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GLOBAL WARMING AND SMALL CYCLE: RISKS AND PROSPECTS

D. Dent, Dr
ORCID ID: 0000-0001-7521-9603
Independent scientist, UK
Bai Zh., PhD
ORCID ID: 0000-0002-3338-5766
ISRIC-World Soil Information, Wageningen (Netherland)

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Dent D., Bai Zh. Global warming and small cycle: risks and prospects

Climate change is altering our understanding of ourselves, our society, the relationships between socio-economic and biophysical systems, and humanity's place on Earth. It is clear that the Earth is warming, but the scientific consensus for half a century has ignored the root cause of this threatening phenomenon, so the response has been ineffective and has not led to a consolidation of efforts. It is noted that the main reasons for the impact on the climate in the agro sector are the clearing of land for agriculture, the loss of year-round vegetation covering the soil, the reduction of forests, which expose the bare soil to solar radiation, creating tangible heat. The cooling effect of evaporation is limited or stopped by vegetation. This significantly changes formation and movement of moisture, stops rain from reaching deep into dry areas. In the article, the authors define the most important directions and some actions to solve the problem of bare soil surfaces.

The earth still behaves as if it is trying to preserve the most favorable environment for all living things. It follows that the safest and most sustainable land use should imitate natural vegetation. Farmers and other land users should avoid exposing bare soil to direct sunlight. For this purpose, it is proposed to minimize tillage (no tillage) leaving the plow; to implement various crop rotations, preferably with perennial crops; to form a motley, diverse landscape that promotes a small water cycle in agroecosystems. The present research identifies only some of the processes through which a bare or non-bare landscape affects weather and climate. The work confirms that the impact of soil stripping from vegetation on atmospheric processes should be taken into account in the policy of regional land management in agro landscapes around the world, and even where significant land clearing for agricultural purposes is impossible.

Key words: climate change, soil, landscape, vegetation, water cycle.

Дент Д., Бай Ч. Глобальне потепління і малий кругообіг: ризики та перспективи

Зміна клімату змінює наше розуміння нас самих, нашого суспільства, взаємозв'язків між соціально-економічними та біофізичними системами й місця людства на Землі. Зрозуміло, що Земля нагрівається, але науковий консенсус пів століття ігнорував першопричину цього загрозливого явища, тож відповідь була неефективною й не спричинила консолідації зусиль. Зауважено, що основними причинами впливу на клімат в агросекторі є розчищення земель для сільського господарства, позбавлення цілорічного покриття ґрунту рослинністю, зменшення лісів, унаслідок чого голий ґрунт стає відкритим для сонячного випромінювання, створюючи відчутне тепло. Обмежується або припиняється ефект охолодження від випаровування рослинністю. Це суттєво змінює надходження й переміщення вологи в тропосфері, припиняє переміщення вологих повітряних мас вглиб сухих територій. Визначено найважливіші напрями та деякі дії для вирішення проблеми оголених ґрунтових поверхонь.

Земля досі намагається зберегти найсприятливіше середовище для всього живого. Отже, найбільш безпечне і стале землекористування має імітувати природний рослинний покрив. Фермерам та іншим землекористувачам потрібно уникати перебування оголеного ґрунту під сонячним промінням. Для досягнення цієї мети запропоновано: мінімізувати обробіток, відмовившись від оранки плугом; впровадити різноманітні сівозміни, головно з багаторічними культурами; формувати строкатий, різноманітний ландшафт, який сприяє малому кругообігу води в агроекосистемах. Визначено лише деякі процеси, через які оголений або неоголений ландшафт впливає на погоду та клімат. Доведено, що вплив оголення ґрунту від рослинності на атмосферні процеси потрібно враховувати в політиці регіонального землеустрою в агроландшафтах у всьому світі, і навіть там, де значне розчищення землі для сільськогосподарських цілей неможливе.

Ключові слова: кліматичні зміни, ґрунт, ландшафт, рослинність, кругообіг води

Problem Formulation. Climate change is a complex problem. Sixty years ago, the Keeling curve of atmospheric carbon dioxide concentrations [10] seemed to point to global heating. President Lyndon Johnson was briefed in 1965 and he briefed Congress [21; 23] but he had a war on his mind, so, more than a decade passed before President Jimmy Carter asked Charles Keeling what the government should do about climate change. Keeling replied: "The problem is far too complicated for people to understand, so focus on greenhouse emissions" [20]. The herd has not focussed on anything else – but emissions are rising faster than ever and the momentum of floods, fires and droughts has taken everyone by surprise. It's time to try a different tack.

Analysis of Recent Research and Publications. Different soil vegetation leads to variegated properties of the land surface on both sides of the fence, which change depending on the season. Moreover, albedo and roughness length in an

agricultural region in summer are higher before harvest and lower when the soil is bare after harvest [8; 9; 22]. Whereas the albedo and surface roughness of the agricultural area decreases substantially following harvest when vegetated surface is replaced by bare soil, the native vegetation areas show very small seasonal variations in surface vegetation characteristics. Rainfall observations show about a 20 per cent decline of winter rainfall since the 1970s confined mainly to agricultural areas [5; 17].

Pitman et al. [19] found that the effect of reduced roughness from land cover change and the associated increase in moisture divergence may be a significant contributor to a decrease rainfall in southwest Western Australia. At locations farther inland, Pitman et al. [19] found that land cover change induced enhanced moisture convergence and rainfall in accordance with observations. However, it is noticeable that the amount of precipitation continues to decrease, despite the cessation of the decrease in vegetation cover in this region [14]. It is significant that land-use change is contributing to the ongoing decline in rainfall in the South West Australian region [16].

Objectives Setting. Since the Earth's climate is dynamically changing, it is important to know what factors cause the planet to heat up. The authors of the work analyse the influence of landscape albedo on the mesoclimate. The basis of the landscape is the soil. If the soil is covered with a variety of vegetation all year round or if the soil is bare without cover, the mesoclimate of the landscape changes significantly. The present research will analyse why it is so.

Presenting Main Material. Greenhouse gases don't generate heat. The heat is generated by the reaction of solar radiation with the Earth's surface. Some of the incoming radiation is reflected *(albedo),* but most of it either heats the Earth's surface (it is called *sensible heat)* or is used up by evapotranspiration (that is to say, *latent heat).* All of us felt the contrast in temperature and humidity between woodland or wetland and open country. Even in flaming June, woods and wetlands hardly reach 20 ^{o}C but bare ground might top 45 ^{o}C. Relative humidity will be greater than 60 per cent in the woods and meadows, but might be less than 20 per cent over bare soil, *e.g.* [3]. The difference is the latent heat of the water evaporated from vegetation.

The sensible heat is emitted as infra-red radiation but, rather than escaping back into space, some is intercepted by greenhouse gases in the atmosphere and re-emitted in all directions. Some does escape but the rest heats up the atmosphere or is reabsorbed by the land or (mainly) the oceans. The evaporated water goes on new adventures illustrated by a story from Australia [15].

The Bunny Fence experiment. In 1859, thirteen wild European rabbits were released into SE Australia for sport shooting. They multiplied and, within 50 years, brought wreck and ruin across the continent. In defence, Western Australia built the longest fence in the world: between 1901 and 1907, more than 2000 miles of rabbit-proof fence was installed in the south-west of the state where native vegetation was cleared for agriculture – mainly wheat, sown in winter and harvested in spring or summer. Eventually, an area of the size of England was cropped whereas land to the east of the fence remained as *mallee* scrub.

During our lifetimes, winter rainfall over the wheat belt has dropped 20 per cent but not, until recently, on the other side of the fence; clouds formed over the mallee commonly disappear as they cross the fence. Tom Lyons at Flinders University suggested this might be accounted for by differences in the surface energy balance between farmland and the native vegetation [13]. To check it out, in December 2005 and August 2007, the international Bunny Fence Experiment released radiosonde balloons measuring altitude, pressure, wind speed and direction, temperature, solid particles and water-vapour droplet size; specially equipped aircraft flew at 10 and 20 m above the canopy measuring energy flux and ultrafine aerosols; soil sensors were stuck in the ground; NASA satellite images were studied; and mainframe computers crunched the data.

They established that changes in the land use have changed the behaviour of regional weather systems that bring winter rain [16]. There was curiously little interest; everyone went home again; and government-funded work ceased.

The small water cycle. Some years previously, Roger Pielke, one of the Bunny Fence team, argued that there is a lot more to climate change than greenhouse gas emissions. He drew attention to the dramatic changes in the global landscape made by the expansion of agriculture, which changes albedo, surface roughness, leaf area index, infiltration and rooting depth; it severs the link between soil and groundwater and evapotranspiration; and aerosols generated by fires and soil erosion influence events far beyond the immediate region [18]. Pielke was branded a climate-change denier.

But the counterpoint of the demonstrable increase of rainfall across the High Plains of North America thanks to extensive irrigation [2] is surely the reduction of rainfall where evapotranspiration has been arrested by cutting, burning and grazing out of forests and loss of soil and vegetation.

We are all familiar with the water cycle where water evaporated from the ocean is drawn over land by the hotter land mass that causes the air to rise. The moist air cools as it is drawn over the hills, creating clouds, and rain that that runs off, back to the ocean. There is another ***small water cycle,*** by which water evaporated from terrestrial vegetation leapfrogs inland to fall again as rain that supports, *e.g.*, the rain forests of the Amazon and Congo and farmland across the steppes and, at the same time, moderates global heating.

The cause-and-effect of land use change on climate undermines the claim of the global South that it is suffering from climate change for which it is not responsible. The global South has directly caused its own heating, cut off its own rainfall and dried up its own rivers by interrupting the small water cycle, and it still is:

Figure 1 can be read in reverse as the global distribution of bare ground – the main source of global heating: NDVI values less than 2 indicate, essentially, bare ground; greater than 8, effectively, complete vegetation cover.

Figure 2 shows the continued loss of green vegetation since 1981 – by which time the Middle East and North Africa had long since destroyed their soil and vegetation and irreparably changed their climate.

Closer to home, Figure 3 depicts the loss of green vegetation across the steppes, where annual mean temperatures are now some 2^{o} C higher than the long-term norm and autumn and spring rainfall has been inadequate for crop establishment in three of the last four years.

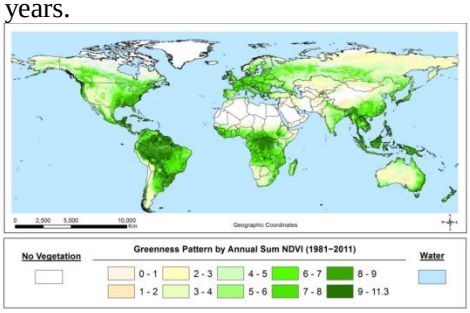

Fig. 1. Global greenness pattern by annual sum NDVI (1881–2011)

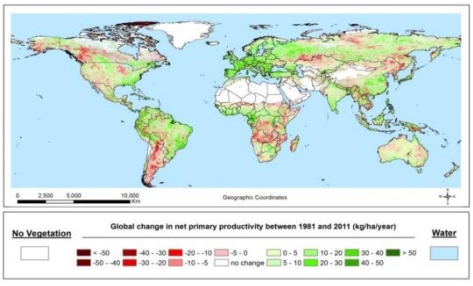

Fig. 2. Global change in net primary productivity between 1881 and 2011

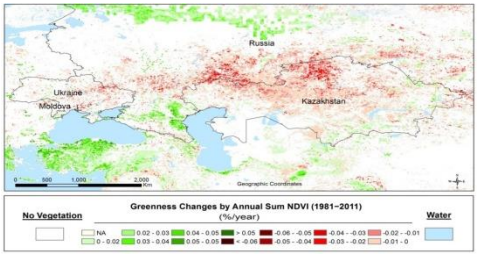

Fig. 3. Changes in RUE-adjuster sum NDVI (1881–2011) cross the Steppes from Moldova to Kazakhstan

Conclusions.

The latest IPCC report, Climate change and land [4] acknowledge the role that landscape plays in climate. But its focus remains on greenhouse gases; and it advances no alternative to cutting emissions to deal with heating and unpredictable rainfall. So, we shall have to do it ourselves. According to James Lovelock [12] and Volodymir Vernadsky [1], the Earth behaves as though it is trying to maintain the most favourable environment for all life. Thus, that the most sustainable land use is to mimic the natural vegetation [11], which means:

1. ***Ban bare soil***. Don't fallow. After harvesting, it is reasonable to plant a cover crop or, at least, to keep the soil covered by a mulch of crop residues. This protects the soil against the elements. Instead of heating the soil, solar energy is partly reflected by the ground cover but, mostly, used to evaporate water from the growing leaves; some 80 per cent is converted to latent heat, only 20 per cent to sensible heat. And protecting the soil surface supports soil structure so that all the rain and snowmelt infiltrates, to be taken up by plant roots, maintain evapotranspiration, and form clouds that deliver more rain further inland.

2. ***Stop ploughing***. Apart from creating bare soil with a monstrous waste of time and energy, ploughing accelerates decomposition of the soil organic matter. Soil organic matter holds more carbon than the atmosphere and all standing vegetation put together; and it is the fuel of life in the soil. It is almost impossible to maintain, let alone build up soil organic matter under the plough: forsaking the plough increases soil fertility, soil structure, infiltration, available water capacity, crop yields, groundwater recharge, and the small water cycle. And a net loss of soil organic matter is transformed to a net gain which draws down the CO_2 concentration in the atmosphere.

3. ***Adopt a diverse cropping system***. The purpose of ploughing is to control weeds. The same can be achieved without resort to poisonous chemicals by a diverse crop rotation. Better still, grow perennial crops. The recent advances in crop breeding have brought the yields of perennial cereals like Kernza® and oilseed crops like *Silphium integrifolium* within touching distance of conventional annual varieties: the future is perennial [6]. Integrating crops and livestock or, alternatively converting the green mass to biogas [7] makes good use of all the biomass we can grow and provides invaluable organic manure.

Create a rough, varied landscape. It is recommended to plant windbreaks against a drying climate and restore wetlands. Allocation of 4 per cent of the land area to windbreaks brings a benefit: cost dividend of 10 per cent through lower air temperature, greater humidity, cutting wind speed, retaining snow and runoff, arresting erosion by wind, and increasing biodiversity. Beyond this, the increased surface roughness and evapotranspiration promote the small water cycle and a more pleasant, habitable landscape.

All these measures are within our purview. The brave new world of post-war revival, recovery and reconstruction will be an opportunity to adopt them without delay. We must be prepared.

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