MOLESTO: Edebiyat Araştırmaları Dergisi

THE TRACES OF GAIA IN THE GAVILAN: RECONSIDERATIONS FOR A PLANETARY LAND ETHIC IN THE ENCOUNTER OF AN ECOCRITIC AND AN ENVIRONMENTAL SCIENTIST
GAVILAN'DA GAIA'NIN İZLERİ: ÇEVRECİ ELEŞTİRMEN İLE ÇEVRE BİLİMCİNİN BAKIŞINDAN KÜRESEL TOPRAK ETİĞİ

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Makale Bilgisi

Gönderildiği tarih:
04.01.2020

Kabul edildiği tarih:
29.01.2020

Yayınlandığı tarih:
05.02.2020

Öz

Araştırma çevrelerinde disiplinlerarası iş birliği yeni açılımlar göstermektedir. Bu makalede bir çevreci eleştirmen ile bir çevre bilimci, Sierra Madre Occidental'da Gavilan bölgesine odaklanarak Aldo Leopold'un bütüncü "toprak organizması" düşüncesini yeniden inceleyecektir. Aldo Leopold, hayatta olduğu yıllarda yayımlayamadığı "Some Fundamentals of Conservation in the Southwest" (1923), başlıklı yazısında, dünyanın canlı bir organizma olduğuna dair "Gaia Hipotezi'ni kabaca tasarlayıp ortaya atmıştı" (Callicott 2017). Leopold'un 1930'lu yılların sonlarına doğru, Meksika'nın Sierra Madre Occidental bölgesinde Rio Gavilan havzasında yaptığı keşifler onun dünyanın canlı bir organizma ("metabolizma" ve "koordineli çalışan organları") olduğuna dair düşüncesine bir açıklama getirebilir. Leopold'un Gavilan'da izlediği sağlıklı ekosistem, onun daha sonraki yıllarda toprak sağlığı üzerine kıyaslamalı araştırmalarını etkilemiştir; bu yabanıl bölgenin bir "toprak laboratuvarı," bir başka deyişle, toprakların sağlığının tayin edileceği bir kontrol bölgesi olmasını önermiştir. Leopold, böylelikle, geleceğin bilim insanlarına "uluslararası bir araştırma girişiminde" ekip halinde çalışacakları bir görev vermiştir. Gelecekteki araştırmalar, Leopold'un deyimiyle "hala kusursuz aborijin sağlıkta bir biyota" mekanizmasını, dahası bu mekanizmanın "kendini yenileme kapasitesini" ("toprak sağlığı") ortaya çıkaracaktır. Sierra Madre Occidental'ın dünyanın belli başlı çöllerinden atmosferik toz taşınımlarıyla Atlantik ve Pasifik okyanusları üzerinden beslenen özel bir bölge olması nedeniyle Leopold'un önerdiği "araştırma girişimi" Gaia bilimi açısından anlamlı olacaktır. Bu makale Sierra Madre Occidental'a toz taşınımlarını, toprakların sağlığının birbiriyle etkileşim halindeki ekosistemler yoluyla sağlandığına işaret eden, Gaia'nın öz düzenlemesine dair bir örnek durum olarak ele alacaktır. Yazarlar, toz taşınımları ile ıslak çökelmenin bölgedeki toprakların sağlığının temeli olduğunu önerecektir. Söz konusu sağlıklı ekosistemde gerçekleştirilecek araştırmalar, Leopold'un tasarladığı "toprak sağlığı bilimine" esin kaynağı olabilecektir.

Article Info

Date submitted:
04.01.2020

Date accepted:
29.01.2020

Date published:
05.01.2020

Abstract

Cross-disciplinary collaboration has gained new ground in research environments. In this article, an ecocritic and an environmental scientist will focus on the Gavilan, in Sierra Madre Occidental, to reconsider Leopold's holistic "land organism." Aldo Leopold, in an essay he left unpublished in his lifetime ("Some Fundamentals of Conservation in the Southwest" 1923), had "sketched, ever so sparingly, the Gaia Hypothesis" (Callicott 2017), a living Earth. Leopold's explorations, in the late 1930s, in Mexico's Sierra Madre Occidental, in the Rio Gavilan watershed, may illuminate his idea of a living Earth, a "metabolism" and its "organs with coordinated functions." The healthy ecosystem of the Gavilan impacted Leopold's comparative research on land health in the subsequent years of his life; he proposed this wilderness area to be a "land laboratory," a control region to assess the health of the lands—a task he gave to the future scientists by teaming up in an "international research enterprise." The future research would reveal the mechanism of, in Leopold's terms, "a biota still in perfect aboriginal health," as well as its "capacity for self-renewal" ("land health"). As the Sierra Madre Occidental is unique in terms of atmospheric dust transfers from the major deserts of the world, feeding the lands from across the Atlantic and Pacific Oceans, Leopold's proposal for a "research enterprise" will be meaningful in terms of Gaian science. The article will take up dust transfers to Sierra Madre Occidental as an exemplary case for a self-regulating Gaia in that the health of the land is maintained through interacting ecosystems. The authors will propose dust transfers and its wet deposition over the receiving bodies as the basis of land health. Research on this healthy ecosystem may finally inspire "the science of land health" that Leopold envisioned.

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Figure 1. Aldo Leopold surveys the landscape of the Rio Gavilan, Chihuahua Province, Mexico during a hunting trip, 1937. Photo by A. Starker Leopold. Courtesy of the Aldo Leopold Foundation.

> *Land ecology is putting the sciences and arts together for the purpose of understanding our environment.*
>
> --Leopold, "The Role of Wildlife in a Liberal Education" 303

> *I do not imply that this philosophy of land was always clear to me. It is rather the end result of a life journey.*
>
> --Leopold, 1947 Foreword to *A Sand County Almanac* 282

The cross-disciplinary collaboration of humanities and sciences gains new ground in the age of climate crisis. One possible indicator is the convergence of humanists and scientists in the Gaia hypothesis.[3] The scientist is moving away from prejudice and is reaching new findings for a living Earth through empirical enquiry. The humanist is re-cultivating respect for the living Earth through moral reasoning, in line with the intuitive direction of science. The Gaian language is one that appeals to both. Leopold, many years ago, to initiate genuine engagement in interdisciplinary dialogue, had stated, "All the sciences and arts are taught as if they were separate. They are separate only in the classroom. Step out on the campus and they are immediately fused" ("The Role of Wildlife" 302-303). Leopold, particularly in "Song of the Gavilan,"[4] one of the Chihuahua and Sonora essays in *A Sand County Almanac,* connected humanistic and scientific outlook and heard

[3] See Lovelock's definition of Gaia in *Gaia: A New Look at Life on Earth* (1979). Lovelock stated, "The entire range of living matter on Earth from whales to viruses and from oaks to algae could be regarded as constituting a single living entity capable of maintaining the Earth's atmosphere to suit its overall needs and endowed with faculties and powers far beyond those of its constituent parts" (p. 10).

[4] Leopold's "Song of the Gavilan," was first published in *Journal of Wildlife Management* 4.3 (1940): 343–346.

both the "song" of the Gavilan, and observed its outstanding biodiversity indicative of its health. In this article, an ecocritic and an environmental scientist will focus on the Gavilan to reconsider Leopold's holistic "land organism," and its self-renewal, in support of the Gaian thinking, a living Earth.[5] In the face of the unprecedented changes in the Earth's climate system, the conception of a self-regulating Gaia, named after the Greek Goddess of Earth, guarding its own health, may give rise to a planetary land ethic, something "not impossible to regard," to use Leopold's terms.

In "Song of the Gavilan," Leopold stated, "Science contributes moral as well as material blessings to the world," and made a plea for the scientist's "objectivity" (153). Significantly, the essay that emerged from Leopold's trips to the Northern Sierra Madre, in the 1930s, is about the Rio Gavilan watershed, a "land of milk and honey," and reveals how the region's healthy lands contributed to the maturing of his wilderness philosophy. Leopold describes the "song" of the Gavilan as "a vast pulsing harmony—its score inscribed on a thousand hills, its notes the lives and deaths of plants and animals, its rhythms spanning the seconds and the centuries" (149). This is the picture of a land that is alive and well. And yet, Leopold also states, "let the chips fall where they may" (154) in the sense of allowing natural phenomena to happen without trying to change them.[6] After his visits, Leopold proposed this wilderness area to be a "land laboratory," a control region to assess the health of the lands—a task he gave to the future scientists by teaming up in an "international research enterprise."[7] The future research would reveal the mechanism of, in Leopold's terms, "a biota still in perfect aboriginal health,"[8] as well as its "capacity for self-renewal" ("land health").[9] This brings to mind the Gaian perspective that the planet has self-regulated since times immemorial. As this vast area is unique in terms of atmospheric dust transfers[10] from the major deserts of the world, feeding the lands from across the Atlantic, Indian and Pacific Oceans, Leopold's proposal of a research enterprise will be meaningful in terms of Gaian science. This may provide scientific evidence for a more inclusive land organism, a "metabolism" whose organs have "coordinated functions,"[11] in Leopold's terms, illustrating the interdependencies of distant

[5] See Callicott's "Toward an Earth Ethic: Aldo Leopold's Anticipation of the Gaia Hypothesis," pp. 17-29. Also see Callicott, *Thinking Like a Planet,* for the foundations of a Leopoldian "earth ethic" which, Callicott argues, springs from his seminal "land ethic" thought.
[6] Leopold is cautious about science serving progress in that "many of the more intricate instruments are stepped upon and broken in the rush to spread progress to all backward lands" (p. 153).
[7] See Leopold, "Conservationist in Mexico (1937)," p. 400.
[8] Leopold's words are from his "1947 Foreword" in *Companion to A Sand County Almanac,* 286.
[9] Leopold, in his essay "Land Health Concept and Conservation" explains "capacity for self-renewal" as "land-health" (p. 219). He further states that "healthy land" is needed "to define health" (p. 220).
Leopold, in his "Wilderness" essay in *A Sand County Almanac*, states, "The most important characteristic of an organism is that capacity for internal self-renewal known as health" (p. 194).
[10] By dust transfer, we mean clay fraction but not the sand fraction of the desert landscape.
[11] See Leopold's use of these words in "Some Fundamentals of Conservation," p. 95.

ecosystems in promoting the flow of nutrients. The enterprise may, among other research, redefine the role of the planetary clouds, the "white fleets," as Leopold put it 70 years ago.[12] The article will take up dust transfers to Sierra Madre Occidental as a case study for a self-regulating Gaia—that the health of the land is maintained through interacting ecosystems.[13] Once the clouds are endowed with life, full of systemic purpose, the planet will lay bare some of its secrets—that it has self-regulated over millions of years. Now, at the threshold of climate crisis, there is hope for "love and respect" for the planet that may also be the foundation for a planetary land ethic.[14]

LEOPOLD AND THE LAND ORGANISM

> The land ethic … cannot be scaled up to meet the challenge of global climate change. Fortunately, given the prominent place of Leopold in all circles environmental, he also faintly sketched an Earth Ethic in a paper written in 1923, which was published posthumously in 1979. The Earth Ethic is informed less by ecology and evolutionary biology than by biogeochemistry and anticipates the Gaia Hypothesis, viz., that the Earth (or biosphere) is, as a whole, a living being.
>
> --Baird Callicott, "Toward an Earth Ethic" 17

The massive Gaia work of the founder of the Gaia hypothesis, James Lovelock, over the decades, is getting increased attention, and is taken up extensively in the recent Lovelock Centenary.[15] Gaian thinking is breaking new ground for the understanding of the land organism, and is also becoming a hope for the climate crises. Callicott, in his "Toward an Earth Ethic: Aldo Leopold's Anticipation of the Gaia Hypothesis" (2010), states that Leopold had "faintly scetched" the Gaia hypothesis in an essay he wrote in 1923, long before atmospheric scientist James Lovelock published his *Gaia: A New Look at Life on Earth* (1979). Callicott's reference is to Leopold's "Some Fundamentals of Conservation in the Southwest" (1923) that was published in a journal, coincidentally, the year James Lovelock published his *Gaia: A New Look at Life on Earth* (20-21).[16] Callicott, with his *Thinking like a Planet* laid the foundations of an earth ethic using "Leopold's attribution of a metabolism to the earth as a whole" (Callicott 23), aiming to say that the land ethic

[12] Leopold, in his "The Green Pasture" in *A Sand County Almanac,* refers to the cloud-mass as "white fleets." Leopold couples the clouds in the skies with the fast growth of fungi on the sand bars in one night that attracts wildlife.
[13] In the case of the Sierra Madre Occidental, desert dust is transported from the Gobi and Taklamakan deserts in Asia, and from the Sahara desert in Africa. Nutrient rich Gobi, Taklamakan, and Sahara dust travels thousands of miles across the Pacific and Atlantic Oceans, and reaches northern Mexico to fertilize and feed the lands. Hence regions like the Sierra Madre still enjoys the pristine land cover as observed by Aldo Leopold.
[14] For the "value of Gaian thinking," Crist and Eileen observed that "scientific ideas, ethical realizations, and environmental implications intersect" (p. 11).
[15] See Lovelock Centenary at https://www.lovelockcentenary.info/gaia-hypothesis/
[16] Lovelock published *Gaia: A New Look at Life on Earth* in 1979. 40 years after its publication, mainstream science is reconsidering the validity of Gaia hypothesis, that the Earth is a whole, a biological organism, a living being, and that "the global ecosystem sustains and regulates itself like a biological organism."

concept cannot be a local ethic, but an ethic that covers the entire land organism. Now, at the threshold of man-made global warming, Aldo Leopold's idea of a land ethic, seeing humans as part of the web of life, is compatible with Lovelock's living Earth. In Leopold's seminal essay, "The Land Ethic,"[17] the functioning of the ecosystems depends on "the cooperation and competition of its diverse parts" (Leopold coined the term, the "land pyramid"[18] to point at the cooperations and competitions). Lovelock maintains that the Earth is a biological organism, that animals, plants and microbes "compete" and "cooperate" to maintain their material environment. Leopold's related observation, that the land regulates itself like a biological organism, may have its roots in his visits to the Rio Gavilan watershed, "a biota" that was still "in perfect aboriginal health,"[19] a biota that was perhaps self-regulating over millions of years. The healthy ecosystem of the Gavilan impacted Leopold's comparative research on land health in the subsequent years of his life. Today, this fairly intact ecosystem can be utilized as a "land laboratory," as Leopold proposed, for understanding the mechanisms of a planetary self-regulation.

In this context, two essays written by Leopold, across a span of almost two decades, gain significance. The first essay, "Some Fundamentals of Conservation in the Southwest" (1923), is noteworthy as regards Leopold's references to a contemporary of his times, the Russian mathematician Peter Ouspensky (1878-1947). Ouspensky's impact on Leopold surfaces in his ideas on the indivisibility of the land, and the deep interconnectedness of all its integrated parts. In this essay, Leopold stated that "The outstanding scientific discovery of the twentieth century … is the complexity of the land organism." Like Ouspensky did, he saw parallels between the unity of the human body and the unity of the earth "with enormously slow, intricate, and interrelated functions among its parts." Following Ouspensky's ideas, Leopold stated that it was "not impossible to regard"

> the earth's parts—soil, mountains, rivers, atmosphere, etc.—as organs, or parts of organs, of a coordinated whole, each part with a definite function. And, if we could see this whole, as a whole, through a great period of time, we might perceive not only organs with coordinated functions, but possibly also that process of consumption and replacement which in biology we call the metabolism, or growth. In such a case we would have all the

[17] Carl Leopold states: "Aldo Leopold was a young man when he first stated his ethical idea. It appeared in 1933 in a publication entitled "The Conservation Ethic." Over the subsequent 15 years he reworked and strengthened this statement before its final publication as "The Land Ethic" in his book, A Sand County Almanac." ("The Land Ethic of Aldo Leopold," p. 194).

[18] In "The Land Ethic," Leopold stated, "The pyramid is a tangle of chains so complex as to seem disorderly, yet the stability of the system proves it to be a highly organized structure. Its functioning depends on the cooperation and competition of its diverse parts."

[19] Leopold's words are from his "1947 Foreword" to *A Sand County Almanac,* published in *Companion to A Sand County Almanac,* edited by Callicott (p. 286).

> visible attributes of a living thing, which we do not now realize to be such because it is too big, and its life processes too slow. ("Some Fundamentals of Conservation" 95)

Thus, the Leopoldian concept of a "land organism" model, with "land organism" being an earth-organism that is large enough to include the "atmosphere" (the last range for scientific exploration), appears as early as the 1920's. Callicott has observed that "this is indeed an early—and maybe the very first—instance of Gaian thinking … suggested by Leopold's attribution of a metabolism to the Earth as a whole" ("From the Land Ethic to the Earth Ethic" 187). Significantly, in this essay, Leopold states that "there appears to be a natural law which governs the resistance of nature to human abuse" ("Some Fundamentals of Conservation" 91). This is the current picture of the Earth as a living body that James Lovelock has popularized in his myriad books, with inter-ecosystemic processes that resist human abuse. Significantly, in "The Land Ethic" essay, Leopold advocates "limitation on the freedom of action," as a way to protect the land organism's capacity for self-healing.

The second essay, "Wilderness as a Land Laboratory" (1941), is significant as regards Leopold's ongoing thinking on his concept of the "land organism" resulting from his explorations in the northern Sierra Madre. In this essay, Leopold pointed out that "the most important characteristic of an organism is that capacity for internal self-renewal known as health," (287); Leopold also said that "the trend of the evidence indicates that in land, just as in the human body, the symptom may lie in one organ and the cause in another. … the science of land-health is a job for the future" (288), wanting the future scientists to carry out long-term research in this area.[20] Almost two decades after the publication of "Some Fundamentals of Conservation," Leopold pointed at the wilderness "on the summit of the Sierra Madre in Chihuahua" and stated, "Its preservation and study, as a norm for the sick lands on both sides of the border, would be a good neighborly act well worthy of international consideration" (289).[21] In the words of Forbes, Leopold wanted the area to be "a control site to research healthy land throughout North America" (i). For Leopold, hope was in ecosystem-scale research, apparently in the long-term records of precipitation, water chemistry, acidification, emissions, concentrations, etc., and the resultant species compositions occurring in the biota. Thus, Leopold's thoughts on the expansive "land organism" may now be clarified, through the study of high degree of plant and animal endemism via atmospheric transfers of desert dust, of the resultant hotspots and corridors that house

[20] In the "Round River" piece, Leopold says "Ecology is an infant just learning to talk. … Its working days lie in the future" (p. 159). He also says that "Science cannot explain the mechanisms of stability…" (p. 162).
[21] Özdağ, in her *Edebiyat ve Toprak Etiği: Amerikan Doğa Yazınında Leopold'cu Düşünce* (Literature and the Land Ethic: Leopoldian Thought in American Nature Writing) (2005), connected Leopold's thoughts on a living Earth in "Some Fundamentals of Conservation in the Southwest" to land health in the Rio Gavilan watershed, p. 28.

exceptional species endemism and diversity in the world. But first, let us take a short look at his wilderness thought that gave rise to his idea of a "land organism."

WILDERNESS: A SELF-WILLED ECOSYSTEM

> Paleontology offers abundant evidence that wilderness maintained itself for immensely long-periods; that its component species were rarely lost, neither did they get out of hand; that weather and water built soil as fast or faster than it was carried away. Wilderness, then, assumes unexpected importance as a laboratory for the study of land-health.
>
> Leopold, **"Wilderness**," 196.

Leopold's unique wilderness philosophy has been dealt with extensively.[22] The wilderness areas that Leopold visited, during his lifetime, played an important role in the formation and evolution of his wilderness philosophy. He had designed the first Wilderness Area in the Gila National Forest, as early as 1924, and his ideas on wilderness evolved as he witnessed extreme forms of land sickness (Dust Bowl regions) and extreme forms of land health (Rio Gavilan watershed). "It is last call," Leopold made a plea, in his "Wilderness" essay that he published in *A Sand County Almanac.*

Roderick Nash, as early as 1976, realized Leopold's connection of wilderness with future resilience. In his essay, "The Value of Wilderness," Nash prioritized Leopold's idea of "wilderness" in a list of eight arguments. In "Argument 1: Wilderness as a Reservoir of Normal Ecological Processes," Nash underlined the significance of wilderness as "a model for healthy, ecologically balanced land":

> Aldo Leopold, wildlife manager and philosopher whose efforts led in 1924 to creation of the first reserved wilderness on National Forest land in the United States, once said that wilderness reveals "what the land was, what it is, and what it ought to be." He added that nature reserves conceivably had more importance for science than they did for recreation. What Leopold meant was that wilderness is a model of healthy, ecologically balanced land. (21)

Nash went on explaining that at a time when so much of the environment is disturbed by technological man, "wilderness has vital importance as a criterion against which to measure the impact of civilization. Without it we have no way of knowing how the land mechanism functions under normal conditions." For Nash, "the science of ecology needs nature reserves as medical science needs healthy people" (Nash: 1976, 21).

But what is Leopoldian wilderness in relation to his idea of a "land organism," the

[22] For an extensive discussion of "wilderness" in Leopold, see Meine, *Corrections Lines,* pp. 89-116. Also see Williams, "Wilderness: A Place of Humility," pp. 99-103.

"indivisibility of the earth," as he stated in "Some Fundamentals of Conservation in the Southwest"? Especially after his visits to the Sierra Madre Occidental, in the 1930s, Leopold's vantage point for his descriptions of "land sickness" was the human body. In other words, he started comparing "land health" and "land sickness" with the terminology of a healthy human body ("aboriginal health"), and of human ailments: "symptoms of sickness in the land organism" (194); "in land, just as in the human body, the symptoms may lie in one organ and the cause in another" (195). In his "Wilderness" essay, Leopold stated that "internal self-renewal known as health" is characteristic of both "man" and "land," as organisms. Comparing the earth organism and the human organism, Leopold stated that "the science of land health is yet to be born":

> The practices we now call conservation are, to a large extent, local alleviations of biotic pain. They are necessary, but they must not be confused with cures. The art of land doctoring is being practiced with vigor, but the science of land health is yet to be born. ("Wilderness" 195-196)

As Leopold observed, land health research was ineffective as scientists had not, yet, taken up the study of "a wild area for comparison with sick ones" (197). What was really missing, for Leopold, was the study of "cause" rather than "symptoms" by "international research enterprise" by which he implied ecosystems scale research. Hence Leopold projected "land health" as a study of the future, and with "wilderness-minded men." The "Wilderness" essay in *A Sand County Almanac*,[23] then, hints at some of the most advanced ideas on the "land organism" as regards a symbiotic, self-regulating system of interdependencies. Leopold proposed comparative research for "land health," and pointed at lands where "land physiology remains largely normal despite centuries of human occupation" (northeastern Europe), as well as wilderness areas where "component species were rarely lost."

This brings to mind Roderick Nash's look into the etymology of the word "wilderness." In one of his more recent lectures, Nash gives us a new perspective into the Leopoldian idea of wilderness as land health centers. In his lecture, Nash reminded us of the word "wilderness" as "land that is self-willed … land that has its own will." Nash went on explaining that "we need to respect that independence of the land (we must not break the will of the land). We need to protect the self-will of the land. Real wilderness means that we need to respect that independence."[24] Long before Nash's explanations on "saving on the planet some self-willed ecosystems from which we can learn how things work," Leopold had proposed the Northern Sierra Madre to be a "land laboratory," for land health research.[25] Considering his 1934 essay, "The Arboretum and the

[23] See also Newton's references to Leopold's essay, "Odyssey," in her *Aldo Leopold's Odyssey,* for Leopold's concept of land health, pp. 322-327.
[24] See Nash's lecture at https://www.youtube.com/watch?v=9chv6jWBP8k
[25] See "1947 Foreword" in which Leopold stated: "It was here that I first clearly realized that land is an organism, that all my life I had seen only sick land, whereas here was a biota still in perfect aboriginal health," pp. 285-286.

University," Leopold had started thinking in the global ecosystem scale; in this essay, Leopold said that the "world-conquest" had led to "ecological destruction on a scale almost geological in magnitude" (209). Leopold explained, that "In Wisconsin, for example, the northern half of the state has been rendered partially uninhabitable for the next two generations by man-made fire, while the south-western quarter has been deteriorated for the next century by man-made erosion" (209-210). The importance Leopold attributes to land restoration, as he states in "Some Fundamentals of Conservation of the Southwest," serves an indivisible Earth. When we consider the year 1924 when Leopold designated the Gila Wilderness, and Leopold's 1936 and 1937 trips to the Sierra Madre Occidental, where he observed hot spots of species endemism, Leopold's wilderness philosophy deepened. As he was earlier focused on lands in his home country, in about a decade, he reached a planetary vision, which would serve the needs of the global ecosystem. His vision that the earth is "a living being, vastly less alive than ourselves in time and space," throws new light on Leopold's Sierra Madre trips, especially from the vantage point of current technologies exposing desert dust and cloud interactions, as well as exposing unique synoptic scale meteorological events in land, oceans, and the atmosphere that result in dust transfers. Let us now take a look into the details of these destined trips.

LEOPOLD'S VISITS TO THE RIO GAVILAN WATERSHED

> (O)ur southwestern mountains are now badly gutted by erosion, whereas the Sierra Madre range across the line still retains the virgin stability of its soils and all the natural beauty that goes with that enviable condition.
>
> Leopold, "Conservationist in Mexico" 394

In the evolving systems approach, how can desert dust and cloud interactions in the skies be viewed as inseparable part of the land organism? Leopold's visits to the Rio Gavilan watershed, to this remote "unspoiled wilderness" in Mexico's Sierra Madre Occidental may hint at an answer.[26]

[26] For site location of the Rio Gavilan watershed, see Figure 2. Also see Forbes's, Map of northwestern Chihuahua (p. 6).

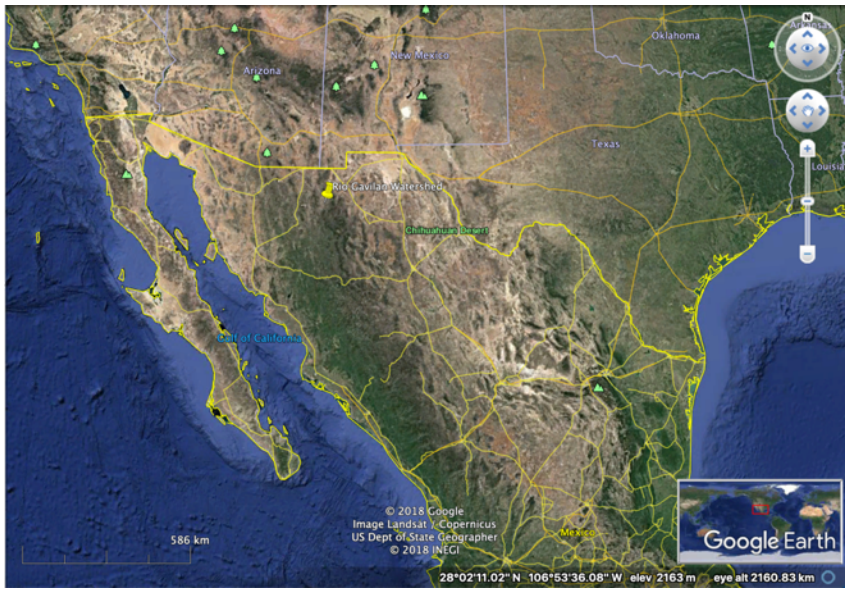

Figure 2. Map showing the location of the Rio Gaviland Watershed. (The site that we have marked on Google Earth is based on the site location of Forbes's dissertation, p. 6)

The visits, dating back to the late 1930's, point at the need to deepen our perception of clouds on a planetary scale, particularly in a time of rising interest in desert dust transfers across the oceans, perhaps enhancing land health in diverse ecosystems.[27] In a nutshell, Leopold wanted this wilderness area, the summit of the Sierra Madre in Chihuahua, to be a "land laboratory" to understand the health mechanism of the "land organism."[28] This is a portrait of Leopold, who, having visited the area twice—this hotspot of species endemism and diversity—and given the limitations of technology in his time, is directing us to what should be done in the future. He advocated "a great international research enterprise" in this area ("Conservationist" 400). Thanks to his essays such as "Sierra Madre, 1937" in the *Round River* book, we now know the circumstances of Leopold's travels in directing us to this future path. Note his words in "23 December" part of the "Sierra Madre, 1937" essay:

> Finally arrived at Colonia Pacheco after surviving the hazards of two days of Mexican travel. The Chihuahua Flyer landed us safely in Casas Grandes yesterday afternoon... ("Sierra Madre, 1937" 130)

[27] Saydam and Senyuva (2002) have pioneered the study of desert dust and cloud interactions. Saydam speculates that this interaction, complete with wet dust deposition, enhances land health.

[28] According to Leopold, the area could escape destructive practices such as overgrazing and logging due to Apache presence. See Leopold, "Conservationist in Mexico," p. 394. Richard L. Knight, in agreement with Leopold, stated that "Apaches continued to inhabit the Mexican Sierra Madre until the late 1930s" (p. 72).

Leopold's "Sierra Madre, 1937" (his essay on the second visit) reveals not only his safety concerns as he was travelling with the Chihuahua flyer, but also the unfavorable conditions there in "Casas Grandes." Leopold says that they were impressed by the "luxury of running water" and that it was extremely cold. The hall, he wrote, "would serve admirably as an ice box." But looking back from the 21st century, one can argue that Leopold had a message to give to the future researchers. He identified this area as the location where the "science of land health" would be born.[29]

In "Wilderness as a Land Laboratory," Leopold stated that "A science of land health needs, first of all, a base-datum of normality, a picture of how healthy land maintains itself as an organism" (288). In this essay, Leopold compared Rio Gavilan in the Sierra Madre Occidental of northern Mexico with the areas he had seen in the Southwest. He found the Sierra Madre "an almost exact counterpart" of his "beloved mountains of Arizona and New Mexico." Several years later, in 1947, in the Foreword to *A Sand County Almanac*), Leopold would write:

> It was (in Sierra Madre in Chihuahua, Mexico) that I first clearly realized that land is an organism, that all my life I had seen only sick land, whereas here was a biota still in perfect aboriginal health. The term "unspoiled wilderness" took on a new meaning. I recorded these impressions in "Song of the Gavilan" and "Guacamaja." (285-286)

In the "Wilderness" essay, Leopold clarifies his ideas on the "science of land health." He states that there is need for "a picture of how healthy land maintains itself as an organism":

> We have two available norms. One is found where land physiology remains largely normal despite centuries of human occupation. I know of only one such place: northeastern Europe. It is not likely that we shall fail to study it.

Leopold further states that "the other and most perfect norm is wilderness." In Leopold's words, "wilderness maintained itself for immensely long periods; that its component species were rarely lost, … that weather and water built soil as fast or faster than it was carried away. Wilderness, then, assumes unexpected importance as a laboratory for the study of land-health" (196).

Leopold's trips to Mexico's Sierra Madre, as early as the 1930's; his proposal for "a great international research enterprise" there; his return to the Sierra Madre with his brother Carl and son Starker, as well as his efforts to "interest the eminent geographer Carl O. Sauer … in his idea of an international research effort"[30] urge us to rethink about the mechanism of a more expansive land organism generating desert dust transfers across the globe, and the dynamics of the region

[29] See Leopold, "Wilderness as Land Laboratory" (1941). Leopold's comments are designed for land since his life places were in the land but not at sea.

[30] Flader reveals that Sauer had done "considerable field work in northern Mexico" and that "the primary focus of the study would be the soil-water-streamflow relation in the northern Sierra Madre, as compared with the 'modified' terrain of similar geologic formation in southern Arizona and New Mexico, in order to determine what the original equilibrium consisted of" (pp. 154-155).

that Leopold saw fit for as a "land laboratory." These trips also urge us to reconsider his essays on his unique explorations on land health in the region: "The Thick-Billed Parrot of Chihuahua" (1937); "Conservationist in Mexico" (1937); "Song of the Gavilan" (1940); and "Wilderness as a Land Laboratory" (1941). Leopold's words, particularly in the essay "Conservationist in Mexico" (1937), which he published in *American Forests,* was his way of drawing the world's attention to this important hotspot area in the early 20th century. In this essay, Leopold accounts for the unusual species endemism, for the "ecological health" of Chihuahua[31]:

> It is ironical that Chihuahua, with a history and a terrain so strikingly similar to southern New Mexico and Arizona, should present so lovely a picture of ecological health, whereas our own states, plastered as they are with National Forests, National Parks and all the other trappings of conservation, are so badly damaged that only tourists and others ecologically color-blind, can look upon them without a feeling of sadness and regret. ("Conservationist in Mexico" 394)

As Flader reveals, Leopold "did not give up hope of one day studying the mechanisms of a truly healthy biota" (155). Nevertheless, Leopold's writings on the northern Sierra Madre, and his inclusion of his essays, "Song of the Gavilan" and "Guacamaja" (thick-billed parrots) in *A Sand County Almanac* is a gift to the world readership today. We share Leopold's curiosity and his particular interest in the Rio Gavilan watershed, that stemmed from the fact that "here was a biota still in perfect aboriginal health." And it persisted despite 10.000-year human presence.[32] But what *is* the source of this "perfect" land health in the Rio Gavilan watershed, that is persisting, despite human interventions in the area?

Now 80 years after, Leopold's proposal for the "great international research enterprise," to initiate the "science of land health," may take off… with a new direction.[33] The enterprise could include, among others, research on atmospheric desert dust transfers, bringing all the riches from across the oceans. Leopold visited this remote site in northern Sierra Madre, despite such unfavorable conditions of travel in the 1930s. Yet, his travels to this hot-spot, right in the middle of continental dust activity from both Asia and Africa has yet to be appreciated, as a vast control

[31] Meine refers to Leopold's mention of "an abundant game population thriving in the midst of its natural enemies" in this area, and he reveals that "most, if not all, of the native flora and fauna persisted, including mountain lions and wolves." See Meine, *Correction Lines,* pp. 127-128.

[32] Forbes, in *Revisiting Aldo Leopold's "Perfect" Land Health*, reveals that "Humans have had a notable presence in the Gavilan since at least the tenth century A.D., through the successively dominant Paquime (10th-14th century), Opata (14th-17th century), Apache (17th-19th century), Spanish (17tyh-19th century), Mormon (19th-20th century), and Mexican mestizo (20th century) cultures (p. 16).

[33] Meunier, Leopold's great grandson, has already pioneered research in this area, revealing the results of long-term fire suppression. See Meunier's dissertation on "Disentangling Fire, Climate, Forest Structure, and Land-Use History Interactions in Mexico's Northern Sierra Madre." Also see Fleming and Forbes, "Following in Leopold's Footsteps: Revisiting and Restoring the Rio Gavilan Watershed." *Ecological Restoration* 24.1 (2006): 25-31.

region to assess land health around the world. Doesn't dust transfers from the deserts, bringing nutrients to distant hot spots, support the "indivisibility of the earth"? As Callicott explained about the concept of "metabolism" in Leopold,

> Earth's putative "organs with coordinated functions" represent its operational closure, while its putative "metabolism" is constituted by its openness to solar energy, gravitational influences from the sun and moon, and ambient cosmic materials. ("Toward an Earth Ethic" 23-24)

A CASE STUDY FOR GAIA'S SELF-RENEWAL: THE RIO GAVILAN WATERSHED AS PERFECT LAND HEALTH

Lovelock, in the centenary interview (written by Mossman), gave an example for Gaia's self-regulation:

> The air on Chesil Beach is uncommonly still. Eighteen miles of open sea and no waves; the shingle bank is a sun-trap, and there's no sound – not even a seabird. The temperate nature of James Lovelock's Dorset home turf is, he'd be the first to point out, a result of pollution. Ancient pollution. Between ice ages the levels of carbon dioxide ("that truly malign waste") rise considerably. If Gaia – as Lovelock likes to call our Earth – had returned that carbon dioxide to the atmosphere as gas, we would have been as hot and dead as Venus a long time ago. Instead, she deposited it as calcium carbonate, in the chalk and limestone cliffs that line the south coast. In doing so, the planet kept her temperature down.[34]

Lovelock's approach is based on oceans since he is much aware of calcium carbonate depositions over the oceans that act as a sink for atmospheric carbon dioxide. Lovelock is also a pioneer in the algea bloom (*Emiliania huxleyi*) DMSP-DMS_MSA and sulfate cycle that results with the formation of clouds and their albedo effect to regulate the impact of greenhouse gases. The authors suggest that it's not the dust or clouds but it's the bioavailable materials that is formed as a result of desert dust and cloud interactions and its wet deposition over the surface ocean that enhances the algae bloom. The ocean fertilization is in fact suggested by Martin, et al (1994) and tested many times as to enhance the phytoplankton blooms slightly adjusted by Saydam (in Guerzoni, et al,1996) as *Cemiliania Hypothesis* since Saydam suggested that wet dust deposition is the key factor that enhances the bloom of *Emiliania huxleyi.* Emiliania huxleyi is the phytoplankton responsible from the formation of calcium carbonate cliffs mentioned by Lovelock.

[34] See Mossman, "James Lovelock at 100: 'My life has been one mass of visions'" at https://www.newstatesman.com/politics/environment/2019/07/james-lovelock-100-my-life-has-been-one-mass-visions

The authors, instead, propose the dust transfers and its wet deposition over the receiving bodies (land or ocean) as the basis of land (or ocean) health. Significantly, the vast ecosystem of the Sierra Madre Occidental is rich in dust transfers (Figure 3 and Figure 4),[35] as well as wet dust deposition (Figure 5).

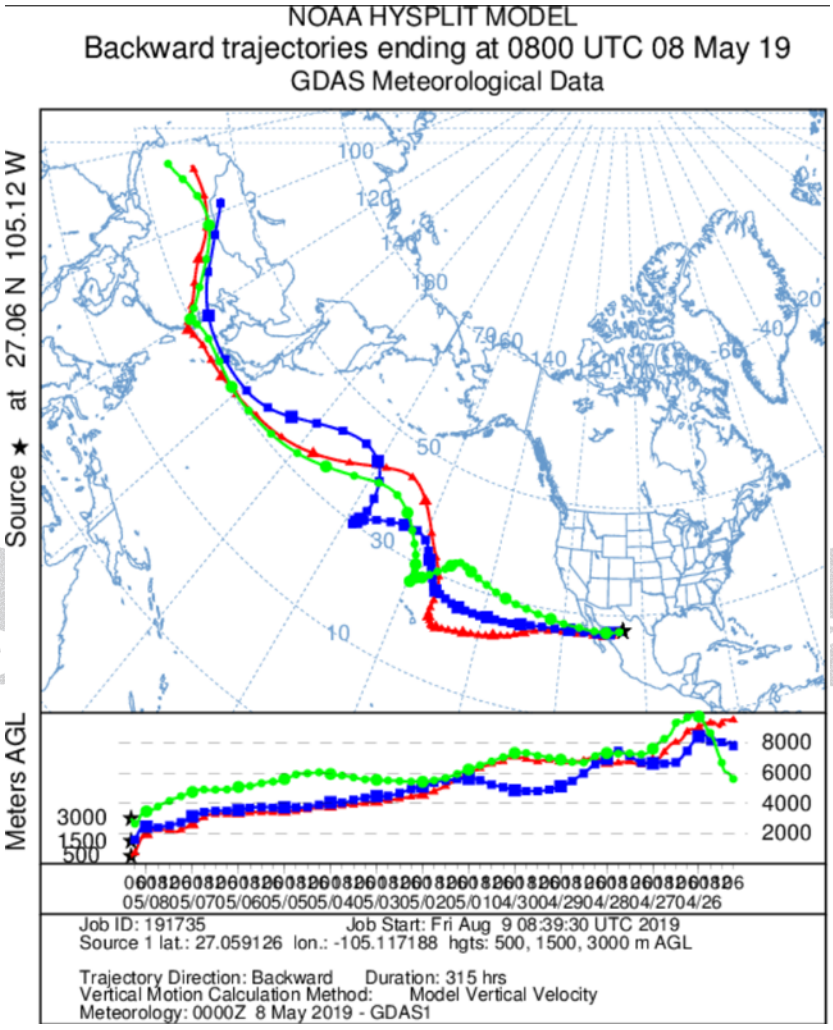

Figure 3. The air mass back trajectory analysis for May 8, 2019 illustrates the impact of Gobi and Taklamakan deserts over the Sierra Madre Occidental.

[35] See Garrison, Virginia H., et al, "African and Asian Dust: From Desert Soils to Coral Reefs," in which they stated: "Hundreds of millions of tons of dust derived from mineral soil are transported annually from the African Sahara and Sahel to the Mediterranean and Europe, and across the tropical Atlantic to the Americas (figure 2; Moulin et al. 1997). A similar global system transports dust from the Gobi and Taklamakan deserts (western China) across Korea, Japan, and the northern Pacific (Duce et al. 1980, Husar et al. 2001) to the Hawaiian Islands (figure 2). The Asian air masses periodically reach western North America and infrequently continue eastward to the Atlantic Ocean." pp. 469-480.

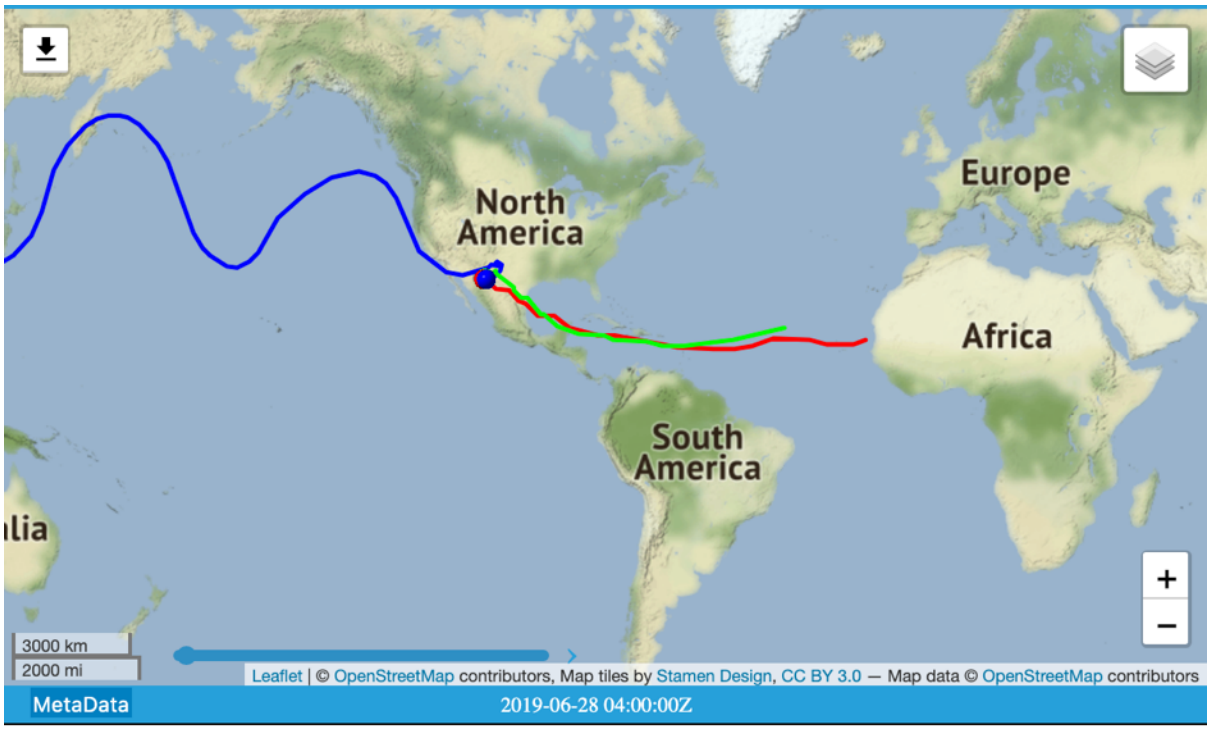

Figure 4. HYSPLIT model illustrating the air masses that reached Sierra Madre Occidental at 500 (red), 1500 (blue) and 3000 (yellow) meters above ground level. June 28, 2019.

Among numerous dust events, the one on June 28, 2019 is given so as to illustrate its unique location. On this day, Sierra Madre was affected both by the air masses that originated from Sahara at 500 and 3000 meters elevation, as well as from mainland Asia from 500 meters elevation. Transport of desert dust is a necessity but not sufficient for the production of bioavailable material within the cloud droplet that enhances the flora and fauna at receiving bodies. Wet dust deposition or rain is essential for self-renewal in this region and radar data (the yellow/green/blue colored area over the map illustrates NEXRAD Radar data, in other words, actual rain detected, superimposed to air mass back trajectory map) confirms this combination (dust+cloud and rain) over the region of interest.

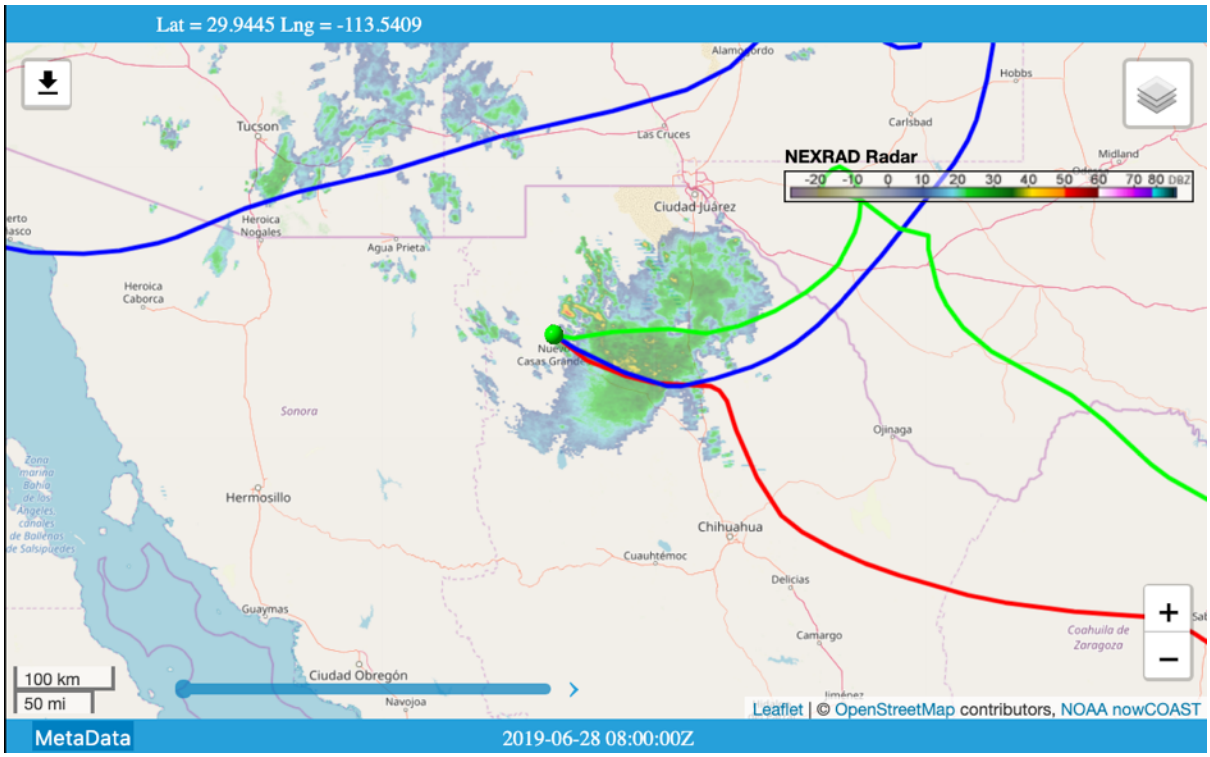

Figure 5. Close up picture of air masses that reached the Rio Gavilan region at 500-1500 and 3000 meters above ground level, on June 28, 2019, superimposed with Radar data as to illustrate the wet deposition over the region.

As we read Leopold's journal notes of the Sierra Madre trips, the life-giving daily showers fill his writing; the essay titled "1936 Mexico Trip" is a case in point: Leopold makes frequent mention of sudden showers and rain during his bow-hunting trips, from September 4th through September 15th—he mentions "rain pools" everywhere: "just as we got camp down it rained pitchforks…"; "caught in a shower…"; "another shower hit us…"; "Just as we located a good bunch of deer it rained on us..." (673-675).[36]

Today, Saydam reveals that Sierra Madre Occidental is an area that receives massive dust transfer from across the Atlantic, Indian, and Pacific Oceans. Combined with massive precipitation, the vast area is self-regulating, i.e., Gaia is at work here.[37] Leopold's words, in "Song of the Gavilan," attests to the living Earth:

[36] See Forbes for detailed climate and precipitation records: "Precipitation averages 650 mm (25.6 inches) per year, with 60 – 70 % (15-18 inches) falling from early July through October," p. 14.

[37] It should be noted that solar light energy is constant over the equator but varies latitudinally hence desert dust cloud combinations do not yield above mentioned reactions everywhere. The iron produced is in reduced state and this is the form of the iron that can be readily usable by living organisms. The amino acids, that is the most important molecule in the formation of protein that is the building blocks of life is produced within the rain drop through the decomposition of chitin molecule--remnants of the past live through a hitherto unrecognized process.

> This song of the waters is audible to every ear, but there is other music in these hills, by no means audible to all. To hear even a few notes of it you must first live here for a long time, and you must know the speech of hills and rivers. (149)

Northern Sierra Madre has faced human impact since Leopold's time, but curiously enough, the flora and the fauna still seem fairly intact.[38] This fact related to the northern Sierra Madre urges us to re-consider the mechanisms of an expansive land organism on a planetary scale, to rethink its capacity for "self-renewal," and include desert dust and cloud interactions. At this point, wet dust deposition is likely to be the key factor that determines land health, whether at the Sierra Madre or the Amazon forest, or any other place on earth, in support of Gaia theory.

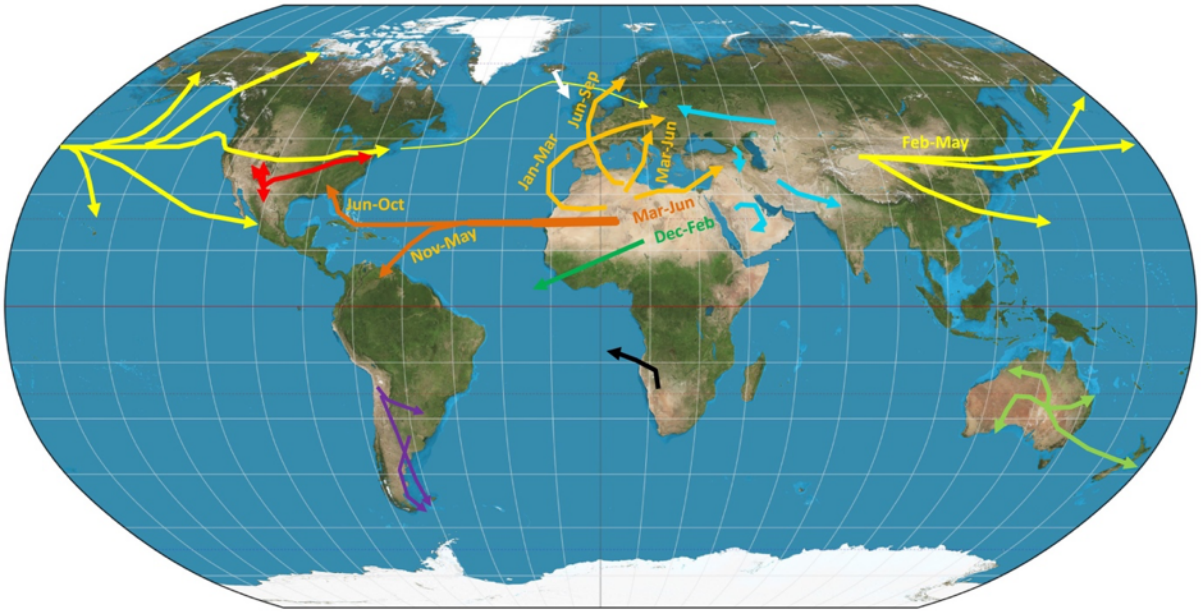

Figure 6. Global desert dust sources and their atmospheric pathways (Querol, et al., 2019).[39]

Deserts, by nature, are the most sensitive lands that are prone to wind erosion, and Sahara is the largest one on Earth in Africa, next to Gobi and Taklamakan in Asia. Deserts in the American continent located within the territories of Mexico and USA in the north supply dust into the atmosphere. In Southern American continent, Patagonia deserts located at Argentine and high Bolivian plateau are the next two deserts for the southern hemisphere. Australian and Namibian deserts are the next two sources that supply to atmospheric dust burden. And, significantly, the

[38] Fleming and Forbes reveal that "One of us (Forbes 2004) recently completed an examination of a broad range of land health indicators in the Rio Gavilan and found that most indicators pointed to mostly moderate (fair) conditions within the watershed," p. 31.
[39] See Querol, et al.'s article at https://doi.org/10.1016/j.envint.2019.05.061

northern Sierra Madre receives life-giving nutrients and amino acids from the majority of the global desert dust sources, and is unique. This special place on Earth is receiving nutrients and amino acids all the way from the Gobi and Taklamakan deserts, across huge portions of both Mongolia and China, and all the way from the Sahara desert in Africa onto the Sierra Madre Occidental, as wet dust deposition—onto the location that Leopold described as "land of milk and honey."[40] Nutrient rich Gobi and Sahara dust travel thousands of miles across the Pacific, Indian, and Atlantic Oceans, and reach northern Mexico to fertilize and feed the lands.[41] To be more precise, over the desert regions winds uplift the dust and along its transport route they have a chance of encountering with cloud water. Upon contact with cloud water what we are witnessing is dusting the cloud as analogous to land irrigation. With the assistance of solar light intensity, the bacteriological fraction becomes active and through a series of chemical reactions various essential ingredients such as reduced iron, essential micro nutrient elements and amino acids are formed within the cloud droplet.[42] Now dust-laden clouds teem with life, this time blanketing the earth from above. When this blanket comes down as rain, it enhances algal blooms over the surface ocean or enhances life on soil.[43]

Hence, the abundance in the Rio Gavilan region. Upon arrival in the Rio Gavilan, Leopold's awe is reflected in the wildlife notes that he compiled in 1936 (Forbes 59).[44] Leopold's essay, "Song of the Gavilan," is about this "land of milk and honey," and it is filled with frequent references to the "song of the waters." Leopold reflects Rio Gavilan's "unspoiled wilderness" as such:

> These twisted oaks and junipers bear each year a crop of mast to be had by wildlings for the pawing. The deer, turkeys, and javelinas spend their days, like steers in a cornfield,

[40] For a lyrical narration of Saydam's extensive research on desert dust and cloud interactions, see Saydam's nature writing book, *Havadan Tozdan,* pp. 56-99. For nutrient rich Gobi and Sahara dust traveling thousands of miles across the Pacific and Atlantic Oceans, see *Havadan Tozdan,* p. 89.

[41] At present, it is possible to trace the air mass past routes up to 315 hrs, in other words, it is possible to know where the air mass came from. This technique allows us to identify where the air mass came from, and whether it crossed over the desert regions, or not. Deserts, with its loose surface matter, act as a source of atmospheric dust. Strong winds and gravitational forces eliminate the large particles and less than ten-micron size can traverse oceans.

[42] For the first time in scientific history, Saydam & Senyuva (2002) has shown that oxalate is produced as an osmosolute within the clouds minutes after the contact of desert dust with clouds. Oxalate then attacks the surrounding clay mineral and forms iron oxalate and water as shown by reaction (I)

$\equiv FeOH + HC_2O_4 \rightarrow \equiv Fe\,C_2O_4 + H_2O$ where ≡FeOH represents the clay mineralogy. Reaction (I).

It should be noted that this reaction mechanism takes place within cloud level and if the solar light energy is sufficient enough then decarboxylation reaction takes place and iron oxalate decomposes through a decarboxylation reaction as shown by Reaction (II).

$\equiv Fe\,C_2O_4$ sufficient solar light energy $\rightarrow Fe(II) + CO_2 + CO_2$. Reaction (II). (See Saydam, A. C., and H. Z. Senyuva. "Deserts: Can they be the potential suppliers of bioavailable iron?" *Geophysical Research Letters* 29.11 (2002): 19-1).

[43] See Appendix: "Scientific Outlook: The Magnificent Journey of the Desert Dust," by C. Saydam.
Also see the two related chapters (in Turkish) on the journey of the desert dust in Saydam's *Havadan Tozdan.*

[44] Forbes included a document from "Leopold Papers" on the wildlife Leopold recorded on his 1936 trip. University of Wisconsin-Madison Archives (Forbes 1936).

converting this mast into succulent meat. These golden grasses conceal, under their waving plumes, a subterranean garden of bulbs and tubers, including wild potatoes. Open the crop of a fat little Mearns' quail and you find an herbarium of subsurface foods scratched from the rocky ground you thought barren. These foods are the motive power which plants pump through that great organ called the fauna. (151)

Such research on this healthy ecosystem may finally inspire "the science of land health" that Leopold envisioned. Leopold's proposal for using this area as a vast "land laboratory," once initiated, may serve as a control site to assess land health for the entire planet.

TOWARDS A HEALTHY GAIA

Only the Sierra Madre Occidental has lived long enough
to listen objectively to the thunder of clouds…

Today, at the threshold of climate crisis, this area needs massive research to further prove the "indivisibility of the Earth." Among field tests (far away from the Sierra Madre), conducted with Saharan desert dust, to speculate on the reason for such species abundance in the Rio Gavilan watershed, the one at Harran University, Turkey, is shown below (Figure 7). During the course of cultivation, to assess the impact, the strawberries were irrigated by Euphrates river water, water enriched by fertilizer, and water enriched by Saharan desert soil (Figure 7). The resultant product clearly illustrates the response of a plant towards desert dust. In this case it was strawberries but it could have been any crop/plant/trees, just as Leopold observed at the Rio Gavilan watershed.

Figure 7. Field tests carried out at Harran University, at Harran/Urfa, under the supervision of Cemal Saydam. 2010.

With the cross-disciplinary collaboration of humanities and sciences, and "possibly in our intuitive perceptions, which may be truer than our science,"[45] we, a literary scholar and a scientist, tried to illustrate "the indivisibility of the earth," and we attempted a new ground for Gaia, the living Earth, in the age of climate crisis. In "Song of the Gavilan," Leopold refers to the reductionist science that turns nature into mindless matter. For Leopold, the "mechanized man" is only able to see parts and not wholes, causing the "discords of misuse." Thus, Leopold celebrates the fact that "Science has not yet arrived on the Gavilan":

> There are men charged with the duty of examining the construction of the plants, animals, and soils which are the instruments of the great orchestra. These men are called professors. Each selects one instrument and spends his life taking it apart and describing its strings and sounding boards. This process of dismemberment is called research. The place for dismemberment is called a university. (…) Professors serve science and science serves progress. It serves progress so well that many of the more intricate instruments are stepped upon and broken in the rush to spread progress to all backward lands. (…) If the professor is able to classify each instrument before it is broken, he is well content. (153)

The area is already a vast "Land Laboratory" as it "still represents Leopold's indicators of healthy land,"[46] yet it still lacks its scientists dedicated to unearthing the ecology of the skies complete with its cloud and desert dust interactions. With this article, with a new outlook to the status of planetary clouds, to the "white fleets" in Leopold's terms, we are inviting such essential research. We believe that once further research endows the clouds with life, nature will lay bare its secrets.

The cloud-mass, strolling in the skies and creating all the core elements essential to life, may now be regarded as the organs of the land organism, and with a purpose. Seeing lands shrouded in desert dust, we think that clouds stroll here and there within daily meteorological conditions.

[45] The reference is to Leopold's words at the end of his "Some Fundamentals of Conservation in the Southwest," p. 95.

[46] As Forbes revealed, "The northern Sierra Madre Occidental still represents Leopold's indicators of healthy land, although in a reduced state" (p. 1).

Figure 8. Tornado. OAR/ERL/National Severe Storms Laboratory (NSSL) via [pingnews].[47]

Not so! The tornadoes, picking up dust from the ground, and pumping it to the clouds… is this phenomenon mere coincidence? A whirlwind terminating with a cloud… is this another coincidence? By pumping dust into the clouds, mother nature provides the necessary ingredients as to induce the basic parameters of life: with the assistance of solar light intensity, dust and cloud interactions result in the formation of amino acids. Amino acids are the building blocks of proteins… the very first step for life.[48] Many phenomena that we think we comprehend are still veiled in mystery, but endowing life to clouds will shed light on the meaning of the "land organism" that Leopold articulated almost a century ago.

To uphold that the Earth is self-regulating does not denote the Earth will somehow recover from the climate crisis. Lovelock, at the age of 100, states that worse days are to come.[49] The Dust Bowl droughts that left a deep imprint on Leopold, in the 1930s, are now being played out on a

[47] Visit: https://www.flickr.com/photos/pingnews/452392668

[48] Saydam explains: What could be the reason of lifting something from its original position to higher elevations and then releasing it, knowing that gravitation forces will bring it to its original position? This phenomenon is in fact against conservation of energy. But let's look up to this process with an analogy that we are performing on a daily basis at our garden. If anyone would like to irrigate his/her garden, he/she goes out there and opens a tap connected to a hose and performs irrigation by using the pressure that is supplied through municipalities. Hose acts as a means of conveyer belt to transport precious water from source to its destination, and at our home the destination is soil. Now let's look at this process for mother nature. If mother nature wants to throw soil into the water, in other words, if you want to dust the clouds or throw soil into the clouds, the tornado acts as a hose for mother nature. But this natural hose necessitates immense power to pick up soil from the ground and pump the fine particulates into the clouds while performing separation using centrifugal forces that may devastate houses and even throw lorries. All it needs is very fine particulate and it clearly uses centrifugal force as to eliminate the large chunks.

[49] For Lovelock's climate projections, also see *The Revenge of Gaia,* pp. 61-83.

planetary scale. Now is the time to embrace the "great international research enterprise," in the Sierra Madre Occidental, envisioned for the future by Leopold. Studies should take up, among others, the land health impacts of wet dust deposition during Asian and African dust events which will inspire further research on cloud and dust interactions. This will perhaps give rise to cautiously regulating the clouds, for the critical ecosystems of Mother Nature. Forty years ago, Lovelock said that "We need to love and respect the Earth with the same intensity that we give to our families and our tribe" … that we "cannot survive without a healthy planet as our home" (*Gaia: A New Look at Life on Earth* viii). For the science of land health, then, let us cherish the Call of Gaia, both the humanities and the sciences!

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APPENDIX
SCIENTIFIC OUTLOOK: THE MAGNIFICENT JOURNEY OF THE DESERT DUST

Desert dust can traverse the oceans in a matter of days under the prevailing wind directions. During the course of such transport dry dust particles may encounter with the cloud droplet, and if they do, they become wet. This process does not only alter the nomenclature of clay particles from dust to mud, dry to wet, but further initiates a unique process that results in the formation of very valuable chemicals. The wetting process triggers an action that wakes up the bacterial and fungal content of dust particles. We know that each gram of topsoil on earth contains some 10^7-10^{14} prokaryotes. In other words, enormous numbers of sub-micron bacteria and fungi reside comfortably within the clay particles. As dry, they can keep their identity for an indefinite period of time. All they need is a drop of water, and this demand is met when dust and cloud combine. "Dusting the clouds" is not a terminology that we are used to, but it's the same process of land irrigation. Upon contact with water, prokaryotes release a chemical, named as oxalate. This oxalate has no chance to go anywhere but to react with the surrounding clay mineral and iron oxalate and one mole of water. Once the clouds are enriched with iron oxalate, the next step is regulated by solar light intensity. If it is above a threshold level (>200Watt/m^2), then iron oxalate can be decomposed through a reaction mechanism named as "decarboxylation." Decarboxylation reaction results in three very important reaction products. First one is reduced iron. In nature, iron exists at its +3 state and this cannot be utilized by mother nature. The readily utilizable form of iron is its +2 or its reduced state. The second reaction product is carbon dioxide. The other very short-lived reaction product is carbonyl radical. Being a radical, this product has a lifetime of a fraction of a second. During this very short time, it can react with iron oxalate and reduces one mole of iron oxalate. Or it may combine, yet, with another carbonyl radical, and form a stable oxalate molecule and act as a feedback mechanism for the above process.

Clay minerals house various types of fungi and chitin is part of the cell walls of fungi. Chitin is a long-chain polymer of glucosamine. In nature, this polymer acts as a source of very valuable raw material in the process of the formation of all known amino acids. Thus, following the wetting of desert dust, a series of reactions take place and the most important one is the formation of amino acids following the reaction of oxalate with chitin molecule.

If this water comes into contact with leaves of a tree, it is directly sucked by the green leaves. If it comes into contact with fresh or seawater, then phytoplankton growth is immediately triggered. We can notice these blooms by various means: By our naked eye as the water color changes into turquoise; or by the foams or brownish signatures that extends over the surface waters; or by the smell since they release chemicals that contain sulfur. This chemical is named as dimethylsulphophosphopropiyonic acid (DMSP) and oxidizes to Dimethyl Sulfide (DMS) and then escapes into the atmosphere. DMS then oxidizes to Methane Sulfonic Acid (MSA) and eventually ends up with the formation of sulfate (SO_4). Sulfate is the best cloud condensation nuclei. The cloud increases the albedo and cools down the crust. This mechanism is the key factor that determines the global temperature balance and everything stems from dust.