The green world

In many ways, plants are fundamentally different from other kingdoms in the domain of life. Through photosynthesis, with its absorption of carbon dioxide and release of oxygen, plants serve as the lungs of planet Earth. As organisms capable of synthesizing their own food from inorganic substances, they are the basis for food webs upon our blue-green planet. From this wondrous arising, the miracle of life moves forth. Diverse forests, grasslands, deserts, tundra, wetlands, and waterways blanket the Earth, providing refuge for untold realms of biodiversity from molecules to species to bioregions and biomes. Vascular plant numbers total over 400,000 taxa, with 20% threatened with extinction. Along with the twin spectres of climate chaos and species extinctions, vast numbers of individual plants and animals are being extirpated beyond our ability to comprehend the losses. The green world is being razed by agricultural expansion and deforestation, as well as from wildfires, industrial agriculture, and indiscriminate use of biocides. Along with immediate steps to reduce human numbers and its attendant consumption, the best conservation science tells us setting aside half the Earth for the preservation of wild nature is crucial if humanity and the more-than-human world is to make it through this plight of our own making.

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Canto LXXXI
Pull down thy vanity, it is not man
Made courage, or made order, or made grace,
Pull down thy vanity, I say pull down.
Learn of the green world what can be thy place.
Ezra Pound

All of life is a miracle of existence, with each organism having its own unique qualities and attributes, Darwin's "endless forms most beautiful and most wonderful." Yet no being exists independently. Ecology and evolution provide ample evidence of species interconnecting to form mutualistic relationships and communities. This interdependence can be viewed as webs of connectivity, or as an ecological pyramid emphasizing trophic levels, serving as a metaphor for the flow of energy through ecosystems.

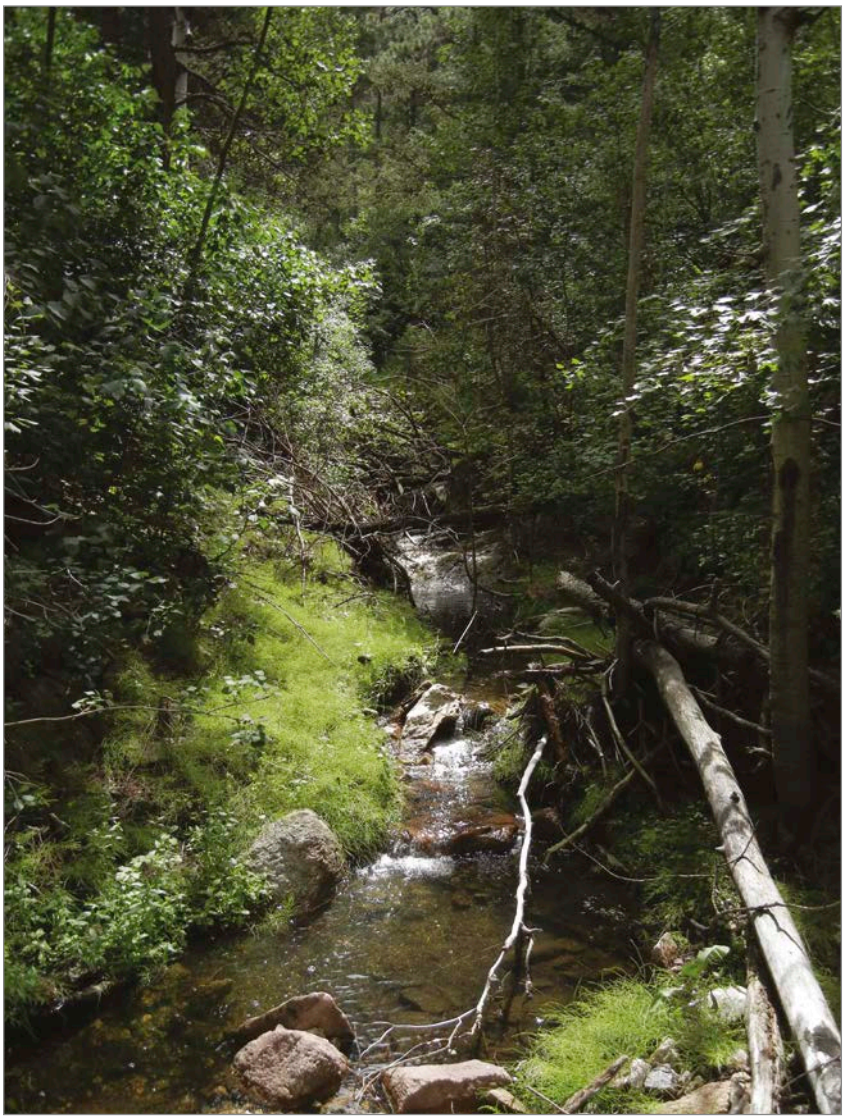
Fundamental to such an ecological view lies the world of plants, the green of the leaf, and the marvel of photosynthesis. "When a particle of light strikes a molecule of chlorophyll, an electron is jolted out of the molecule and raised to a higher energy level. Within a fraction of a second, it returns to its previous energy state. All life on this planet is dependent upon the energy momentarily gained by the electron. Photosynthesis is the vital link between the physical and biological world [...] 'What drives life is a little current, kept up by the sunshine,' (Nobel laureate Albert Szent-Györgyi)" (Raven and Curtis, 1981).

Through respiration, animals breathe in oxygen to release the energy from the food we eat and exhale carbon dioxide as a waste product; plants absorb immense quantities of carbon dioxide through photosynthesis, and release oxygen as a waste product. There is more than just metaphor at play in the perception that the green world serves as the lungs of planet Earth (Jabr, 2019).

What of the green world here in the early decades of the 21st century? From the Arctic tundra and the realm of circumboreal conifer forests, to the tropics with their vast rainforests, mangroves and other habitats of prolific diversity, the vegetation of the Earth, like so much else, is under assault from expanding human economies and the crush of our numbers.

Vegetation, as the collective assemblage of plants in the landscape, is distinct from the *flora* of an area. The latter, in its most elemental sense, is a list of the plant species occurring there. The basic unit of a flora is the species; the basic unit of vegetation is the community or association. Implicit in the term plant community are such attributes as soil type, moisture regime, microclimate, slope, aspect, elevation, temperature and disturbance history. In other words, an integrator of factors defining qualities of habitat.

The species diversity of the world's flowering plants is being extirpated to the extent that fully one in five (20%) of the estimated 390,000 vascular plants are threatened with extinction (RBG Kew, 2016). Another study, released from Kew as this paper goes to press, found that 571 species had been extirpated since the beginning of the Industrial Revolution, with the caveat that the true number is likely to be much higher (Humphreys *et al.*, 2019). Researchers said the extinction rate was 500 times greater now than before 1750, and this number is also likely to be an underestimate (Carrington, 2019).



Extinctions in plant species are difficult to assess compared to most animals. Extinction is an absolute term, meaning no individuals remain alive (RGB Kew, 2016). Proving an absence is a fool's errand in field biology, no matter the level of searching; this is true for animals as well as for plants. For plants however, there can be long extinction lag times influenced by numerous factors. Species–area curves describe the relationship between the area of a habitat and the number of species found within that area. These are not as effective in predicting populations of stationary plants as compared to mobile animals owing to the influence of features such as spatial scales and patch structure. More intrinsic factors affecting lag times include long-lived seed banks in the soil, the longevity of woody plants, particularly in the tropics, and the numerous ways plants can reproduce themselves through asexual means or self-fertilization (Cronk, 2016).

One botanist's account of tropical species loss is as follows (Tripp, 2016):

> *Ruellia speciosa* is, true to its epithet, a beautiful species. And one of my favorites. I could probably write a short story about this one, about watching for hours the hummingbirds fawn over it in a deep fissure on top of a mountain overlooking Ciudad Oaxaca [...] about its wonderfully pungent odor [...] about the population mutants that produce the strangest internal floral accessory structures. Well, best just to read all about it in the taxonomic revision of *Ruellia*. I owe a great deal of gratitude to Salvador Acosta for leading me to this population in 2005, which represents the only time I've seen this species alive in the field. I have searched and searched for many other populations, based on localities from

historical herbarium records, but all such attempts were unsuccessful.

Update as of January 2016: I returned to the above locality some 10 years after I first visited it. The population has now been extirpated from housing development. Not all stories have a happy ending.

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There is an old saying in conservation about "saving the last of the least, and the best of the rest." The 'least' are those species on the precipice of extinction and being lost forever. The 'rest' are those populations and habitats with a chance of being saved. They provide a source of diversity to build upon in the hope of restoring a small park, a large county, or a vast reach of native prairie, forested uplands or alpine mountains where genuine rewilding can proceed.

As readers of this journal are keenly aware, one of the most pressing ecological concerns of the 21st century is the extinction and extirpation of species across the planet. Normally staid scientists and journals are speaking of 'ecocide', 'biological annihilation' and 'ecological Armageddon', as plant and animal numbers are extirpated beyond our ability to comprehend the full scope of the losses (Ceballos *et al.*, 2017; Hallmann *et al.*, 2017). Here, the emphasis is not on species extinction, an attendant horror to extirpation, but rather the decimation of individual beings on such a scale as to be truly horrific in its implications for the fabric of life on Earth: in short, the loss of wild nature's abundance and the cumulative impacts this has on food webs, biogeochemical cycles and energy paths linked to that abundance. One scientist involved in some of the referenced studies listed the top three threats to biodiversity as "habitat loss, habitat loss, and habitat loss."

Before addressing some of the major threats to the green world and the biota it sustains, let us concede that without an immediate start to lowering human numbers and their attendant consumption, there is little hope of building a sustainable and just society, let alone restoring a world with room for wildness to play an unbounded role. The late Al Bartlett, a physics professor at the University of Colorado, gave what would prove to become a celebrated talk on exponential growth. It was titled *Arithmetic, Population and Energy:*

"Before addressing some of the major threats to the green world and the biota it sustains, let us concede that without an immediate start to lowering human numbers and their attendant consumption, there is little hope of building a sustainable and just society, let alone restoring a world with room for wildness to play an unbounded role."

Sustainability 101, and was presented over 1700 times. He would often end his presentation with a simple question. "Can you think of any problem in any area of human endeavor on any scale, whose long-term solution is in any way aided, assisted, or advanced by further increases in population, locally, nationally, or globally?" (Bartlett, 2013). In looking at some of the most troubling threats to the green world, the answer is clearly no.

A 2016 analysis in the journal *Nature* lists two of the greatest threats to species diversity as: one, agricultural expansion, which includes food, fibre, fuel and livestock production; and, two, over-exploitation, which includes deforestation, hunting and fishing (Maxwell *et al.*, 2016). The authors are aware that assigning categories to threats may be more of a distraction than an exercise in clarification, pointing out that more than 80% of the species included in their analysis are affected by a combination of agriculture and over-exploitation. They suggest that a better understanding of how threats act "additively, synergistically or antagonistically" is needed to more effectively evaluate the conservation costs of human impacts (Maxwell *et al.*, 2016). Once again, we come back to interdependence, but this time with the awareness that the complexity it engenders can determine the dynamics of ecological ruin as much as it can beget ecological integrity and beauty.

"A 2016 analysis in the journal *Nature* lists two of the greatest threats to species diversity as: one, agricultural expansion, which includes food, fibre, fuel and livestock production; and, two, over-exploitation, which includes deforestation, hunting and fishing."

Another study reports that 27% of the total loss of forests worldwide between 2001 and 2015 was due to industrial-scale farming and ranching (Curtis *et al.*, 2018). Most of this permanent land use change (deforestation) occurred in the tropics. Large swathes of Amazonia have been converted to cattle ranches and soybean farms, while South-East Asian forests have been converted to palm oil plantations. The remaining areas maintained the same land use over 15 years; in those areas, loss was attributed to forestry (26%), shifting agriculture (24%) and wildfire (23%). These latter effects may represent an erosion of the integrity of habitats, but not a permanent loss of wild nature. This analysis was driven, in part, to assess the effectiveness of corporate commitments to zero deforestation in their supply chain by 2020. The conclusion was that the rate of commodity-driven deforestation has not declined (Curtis *et al.*, 2018).

Moist tropical deforestation is perhaps the greatest concern in the 21st century for terrestrial habitat and species loss, but its contemporary prevalence should not obscure the historical despoilment of vast tracts of the Earth's surface. Reliable figures are disturbingly difficult to pin down, but it appears that over 50% of the planet's land area has been converted to human-dominated use. Recent reports go as high as 75% (IPBES, 2019). According to Hoekstra *et al.* (2005: 24): "Habitat loss has been most extensive in tropical dry forests (69% converted in SE Asia); temperate broadleaf and mixed forests, temperate grasslands and savannahs (>50% lost in North America); and the majority of Mediterranean forests, woodlands and scrub." From these areas major civilizations emerged – Eastern/rice, New World/corn and Western/wheat – and were largely defined by the impacts of agriculture and the spread of metropolitan centres. The loss of species across these biologically rich, continental-scaled biomes is a disquieting reproach to our human tenure on planet Earth.

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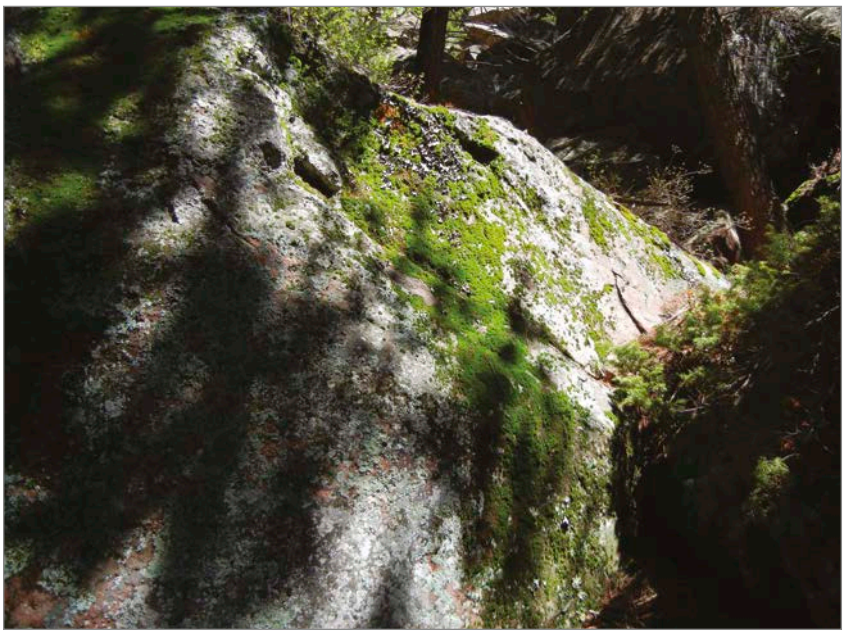
Even in the absence of climate disruption, the green Earth would be in a world of hurt. While anthropogenic climate upheaval exacerbates virtually all ecological impacts, there are some effects more directly linked to the new climate regime. As a resident of western North America, and more precisely the Southern Rockies bioregion, I have witnessed a host of fires far outside the range of natural variability over the past 40 years. According to a Colorado State University assessment, "wildfires in Colorado destroyed less than 100,000 acres per decade over the 1960s and the 1970s. For the 1980s and 1990s, the total was over 200,000 acres per decade. For the 2000s, the total [has been over] 1,000,000 acres" (Wikipedia, 2019).

We appear to be moving into a 'state-shift' where low-elevation forested sites consisting of ponderosa pine and Douglas fir are crossing climatic thresholds involving, for example, soil moisture and maximum surface temperatures. High fire

severity and low seed availability further compromise post-fire regeneration. Davis *et al.* (2019: 1) have noted: "At dry sites across our study region, seasonal to annual climate conditions over the past 20 years have crossed these thresholds, such that conditions have become increasingly unsuitable for regeneration".

While such studies concentrate on low-elevation sites, there are other reports focusing on forests at higher altitudes and latitudes (Harvey, 2016). These emphasize a significant decrease in regeneration in the 21st century, pointing to moisture deficits and, to a lesser degree, distance to seed source. The vegetation these sites will support in the future range from reduction in forest density and extent, to compensatory increases from lower-montane and upper-



treeline species. Further scientific research may be needed, but savvy naturalists and the intimacy of those who have lived for generations in a particular place also have a role to play in this work (Noss *et al.*, 2012; Turner, 2014).

In recent years, phenology, the study of the seasonal timing of life's processes, has experienced a revival in the light of climate woes. Concerns over plant–pollinator dynamics have been among the most studied systems in looking at disruptions of ecological interactions (Memmot *et al.*, 2007). An interesting side to the story involves Henry David Thoreau and his efforts to map the seasonal patterns of Concord's natural history. Richard Primack and his colleagues have looked at this in some detail, providing those of us with a life-long affection for the sage of Concord with another story to tell of ol' Henry traipsing for miles to find the earliest blooms of the season (Primack and Miller-Rushing, 2012).

Here in the Southern Rockies of Colorado, at the Rocky Mountain Biological Laboratory (RMBL), David Inouye and his students have pursued phenological studies to previously unheard levels of detail after 40 years of work. Tucked away in their Elk Mountain redoubt, they have built a dataset of some 2 million individual flowers from 121 species, establishing that since the 1970s the wild-flower season has extended an average of 35 days at the RMBL site (Langlois, 2014). Their studies bring to mind the old caveat about nature not being more complicated than we think, but more complicated than we *can* think; nature rarely if ever proceeds in a straight line. Cardona *et al.* (2014: 4916) have commented: "A diversity of species-level phenological shifts contributes to altered co-flowering patterns within the community, a redistribution of floral abundance across the season, and an expansion of the flowering season. These results demonstrate the substantial reshaping of ecological communities that can be attributed to shifts in phenology."

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Documenting state shifts from forests to shrub-lands in the wake of wildfires, the reshaping of communities as a result of phenological shifts attributable to climate change, or the decline of insect populations due to expanding agriculture impacts all point to the loss, if not extinction, of ecological interactions. In some cases these can be ascribed to out-of-kilter food-web interactions (Sanders *et al.*, 2018), in others to the direct or secondary mortality resulting from insecticides and herbicides (Gassmann *et al.*, 2014; Hladik *et al.*, 2018).

In the case of disruptions from pesticides, often associated with genetically modified crops, we see the serious impact of industrial agriculture with its practice of fence-row to fence-row cultivation. While concern over health impacts from consuming GMO foods may be warranted, the ecological effects of producing these foods upon soils, watershed and biota are seldom given the attention they deserve. Along with a humane and ecologically just reduction in global population, an urgent transformation away from industrial agriculture is imperative if the richness and variety of life on our blue–green planet is to make it through the 21st century. Sustainable agriculture systems rooted in ecological practices mimicking natural processes must be embraced and, over time, put into place worldwide. Such an agroecology would not only produce healthier food, it would support wildlife,

restore the quality of soils and water, and sequester carbon from the atmosphere (Union of Concerned Scientists, 2019).

Nevertheless, even more is called for if the aspirations of this journal and the readers who come to it are to be realized. *The Ecological Citizen*'s mission statement declares its commitment to "address the central issue of our time: to halt and reverse our current ecocidal course and create an ecological civilization." Organizations such as the Wildlands Network, Nature Needs Half and Half Earth are spearheading these visions, providing support for myriad grassroots groups doing the hard work on the ground (Foreman, 2004; Wilson, 2016; https://natureneedshalf.org).

As audacious as proposals to secure half the planet as biodiversity preserves may once have sounded, the best conservation science tells us this is what is necessary if the twin spectres of the sixth mass extinction and climate chaos are to be averted. This is also the enduring message from the traditions of indigenous people around the planet, as well as the coyote wisdom of a gifted 16-year-old girl from Sweden and the rebellion of young activists she has spawned (Turner, 2014; Dodd *et al.*, 2019).

In researching this paper I was charmed to discover that, as early as 1972, Eugene Odum, the author of my first ecology textbook, published research concluding: "It would be prudent for planners everywhere to strive to preserve 50% of the total environment as natural environment" (Odum and Odum, 1972). Twenty years later, Reed Noss, another of my ecological mentors, came to the same conclusion, publishing his findings in *Wild Earth*. Then, a further 20 years on he co-authored a seminal paper on the topic

in *Conservation Biology* (Noss, 1992; Noss *et al.*, 2012).

Most recently, in 'A Global Deal for Nature [GDN]: Guiding principles, milestones, and targets', Eric Dinerstein and his colleagues (2019: 1) map out "a time-bound, science-driven plan to save the diversity and abundance of life on Earth. Pairing the GDN and the Paris Climate Agreement [to] avoid catastrophic climate change, conserve species, and secure essential ecosystem services." With the help of social media, millions of people around the planet were alerted to the GDN's release and downloaded the plan. Even as I write these words, the UN Report on Biodiversity and Ecosystem Services has been released by IPBES (2019). The dire findings reported in this document only amplify the need for urgent action.

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As a denizen of western North America, I have been blessed with the endowment of public lands, lands serving as a geography of hope for our democracy. I cut my conservation teeth on visions of the Great Plains restored to a buffalo commons and of the Rocky Mountains serving as a continental corridor for large mammals. More recently, in conjunction with a floristic survey of a natural area in Boulder County, Colorado, I assessed the county as a whole to determine the extent of protected lands in the region. It turns out over 60% of these lands are under some form of protection as city or county open space, state parks, US Forests Service lands, statutory wilderness areas or national park. This is in a county of 740 square miles (1920 km^2) with a population of 325,000 people.

I am fortunate to live in a place where those who came before us had the foresight to recognize the beauty of these lands and worked to set aside relatively large parcels for their natural values. In recent years, we seem to have lost that spirit, forgetting we each need to lighten our steps if their ecological integrity is to survive. We need to revivify our covenant with the natural world, to embrace an ethic of membership and stewardship, and, in the words of Barry Lopez, rediscover that spot "between the extremes of nature and civilization where it is possible to live without regret" (Lopez, 1989: 178).

> "We need to revivify our covenant with the natural world."

I would like to suggest to my neighbours – and are we not all neighbours? – that we begin to view these lands as a commons. Not the commons of tragedy on which individuals pursue their singular ends, but rather a multispecies commons of sharing and cooperation. A bestowal upon which the citizenry as a whole has come to an agreement as to what is best for the plant and animal communities that flourish here, and for those of us who are fortunate enough to share it with this more-than-human-world. This can become the context in which we restore, and begin to make reparation, with these lands and with each other.

In the end, we need the solace and calm of wild nature to be whole. To be held by the gaze of a wild animal, to be nourished by a quiet trail. And beauty, beauty most of all, is essential. ■

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For the Children

The rising hills, the slopes,
of statistics
lie before us.
The steep climb
of everything, going up,
up, as we all
go down.

In the next century
or the one beyond that,
they say,
are valleys, pastures,
we can meet there in peace
if we make it.

To climb these coming crests
one word to you, to
you and your children:

stay together,
learn the flowers,
go light

Gary Snyder (1974)

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