Methodology for optimization of coordinated forestry, bioenergy and infrastructure investments with focus on Russian Federation

Методология оптимизации координированных инвестиции в лесное хозяйство, биоэнергетику и инфраструктуры на примере РФ

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There are very good options to strongly increase the industrial utilization of raw materials from the forests, such as stem wood and other assortments, irrespective of how these assortments are distributed between saw mills, pulp mills and companies in the energy industry.	**Имеются хорошее перспективы значительного увеличения объемов лесосырья разного ассортимента, например круглого леса.** **Независимо от распределения между лесопилками, ЦБК и энергетическими компаниями.** **Изучаются общие пути оптимизации скоординированного расширения мощностей поставщиков лесосырья и биоэнергии и инфроструктуры.** **Рассматриваются альтернативные динамические модели.**

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The general structure of the optimization problem of coordinated expansion of sustainable forest and bio energy supply chains, infrastructure and industrial plants is studied. **Alternative dynamic models are described. Optimal solutions are derived for alternative cases and preliminary conclusions are made.** **Capacities of industries of different kinds, using raw materials from the forests, should be strongly expanded.** **This also leads to increased employment in all concerned regions over an infinite horizon.**	**Выводятся оптимальные решения для различных случаев и делаются предварительные выводы по поводу значительного расширения промышленных мощностей разного рода использующих лесосырье, что в свою очередь, ведет к увеличению занятости во всех заинтересованных лесных регионах в рассматриваемом временном периоде планирования.**

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The total economic value, the present value of all activities in forestry, the forest products industry and the energy industry, increases strongly if harvesting and capacity expansion develop in the ways derived and suggested by the optimization models.	Общая экономическая стоимость, текущая дисконтированная стоимость всех операций в лесном хозяйстве, затраты на производство лесопродуктов и энергии значительно увеличиваются если вырубка и расширение объемов сырья производятся в рамках предлагаемых оптимизационных моделей.

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Furthermore, the complex problems of the global system with green house gases and global warming and the level of the carbon stock in the forests, has become a dominating topic in all media and conferences during the latest years. With increasing utilization of the production potential of the forests, the forests can capture more CO2 from the atmosphere and we may solve the global warming problem. When we harvest a forest and use the timber to build wooden houses, bridges and other constructions, the carbon that was originally captured by and stored in the forest is moved to the constructions.	Кроме того за последние годы, доминирующей темой во всех СМИ и на конференциях стали комплексные проблемы связанные с: глобальным потеплением, парниковым эффектом и уровнем запаса углерода в лесах. При оптимизации использования промышленных лесов, леса способны удерживать больше CO2 и таким образом мы можем решить проблему глобального потепления. Когда мы вырубаем лес и используем пиломатериалы, для постройки деревянных домов, мостов и других конструкций, накопленный в древесине углерод остается в конструкциях.

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When we harvest the forest, the forest land is released and can be used for a new plantation. This new plantation can absorb even more CO2 from the atmosphere. In case we do not use the old forest and harvest it, the forest net growth sooner or later stops. Then, the forest does not contribute to the net uptake of CO2 anymore.	Более того, при вырубке освобождается место под новые плантации, которая в свою очередь, может абсорбировать больше углерода из атмосферы. Если мы не будем использовать неприрывное неистощительное лесопользование, то рано или поздно чистый рост леса прекращается, что ведет к прекращению поглощения CO2 из атмосферы.

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IMPORTANT OBSERVATIONS

EU has the target of 20% renewable energy in the year 2020. http://ec.europa.eu/energy/index_en.htm

In Russian Federation, the potential sustainable forest harvesting level is many times higher than present harvesting.

These biomass resources may be used as a sustainable source of energy in central Europe.

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ENERGY

OVERVIEW AND SECURITY OF SUPPLY 2.2.2

Gross Inland Consumption
2007 (Mtoe)

	ALL FUELS	Solid fuels	Oil	Natural gas	Nuclear	Renewables	Other (*)
EU-27	1 806.4	331.2	656.9	432.4	241.3	141.0	3.5
Share	100.0%	18.3%	36.4%	23.9%	13.4%	7.8%	0.2%
EU-25	1 746.0	313.2	641.6	416.4	235.5	135.3	3.9
Share	100.0%	17.9%	36.7%	23.9%	13.5%	7.8%	0.2%

Source: Eurostat, May 2009

http://ec.europa.eu/energy/publications/statistics/doc/2010_energy_transport_figures.pdf

Conversion Factors

ENERGY

FROM: TO:	TJ	Gcal	Mtoe	GWh
TJ	1	238.8	2.388×10^{-5}	0.2778
Gcal	4.1868×10^{-3}	1	1×10^{-7}	1.163×10^{-3}
Mtoe	4.1868×10^{4}	1×10^{7}	1	11 630
GWh	3.6	860	8.6×10^{-5}	1

1806.4 Mtoe * 11.630 TWh/Mtoe = 21 008 TWh

(20% - 7.8%) of 21 008 TWh = 2 563 TWh

CENTRAL QUESTIONS:

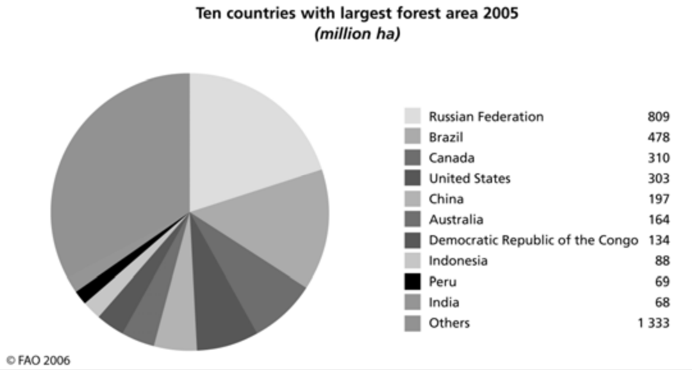
- ***Where can Europe find 2 563* TWh *of ”new” renewable energy ?***
- ***Would it be profitable to deliver this renewable energy to Europe?***

Cubic metres to energy:

1 million cubic metres (on bark) can give approximately 2 TWh.

The number ”2” is a rough approximation for average conditions” with 50% water contents. Water contents and other properties affect these figures.

References:
Lohmander, P., Stor potential för svensk skogsenergi, Nordisk Energi, Nr. 2, 2009
http://www.lohmander.com/Information/ne1.jpg
http://www.lohmander.com/Information/ne2.jpg
http://www.lohmander.com/Information/ne3.jpg
http://www.lohmander.com/PL_SvSE_090205.pdf


Ten countries with largest forest area 2005
(million ha)
Russian Federation 809
Brazil 478
Canada 310
United States 303
China 197
Australia 164
Democratic Republic of the Congo 134
Indonesia 88
Peru 69
India 68
Others 1 333
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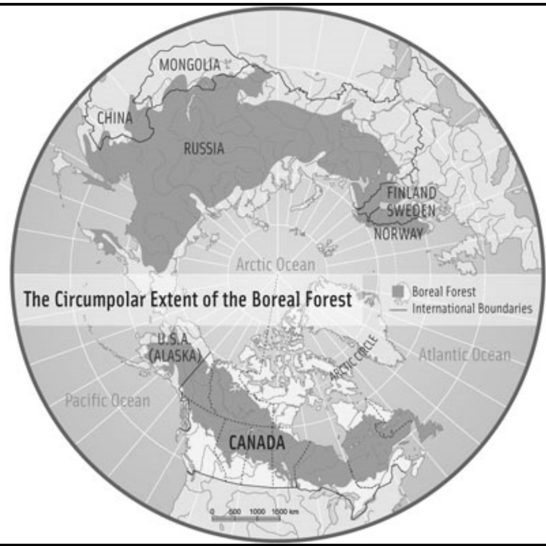
MONGOLIA
CHINA
RUSSIA
FINLAND
SWEDEN
NORWAY
Arctic Ocean
The Circumpolar Extent of the Boreal Forest
Boreal Forest
International Boundaries
U.S.A. (ALASKA)
ARCTIC CIRCLE
Atlantic Ocean
Pacific Ocean
CANADA

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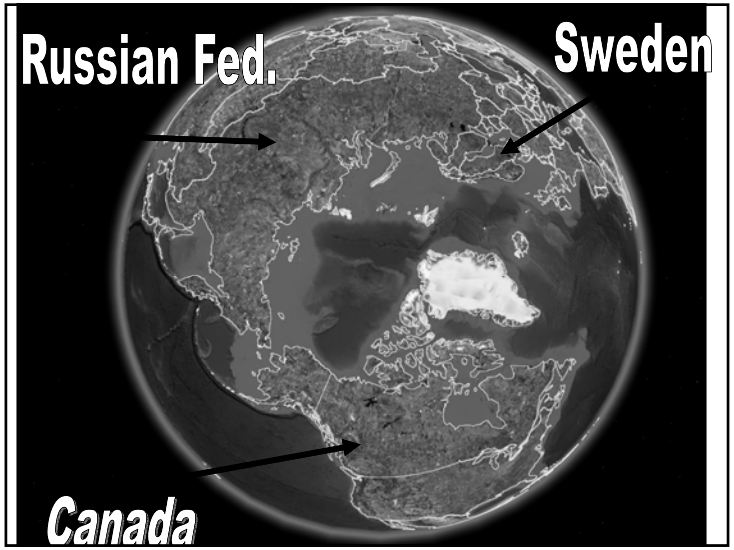
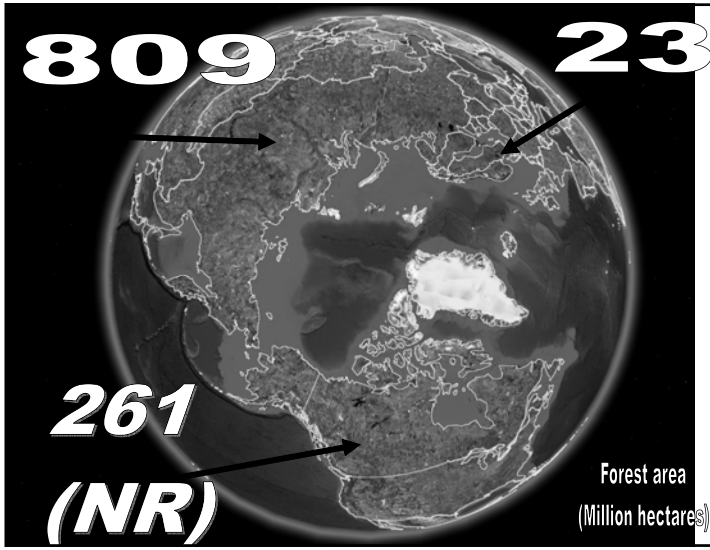

Russian Fed.
Sweden
Canada


809
23
261
(NR)
Forest area
(Million hectares)

Forest area (million hectares):

- Sweden: 23.000 (SVO, 2009)
- Russian Federation: 808.790 (FAO, 2005)
- Canada: non res. = 260.643. (Canfi 2001)

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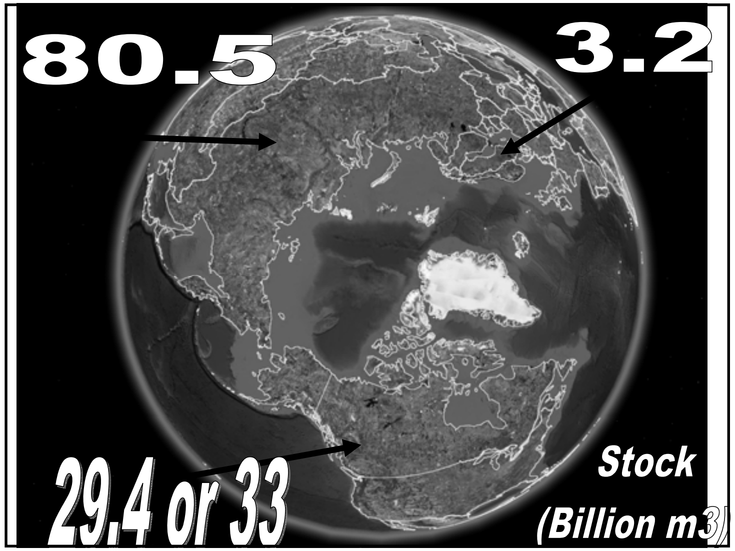

Forest stock (million cubic metres):

Sweden:	**3 155**	**(SVO, 2008)**
Russian Federation:	**80 479**	**(FAO, 2005)**
Canada:	**29 384**	**(Canfi 2001)**
Canada	**32 983**	**(FAO 2005)**

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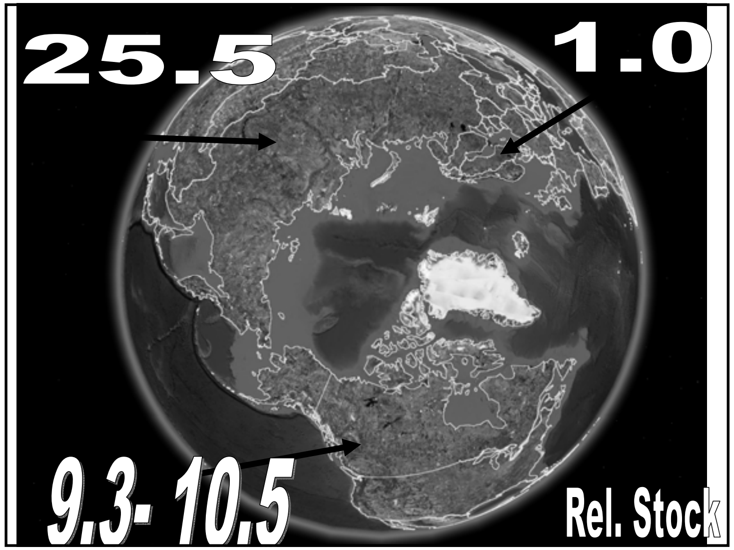
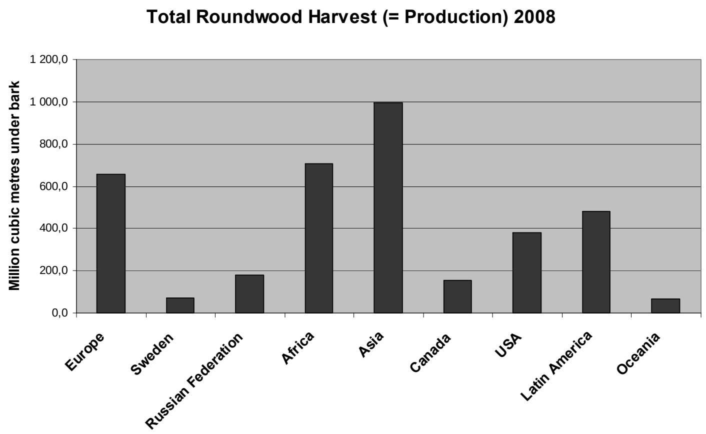




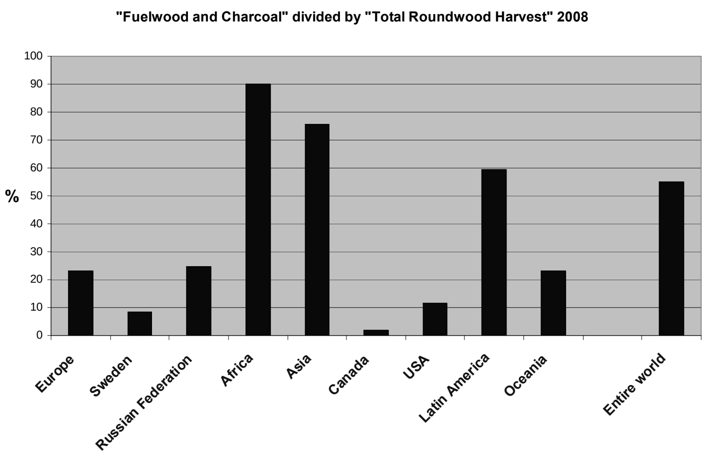
Source: FAOSTAT
Adaptions by Peter Lohmander.

Roundwood production by region and country, year 2008

Region/country	Industrial wood coniferous sp. Total[1]	Sawlogs and veneer logs	Pulp-wood	Industrial wood non-coniferous sp. Total[1]	Sawlogs and veneer logs	Pulpwood	Fuelwood and charcoal	Total roundwood
	million m3 fub							
Europe	385,5	234,7	129,9	119,1	52,4	57,7	152,5	657,1
Sweden	59,9	32,1	27,6	3,2	0,2	2,7	5,9	69,0
Russian Federation	101,2	60,5	28,6	35,5	17,7	14,1	44,7	181,4
Africa	9,3	4,7	4,1	61,0	21,8	12,3	637,6	707,9
Asia	93,8	57,4	11,1	149,5	94,2	23,9	753,7	997,0
Canada	125,0	116,0	8,6	27,7	13,2	11,9	2,9	155,5
USA	225,0	137,2	83,4	111,7	51,7	56,1	43,6	380,2
Latin America	86,3	48,5	35,0	110,5	41,0	61,4	285,9	482,7
Oceania	34,7	18,7	8,0	17,6	7,7	9,6	15,9	68,3
Entire world	960	617	280	597	282	233	1 892	3 449

1 Inkl. övrigt rundvirke (pålar, stolpar, gruvstolpar m.m.). *Includes other industrial roundwood such as poles, pitprops, posts etc.*

Källa: FAOSTAT Databas *Source: FAOSTAT Database*

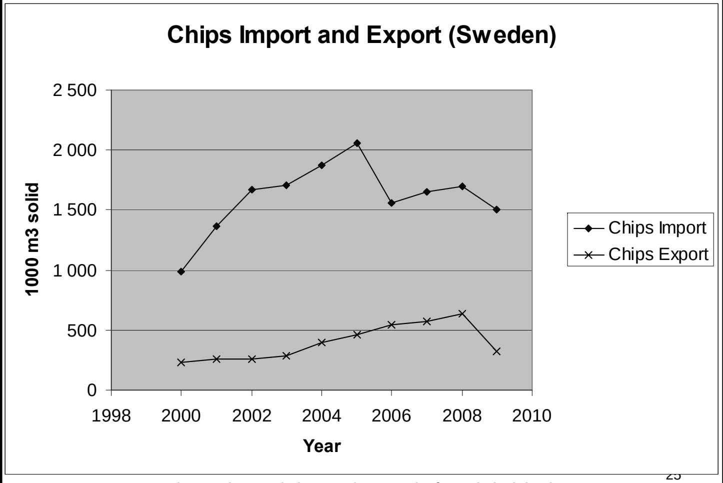


Source: FAOSTAT
Adaptions by Peter Lohmander.

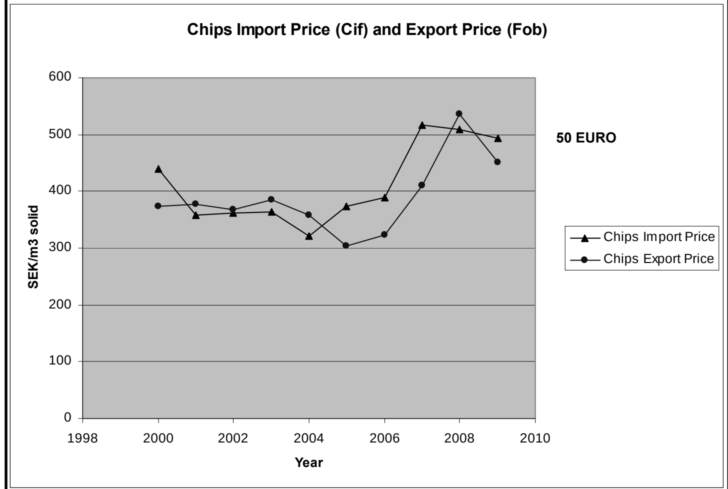
Export and import of roundwood, chips, particles and wood residues, year 2008

Region/country	Export: Coniferous species	Export: Non-coniferous species, Tropical	Export: Non-coniferous species, Other	Export: Chips, particles & wood residues	Import: Coniferous species	Import: Non-coniferous species, Tropical	Import: Non-coniferous species, Other	Import: Chips, particles & wood residues
	1 000 m3f ub							
Europe	50 657	61	25 241	25 536	31 953	865	22 786	29 532
Sweden	2 334	0	15	854	3 377	3	3 402	2 716
Russian Fed.	25 034	0	11 750	3 081	286	0	0	5
Africa	202	2 912	301	3 393	280	132	342	19
Asia	454	7 446	60	4 509	32 158	9 936	13 131	27 469
North America	10 379	7	2 652	9 121	4 207	6	1 826	4 879
Canada	2 659	5	174	2 775	3 035	1	1 573	3 891
USA	7 720	2	2 478	6 346	1 171	5	253	988
Latin America	327	329	3 965	9 325	353	14	84	253
Oceania	7 587	2 724	1184	10 190	9	2	6	6
Entire world	69 607	13 479	33 403	62 075	68 961	10 954	38 175	62 159

Source: FAOSTAT Database



Source:"Foreign Trade", Statistics Sweden; Sweden´s statistical databases



Source:"Foreign Trade", Statistics Sweden; Sweden´s statistical databases

Foreign trade in wood residues, sawdust etc. *(Sweden)*

Year	Import			Export		
	Quantity	Value (Cif)	Average price	Quantity	Value (Fob)	Average price
	1000 m³ f ub	1 000 SEK	SEK/m³ f ub	1000 m³ f ub	1 000 SEK	SEK/m³ f ub
2000	331	156 592	473	53	20 260	380
2001	366	190 511	520	118	51 781	437
2002	377	203 896	541	137	63 083	459
2003	567	363 394	641	81	48 051	597
2004	736	397 918	541	191	91 067	478
2005	805	411 335	511	311	189 809	609
2006	1 018	644 689	633	280	202 666	723
2007	871	600 619	689	234	153 389	656
2008	1 016	731 449	720	214	193 696	905
2009[2]						
Wood residues[3]	601	276 201	459	19	20 188	1 063
Sawdust[3]	47	14 941	317	52	61 141	1 176
Pellets[3]	939	727 016	775	143	130 666	912

1. Nettoimport markerat med minustecken. *Net trade (minus sign indicates net import)*
2. Uppgifter särredovisas från 2009. Tidigare uppgifter ingick i träavfall m.m. Fr.o.m. 2009 är jämförelse med tidigare år ej relevant. För ytterligare information se kapiteltexten
Figures separated in 2009. Earlier years the figures were incl into wood residues etc. From 2009 onward, comparison with previous years are not relevant. For further information see English summary
3. Träavfall/ *wood residues avser refers to KN/CN* stat nr 44013080; sågspån/ *sawdust avser refer to KN/CN* stat nr 44013040; pelleter *avser refer to* stat nr 44013020

Källa: SCB, Utrikeshandel, Sveriges statistiska databaser
Source:"Foreign Trade", Statistics Sweden; Sweden's statistical databases.

Exchange rate: Approximately 10 SEK/EURO

Wood fuel, Price (SEK/MWh), Sweden

Tabell 1 Trädbränsle, kronor/MWh fritt förbrukare, löpande priser exklusive skatt. Sveriges officiella statistik

Period	2006	2007	2008	2009				2009:2	2009:3	2009:4	2010:1	
				Hela Sverige	Norra[1,2]	Mellersta[1,3]	Södra[1,4]					
Förädlade trädbränslen: (briketter & pellets)	**Pellets etc.**										**31 EURO**	
Värmeverk	211	244	271	298	316	308	290	282	305	309	310[P]	*
Skogsflis:	**Forest chips**										**20 EURO**	
Industri	119	128	146	176	-[1]	-[1]	-[1]	177	188	186	199[P]	
Värmeverk	146	158	167	181	187	186	171	174	178	195	199[P]	*
Biprodukter:												
Industri	112	153	160	172	-[1]	-[1]	-[1]	179	167	189	184[P]	
Värmeverk	128	134	157	170	178	172	155	167	166	180	178[P]	
Returträ:												
Värmeverk	78	64	69	78	55	77	85	70	80	92	101[P]	

1) Den regionala redovisningen omfattar endast värmeverken. Observera att medelpriserna i regionerna är mera osäkra än medelpriset för riket. **2)** Y, Z, AC och BD län. **3)** AB, C, D, E, S, T, U, W och X län. **4)** Övriga landet. **5)** Alltför få uppgifter i underlaget för att redovisa. **R)** Uppgiften har reviderats sedan Prisblad 1/2010. **P)** Preliminär uppgift.

(Calculations based on exchange rate 10 SEK/EURO)

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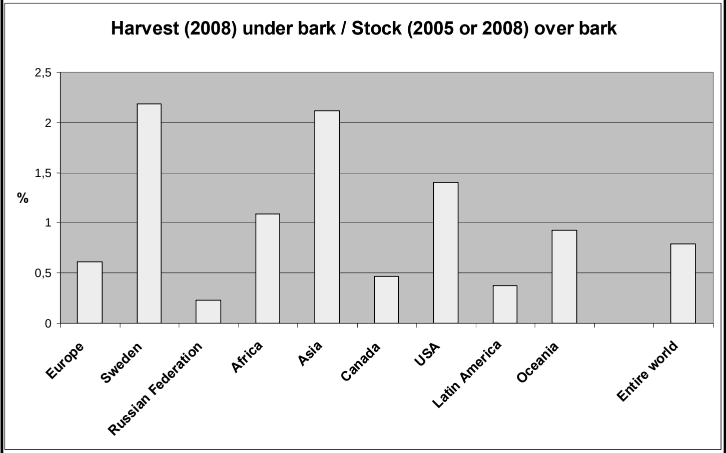

P.S. This graph is based on the simplifying assumption that the stock in "Latin America" = the stock in "South America".

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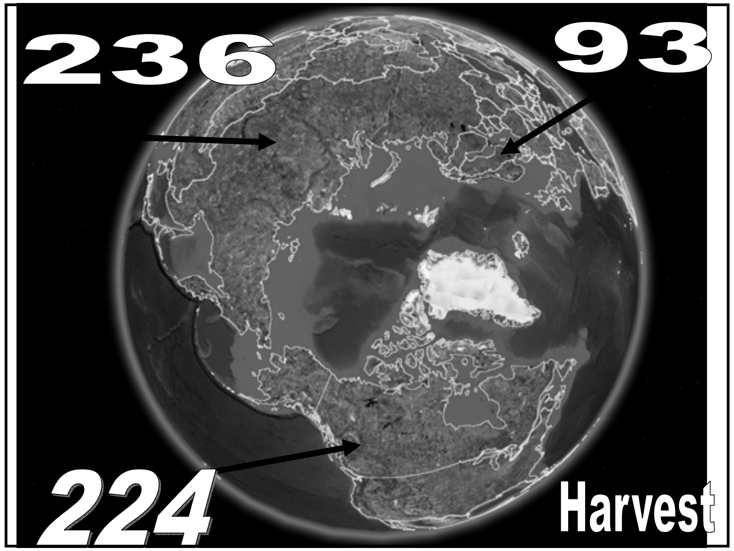

Forest harvest *(million cubic metres) (FAO, 2005):*

- Sweden: 92.8 (Roundwood + pulpwood)
- Russian Federation: 236 (Roundwood + pulpwood)
- Canada: 223.5 (Industrial roundwood 219.5 + woodfuel 4)

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Growth potential: Russian site index tables show that the potential sustainable growth and harvest are several times higher than the reported growth.

- ***Total growth potential 2919 million cubic metres on 645 million hectares (the best soils) gives 4.53 m3/ha.***
- ***Total growth potential 2919 million cubic metres per 809 million hectares (total forest area) gives 3.608 m3/ha.***
- *http://www.lohmander.com/RuMa09/Lohmander_Presentation.ppt*
- http://www.iiasa.ac.at/Research/FOR/forest_cdrom/english/for_fund_en.html

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Table 9

Distribution of forests by relative stocking and site index, 10^3 ha

Subjects of RF, groups of main forest forming species	Total area covered by forest vegetation	Site index: I I and higher			I I I			I V			V			Va and lower		
		Distribution of forest area by relative stocking														
		1.0 - 0.8	0.7 - 0.5	0.4 - 0.3	1.0 - 0.8	0.7 - 0.5	0.4 - 0.3	1.0 - 0.8	0.7 - 0.5	0.4 - 0.3	1.0 - 0.8	0.7 - 0.5	0.4 - 0.3	1.0 - 0.8	0.7 - 0.5	0.4 - 0.3
Russian Federation																
Coniferous	504315,8	9194,3	19437,2	2721,7	12405,5	47261,6	12629,7	16327,9	86702,6	31586,3	13148,0	97777,9	51896,8	5193,6	48686,2	49346,5
Hard deciduous	17469,5	434,8	1236,4	127,7	456,0	2177,1	568,2	395,3	2713,4	1067,2	716,1	3467,7	1474,7	294,3	1541,1	799,5
Soft deciduous	123187,1	15071,7	21250,9	2549,0	10477,3	23849,7	4818,0	6086,1	16837,1	3709,9	2524,0	7650,1	1941,1	968,9	3746,3	1707,0
European-Ural part of the Russian Federation																
Coniferous	88090,6	6042,9	10183,0	543,3	3608,9	8719,6	674,5	3256,1	13493,9	1334,1	1625,1	20262,2	3576,5	452,8	9388,7	4929,0
Hard deciduous	5106,5	420,6	1155,7	98,0	348,9	1357,1	110,8	184,6	845,9	90,9	48,5	291,7	38,2	22,3	83,1	10,2
Soft deciduous	47579,8	12041,6	12799,1	561,1	4634,5	7013,1	498,1	1892,0	3363,7	337,1	560,1	1397,5	319,8	212,7	1131,3	818,1
Asian part of the Russian Federation																
Coniferous	416225,2	3151,4	9254,2	2178,4	8796,6	38542,0	11955,2	13071,8	73208,7	30252,2	11522,9	77515,7	48320,3	4740,8	39297,5	44417,5
Hard deciduous	12363,0	14,2	80,7	29,7	107,1	820,0	457,4	210,7	1867,5	976,3	667,6	3176,0	1436,5	272,0	1458,0	789,3
Soft deciduous	75607,3	3030,1	8451,8	1987,9	5842,8	16836,6	4319,9	4194,1	13473,4	3372,8	1963,9	6252,6	1621,3	756,2	2615,0	888,9
Forest regions of the Russian Federation																
Coniferous	73291,0	2448,8	3843,9	226,9	2893,9	6919,2	557,0	3034,4	12648,7	1275,0	1559,2	19828,8	3523,5	428,1	9222,9	4880,7
Hard deciduous	476,5	3,4	14,5	1,0	14,2	107,6	15,1	13,2	216,3	28,5	1,5	45,2	9,2	0,0	4,6	2,2
Soft deciduous	30708,0	7084,0	5322,5	258,4	3784,6	4928,0	346,3	1734,5	2834,7	262,9	528,4	1236,8	280,7	207,5	1088,9	809,8
Non-chernozem zone of the Russian Federation																
Coniferous	84079,0	4864,6	8502,2	445,3	3412,3	8222,5	611,6	3205,8	13338,0	1307,1	1616,1	20222,5	3569,1	452,2	9382,0	4927,7
Hard deciduous	615,2	81,5	311,5	23,6	22,9	146,2	14,3	2,1	11,8	0,7	0,0	0,6	0,0	0,0	0,0	0,0
Soft deciduous	39133,9	10389,0	10408,1	395,0	3897,7	4892,5	290,6	1755,1	2654,6	239,5	542,2	1273,0	282,6	208,2	1094,8	811,0
Baikal lake basin																
Coniferous	11231,0	15,5	54,6	10,5	258,7	1274,8	263,3	686,2	4492,9	1111,0	205,6	1669,3	611,7	43,4	359,3	174,2
Soft deciduous	2083,5	12,9	21,0	2,1	180,0	447,7	66,9	239,3	697,8	111,2	55,0	162,6	35,3	7,9	32,8	11,0
Shoreline around Baikal lake																
Coniferous	1683,6	5,2	13,5	2,7	65,6	218,4	41,0	122,2	483,4	112,3	54,2	248,9	97,0	20,8	128,2	70,2
Soft deciduous	411,9	6,3	8,1	0,7	49,0	80,8	9,3	49,2	86,6	16,2	19,0	40,2	11,5	5,1	20,9	9,0

Source:
http://www.iiasa.ac.at/Research/FOR/forest_cdrom/english/for_fund_en.html
(From Roslesinforg, 2003, VNIILM, 2003)

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Siteindexkalkyl 090323

Calculation of the long run sustainable production level

Table 9

Distribution of forests by relative stocking and site index, 10^3 ha

Subjects of RF, groups of main forest forming species	Total area covered by forest vegetation	Site index: I I and higher			I I I			I V			V			Va and lower		
		Distribution of forest area by relative stocking														
		1.0 - 0.8	0.7 - 0.5	0.4 - 0.3	1.0 - 0.8	0.7 - 0.5	0.4 - 0.3	1.0 - 0.8	0.7 - 0.5	0.4 - 0.3	1.0 - 0.8	0.7 - 0.5	0.4 - 0.3	1.0 - 0.8	0.7 - 0.5	0.4 - 0.3
Russian Federation																
Coniferous	504315,8	9194,3	19437,2	2721,7	12405,5	47261,6	12629,7	16327,9	86702,6	31586,3	13148,0	97777,9	51896,8	5193,6	48686,2	49346,5
Hard deciduous	17469,5	434,8	1236,4	127,7	456,0	2177,1	568,2	395,3	2713,4	1067,2	716,1	3467,7	1474,7	294,3	1541,1	799,5
Soft deciduous	123187,1	15071,7	21250,9	2549,0	10477,3	23849,7	4818,0	6086,1	16837,1	3709,9	2524,0	7650,1	1941,1	968,9	3746,3	1707,0
Sum	644972,4	24700,8	41924,5	5398,4	23338,8	73288,4	18015,9	22809,3	106253,1	36363,4	16388,1	108895,7	55312,6	6456,8	53973,6	51853,0
Siteum				72023,7			114643,1			165425,8			180596,4			112283,4
Prod				9,0			6,0			4,5			3,4			2,0
Total Prod	2919082,6			648213,3			687858,6			744416,1			614027,8			224566,8
European-Ural part of the Russian Federation																
Coniferous	88090,6	6042,9	10183,0	543,3	3608,9	8719,6	674,5	3256,1	13493,9	1334,1	1625,1	20262,2	3576,5	452,8	9388,7	4929,0
Hard deciduous	5106,5	420,6	1155,7	98,0	348,9	1357,1	110,8	184,6	845,9	90,9	48,5	291,7	38,2	22,3	83,1	10,2
Soft deciduous	47579,8	12041,6	12799,1	561,1	4634,5	7013,1	498,1	1892,0	3363,7	337,1	560,1	1397,5	319,8	212,7	1131,3	818,1
Sum	140776,9	18505,1	24137,8	1202,4	8592,3	17089,8	1283,4	5332,7	17703,5	1762,1	2233,7	21951,4	3934,5	687,8	10603,1	5757,3
Siteum				43845,3			26965,5			24798,3			28119,6			17048,2
Prod				9,0			6,0			4,5			3,4			2,0
Total Prod	797696,1			394607,7			161793,0			111592,4			95606,6			34096,4
Asian part of the Russian Federation																
Coniferous	416225,2	3151,4	9254,2	2178,4	8796,6	38542,0	11955,2	13071,8	73208,7	30252,2	11522,9	77515,7	48320,3	4740,8	39297,5	44417,5
Hard deciduous	12363,0	14,2	80,7	29,7	107,1	820,0	457,4	210,7	1867,5	976,3	667,6	3176,0	1436,5	272,0	1458,0	789,3
Soft deciduous	75607,3	3030,1	8451,8	1987,9	5842,8	16836,6	4319,9	4194,1	13473,4	3372,8	1963,9	6252,6	1621,3	756,2	2615,0	888,9
Sum	504195,5	6195,7	17786,7	4196,0	14746,5	56198,6	16732,5	17476,6	88549,6	34601,3	14154,4	86944,3	51378,1	5769,0	43370,5	46095,7
Siteum				28178,4			87677,6			140627,5			152476,8			95235,2
Prod				9,0			6,0			4,5			3,4			2,0
Total Prod	2121386,5			253605,6			526065,6			632823,8			518421,1			190470,4

Index (Jonson)	I	II	III	IV	V	VI	VII	VIII
m3sk/ha,year	10.5	8.0	6.0	4.5	3.4	2.5	1.8	1.2

Source:
http://www.skatteverket.se/rattsinformation/allmannarad/aldrear/1997/1997/rsvs199712a.4.18e1b10334ebe8bc80005139.html

Russian site index tables give:

- *Total growth potential 2919 million cubic metres on 645 million hectares (the best soils) gives 4.53 m3/ha.*
- *Total growth potential 2919 million cubic metres per 809 million hectares (total forest area) gives 3.608 m3/ha.*

- *http://www.lohmander.com/RuMa09/Lohmander_Presentation.ppt*
- http://www.iiasa.ac.at/Research/FOR/forest_cdrom/english/for_fund_en.html

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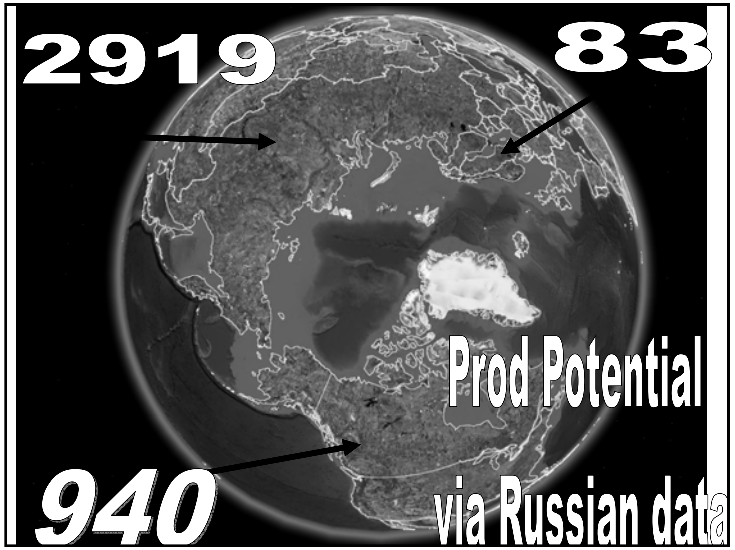

Tabell 3.13 Tillväxt i virkesförrådet, i genomsnitt för perioden 2002-2006. Inklusive tillväxt för avverkade träd
Mean annual volume increment 2002-2006. Including growth on felled trees

Län och landsdel[2] Counties and regions[2]	Skogsmark Forest land						Alla ägoslag[1] All land use classes[1]				
	Tall Scots pine	Gran Norway spruce	Björk Birch	Övr löv Other broad-leaves	Summa Total	volym/ha volume per ha	Tall Scots pine	Gran Norway spruce	Björk Birch	Övr löv Other broad-leaves	Summa Total
	milj. m³sk per år					m³sk/ha	milj. m³sk per år				
Norrbottens	5,34	1,98	1,80	0,17	9,30	2,59	5,71	2,27	2,10	0,21	10,29
Västerbotten	4,60	3,28	1,95	0,18	10,01	3,13	4,98	3,43	2,15	0,20	10,76
Jämtlands	3,43	3,94	1,47	0,24	9,09	3,41	3,63	4,19	1,70	0,27	9,79
Västernorrla	2,67	3,94	1,38	0,51	8,50	5,00	2,84	4,01	1,43	0,55	8,83
Gävleborgs	3,78	3,02	1,08	0,26	8,15	5,25	3,89	3,05	1,14	0,33	8,41
Dalarnas	3,71	2,66	0,88	0,15	7,40	3,92	3,84	2,69	0,96	0,17	7,66
Värmlands	2,40	4,21	1,04	0,27	7,92	5,93	2,62	4,24	1,10	0,32	8,28
Örebro	1,07	1,87	0,54	0,25	3,72	6,51	1,15	1,88	0,58	0,33	3,94
Västmanlanc	0,75	1,11	0,31	0,15	2,31	6,31	0,79	1,11	0,33	0,22	2,45
Uppsala	0,82	1,15	0,33	0,22	2,52	6,01	0,87	1,17	0,34	0,30	2,68
Stockholms	0,43	0,68	0,25	0,24	1,60	5,84	0,55	0,70	0,30	0,37	1,92
Södermanlar	0,83	1,14	0,22	0,18	2,37	6,95	0,90	1,15	0,26	0,24	2,55
Östergötland	1,44	2,36	0,48	0,43	4,71	7,42	1,60	2,37	0,52	0,53	5,02
Västra Götal	1,73	5,96	1,17	0,69	9,56	7,60	1,98	6,04	1,31	0,89	10,22
Jönköpings	1,10	3,25	0,60	0,28	5,23	7,19	1,17	3,27	0,66	0,38	5,48
Kronobergs	0,89	3,03	0,56	0,24	4,72	7,30	0,94	3,05	0,60	0,29	4,88
Kalmar	1,56	2,27	0,51	0,51	4,84	6,68	1,65	2,28	0,56	0,62	5,11
Gotlands	0,22	0,05	0,03	0,03	0,34	2,93	0,24	0,05	0,04	0,05	0,38
Hallands	0,29	1,88	0,25	0,23	2,66	8,66	0,34	1,89	0,28	0,27	2,78
Blekinge	0,12	1,12	0,19	0,27	1,70	8,90	0,13	1,12	0,20	0,32	1,77
Skåne	0,26	2,30	0,31	0,73	3,59	9,25	0,29	2,31	0,35	0,81	3,76
N Norrland	9,94	5,26	3,76	0,35	19,31	2,84	10,69	5,70	4,26	0,40	21,05
S Norrland	9,88	10,91	3,94	1,02	25,75	4,35	10,36	11,25	4,27	1,15	27,03
Svealand	10,00	12,82	3,57	1,46	27,84	5,36	10,71	12,95	3,88	1,95	29,49
Götaland	7,60	22,22	4,10	3,42	37,34	7,48	8,34	22,39	4,53	4,16	39,42
Hela landet Entire country	37,42	51,21	15,37	6,24	110,24	4,81	40,10	52,30	16,93	7,66	116,99

1. Exklusive fjäll, fridlyst mark, militära impediment, bebyggd mark och söt och saltvatten.
1. Excluding high mountains, nature reserves, military wasteland, urban land and water
2. Beträffande områdesindelningen, se bilaga 7 fig 2. Boundaries of counties and regions are shown in Appendix 7, Figure 2
m³sk per år = cubic metre standing volume per year, from stump to tip including bark
m³sk per ha = cubic metre standing volume per hectare, from stump to tip including bark
Källa: Riksskogstaxeringen Source: Swedish National Forest Inventory
Sveriges officiella statistik

Sweden

Annual volume growth
(increment)

116.99

37

Forest production potential (using Russian figures per hectare) (million cubic metres per year):

- Sweden: 23.000*3.608 = **<u>83</u>** (Observed growth = 117, SVO, 2009)
- Russian Federation: 808.790 000*3.608 = **<u>2 918</u>**
- Canada: (non reserved land): 260.642*3.608 = **<u>940</u>**

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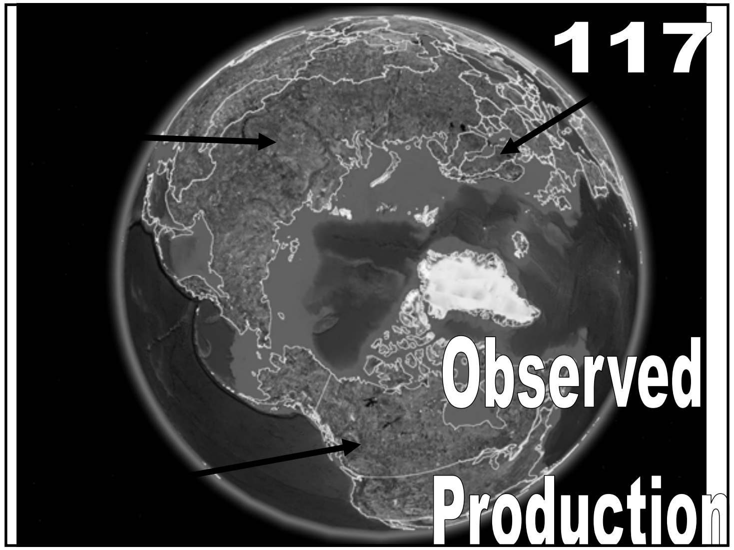

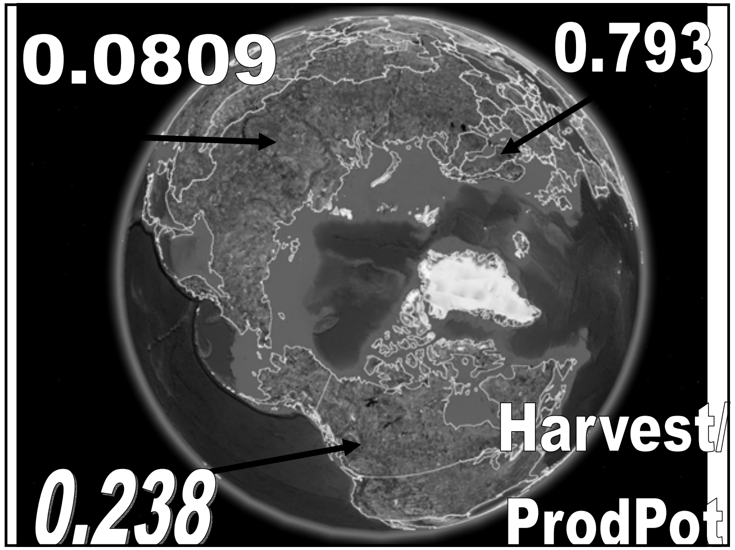

Harvest in relation to observed growth (or in relation to potential growth):

- Sweden (estimated): 92.8/83 = **1.12**
- Sweden (observed): 92.8/117 = **0.793**
- Russian Federation: 236/2918 = **0.0809**
- Canada: 223.5/940 = **0.238**

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The **Siberian Larch** (***Larix sibirica***)

42

The **Siberian Pine** (***Pinus sibirica***) 45

Siberian Fir (*Abies sibirica*) 46

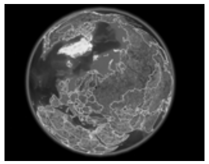
No country has a larger forest than Russia.

The growing stock is 25.5 times larger in Russia than in Sweden.

The growing stock is 37.3 times larger in Russia than in Finland.

The sustainable long run utilization of the Russian forest could increase very much, more than ten times!

The harvest levels of the main wood assortments are only 2-3 times higher than in Sweden.



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According to FAO (2005):

- The growing stock in Russia (in the land class "forest") is 80 479 million cubic metres over bark. The growing stock in Russia that is defined as "Commercial growing stock" is 39 630 million cubic metres over bark.
- ***Comment by Peter Lohmander:*** ***It is however very important to be aware that the size of the stock that is "commercial" depends on the prices in the product markets and production factor markets, the availability of infrastructure such as railroads and roads etc..***

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Russia has enormous forest resources, clearly illustrated by the very large growing stock.

The sustainable, long run, utilization of the forest resource could be very much higher.

Maybe the long run sustainable round wood harvest is ten (or more!) times higher than today.

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With suitable time consistent contracts, foreign capital and labour and Russian capital and labour would benefit from participating in these operations in the form of a joint venture.

An increased use of the Russian resources can lead to improved **economic results** for Russia and possible cooperating countries, increased production of **electrical power** and other energy products, increased **employment** and general **regional development** in large areas of Russia and **environmental improvements** with respect to the CO_2 - global warming issue.

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- **Since the relative prices of different production factors, inputs, are not the same in Russia and Sweden, we can be almost sure that the optimal combination of such inputs should be different.**
- **It is very likely that the optimal forest regeneration methods are different, that the optimal numbers of seedlings per hectare are different, that the optimal species mixes are different etc..**
- **The optimal harvest schedules and use of the forest resources should be expected to be quite different in Russia and Sweden.**

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- **It is not possible to calculate the rational use of the forest resources without a dynamic optimization framework in which also the investments in infrastructure, forest industry and energy industry are integrated as endogenous variables.**

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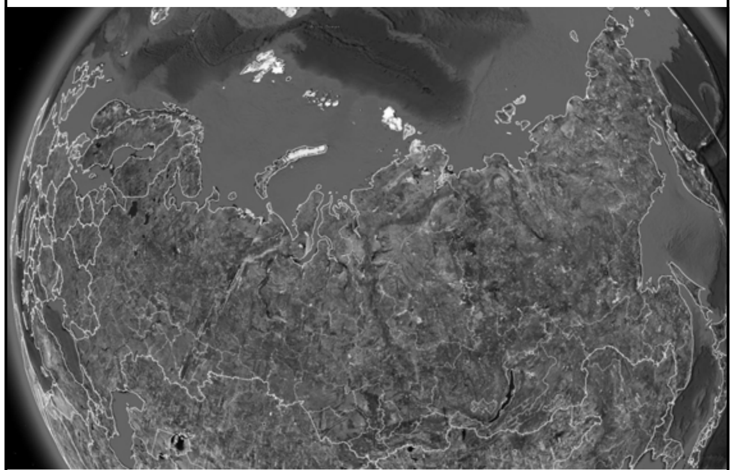
Infrastructure investments

(in optimal combination with harvesting and transport)

The general structure of dynamic quadratic programming models for optimal coordinated expansion of sustainable forest and bio energy supply chains, infrastructure and industrial plants will be studied.

Alternative dynamic quadratic programming models will be described.

Typical dynamic solutions will be derived for a region in low resolution.



Key Transport Statistics 2009

Countries	RAIL			
	Goods Transport (million T-km)			
	National		International	
	2009	Δ% 09/08	2009	Δ% 09/08
Russia	1 865 305	-11.9		

http://www.internationaltransportforum.org/Pub/pdf/10KeyStat2009.pdf

OBSERVATION: 1000 M m3 * 0.8 ton/m3 * 3000 km = 2 400 000 M ton-km

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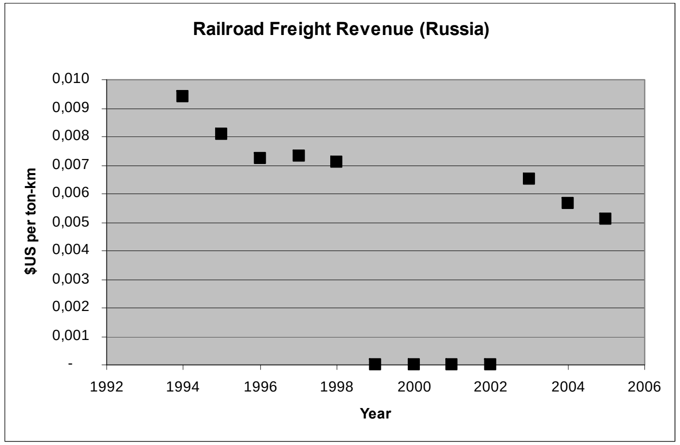

Source:

The World Bank, World Bank Railway Database, 2010

- http://siteresources.worldbank.org/EXTRAILWAYS/Resources/515244-1268663980770/6863841-1276539314873/railways_database_2007.xls

58

Railroad freight cost calculation

(based on the World Bank Railway Database)

3000 km *

0.005 $/tonkm *

0.8 ton/m3

= 12 $/m3

12$/m3 *

0.773 EURO/$

= 9.28 EURO/m3

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Alternative delivery cost calculation (with function estimation by Peter Lohmander)

”The delivery cost of energy wood by railway varied from 28.9 to 43.5 €/m3.”

About 70% of the energy wood was from harvesting, consisting of non-industrial roundwood, unused branches and tops, defective wood resulting from logging, spruce stumps removed after final felling, and 30% from sawmills and plywood mills, i.e., chips, sawdust and bark.

…maximum distance as 2110 km to the border station.

Source of the empirical investigation:

Gerasimov, Y., Karjalainen, T., Estimation of supply and delivery cost of energy wood from Northwest Russia, 2009
http://www.metla.fi/julkaisut/workingpapers/2009/mwp123.htm

60

Alternative delivery cost calculation and cost function per m3 continued

Assumption: Transport distances vary from 0 to 2110 km.
Energy contents: 2 MWh/m3
(43.5 € - 28.9 €) / (2110 km) = 0.00692 €/km

Alternative delivery cost function:
C = 28.9 + 0.00692 d
C = Delivery cost (€/m3)
d = Transport distance (km)

<u>Example:</u>
d=3000 km gives
C = 28.9 + 0.00692*3000 = 49.66 €/m3 (or 24.83 €/MWh)

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Observations:

A. The cost of stem wood harvesting and terrain transport is not the same as the cost of collecting stumps, chipping branches and tops etc..

B. The transport cost is not the same for stem wood as for chips from branches, tops and stumps.

Alternative delivery cost function:
C = 28.9 + 0.00692 d
C = Delivery cost (€/m3)
d = Transport distance (km)

(About 70% of the energy wood was from harvesting, consisting of non-industrial roundwood, unused branches and tops, defective wood resulting from logging, spruce stumps removed after final felling, and 30% from sawmills and plywood mills, i.e., chips, sawdust and bark.)

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Observations:

C. **The cost of "stem wood harvesting and terrain transport" differs very much between companies and technologies. In the Republic of Karelia, the costs were found in this interval:**

3.41 €/m3 **(134 RUB/m3)** **– 9.39 €/m3** **(369 RUB/m3)**

(Exchange rate, 2010-09-08: 39.31 RUB/ €)

<u>Source (empirical investigation):</u> Syunev et al, Comparision of wood harvesting methods in the Republic of Karelia, 2009
http://www.metla.fi/julkaisut/workingpapers/2009/mwp120.htm

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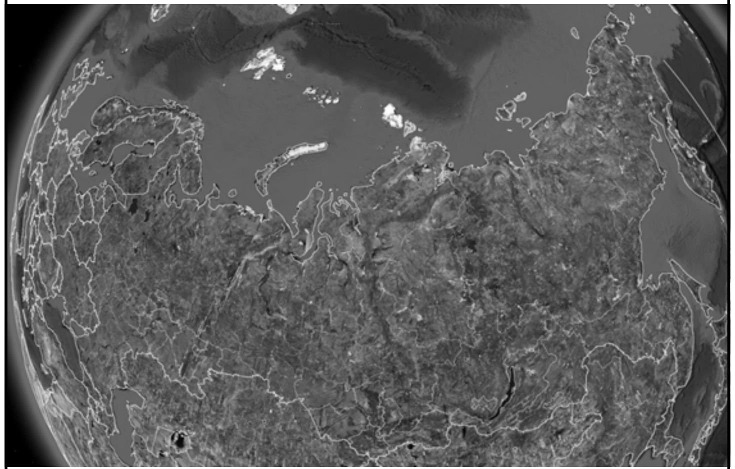

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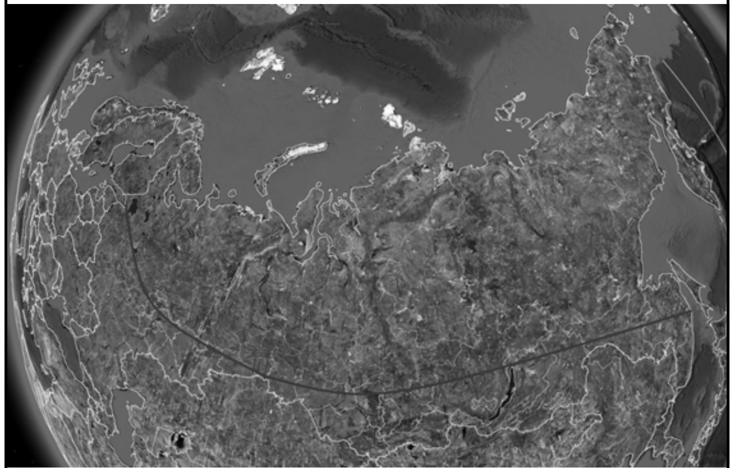
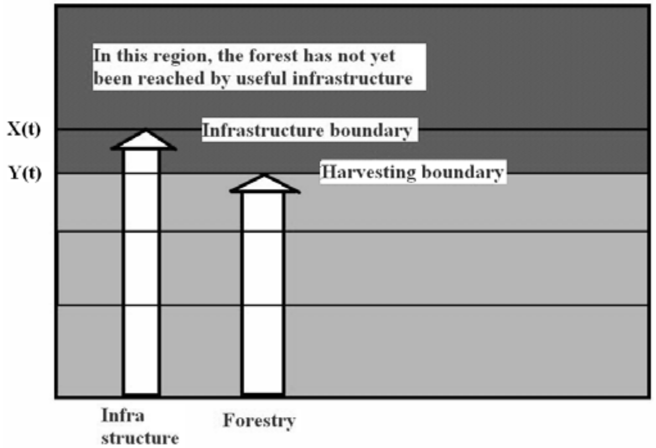


65


In this region, the forest has not yet been reached by useful infrastructure
X(t)
Infrastructure boundary
Y(t)
Harvesting boundary
Infra structure
Forestry

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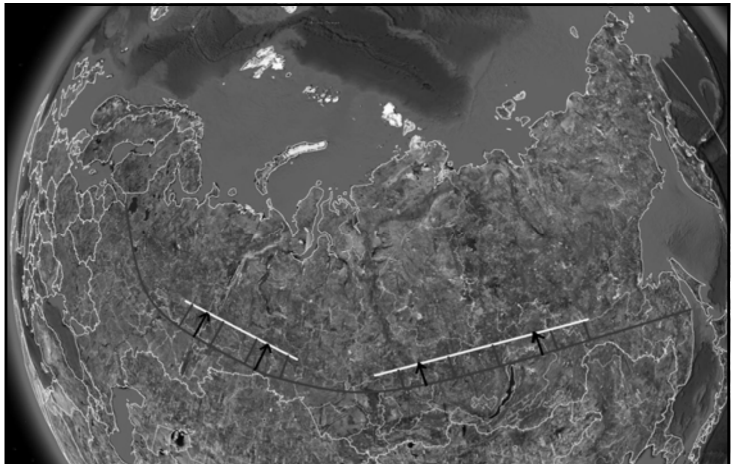
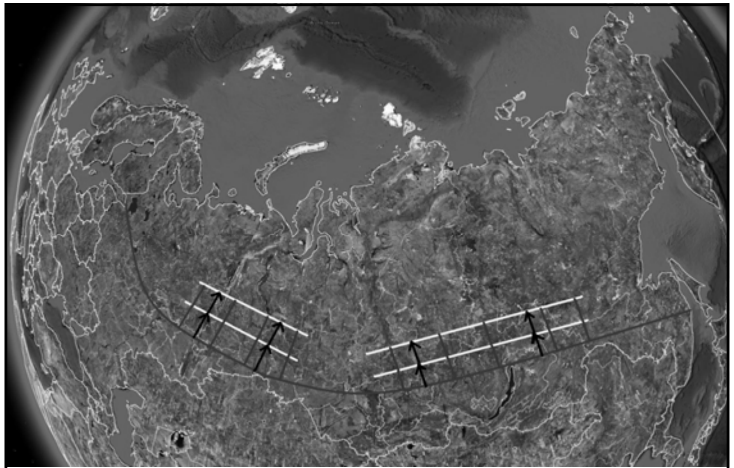


68



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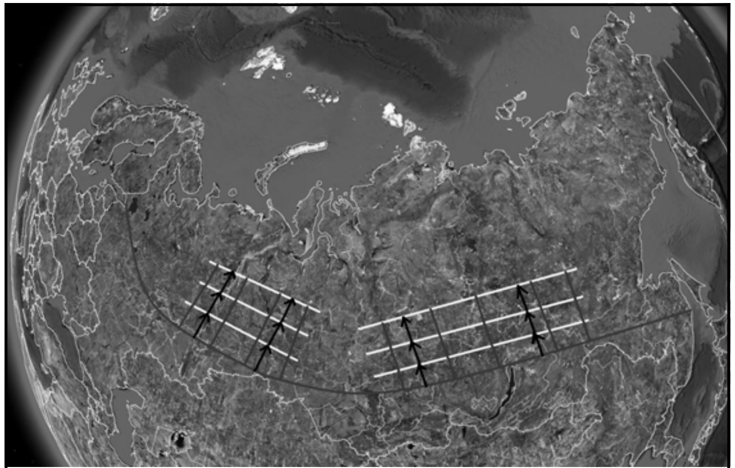

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Method:

Multi period
quadratic programming

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MODEL 1:

$$\max_{d_1,\ldots,d_T} \Pi = \sum_t e^{-rt}\pi(t)$$

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The profit in a particular period is a function of the decisions in that period and the decisions in earlier periods

$$\pi(t) = \pi(t, d_t, d_{t-1}, ., d_0; \bullet) \quad , \quad \forall t$$

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The decisions include investments and other decisions in infrastructure, forest industry and energy industry (=x) and forestry (=y).

$$d_t = \{x_t, y_t\} \quad , \quad \forall t$$

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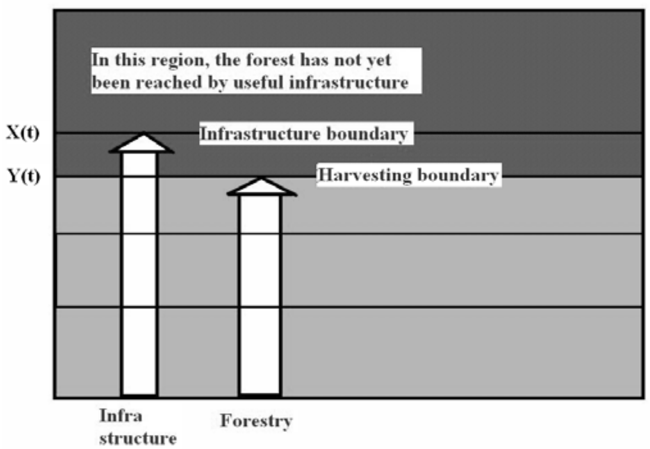

In each period, the forestry activities are constrained by the infrastructure boundary

$$y_t <= x_t \quad , \quad \forall t$$

76

The volume of ”first harvest” during a particular period can be described as a function of the change of the ”harvesting boundary”.

$$h_{0,t} = h_{0,t}(y_t, y_{t-1}; \bullet) \quad , \quad \forall t$$

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The volume of ”later harvests” during a particular period can be described as a function of the earlier changes of the ”harvesting boundaries”.

$$h_{n,t} = h_{n,t}(y_{t-s}, y_{t-s-1}, y_{t-2s}, y_{t-2s-1}, ., y_{t-ns}, y_{t-ns-1}; \bullet) \quad , \quad \forall t, n$$

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Investments (of different kinds) during a particular period are functions of the change of the infrastructure boundary.

$$inv_t = inv_t(x_t, x_{t-1}; \bullet) \quad , \quad \forall t$$

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In a particular period, the capacities of railroads, roads and different kinds of industries are functions of the infrastructure boundary

$$rail_t = rail_t(x_t; \bullet) \quad , \quad \forall t$$

$$road_t = road_t(x_t; \bullet) \quad , \quad \forall t$$

$$indc_t = indc_t(x_t; \bullet) \quad , \quad \forall t$$

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Model 2:

$$\max_{(x_1,...,x_T)} \Pi = \sum_{t=1}^{T} e^{-rt} P_t(h_t) h_t - C(.)$$

Π Total present value (M EURO)

t Period (year)

T Time horizon (year)

x_t Advancement during period t (km)

r Rate of interest

h_t Harvest volume during period t (M m3)

$P_t(h_t)$ Net price = Price minus variable harvesting costs per cubic metre (EURO/m3)

$C(.)$ Costs of infrastructure investments and other costs not included in $P_t(h_t)$ (M EURO)

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$$\sum_{t=1}^{T} x_t \le M$$

x_t Advancement during period t (km)

M Total advancement limit (km)

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$$h_t = v_1 x_t \quad t \in \{1, ..., \Delta t\}$$

$$h_t = v_1 x_t + v_2 x_{t-\Delta t} \quad t \in \{\Delta t + 1, ..., 2\Delta t\}$$

$$h_t = v_1 x_t + v_2 x_{t-\Delta t} + v_2 x_{t-2\Delta t} \quad t \in \{2\Delta t + 1, ..., T\}$$

$$h_1 = "h\_init"$$

h_t Harvest volume during period t (M m3)

Δt Harvest interval (years)

v_1 Harvest volume per advancement distance during the first harvest (M m3/km)

v_2 Harvest volume per advancement distance during the second (or later) harvest (M m3/km)

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v_1 Harvest volume per advancement distance during the first harvest (M m3/km).

Examples:

Distance from west to east = 3000 km.

1 km*3000km = 3000 km*km = 300 000 ha

"First harvest" / km
50 m3/ha * 300 000 ha/km
= **15 M m3/km**
or
= 100 m3/ha * 300 000 ha/km
= **30 M m3/km**

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v_2 Harvest volume per advancement distance during the second (or later) harvest (M m3/km).

Example:

Distance from west to east = 3000 km.

1 km*3000km = 3000 km*km = 300 000 ha

"Second (or later) harvest" / km = 50 m3/ha * 300 000 ha/km
= **15 M m3/km**

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$$(1-dhm) < \left(\frac{h_{t+1}}{h_t}\right) < (1+dhp) \quad t \in \{1,...,T-1\}$$

$$h_{t+1} - (1+dhp)h_t < 0 \quad t \in \{1,...,T-1\}$$

$$(1-dhm)h_t - h_{t+1} < 0 \quad t \in \{1,...,T-1\}$$

dhp Highest acceptable relative increase, per period, of h_t

dhm Highest acceptable relative decrease, per period, of h_t

86

A concrete example

Area = 3000 km * 1000 km = 300 M ha

Growth per ha: (m3/year)	**2.5**	**3.5**	**4.5**
Total growth and possible sustainable harvest: (M m3/year)	750	1 050	1 350
Total growth and possible sustainable harvest: (TWh/year)	**1 500**	**2 100**	**2 700**

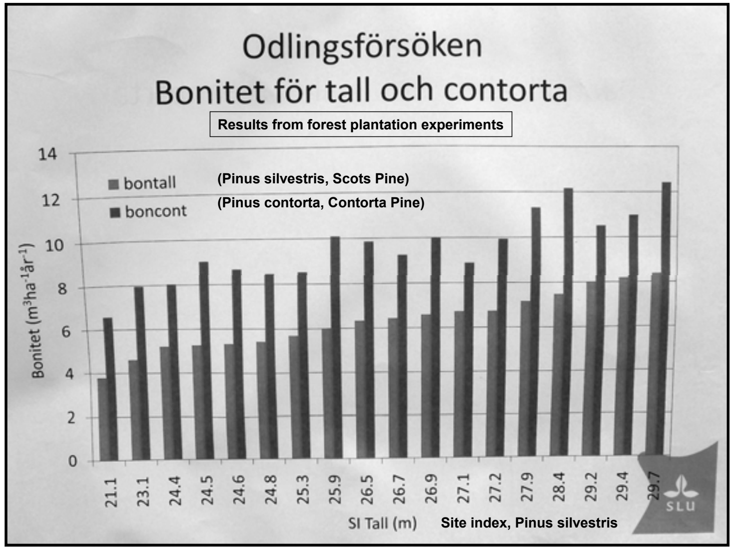
87

Growth comment: Russian site index tables show that the potential sustainable growth and harvest are several times higher than the reported growth.

- ***Total growth potential 2919 million cubic metres on 645 million hectares (the best soils) gives 4.53 m3/ha.***
- ***Total growth potential 2919 million cubic metres per 809 million hectares (total forest area) gives 3.608 m3/ha.***

- http://www.lohmander.com/RuMa09/Lohmander_Presentation.ppt
- http://www.iiasa.ac.at/Research/FOR/forest_cdrom/english/for_fund_en.html

88



Pinus contorta 31 years,

204 m3/ha, Strömsund, Sweden, 2010-09-03

91

Harvester in Pinus contorta thinning operation, Strömsund, Sweden, 2010-09-03

Forwarder in Pinus contorta thinning operation, Strömsund, Sweden, 2010-09-03

93

First thinning result, Pinus contorta, Strömsund, Sweden, 2010-09-03

94

Pinus contorta, planted 82 years ago.
Total production until age 75: 505 m3sk.
Average production: 6.73 m3sk/ha,year
Source: SCA, Korseleberget, 2010-09-03

95

Production example without thinnings
Pinus contorta, average conditions, Jämtland, Sweden, from Magnus Andersson, SCA, during excursion 2010-09-03

- **Year 0:** Plantation of 2200 seedlings per hectare
- **Year 55:** Harvest of 450 m3sk per hectare
- **Average production:**

8.18 m3sk/ha,year

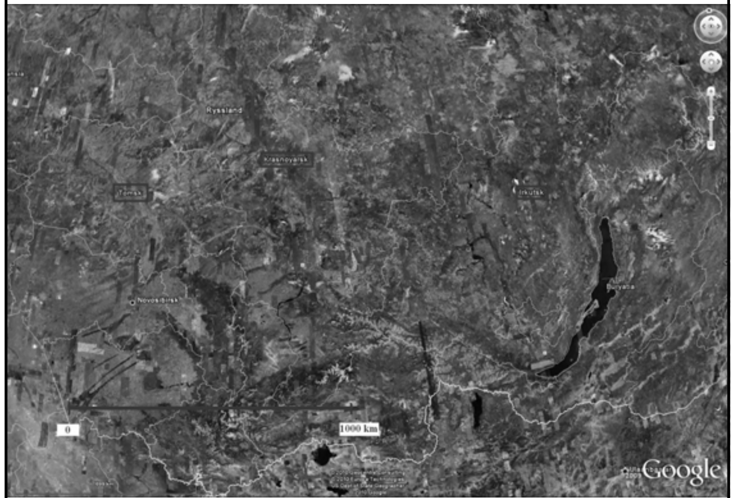
96

Production example with thinnings
Pinus contorta, average conditions, Jämtland, Sweden from Magnus Andersson, SCA, during excursion 2010-09-03

- **Year 0:** Plantation of 2200 seedlings per hectare
- **Year 31:** Thinning 42 m3sk per hectare
- **Year 41:** Thinning 80 m3sk per hectare
- **Year 65:** Harvest 375 m3sk per hectare
- **Average production:**

7.65 m3sk/ha,year

97



Partial Russian Forest Data Table

Prepared by Peter Lohmander 2010-08-22

Original data sources:

© Roslesinforg, 2003 © VNIILM, 2003.

Region	Forest Land	Stock	Total average increment of major forest forming species, M m3	m3perha	incperha
Russian Federation	882975,2	82130,1	993,82	93,01518321	1,125535576
Moscow oblast	1973,8	410,77	6,68	208,1112575	3,384334786
Krasnoyarsk Kray	55038,1	7795,6	78,5	141,6400639	1,426284701
Irkutsk oblast	64610,5	9059,08	94,71	140,2106469	1,465860812
Tomsk oblast	19282,3	2779,52	31,31	144,1487789	1,623768949

Aggregated information has been prepared by State Enterprise "Roslesinforg" (author team V.F. Fomchenkov, V.V. Sdobnova, N.K. Danilov, S.V. Danilova, G.V. Kurdina, and T.F. Beljakova) based on data of State Forest Account, presented by regional agency of state forest management. Data have been published in V.F. Fomchenkov *et al.*, *Forest Fund of Russia (data of State Forest Account, state by January 1, 2003)*, Reference Book, Moscow, VNIILM (All-Russia Research Institute of Forestry and Mechanization), 640 pp. [in Russian].

99

Growth comments:

- In the area on the map, present growth is reported to be about 1.5 m3/year.
- ***OBS: The reported growth is not real growth. The figures are derived via average stock level changes between age class averages, from production functions, according to an initiated source.***
- Site index tables in Russia seem to give potential growth much higher than than reported growth.
- Growth potential on average forest land is 3.6 m3/year according to site index tables.
- 3.5 m3/year (and 300 M ha) would give sustainable growth and harvest of 1 050 M m3/year
  (or 2 100 TWh/year)

100

Optimization

(Continuous cover ***or*** final fellings with reforestation. Irrespective of method, the harvest volumes per hectar are given with respect to the advancement. The growth assumption made here is far below the production potential.)

Growth per ha = 2.5 m3/year

- First harvest = 50 m3/ha
- Later harvests (20 year intervals)= 2.5*20 = 50 m3/ha

Observation:

It is possible to increase the growth considerably. Then, the optimal sustainable harvest also increases.

101

Costs and profits etc.

- **The profit will probably be higher than the calculated profit .**

Reason:

- The costs of harvest operations, road investments etc. are assumed to be the same as in Sweden. This probably overestimates these costs considerably. Average wages are considerably lower in Russian federation but on the other hand, the labour efficiency is higher in Sweden in many cases.

102

Numerical optimization (VERSION 1)

```
! INTERNAT7.lng;
! Peter Lohmander 2010_08_23;

MODEL:

SETS:
time/1..50/:x,h,Prof,d;
ENDSETS

rate = .05;
h_init = 100;
h(1) = h_init;
```

103

!Import price in Europe (Chips import price, Sweden, 2009), 50 EURO per m3;

IMPP = 50;

!Harvest cost (including terrain transport), 6.7 EURO/m3 (final fellings) (Sweden 2006), 13.1 EURO/m3 (thinnings).

(Exchange rate = 10 SEK/EURO);

HARVC = 10;

104

```
!Investment in reforestation, precommercial thinnings,
   fertilization, maintenance and new investments in
   roads etc are about 45% of harvest costs in Sweden
   (2006);
IMC = HARVC/2;
!Transport cost (mainly railroad transport) from road or
   railroad in central Russian Federation to central
   Europe.
Railroad transport cost:
3000 km * 0.005 $/tonkm * 0.8 ton/m3 = 12$/m3 =
9.28 EURO/m3. ;
TRPC = 15;

NETP = IMPP - HARVC - IMC - TRPC;

dNETPdh = -.004;
@FREE(dNETPdh);
```

105

```
@FOR(time(t): d(t)=@exp(-rate*t));

max = PresV;

@for(time(t): Prof(t) = (NETP +
  dNETPdh*h(t))*h(t)*1000000);
```

106

```
@for(time(t)| t#LE#20 : h(t) = 15*x(t));

@for(time(t)| t#GT#20 #AND# t#LE#40 :
          h(t) = 15*x(t) + 15*x(t-20));

@for(time(t)| t#GT#40 #AND# t#LE#60 :
     h(t) = 15*x(t) + 15*x(t-20) + 15*x(t-40));
```

107

```
PresV = @sum(time(t): d(t)*Prof(t));

[totd] @sum(time(t):x(t)) <= 1000;

@for(time(t)| t#LT#50 : h(t+1) < 1.2*h(t));

@for(time(t)| t#LT#50 : h(t+1) > 0.98*h(t));
```

108

```
!Sustainable harvesting constraint;
@for(time(t)| t#GT#30 : h(t) > 750);

toth = @SUM(time(t): h(t))/50;
tote = 2*toth;
```

109

```
DATA:
@OLE('internat7.XLS')=x,h,Prof, h_init,
  rate, PresV, toth, tote;
ENDDATA

end
```

110

The Optimal Present Value

PresV
1,64032E+11

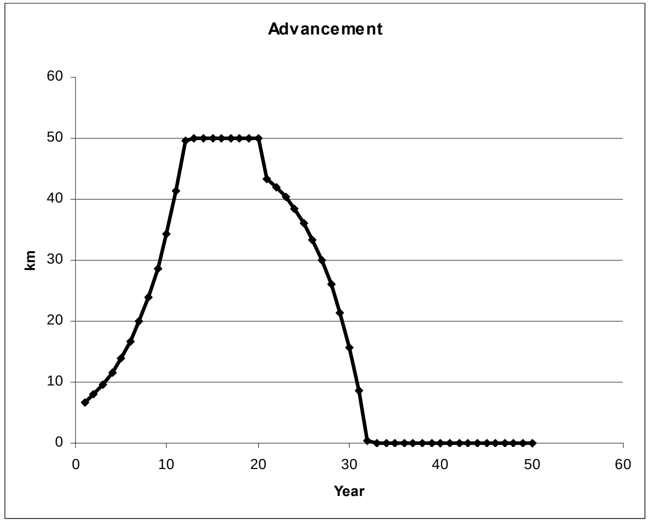
(Approximately 164 billion Euro)

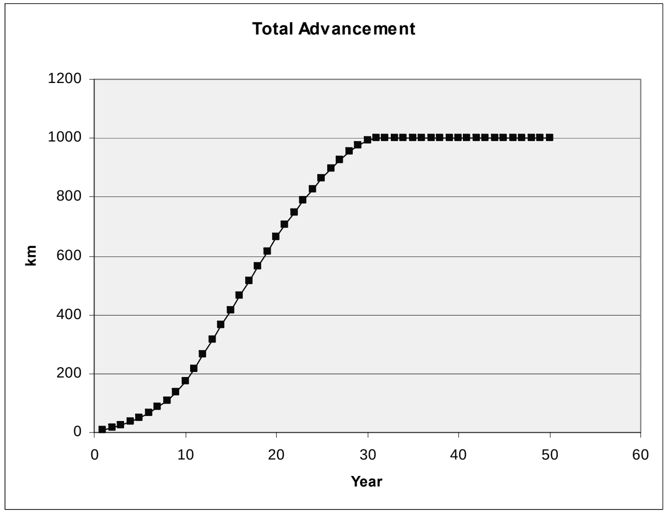
111

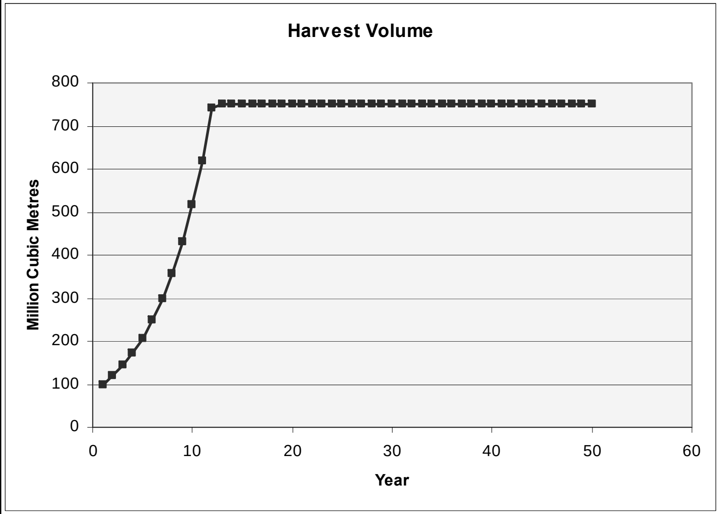
Toth M m3 (harvest/year)
649,1610045

Tote TWh (energy/year)
1298,322009

112



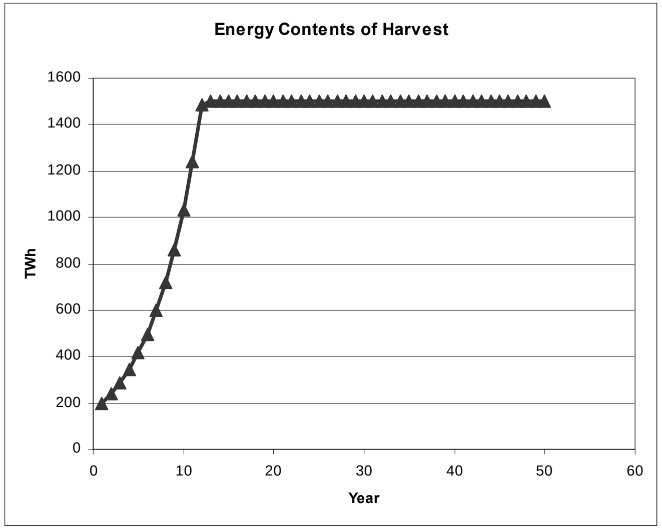




CENTRAL QUESTION:

Where can Europe find 2 563 TWh *of ”new” renewable energy ?*

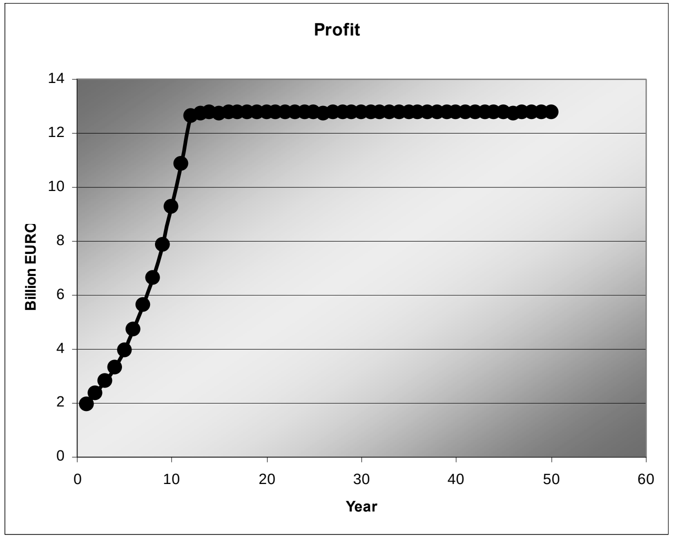
116

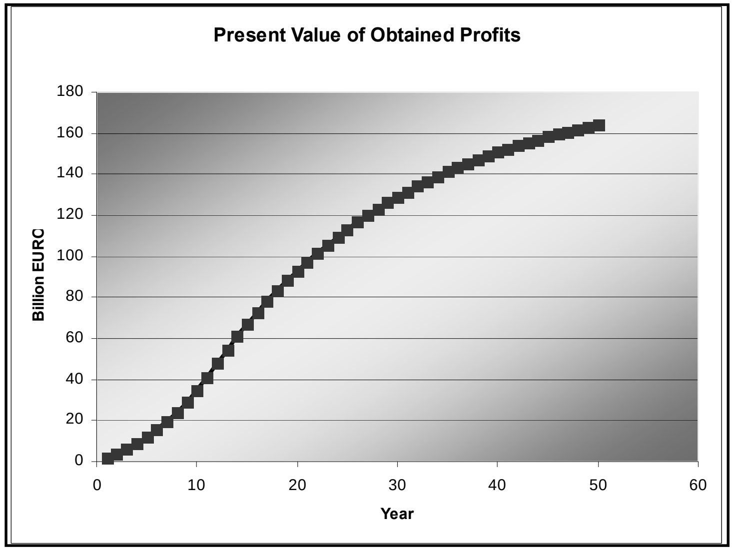


CENTRAL QUESTIONS:

Would it be profitable to deliver this renewable energy to Europe?

118





Numerical optimization (VERSION 2) (Growth = 3.5 m3/year)

```
! INTERNAT7.lng;
! Peter Lohmander 2010_08_23;

MODEL:

SETS:
time/1..50/:x,h,Prof,d;
ENDSETS

rate = .05;
h_init = 100;
h(1) = h_init;
```



```
!Import price in Europe (Chips import
  price, Sweden, 2009),  50 EURO per m3;
IMPP = 50;
!Harvest cost (including terrain
  transport), 6.7 EURO/m3 (final fellings)
  (Sweden 2006), 13.1 EURO/m3
  (thinnings).
(Exchange rate = 10 SEK/EURO);
HARVC = 10;
```



```
!Investment in reforestation, precommercial thinnings,
  fertilization, maintenance and new investments in
  roads etc are about 45% of harvest costs in Sweden
  (2006);
IMC = HARVC/2;
!Transport cost (mainly railroad transport) from road or
  railroad in central Russian Federation to central
  Europe.
Railroad transport cost:
3000 km * 0.005 $/tonkm * 0.8 ton/m3 = 12$/m3 =
9.28 EURO/m3. ;
TRPC = 15;

NETP = IMPP - HARVC - IMC - TRPC;

dNETPdh = -.004;
@FREE(dNETPdh);
```



```
@FOR(time(t): d(t)=@exp(-rate*t));

max = PresV;

@for(time(t): Prof(t) = (NETP +
  dNETPdh*h(t))*h(t)*1000000);
```

```
@for(time(t)| t#LE#20 : h(t) = 21*x(t));

@for(time(t)| t#GT#20 #AND# t#LE#40 :
          h(t) = 21*x(t) + 21*x(t-20));

@for(time(t)| t#GT#40 #AND# t#LE#60 :
     h(t) = 21*x(t) + 21*x(t-20) + 21*x(t-40));
```

125

```
PresV = @sum(time(t): d(t)*Prof(t));

[totd] @sum(time(t):x(t)) <= 1000;

@for(time(t)| t#LT#50 : h(t+1) < 1.2*h(t));

@for(time(t)| t#LT#50 : h(t+1) > 0.98*h(t));
```

126

```
!Sustainable harvesting constraint;
@for(time(t)| t#GT#30 : h(t) > 1050);

toth = @SUM(time(t): h(t))/50;
tote = 2*toth;
```

127

```
DATA:
@OLE('internat7.XLS')=x,h,Prof, h_init,
  rate, PresV, toth, tote;
ENDDATA

end
```

128

The Optimal Present Value

PresV

1,97976E+11

(Approximately 198 billion Euro)

129

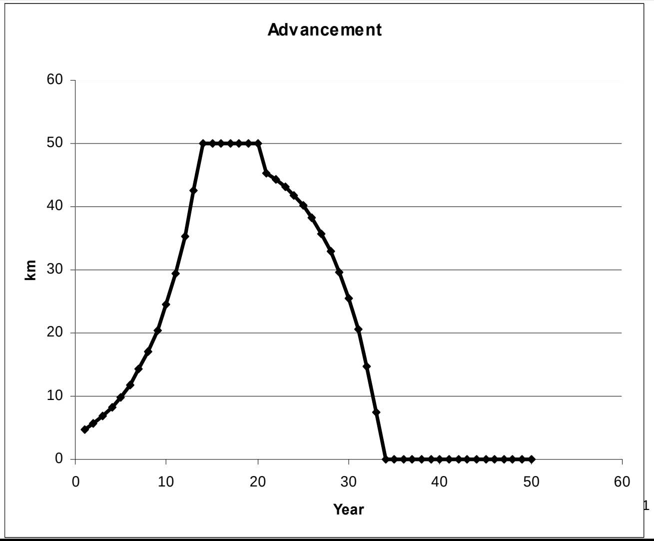
Toth (M m3/year)

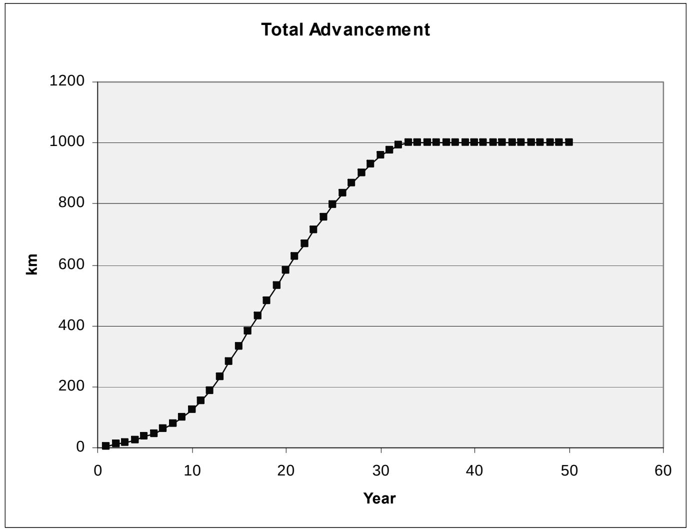
873,9932054

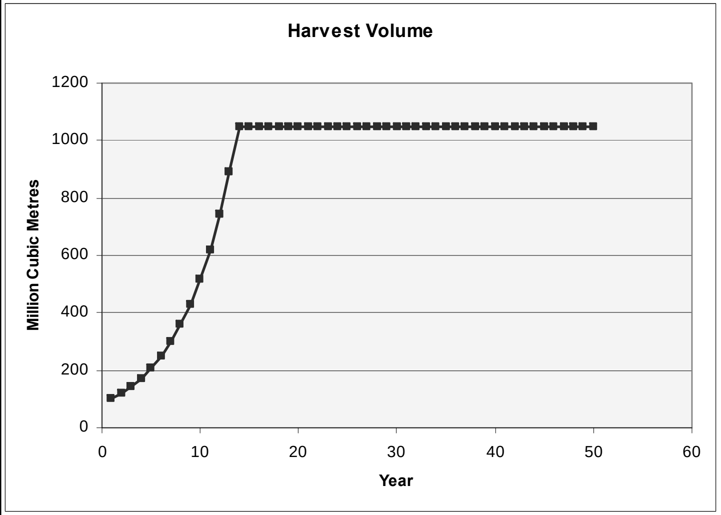
Tote (TWh/year)

1747,986411

130



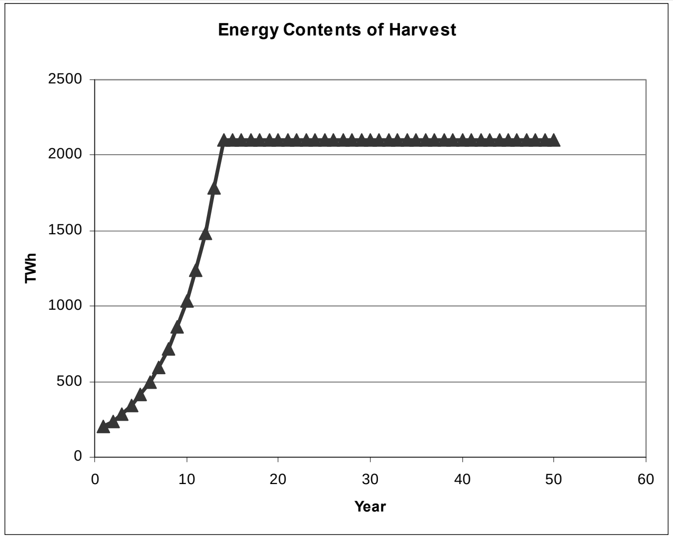




CENTRAL QUESTION:

Where can Europe find 2 **563 TWh** ***of "new" renewable energy ?***

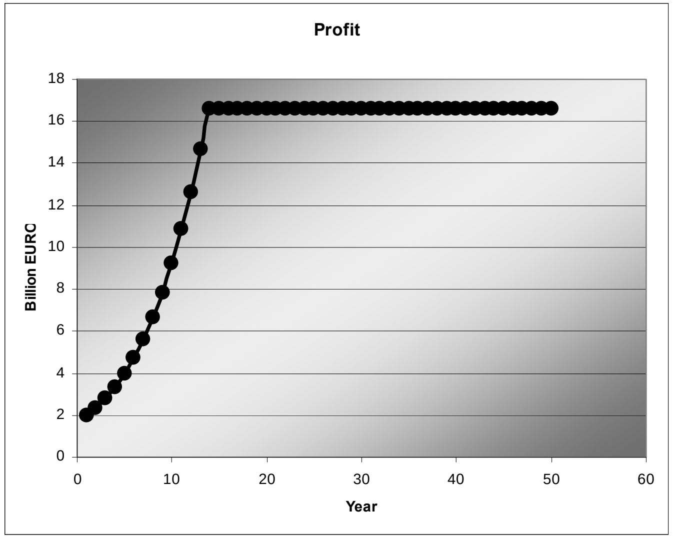
134

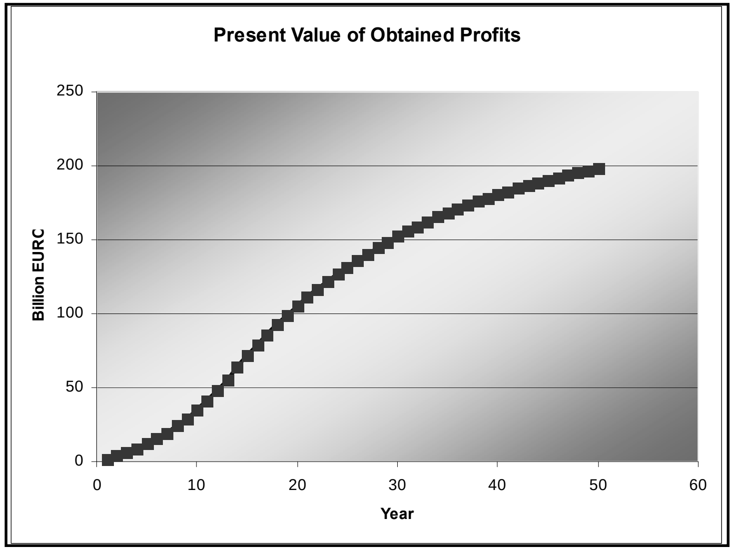


CENTRAL QUESTIONS:

Would it be profitable to deliver this renewable energy to Europe?

136





Observation

If the growth would be
4,271666 m3/year,
Then, 2 563 TWh
would be possible to deliver,
each year, for ever, from this area.

139

There are enormous options in the Russian forest sector if we optimize the dependent activities!

140

GENERAL SUGGESTIONS:

Investigate, in detail, the most rational ways to improve the total solution.

Some of the important parts to investigate are growth under different treatments and costs of harvesting and transport (including infrastructure investments and maintenance) under different designs of the total operation.

Then: Follow the optimized plan!

This way, Europe will get the desired amount of renewable energy, the world climate improves and considerable profits are generated!

141

Conclusions

In Russian Federation, the potential sustainable forest harvesting level is more than ten times higher than present harvesting.

The forest resource may be used as a sustainable source of energy in large regions of the world, such as central Europe. EU has the target of 20% renewable energy in the year 2020.

The general structure of dynamic quadratic programming models for optimal coordinated expansion of sustainable forest and bio energy supply chains, infrastructure and industrial plants has been studied.

Alternative dynamic quadratic programming models have been described.

Typical dynamic solutions have been derived for a region in low resolution.

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A global project

Rational and sustainable international policy for the forest sector

- with consideration of energy, global warming, risk, and regional development

Coordinator:

Professor Dr. Peter Lohmander, SLU, SE-901 83 Umea, Sweden, Peter@Lohmander.com

143

Objectives:

- The project should **develop a rational and sustainable international policy** for the forest sector with consideration of energy, global warming, risk, and regional development.
- Specific national issues and conditions should be considered in this process.

144

Regions and Partners

- The project organization design process is still going on. Regional coordinators have already been defined for most parts of our planet.

145

Project plan

A preliminary project plan with national perspectives on the global project can be downloaded here:

http://www.lohmander.com/ip090805.pdf

Observation: The time plan will be updated.

146

Thank you for listening!
Questions?

Peter Lohmander

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