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Patterned Vegetation Created by Red Harvester Ants and Evidenced in Satellite Images

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Abstract

Large-scale areas of patterned vegetation, with distinctive and repetitive patterns, can arise because of natural phenomena that differentially influence plant growth or mortality and by biotic interactions of animals and plants. Such patterns can be easily observed in satellite images, if they have a high enough resolution for the specific observation. Here we will show that a large area of a patterned vegetation with a “polka-dot” arrangement can be observed in the Toroweap Valley of Arizona, near the Grand Canyon. In this case, the vegetation has been patterned by the presence of the nests of red harvester ants. The observation is remarkable for the large surface occupied by such colonies.

Keywords: Pattern Formation, Patterned Vegetation, Ecosystems, Satellite Images.

Subject Areas: Environmental Sciences, Ecosystem Science, Ecology.

1. Introduction

Characteristic arrangements of forms and structures are often found in the natural world. Sometimes these arrangements are producing regular patterns that are recurring in different contexts, as shown by pattern formations observed in Biology, Physics, Astrophysics and Chemistry, and those that can be studied and simulated by Mathematics and Computer graphics [1-5]. Therefore, the origin of pattern formations is the subject of several scientific researches, having an interdisciplinary nature, which aim at giving the theoretical models of the self-organization of natural phenomena, observed from microscopic to macroscopic scales. In the last case, it means that we are studying the pattern formation in a natural environment, which is visible on a so large scale that the best device to investigate it is the satellite imagery. Among these phenomena, we find those of the patterned vegetation.

Large-scale areas of patterned vegetation, with distinctive and repetitive patterns, can arise because of natural phenomena that differentially influence plant growth or mortality and by the biotic interaction of animals and plants. Vegetation patterns are for instance the “tiger bush”, an example of which is given in the Figure 1A, and the “fir waves” [6,7]. Tiger bush consists of stripes of bushes which appears on the slopes of arid lands, where the vegetation growth is limited by rainfall; each stripe of vegetation absorbs water from the bare zone immediately above it [6,8]. Fir waves occur in forests on mountain slopes after wind disturbance, during regeneration processes [8].

Besides the patterns of vegetation produced by environmental condition, such as the tiger bush, we have that large-scale regular spatial patterns can arise within homogeneous landscapes from local biotic interactions [9-12], where the organization of living beings naturally scales up to produce quasi-regular patterns across large landscapes. Due to the recent availability of satellite imagery of high resolution, such patterns have been increasingly reported in the ecological literature [9]. For instance, it is possible to observe, in semi-arid East Africa, the mounds built by *Odontotermes* termites frequently occurring in uniform “polka-dot” arrangements [9]. Another case investigated by means of the satellite images of Google Earth is that of the “fairy circles” of Namibia (see Figure 2B) [13-15]. According to Ref.15, the sand termite *Psammotermes* *Allocerus* generates local

ecosystems which create rings of perennial vegetation that facilitate termite survival. Recently it had been reported that the “fairy circles pattern” exists in the remote outback of Australia [16] (see Figure 2). Using field-work, remote sensing, and spatial pattern and mathematical modeling, the researchers proposed a pattern-formation theory for the Australian environment.

Here, we will consider the case of another biotic interaction of animals and plants, the patterned vegetation created by ants. Such patterns can be easily observed in satellite images, if they have a high enough resolution for the specific observation. Here we show that some large areas of patterned vegetation with a “polka-dot” arrangement can be observed in the Toroweap Valley of Arizona, in the National Park of Grand Canyon [17]. In this case, the vegetation is patterned by the presence of the nests of red harvester ants. The patterned vegetation is visible in the Google Earth images of an area 10 km long in the valley of Arizona, near the Vulcan’s Throne of Grand Canyon.

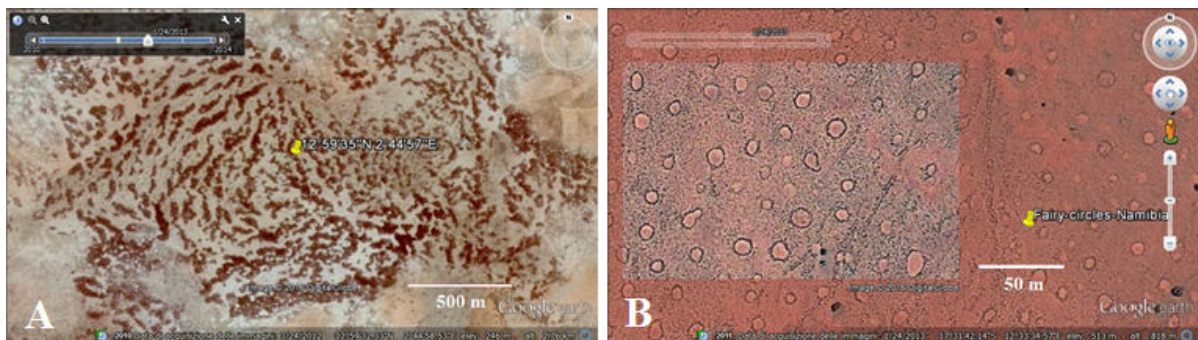


Figure 1. On the left (A), an example of “tiger bush” in Niger (Courtesy Google Earth). It consists of stripes of bushes which appear on the slopes of arid lands, where the vegetation growth is limited by rainfall; each stripe of vegetation absorbs water from the bare zone immediately above it [6,8]. On the right (B), fairy circles in Namibia (Courtesy Google Earth). Sand termites generate local ecosystems through removal of short-lived vegetation that appears after rain, leaving circular barren patches [15]. Since water is retained within the circles, rings of perennial vegetation are created that facilitate termite survival. “This termite-generated ecosystem persists through prolonged droughts lasting many decades” [15].

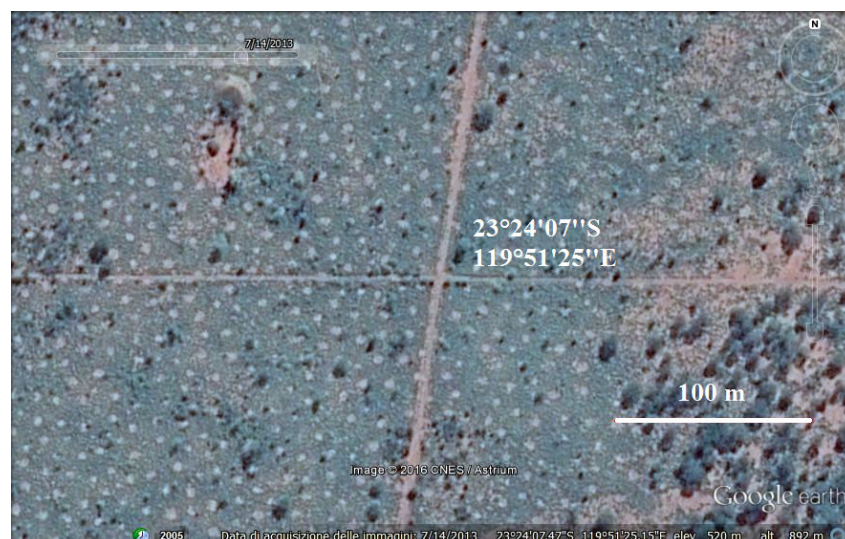


Figure 2. Vegetation pattern as seen in Google Earth satellite image of 14 July 2013, of a location in Australia. This is an example of “fairy circles” pattern outside Namibia given in [16].

2. Vegetation and Ants

As shown by the example of the “fairy circles”, from satellites, it is possible to investigate some aspects of the life of insects, in particular of the colonies that insects can create, such as those of ants and their nests. For in-

stance, the red harvester ants create nests that, with their surrounding area can reach a dimension which is possible to be observed in satellite images having a high enough resolution. These nests are not isolated; each one can be surrounded by several other nests, giving rise to a patterned local vegetation, which is visible from above, much better than from the ground.

The use of satellites for monitoring ant colonies was proposed in [18], for supporting natural resource managers that were interested in locating red harvester ant mounds. These are ants that can have a negative impact on human activities due to heavy infestations on pastures. However, they are also important for the survival of other animals, such as lizards [18]. In their study on the red harvester ants, the researchers evaluated the QuickBird imagery as a tool for detecting the ant mounds. The research gave the result that natural resource managers can use this imagery to determine the severity of infestations.

As previously told, uniform “polka-dot” arrangements of the mounds termites are frequently occurring [19]. These arrangements can be observed in satellite images also for the nests of red harvester ants. The nests are visible for the following reasons. They are characterized by a lack of plant growth and small pebbles surrounding the entrance of them. Hulls of seeds may be found scattered around the nest. Therefore, in grassland areas, the lack of vegetation makes the red harvester ant colonies very easy to notice. The mound corresponding to the nest are typically flat and broad, 0.3 to 1.2 m in diameter [19]. Even larger bare areas, on the order of 10 m², are created. Trails typically lead away from the mound, like “arms”. These trails are used by ants to collect and bring food back to the mound. In [20], the nest and the related bare areas are defined as “nest discs”. Alexander Wild, in his web article [20], is showing some examples of how they appear in images. One image from Google Earth is concerning an area South of Tucson, Arizona (31°38.097' N, 111°03.797' W). The area is showing a pattern of evenly-spaced “polka-dots” [20]: the dots are the “nest discs of one of our most conspicuous insects in the Sonoran desert, the red harvester ant *Pogonomyrmex Barbatus*”. On the ground, it is hard to recognize the even spacing of the nests, but they are plenty obvious. “The ants keep the large area around their nest entrance free of vegetation and other unwanted debris” [20].

Reference 20 is fundamental to understand the patterned vegetation that we can find in another area of Arizona. It is a valley, the Toroweap Valley, near the Vulcan's Throne, a cinder cone volcano and a prominent landmark on the North Rim of the Grand Canyon. This area is not reported in [20], probably because in 2008 the satellite images had a low resolution. Today, using Google Earth for the areas marked in the map shown in the Figure 3, we can see a large landscape covered by discs, that look like those shown in Ref.20. For this reason, in a previous discussion proposed in [21] on this patterned vegetation, we proposed these discs as nest discs of ant colonies. The number of these discs, disseminated in the valley 10 km long, is impressive.

In the Figure 3, the markers are showing a large area, near the Grand Canyon rim, where, using Google Earth, we can see a patterned vegetation like that given in the Figure 4. The patterned vegetation has a “polka-dot” arrangement of discs (the pattern is given in images with smaller scales). The irregularity of the polka-dot pattern excludes an unnatural origin.



Figure 3. The markers show a large area, 10 km long, in the Toroweap Valley of the Grand Canyon, where it is possible to observe a patterned vegetation, like that given in the following Figure 3.

3. Local investigation

In a previous discussion, proposed in [21], we compared the discs in the Figure 4, with a red harvester ant nest sketched in Ref.22. Comparison told that they are probably nests of these ants. However, since the dryland ecosystems can exhibit patterns of vegetation created by the competition among individual plants [23], in [21] it was stressed the importance of a local investigation. In fact, after publications [21,24], Robert Nagell, Doctor of Veterinary Medicine, [25], visited the area of Toroweap Valley of Arizona, confirming that spots are ant mounds. In his courtesy pictures, here adapted in Figure 5, it is visible the cone of the nest and the surrounding area cleared of vegetation. Then, the area of “polka-dot” vegetation of Toroweap Valley represents a remarkable large surface occupied by such colonies of ants.



Figure 4. On the left, the patterned vegetation having a “polka-dot” arrangement (Courtesy Google Earth, coordinates: 36°15'19.18" N, 113° 04' 55.38" W). On the right, the “dots” are shown in detail (Courtesy Google Earth, coordinates: 36°14'55.07" N, 113°05'05.22" W). The sites are in the Toroweap Valley of the Grand Canyon.



Figure 5. After visiting the Toroweap Valley of Arizona, Robert Nagell, Doctor of Veterinary Medicine, confirmed that spots are ant mounds. In his courtesy pictures, it is visible the cone of the nest and the surrounding area cleared of vegetation.

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