43</td>
</tr>
<tr>
<td>Pine forest</td>
<td>32</td>
<td>31</td>
</tr>
<tr>
<td>Mixed spruce/pine forest</td>
<td>8.9</td>
<td>9.5</td>
</tr>
<tr>
<td>Birch forest</td>
<td>4.4</td>
<td>6.0</td>
</tr>
<tr>
<td>Nobleb broadleaved forest</td>
<td>2.3</td>
<td>2.9</td>
</tr>
<tr>
<td>Others broadleaved forestc</td>
<td>3.4</td>
<td>3.7</td>
</tr>
<tr>
<td>Coniferous/broadleaved (mixed)</td>
<td>3.4</td>
<td>3.6</td>
</tr>
<tr>
<td>Young forest (&lt;7 m)</td>
<td>22</td>
<td>21</td>
</tr>
<tr>
<td>High forest (&gt;7 m)</td>
<td>78</td>
<td>79</td>
</tr>
<tr>
<td>Total forest area, 1000 ha</td>
<td>7296 (100)</td>
<td>7284 (100)</td>
</tr>
</tbody>
</table>

a See Fridman and Wallheim (2000) for formula and calculation of forest area.  
b See Table 1 for definitions, based on basal area of tree species.  
c Consisted mainly of aspen, alder, rowan and sallow.
heavier on the group of other broadleaves than on the birches (Fig. 3).

For conservation trees (≥15 cm dbh) we analysed changes in coniferous forest types and broadleaved/mixed forest types (young forests). In coniferous forest, the density of oak trees increased by 120% between 1985 and 2000 (Fig. 4). Increase (by 45%) was also recorded for birches, and (non-significant) increases for beech, and other broadleaved tree species (dominated by aspen and alder; includes also ‘other nobles’). In broadleaved/mixed forest, tree densities also increased, though not significantly for oak and beech (Fig. 4).

4.2. Coniferous versus broadleaved trees

Here and in the next section we compare densities of conservation trees of conifers and broadleaves in young forest in 1985 and 2000. In coniferous forest, the densities increased for both broadleaves (52.4%) and conifers (50.8%; Table 5). Thus, the proportional increase was slightly higher for broadleaves than for conifers, but the absolute increase in density was almost twice as high for conifers (Table 5). In broadleaved forest, broadleaved and conifer conservation trees increased, especially the broadleaves (Table 5).

4.3. Tree size and land productivity

In the young forest, many broadleaved conservation trees belonged to the size class 15–19.9 cm, and they increased between 1985 and 2000, by about 24% (Fig. 5). The broadleaved trees in the larger size classes also increased, with larger relative increases, about 75–150% (Fig. 5). For conifers (Fig. 5), the smallest, and in particular largest size class increased – probably due to the use of large trees as seed/shelter trees (see Section 5).

The density of broadleaved conservation trees was lowest on forestland of low productivity, and highest on land of high productivity (Fig. 6). Moreover, the increases in tree density from 1985 to 2000 were highest on forestland of intermediate and high productivity (Fig. 6).

5. Discussion

5.1. Changes in sapling densities

For saplings, ‘other noble broadleaves’ increased in density between 1985 and 2000, but these trees were not common. We found no increase in birch density, and the oak saplings decreased. Many seedlings and saplings of broadleaves are removed during pre-commercial and commercial thinning, but changes in thinning practise probably do not explain decreased sapling density (NFI, unpublished data). Continued planting (and natural regeneration) of conifers on clear-cuts, and increased browsing pressure may explain declines or tendencies for decline in birch, oak and beech saplings in the young forest. In the study area in the 1990s, unregulated densities were high, about 10–15 moose Alces alces and about 100–200 roe deer Capreolus capreolus per 1000 ha (data from the Swedish Association for Hunting and Wildlife Management). For oak (possibly also beech) seedlings, browsing may retard or stop height growth (Kullberg and Bergström, 2001; Götmark et al., 2005b and references therein). To some extent, birch may also be disfavoured by browsing. Other noble broadleaved trees were mainly shade-tolerant species such as ash, that grow well in relatively dark forests and are less sensitive to browsing than oak (Götmark et al., 2005a,b).

Table 5

<table>
<thead>
<tr>
<th>Forest type</th>
<th>Mean no. of trees per ha and change in density (and percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1985 2000 Change (%)</td>
</tr>
<tr>
<td>Coniferous forest</td>
<td>Broadleaves 6.3 9.66^b +3.3 (52) 12.2 18.4^b +6.2 (51)</td>
</tr>
<tr>
<td></td>
<td>Conifers 12.7 20.7^b +8.0 (63) 11.4 15.5^b +4.1 (36)</td>
</tr>
<tr>
<td>Broadleaved forest</td>
<td>Broadleaves 12.7 20.7^b +8.0 (63) 11.4 15.5^b +4.1 (36)</td>
</tr>
</tbody>
</table>

a Trees ≥15 cm dbh (diameter at 1.3 m), saved at harvest in the forest type.

^b Significant increase (*) in density from 1985 to 2000 based on 95% confidence intervals.
Thus, the soft policy did not lead to increased sapling densities of broadleaves. Nearly all forest owners are aware of the browsing by moose and deer, and they could have fenced plantations or increased their hunting pressure. However, hunting is popular as recreation among forest owners and this contributes to a relatively high tolerance level to browsing damages (Sverdrup and Stjernquist, 2002).

5.2. Changes in tree densities

Most of the young forest analysed had been harvested before the survey periods, i.e. about 1973–1983 and 1988–1998. In contrast to saplings, retained trees of broadleaves increased in density between 1985 and 2000. The density of coniferous trees also increased. In young production forest, trees of both types may be conservation trees or seed and shelter trees (later mostly harvested). The extent of the two types of retention is difficult to estimate, but data from the forestry boards (1998–2000) suggest that 77% of the conifers and 8% of the broadleaves were seed or shelter trees (Table 5.15 in SYF, 2007, volume data for Sweden). Of the coniferous trees, 68% (1985) and 70% (2000) were pines that unlike spruces often are used as seed/shelter trees. Many of these pine trees will probably be harvested when the regeneration is secured, unlike spruce and broadleaves that more likely will be left and serve ecosystem, biodiversity, and aesthetic functions. At present, most trees in the young forest are too small to be valuable for rare and demanding species that use trees. It is encouraging in a conservation context that most trees were saved on forestland of intermediate and high productivity, a type of land that is generally under-represented in the forest reserve system in Sweden and elsewhere (Fridman, 2000; Anon., 2006).

In young broadleaved forest, conservation tree densities were higher than in young conifer forest, and also increased during the period. The area of broadleaved forest types was small and these stands may not be much used for wood production (possibly of lower productivity, or successional habitat on abandoned agricultural land).

5.3. Evaluation of changes and the soft policy

For broadleaved trees the increased density was probably mainly a long-term result of the Swedish soft conservation policy, and especially the education efforts. Possibly, the existence of a law per se, although not enforced, could contribute to the increased tree densities. But education and changing views about the value of cultural land).

In contrast to the soft policy, for forest protection through reserves there are national quantitative area goals, evaluated regularly (EOC, 2007). We suggest integration between the forest reserve program and the mainly voluntary soft policy, including studies of whether small units such as saved trees could act as links or stepping stones between units of intermediate size (WKHs, about 1–5 ha) and larger units (reserves, about 25–2500 ha). Also, the soft policy should be evaluated economically (Naidoo et al., 2006). Payment for saved trees to forest owners should be considered. For young coniferous forest in the study area, one may estimate the wood value of the increase in birch (2000 minus 1985) at 106 million SEK (15 million US dollar) based on the 2007 market value. As saved trees grow larger, they will increasingly compete with planted seedlings (Elfving and Jakobsson, 2006). Presumably, many of the ‘saved’ trees 1985 were later cut down (or subject to wind throw), since tree diameters overall were quite similar in 1985 and 2000. Economical support to forest owners for conservation management may be given in Sweden by 50-year civil agreement, but only as a conservation option for the small WKH patches and not for saved trees in production forest. In the “Swedish model” for forest protection and considerations in forestry (Terstad, 1999; EOC, 2007), substantial voluntary set-asides of valuable stands are assumed (>50% of the conservation forest area goal for 2020). The future of this model is uncertain, although Ask and Carlsson (2000) found that some forest owners avoid cutting in parts of their forests.

Forest certification (Leslie, 2004) seems to be driven mainly by the market, although it includes aspects of soft policies. Certification could only marginally have influenced the results reported here. Non-industrial private forest owners dominate the study area (SYF, 2007) and own about 70% of all forestland there. In December 2000, the largest certification scheme in southern Sweden (PEFC) had certified only about 13% of the total forestland in the study area (data from M. Lagerkvist, PEFC, personal communication). The latter is mostly based on regeneration of conifers and one may not expect any marked changes in densities of broadleaved saplings during a 15-year period.

One advantage of the Swedish soft policy is its educational and democratic approach. Based on sound information and advice, at least some forest owners invested in conservation on their land. Soft policies probably lead to fewer conflicts and legal disputes, for which there are costs to society and forest owners. One possible problem with the soft policy is that many forest owners are more interested in financial return from harvesting than the more indirect values based on saved trees. The state also encouraged planting and regeneration by broadleaved trees, and if the interest for harvesting of these trees increases, they would also become more common in the landscape. Major problems in this context are deer browsing of seedlings and saplings and lower financial return for broadleaves than for spruce (on the average, present conditions). At harvest, retention of broadleaved trees is not compensated by the state. The Forestry Act requires some tree retention at harvest, but do not specify tree densities. A few legal cases have been used to establish an approximation of what maximally can be required for conservation by forest owners without economical support: about 4% of the net economic value of harvest, declining to 2% for harvest of >350 m³ of wood per property and harvest unit (data from Tom Stjernquist, 1998; P. Johansson, personal communication).

In conclusion, during a 15-year period the soft conservation policy for Swedish forestry did not increase the regeneration of
broadleaved saplings in young forest, but the density of broad-leaved conservation trees increased there. This increase is promising, as it occurred without economic compensation to forest owners. Our study suggests that education and advice can have positive environmental effects in forestry.

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References