Deserts: Are They Expanding or Shrinking?

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DESERTS: ARE THEY EXPANDING OR SHRINKING?

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Back when the atmosphere's CO_2 concentration was approximately 340 ppm (up from a pre-industrial value on the order of 280 ppm), Idso (1982) stated in a small self-published book (*Carbon Dioxide: Friend or Foe?*) that if the air's CO_2 content continued to climb, it would ultimately enhance plant growth and water use efficiency to the point that semi-arid lands not then suitable for cultivation "could be brought into profitable production," further stating that "the deserts themselves could 'blossom as the rose'." A few years later he advanced essentially the same thesis, but this time in the pages of *Nature* (Idso, 1986) in a brief paper entitled "Industrial Age Leading to the Greening of the Earth."

Throughout many of the succeeding years, however, this optimistic view of the ongoing rise in the air's CO_2 content -- and the great good it could do for humanity and nature alike -- was largely ignored, as the world's climate alarmists took center stage with headline-grabbing predictions of catastrophic CO_2-induced global warming. But as time progressed, this positive view began to be taken more seriously, as suggested by the following titles of some science articles that appeared in the popular press near the end of the past century.

"Greenhouse Gas Might Green Up the Desert" declared a *ScienceDaily* headline. "Missing Carbon Dioxide Greens Up the Desert" chimed in the *Israel National News*. "Greenhouse Gas Soaked Up by Forests Expanding into Deserts" proclaimed *The Independent*. And in a grudging acknowledgement of the hard-to-ignore good findings, the *World News* reported that "Deserts Bloom in Bad Air."

Idso (1982) stated in a small self-published book (Carbon Dioxide: Friend or Foe?) that if the air's CO_2 content continued to climb, it would ultimately enhance plant growth and water use efficiency to the point that semi-arid lands not then suitable for cultivation "could be brought into profitable production," further stating that "the deserts themselves could 'blossom as the rose'."

What were the sources of this spate of positive stories? One that cannot be ignored was the study of Grunzweig *et al*. (2003)[1], wherein the authors told the tale of the Yatir forest -- a 2800-hectare stand of primarily Aleppo pine (*Pinus halepensis* Mill.) that contained smaller amounts of

[1] http://www.co2science.org/articles/V6/N21/EDIT.php

Cupressus sempervirens and other pine trees (mostly *P. brutia*) -- which was planted some 35 years earlier at the edge of the Negev Desert in Israel.

An intriguing aspect of this particular forest -- which Grunzweig *et al*. characterized as growing in poor soil of only 0.2- to 1.0-meter depth above chalk and limestone -- was that although it was located in an arid region that received less annual precipitation than all of the other scores of global FluxNet stations that measured exchanges of CO_2 between terrestrial ecosystems and the atmosphere (Baldocchi *et al*., 2001), its annual net ecosystem CO_2 exchange was just as high as those of many high-latitude boreal forests; and it was actually *higher* than that of most temperate forests.

Grunzweig *et al.* noted that the increase in atmospheric CO_2 concentration that had occurred since pre-industrial times should have improved the water use efficiency of most of Earth's plants by increasing the ratio of CO_2 fixed by photosynthesis to water lost via transpiration.

So how could this possibly be? Grunzweig *et al*. noted that the increase in atmospheric CO_2 concentration that had occurred since pre-industrial times should have improved the water use efficiency (WUE) of most of Earth's plants by increasing the ratio of CO_2 fixed by photosynthesis to water lost via transpiration. And that this hypothesis was indeed correct was proven under controlled experimental conditions by Leavitt *et al*. (2003)[2] within the context of the long-term atmospheric CO_2 enrichment study of Idso and Kimball (2001) on sour orange (*Citrus aurantium* L.) trees. In addition, it was also confirmed in nature by Feng (1999)[3], who obtained identical CO_2-induced WUE responses for 23 groups of naturally-occurring trees (scattered across western North America) that were caused by the rise in the air's CO_2 content that occurred between 1800 and 1985.

In commenting on these findings, Feng said that this phenomenon "would have caused natural trees in arid environments to grow more rapidly, acting as a carbon sink for anthropogenic CO_2," which is exactly what Grunzweig *et al*. had demonstrated to be happening in the Yatir forest on the edge of the Negev Desert. In addition, they reported that "reducing water loss in arid regions improves soil moisture conditions, decreases water stress and extends water availability," which "can indirectly increase carbon sequestration by influencing plant distribution, survival and expansion into water-limited environments."

Much the same conclusions may be derived from the study of Grunzweig and Korner (2001)[4], who constructed model grasslands representative of the Negev of Israel and placed them in growth chambers maintained at atmospheric CO_2 concentrations of 280, 440 and 600 ppm for a period of five months. In doing so, they found that the elevated CO_2 treatments reduced rates of evapotranspiration and increased soil moisture contents in the communities exposed to elevated

[2] http://www.co2science.org/articles/V5/N49/EDIT.php
[3] http://www.co2science.org/articles/V2/N20/B1.php
[4] http://www.co2science.org/articles/V4/N26/B2.php

CO_2. Between two periods of imposed drought, for example, soil moisture was 22 and 27% higher in communities exposed to 440 and 600 ppm CO_2, respectively, than it was in control communities exposed to pre-industrial levels of atmospheric CO_2.

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These increases in soil moisture content likely contributed to peak ecosystem CO_2 uptake rates that were 21 and 31% greater at 400 and 600 ppm CO_2 than they were at 280 ppm CO_2. In addition, the two levels of atmospheric CO_2 enrichment had no effect on nighttime respiratory carbon losses from the ecosystems. Thus, these model semi-arid grasslands were clearly acting as carbon sinks under CO_2-enriched conditions. In fact, the elevated CO_2 levels increased total community biomass by 14% over that produced by the communities exposed to the sub-ambient CO_2 concentration. Also, when the total biomass produced was related to the total amount of water lost via evapotranspiration, the communities grown at atmospheric CO_2 concentrations of 440 and 600 ppm exhibited CO_2-induced increases in water-use efficiency that were 17 and 28% higher, respectively, than those displayed by the control communities exposed to air of 280 ppm CO_2.

That these phenomena are indeed widespread and operative in the real world was suggested by a number of observational studies, beginning with that of Nicholson *et al*. (1998)[5], who used satellite images of the Central and Western Sahel from 1980 to 1995 to determine the extent of purported desertification in this region. In addition, *rain-use efficiency* (RUE), which relates plant productivity to rainfall, was calculated to determine if the biological productivity of the area was affected by factors other than drought; and this work revealed no overall expansion of deserts during the 16-year study period, as well as no decrease in RUE, although vegetation did expand and contract somewhat in response to periods of relatively more or less rainfall. Hence, neither human activities nor periodic climatic changes in this huge arid region caused massive desertification of the type that was so highly hyped by the United Nations in the 1970s.

In another such study, Prince *et al*. (1998)[6] also used satellite images and RUE to map the occurrence and severity of desertification; but they did so for the *entire* Sahel from 1982 to 1990. They, too, could find no evidence of widespread desertification; and they determined that RUE did not decline during their 9-year investigation. In fact, they discovered a small but steady *rise* in RUE for the Sahel as a whole, suggesting that plant productivity there had *increased* over the time of their study.

[5] http://www.co2science.org/articles/V2/N6/B4.php
[6] http://www.co2science.org/articles/V2/N6/B5.php

A third study of note was conducted by Eklundh and Olsson (2003)[7], who analyzed Normalized Difference Vegetation Index (NDVI) data from the NOAA Advanced Very High Resolution Radiometer that were obtained over the African Sahel for the period 1982-2000. And, as they described their findings, “strong positive change in NDVI occurred in about 22% of the area, and weak positive change in 60% of the area,” while “weak negative change occurred in 17% of the area, and strong negative change in 0.6% of the area.” And they also reported that “integrated NDVI has increased by about 80% in the areas with strong positive change,” while in areas with weak negative change, “integrated NDVI has decreased on average by 13%.” The primary story told by these data, therefore, was one of strong positive trends in NDVI for large areas of the African Sahel over the last two decades of the 20th century; and Eklundh and Olsson thus concluded that the “increased vegetation, as suggested by the observed NDVI trend, could be part of the proposed tropical sink of carbon.”

Also questioning the climate-alarmist claim that desertification will intensify as a consequence of CO_2-induced global warming was the study of Nicholson (2001)[8], who reviewed what was then known about precipitation changes in Africa over the past two centuries, much of which work she herself was instrumental in conducting. “The most significant climatic change that has occurred,” as she wrote, “has been a long-term reduction in rainfall in the semi-arid regions of West Africa,” which has been “on the order of 20 to 40% in parts of the Sahel.” And as a result, as she wrote, there had been “three decades of protracted aridity,” such that “nearly all of Africa has been affected ... particularly since the 1980s.” *However*, she also noted that “the rainfall conditions over Africa during the last 2 to 3 decades are not unprecedented,” and that “a similar dry episode prevailed during most of the first half of the 19th century.”

Continuing, Nicholson wrote that “the 3 decades of dry conditions evidenced in the Sahel are not in themselves evidence of irreversible global change.” And they were certainly not evidence of global warming-induced change, because (1) a longer historical perspective of the type we are constantly striving to obtain clearly indicates that an even *longer* period of *similar* dry conditions occurred between 100 and 1850, and (2) this remarkable dry period occurred when the Earth was still in the icy grip of the Little Ice Age, a period of cold that is without precedent in at least the last 6500 years ... *even in Africa*. Hence, there was no good reason to think that the prior two- to three-decade Sahelian drought was in any way unusual or that it was caused by the putative higher temperatures of that period. Simply put, like many other things, *droughts happen*.

As ever more data were thus obtained from various parts of the world, the CO_2-induced *reverse desertification theory* of Idso (1982, 1986) gained ever more support in the way of real-world observations, one example of which was provided by Cheddadi *et al*. (2001)[9], who applied what was known about these matters to lands bordering the Mediterranean Sea. More specifically, they employed a standard biogeochemical model (BIOME3) -- which used monthly temperature and precipitation data, certain soil characteristics, cloudiness and atmospheric CO_2 concentration as inputs -- to simulate the responses of the various biomes of the region to changes in both climate (temperature and precipitation) and the air’s CO_2 content.

[7] http://www.co2science.org/articles/V6/N21/EDIT.php
[8] http://www.co2science.org/articles/V5/N3/C2.php
[9] http://www.co2science.org/articles/V5/N16/EDIT.php

Cheddadi *et al*.'s first step in this process was to validate the model for two test periods: the present (the turn of the century, in their case) and 6000 years before present (BP). Recent instrumental records provided the 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 were in AD 2000, that annual rainfall was approximately 200 mm less, and that the air's CO_2 concentration averaged 280 ppm, which was 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. And applying the BIOME3 model to these two sets of conditions, they demonstrated that it "can be used to simulate ... the vegetation distribution under ... different climate and [CO_2] conditions than today," where [CO_2] is the abbreviation they used to represent "atmospheric CO_2 concentration."

Cheddadi *et al*.'s next step was to use their validated model to explore the consequences of an increase in anthropogenic CO_2 emissions that pushed the air's CO_2 concentration to a value of 500 ppm and its mean annual temperature to a value 2°C higher than its 2001 mean. And in doing so, they found that 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."

> *Contrary to what is often predicted for much of the world's moisture-challenged lands, therefore, Cheddadi et al. 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 defined a drastic decrease as a decline of 30% or more.*

More specifically, in the words of the authors, "when precipitation is maintained at its present-day level, an evergreen forest spreads in the eastern Mediterranean and a conifer forest in Turkey." Also, 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 had been.

What was the basis for these positive developments? The three researchers wrote that "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 noted 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."

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However, there had been considerable concern about the *nutrient deficiency* that was believed to exist throughout the world's deserts, which had long been thought to be notoriously lacking in *nitrogen*, and which in their upper reaches indeed had been, as was reported much earlier by West and Skuijins (1975). From whence, therefore, could the needed nitrogen come?

In a subsequent fortunate development, Walvoord *et al*. (2003)[10] measured vertical profiles of nitrate nitrogen in a number of U.S. desert soils to depths of several meters, discovering that "a large reservoir of bioavailable nitrogen (up to ~10^4 kilograms of nitrogen per hectare, as nitrate) had been previously overlooked in studies of global nitrogen distribution." This amount of new nitrogen, they wrote, "raises estimates of vadose-zone nitrogen inventories by 14 to 71% for warm deserts and arid shrublands worldwide." Viewed another way, the 2,000 to 10,000 kg of nitrogen per hectare they found at depth *vastly* overshadowed the 25 to 250 kg of nitrogen typically applied each year to the surfaces of agricultural fields by farmers.

This deep reservoir of *bioavailable nitrogen*, as Walvoord *et al*. referred to it, was a "potential bonanza," in the words of Stokstad (2003), just waiting to be tapped. In fact, Stokstad said that Duke University ecologist Robert Jackson wondered "if the pool of nitrate could help explain why deep-rooted woody plants have invaded the Southwest over the past century or so." Whether it can or can't, the worldwide encroachment of deep-rooted woody plants upon the world's arid lands that has accompanied the development and progression of the Industrial Revolution will likely provide the physical pump required to transport the long-hidden nitrogen from several meters' depth to the soil's surface layer, where *all* plants may share in the blessings it provides, as *the greening of the Earth continues*.

One year later, Peterson and Neofotis (2004)[11] grew velvet mesquite (*Prosopis velutina* Woot.) seedlings for six weeks from their time of planting (as seeds) in small pots located within environmentally-controlled growth chambers that were maintained at atmospheric CO_2

[10] http://www.co2science.org/articles/V6/N47/B1.php
[11] http://www.co2science.org/articles/V7/N50/B1.php

concentrations of 380 and 760 ppm and two levels of water availability (high and low). And although they did not see a significant CO_2-induced increase in plant growth, they said that by the end of their six-week study, they observed a highly significant reduction of approximately 41% in the volume of water transpired by *P. velutina* in response to the experimental doubling of the air's CO_2 content, which "large reduction in whole-plant water use," as they described it, "occurred because the reduction in transpiration per unit leaf area at elevated CO_2 was not offset by a proportional increase in total leaf area."

The pair of scientists from the Biosphere 2 Center near Oracle, Arizona, USA, thus suggested that "under a future [high-CO_2] scenario, seedlings may deplete soil moisture at a slower rate than they do currently," and that "this could facilitate seedling survival between intermittent rain events," noting that their work "corroborates the conclusions of Polley *et al*. (1994, 1999, 2003) that increasing levels of atmospheric CO_2 may facilitate the establishment of mesquite seedlings through a reduction in soil water depletion." And that such has indeed occurred is suggested by the fact, again quoting Peterson and Neofotis, that "mesquites and other woody species in the semiarid southwestern United States have shown substantial increases in population density and geographic range since Anglo-American settlement of the region approximately 120 years ago," in support of which statement they cited the studies of Van Auken and Bush (1990), Gibbens *et al*. (1992), Bahre and Shelton (1993), Archer (1995), Boutton *et al*. (1999), Van Auken (2000), Ansley *et al*. (2001), Wilson *et al*. (2001) and Biggs *et al*. (2002).

With the passing of another year, Piao *et al*. (2005)[12] published a paper describing how they used a time series data set of Normalized Difference Vegetation Index (NDVI) that they obtained from the Advanced Very High Resolution Radiometer (AVHRR) for the period 1982 to 1999 (Tucker *et al*., 2001; Zhou *et al*., 2001), along with precipitation and temperature data sets, in order to investigate variations of desert area in China by identifying the climatic boundaries of both arid and semiarid areas, along with changes in NDVI in these areas. And what did they thereby learn?

Piao *et al*. found that "average rainy season NDVI in arid and semiarid regions both increased significantly during the period 1982-1999." More specifically, they determined that the NDVI increased for 72.3% of total arid regions and for 88.2% of total semiarid regions, such that the area of arid regions decreased by 6.9% and that of semiarid regions decreased by 7.9%. They also noted that by analyzing Thematic Mapper satellite images, Zhang *et al*. (2003) had documented that "the process of desertification in the Yulin area of Shannxi Province showed a decreased trend between 1987 and 1999," and that "according to the national monitoring data on desertification in western China (Shi, 2003), the annual desertification rate decreased from 1.2% in the 1950s to -0.2% at present."

Last of all, and noting that "variations in the vegetation coverage of these regions partly affect the frequency of sand-dust storm occurrence (Zou and Zhai, 2004)," Piao *et al*. concluded that "increased vegetation coverage in these areas will likely fix soil, enhance its anti-wind-erosion ability, reduce the possibility of released dust, and consequently cause a mitigation of sand-dust storms." And, in fact, they were able to report that recent studies had indeed suggested that "the frequencies of strong and extremely strong sand-dust storms in northern China significantly

[12] http://www.co2science.org/articles/V8/N22/B1.php

declined from the early 1980s to the end of the 1990s," citing the studies of Qian *et al*. (2002) and Zhao *et al*. (2004).

Consequently, it would appear that the dreaded global climatic change claimed to have been experienced by the earth over the latter part of the 20th century was either (1) not so dreaded after all or (2) *totally dwarfed* by opposing phenomena that significantly *benefited* China, as its lands grew ever greener during this period and its increased vegetative cover helped to stabilize its soils and throw feared desertification into reverse.

About this same time, Herrmann *et al*. (2005)[13] noted that there had been "a long history of assertions of widespread and irreversible desertification occurring in the Sahel of Africa," citing the studies of Dregne (1983), Lamprey (1988) and Middleton *et al*. (1997). In fact, during the 1970s -- when Lamprey's report was originally written -- the United Nations had spearheaded a massive media campaign to warn the world about the phenomenon; and in August of 2002, leaders of the UN Environment Program told the World Summit on Sustainable Development held in Johannesburg that over 45% of that continent was at that time experiencing severe desertification. Several years earlier, however, scientists had already begun to realize that these assertions were no longer true, as demonstrated by the work of Nicholson *et al*. (1998) and Prince *et al*. (1998), which fact had also been confirmed by the more recent studies of Eklundh and Olsson (2003), Anyamba and Tucker (2005) and Olsson *et al*. (2005).

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Herrmann *et al*. provided addition support for the newer findings as a result of their investigation of "temporal and spatial patterns of vegetation greenness and rainfall variability in the African Sahel and their interrelationships based on analyses of Normalized Difference Vegetation Index (NDVI) time series for the period 1982-2003 and gridded satellite rainfall estimates." And what, precisely, did they thereby learn?

For the period 1982-2003, the three researchers determined that "the overall trend in monthly maximum NDVI [was] positive over a large portion of the Sahel region, reaching up to a 50%

[13] http://www.co2science.org/articles/V9/N23/B1.php

increase in the average NDVI in parts of Mali, Mauritania and Chad." In addition, they found that "rainfall emerges as the dominant causative factor in the dynamics of vegetation greenness in the Sahel at an 8-km spatial resolution," but that "the presence of spatially coherent and significant long-term trends in the residuals suggests that there might be another, weaker, causative factor," which was also suggested by the fact that the "recovery of vegetation greenness [was] beyond what would be expected from the recovery of rainfall conditions alone."

Herrmann *et al*. thus stated that their study "confirms previous regional-scale findings for the period 1982-1999 by Eklundh and Olsson (2003) and Olsson *et al*. (2005), who observed widespread positive trends of both time-integrated NDVI and NDVI amplitudes, and Anyamba and Tucker (2005), who [observed] increases in growing season NDVI across most parts of the region." In concluding, they therefore wrote that "a greening of the Sahel expressed in positive trends in NDVI indicates a net increase in biomass production during the period 1982-2003, which challenges the notion of irreversible desertification in the Sahel."

Jumping ahead five years, Peng *et al*. (2010)[14] used snow-depth measurements collected at 279 meteorological stations scattered across China, plus co-located satellite-derived Normalized Difference Vegetation Index (NDVI) data, to investigate spatiotemporal changes in snow depth over the period 1980-2006 and the effects of those changes on vegetative growth the following spring and summer.

This work revealed, in the words of the five researchers, that "over the past three decades, winter snow depth overall increased in northern China, particularly in the most arid and semiarid regions of western China where desert and grassland are mainly distributed." And they further noted that in those specific areas there were positive correlations between mean winter snow depth and spring NDVI data. In addition, they stated that Piao *et al*. (2005) determined that the net primary productivity of the same desert and grasslands during 1982-1999 "increased by 1.6% per year and 1.1% per year, respectively," and that "desertification has been reversed in some areas of western China since the 1980s," citing the work of Runnstrom (2000), Wu (2001), Zhang *et al*. (2003) and Piao *et al*. (2005).

In discussing the implications of their findings, Peng *et al*. wrote that the "increase in vegetation coverage in arid and semi-arid regions of China, possibly driven by winter snow, will likely restore soil and enhance its anti-wind-erosion ability, reducing the possibility of released dust and mitigating sand-dust storms," while also noting that the frequency of sand-dust storms had indeed "declined in China since the early 1980s (Qian *et al*., 2002; Zhao *et al*., 2004)." Thus, as the world has warmed over the past three decades, there has been another concomitant climatic change across China above 40°N latitude (an increase in winter snow depth) that has prompted a biological change (increased vegetative growth in desert areas and grasslands) that has prompted yet another climatic change (a reduction in sand-dust storms), all of which would be recognized by most rational people as *positive developments*, as opposed to the catastrophic consequences typically conjured up by the world's climate alarmists.

[14] http://www.co2science.org/articles/V14/N1/C1.php

One year later, working in the semi-arid Loess Plateau of northwestern Shanxi, China, Yang *et al*. (2011)[15] studied characteristics of *Caragana microphylla* plantations that had been established there five, ten, twenty, thirty and forty years previously, in efforts to combat desertification, which in the 1960s had claimed 48.5% of the region's surface area. These perennial leguminous and sand-binding shrubs were chosen for the task because they have well-developed stems with many clustered branches and large root systems capable of adapting to poor nutrient conditions; and they were thus positioned in groups to act as sand barriers and windbreaks. So what did Yang *et al*. learn by scrutinizing the different-aged plants' environments?

The establishment and development of the *C. microphylla* shrubs, in the words of the Chinese scientists, "improved soil texture, enhanced soil organic matter (SOM), total nitrogen (TN), and cation exchange capacity (CEC)." In addition, they reported that "SOM, TN, and CEC were significantly higher at the center than at the outside of the shrub canopies and were higher at the 0-5 cm depth than at the 5-10 cm depth." Moreover, they stated that "the differences in SOM, TN, and CEC from the center to the outside of shrub canopies were greater under 30- and 40-year-old shrubs than under 10- and 5-year-old shrubs." And they even discovered that the spatiotemporal heterogeneity of the soil properties "facilitated the development of herbaceous species diversity and the restoration of the [region's] natural ecosystem," which had previously been lost to desertification.

Clearly, therefore, once the photosynthesis-promoting and transpiration-reducing impacts of atmospheric CO_2 enrichment *kick-in*, so to speak, and shrubs begin to grow in arid and semi-arid lands -- even *without* being planted there by man -- a host of additional beneficial phenomena begin to operate, hastening the ongoing *greening of the Earth* that is currently in the process of totally transforming the terrestrial surface of the planet.

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At approximately the same time, Zhao *et al*. (2011)[16] wrote that "many studies based on analyses of satellite images have detected a greening trend at global (Myneni *et al*., 1997; Nemani *et al*., 2003; Potter *et al*., 2007; Zhou *et al*., 2001) and regional scales (Donohue *et al*., 2009; Fang *et al*.,

[15] http://www.co2science.org/articles/V14/N21/EDIT.php
[16] http://www.co2science.org/articles/V14/N46/B1.php

2004; Herrmann *et al*., 2005).” However, they added that “the response of vegetation to climatic changes widely differed by biome (Fang *et al*., 2005; Piao *et al*., 2006) and bioregion (Verbyla, 2008).”

Focusing, therefore, on the grassland-oasis-desert complex of northwest China, Zhao *et al*. investigated “spatio-temporal changes in vegetation growth and their responses to a changing climate by biome and bioregion, using satellite-sensed Normalized Difference Vegetation Index (NDVI) data from 1982 to 2003, along with corresponding climate data.” And as a result of their efforts, the four Chinese researchers found that over the 22 years of their study, when annual mean temperature increased by 0.06°C/year, “about 30% of the total vegetated area showed an annual increase of 0.7% in growing season NDVI,” which trend “occurred in all biomes and all bioregions except Sawuer, a sub-region of the study area with no significant climate change.”

And breaking this result into three sub-periods, they found that the NDVI increase was rather *remarkable* during 1982-1988, then tended to be *slight*, and finally actually *declined a bit* from 1998 to 2003, which pattern largely resembled the concomitant pattern of *global* air temperature change, which could have been responsible for the shifts in regional precipitation that appeared to be driving the observed shifts in NDVI. And in further support of this connection, Zhao *et al*. noted that “previous analyses of satellite-measured vegetation growth suggested a greening trend of vegetation in the central United States (Wang *et al*., 2001, 2003) and the Sahel (Anyamba and Tucker, 2005; Herrmann *et al*., 2005) due to the effects of increasing precipitation at seasonal or annual scales.”

As with most of the rest of the world, therefore, as global temperatures go, so also goes the *greening of the Earth* ... driven *directly* by the ongoing rise in the air’s CO_2 content, and possibly *indirectly* by warming-induced alterations in global precipitation patterns.

Last of all, and in introducing their latest study, Bonachela *et al*. (2015)[17] noted that in arid and semi-arid savannas and grasslands, plants facilitate *neighbors* by increasing water infiltration while competing for water with *distant* individuals, citing Rietkerk *et al*. (2002). And they go on to say that “reducing rainfall generates a predictable sequence of patterns with decreasing overall plant biomass,” going from over-dispersed gaps to “labyrinths, spots, and finally, barren desert,” which last transition, in their words, “is known as a ‘catastrophic shift,’ or sudden collapse to an un-vegetated state,” citing Rietkerk *et al*. (2004) and Scheffer *et al*. (2009).

In many arid ecosystems, however, they note that *termite nests* create substrate heterogeneity by altering soil properties and thereby “enhancing plant growth” and creating “islands of fertility (Sileshi *et al*., 2010)” that can serve as “refugia for plants and nuclei for re-vegetation,” which phenomena can in turn “enhance drylands’ resistance to and recovery from drought.” And “by such engineering of soil,” as they concluded in the final sentence of their paper, the six scientists suggest that “termites and other ecosystem engineers may buffer the effects of anthropogenic global change in some of the world’s most environmentally and socioeconomically sensitive regions.”

[17] http://www.co2science.org/articles/V18/may/a21.php

So what's the take-home message of these latter findings? Could it be that *termites might be good for something?*

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