GREENING OF THE EARTH IN EUROPE

SPPI & CO2SCIENCE ORIGINAL PAPER ♦ October 16, 2013

SPPI
Science & Public Policy Institute
"science-based policy for a better world"

GREENING OF THE EARTH IN EUROPE

Citation: Center for the Study of Carbon Dioxide and Global Change. "Greening of the Earth in Europe." Last modified October 16, 2013. http://www.co2science.org/subject/g/summaries/europegreen.php.

Among the many climate-alarmist fears of CO_2-induced global warming is the concern that the productivity of the biosphere will decline if global temperatures rise to the extent predicted by computer models. Because of such concern, several researchers have investigated the relationship between temperature, atmospheric CO_2, and biospheric productivity across a range of spatial and temporal scales. In this review we examine what has been learned about the subject for locations in Europe.

Using an empirically-based mechanistic model of Mediterranean shrub vegetation, Osborne *et al.* (2000)[1] set out to address two important questions: (1) Has recent climate change, especially increased drought, negatively impacted Mediterranean shrublands? and (2) Has the historical increase in the air's CO_2 concentration modified this impact? The data-based model they employed suggests that the warming and reduced precipitation experienced in the Mediterranean area over the past century should have had negative impacts on net primary production and leaf area index. When the measured increase in atmospheric CO_2 concentration experienced over the period was factored into the calculation, however, these negative influences were overpowered, with the net effect that both measures of vegetative prowess *increased*: net primary productivity by 25% and leaf area index by 7%. These results, in their words, "indicate that the recent rise in atmospheric CO_2 may already have had significant impacts on productivity, structure and water relations of sclerophyllous shrub vegetation, which tended to offset the detrimental effects of climate change in the region."

The recent rise in atmospheric CO_2 may already have had significant impacts on productivity, structure and water relations of sclerophyllous shrub vegetation, which tended to offset the detrimental effects of climate change in the region.

With respect to model-predicted changes in Earth's precipitation regime, a doubling of the air's CO_2 content is projected to lead to a modest intensification of the planet's hydrologic cycle. In the case of the Mediterranean region over the last century, however, there has been a recent tendency toward *drier* conditions. Hence, the specific case investigated by Osborne *et al.* represents a *much*-worse-case scenario than what is predicted by current climate models for

[1] http://www.co2science.org/articles/V3/N19/B1.php.

the Earth as a whole. Nevertheless, the area's vegetation has done even better than it did before the climatic change, thanks to the over-powering beneficial biological effects of the concurrent rise in the air's CO_2 content.

In another model-based study, Cheddadi *et al*. (2001)[2] employed a standard biogeochemical model (BIOME3) - which uses monthly temperature and precipitation data, certain soil characteristics, cloudiness and atmospheric CO_2 concentration as inputs - to simulate the responses of various biomes in the region surrounding the Mediterranean Sea to changes in both climate (temperature and precipitation) and the air's CO_2 content. Their first step in this endeavor was to validate the model for two test periods: the present and 6000 years before present (BP). Recent instrumental records provided actual atmospheric CO_2, temperature and precipitation data for the present period; while pollen data were used to reconstruct monthly temperature and precipitation values for 6000 years BP, and ice core records were used to determine the atmospheric CO_2 concentration of that earlier epoch. These efforts suggested that winter temperatures 6000 years ago were about 2°C cooler than they are now, that annual rainfall was approximately 200 mm less than today, and that the air's CO_2 concentration averaged 280 ppm, which is considerably less than the value of 345 ppm the researchers used to represent the present, i.e., the mid-point of the period used for calculating 30-year climate normals at the time they wrote their paper. Applying the model to these two sets of conditions, they demonstrated that "BIOME3 can be used to simulate ... the vegetation distribution under ... different climate and CO_2 conditions than today."

Cheddadi *et al*.'s next step was to use their validated model to explore the vegetative consequences of an increase in anthropogenic CO_2 emissions that pushes the air's CO_2 concentration to a value of 500 ppm and its mean annual temperature to a value 2°C higher than today's mean value. The basic response of the vegetation to this change in environmental conditions was "a substantial southward shift of Mediterranean vegetation and a spread of evergreen and conifer forests in the northern Mediterranean."

More specifically, in the words of the researchers, "when precipitation is maintained at its present-day level, an evergreen forest spreads in the eastern Mediterranean and a conifer forest in." Current xerophytic woodlands in this scenario become "restricted to southern Spain and southern Italy and they no longer occur in southern France." In northwest Africa, on the other hand, "Mediterranean xerophytic vegetation occupies a more extensive territory than today and the arid steppe/desert boundary shifts southward," as each vegetation zone becomes significantly more verdant than it is currently.

What is the basis for these positive developments? Cheddadi *et al*. say "the replacement of xerophytic woodlands by evergreen and conifer forests could be explained by the enhancement of photosynthesis due to the increase of CO_2." Likewise, they note that "under a high CO_2 stomata will be much less open which will lead to a reduced evapotranspiration and lower water loss, both for C_3 and C_4 plants," adding that "such mechanisms may help plants to resist long-lasting drought periods that characterize the Mediterranean climate."

2 http://www.co2science.org/articles/V5/N16/EDIT.php.

Contrary to what is often predicted for much of the world's moisture-challenged lands, therefore, the authors were able to report that "an increase of CO_2, jointly with an increase of *ca.* 2°C in annual temperature would not lead to desertification on any part of the Mediterranean unless annual precipitation decreased drastically," where they define a *drastic* decrease as a decline of 30% or more. Equally important in this context is the fact that Hennessy *et al*. (1997) have indicated that a doubling of the air's CO_2 content would in all likelihood lead to a 5 to 10% *increase* in annual precipitation at Mediterranean latitudes, which is also what is predicted for most of the rest of the world. Hence, the results of the present study - where precipitation was held constant - may validly be considered to be a *worst*-case scenario, with the *true* vegetative response being even *better* than the good-news results reported by Cheddadi *et al*., even when utilizing what we believe to be erroneously-inflated global warming predictions.

As intriguing as these model-based studies are, however, it is important to examine this issue through the lens of real-world data to see how plant productivity has responded to modern warming, which the IPCC claims is unprecedented over the past one to two thousand years. And, fortunately, a number of scientists have done just that.

Introducing their work, Bellassen *et al*. (2011)[3] write that "several parties to the United Nations Framework Convention on Climate Change (UNFCCC) are calling for 'forward-looking baselines'," so that country-specific scenarios based on forest age structure could be used "to credit only the part of the forest sink going beyond business-as-usual practices." And they thus proceed to derive such a baseline for all of Europe.

Using ORCHIDEE-FM - a process-based vegetation model that differs from earlier versions of ORCHIDEE by "its explicit representation of stand growth and idealized forest management" - Bellassen *et al*. applied the model on a grid across Europe to "simulate changes in the net ecosystem productivity (NEP) of forests with and without changes in climate, CO_2 and age structure." In doing so, the six scientists report that the model they used "simulates carbon stocks and volume increments that are comparable … with inventory-derived estimates at country level for 20 European countries," providing "an upwards trend of forest NEP of 1 ± 0.5 g C/m^2/year between 1950 and 2000 across the EU 25," ending with "a mean European forest NEP of 175 ± 52 g C/m^2/year in the 1990s." And they say that "61% of the change in NEP [over the last half of the 20th century] was attributed to changes in CO_2, 26% to changes in climate, and 13% to changes in forest age structure."

---

3 http://www.co2science.org/articles/V15/N5/B2.php.

As intriguing as these model-based studies are, however, it is important to examine this issue through the lens of real-world data to see how plant productivity has responded to modern warming, which the IPCC claims is unprecedented over the past one to two thousand years. And, fortunately, a number of scientists have done just that.

Allen *et al*. (1999)[4], for example, analyzed sediment cores from a lake in southern Italy and from the Mediterranean Sea, developing high-resolution climate and vegetation data sets for this region over the last 102,000 years. These materials indicated that rapid changes in vegetation were well correlated with rapid changes in climate, such that complete shifts in natural ecosystems would sometimes occur over periods of less than 200 years. Over the warmest portion of the record (the Holocene), the total organic carbon content of the vegetation reached its highest level, more than doubling values experienced over the rest of the record, while other proxy indicators revealed that during the more productive woody-plant period of the Holocene, the increased vegetative cover also led to less soil erosion. The results of this study thus demonstrate that the biosphere can successfully respond to rapid changes in climate. As the 15 researchers involved in the work put it, "the biosphere was a full participant in these rapid fluctuations, contrary to widely held views that vegetation is unable to change with such rapidity." Furthermore, their work revealed that *warmer* was always *better* in terms of plant growth; and, therefore, it is likely that future warming in this region may return it to a higher level of biological productivity than what it currently exhibits.

Examining a much shorter time period was Bert *et al*. (1997)[5], who calculated a 120-year (1860-1980) history of *intrinsic water-use efficiency* (defined as the ratio of CO_2 assimilation rate to stomatal conductance for water vapor) for silver fir (*Abies alba* Mill.) trees, based on $\delta^{13}C$ data obtained from cores extracted from individual trees of this species that grew within 208 pure stands in the Jura Mountains near the border that separates France and Switzerland. Results indicated that from 1860 to 1930 there was little net change in silver fir water-use efficiency; but over the next half-century (1930 to 1980), when the atmosphere's CO_2 concentration rose at a rate that was more than three times greater than its rate-of-rise over the earlier period, this important tree physiological property rose by approximately 30%. With regard to their findings, the three researchers state that their results - which were "obtained at the level of mature trees" - are "consistent with the physiological effects of increasing CO_2 concentrations as observed in controlled experiments on young seedlings," and that they are additionally "consistent with the strong increases in radial growth observed for *Abies alba* in western Europe over the past decades."

Working in the Vienna basin of Austria in the European Eastern Alps, Leal *et al*. (2008)[6] discovered what they describe as "a very clear change in the sensitivity of the growth rate of [black pine (*Pinus nigra*)] tree stems to water availability in the late 20th century," noting that "trees previously sensitive to spring-summer drought show a lack of response to this climatic parameter in recent decades." That is to say, as they explain it, that "tree-ring indices were larger in the second half of the 20th century than predicted given prevailing spring-summer drought conditions and the previous sensitivity of growth to these conditions." In addition, they

[4] http://www.co2science.org/articles/V2/N18/C2.php.

[5] http://www.co2science.org/articles/V11/N46/B2.php.

[6] http://www.co2science.org/articles/V11/N50/B2.php.

found "a decrease in correspondence between the occurrence of extreme events in precipitation and rate of change of growth," such that "in the second half of the century this correspondence was not significant," and that "recent extreme droughts did not result in the formation of very narrow rings, which means the droughts were not as limiting to tree growth as they had been in the past."

The five researchers concluded their paper by suggesting that the greater atmospheric CO_2 concentrations of the latter decades of the 20th century "induced improved water-use efficiency enabling *P. nigra* growing in the Vienna basin to avoid the impact of recurrent dry conditions," which phenomenon has also been observed in many other parts of the world in a number of different tree species, which is but another indication of the propensity of the ongoing rise in the air's CO_2 content to promote a greening of the Earth.

Martinez-Vilalta *et al*. (2008)[7] used tree-ring data from the Catalan Ecological and Forest Inventory "to study the temporal variability of Scots pine stem radial growth (period 1901-1997) across a relatively large region (Catalonia, NE Spain) situated close to the southern limit of the distribution of the species." This inventory "included a total of 10,664 plots randomly distributed throughout the forested area of Catalonia." Scots pine was present in 30.2% of the plots, and it was the dominant tree species in 18.4% of them.

In describing their findings, the researchers say they found "an overall increase of 84% in Scots pine BAI [basal area increment] during the 20th century, consistent with most previous studies for temperate forests" and in harmony with the *greening of the earth* phenomenon that has accompanied the historical increase in the air's CO_2 content. And in this regard, they make a point of stating that "this trend was associated with increased atmospheric CO_2 concentration," which they interpreted to be "a fertilization effect." What is more, the five scientists also note that over the same time period there was "a marked increase in temperature across the study region (0.19°C per decade on average)," and they report that "this warming had a negative impact on radial growth, particularly at the drier sites." However, they found that "its magnitude was not enough to counteract the fertilization effect."

Noting that "protected areas provide excellent opportunities for [determining] baseline descriptions and trends that ... can be used to evaluate the impact of global environmental change on terrestrial ecosystem functioning," Alcaraz-Segura *et al*. (2008)[8] employed satellite-derived *normalized difference vegetation index* (NDVI) data - which provide a measure of net primary production that is described by them as "the most integrative indicator of ecosystem functioning" - to "evaluate the impact of global environmental change on terrestrial ecosystem functioning of [Spain's] national parks," which provides a sound basis for determining what could have been expected to have occurred throughout the rest of the country and much of Europe (Julien *et al*., 2006) *independent of confounding effects not related to global environmental change*. So what did they find?

[7] http://www.co2science.org/articles/V12/N5/B2.php.
[8] http://www.co2science.org/articles/V12/N34/B1.php.

The four researchers, hailing from Argentina, Spain and the United States, report that "most parks showed areas with positive NDVI trends that tended to have higher proportions of Mediterranean coniferous and mixed forests, oro-Mediterranean scrublands, heathlands, maquis and garrigues," while "negative trends were scarce." Alcaraz-Segura *et al*. conclude the report of their findings by stating that "protected areas are changing in the short term and, at least in terms of vegetation greenness, they are changing in a directional way," such that "a large part of the Spanish National Parks is intercepting more photosynthetically active radiation than in the past."

Working at a site just three kilometers from the Abisko Scientific Research Station (68°21'N, 18°49'E) in the Northern Swedish Scandes, Hallinger *et al*. (2010)[9] studied male plants of the medium-sized *Juniperus nana* shrub, collecting the main stems of five to eight shrubs every hundred meters of elevation until the shrub zone ended. Ring-width measurements on these stems were then performed, as they describe it, "to measure radial and vertical growth, to track growth changes over time, to age the shrub individuals and to correlate annual shrub growth with climate," the characteristics of which latter factor were derived from records of the nearby Abisko Station. And what did their measurements reveal?

According to the three researchers, their analysis "documented a distinct increase in radial and vertical growth rates of *J. nana* shrubs during recent decades in the subalpine zone of North Sweden," and they say that "the age structure of shrubs along the elevational gradient provides evidence that an upslope advance of the altitudinal shrubline is underway." In addition, they state that they "observed significant, strong and stable correlations between annual ring width and summer temperatures (June, July, August)," and that "the acceleration of radial and vertical growth since 1970 also coincides with the recent three decades of rising arctic air temperatures and the warming trend of 0.2°C per decade for the average temperature since 1956 at Abisko." These findings, in their words, add to the "mounting evidence that shrubs are expanding into alpine and arctic areas because of climate warming," and they note that "this expansion occurs in both evergreen and deciduous shrub types," citing the additional findings of Forbes *et al*. (2009).

Also working in the Swedish Scandes, Kullman (2010a)[10] presented what he called "an integrative review of results from long-term monitoring of subalpine/alpine vegetation," from which he derived "tentative projections of landscape transformations in a potentially warmer future," which were based on "actual observations and paleoecological data (Kullman and Kjallgren, 2006; Kullman 2006)." In doing so, the professor of physical geography at Sweden's Umea University indicates that post-Little Ice Age warming has, at long last, broken the back of "a multi-millennial trend of plant cover retrogression" and "floristic and faunal impoverishment, all imposed by progressive and deterministic neoglacial climate cooling," as he reports that the "upper range margin rise of trees and low-altitude (boreal) plant species, expansion of alpine grasslands and dwarf-shrub heaths are the modal biotic adjustments during the past few decades, after a century of substantial climate warming." Currently, therefore, the situation is one where "alpine plant life is proliferating, biodiversity is on the rise and the mountain world

9 http://www.co2science.org/articles/V13/N37/B2.php.
10 http://www.co2science.org/articles/V14/N10/B2.php.

appears more productive and inviting than ever." And he makes it very clear that "in contrast to model predictions, no single alpine plant species has become extinct, neither in Scandinavia nor in any other part of the world in response to climate warming over the past century," citing, in addition to his own studies, the work of Pauli *et al*. (2001, 2007), Theurillat and Guisan (2001), and Birks (2008).

So just how great is the recent proliferation of plant life of which Kullman writes? In a contemporaneous study published in the *Nordic Journal of Botany*, he provides an answer (Kullman, 2010c[11]), reporting what he learned from species inventories he conducted on the uppermost 20 meters of four high-mountain summits in the Swedish Scandes (Kullman 2007a,b), the results of which he compared with the findings of "historical species inventories from the early 1950s, executed by a highly competent and experienced botanist (Kilander, 1955)," which endeavor, in his words, "can be seen as an evaluation of a full-scale 'natural experiment' (cf. Grabherr *et al*., 2001)."

In contrast to model predictions, no single alpine plant species has become extinct, neither in Scandinavia nor in any other part of the world in response to climate warming over the past century.

Specifically, Kullman (2010c) writes that the species pools at the tops of the studied mountains have (1) "increased by 60-170% since the 1950s," that (2) "some of the invading species are new to the alpine tundra, with more silvine and thermophilic properties than the extant alpine flora," and -- last of all, that (3) "not a single species of the original flora has disappeared from any of the summits." Concluding, Kullman thus writes that "the alpine flora appears to be more adaptive and responsive to climate change than generally believed," and that "overall, a richer, greener and more productive alpine world has emerged in the wake of the recent climate warming episode (Kullman, 2010a, 2010b)."

Still in Sweden, but working on an east-facing slope of the Slattatjakka/Njulla mountains (68°21'N, 18°49'W) in the Abisko Valley about 200 km north of the Arctic Circle, Rundqvist *et al*. (2011)[12] write that they documented "rapid and substantial increases in the abundance of prominent tree and shrub species near [the] tree-line and forest-line in sub-Arctic Sweden," and that they "recorded an invasion by a thermophilic tree species not present in the plots 34 years ago."

In discussing their findings, the seven Swedish scientists describe how they mesh well with those of many other researchers, noting that "there is an indication that the shrub layer near the tree-line has expanded, since the 1930s, in the Abisko area (Enquist *et al*., 1933; Sandberg, 1963)," while "data from Canada, Fennoscandia, Alaska and Russia reveal that there is a Pan-

11 http://www.co2science.org/articles/V14/N11/EDIT.php.
12 http://www.co2science.org/articles/V15/N19/B1.php.

Arctic expansion of shrubs and trees in progress (e.g. Kullman, 2002; Tommervik *et al*., 2004; ACIA, 2005; Tape *et al*., 2006; Karlsson *et al*., 2007; Olofsson *et al*., 2009; Hallinger *et al*., 2010; Hendenas *et al*., 2011)." And they state that the change in shrubs and small trees they observed is "consistent with anticipated changes due to climate change and reduced herbivory," which change in climate, in their words, "could be interpreted as an ongoing natural re-establishment of plants at higher altitudes due to a natural increase in the temperature since the 'Little Ice Age' (Kammer *et al*., 2007)."

Writing as background for their study, Hedenas *et al*. (2011)[13] state that "during the last 15 years, there has been an increasing focus on how climate change has and will affect the distribution and extent of ecosystems around the globe including alpine and Arctic areas (e.g., Callaghan *et al*., 2005)," and in this regard they report that "field studies and remote sensing have revealed a recent increase in altitude of the tree line (e.g., Kullman, 2002)," as well as "an extension and increased cover of mountain birch forest (Tommervik *et al*., 2009; Rundqvist *et al*., 2011)." More specifically, they say that Tommervik *et al*. have determined that "tree biomass has doubled over a 43-year period, within an area of Finnmarksvidda, and Rundqvist *et al*. have observed an increased density and cover of mountain birch in the treeline over the last three decades, within an area near Abisko village."

In a continuation of these types of studies, Hedenas *et al*. say that in 2010 they re-surveyed shrub, tree and vegetation data at 549 plots grouped into 61 clusters that were originally surveyed in 1997 in two areas close to the Abisko village, which is located approximately 200 km north of the Arctic Circle at 68°20'N, 18°50'E. Their results indicated that "tree basal area and biomass increased by 19% between 1997 and 2010 with the main increase occurring in established birch forest," and they say that this result "concurs with the results of other studies which suggest that there has been a general increase in cover and biomass of trees and shrubs in sub-Arctic and Arctic areas," additionally citing in this regard, the studies of Sturm *et al*. (2001), Tape *et al*. (2006), Danby and Hik (2007), Forbes *et al*. (2010), Hallinger *et al*. (2010) and Van Bogaert *et al*. (2011). What is more, the 19% net increase in biomass occurred in spite of the increased browsing pressure provided by an increasing reindeer population over the period of their study, as well as periodic outbursts of geometrid moths - which severely defoliated the birch trees in their study area in 2004 (Babst *et al*., 2010). As for the cause of this welcome phenomenon, they say "it has been suggested that increased nutrient availability associated with higher soil temperatures, and a longer growing season could underpin increased tree and shrub abundance and biomass in the Arctic (e.g., Chapin, 1983; Weih and Karlsson, 1997; Hartley *et al*., 1999)," as a result of "a delayed re-expansion of shrubs and trees following the 'Little Ice Age'," as suggested by Grubb (2008).

Noting that forests are exposed to a changing environment and that "responses to recent climate change start to become visible if observation periods become long enough," Pilegaard *et al*. (2011)[14] present the results of continuous CO_2 flux measurements that they made above a mature Danish beech stand in the "Lille Bogeskov" forest located near Soro on the island of

[13] http://www.co2science.org/articles/V15/N19/B2.php.

[14] http://www.co2science.org/articles/V14/N29/B1.php.

Zealand (55°29'13"N, 11°38'45"E) over the period 1996-2009, describing the long-term changes they observed and relating them to possible causes.

According to the researchers, they observed "significant linear trends of increasing gross ecosystem exchange (GEE: 29 g C/m^2/year) and increasing net ecosystem exchange (NEE: 23 g C/m^2/year), while the positive trend for ecosystem respiration (RE: 5 g C/m^2/year) was not significant." They also state that "the length of the carbon uptake period increased by 1.9 day/year, whereas there was a non-significant increase of 0.3 day/year in the leafed period," which means, in their words, that "the leaves stay active longer." Nevertheless, they indicate that "the increase in the carbon uptake period explained only part of the increasing NEE (9 gC/m^2/year)." And noting that "the maximum rate of photosynthetic assimilation increased by 15% during the 14-year period," they speculate that the increase in canopy carbon uptake capacity "could be due to a combination of [the] increase in atmospheric CO_2, higher summer precipitation, and increased availability of nitrogen."

Working in the Komi Republic in the northeast European sector of Russia, Lopatin *et al*. (2006)[15] (1) collected discs and cores from 151 Siberian spruce trees and 110 Scots pines from which they developed ring-width chronologies that revealed yearly changes in forest productivity, (2) developed satellite-based time series of NDVI for the months of June, July, August over the period 1982-2001, (3) correlated their site-specific ring-width-derived productivity histories with same-site NDVI time series, (4) used the resulting relationship to establish six *regional* forest productivity histories for the period 1982-2001, and (5) compared the six regional productivity trends over this period with corresponding-region temperature and precipitation trends. For all six vegetation zones of the Komi Republic, this work indicated that the 1982-2001 trends of integrated NDVI values from June to August were *positive*, and that the "increase in productivity reflected in [the] NDVI data [was] maximal on the sites with increased temperature and decreased precipitation."

In discussing their findings, the three scientists state that "several studies (Riebsame *et al*., 1994; Myneni *et al*., 1998; Vicente-Serrano *et al*., 2004) have shown a recent increase in vegetation cover in different world ecosystems." What is special about their study, as they describe it, is that "in Europe, most forests are managed, except for those in northwestern Russia [the location of their work], where old-growth natural forests are dominant (Aksenov *et al*., 2002)." Consequently, and because of their positive findings, they say we can now conclude that "productivity during recent decades also increased in relatively untouched forests," where non-management-related "climate change with lengthening growing season, increasing CO_2 and nitrogen deposition" are the primary determinants of changes in forest productivity.

We conclude with one final study that integrates all of Europe. In that study, Julien *et al.* (2006)[16] "used land surface temperature (LST) algorithms and NDVI [Normalized Difference Vegetation Index] values to estimate changes in vegetation in the European continent between 1982 and 1999 from the Pathfinder AVHRR [Advanced Very High Resolution Radiometer] Land (PAL) dataset." This program revealed that arid and semi-arid areas (Northern Africa, Southern

[15] http://www.co2science.org/articles/V10/N13/B1.php.
[16] http://www.co2science.org/articles/V9/N39/B2.php.

Spain and the Middle East) have seen their mean LST increase and NDVI decrease, while temperate areas (Western and Central Europe) have suffered a slight decrease in LST but a more substantial increase in NDVI, especially in Germany, the Czech Republic, Poland and Belarus. In addition, parts of continental and Northern Europe have experienced either slight increases or decreases in NDVI while LST values have decreased. Considering the results in their totality, the Dutch and Spanish researchers concluded that, over the last two decades of the 20th century, "Europe as a whole has a tendency to greening," and much of it is "seeing an increase in its wood land proportion."

In considering each of the studies conducted in Europe that are listed above, we note that within the context of today's obsession with the ongoing rise in the atmosphere's CO_2 content, as well as the many environmental catastrophes it has been predicted to produce, the overwhelmingly positive results that have been obtained are truly remarkable. And this assessment is even *more* remarkable in light of the fact that the world's climate alarmists claim the warming of the past quarter-century was unprecedented over the last two millennia or more, and that this phenomenon is the greatest threat ever to be faced by the planet.

Apparently, the *plants* of Europe just don't understand the seriousness of the situation.

> *Over the last two decades of the 20th century, Europe as a whole has a tendency to greening, and much of it is seeing an increase in its wood land proportion.*

References

ACIA. 2005. *Arctic Climate Impact Assessment*. Cambridge University Press, Cambridge, United Kingdom.

Aksenov, D., Dobrynin, D., Dubinin, M., Egorov, A., Isaev, A., Karpachevskiy, M., Laestadius, L., Potapov, P., Purekhovskiy, P., Turubanova, S. and Yaroshenko, A. 2002. *Atlas of Russia's Intact Forest Landscapes*. Global Forest Watch Russia, Moscow.

Alcaraz-Segura, D., Cabello, J., Paruelo, J.M. and Delibes, M. 2008. Trends in the surface vegetation dynamics of the national parks of Spain as observed by satellite sensors. *Applied Vegetation Science* **11**: 431-440.

Allen, J.R.M., Brandt, U., Brauer, A., Hubberten, H.-W., Huntley, B., Keller, J., Kraml, M., Mackensen, A., Mingram, J., Negendank, J.F.W., Nowaczyk, N.R., Oberhansli, H., Watts, W.A., Wulf, S. and Zolitschka, B. 1999. Rapid environmental changes in southern Europe during the last glacial period. *Nature* **400**: 740-743.

Babst, F., Esper, J. and Parlow, E. 2010. Landsat TM/ETM plus and tree-ring based assessment of spatiotemporal patterns of the autumnal moth (*Epirrita autumnata*) in northernmost Fennoscandia. *Remote Sensing of Environment* **114**: 637-646.

Bellassen, V., Viovy, N., Luyssaert, S., Le Marie, G., Schelhaas, M.-J. and Ciais, P. 2011. Reconstruction and attribution of the carbon sink of European forests between 1950 and 2000. *Global Change Biology* **17**: 3274-3292.

Bert, D., Leavitt, S.W. and Dupouey, J.-L. 1997. Variations of wood $\delta^{13}C$ and water-use efficiency of *Abies alba* during the last century. *Ecology* **78**: 1588-1596.

Birks, H.H. 2008. The late-quaternary history of arctic and alpine plants. *Plant Ecology and Diversity* **1**: 135-146.

Callaghan, T.V., Bjorn, L.O., Chapin, T., Chernov, Y., Christensen, T.R., Huntley, B., Ims, R.A., Johansson, M., Riedlinger, D.J., Jonasson, S., Matveyeva, N., Oechel, W., Panikov, N., Shaver, G., Elster, J., Henttonen, H., Jónsdóttir, I.S., Laine, K., Schaphoff, S., Sitch, S., Taulavuori, E., Taulavuori, K. and Zöckler, C. 2005. Arctic tundra and polar desert ecosystems. In: *Arctic Climate Impact Assessment (ACIA)*. ACIA Scientific Report: Cambridge University Press, Cambridge, United Kingdom, p. 243-352.

Chapin III, F.S. 1983. Direct and indirect effects of temperature on Arctic plants. *Polar Biology* **2**: 47-52.

Cheddadi, R., Guiot, J. and Jolly, D. 2001. The Mediterranean vegetation: what if the atmospheric CO_2 increased? *Landscape Ecology* **16**: 667-675.

Danby, R.K. and Hik, D.S. 2007. Variability, contingency and rapid change in recent subarctic alpine tree line dynamics. *Journal of Ecology* **95**: 352-363.

Forbes, B.C., Fauria, M.M. and Zetterberg, P. 2009. Russian Arctic warming and greening are closely tracked by tundra shrub willows. *Global Change Biology* **15**: 1-13.

Forbes, B.C., Fauria, M.M. and Zetterberg, P. 2010. Russian Arctic warming and 'greening' are closely tracked by tundra shrub willows. *Global Change Biology* **16**: 152-1554.

Grabherr, G., Gottfried, M. and Pauli, H. 2001. Long-term monitoring of mountain peaks in the Alps. In: Burga, C.A. and Kratochwil, A. (Eds.), *Biomonitoring: General and Applied Aspects on Regional and Global Scales. Tasks for Vegetation Science*. Kluwer, Dordrecht, Germany, pp. 153-177.

Grubb, H. 2008. Tornetrask tree-ring width and density AD 500-2004: A test of climatic sensitivity and a new 1500-year reconstruction of north Fennoscandian summers. *Climate Dynamics* **31**: 843-857.

Hallinger, M., Manthey, M. and Wilmking, M. 2010. Establishing a missing link: warm summers and winter snow cover promote shrub expansion into alpine tundra in Scandinavia. *New Phytologist* **186**: 890-899.

Hartley, A.E., Neil, C., Melillo, J.M., Crabtree, R. and Bowles, F.P. 1999. Plant performance and soil nitrogen mineralization in response to simulated climate change in subarctic dwarf shrub heath. *Oikos* **86**: 331-343.

Hedenas, H., Olsson, H., Jonasson, C., Bergstedt, J., Dahlberg, U. and Callaghan, T.V. 2011. Changes in tree growth, biomass and vegetation over a 13-year period in the Swedish Sub-Arctic. *Ambio* **40**: 672-682.

Hennessy, K.J., Gregory, J.M. and Mitchell, J.F.B. 1997. Changes in daily precipitation under enhanced greenhouse conditions. *Climate Dynamics* **13**: 667-680.

Julien, Y., Sobrino, J.A. and Verhoef, W. 2006. Changes in land surface temperatures and NDVI values over Europe between 1982 and 1999. *Remote Sensing of Environment* **103**: 43-55.

Kammer, P.M., Schob, C. and Choler, P. 2007. Increasing species richness on mountain summits: Upward migration due to anthropogenic climate change or re-colonization? *Journal of Vegetation Science* **18**: 301-306.

Karlsson, H., Hornberg, G., Hannon, G. and Nordstrom, E.-M. 2007. Long-term vegetation changes in the northern Scandinavian forest limit: A human impact-climate synergy? *The Holocene* **17**: 37-49.

Kilander, S. 1955. Karlvaxternas ovre granser pa fjall i sydvastra Jamtland samt angransande delar av Harjedalen och Norge. *Acta Phytogeogr. Suec.* **35**: 1-198.

Kullman, L. 2002. Rapid recent range-margin rise of tree and shrub species in the Swedish Scandes. *Journal of Ecology* **90**: 68-77.

Kullman, L. 2006. Transformation of alpine and subalpine vegetation in a potentially warmer future, the Anthropocene era. Tentative projections based on long-term observations and paleovegetation records. *Current Trends in Ecology* **1**: 1-16.

Kullman, L. 2007a. Long-term geobotanical observations of climate change impacts in the Scandes of west-central Sweden. *Nordic Journal of Botany* **24**: 445-467.

Kullman, L. 2007b. Modern climate change and shifting ecological states of the subalpine/alpine landscape in the Swedish Scandes. *Geo-Oko* **28**: 187-221.

Kullman, L. 2010b. One century of treeline change and stability -- experiences from the Swedish Scandes. *Landscape Online* **17**: 1-31.

Kullman, L. 2010a. A richer, greener and smaller alpine world -- review and projection of warming-induced plant cover change in the Swedish Scandes. *Ambio* **39**: 159-169.

Kullman, L. 2010c. Alpine flora dynamics -- a critical review of responses to climate change in the Swedish Scandes since the early 1950s. *Nordic Journal of Botany* **28**: 398-408.

Kullman, L. and Kjallgren, L. 2006. Holocene tree-line evolution in the Swedish Scandes: Recent tree-line rise and climate change in a long-term perspective. *Boreas* **35**: 159-168.

Leal, S., Eamus, D., Grabner, M., Wimmer, R. and Cherubini, P. 2008. Tree rings of *Pinus nigra* from the Vienna basin region (Austria) show evidence of change in climatic sensitivity in the late 20th century. *Canadian Journal of Forest Research* **38**: 744-759.

Lopatin, E., Kolstrom, T. and Spiecker, H. 2006. Determination of forest growth trends in Komi Republic (northwestern Russia): combination of tree-ring analysis and remote sensing data. *Boreal Environment Research* **11**: 341-353.

Martinez-Vilalta, J., Lopez, B.C., Adell, N., Badiella, L. and Ninyerola, M. 2008. Twentieth century increase of Scots pine radial growth in NE Spain shows strong climate interactions. *Global Change Biology* **14**: 2868-2881.

Myneni, R.B., Tucker, C.J., Asrar, G. and Keeling, C.D. 1998. Interannual variations in satellite-sensed vegetation index data from 1981 to 1991. *Journal of Geophysical Research* **103**: 6145-6160.

Olofsson, J., Oksanen, L., Callaghan, T., Hulme, E.P., Oksanen, T. and Suominen, O. 2009. Herbivores inhibit climate-driven shrub expansion on the tundra. *Global Change Biology* **15**: 2681-2693.

Osborne, C.P., Mitchell, P.L., Sheehy, J.E. and Woodward, F.I. 2000. Modellng the recent historical impacts of atmospheric CO_2 and climate change on Mediterranean vegetation. *Global Change Biology* **6**: 445-458.

Pauli, H., Gottfried, M. and Grabherr, G. 2001. High summits of the Alps in a changing climate. In: Walther, G.-R., Burga, C.A. and Edwards, P.J., Eds. *Fingerprints of Climate Change.* Kluwer, New York, New York, USA., p. 139-149.

Pauli, H., Gottfried, M., Reiter, K., Klettner, C. and Grabherr, G. 2007. Signals of range expansions and contractions of vascular plants in the high Alps: Observations (1994-2004) at the GLORIA master site Schrankogel, Tyrol, Austria. Global Change Biology **13**: 147-156.

Pilegaard, K., Ibrom, A., Courtney, M.S., Hummelshoj, P. and Jensen, N.O. 2011. Increasing net CO_2 uptake by a Danish beech forest during the period from 1996 to 2009. *Agricultural and Forest Meteorology* **151**: 934-946.

Riebsame, W.E., Meyer, W.B. and Turner, B.L. 1994. Modeling land-use and cover as part of global environmental-change. *Climatic Change* **28**: 45-64.

Rundqvist, S., Hedenas, H., Sandstrom, A., Emanuelsson, U., Eriksson, H., Jonasson, C. and Callaghan, T.V. 2011. Tree and shrub expansion over the past 34 years at the tree-line near Abisko, Sweden. *Ambio* **40**: 683-692.

Sandberg, G. 1963. Vaxtvarlden I Abisko nationalpark. In: Curry-Lindahl, K. (Ed.). *Natur i Lappland*, II. Bokforlaget Svensk Natur, Uppsala, Sweden.

Sturm, M., Racine, C. and Tape, K. 2001. Climate change - increasing shrub abundance in the Arctic. *Nature* **411**: 546-547.

Tape, K., Sturm, M. and Racine, C. 2006. The evidence for shrub expansion in Northern Alaska and the Pan-Arctic. *Global Change Biology* **12**: 686-702.

Theurillat, J.-P. and Guisan, A. 2001. Potential impacts of climate change on vegetation in the European Alps: A review. *Climatic Change* **50**: 77-109.

Tommervik, H., Johansen, B., Riseth, J.A., Karlsen, S.R., Solberg, B. and Hogda, K.A. 2009. Above ground biomass changes in the mountain birch forests and mountain heaths of Finnmarksvidda, northern Norway, in the period 1957-2006. *Forest Ecology and Management* **257**: 244-257.

Tommervik, H., Johansen, B., Tombre, I., Thannheiser, D., Hogda, K. and Gaare, E. 2004. Vegetation changes in the Nordic mountain birch forest: The influence of grazing and climate change. *Arctic, Antarctic, and Alpine Research* **36**: 323-332.

Van Bogaert, R., Haneca, K., Hoogesteger, J., Jonasson, C., De Dapper, M. and Callaghan, T.V. 2011. A century of tree line changes in sub-Arctic Sweden show local and regional variability and only a minor role of 20th century climate warming. *Journal of Biogeography* **38**: 907-921.

Vicente-Serrano, S.M., Lasanta, T. and Romo, A. 2004. Analysis of spatial and temporal evolution of vegetation cover in the Spanish central Pyrenees: Role of human management. *Environmental Management* **34**: 802-818.

Weih, M. and Karlsson, P.S. 1997. Growth and nitrogen utilization in seedlings of mountain birch (*Betula pubescens* ssp. tortuosa) as related to plant nitrogen status and temperature: A two-year study. *Ecoscience* **4**: 365-373.

Cover photo of a forest path in Yvelines, France
by Tognopop as posted to [WikiMedia Commons](https://commons.wikimedia.org).