Economic optimization of sustainable energy systems based on forest resources with consideration of the global warming problem: International perspectives

Peter Lohmander
Professor Dr., SLU, Umeå, SE-901 83, Sweden
Peter.Lohmander@SLU.se

INTERNATIONAL YEAR OF FORESTS • 2011

SKOGEN ÖVER GRÄNSERNA
Program för den 26 oktober 2011

More details, sources and optimizations:

These things have been presented and discussed with more details at many international conferences.

Complete presentations and articles, reports and pictures from Argentina, Austria, Chile, China, England, Russia, Spain, Sweden and USA, can be downloaded from:

http://www.Lohmander.com

Lohmander, P., Ekonomisk skogsproduktion m.h.t. skogsindustri och energiindustri, Economic forest production with consideration of the forest and energy industries, June 7, 2011
http://www.lohmander.com/PL_EON_110607.pdf

CHP – Combined Heat and Power

Sustainable energy from forest resources

OPTIMAL RESULTS FROM DHINV
Software by
Peter Lohmander 2010

OPTIMAL TIME AND STATE DEPENDENT DECISIONS AND EXPECTED PRESENT VALUES

t = 1

i(t)	E(PV)	i(t+1)	DEC	CVIA	Entering Partial States
1	34830.	5	1	0	0 0 0

t = 2

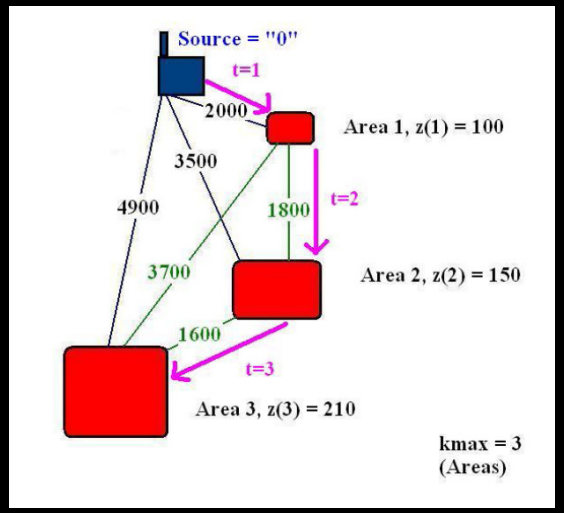
i(t)	E(PV)	i(t+1)	DEC	CVIA	Entering Partial States
5	40538.	7	2	1	1 0 0

t = 3

i(t)	E(PV)	i(t+1)	DEC	CVIA	Entering Partial States
7	45062.	8	3	2	1 1 0

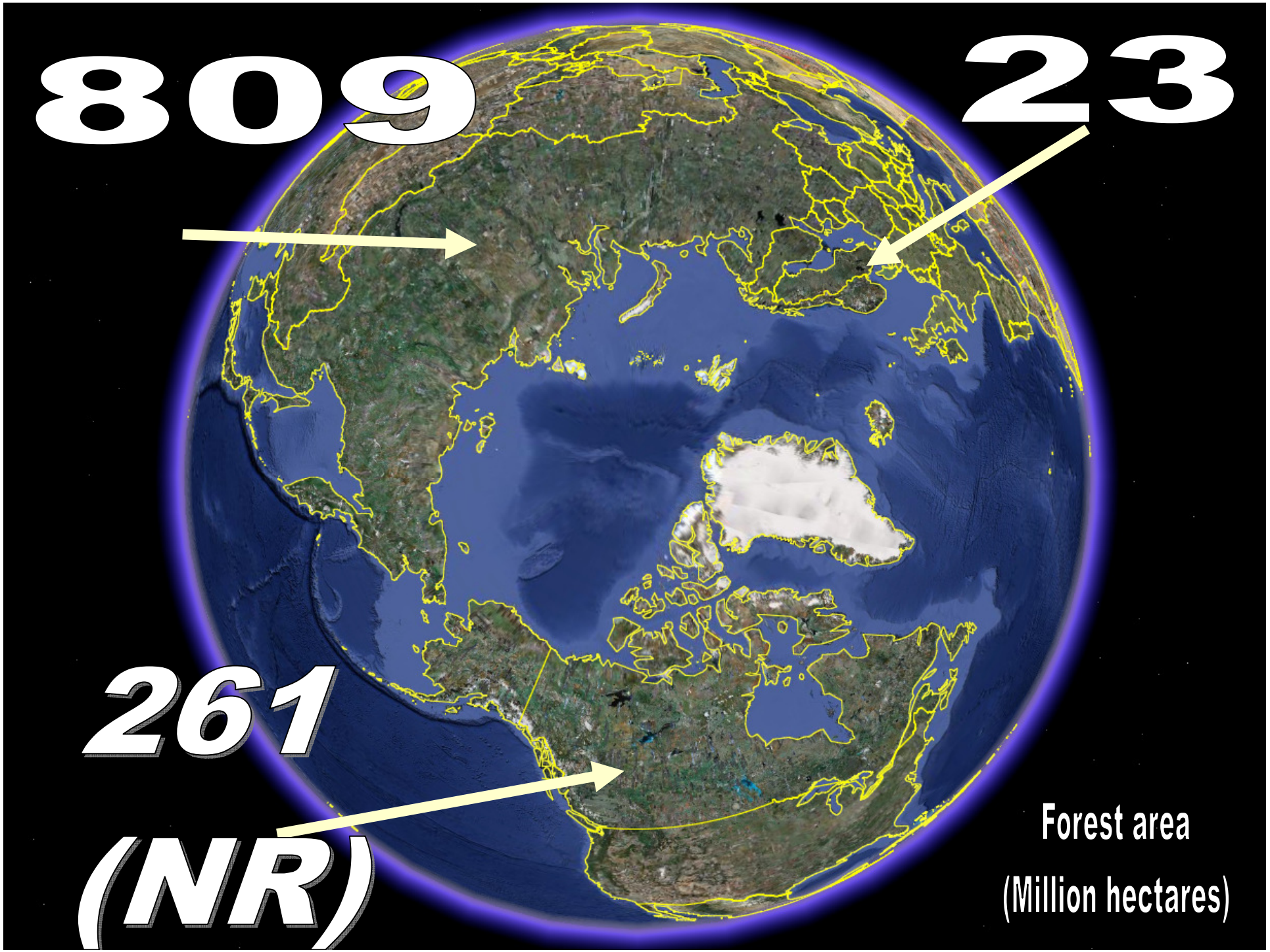
t = 4

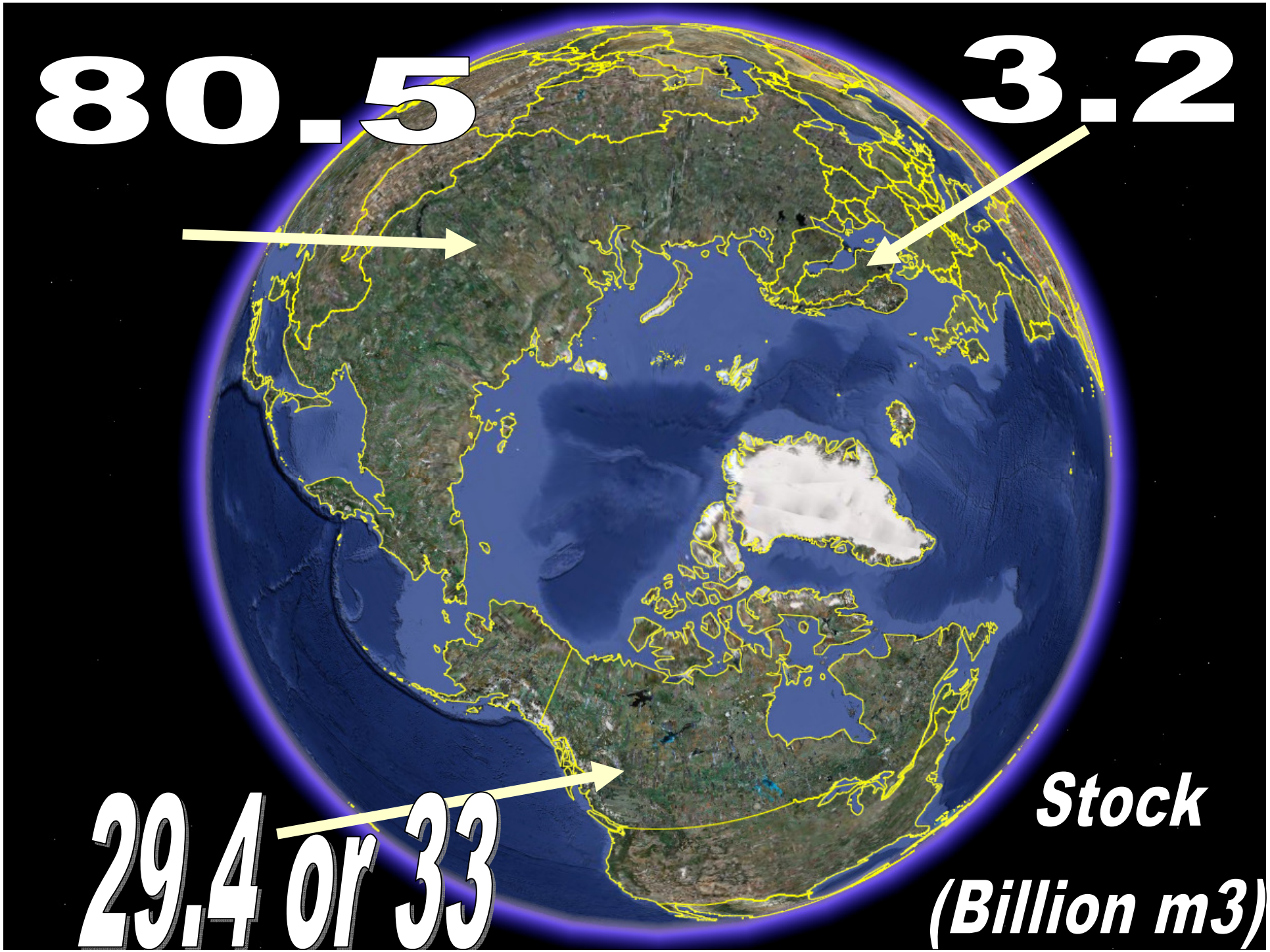
i(t)	E(PV)	i(t+1)	DEC	CVIA	Entering Partial States
8	51517.	8			1 1 1

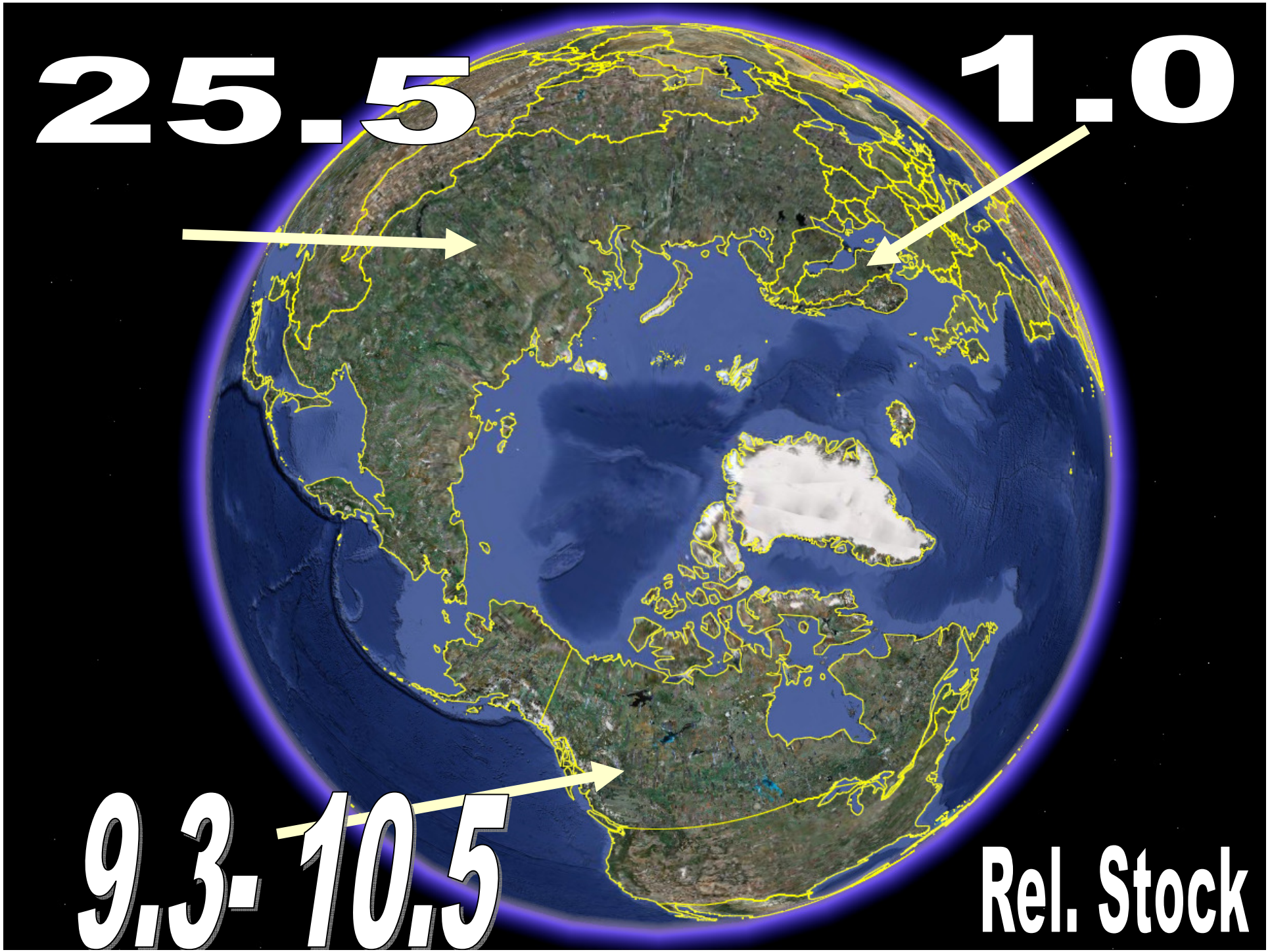


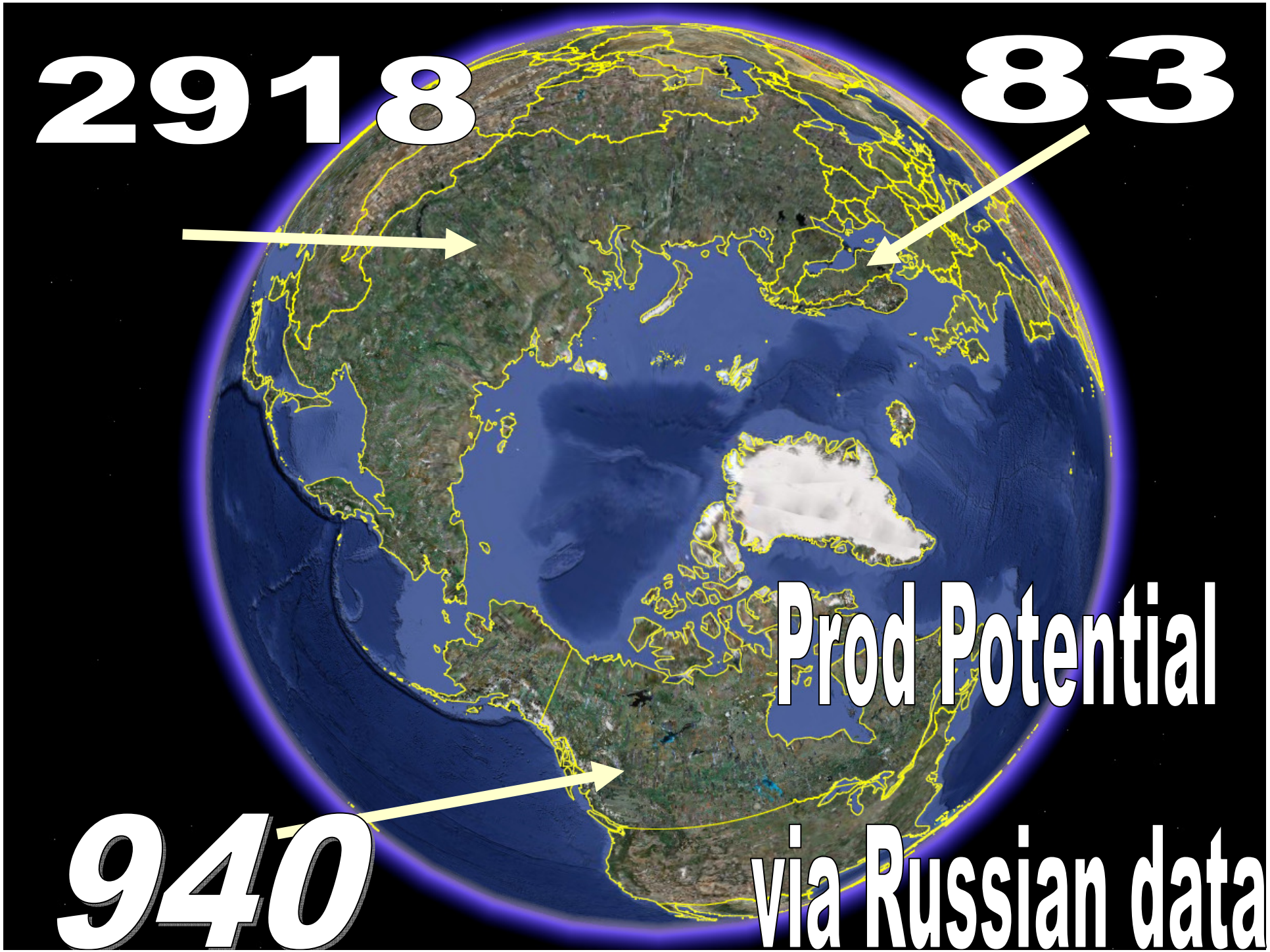

MONGOLIA
CHINA
RUSSIA
FINLAND
SWEDEN
NORWAY
Arctic Ocean
The Circumpolar Extent of the Boreal Forest
Boreal Forest
International Boundaries
U.S.A. (ALASKA)
ARCTIC CIRCLE
Atlantic Ocean
Pacific Ocean
CANADA
0 500 1000 1500 km

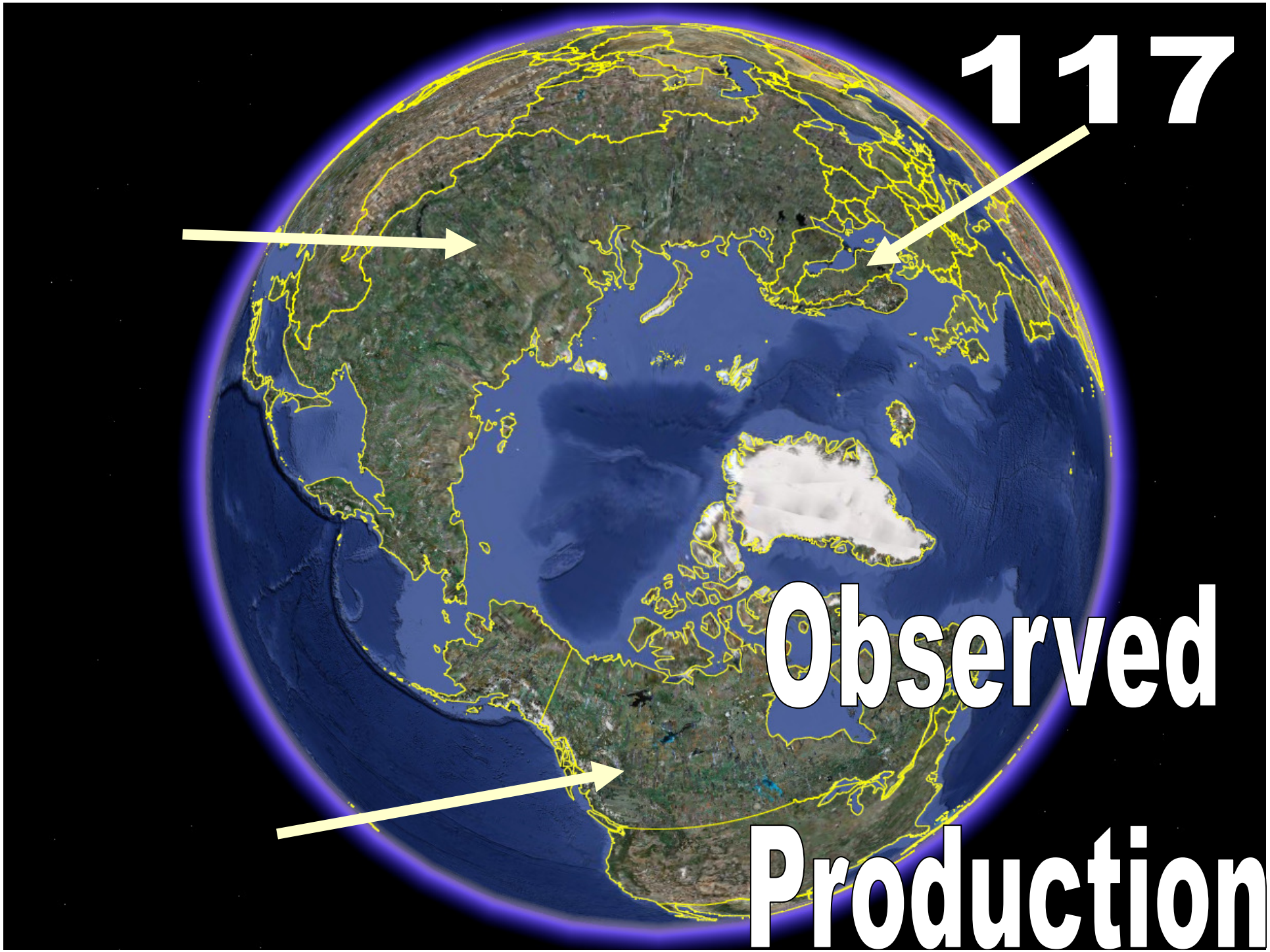

Russian Fed.
Sweden
Canada

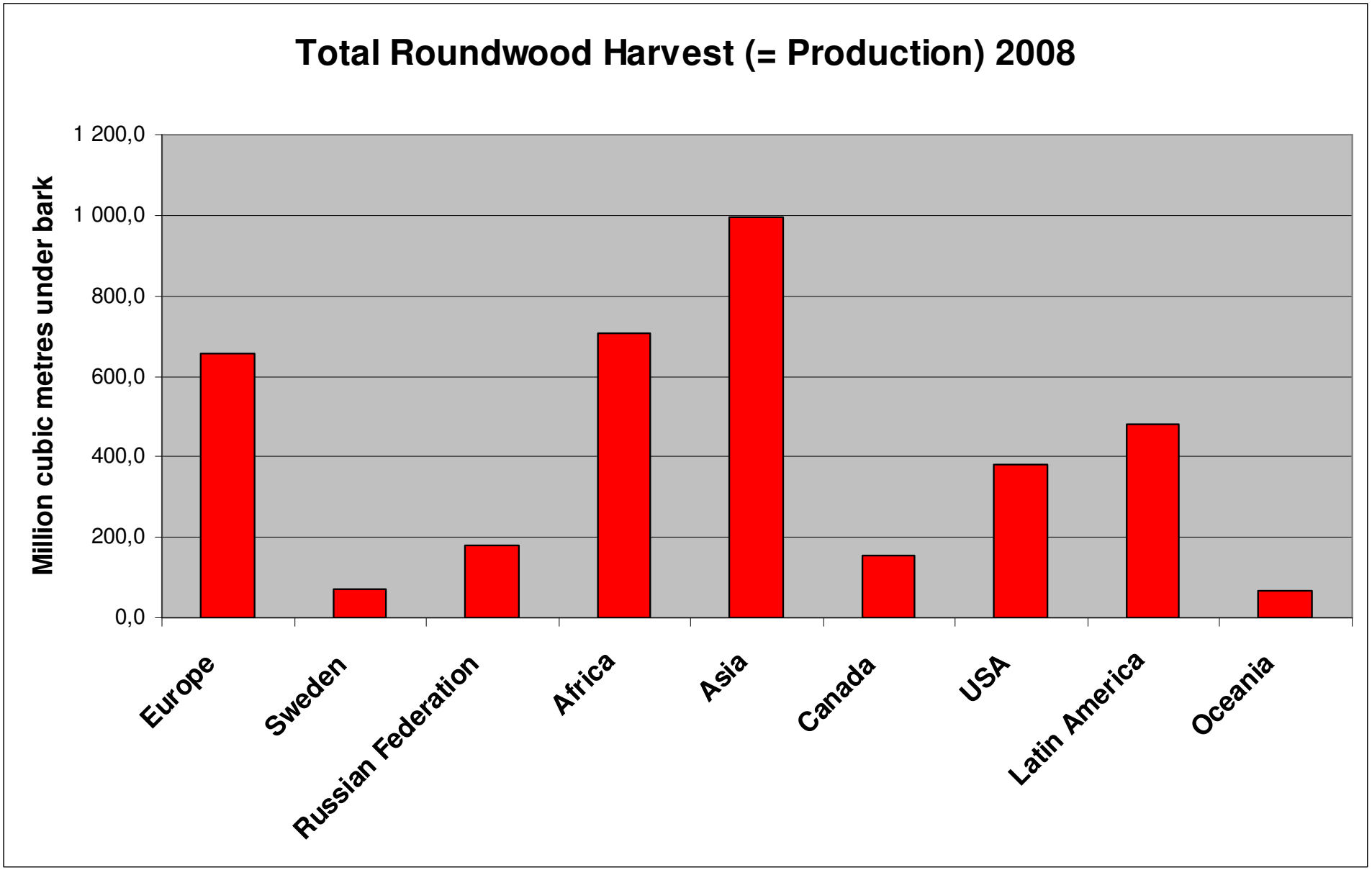

809
23
261
(NR)
Forest area
(Million hectares)


80.5
3.2
29.4 or 33
Stock
(Billion m3)

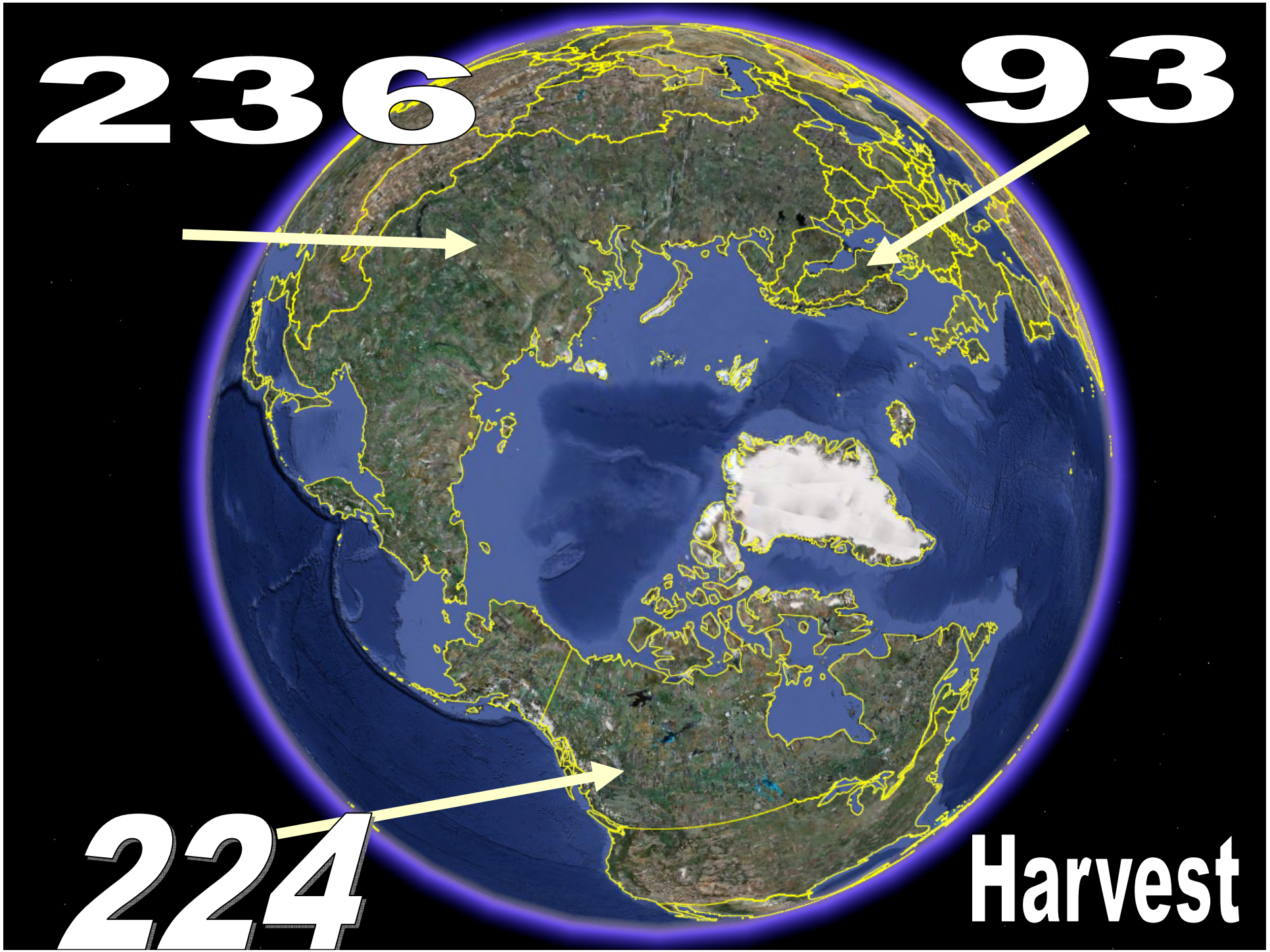

25.5
1.0
9.3-10.5
Rel. Stock

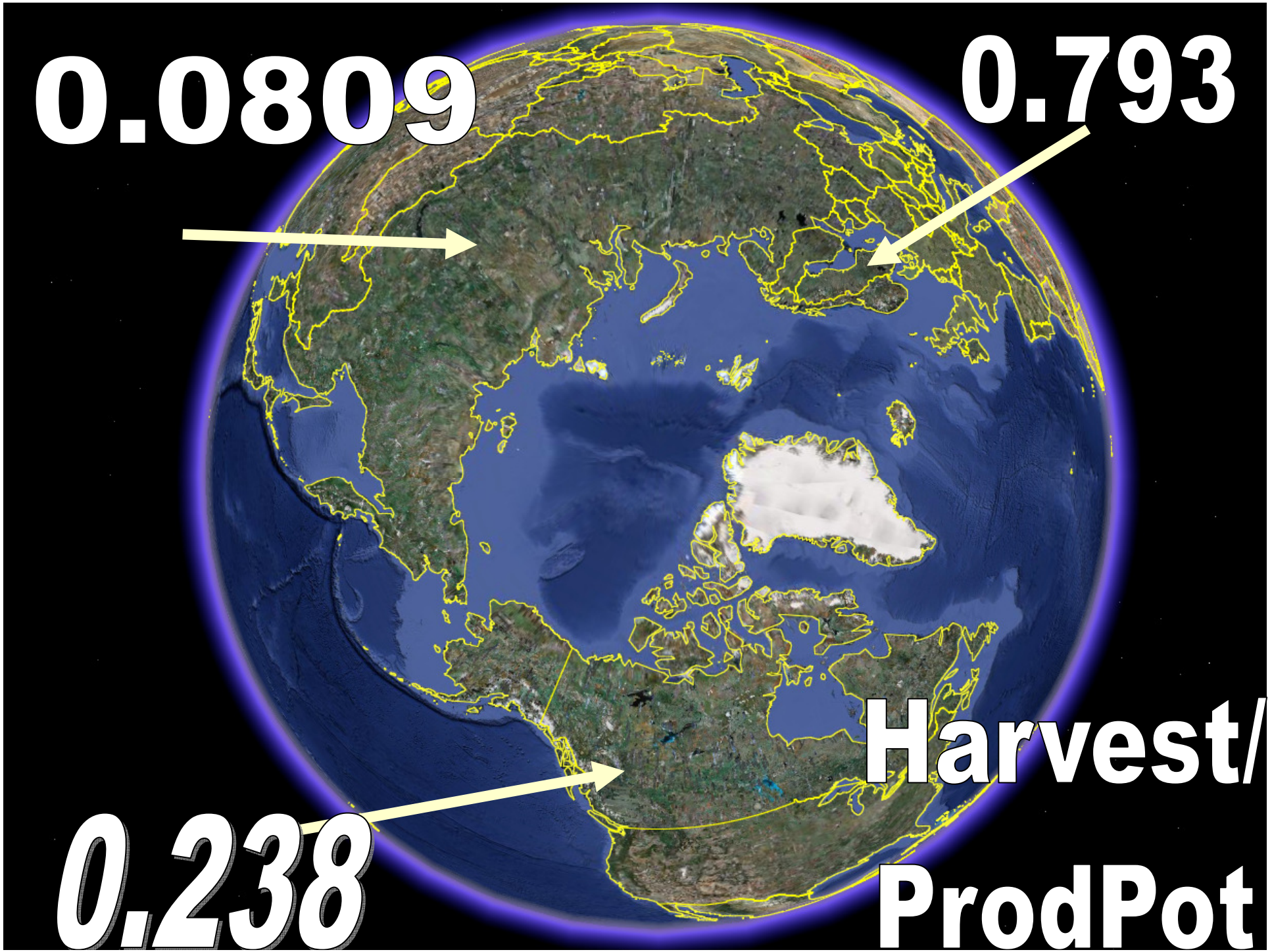

2918
83
Prod Potential
940
via Russian data

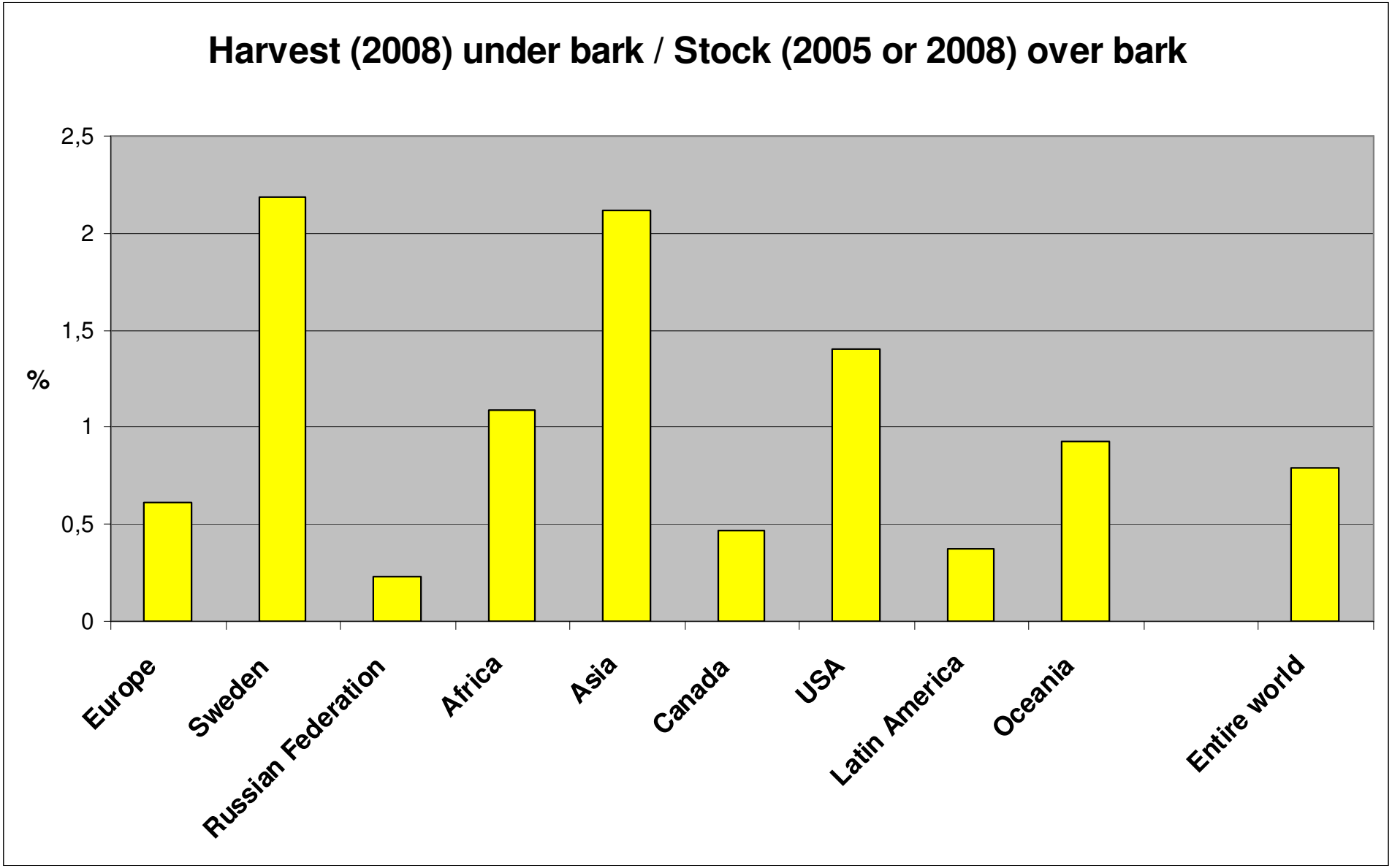

117
Observed
Production



Source: FAOSTAT
Adaptions by Peter Lohmander.


236
93
224
Harvest


0.0809
0.793
0.238
Harvest/
ProdPot



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

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 and Canada, the potential sustainable forest harvesting levels are several times higher than present harvesting.

These biomass resources may be used as a sustainable source of energy in large regions of the world, such as central Europe.

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?***

Energy from different fuels

Water contents

Stem wood and chips

Energy forest

Bränslesortiment	Fukthalt	MWh/ton (enligt angiven fukthalt)
Stamved och flis	0 %	5,4
Stamved och flis	50 %	2,4
Energiskog	0 %	4,9
Övriga träddelar	0%	4,9
Bark	50%	2,4
Kol		7,5
Eldningsolja 1 (EO1)		9,9
Eldningsolja 5 (EO5)		10,8
Ved	50%	1,9 MWh/m³f

1 m³ EO1 = 0,835 ton
1 m³ EO5 = 0,940 ton
Ved och flis, 50 % fukthalt = 0,800 ton/m³f
Bark, 50 % fukthalt = 0,670 ton/m³f

Källa: Virkesbalanser 1992, Meddelande 2-1993, Skogsstyrelsen

Canada

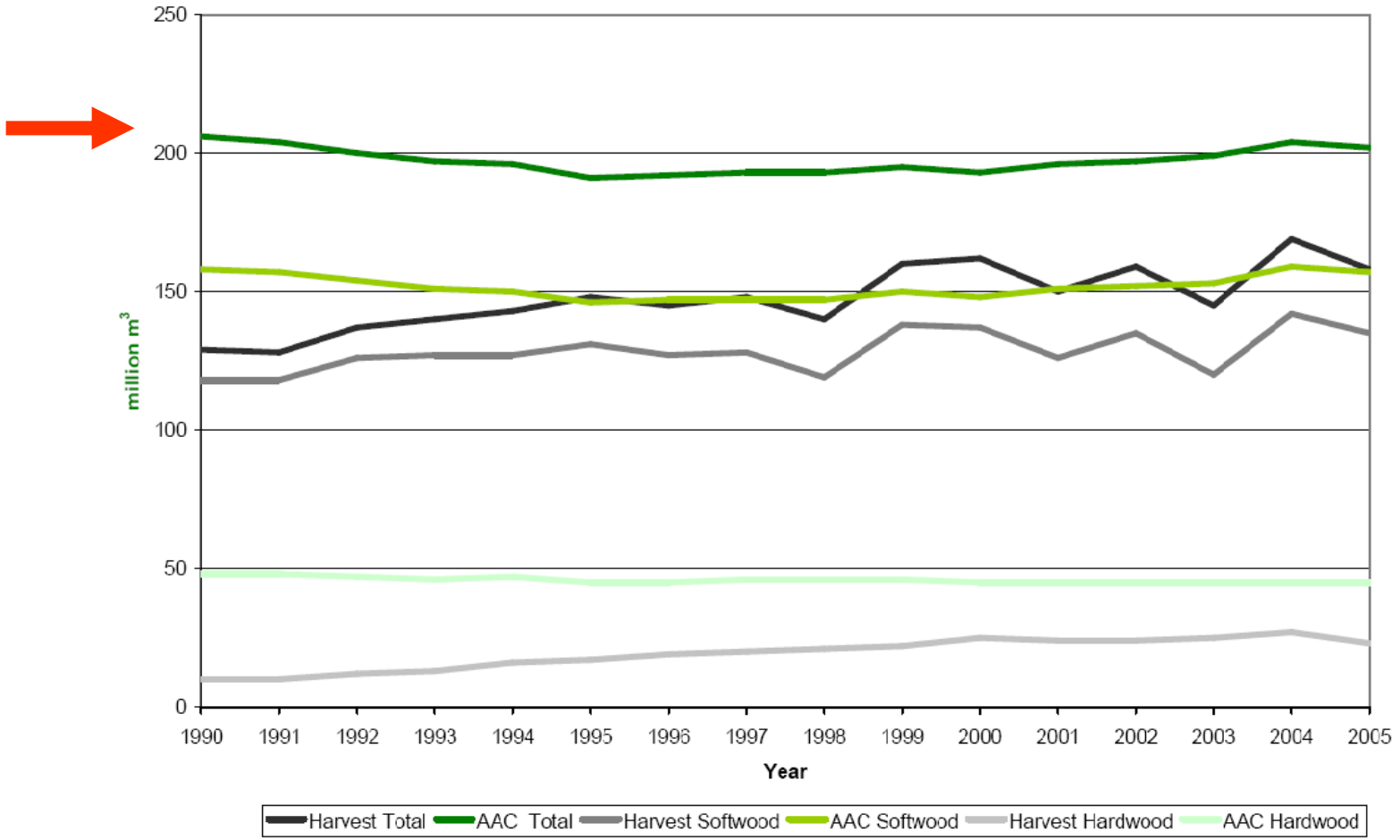


Figure 5.3a Allowable annual cut versus actual harvest (provincial crown land), 1990–2005 (million m3) (CCFM, 2008).

Criteria and Indicators of Sustainable Forest Management in Canada: National Status 2005
Data updated: January 2008

http://www.ccfm.org/ci/rprt2005/English/pdf/5.3a.pdf

Natural Resources Canada | Ressources naturelles Canada

http://www.canadaforests.nrcan.gc.ca/articletopic/14

A global endowment
Article Date: 2005-09-01

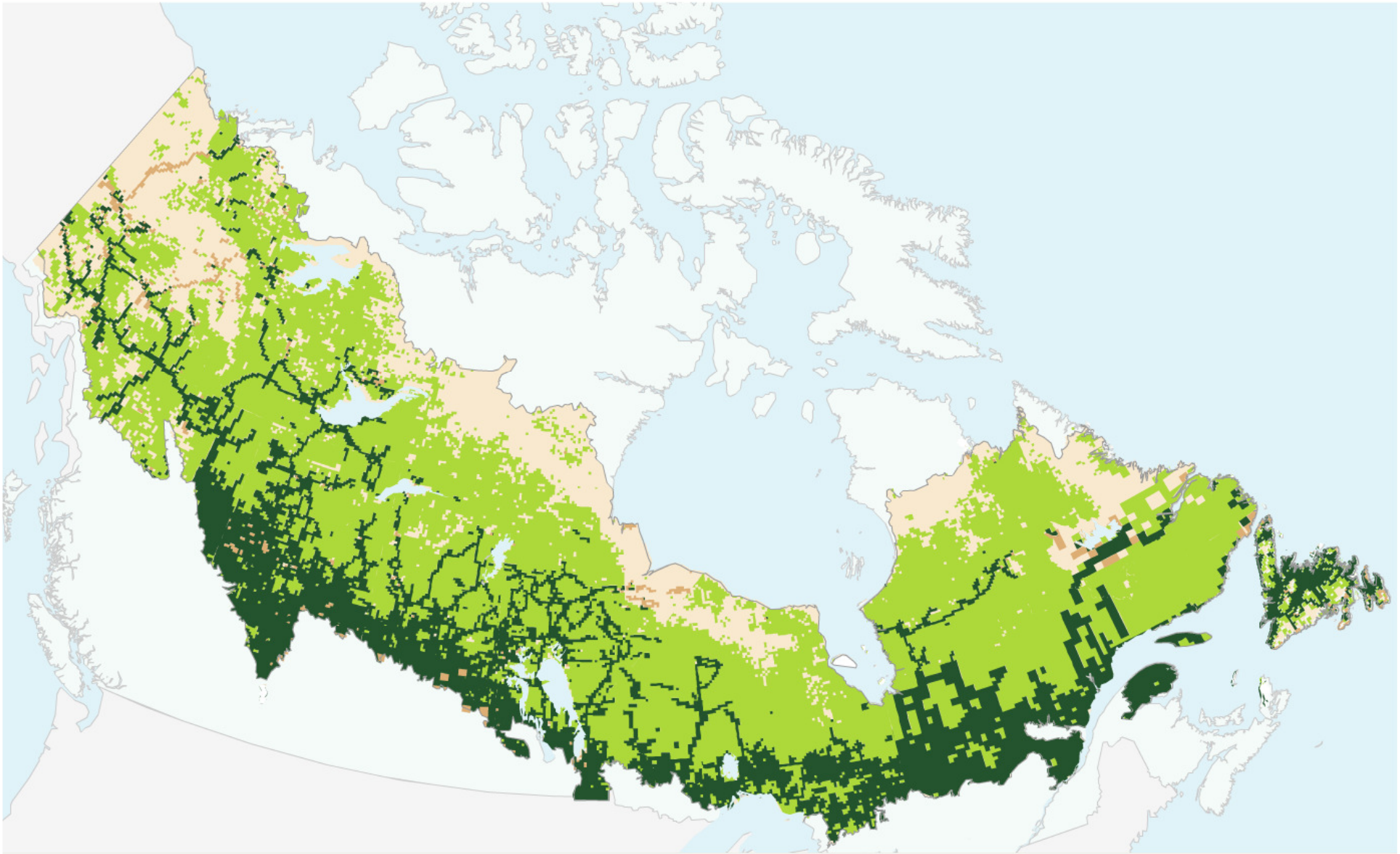
About 750 000 hectares—or 0.2 percent of the total boreal forest —are harvested each year.

The part not managed for timber production is either unavailable because it has been designated as protected areas and reserves, or currently considered inaccessible.

Unlike the forests of the United States, Scandinavia and the majority of other nations, most of Canada's forests (93 percent) are publicly owned. The remaining 7 percent are held by private owners.

Access by Road to Canada's Boreal Region

OTHER



http://www.sfmcanada.org/english/im-accessbyroad.asp

Russian Federation

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, maybe ten times!

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

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..***

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.

The sustainable round wood harvest could be at least ten times higher than today.


Arctic Ocean

ТРАНССИБИРСКАЯ МАГИСТРАЛЬ

и другие основные транзитные линии России

УСЛОВНЫЕ ОБОЗНАЧЕНИЯ

Ж/Д ЛИНИИ

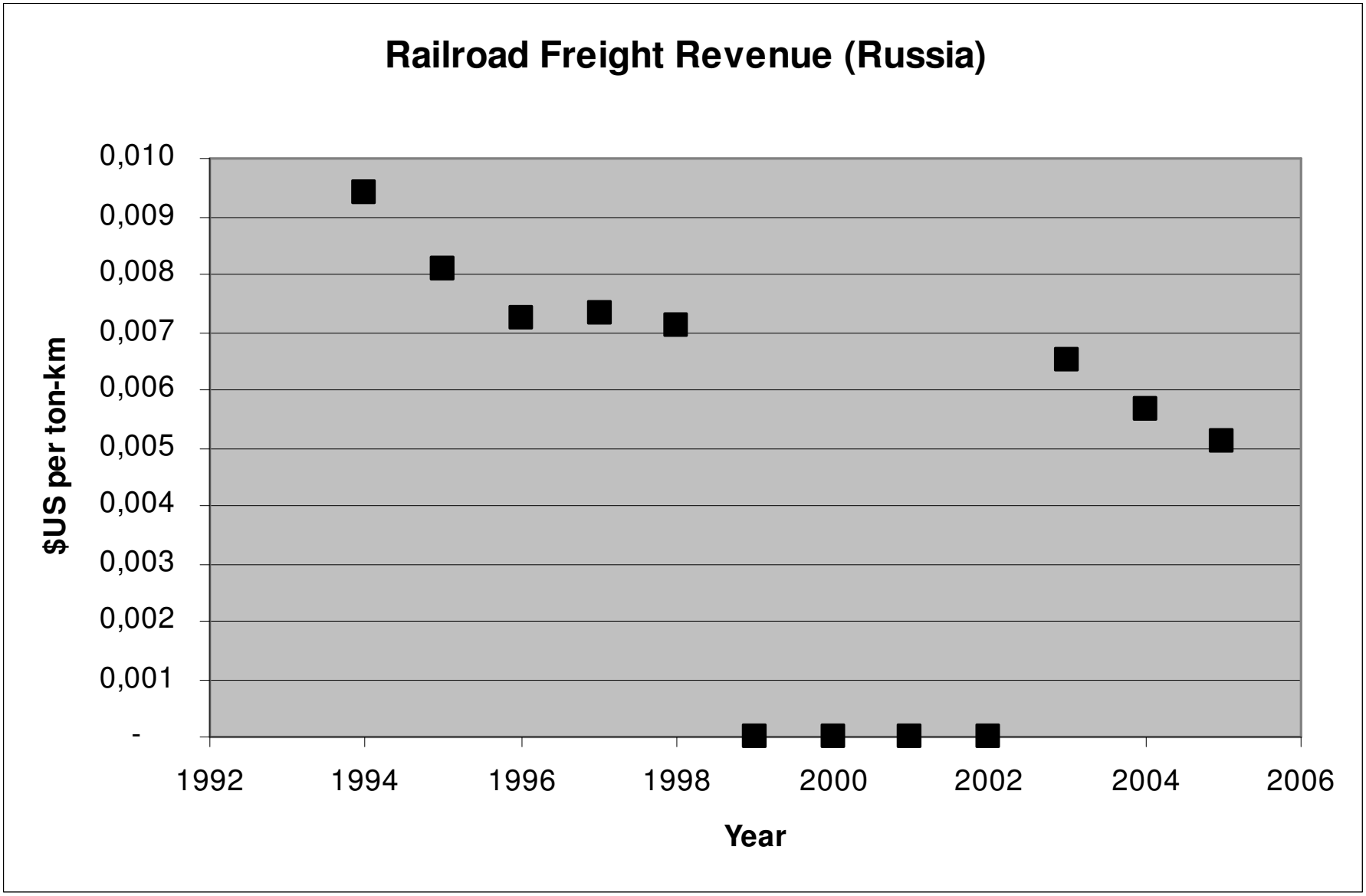
- Транссиб (основной пасс. ход)
- Транссиб (новый пасс. ход)
- БАМ (Байкало-Амурская магистраль)
- Трансмонгольская и Трансманьчжурская линии
- Южно-Уральский ход
- Турксиб (Туркестано-Сибирская магистраль)
- Другие линии, имеющие транзитное значение
- Основные выходы за рубеж

НАСЕЛЕННЫЕ ПУНКТЫ

- МОСКВА — Столицы государств
- Владивосток — Транспортные узлы на Транссибе
- Калининград — Транспортные узлы на других линиях

ГРАНИЦЫ

- Государственная граница Российской Федерации
- Морское побережье Российской Федерации
- Границы субъектов федерации (кроме Автономных округов)



Source:

The World Bank, World Bank Railway Database, 2010

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

Railroad freight cost calculation

3000 km *

0.005 $/tonkm *

0.8 ton/m3

= 12 $/m3

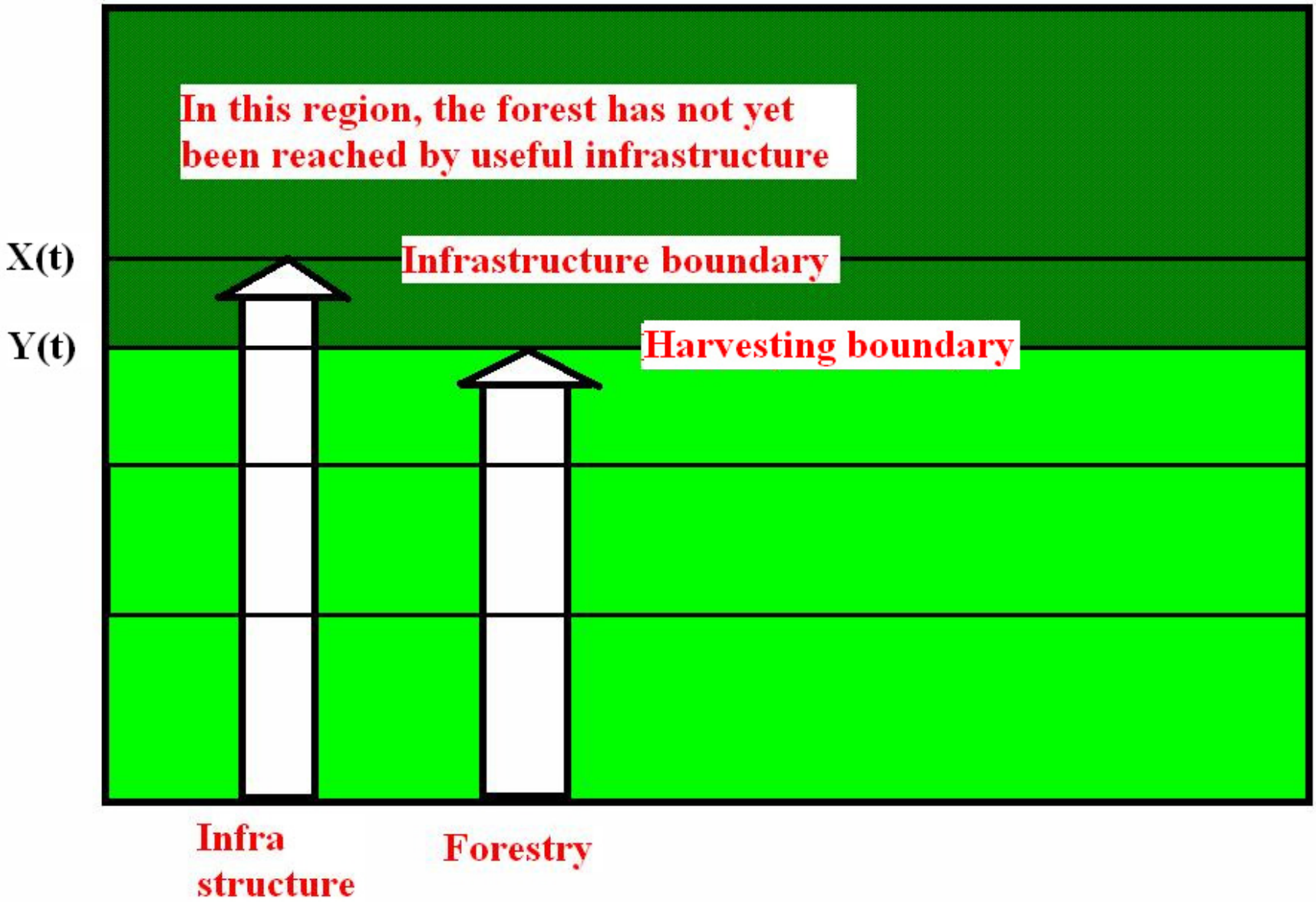
12$/m3 *

0.773 EURO/$

= 9.28 EURO/m3

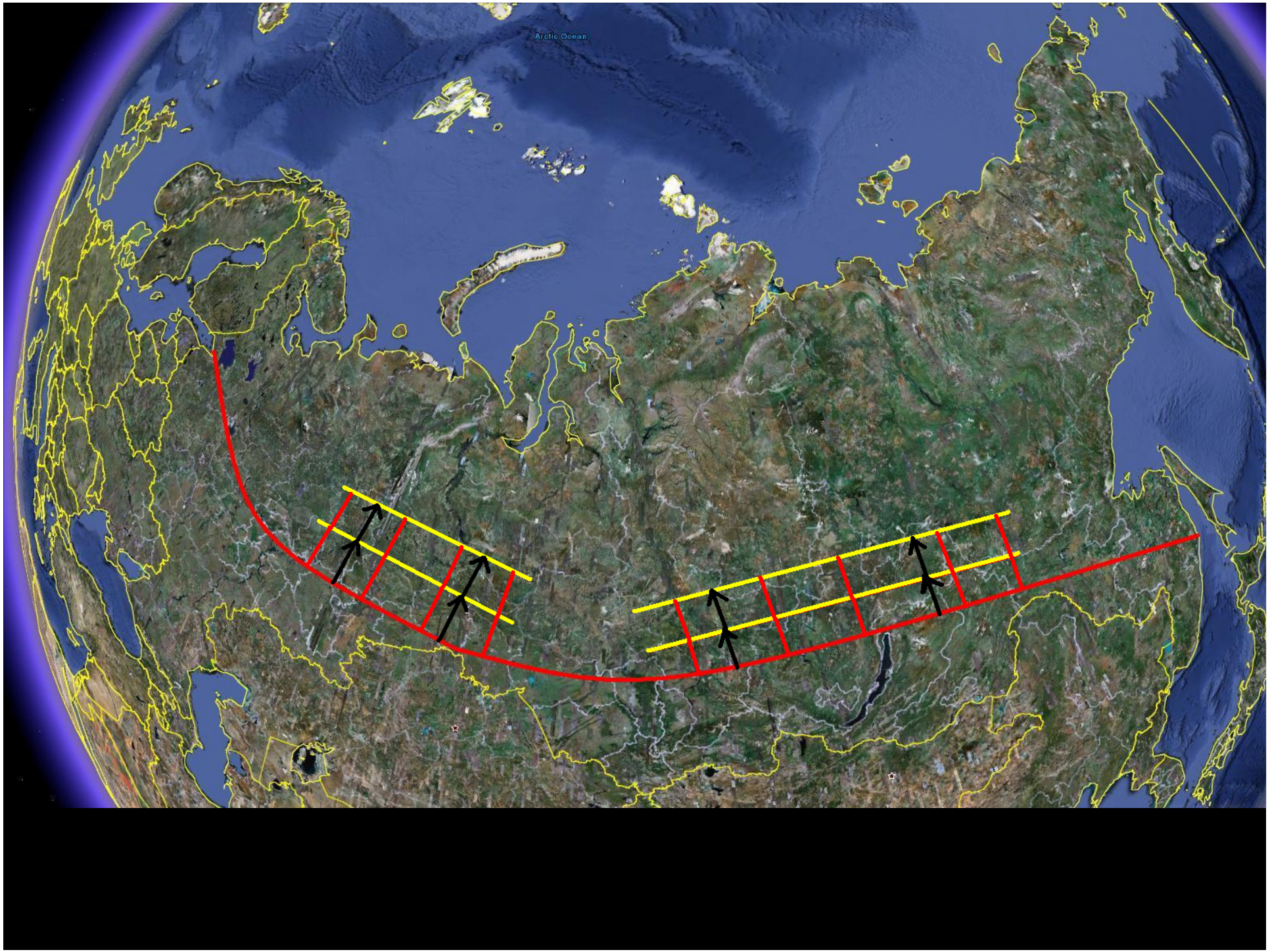

Arctic Ocean

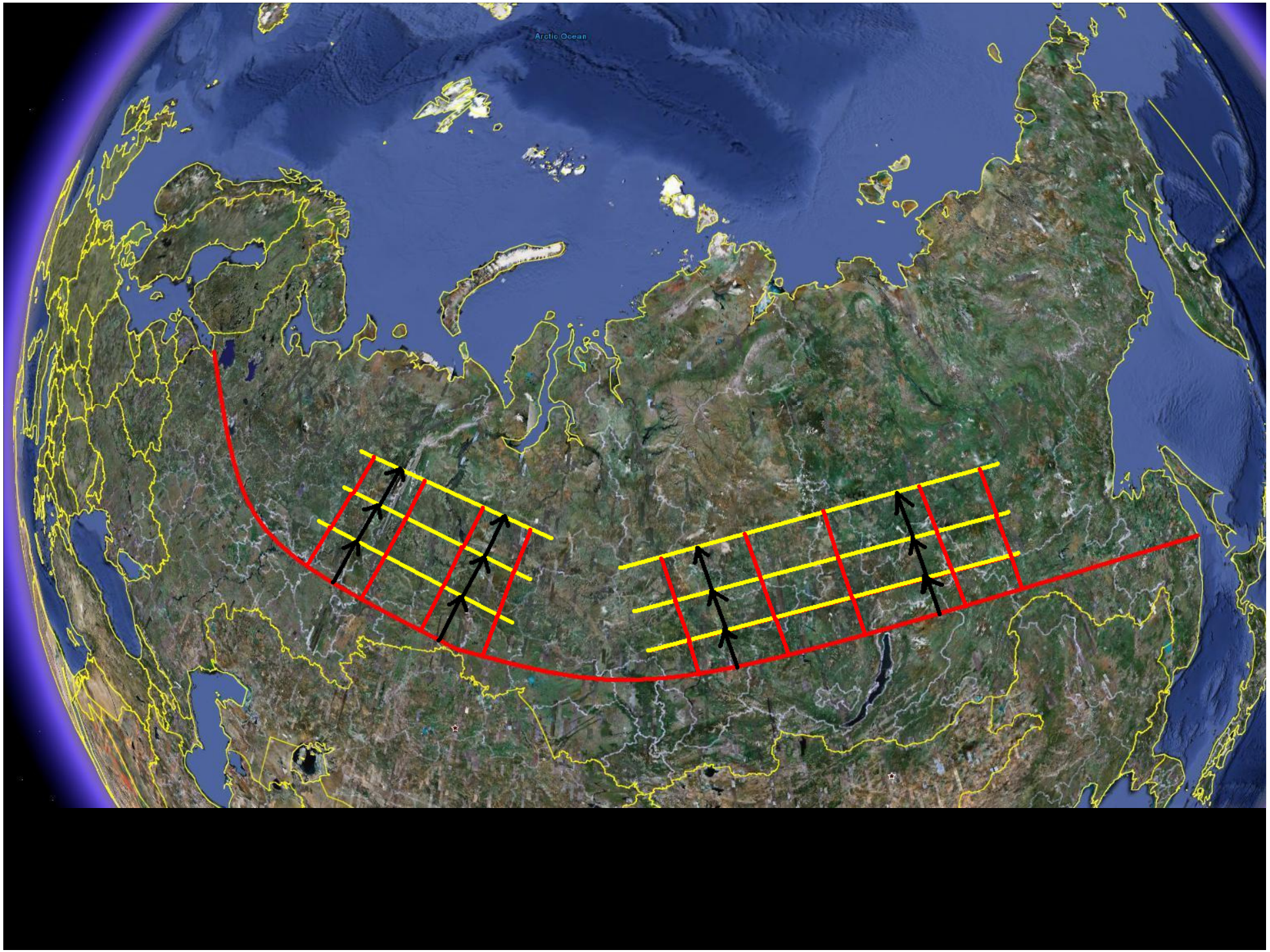

Arctic Ocean


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


Arctic Ocean


Arctic Ocean


Arctic Ocean


Arctic Ocean

Optimization:

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

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)

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

x_t Advancement during period t (km)

M Total advancement limit (km)

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

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

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

$$h_1 = "h\_init"$$

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)

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

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

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

dhp Highest acceptable relative increase, per period, of h_t

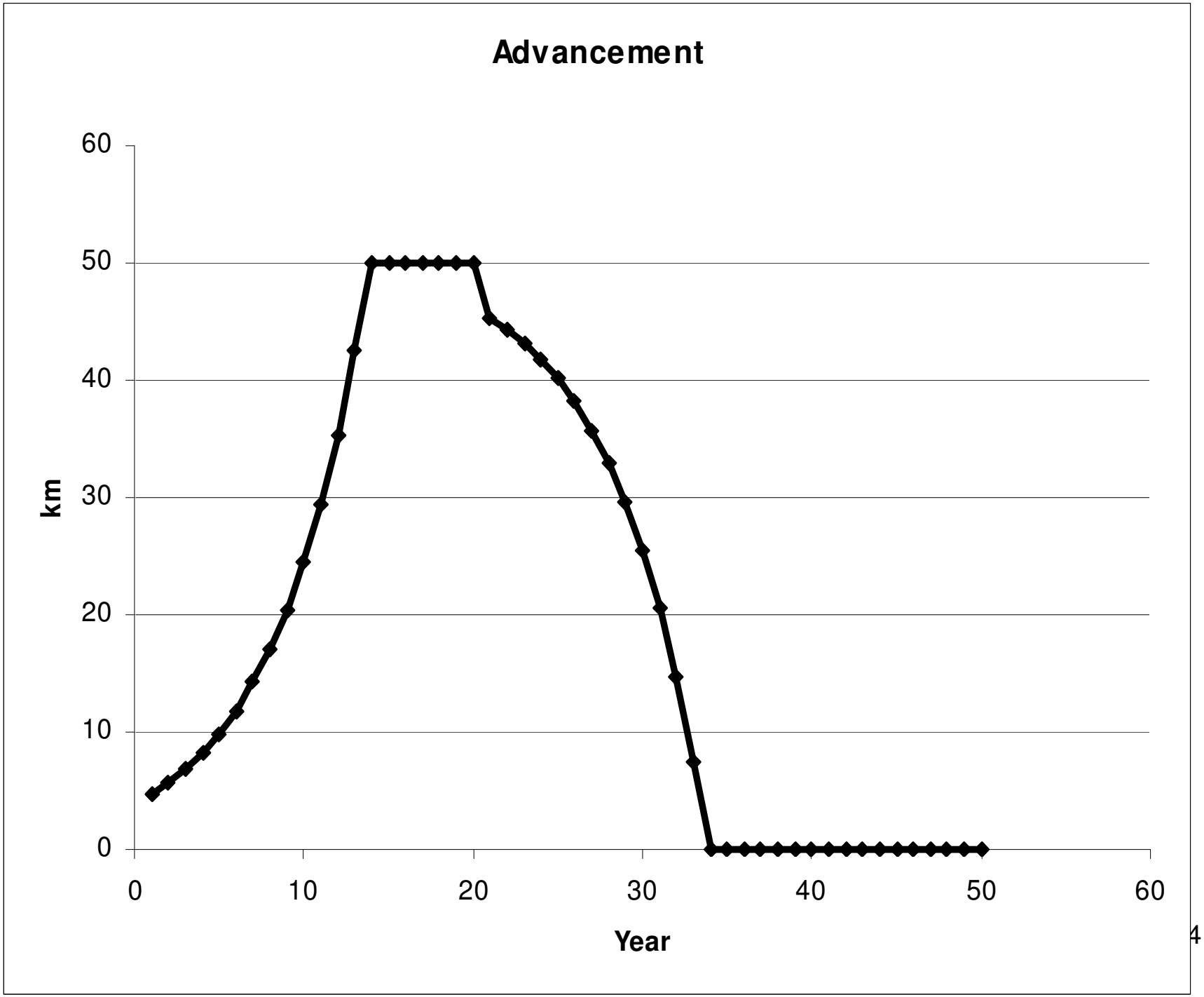
dhm Highest acceptable relative decrease, per period, of h_t

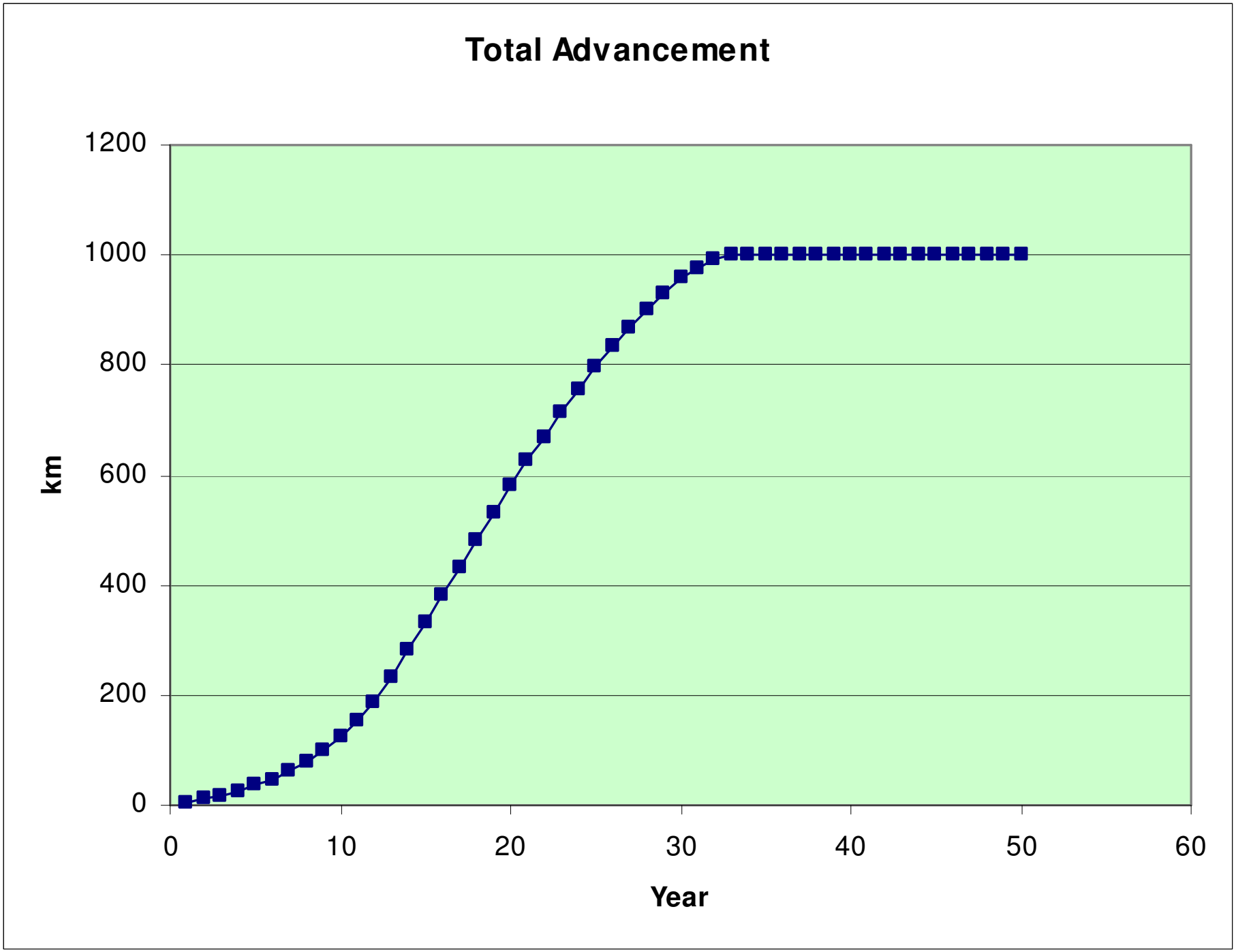
A concrete example

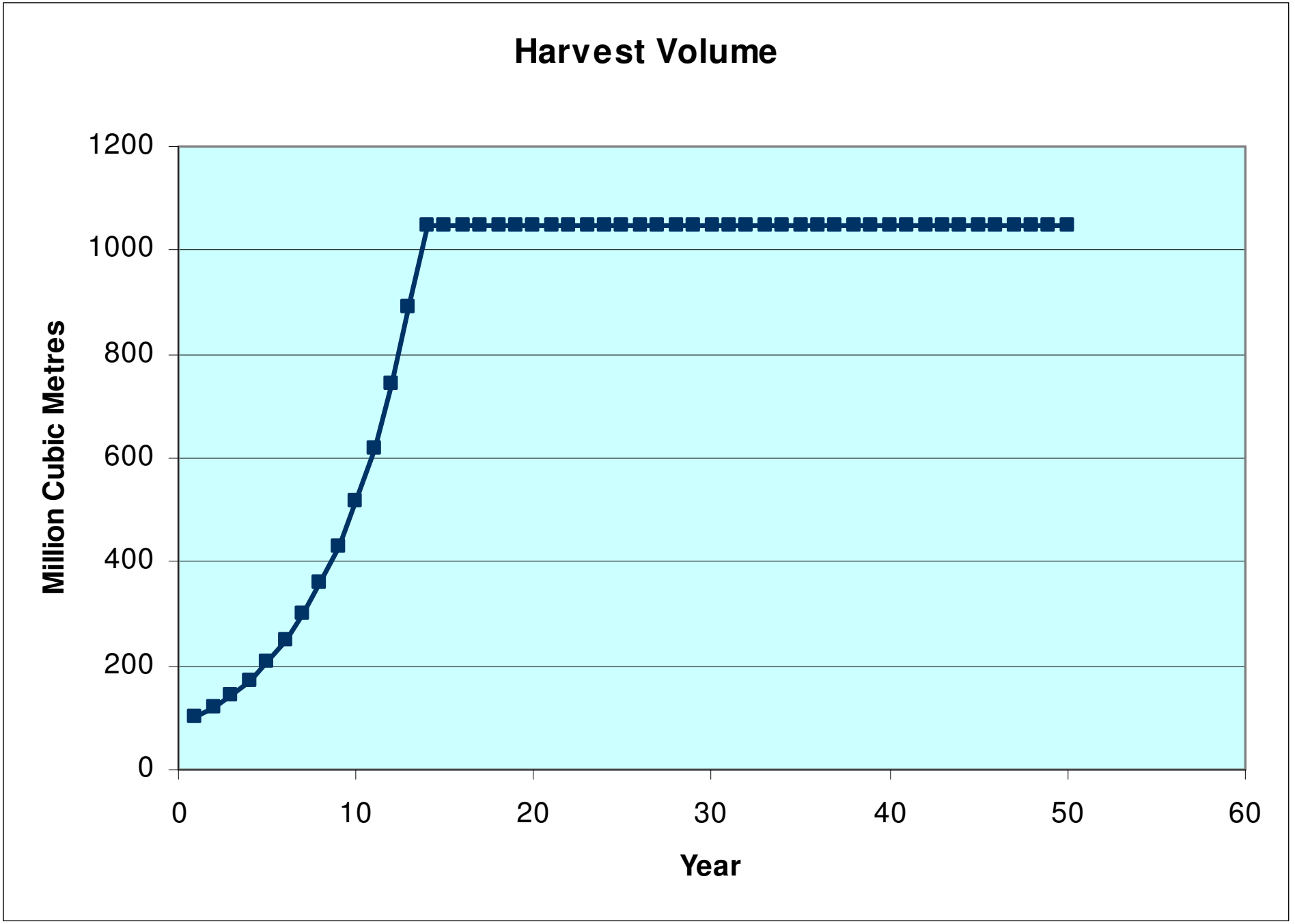
Area = 3000 km * 1000 km = 300 M ha

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)	1 500	2 100	2 700

Numerical optimization (Growth = 3.5 m3/year)

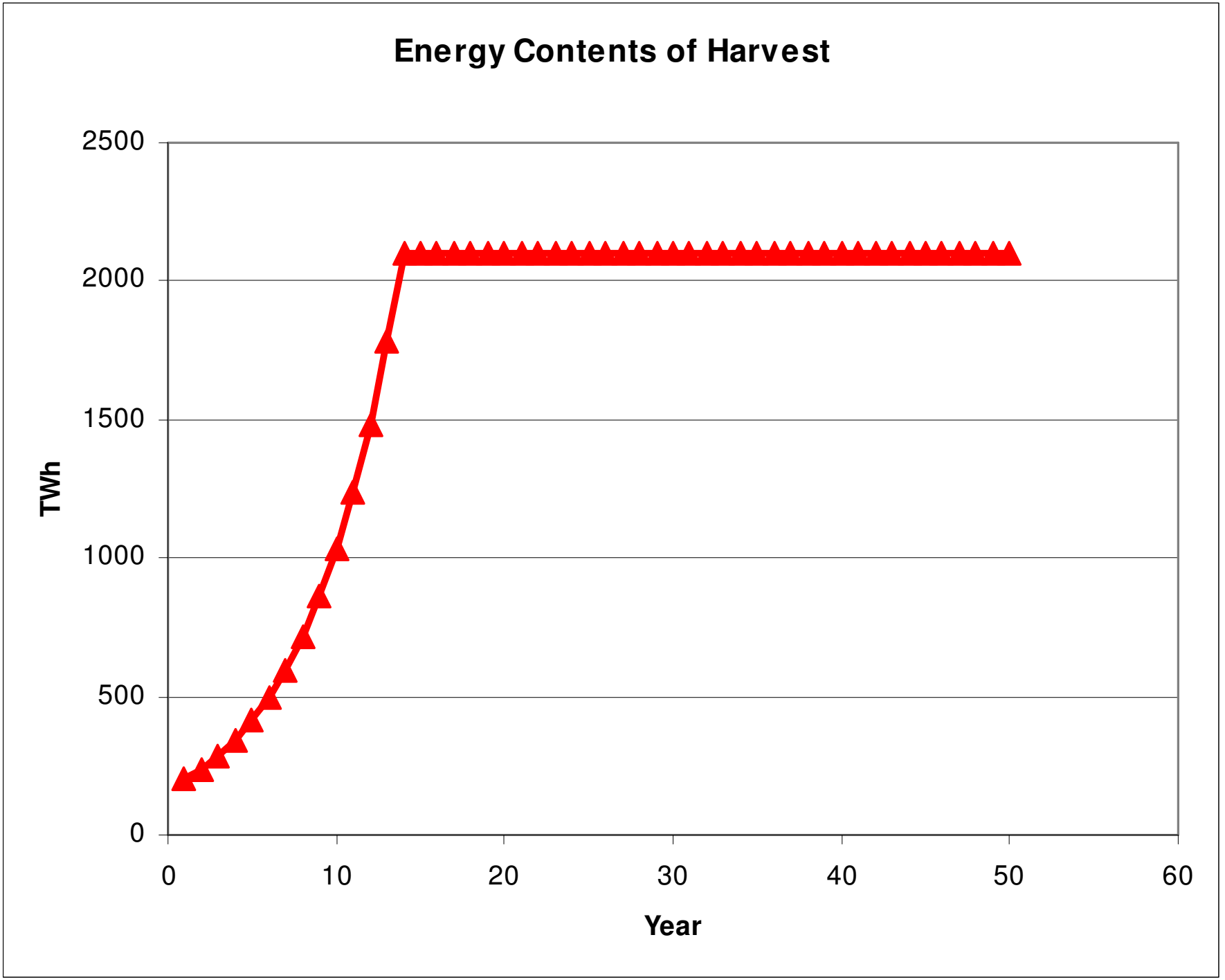

Advancement
60
50
40
30
20
10
0
km
0
10
20
30
40
50
60
Year


Total Advancement
1200
1000
800
600
400
200
0
km
0
10
20
30
40
50
60
Year


Harvest Volume
Million Cubic Metres
1200
1000
800
600
400
200
0
0
10
20
30
40
50
60
Year

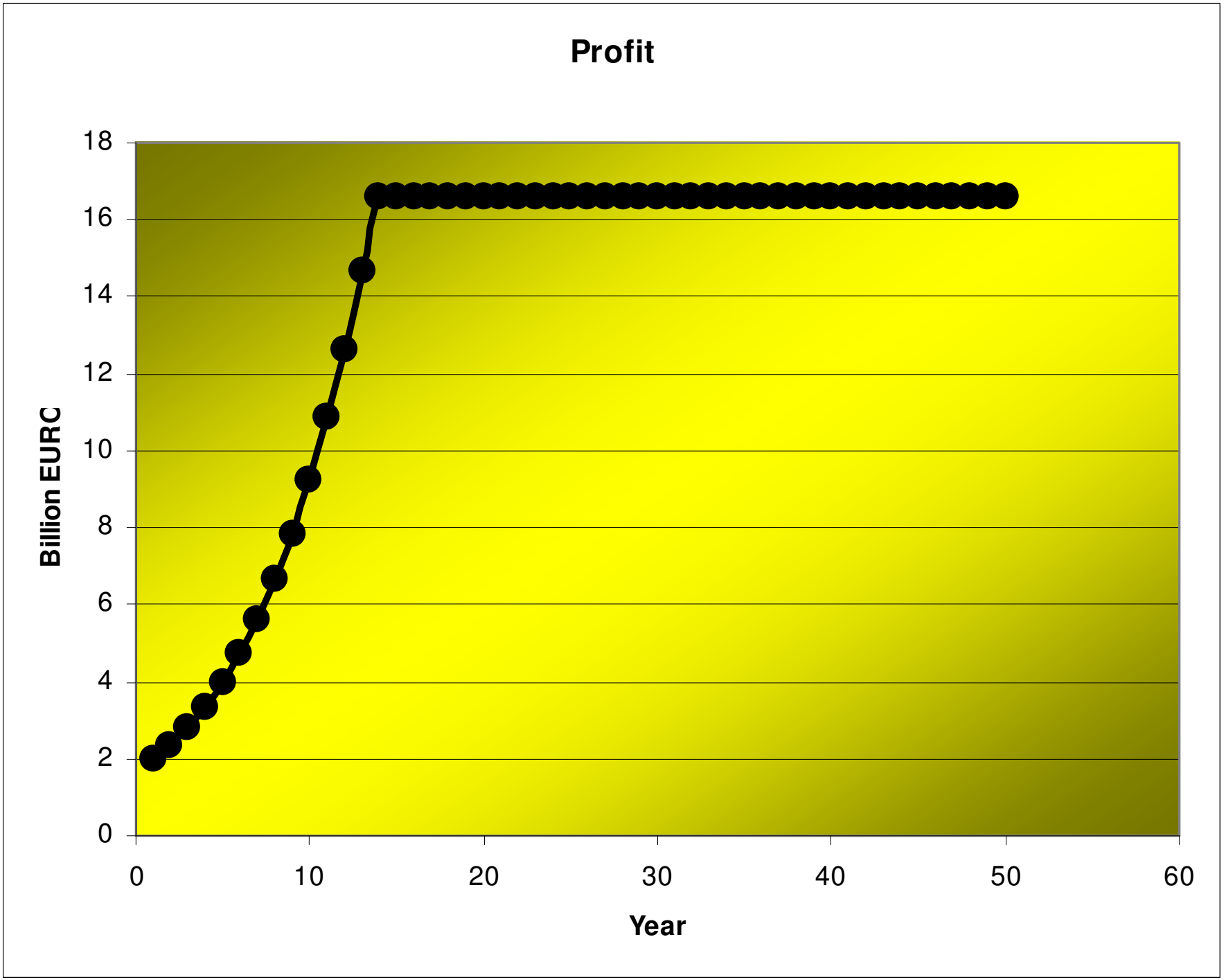
CENTRAL QUESTION:

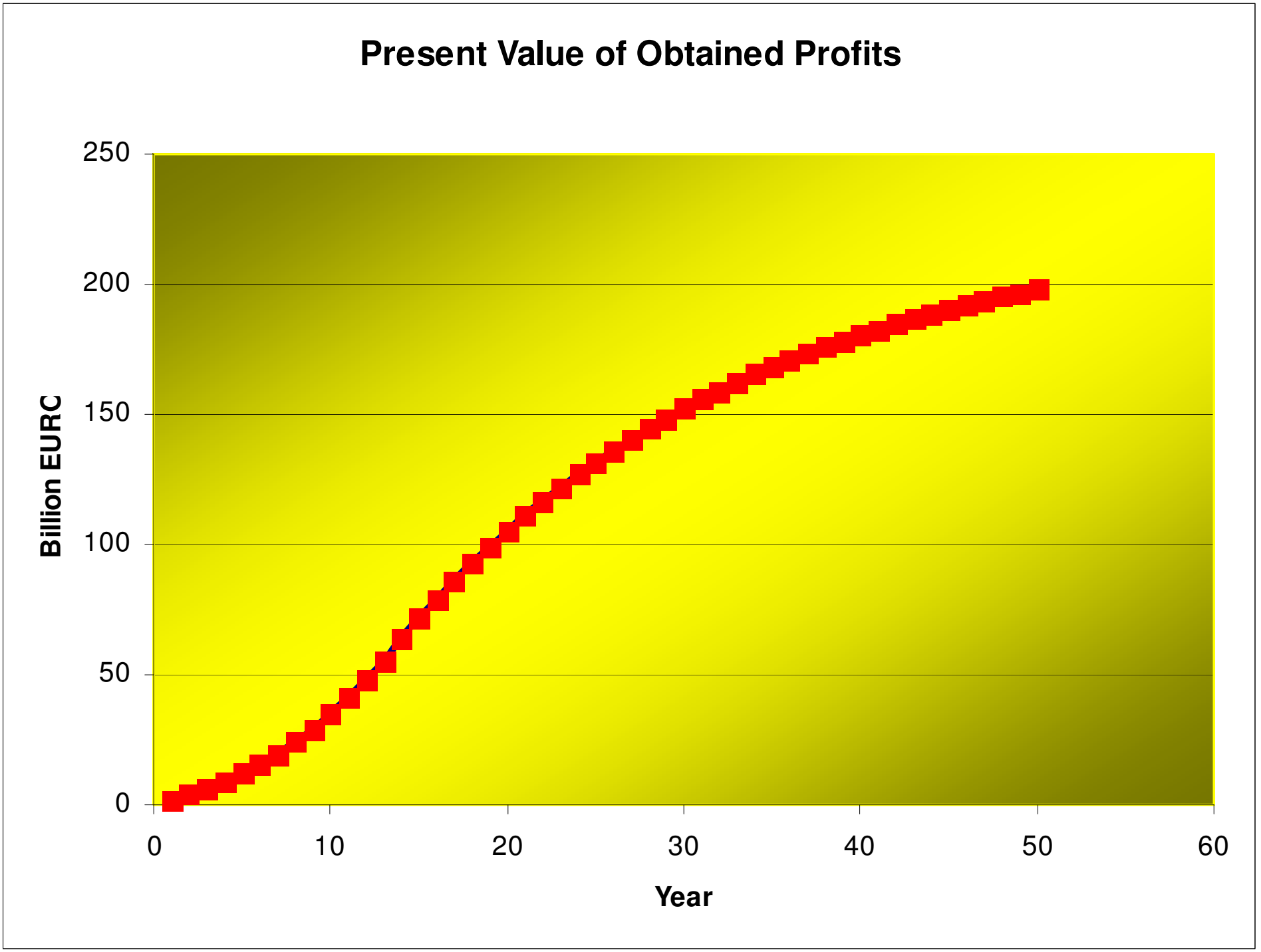
Where can Europe find 2* 563 TWh *of ”new” renewable energy ?


Energy Contents of Harvest
2500
2000
1500
1000
500
0
TWh
0
10
20
30
40
50
60
Year

CENTRAL QUESTIONS:

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


Profit
Billion EURC
18
16
14
12
10
8
6
4
2
0
0
10
20
30
40
50
60
Year


Present Value of Obtained Profits
250
200
150
100
50
0
Billion EURC
0
10
20
30
40
50
60
Year

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.

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

Conclusions

In Russian Federation and Canada, the potential sustainable forest harvesting levels are several times higher than present harvesting.

These biomass resources 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.

This would also be a very profitable activity.

More details, sources and optimizations:

These things have been presented and discussed with more details at many international conferences.

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Questions?

Peter Lohmander

Peter.Lohmander@SLU.se