
Supplementary Material

In order of appearance.

Table S1. Rotation length and mean annual increment (MAI) on different site quality classes (SQC) for spruce (G36–G24), pine (T28–T26), and birch (B26–B24). The SQC-figures for spruce and pine are dominant height in meters at 100 years of total age and for birch dominant height at 50 years of age after breast height. The rotations and increments for spruce and pine are the economically optimal ones at year 2017 reforestation costs and net conversion values, 3% real interest, and genetically improved seedlings growing 15% faster than unimproved seedlings of today.

SQC	Rotation, No. Year	MAI, m3sk/Year
G36	50	16.2
G34	51	13.5
G32	56	11.3
G30	63	9.6
G28	69	8.2
G26	76	7.0
G24	84	6.0
T28	59	8.3
T26	65	7.0
B26	55	7.2
B24	64	6.1

Sources: Spruce and pine [36] and birch [41].

Table S2. Calculation of annuity of net present value (ANPV) for planted genetically improved spruce on site quality class (SQC) G28 and naturally regenerated birch on SQC B24, Swedish crowns (SEK)/ha, 1 SEK $\approx$ 0.1 Euro.

Year	Species/Measures	Cost (–) and Revenues (+)	Present Value of Costs and Revenues		
			2% Interest	3% Interest	4% Interest
	Planted spruce G28				
0	Cleansing of clear felled land	–700	–700	–700	–700
1	Soil scarification	–2400	–2353	–2330	–2308
2	Planting	–14,345	–13,788	–13,522	–13,263
3	Plant inventory	–100	–94	–92	–89
4	Help planting	–1400	–1293	–1244	–1197
11	Pre-commercial thinning	–4000	–3217	–2890	–2589
35	Thinning 1	+2315	1158	823	587
48	Thinning 2	+12,865	4973	3113	1958
69	Final felling	+150,411	38,359	19,566	10,046
	Net present value		23,044	2726	–7564
	ANPV		619	94	–324
	Naturally regenerated birch B24				
0	Cleansing of clear felled land				
		–1000	–1000	–1000	–1000
0	Soil scarification	–3000	–3000	–3000	–3000
13	Pre-commercial thinning	–5500	–4252	–3745	–3303
24	Thinning 1	–2900	–1803	–1427	–1131
34	Thinning 2	+2400	1224	879	633
49	Thinning 2	+11,800	4472	2772	1727
64	Final felling	+55,900	15,740	8430	4542
	Net present value		11,381	2909	–1533
	ANPV		317	103	–67

Sources: Spruce own calculation based on data from [36] and birch own calculations based on [41].

Table S3. Grazing periods, feed consumption, net yields, and cost of feed production in a basic calculation for southern, central, and northern Sweden. Cows+ is beef suckler cows + rearing of their calves to slaughter and replacement, DM is dry matter, SEK is Swedish crowns, 1 SEK $\approx$ 0.1 Euro.

	Southern Sweden	Central Sweden	Northern Sweden
Grazing period ¹⁾			
Suckler cow, months/year	7.0	6.5	5.4
Replacement heifer, months/head	5.5	5.1	4.2
Slaughter heifer slaughtered, months/head	5.5	5.1	4.2
Steer, months/head	10.0	9.2	7.7
Feed consumption ²⁾			
Pasture, kg DM/cow+	4700	4300	3600
Grass/clover silage, kg DM/cow+	3800	4200	4900
Concentrate, kg/cow+	80	80	80
Net yield			
Semi-natural pasture, kg DM/ha ³⁾	1500	1300	1200
Forest grazing, kg DM/ha ⁴⁾	50	50	50
Pasture on arable land, kg DM/ha ³⁾	3300	2700	2600
Grass/clover silage, kg DM/ha ³⁾	6700	5500	5300
Cost of feed production			
Semi-natural pasture, SEK/kg DM ⁵⁾	1.27	1.46	1.58
Pasture on arable land, SEK/kg DM ⁵⁾	0.81	0.99	1.03
Grass/clover silage, SEK/kg DM ⁶⁾	1.53	1.66	1.94
Concentrate, SEK/kg (purchase price) ⁷⁾	2.90	2.90	2.90

Sources: ¹⁾ Southern Sweden [45]. Shortened grazing period in central and northern Sweden proportional to the reduction of the vegetation period according to [46].

²⁾ Southern Sweden [45]. Reduced pasture consumption in central and northern Sweden proportional to the reduction of the vegetation period according to [46]. Increased grass/clover silage consumption in central and northern Sweden is equal to decreased pasture consumption in respective area.

³⁾ Southern Sweden [29]. Reduced net yield in central and northern Sweden proportional to the reduction of 10-year mean for total yield of temporary grass according to [47].

⁴⁾ The amount of grazing utilized on the forest land in the pasture mosaic is assumed to be 50 kg DM / ha. This is half the amount utilized by grazing only in forest according to experience from the time when forest grazing still was common [49,50] and its damage to timber production was extensive due to high grazing pressure [51]. Experience from that time also suggests that damage to the forestry will be insignificant if the cattle, in addition to forest grazing, also have access to other more lush pasture [52] as they will have in the pasture-forest mosaics. Any damage to the timber production by grazing in the mosaics is assumed to be compensated by its silvicultural utility by controlling competing grass and thicket vegetation in spruce plantations [53]. Therefore, forest grazing is supposed to result in zero net costs.

⁵⁾ Calculated as (Cost of fence and water according to Figure S1 + Cost of pasture management etc. according to [29])/Net yield.

⁶⁾ Calculated as (Cost of machinery, fuel and labor calculated by [54] based on [55] + Cost of seed and management according to [29])/Net yield. Average field size is supposed to be 3 ha and average distance to the fields 5 km in southern and central Sweden and 10 km in northern Sweden. The need for machine work on farms with only pasture and silage production for beef cattle is unevenly distributed over the year with some distinctive work peaks between which the machines are unused. This results in inefficient use of own machines. Therefore, it is assumed that contract machinery services are used. The contract tariffs cover all costs of labor, fuel, and machines efficiently utilized throughout all the plant growing season, plus 10% addition for driving up and profit margin.

⁷⁾ [29].

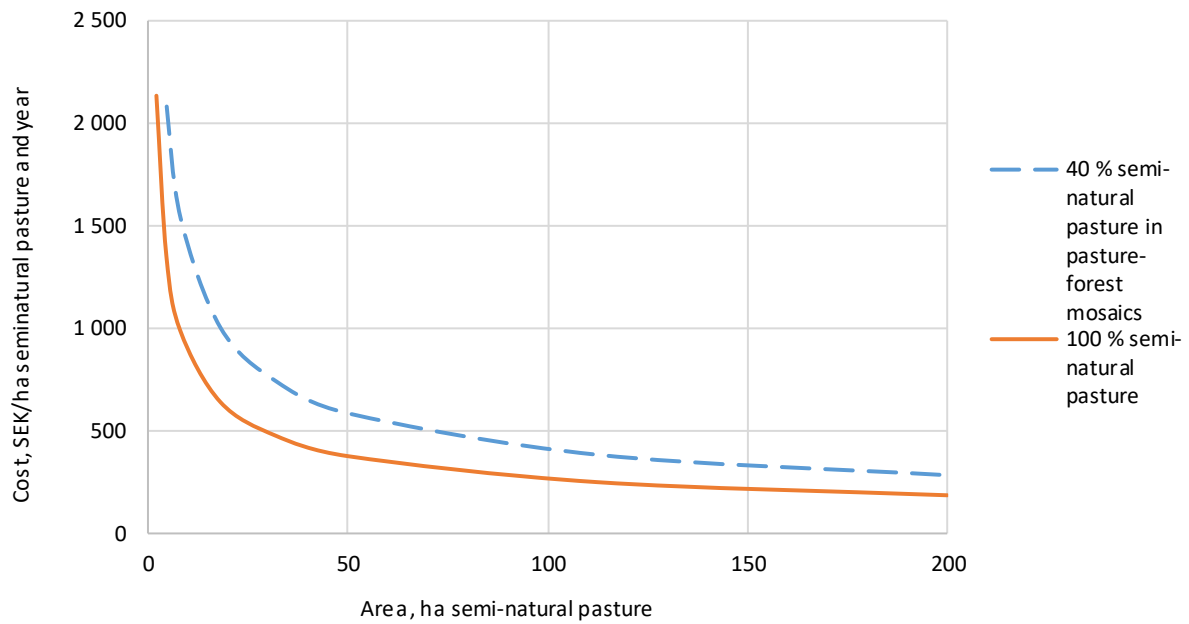


Figure S1. Annual cost of electric fences with three wires and the animal water supply by hose from existing water pipe to water trough with float-valve. Alternative 40% semi-natural pasture means enclosures of 32 ha rectangles (800×400 m) consisting of pasture-forest mosaics where 40% of the area is small scattered semi-natural pastures and 60% adjacent forest that tie together the scattered semi-natural pastures, 100% semi-natural pasture means enclosures consisting of only semi-natural pastures, e.g., previous pasture-forest mosaics where all forests have been converted to pasture after final felling. Assumed 15 years depreciation, 4% interest on the average value during the depreciation period and 2 SEK/m annual maintenance cost for the fence. SEK is Swedish crowns, 1 SEK $\approx$ 0.1 Euro.

Sources: Material and installation of fences according to information from Bosgården fencing contractor, water equipment according to information from various suppliers, and maintenance cost according to information from various farmers with wooded pastures.

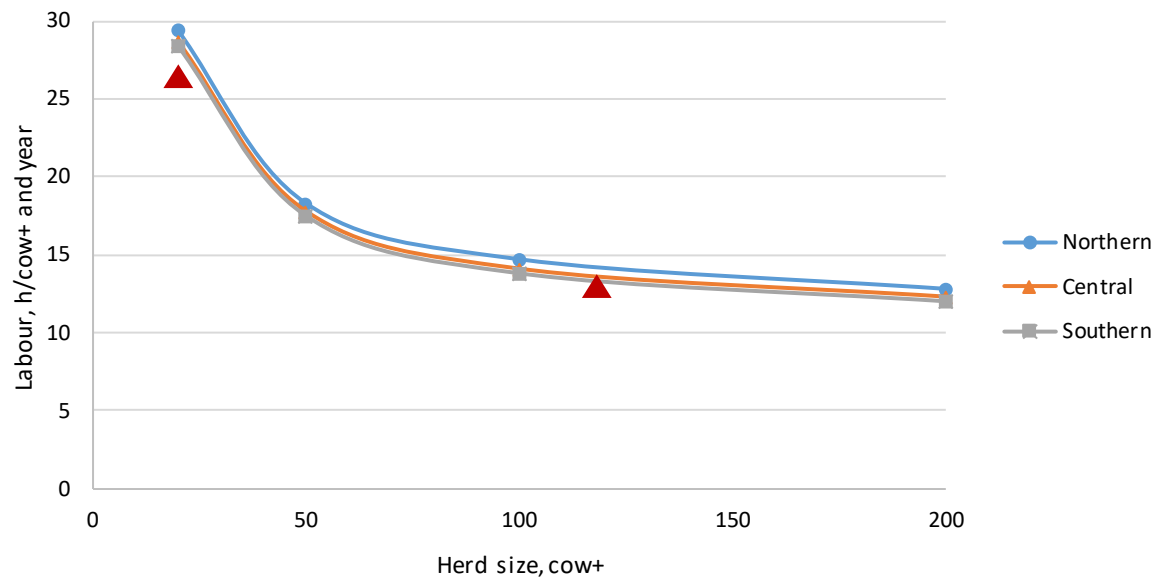


Figure S2. Calculated annual labor requirement per cow+ (excluding field work on arable land and pasture) in herds with 20, 50, 100, and 200 cows+ in northern, central, and southern Sweden (dots), where cows+ is number of beef suckler cows + rearing of their calves to slaughter and replacement. The triangles show the labor requirement per cow+ calculated on the basis of the labor needed per cow and per young cattle for 20 cows+ [29] and 120 cows+ [58] and show good consistency with the other estimates. The estimated daily labor requirement per animal category (pregnant cows during the housing period, cows during the calving period, cows with calves on pasture, and young cattle in different age groups during the indoor period and on pasture) consists of a fixed part which is independent of the number of animals and a variable part which is proportional to the number of animals in respective category [56,57].

Sources: Own calculations based on [56,57].

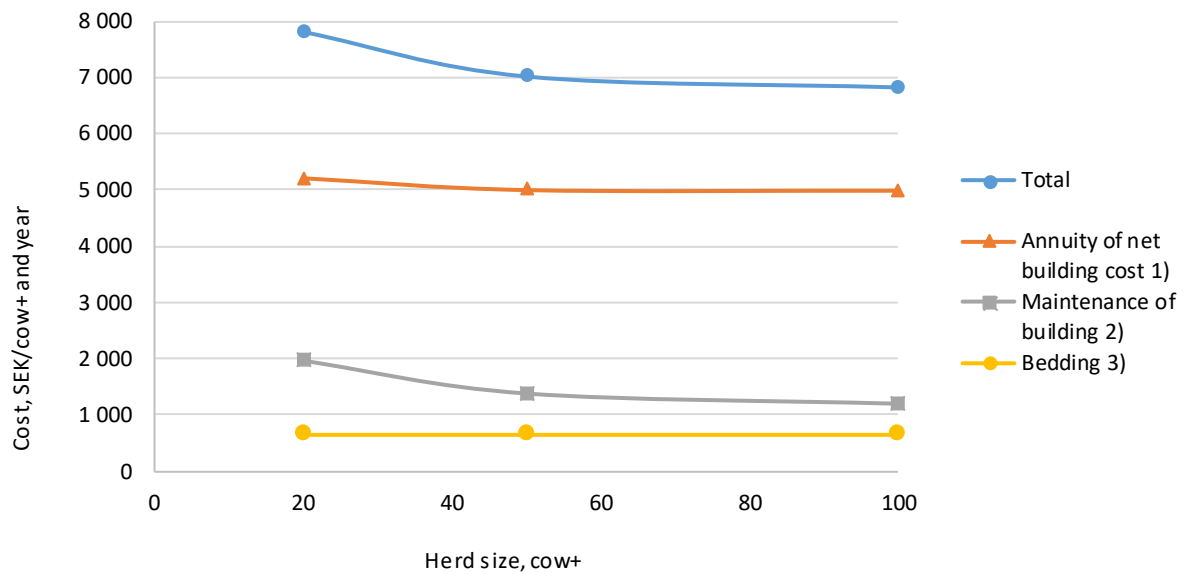


Figure S3. Annual costs of building and bedding per cow+ for herds with 20, 50, and 100 cows+ in cubicle barns, where cows+ is number of beef suckler cows + rearing of their calves to slaughter and replacement. SEK is Swedish crowns, 1 SEK $\approx$ 0.1 Euro.

¹⁾ The area requirements for various animal categories, including calving pens, are calculated on basis of the floor space regulations of the Swedish Board of Agriculture [60] which, for cubicle barns, comply with the requirements in organic production [44]. The investment cost for various sized barns is calculated by a building consultant [61]. From the investment cost, investment support of 40% of the building cost is deducted up to a maximum amount of SEK 1.2 million [59]. The relatively small cost difference between herd sizes is due to the maximized investment support which is achieved already at 20 cows+ [59]. The annual net construction cost is the net investment cost times the annuity for 20 years (depreciation period) and 4% (interest rate).

²⁾ Annual maintenance cost is 1.5% of the investment cost excluding investment support.

³⁾ Bedding cost for central Sweden according to [29]. Bedding cost used in the calculations for southern and northern Sweden are recalculated by the length of the indoor periods.

Table S4. Interest and various costs per cow+ in herds with 100 cows+ in southern Sweden, where cows+ is number of beef suckler cows + rearing of their calves to slaughter and replacement. Rounding off to even 100s SEK, Swedish crowns, 1 SEK $\approx$ 0.1 Euro.

Cost Item	SEK/Year/Cow+
Interest on animal capital ¹⁾	900
Interest on working capital ²⁾	600
Various costs (minerals, part in breeding bull, veterinary and medicine, organic certification fee, consulting etc.) ³⁾	1400

¹⁾ Market value of cattle according to [29] times rearing time in years times interest (4%)

²⁾ Cost of feed, labor, building maintenance, and various times rearing time in years times 0.55 [29]. In herds with fewer cows+ interest on working capital is somewhat higher due to higher costs of labor and building maintenance per cow+.

³⁾ Quantity of minerals according to [45]. Certification fees [62]. All other quantities, prices, and costs according to [29]. Various costs are somewhat higher in central and northern Sweden due to higher costs of feed production.

Table S5. Calculation of beef revenues per beef suckler cow including rearing of her calves to slaughter and replacement (repl.). SEK is Swedish crowns, 1 SEK $\approx$ 0.1 Euro.

	Cow	Repl. Heifer	Beef Heifer	Steer	Total, SEK
Heads ¹⁾	1	0.20	0.221	0.421	
Slaughtered/year	0.16 ²⁾		0.221	0.421	
Carcass weight, kg ¹⁾	375		310	390	
Beef, SEK/kg ³⁾	36.50		45	46.50	
SEK/year	0.16*375*36.50		0.221*310*45	0.421*390*46.50	12,903

¹⁾ [45]

²⁾ Fewer cows are slaughtered and result in beef revenue than the number of replacement heifers due to a few cows that are euthanized or die due to unhealth and thus do not give any slaughter revenue [45].

³⁾ Including 3 SEK/kg premium for organic beef [29].

Table S6. Calculation of headage support to cattle ≥ 1 year, payment to organic production, support to less favored area, environmental payments to semi-natural pasture, and single farm payment and enterprise support per beef suckler cow including rearing of her calves to slaughter and replacement in southern Sweden (support area 7). In central Sweden (support area 6) and especially in northern Sweden (support area 3) the supports and payments are higher due to higher support to less favored area and larger area per cow due to lower yields. SEK is Swedish crowns, 1 SEK $\approx$ 0.1 Euro.

	Cow	Replacement Heifer	Beef Heifer	Steer	Σ Units	Σ Units/ha	SEK/Unit	SEK
Heads	1	0.20 ¹⁾	0.22	0.42				
End of production, mo		18.0	21.0	30.0				
Cattle ≥ 1 year, years	1	$0.2 \cdot (18-12)/12=0.10$	$0.22 \cdot (21-12)/12=0.17$	$0.42 \cdot (30-12)/12=0.63$	1.90		878	1666
Organic production, animal units	1	$0.2 \cdot (18-6)/12 \cdot 0.6=0.12$	$0.22 \cdot (21-6)/12 \cdot 0.6=0.17$	$0.42 \cdot (24-6)/12 \cdot 0.6=0.38$	1.66		1600	2663
Less favored area, animal units	1	$0.2 \cdot (18-6)/12 \cdot 0.6=0.12$	$0.22 \cdot (21-6)/12 \cdot 0.6=0.17$	$0.42 \cdot ((24-6)/12 \cdot 0.6 + (30-24)/12 \cdot 1)=0.59$	1.88	$1.88/3.31=0.57^1)$		
Less favored area, ha semi-natural pasture and arable land					3.31		700 ¹⁾	2316
Semi-natural pasture base, ha					1.87		1000	1874
Semi-natural pasture extra, ha					0.62		2800	1750
Single farm payment and enterprise support, ha semi-natural pastures and arable land					3.31		1914	6332
Total								16,600

¹⁾ 0.57 animal units/ha means agricultural type 2 and 700 SEK/ha in support area 7 at up to 200 ha. At more than 200 ha, the support is reduced by 20% per ha exceeding 200, based on the support and payment rules and amounts in the year 2017.

Source: [63] based on [64].

Table S7. Summary of calculation of annual contribution to land, management, and risk (CLM&R) per cow+, per ha semi-natural pasture and arable land, and per herd in holdings with 20, 50, and 100 cows+ in southern, central, and northern Sweden, respectively. Cows+ is number of beef suckler cows + rearing of their calves to slaughter and replacement and SEK is Swedish crowns, 1 SEK $\approx$ 0.1 Euro.

	Southern Sweden			Central Sweden			Northern Sweden		
	20	50	100	20	50	100	20	50	100
Number of cows+									
Beef (incl. 880 SEK extra for organic beef)	12,903	12903	12,903	12,903	12,903	12,903	12,903	12,903	12,903
Support and payments	16,601	16,601	16,418	18,843	18,843	18,511	22,040	22,040	21,393
Feed	-11,373	-11,373	-11,373	-12,845	-12,845	-12,845	-14,829	-14,829	-14,829
Building	-7758	-6964	-6770	-7816	-7022	-6828	-8022	-7228	-7034
Labor	-6731	-4148	-3271	-6802	-4219	-3342	-6968	-4337	-3484
Other costs	-3536	-3448	-3419	-3580	-3492	-3463	-3645	-3556	-3528
CLM&R, SEK/cow+	106	3571	4488	703	4168	4936	1479	4993	5421
Semi-natural pasture and arable land, ha/cow+	3.31	3.31	3.31	3.66	3.66	3.66	3.54	3.54	3.54
CLM&R, SEK/ha	32	1 079	1356	192	1139	1349	418	1410	1531
Semi-natural pasture and arable land, ha/holding	66	166	331	73	183	366	71	177	354
CLM&R, SEK/holding	2120	178,550	448,800	14,060	208,400	493,600	29,580	249,650	542,100