A badly supported message that Swedish forestry is not ecological vital is spread from Yale!

Readers of a recent EPI (Environmental Performance Index)-report from Yale get the impression that the Swedish Forest is not ecological vital, as the forest area in Sweden seems decreasing fast in an international comparison http://www.epi.yale.edu/epi/issue-ranking/forests , where Sweden get score 14 on a scale where 100 is best and 0 worst based on an article in Science.

Deforestation is an important global problem deserving surveillance and the Science article used as a basis is a good start of something with huge potential applications, so I am not too happy about the doubt about the documentation of forest cover changes seeded in this document. But it can help both EPI, Global Forest Watch and those involved in the matter of the Science article to develop a more useful and accepted product, and it can help Swedes to understand the reasons why international canopy cover result seemingly could be different than Swedish opinions.

I have thought about the matter. Deeper penetration is justified. Something can be learnt from the discussion, which will lead to better understanding and analyses. I got a contribution posted 140922 at http://www.nbforest.info/blog/deforestation-north, where the focus is that according to EPI *all* northern countries get reduced forest cover, which is badly supported. The presentation technique by EPI is not discussed in that article. The current article was written while I thought the problem through.

Umeå 140923 Dag Lindgren (Dag.Lindgren@slu.se)

Addition. 141008 a blogg article, where the main author (M Hansen) of the data EPI uses, clarify that these data are unsuitable for the calculating net forest change as EPI has done: http://www.nbforest.info/blog/response-dag-lindgrens-blog-entry-deforestation-north Thus, a considerable part - but not all - of this document is now somewhat outdated, but I will not update the document to remove those redundant or outdated parts. If looking through the document, try to find the parts which are still of interest.

Umeå 141009 Dag Lindgren.

Summary

EPI evaluates and publishes comparisons of countries for "ecosystem vitality" for forests and refers to a Science article. The results seem misleading and insufficiently supported. EPI refers to data in a Science article.

- The Science article does not seem to deal with loss and gain of forest in a symmetric way. Thus changes in forest cover cannot be accurately calculated. The main author (Hansen) of the Science article seems not to support with the way EPI handles the data.
- For countries (like Sweden) in the middle between best and worst, the "issue score" with its visual exaggeration make them appear unfairly bad in country-ranking.
- The area of forest land in Sweden increases according to the Swedish expertise. If the EPI interpretation of Science based data are correct, they may reflect changes in regeneration practice several decades ago or other changes, which should not be interpreted as recent decline in forest cover.

- There is no good quantitative discussion about possible reasons for possible change in forest cover with the Science definition relevant for Sweden.
- The calculations behind the conclusions are not transparent for me – and when probably not for anyone else. I just do not understand, and the key concepts – like percent gain and canopy cover - does not seem sufficiently defined.
- The Science global map is quite fresh, it has uncertainties, where are doubts. It seems early to draw too wide conclusions from the Science map, before it is better understood what observations really means in real world. It is immature to apply for such controversial matters as country rankings for cases, where country observations from the ground seem to contradict.

It is hard to find out exactly how EPI and Science have calculated and there are many uncertainties, e.g. exactly how gain and canopy cover is defined and concluded, and to what degree loss and gain are symmetric and compatible. Even if the information in Science based on Landsat data on tree height and canopy cover should be correct, it is doubtful they give the most relevant information. There are important uncertainties. I am not aware of any really relevant discussion what the real causes of the low score of countries like Sweden may be. It would be better to wait spreading widely that Sweden loses its forest cover until the national expertise feel more able to understand why and until it is better understood if EPI forest score really is supported by the Science results. The results by Hansen et al 2013 could possibly be compatible with National observations and estimates, as there are differences about what is observed, but this should be better and more convincingly discussed before making international comparisons.

Background

Environmental Performance Index (EPI) is issued annually. The current comment refers to: Hsu, A., J. Emerson, M. Levy, A. de Sherbinin, L. Johnson, O. Malik, J. Schwartz, and M. Jaiteh. (2014). The 2014 Environmental Performance Index. New Haven, CT: Yale Center for Environmental Law and Policy. This document concerns only forest. The Environmental Performance Index ranks country-level environmental performance based on scores in nine Issue Categories. Six of these issues are claimed to measure "ecosystem vitality". One of those issues is "Forests". EPI calculates a score for forest "ecosystem vitality" for each country. http://www.epi.yale.edu/epi/issue-ranking/forests. Forests scores were calculated in a new way this year. Countries are scored and ranked for assumed change in forest cover based on information in Hansen et al 2013 (M.C. Hansen et al. (2013). High-Resolution Global Maps of 21st-Century Forest Cover Change. Science. 342 (6160): 850-853.). A spectacular low score for Sweden for "ecosystem vitality" of forests - illustrated by an "EPI rose" magnifying the "bad" impression for Swedish forests - received my attention. I tried to understand the reasons. I found that it is very hard to follow the calculations, almost no EPI reader will understand more than that Sweden has a low score in "ecosystem vitality" connected to a considerable reduction in area with forest, and readers will believe this is a trustworthy fact as it is supported by a study in a well-reputed journal (Science). I doubt the results, and still more their relevance for "ecosystem vitality". I am not alone with these doubts.

How does EPI derive country scores?

Country scores and ranks are the only numerical information easily – actually "too" easily – available from EPI. It takes a lot of effort and time to understand and figure out the derivation from EPIs web and the Hansen et al 2013 values, but I think I finally have got the major issues. I take it in an easy version first:

First EPI looks in an appendix to Hansen et al 2013, where the used values appears in a Table together with many other values and with entries difficult to understand. Then values are formed from two columns, one for "lossEPI" and one for "gainEPI" (I add sometimes EPI as it is an EPI decision how to interpret Science data). Values of (gainEPI – lossEPI) = column p – column n (in Table S3 below) = 6.4 – 10.5 = -4.1 (figures exemplified for Sweden) are presented in http://www.epi.yale.edu/files/forests.xls and called FORCH. Countries where FORCH is positive (and thus no forest cover reduction indicated) all get score 100. Countries where FORCH is lower than a value around - ≈8%, and thus the forest cover reduction is assumed to be larger than ≈8% get score 0. How scores for countries in between are calculated I have not bothered to understand.

EPI explains its calculation methods in http://epi.yale.edu/files/2014_epi_metadata.pdf . Data are said to be obtained from Table S2, but that is impossible as Table S2 does not have countries as entries, but ecozones. I assume Table S3 (see below) is meant.

Gain and loss in the Science article

Peter Holmgren made a presentation 140929 "Big Data – Far Reach – Great Responsibilities" where Science data is "orally" mentioned https://dl.dropboxusercontent.com/u/106629579/Holmgren%2029%20Sep%202014%20WRI%20keynoteb.pptx

It is said that Hansen (main author of Science article) thinks that gain and loss in the Science article are not symmetric. I try to read the Science article and the supplement and understand.

Citations from the Science article itself: The start of the summary is: "*Quantification of global forest change has been lacking*"; Opening of article itself is: "*Changes in forest cover affect the*". From the opening paragraph: "*Forest gain was defined as the inverse of loss, or the establishment of tree canopy from a nonforest state*". It seems completely impossible for a reader to see, realize or even suspect that loss and gain are not symmetric from the "paper" article itself and that it may be impossible to draw conclusion about change in forest cover from the Science paper. Neither there seems to be clear reservations.

There is a supplement to the article, which can be obtained from the web on the URL given in the Science article. The base is landsat data which go through an elaborate, complicated and not transparent process. Citations: "*Forest loss was defined as a stand-replacement disturbance. Results were disaggregated by reference percent tree cover stratum (e.g. >50% crown cover to ~0% crown cover) and by year…. Gain was defined as the inverse of loss, or a non-forest to forest change; longer-lived regrowing stands of tree cover that did not begin as non-forest within the study period were not mapped as forest gain. Gain was …reported as a twelve year total.*"; "*Outputs per pixel include annual percent tree cover, annual forest loss from 2000 to 2012, and forest gain from 2000 to 2012.*"; "*characterize year 2000 percent tree cover and subsequent tree cover loss and gain through 2012*".

Loss seems to a higher extent be accumulated over individual years, while gain is more considered over the whole period.

Other citations from the article: "*We mapped global tree cover extent, loss, and gain for the period from 2000 to 2012 at a spatial resolution of 30 m*" which I interpret as "pixels" 30*30 m.

From the supplement: "*trees were defined as all vegetation taller than 5m in height.*"; at verification a reservation for Nordic latitudes "*Forest gain was not allocated annually, but over the entire study period. To compare GLAS… All climate domains except for the boreal ... The growth-limiting climate of the boreal domain would preclude the observation of regrowth over such a short period.*";

The explanation of Hansen et al 2013 data as done by GFW I extract:

"*"tree cover" was defined as all vegetation taller than 5 meters in height.*"; "*Tree cover" is the biophysical presence of trees and may take the form of natural forests or plantations existing over a range of canopy densities.*"; "*This data set displays tree cover over all global land… for the year 2000 at 30 × 30 meter resolution. "Percent tree cover" is defined as the density of tree canopy coverage of the land surface...*"; "*Data in this layer were generated using multispectral satellite imagery from the Landsat 7 thematic mapper plus (ETM+) sensor. The clear surface observations from over 600,000 images were analyzed using Google Earth Engine, a cloud platform for earth observation and data analysis, to determine per pixel tree cover using a supervised learning algorithm.*"; "*Tree cover loss is defined as "stand replacement disturbance," or the complete removal of tree cover canopy at the Landsat pixel scale. Tree cover loss may indicate a number of potential activities, such as timber harvesting, fires or disease, the conversion of natural forest to other land uses, or the crop rotations cycle of tree plantations. Tree cover gain was defined as the inverse of loss, or the establishment of tree canopy in an area that previously had no tree cover.*"; "*Loss: Annual Gain: 12-year cumulative*" updated annually";

Material and methods in supplement are not understandable to me except the first paragraph. It is a question of training sets for finding relations with the Landsat observations. From the last sentence it is evident that it was a very complicated process "*A total of 20 terapixels of data were processed using one million CPU-core hours on 10,000 computers in order to characterize year 2000 percent tree cover and subsequent tree cover loss and gain through 2012.*" This is however not the same thing as common sense and high trustworthiness.

The generated data are described in http://earthenginepartners.appspot.com/science-2013-global-forest/download.html from that

"***Global forest cover loss 2000–2012 (`loss`)***

Forest loss during the period 2000–2012, defined as a stand-replacement disturbance, or a change from a forest to non-forest state. Encoded as either 1 (loss) or 0 (no loss).

Global forest cover gain 2000–2012 (`gain`)

Forest gain during the period 2000–2012, defined as the inverse of loss, or a non-forest to forest change entirely within the study period. Encoded as either 1 (gain) or 0 (no gain).

Year of gross forest cover loss event (`lossyear`)

A disaggregation of total forest loss to annual time scales. Encoded as either 0 (no loss) or else a value in the range 1–12, representing loss detected primarily in the year 2001–2012, respectively."

I interpreted that it can maximally be one loss and one gain per pixel.

Main interpretation of difficult to understand descriptions of what gain is

The critical is "gain", which seems too low as "gain" should generally replace and balance "loss". In particular "gain" should compensate for "loss" for recent logging in Sweden.

My main assumption is that “gain” in a pixel according to Hansen et al 2013 occurs if the forest cover is <50 % 2000 and at least 50 % year 2012. Reasons:

- I believe the EPI and WGF organizations and experts are honest enough to include all forest canopy gain and not just that occurring after some badly specified loss;
- It is the most logic alternative;
- If the gain could occur only after a loss 2000-2012 when all gain would be combined with a loss and where would be only pixels with gain and loss, but there are independent gain pixels;
- For northern forest the gain would have been still smaller.

But definitions above are unclear, so I feel not certain.

Does the Science article wants to evaluate change in forest cover?

The Science papers seem to try to evaluate the changes in forest cover by gain and loss. For gain the work can be considered as pioneering. But the intention seems not to get the actual result on change of forest cover of the combined action of loss and gain. If that had been the case the net change in forest cover 2000-2012 had been calculated in the article or supplement, but it is not. That daring step and the criticism the operation may raise is left to others (like EPI and GFW).

How to get change in forest cover based on the material Science has compiled?

The change in forest cover 2000-2012 can be directly obtained by comparing forest cover 2000 and 2012. The area of gain and loss in that period can be analyzed. The change in forest cover could be analyzed in an article without leaving to the readers calculate the difference. No complications with both gain and loss in the same pixel or annual changes which may not be symmetric would occur. Even if the results of individual pixels is uncertain, the average change over groups of many pixels would be expected to be rather certain. The results would be expressed similar to UNEP 1990-2006 http://www.unep.org/vitalforest/Report/VFG-02-Forest-losses-and-gains.pdf even if the methods may be different.

EPI points finger by assigning many countries like Sweden a spectacular low score!

Sweden has a FORCH -4.1% (thus forest cover is suggested to be reduced 4.1% in 12 years). On a scale extending from 100 (best) to 0 (worst), Sweden is in the middle of assumed forest reduction (between 0 and ≈8% reduction), and would be expected to get a score around 50. If Paraguay was the bottom line (17% reduction), the fair score for Sweden would have been 75 (instead of 14). But Sweden get only 14.35 as issue score, one third of what seems logic. The misleading impression of the relative magnitude of the problem is further magnified by the presentation technique of the “EPI-rose” in the upper right corner of the country profile http://www.epi.yale.edu/epi/country-profile/sweden . The skew score of Sweden was what put me on the track of finding out what was behind, this letter would not have been written without that provocation. That Sweden actually is in (or above) the middle, no reader of the EPI reports will understand. Only 40 countries out of 137 get a score above the intuitively expected average, 50%, but the score scale is not what is intuitively expected.

Sweden gets a favorable rank in some of the measures used by Hansen et al 2013

In Fig S1 Sweden ranks in the best quartile for low loss share when loss is calculated as a percentage of loss + gain. Another way of expressing this (used for some examples by Hansen et al 2013) is the ratio “loss” to “gain”. I calculated that. Sweden is top-ranking (the best) among the 13 countries listed before Sweden in Table S3 (see below). Thus the bad impression of the EPI evaluation is dependent on how Hansen et al 2013 data are managed, and other management used by Hansen et al 2013, would result in a much better rank and score for Sweden.

Everything which contain IT and is not transparent can hide important unidentified errors.

So with the map of Hansen et al 2013. Airplanes crash, trains are late, power fails, information tables have errors, computers malfunction, web services do not work, systems are incompatible, it is impossible to understand what button to press, etc. etc. I get daily trouble from this large heap of imperfections. We should not trust everything which is written even when assurances that it is extremely trustworthy are made in a loud voice. Reasonable agreement with other observations, logic results expected from logic reasoning, and few seemingly contradictions should be possible additional criteria for acceptance. Against that background I suggest global forest cover change estimated with methods applied by EPI and Science is far from free from doubt.

The Landsat pixels used by Hansen et al 2013 are unreliable measures of forest cover and forests higher than 5m.

Pixel statistics given by Hansen et al 2013 are claimed to give estimates of forest cover of trees above 5m .The Science article is seemingly based on that tree height and tree cover of each tree is known, but it is not so, it is assumptions how to get relations between Landsat reading and the classified pixels and that is a complex and uncertain business. Is far from a direct observation, but an interpretation of the Landsat surveys. The Landsat measures reflected sunlight for 30*30 meter pixels, thus accumulated effect of many trees. The drastic changes at clear cutting are mostly relatively easy to identify and thus “loss” is much less problematic for Sweden than “gain”. To identify when a pixel got new forest is difficult and highly uncertain. The Landsat registration is not only depending on the situation concerning height and tree cover. The state of the atmosphere the actual day time matters. The vegetation and ground (like slope and blocks) matter besides the trees higher than 5 meters. Clouds must be correlated for. Sight through atmosphere may vary. The calibration of the sensors matter. The angle of sun matters, which depends on geographic location, date and exact time. In the far north - like Sweden - sun is far from zenith and the shadows are long, which may require special consideration for northern locations. Needles and leaves change characteristics during the season and the change is more drastic in northern countries like Sweden, where vegetation period is short. The ground and to some extent the trees are covered by snow a considerable but some variable part of the year. Variations in leaf area index may matter. It is a long and uncertain process between Landsat measurements of a pixel and evaluation of it.
I understand that only pixel observations without clouds are counted and that the season does not matter.

The creation of a new forest can be seen as a gradual change, but as reflected by a Landsat pixel it will be much noise and uneven development. Not only tree height and canopy cover, but also other characteristics of the trees and ground change while trees grow during regeneration, which also may influence the Landsat observations. In the generation of clear-cuts some widely spaced mature seed trees remain to a different extent for variable time or become a part of the new stand. Pre-commercial thinning is generally practiced in Sweden and will also be reflected in a staggering and unstable behavior of Landsat observations of how regenerations develop. It seems likely that a developing pixel with young forest during some years can switch form no forest to forest to no forest to forest several times. Thus several repeated loss and gain during a period for the same pixel.
Commercial thinning may make a stand change from slightly above 50% canopy cover to slightly below. In absence of calibration to field data representing a wide range of conditions, it is impossible to make firm conclusions about the relations of Landsat observations on one hand and actual height and tree cover on the other. 30*30 land areas are not uniform. The degree of uniformity matters when then pixel information is accumulated to evaluate forest cover and uniformity may change over time.
An example of what may matter. In Sweden the development has been that clear-cuts (and thus regenerations) become smaller, get less “rectangular”, and contain more old trees or old group of trees. Thus 30*30 m pixels contain to a higher extent non-uniform mixes of mature trees and no trees or young trees. Sweden has natural regenerations, where many mature trees may remain for a decade and when may be removed. This certainly has effect on the pixels with more or less than 50% tree cover and may appear as changes of loss over time even at a constant “real” loss. With “gain” the same phenomenon may appear, but with several decades delay.

The net forest cover loss indicated by Hansen et al 2013 in many countries (examples in the top of Table S3 see below) is difficult for me to understand. In a steady state situation, losses are expected to be compensated by gains. On an individual loss pixel this gain may appear several decades after the loss, but in a steady situation the gain will come from replacement of previous losses and the forest cover on the country level would be constant. E.g. fire losses will be compensated by the gain replacing earlier fire losses which may have happened long before year 2000. Probably fire loss is decreasing in many countries because of development in fire control, and wherefore the gain replacing earlier fires is expected to be higher than late losses. Still e.g. Russia and Canada seem to show *much* larger loss than gain.

Hansen et al 2013 is the first effort to present globally consistent and locally relevant map data on forest cover change. I think it is very good if sufficiently safe and informative such maps could be made. The first effort cannot be expected to be perfect, but is likely to suffer from a number of unidentified problems. It is good for the development of remote sensing techniques and applications if deviations between Landsat observations and other observations are discussed with an open mind. The methods used by the Science article may be too rough at least for gain. To use the Landsat data for such specific purposes as ranking and scoring individual countries - as EPI does - seems to me yet immature. Certainly future developments will result is in more reliable evaluation based on satellite information for the good reasons listed by Hansen el al 2013.

There is much more experiences in interpretation of satellite data for forest loss than for forest gain. Hansen et al 2013 are pioneering in forest gain and net forest cover changes, while forest loss relies on more experience.

I interpret it as canopy cover including only canopy cover of trees with a height above 5 meter, shorter trees are neglected (smaller trees are just thought non-existing). I do not find that restriction on canopy elsewhere. I guess to go from light reflections measured by Landsat to conclusion about canopy cover of a part of the trees is complicated and leaves plenty of room for mistakes and uncertainties. But the exact definition of canopy cover is uncertain and not much discussed. What is actually tree cover and canopy cover? Is it the horizontal projection of the crown? Is the crown a polygon with room for the smallest branches most away from the trunk (probably not)? Or is it the size of the shadow the tree would make if illuminated from above? Or formulating it differently, the part of the ground and vegetation shorter than 5 m which would be seen if watched from above? How are dead branches considered? How does variations in leaf area index influence? What exact time are the annual measurements made? How does growth of the crown and changing characteristics of the needle/leaves during the vegetation period matter (like trees dropping their leaves)? Etc. Etc. Questions which I do not know the answer to. It would have been better if the EPI work had been based on more classical definitions of crown cover.

In my opinion the conclusions based on Landsat for forest cover changes are currently too uncertain to be accepted as the truth in situations for cases where they seem to be contradicted by other observations, in particular for gain.

Riksskogstaxeringen om slutenhet

Dag L fråga: En skillnad mellan Hansen 2013 och Sverige är att Hansen beaktar kronslutenhet. Kronslutenhet ligger i definitionen på skog. Slutenhet är ett viktigt kriterium för beslut. Det är väl bra att skatta hur skog ändras dynamiskt med kronslutenhet. Även om det är något fel på Hansen uppsatsen, så verkar internationella jämförelser med kronslutenhet vara på kommande. Global Forest Watch har näst intill som affärs-idé att tillhandahålla pixlar med hur skogen ser ut. Jag förefaller kunna se Sveriges skogars kronslutenhet år 2000 ner på procent-nivå med hög upplösning. Eftersom dessa data har sina brister, kanske det är bättre att i Sverige utveckla algoritmer som kan användas på svensk skog och stämmer med taxeringens provytor och kan införlivas med de internationella datadelningssystemen. Så man kan göra vad som görs i Sverige, med lager som läggas ovanpå varandra och kopplas ihop med internationella system, men då måste man ju ha kompetensen för att göra det kompatibelt och möjligt att koppla till andra system, som Hansen, World Resources Institute och Global Forest Watch försöker utveckla och tillhandahålla. Men söker jag på kronslutenhet på taxen hittar jag ingenting. Varför är Sverige/rikstaxen inte mer intresserat av statistik över skogarnas slutenhet?
Svar från Jonas Fridman, skogstaxeringen. I ett projekt i samarbete med Skogsstyrelsen håller Håkan Olssons fjärranalysgrupp fn på att ta fram heltäckande produkter över Sverige där bl a kronslutenheten ingår som parameter. Underlag är såväl den nationella laserskanningen som data från optiska satelliter. Vad gäller olika mått på slutenhet så samlar Riksskogstaxeringen in uppgifter om massaslutenhet (medelhöjd ≥ 7m), h-slutenhet (medelhöjd < 7 m) samt krontäckning (se sid 6:23 i vår fältmanual som finns att ladda ner i pdf-format på nätet). På frågan om varför Sverige/Rikstaxen inte är intresserade av statistik om hur skogarna fördelas på dessa variabler kan jag bara spekulera! Ett svar torde vara att vi är mer intresserade av produktionsförmåga och volymer, dvs hur arealer fördelar sig på bonitet respektive virkesförråd! Inte så konstigt heller med tanke på att skogsbruk i Sverige bedrivs på Produktiv skogsmark som definieras av produktionsförmågan och inte av slutenheten! "De gröna lögnerna" är ett bra exempel på när vi hade stora arealer med krontäckning men väldigt låga volymer! I SVL inträder föryngringsplikt när slutenheten går under 03, vilket ju pekar på ett exempel på hur vi använder slutenhetsmått i Sverige operativt idag.

The map is available on the net and I made a very small study with it.

The results are depicted in Fig 1 in the Science paper, the figure is available with a resolution better than a meter at http://earthenginepartners.appspot.com/science-2013-global-forest Fun, like with Google Earth! I can see details and identify the pixels closest to my home (Appendix 1 http://daglindgren.upsc.se/Naturv/gronstenskogen.pdf)! It is an extremely informative and generous contribution by Hansen et al 2013! Generally it seems to me that a fair map can be done for the world and links rather well to the real world. To better understand the relations between Landsat observations and their interpretation by Hansen et al 2013 and the connection to the real world geography, I went out and looked at the forest area closest to my home. Generally I could orientate myself among the pixels. It raises some speculations of doubt in the interpretation of data. It seems that "no forest 2000" may mean less than 75% crown coverage and not less than 50, but "gain" forest requires only >50%. It seems many pixels only a quarter of required size (15*15 m instead of 30*30). It seems a forest path *besides* the pixel matter. And it seems a possibility there are false "gain and loss" pixels. In another object "losses" were missed and an illogic gain occurred.

Similar maps are available from GFW and they give more options to play with! http://www.globalforestwatch.org/map/3/0.41/27.00/ALL/grayscale/loss/596?begin=2001&end=2013 But GFW commits itself to a probably misleading work similar to EPI, which overemphasize loss compared to gain, and does not seem to realize the limits of the Science values.

In earlier statistics Sweden appears as one of the few countries, where forest cover increases

In UNEP 1990-2005 Sweden appears on the lead in *increasing* forest cover http://www.unep.org/vitalforest/Report/VFG-02-Forest-losses-and-gains.pdf (FAO statistics is similar). It seems surprising if Sweden in a few years would change from top to bottom, and that such a drastic change from increase to decrease should not be more noted and discussed within Sweden earlier than 2014. The Swedish statistics ought to have a rather good quality and be considered as reliable.

No country at high latitudes get a high score, indicating that latitude and not decreasing forest cover is the problem

The highest issue score of a country with forests at least as far to the north as Sweden is Russia (score 35, rank 57, slightly above the median). Norway, Lithuania, Denmark, Canada, Finland, Estonia and Latvia all come longer down on the list. Thus all mentioned countries are suggested to loose forest area by EPI. No of these countries would probably subscribe to ongoing *rapid* deforestation and I am not aware of a reason that they should. FAO reports that in this countries 2005-2010 either the forest area increases or is not changing, see figure below. Loss of forest seem according to FAO to be an unusual problem north of the latitudes of Mexico and Burma. The problem may be interference bias of results with latitude rather than real forest cover decrease.

Others follow the Science article

Global Forest Watch http://www.globalforestwatch.org/ and Word Resource Institute seems to use the same data from Science for estimations in the same way: http://www.globalforestwatch.org/country/SWE . World map: http://www.globalforestwatch.org/map/3/-30.93/27.00/ALL/grayscale/loss/596?begin=2001&end=2013 , (northern countries like Sweden are not visible in the start window, but I do not think that has any significance).

The Science article does not agree with FAO statistics

From the figure below it is evident that the difference is large. The different statistics use widely different definitions of "forest land" and need thus not agree. The FAO statistics must necessary be based on some trust and confidence to national authorities. Country statistics is obtained differently in different countries. This affects the FAO statistics to an uncertain degree. It is an advantage if these factors could be eliminated by a uniform remote sensing technology as tried by the Science article. The statistics obtained in different ways should agree better for changes in forest cover than in total forest cover. The differences are large even for countries where much of the area is forest and thus it matter less that Science considers land which is not defined as forest land in the FAO statistics. FAOs evaluation on http://www.fao.org/docrep/013/i1757e/i1757e.pdf and http://www.fao.org/forestry/fra/fra2010/en/ . Differences to FAO statistics is discussed in supplement of the Science article.

Comment in Science says that Swedish forest area does not decrease, but rather increase

The Science article by Hansen et al 2013 is commented in Science: http://comments.sciencemag.org/content/10.1126/science.1244693 . The same comment is published in Swedish on the University web (Swedish University of Agricultural Sciences), presented as the universities view: http://www.slu.se/sv/om-slu/fristaende-sidor/aktuellt/alla-nyheter/2013/12/sveriges-skogsmarksareal-okar-trots-uppgifter-om-motsatsen-i-tidskriften-science/ The authors claim that the forest area in Sweden does not decrease and rather seem to be ***increasing*** in the actual period, in contrast to the EPI and Science data. The authors of the comment (Fridman and Olsson) are those most relevant for the subject of the comment, the head of the national forest survey and the professor in remote sensing. This is the only comment which appeared on the Science article, although some other discussion has appeared in Science. No objection of this comment has appeared.

The Swedish forest survey is described in a recent article at http://www.silvafennica.fi/pdf/article1095.pdf A better comparison between this two different estimation methods could be done using that article as a basis.

Can it be true that Sweden has lost "forest cover" 2000-2012?

The definition of "forest cover" EPI and Science use is different to what Swedes are accustomed to. Thus it has to be discussed if Fridman and Olsson comment could be compatible with EPI. Also it is a question if gain can occur for all pixels with less than50% canopy cover 2000, but I assume it can. First I note that any of the causes mentioned (discussed) in the EPI documentation (land conversation from agriculture, logging, fire, decease or storm) are unlikely to be a major cause for the suggested reduction in the forest cover of Sweden.

This must be a speculative discussion. But I comment the following possible causes and if they are likely:

- The area of clear cut has increased over time – **No**, the clear cut area has been constant or decreased over time (Fig 7.8). The clear cut area was higher 1955 than now. It is a widely spread misconception that the clear felled area increases when the felled volume increases. The growth and standing timber per area has increased, more is harvested from the same area. In the past, expansion of the area exposed to final felling probably lead to less area, which full-filled the Landsat requirement for forest land, but that is not the current situation. Forest gain from clear-cuts different times ago will replace recent losses. Some of the former clear cuts took place in poorly stocked degraded forests, which may not have been recognized as forests by Landsat criteria, but they should still generate gain pixels after regeneration.

- Land converted to agriculture – **No**, more agriculture land has been converted to forest than the reverse way!
- Exploitations (roads, cities etc.) – **No**, contributes too little to explain more than a minor part (but it contributes somewhat). And felling for exploitation is included in the constant clear felling, although it has a Long term effect as this logging will not cause a gain some decades later.
- The Swedish forest gets younger, thus a larger part of the area has not reached the state above 50% canopy closure of trees higher than 5m. – **Yes perhaps**, that could be a reason for some of the observed effect. But that should not be classified as and compared with deforestation in other countries! If rotation time sinks it should be reflected as increasing final felling and we have not seen that. Better growth also means that young trees grow faster and reach “forest status” earlier.
- An increasing share of the Swedish forest land arise after clear-cut. - **No**, how could that explain an increasing loss?
- Global warming – **No**, global warming results in “forest gain” as tree line raises.
- Unusual incidents of losses in the period – **No**. The extraordinary storm “Gudrun” caused damage, which contributes to extraordinary loss in the period (mentioned in “Science”), but this cannot be a major quantitative explanation, although it can contribute a tenth added extraordinary loss.
- Change in clear-cuts making them less uniform – **Yes**. Clear cuts get smaller with less straight borders. Individual trees and groups of trees irregularly spaced are saved more often. This means that a higher fraction of pixels are border pixels with less uniformity, and may mean that less pixels get more that 50% canopy cover even if the areas do not change. That may be interpreted by Landsat as a forest land reduction, although this is not a good interpretation.
- Changes in forest regeneration practices over time – **Yes**. This seems to me the most plausible explanation, I discuss more below. But still I have difficulties to see that it could be the single explanation.
- So called energy-forest or short rotation forest (Salix) is planted on agriculture land, it is not seen as forest in Sweden. This has a rotation time of something like five years. It often reaches five meter height before harvest and it can thus considered as forest land in EPI although it does not appear in the statistics of riksskogstaxeringen. A plantation can appear as several cases of loss but no case of gain in the EPI statistics. **No**. As the area is small (10 000 – 15 000 hectares), thus this cannot be an important part of the explanation.
- Actually areas of earlier drained forest are converted to water. **No**, much too small area.
- There are many other hypothetical explanations, but I do not know enough to expend. I have no information making any such factor a likely explanation and think I should be aware of it if such a factor was important.

No single factor seems able to quantitatively explain the loss in forest cover suggested by EPI, but it does not seem impossible that a combination of factors is a sufficient explanation. That could be further analyzed and Swedish scientists could consider what effects other used definitions of "forest" has on Sweden. Data of the type presented in Science will be more common and it is important to understand the relevance for Sweden when global maps occur.

It should be noted that the most likely explanations are unique for the period and this will lead to a higher score next decade. Quite possible Sweden will get a top ranking for the next decade if EPI does not change methods.

I should not have written this letter if it was only Sweden I got impression from, but as mentioned the forest cover reduction in some other countries by EPI methods seem also suspiciously high.

Why should EPI publish scores in a way indicating trends, if scores seem likely to change drastically from now on, provided they are correct?

Change in regeneration practices over time seem a plausible candidate for explaining some of the observed reduction in forest cover!

In an ideal steady permanent constant situation the forest area will not change over time. Loss is replaced by gain. For an individual pixel it takes often many decades till a loss has been compensated by a gain (till the new forest replacing the lost has got sufficient height and canopy coverage). But over an area gain will appear where losses were made before and - provided constant overall conditions the forest over the area will remain unchanged. This goes for fire, storm, disease and cutting, given overall conditions does not change. Even annual variations in catastrophes will be compensated and the forest will remain, but with some fluctuations. Even after clear-felling the forest may be replaced by planting or natural sources. Even if nothing is done after a clear-felling new forest usually appear, but with a longer delay than if actions for reforestation are done. The loss at felling will be compensated by later gain. For Swedish clear-cuts this is generally true. Even if a planting fails in Sweden natural forces will create a new forest. Even if the loss is caused by fire or disease or wind it will in Sweden almost certain be replaced by gain after a – sometimes long – delay. The land owner is forced by law to get a new decent forest. Sometimes the time delay between loss by logging and gain can take very long time, with the criteria applied by EPI for some of the pixels it may be four decades delay. Pre-commercial thinning will delay the time when gain occur in the loss pixels. It may never come a new forest, the most common reason is development (the clear-cut was made to give room for a road or house or something like that). It happens that the land is converted to impediment by clear-felling, but that is probably rather rare and not a major reason for loss of forest area in current Sweden. The area of "legally defined" forest land seems to increase rather than decrease in Sweden in spite of some permanent losses due to "infrastructure development" (Fridman and Olsson 2014).

But the situation in Sweden is not permanent and steady. Things change over time. The regeneration practices change over time. The delay between loss and gain depends on these changes. If the delay increases over time an area of loss will not be compensated by a corresponding area of gain even if the loss per year is constant. This situation is not constant as the delay cannot raise forever and may sink in a later period. A possibility of such a mechanism is given, there is one factor making it likely that the delay in gain for the logging losses made around 1990-2004, which could be expected to be gain replacing the losses 2000-2012, was prolonged. That is that natural regeneration was considerable higher in that period. It takes much longer after final felling to get 5 meter trees after natural regeneration than after planting. And the regeneration will be considerable more uneven, so it takes more time to reach 50% tree cover

See http://www.skogsstyrelsen.se/Global/myndigheten/Statistik/Skogsstatistisk%20%C3%A5rsbok/01.%20Hela%202013%20-%20Entire%202013/Skogsstatistisk%20%C3%A5rsbok%202013%20(hela).pdf Figures 6.9 and 6.10

The regeneration practices may affect when and if gain occur many decades after the loss. Earlier Swedish forestry more or less regarded birch as a weed. Herbicide spraying was used in a big scale. Birch was vigorously removed at pre-commercial thinning. Today the praxis is to leave birch trees which cannot be predicted to severely outcompete conifers. This lead earlier to stands which reached the demand of canopy closure of trees more than five meters late. That can still be reflected as lower gain today. But the early practices of removing birch lead to stands which got a higher value production and better growth at a mature stage, it cannot be regarded as deforestation.

There may be other such variations connected to the regeneration practices. The use of the exotic lodgepole, which grow fast after planting, has decreased. Where may be reasons I am not aware of and it may not be known. If regeneration is done more in the south the new forest will come faster. The techniques of scarification changes. The control of animals harming regenerations (like reindeer and moose) changes.

Influence of the EPIs presentation of the forest issue

There are many ranking efforts for countries for widely different purposes, most have limited consequences. But for forestry in Sweden EFI magnified by others may have an effect I regard as undesirable. The by far most common reason for “loss” in Sweden is final felling leaving clear cuts. Swedish Foresters and Forest Scientists generally believe clear-cuts are mostly a good practice, at least for timber production. This has always been controversial, the clear-cuts are not nice and look like destruction. Green organizations, including political parties, pick up the information they can find supporting that clear cutting is a bad thing. This leads to problems and inefficient decisions even on the highest hierarchy of decisions. I consider forestry as very environmental, the forest is a renewable increasing resource. The business idea of forestry is to convert water, air (carbon dioxide actually) and sunshine to what we need. Clear-cuts means that forests with lower “vitality” are replaced by forests with higher “vitality”, thus generally can be argued to improve ecosystem vitality. The EPI presentation pushes Sweden to a forestry based on less vital trees, and in my opinion that means a worse future from the environmental point of view, without well-based reasons. Even the carbon dioxide situation will benefit from more vital trees.

However, probably the low EPI score of Sweden does not focus much attention so it is not worth as much time as I invest to argue against it. A more important reason is to get the Landsat use improved and the global maps more trustworthy to pinpoint on the problem EPI wants to address.

The EPI scoring for countries, which feel them biased, will increase the criticism about measures for deforestation globally and this may have the global effect that support for actions against deforestation will decrease even in the many situations where it is well motivated. It will also reduce the impact of the EPI scorings.

Should Sweden decide to improve its EPI rank in the coming decades, the most efficient methods seem for me to be:

- less natural regeneration,
- much increased use of the exotic lodgepole pine,
- improved scarification,
- reduction of the rein deer herds kept on unfenced land by the native population in the north,
- intensified tree planting of already abandoned agricultural and pasture land,
- – if technically and economically feasible, which has not been the case till now - more clonal forestry,
- Less forest grown for fuel (as it has short rotation time, it appears as “loss” more often),
- improvement of drainage at reforestation,
- for a time perspective beyond the next decade – intensified tree breeding and seed orchard programs.

Ecologists would probably disagree on that most of these actions increase the ecosystem vitality of the Swedish forest. But I insist they do, at least if ecosystem vitality is defined as EPI does. But many ecologists would argue that EPI pushes Swedish forestry in the wrong direction. I have assumed that change in logging area is not considered.

What is Sweden?

Some facts on http://www.nbforest.info/country-information# . Sweden is to my knowledge the country in the European Union with the largest forest area and the highest harvest. Sweden is second only to Canada for export of major wood products. The standing timber volume has increased for as long as known (Fig 3.11). Probably Sweden has now a higher standing volume with a faster growth than ever before. The percentage of forest cover is among the highest in EU. The annual forest growth has increased continuously and much. The area exposed to final felling has decreased considerable since 1970, but can be viewed as steady 1977-2012 (Fig 7.8). In Sweden it is in principle criminal for the land-owner with and insufficient forest cover on forest land. If the forest is exposed to final felling, the landowner is obliged to get a satisfactory new growth in a reasonable time. Sustainability is considered a fundamental pillar for forestry. Sweden often ranks rather well in international comparisons for different things and have hopefully a rather good reputation in caring for and investigating matters. In the overall EPI-ranking, Sweden ranks 9 among 178.

Therefore Sweden’s low EPI rank for “forestry” – an issue which is more important for Sweden than most other countries and get much attention – probably is not an indication of something serious in the real world, but rather a problem for the EPI trustworthiness.

Different analyzers get different quantitative results interpreting the Science data.

EPI calculates from the Science article that Sweden loses 4.1% forest cover over 13 years (4.1/12=0.34% per year), but Fridman and Olsson (2014) state that the forest cover loss based on "Science" is 0.5% per year. There is a difference of a factor 2/3 by different evaluators of the Science data. That indicates inherent difficulties to interpret the "Science" data. That different evaluators come to different results indicate that the Science study is not quite transparent.

Changes in forest status are more certain than forest status

There are many uncertainties how well the Landsat data observe forest cover and tree height, but *changes* in forest cover ought to be better predicted than actual forest cover. Many uncertainties will so to say level out, when changes over time are estimated for large areas. Errors which change systematically over time matters. But it is difficult to believe that e.g. the air characteristics should have changed much enough in the period to matter for the degree of uncertainty in Landsat readings concerning changes in the period 2000-2012.

On http://www.globalforestwatch.org/map/4/62.98/17.65/SWE/grayscale/loss,forestgain?begin=2001-01-01&end=2013-12-30&threshold=10 the annual loss per year is shown graphic and it is possible to change the canopy cover % for acceptance as a forest

Efforts to get questions connecting to this document answered

I have tried to get contact through the EPI contact form and the EPI director. I have asked on the GFW that a representative able to discuss these matters with me contact me. This document was sent to some I thought may be interested including Hansen. Till now no response was received. I wrote the following on the GFW blog:
https://groups.google.com/forum/?hl=en#!forum/globalforestwatch

Loss larger than gain when cover constant?

Forest cover loss seems larger than gain when forest cover does no change!
A pixel is regarded as gain if it is has no forest cover 2000 but a cover 2012. A gain may be shadowed by a later loss and multiple gains are not recognized.
Loss is registered annually and therefore several losses may occur 2000-2012.
Or do I misunderstand?

Hey Dag,
While I am no expert on this data, I have been working with it a bit. I believe most of your points are correct, gain is only registered if the pixel has no forest cover in 2000 and shows forest cover in 2012. If forest grows in a particular place and is then cleared before 2012, it will not be counted as gain.
As for whether multiple losses can be registered between 2000-2012, I dont believe that this is the case. As the raster data only allow for each pixel to take one value, I do not think that any pixel can be listed as deforested in 2002 and again in 2010 (for example).
If anyone out there happens to know otherwise, I would be really interested in hearing about it!
-Ryan

Hi Ryan
Loss can occur more than once in a pixel - still my proposal!
It is raster data for loss each independent year!!! Thus the argument raised against repeated losses different years is weak!!
In the map by Hansen et al 2013 where are pixels which carry information of at least two events – a gain and a loss – (in magenta).
In the GFW web a country can be selected and returns loss for all individual years, which seems to sum up perfectly to the total loss for the country.

Like http://www.globalforestwatch.org/country/BRA
The cumulative loss can be seen on a map for each year. But the annual losses for each year are just added when the total loss is estimated.
Nowhere in the documentation has something else seemed indicated!!
Someone of the creators could reply? After all, one of the purposes of this web is: “Ask questions about data and get technical support from creators of forest change datasets”
Another question I have to the creators is: Why not just look if there is a “forest” in the pixel 2000 and if there is a “forest” in 2012. No forest 2000 and forest 2012 is a gain pixel and forest 2000 but no forest 2012 it is a loss pixel. Then the change in forest cover 2000 to 2012 is easily calculated. And where is no need of dealing with questions or uncertainties like mine!
Dag

Hi Dag,

I have done a fair amount of work with this data, and wanted to chime in to echo Ryan's input regarding forest loss from the Global Forest Change (GFC) product. According to the definitions adopted in the Hansen et al. 2013 paper and supplemental materials, loss can occur only once per pixel. The original loss data from the GFC product is delivered as a single raster layer, in which each pixel is coded as 0 (no loss) or (for pixels where loss occurred) an integer from 1-12 indicating the the year of loss for that pixel. See the "Dataset Details" heading on this page for more on this.

Alex

Annual loss and gain in Sweden. GFW give values on http://www.globalforestwatch.org/country/SWE as follows below.
Annual gain average GFW = 127,339 (does not depend on canopy cover limit in this presentation
Fridman & Olsson 2014 23 838/12 = 198,650

Limit canopy density	Area forest (Mha)	Total loss (Mha =100kvmil)
>10%	26.86	2550
>25%	25.69	2544
>50%	21.47	2514
>75%	13.07	2335
Annual Loss >50%		
Year	Annual Loss	Cumulative Loss
2001	142,461	
2002	175,337	
2003	91,295	
2004	267,618	
2005	244,659	
2006	245,335	
2007	180,398	
2008	289,034	
2009	206,102	
2010	261,716	
2011	201,398	
2012	208,221	
2001-2012		2513,574

Fridman & Olsson 2014	205,967	2471,600

Remarks: Annual loss is in reasonable agreement with Swedish opinions. Annual gain according to Swedish opinions is close to annual loss, thus lost forest is replaced by new.

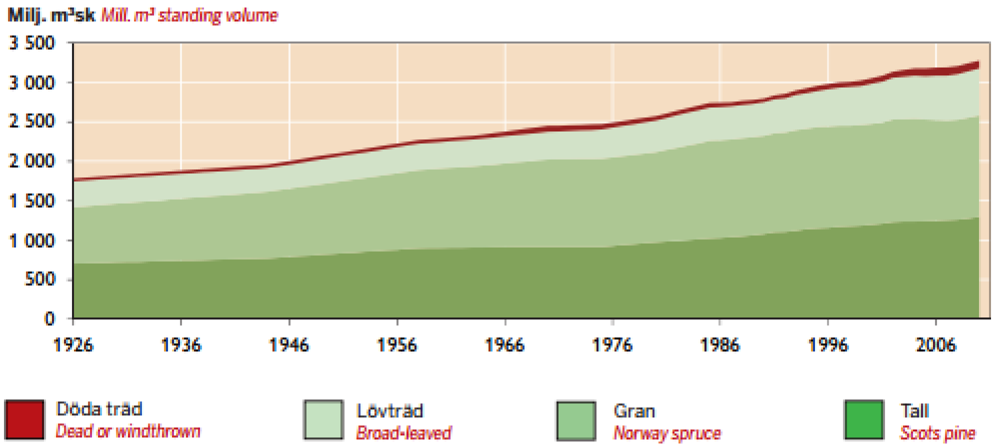
Who I am and why I comment

I am a retired university professor of Forest Genetics from Swedish University of Agricultural Sciences. While browsing, my eyes fall on the EPI 2014 report with its poor performance score for “ecological Swedish forests” and its suggested decline of Swedish forest cover. I tried to understand why the forests in Sweden appeared in this way and found that it is not well-supported. Some other scientists share this view. This document is written to get presentations clearer, better supported and more objective and fair.

Acknowledgements: This document has been preceded by helpful discussions with others since early August 2014, among them Lars Laestadius, Håkan Olsson, Seppo Ruotsalainen, and Göran Ståhl.

Figures:

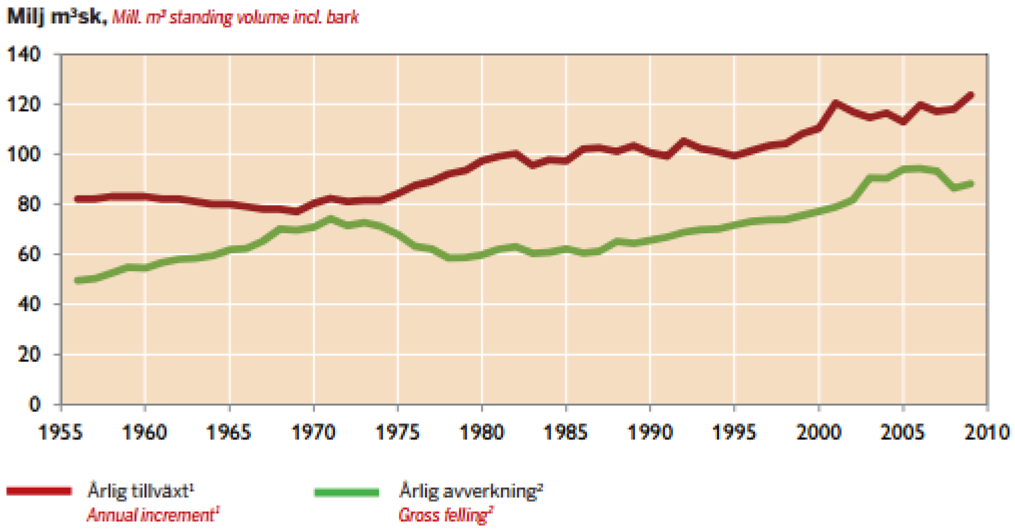
Figur 3.11 **Virkesförrådets utveckling sedan 1920-talet, glidande 5-årsmedeltal. Alla ägoslag[1]**
Trend for total standing volume since 1920. Moving 5-years average. All land use categories[1]



[1]Exkl. fridlyst mark och ägoslagen fjäll och bebyggd mark.
Excl. land use categories high mountains and urban areas.

Källa: Bearbetning av officiell statistik från Sveriges Lantbruksuniversitet, Riksskogstaxeringen.
Source: Processed official statistics from Swedish University of Agricultural Sciences, Swedish National Forest Inventory.

Figur 7.2 **Årlig avverkning och avsatt tillväxt. Alla ägoslag exkl. skyddad mark**
Annual increment and gross fellings. All land excl. protected areas



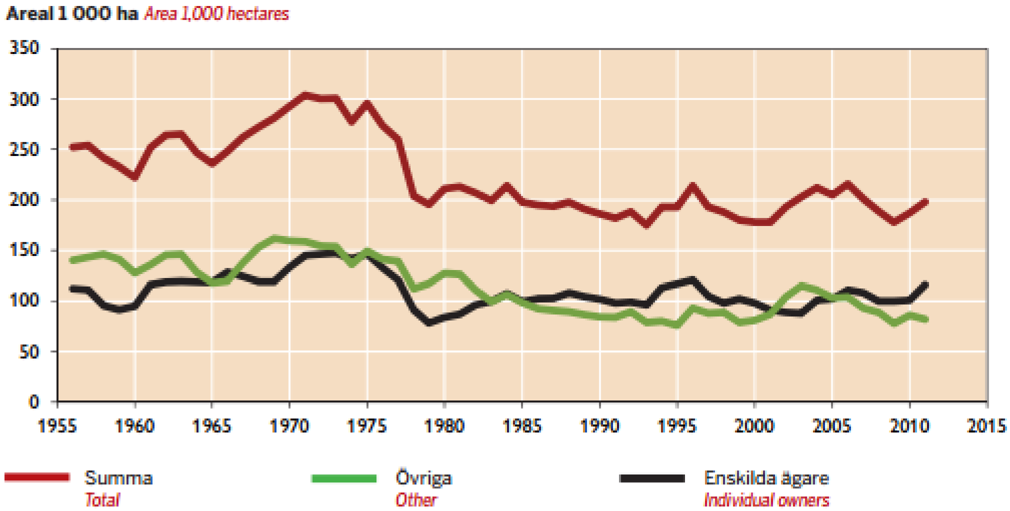
Anmärkning: Uppgifterna avser glidande femårsmedeltal.
Note: Figures are 5-year averages.

[1] SLU, Riksskogstaxeringen.
Swedish National Forest Inventory.

[2] Skogsstyrelsen.
Swedish Forest Agency.

Källa: Sveriges Lantbruksuniversitet, Riksskogstaxeringen, Skogsstyrelsen.
Source: Swedish University of Agricultural Sciences, Swedish National Forest Inventory, Swedish Forest Agency.

Figur 7.8 **Slutavverkningsareal med fördelning på ägarklass[1]**
Area subject to final felling, by ownership class[1]



Anmärkning: Uppgifterna avser glidande treårsmedeltal.
Note: Figures are 3-year averages.

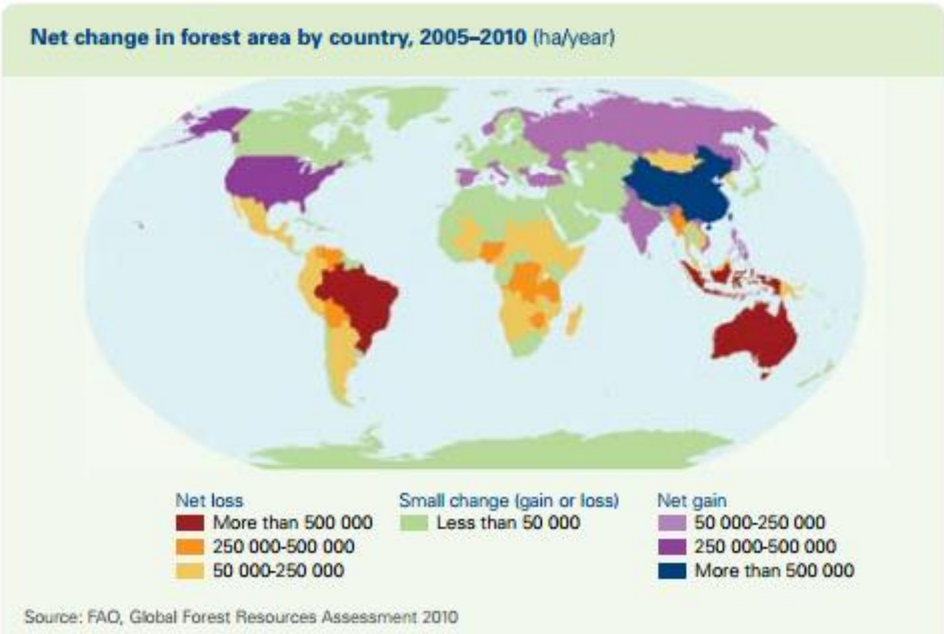
[1] Ägarklasser enligt Skogsstatistisk Årsbok, se bilaga 3.
Definitions of ownership classes according to Statistical Yearbook of Forestry, shown in Appendix 3.

Källa: Sveriges Lantbruksuniversitet, Riksskogstaxeringen.
Source: Swedish University of Agricultural Sciences, Swedish National Forest Inventory.

Data from supplement to Hansen et al 2013

Table S3. Country tree cover extent, loss and gain summary statistics (km^2), ranked by total loss.

Country	Total loss	Total gain	Treecover 2000				Loss within treecover				Total loss / total land area (excluding water) (%)	>25% tree cover loss / year 2000 >25% tree cover (%)	>50% tree cover loss / year 2000 >50% tree cover (%)	>75% tree cover loss / year 2000 >75% tree cover (%)	Total gain / year 2000 >50% tree cover (%)	>50% loss + total gain / 2000 >50% tree cover (%)	Previous column less double counting pixels with both loss and gain (%)
			<25%	26-50%	51-75%	76-100%	<25%	26-50%	51-75%	76-100%							
a)	b)	c)	d)	e)	f)	g)	h)	i)	j)	k)	l)	m)	n)	o)	p)	q)	r)
Russia	365015	162292	8414687	1846554	2707260	3304608	43907	62789	88346	169972	2.2	4.1	4.3	5.1	2.7	7.0	7.0
Brazil	360277	75866	3118579	509317	464530	4292417	23699	30816	43577	262185	4.3	6.4	6.4	6.1	1.6	8.0	7.5
United States	263944	138082	6294153	424662	462709	1982786	9274	17956	30306	206408	2.9	8.9	9.7	10.4	5.6	15.3	13.4
Canada	263943	91071	4141357	1068282	1074635	2167262	6860	44780	46295	166007	3.1	6.0	6.5	7.7	2.8	9.4	9.1
Indonesia	157850	69701	252964	68334	141996	1411892	1558	1611	8887	145795	8.4	9.6	10.0	10.3	4.5	14.4	12.4
China	61130	22387	7565646	387994	694764	618901	2250	3955	17457	37469	0.7	3.5	4.2	6.1	1.7	5.9	5.5
DRCongo	58963	13926	175163	469228	453121	1190506	917	4863	12362	40821	2.6	2.7	3.2	3.4	0.8	4.1	3.8
Australia	58736	14142	7209820	209287	79484	177890	28168	17318	2335	10915	0.8	6.6	5.1	6.1	5.5	10.6	9.1
Malaysia	47278	25798	32061	5538	17263	272365	289	309	1818	44862	14.4	15.9	16.1	16.5	8.9	25.0	20.6
Argentina	46958	6430	2352414	170266	125227	105950	5039	14574	14378	12966	1.7	10.4	11.8	12.2	2.8	14.6	13.9
Paraguay	37958	510	146165	110139	64482	75473	1230	12592	11751	12385	9.6	14.7	17.2	16.4	0.4	17.6	17.6
Bolivia	29867	1736	424460	75142	96512	478387	464	1340	4295	23768	2.8	4.5	4.9	5.0	0.3	5.2	5.1
Sweden	25533	15281	130774	42494	85855	153996	95	302	1790	23346	6.2	9.0	10.5	15.2	6.4	16.9	16.6
Colombia	25193	5516	302224	41544	61240	721695	315	619	1943	22315	2.2	3.0	3.1	3.1	0.7	3.8	3.7



Changes in area covered by forest, 1990-2005