Note: This is a draft of a chapter in a book I am working on. It is not intended to be a monograph, so I apologize for the tone and style (and use of references) not being what you would expect from an academic article. The chapter is going to be longer, but here I have tried to pick out the necessary parts to make a paper-length coherent argument.

What is degradation?

Meredith Root-Bernstein
UMR CESCO, CNRS, Muséum National d'Histoire Naturelle, Paris, France
Instituto de Ecología y Biodiversidad, Santiago, Chile
Center of Applied Ecology and Sustainability, Santiago, Chile

Writing in 1868, the physical geographer George Marsh opens his book *Earth as Modified by Human Action* with a discussion of the "Physical Decay of the Territory of the Roman Empire." He claims that "more than one-half" of the former Roman Empire

> "..is either deserted by civilized man and surrendered to hopeless desolation, or at least greatly reduced in both productiveness and population. Vast forests have disappeared from mountain spurs and ridges: the vegetable earth accumulated beneath the trees by the decay of leaves and fallen trunks, the soil of the alpine pastures...and the mould of the upland fields, are washed away; meadows, once fertilized by irrigation, are waste…rivers famous in history and song have shrunk to humble brooklets…the…diminished velocity and increased lateral spread of the streams which flow into [estuaries], have converted thousands of leagues of shallow sea and fertile lowland into unproductive and miasmatic morasses." (p. xx)

He goes on to explain,

> "The decay of these once flourishing countries is partly due, no doubt, to that class of geological causes whose action we can neither resist nor guide, and partly also to the direct violence of hostile human force; but it is, in a far greater proportion, either the result of man's ignorant disregard of the laws of nature, or an incidental consequence of war and of civil and ecclesiastical tyranny and misrule." (p. xx)

Nature was also understood as inherently stable, and always returning to equilibrium unless utterly destroyed. Marsh writes,

> "The Earth was not, in its natural condition, completely adapted to the use of man , but only to the sustenance of wild animals and wild vegetation…In short, without man, lower animal and spontaneous vegetable life would have been practically constant in type, distribution, and proportion, and the physical geography of the earth would have remained undisturbed for indefinite periods…" (p. xx)

The book is an interesting mix of caveats about the limits of scientific and historical environmental knowledge, and a Christian and colonial worldview presented in scientific terminology. Over the years, as our scientific measurement and interpretive capacity has increased, some elements of this story have been abandoned or tempered, but most have clung on in different guises. Ecologists and conservationists no longer believe that nature is inherently stable, but the traces and structures of a Christian ontology inform the worldview of which environmental science is generally a part.

In 1977, as the idea of ecological science as the primary authority about the environment began to flourish, the botanist Ruggero Tomaselli returned to the issue of the declining environment in the region of the former Roman Empire:

> "Over the centuries there has been increasingly serious interference with natural biological balances throughout the Mediterranean basin, which has impaired the original aspect of the countryside and brought about, through a constant process of deterioration, extremely precarious situations requiring urgent and appropriate remedies.
>
> One of the problems preoccupying ecologists, economists and forestry workers, together with thoughtful people everywhere, is that of the degeneration of the Mediterranean maquis.., which is so marked that entire regions which used to be evergreen are gradually being turned into desert."

Just a few years later in 1983, the naturalist and conservationist Gerald Durrell, who had spent a large part of his childhood in another part of the Mediterranean, the island of Corfu, wrote about the beauty of the French equivalent to maquis, and the many animals and plants one could find there and in similar habitats in California, Australia, South Africa and Chile.

> "The holm oak and other trees that are dotted about the terrain hardly ever grow to more than 12 feet high and the dry land is covered with wild herbs and heath…an astonishing variety of creatures inhabit this area. There are herds of wild boar and numerous forms of..reptiles…Many species of rodents thrive there also, and because of this you see a number of birds of prey, including quite rare ones…Such enchanting shrubland habitat goes under the name of "garrigue."..The hot air was heavy with aromatic scents from wild herbs and busy with a constant humming and droning from the insect hordes" (Durrell & Durrell 1982, p. 63).

Tomaselli (like Marsh, but with less historical nuance) attributes what has become known as the "degradation" of the Mediterranean maquis to woodcutting and agricultural practices starting with the Romans. Durrell was not unaware that the Mediterranean used to have more and larger trees and even wild lions. How then, could a sensitive naturalist immersed in Nature from his early life have been so enchanted by the state of the world surrounding him? What is it about degradation that he, of all people, could not perceive?

Many environmentalists explain this sort of thing by pointing to the psychological phenomenon known as the shifting baseline effect. This is the idea that whatever the state of the world is when we first observe it, this is what we consider to be good and appropriate. Ecologists thus claim that contemporary observers whose expectations are not set by historical conditions lose track of "How the World Ought to Be". Under this view, Durrell is naïvely misguided when he appreciates a present that is less rich than another state of the environment

in that place, in the past. He should be depressed, in mourning, struggling with despair. He should be restoring the habitat, not celebrating it.

While the shifting baseline psychological phenomenon does exist, the assumptions surrounding it can be problematic. Why do humans (or, indeed, a human such as Tomasseli rather than one such as Durrell) have the last word on how the world Ought To Be or what kind of environmental condition is a Bad Thing?

Defining good and bad ecological states

Ecologists and conservationists have long struggled to come up with some kind of universal regularities of environmental dynamics that could be used to classify empirical observations of the relations between living and nonliving things. This search for universal regularities helped establish ecology as a science, rather than a branch of history (that is, natural science vs. natural history). While other hard sciences, like physics, are also interested in different kinds of states of matter, they do not assign these moral valences or hierarchies of anthropocentric desirability. Solids, liquids and gases, for example, are alternative states of matter without values attached to them. Entropy is not understood as a bad force, and governments and NGOs do not set up committees to guide its eradication. This value neutrality does not exist in ecology. What I will call ecological states—organizations of biotic and abiotic[1] things into dynamic groups with trajectories of change and transformation—are assigned a complicated set of valuations and degrees or kinds of desirability. This desirability, although usually corresponding to certain situated social preferences, is naturalised as also indicating what is good for Nature as a whole.

Many recent critiques of ecology have pointed to the ways in which biology and ecology incorporated socio-economic models that were popular in the 1700 and 1800s, in which the living world is understood as analogous to a household economy. However, I think this critique, while accurate, is a little behind the times. Many of the assumptions derived from this household economy worldview, such as equilibria and fixed species distributions, have been challenged on purely ecological or biological terms, and are being abandoned by ecologists. There is a new socio-economic model taking its place, which I call the state model.

In the state model of ecology-as-economy, the living world is understood as a subject of state bureaucratic management. This is not just the observation that the biological and ecological become objects of governance and state bureaucracy: rather, bureaucratic governance becomes the primary subject of ecology. The state's interests in resources, stability, resilience, economic growth, etc., are implemented via different readings of neoliberalism[2] that are folded into ecological data formats intended to be directly used by civil servants and bureaucracies to perform centralized efficient allocation of resources across the landscape.

The state model is primarily, but not only, implemented through methods of remote sensing

[1] Biotic means living or dead, for example anything made with organic compounds; abiotic means everything not considered living or dead, such as rock or water.

[2] What is meant by neoliberalism is a complex set of claims that is not necessarily entirely coherent (see for example Mirowski 2013). Yet, as Mirowski discusses, the claims of neoliberalism have taken over theories and assumptions about nearly all aspects of vellus-haired ape behaviour, biological theory, etc., to the extent that they may be confused, at least in highly neoliberal economies like the US or Chile, with common-sense observations of "human nature"; neoliberalism has become an all-encompassing worldview in such contexts.

and spatial analysis. One of the specific claims often associated with neoliberalism is that markets, better than any other mechanism, perform efficient allocation of information: for this reason states often use economic concepts or mechanisms to arrive at the proper allocation of Nature to the territory. This is present in economic concepts like Natural Capital, or Ecosystem Services (now called Nature's Contributions to People). Nature's Contributions to People, originally a communication device for talking to businesses and state-level decision-makers when first presented in the Millenium Ecosystem Assessment, over the last fifteen years made the transition to a major research paradigm or theory, and the main expression of the state model. It does not depend on household economy-style equilibrium and fixist assumptions about how Nature Ought to Be. The efficient spatial arrangement of ecosystem states, farmland, water, and cities that the Nature's Contributions to People framework projects may, rather, be inherently unstable and "unnatural," which makes it all the more important that we use optimization techniques to create and maintain it. Nature now has no inherent dynamics or trajectories, consisting merely of background conditions (temperature, precipitation, elevation, etc.) that need to be taken into account as parameters when calculating optimization scenarios. Nature has become nothing but a boardgame surface on which resources are placed.

Degradation, previously of particular interest to empires and in colonial and post-colonial contexts, has regained relevance under the Nature's Contributions to People approach. Degradation is a main form of bad ecosystem state in this perspective, and one of the first reports of the Intergovernmental Panel on Biodiversity and Ecosystem Services[3] was devoted to assessing the current conditions of degradation in the world. Major global reports warn that degraded ecosystems, like the Mediterranean ones described by Marsh and Tomasello, are feared to lack the capacity to support human life; degradation may soon lead to the collapse of rainfall, soil formation, plant growth, and so on, resulting in mass starvation, disease, and armed conflict (IPBES 2018; UNCCD 2017). I argue that degradation, in the state model of ecology, can be understood either as an ecological state, or a process leading to an ecological state, that is unacceptable from the perspective of economic and development goals. This is not how these documents define degradation, because they define degradation as a pure ecology concept.

Degradation is usually defined in a pure-ecology way as a reduction in ecosystem productivity, through changes in species composition (usually losses in biodiversity), which are expected to be irreversible (IPBES 2018; UNCCD 2017). We might thus imagine degradation as a very specific case in which lower productivity, meaning conversion of carbon dioxide in the air to plant biomass, is aligned with decreasing biodiversity, meaning the number of species and evenness of their population sizes. There are plenty of ecological states where these two things do not coincide, i.e. biodiversity declines but productivity increases, or vice versa, or both are high together, so this could be a meaningful definition that forms a nice Venn diagram of things that are and are not degradation. On the other hand, what is meant by irreversible is not always very clear: when made explicit, this usually means that the ecosystem does not return to its immediately previous state within a few decades. Since ecological processes such as tree growth or peat layer formation can continue and mature over hundreds or thousands of years, a couple of decades is an ecologically meaningless timescale. This stipulation in the definition of degradation makes it clear that the concept is in fact designed to be relevant to socio-economic time frames.

[3] Intended to be the equivalent to the IPCC, by summarizing concensus scientific evidence and alerting the world's governance systems to ecological crises.

To understand why degradation is defined in pure ecology terms within a state model that converts ecology into bureacracy-ready material, we have to appreciate a parallel sociology-of-science force transforming ecology, which perhaps surprisingly has found plenty of synergy with the state model. This other important transformation of ecology is the progressive conversion of natural history into a hard science of ecology, which has been underway since at least the mid 20th century. One of the outcomes of the sciencification of natural history has been that explicitly qualitative, value-laden, historically contextual processes like those described by Marsh have been reorganized into strictly ecological, static, and universal categories. That is, the various deplored changes in the landscape of the Mediterranean stopped being facets of the instructive history of the Roman Empire, and were reconceived as a universal type or category of ecological state called "degradation". Degradation as a pure ecology concept supposedly extracted from history and culture, formally exists without reference to particular relationships to humans. Ecology derives its credibility as science (rather than as history) from claims of timelessness, universality, and the use of stand-alone concepts that do not require socio-cultural-political-historical contextualization.

There is thus a complex synergy between the sciencification of concepts like degradation, which are made to appear to lack social-cultural-political-historical aspects, and the state model of ecology in which ecological states become things that can be efficiently allocated with and for market and governance mechanisms, rather than via any inherent dynamics particular to living things.

Certain ecologists have continued to insist that Nature does have its own dynamics and trajectories, which have traditionally been called "succession", or on longer time scales, Earth system succession, which includes the evolution of new species and emergence of geological processes. In addition to being a challenge to approaches that treat ecosystems as inert things placed at will on a matrix or background, these claims have another cutting edge as well. They recuperate succession from being associated with descriptive natural history, and claim that it can be made to be part of a hard science approach to ecology because it has rules and regularities that can be quantified. Whether this is really true is another story.

Degradation as overlapping ecological states and economic situations

My claim is that degradation is the dysfunctional overlap or interaction between ecological and economic or livelihoods systems. Thus, I propose that degradation occurs in every phase of the life-cycles, or succession, of ecosystems: it is not a specific ecological state or separate phenomenon from succession. It can be found all across processes of ecosystem change, in any ecological state. The dysfunctions described as degradation typically take the form of a loss, restriction, or reduced rate of circulation of resources needed for an economic system. Resources are, of course, not objective things given by the environment, but particular uses, transformations, and valuations of materials, which are highly contextual and subjective. Thus whether an ecosystem is understood to yield any resources is entirely relative to the economic/ livelihoods/ productive system in question.

There are at least four ways in which livelihoods resources become scarce. The first is the most obvious, that is, a simple result of overexploitation of the resource through the emergence of uncoordinated economic demand. Despite what one might think, this is by no means necessarily the most common socio-economic cause of resource scarcity. Rather, many resources disappear because they are regulated out of existence—for example, they become part of protected Nature or part of private property, and can no longer be accessed by most

people (legally). Other resources become scarce because some second resource is being extracted from the landscape, which has been reorganized to produce this second resource, and this leaves insufficient space, energy, nutrients, or ecological functioning capacity to produce the first resource. The last way that loss of resources happens is that ecosystem states change through succession, but livelihoods arrangements are static or change more slowly, and do not respond adaptively to the changing ecology.

Resource overexploitation is often discussed as a process leading to degradation, but resource loss by regulation and by land-use are rarely understood as or recognized as forms of degradation. However, if we think of degradation as a dysfunctional fit between economy and ecology, then all relationships in which some livelihood lacks its resources, for any reason, are functionally the same as resource over-exploitation[4].

Next I discuss some case studies of the last three, less familiar, forms of degradation. Each case is highly contextual and relatively complex, underlining that degradation is everything except the application of a pure ecology definition to an ecological state. First, however, I start with a case in which despite persistent claims of degradation, the habitat in fact appears to be highly resistant to degradation.

Bowal: Resistance to degradation

Bowal, plural bowé, is a kind of grassland in West Africa. Bowalisation refers to the process of hardening of ferricretes or lateric crusts, these being soils formed by chemical weathering in the presence of iron in solution in water, usually over porous and sedimentary rocks. These crusts are covered only by thin layers of soil, and are found mainly on plateaus and hills in West Africa, interspersed with forests (Padanou et al. 2015). Bowalized soil prevents root growth and water retention, leading to bowé being dominated by annual dry-adapted grasses and scattered dwarf trees (Padanou et al. 2015). This also leads bowé to burn almost every summer, and can also lead to flooding or waterlogging at other times of year (Zwarg et al. 2012).

In parallel to this geographic explanation for bowal distribution in the landscape, colonial observers as well as current development programmes have claimed that bowé are caused by fire, overgrazing, forest fragmentation from woodcutting, overpopulation, and exhaustion of agricultural soils. These observers claim that the poor soils and lack of continuous tree cover have been created by a few hundred years of occupation by local African populations, notably causing the dramatic provocation of soil erosion. According to Padanou et al. (2015), bowé are unsuitable for livestock production and the only thing that can be grown on bowalized soils are nitrogen-fixing crops, otherwise they are abandoned and fail to recover within useful timeframes.

Bowé have also been reinterpreted as an example of colonial and post-colonial perceptions that the local rural people are, through ignorance and vice, mismanaging a previously lush and verdant continuous forest (André et al. 2003; Ballouche 2016). André et al. show that in Guinea (and by extension, throughout West Africa) the soil qualities of the bowé and

[4] Of course this depends on the perspective you take. From the perspective of a squirrel, it of course makes a difference whether local humans have overharvested all the walnuts so there are no more walnuts to be found, or just put a big wall around the walnut trees, because squirrels can climb walls. It also makes a difference to the walnut trees in question. One thing it probably does not make a difference to is the persistence of life on Earth itself. We could of course develop a multi-species concept of degradation, but I do not develop this issue in this particular paper due to lack of space.

landscape in general have existed since the last couple of million of years, strongly constrained by the underlying rock types as described above; moreover there is essentially no ongoing soil erosion due to these same characteristics. Traditionally, the local people use swidden rotations to grow fonio on bowé, followed by five to fifteen years of fallow. They supplement this by creating small fenced agroforestry gardens and woodlands in or near grazing areas, which are maintained with human and livestock feces, and other waste. It seems plausible that the failure to maintain crop fields on bowé, used as proof of their non-restorability in the ecological literature, is actually a misrepresentation or misunderstanding of traditional swidden fallow periods.

I suggest that bowal swidden farming is not on the verge of socio-economic collapse due to environmental degradation, but simply is not as economically productive as outside observers believe that their own farming systems would be, were they able to implement them. This is degradation as compared to a hypothetical resource production baseline. However, the geological and ecological resistance to more-intensive agricultural exploitation (that is, the essential unavailability of resources exploitable by intensive agriculture in bowal habitat) seems to prevent an economic mismatch of resource valuation and exploitation from actually being implemented.

Espinal: Degradation by regulating resources of out of existence or access

The changing fate of the 'espinal' silvopastoral woodland of central Chile is an interesting case in which changing understandings of what makes a habitat degraded, or whether it is degraded at all, make little difference to the way that degradation is imagined, mobilized and enacted from a socio-economic perspective. Central Chile, like many other semi-arid habitats of the world, was long described as degraded. The blame for this condition was placed on supposedly ignorant peasants and their supposedly irresponsible land-management practices. This discourse imagined mestizo peasant livelihoods practices as static, unadaptive versions of European peasant practices, unresponsive to and unaffected by historical events. This is certainly untrue however: the California gold rush of the late 1800s led to massive central Chilean deforestation to grow wheat to export to California. Once abandoned, wheat fields would have taken 50-100 years to return to a forested state. Land reform and its reversal in the mid-twentieth century also resulted in a large increase in fencing, parcelization of the land and probably thus forest fragmentation, and probably contributed to accelerating the conversion of latifundia[5] to industrial wine and fruit plantations[6].

It was also claimed and generally believed by ecologists working in Chile that the principal tree in the espinal landscape, the acacia *Acacia caven*, called *espino,* was brought to Chile by indigenous peoples or colonists from the Chaco (where it is also found), making it "invasive". With the excuse that espinal is a non-native tree formation, and degraded, the government has allowed it to be converted to industrial agriculture without compensation using a tolerated loophole in environmental regulations (which was finally closed in 2021).

[5] Large estates owned by colonist families, on which mestizo peasants who were essentially serfs worked. They did not own any property and were often paid in kind and kept in debt to the *patrón*. Land reform in the 1950s and 1960s confiscated many latifundia (*fundos*) and turned them over to peasant cooperatives. After the coup in 1973, many cooperative *fundos* were reappropriated and either returned to their original owners or sold to friends of the regime.

[6] Unfortunately I am not aware of any historical ecology studies of the impacts of economic developments and social reform policies on landscapes in the region.

After several decades of conservation neglect and habitat loss, espinal woodlands were discovered to be spontaneously undergoing succession to more-biodiverse native and endemic hard-leaf woodlands (Hernández et al. 2016; Root-Bernstein et al. 2017). This is because shade and moisture-loving endemic hard-leaved trees establish under the canopies of *espinos*—the opposite of what had been thought to happen—thus increasing tree density and forming small patches of forest-like conditions which gradually expand. After the forest has been razed, the espino is the primary early-succession tree species present in central Chile capable of establishing in full sunlight. It is, however, a hardwood tree, and thus grows slowly. Establishment of hard-leaf forest trees under *espino* canopies is also dependent on connections between woodlands that are made through the bodies of wild animals like birds that move seeds around, but also, since all large wild herbivores are extirpated from the region, through silvopastoralism itself: cattle move larger seeds, their herbivory may open forest tree germination spots under *espinos*, and when they are exposed to woodlands as juveniles they learn to eat around tree seedlings (which lack sugar) which may actually benefit the seedlings (Root-Bernstein et al. preprint). They also eat all standing grass and herbs, and may disturb leaf litter layers, both of which can contribute to the progression of espinal succession towards forest by preventing high-heat wildfires. However, the 50-100 year successional process will have given the impression that peasants, by creating and subsisting in espinal landscapes, degrade their own means of subsistence.

Funding through the UN REDD+[7] program, the UNCCD (United Nations Convention to Combat Desertification) mechanism, and the UNFCCC (UN Framework Convention on Climate Change) mechanism require that Chile develop plans for dryland conservation, degradation control, and restoration. This has forced the state to develop conservation and restoration plans for espinal. As part of these plans, traditional land-management practices, including silvopastoral cattle husbandry and leaf litter collection, have been targeted for eradication on the grounds that anthropogenic influences must be removed in order to restore forests (because humans and their ecological influences are bad). In a political context in which subsidies of the rural poor and smallholders are no longer considered desirable, peasants will be incentivized to folklorize their livelihoods for tourism. While I cannot assess whether folkloric tourism will end rural poverty, it does seem possible that the elimination of peasant livelihoods will actually *create* degradation of espinal and forests in two ways: firstly it will create woodlands in which peasants cannot access any resources for their traditional livelihoods, and secondly (due to the resulting accumulation of ungrazed grass and uncollected leaf litter) it will probably lead to increasing intensity and frequency of wildfires which will likely result in a state of low biodiversity and low productivity that takes many decades to reverse. In this sense, the debate about degradation in this region is, and always has been, a purely social and economic argument about how to eliminate the problem of the rural poor, cloaked in ecological concepts.

The Chaco: Allocation of part of the landscape to one economic model leaves insufficient space or energy to produce other resources for other livelihoods

The Chaco of Bolivia, Argentina, Paraguay, and Brazil, provides an example of how economics makes a material difference to ecologies—and not only in the obvious sense of how much habitat can be destroyed through resource extraction. The Chaco is a seasonally dry woodland type that formed a large block to the south-west of the Amazon tropical forests, covering 1,200,000 km^2. When models suggest that the Amazon will suddenly flip into a

[7] A funding mechanism to plant trees and/or prevent forests from being cut down, funded through global carbon markets or government subsidies.

degraded dry state due to deforestation, it would presumably resemble the Chaco or the Cerrado, the other large seasonally-dry forest south of the tropical forests. Seasonally-dry forests, as the name suggests, are dry half the year and wet the other half. Since the Pleistocene more or less, the Chaco has been a mosaic of grasslands, shrublands, and woodlands (Abril & Bucher 1999).

What is meant by degradation in this case starts with historical logging for picket fences and railroad ties starting in the late 19th century, extraction of tannin from trees, and intensification of the formerly extensive, low-imput ranching (Murgida et al. 2014; Bonino 2006; Bucher & Huszar 1999). Recently, further deforestation takes the form of conversion of timber forests and ranching lands to agriculture, for wheat (now largely abandoned) (Belotta et al. 2006) or soy (Murgida et al. 2014; Bonino 2006; Bucher & Huszar 1999). Logging was selective and preserved tree seed sources until the 1990s, when the use of bulldozers and fire to clear land for agriculture became widespread, reducing forest recovery and continuity (Belotta et al. 2006).

Rural peasants, a mestizo population, have recently expanded into the Chaco, first as cattle ranchers, and then, following overgrazing, as herders of browsing goats (Bucher & Huszar 1999). These rural peasants also, it is reported, no longer create degradation by deforestation but by collecting water in depressions they dig, called *puestos,* next to their villages. This alteration of the landscape is attractive and usable by some species, and unattractive or unusable to others. Bird diversity increases near *puestos* (Macchi & Grau 2012), but they are avoided by peccaries and jaguar. The livestock that use the *puestos* are also understood to locally alter vegetation composition, promoting spiny and succulent species, and reducing fire frequencies, by eating all the non-spiny and flammable herbs. Here, the reduction in fires is considered bad by ecologists, since fires caused by lighting or humans were common in pre-colonial times and plants are adapted to them.

Bucher & Huszar (1999) point out that the degradation of the environment via the *puesto* system corresponds to a degradation of the economic system. Influxes of mestizo peasants to the Chaco since the 1800s rapidly over-exploited timber and other forest resources that did not promptly re-accumulate, leading to widespread poverty and subsequent out-migration. These authors describe a form of restoration (the "Salta method") they have tested over 20 years that removes deadwood, thus reducing the populations of a rodent that lives in it and eats tree seedlings, and keeps cattle at very low densities only to act as seed dispersers. To address economic degradation, they consider how remaining local peasants, currently using the *puesto* system, will make a living in the restored landscape. They conclude that a mix of shrub and deadwood conversion to charcoal, selective logging, and extensive low-intensity livestock production yields almost 4 times the current income per hectare. Thus, both the economic system and the ecology could be restored together. However, it requires a substantial investment up-front and operates at a loss for the first 10 years. This, the authors recognize, is unattractive or impossible for peasants, without state support.

A noted degradation researcher who as a student was involved in assessing the ecological impact of the Salta method and comparing it to the *puesto* system, notes that both were quite biodiverse, but that this is now irrelevant since both have been replaced by industrial agriculture (Bestelmeyer 2014). He and other commentators note that the characterization of *puesto* systems as degraded helped justify their conversion to industrial agriculture.

Since the Salta method has not been invested in, restoration of Chaco forests is carried out by removing livestock and preventing logging for timber or charcoal production (Abril & Bucher

1999), which whatever its effect on ecological processes (probably mixed), reduces peasant access to livelihoods resources. While eradication of peasant livelihoods is, as always, treated as within the scope of ecological restoration, eradication of industrial agriculture is treated as a politico-economic issue outside the scope of ecological restoration, or perhaps simply outside the scope of the imagination. A study of the Chaco from a decade after the paper on the Salta method (Boix & Zinc 2008) is a good example of this. They propose to optimally allocate space in the Chaco to industrial crops (soy and others), traditional subsistence farmers doing what they already do, and conservationists. Conservationists, in their simulation model, are given the degraded land to make it productive through ecological restoration (at which point it is presumably allocated to soy production). This illustrates the scope of state-model approaches to restoration and conservation planning.

All of these approaches seem to ignore another facet of degradation in the Chaco. The Guaraní and Nivacle are two indigenous peoples of the Paraguayan Chaco[8]. The colonization of Guaraní and Nivacle lands, the incursion of Christian missionaries whose ideology went hand in hand with the economic needs of the colonists for cheap labor, and the degradation resulting from deforestation and resource over-exploitation has led to a smaller and smaller space left for their own livelihoods practices. They can no longer sow fields in the forest, hunt, gather, or pasture-- through a combination of lack of access to land and forests which are now private landholdings, and missionaries spreading an ideology of salvation from sin through wage labor. The Paraguayan ranchers who control the Chaco argue that lands left to the indigenous peoples and not converted to ranching or logging are "unproductive" or put to "irrational" use (Regher & Regher 2018). This productive use for the relatively small number of landowners also creates degradation from the perspective of the Nivacle and the Guaraní: some of the resources they used to live off may be there, but they have been excluded from them. The missionary teaching that wage labor is morally superior creates internal tensions in their communities, and is another way to degrade their access to their traditional resources.

Shrub encroachment: static production practices in changing ecosystems creates degradation

Shrub encroachment is an emblematic form of degradation, and a case in which some livelihoods are functional and others are not. Shrub encroachment is an increase in shrubs, which are perennial woody species: this does not necessarily lead to reduced productivity or reduced biodiversity. Shrub habitats are widely seen as inferior to both forests and grasslands, although in many areas of the world shrublands, woodlands and grasslands form mosaics and constantly interconvert under the influences of fire, rain, drought, herbivory, and soil nutrient cycling. The reason rangeland ecologists class shrub encroachment as degradation is because many ranchers believe that cattle, sheep, and other livestock cannot eat shrubs and that this reduces their productivity (weight gain).

Nevertheless, shrub encroachment is only degradation from the perspective of particular forms of ranching. This is particularly obvious when we note that in areas that have livestock but lack commercial ranching, the concept of shrub encroachment does not exist despite there often being a high abundance of shrubs. For example, in central Chile, despite centuries of small-scale cattle husbandry practices, and plenty of shrubs, shrub encroachment is never discussed or evaluated. On the other side of the Andes in Argentina, where ranching is larger scale and commercial rather than for subsistence, shrub encroachment in similar habitats is considered a degradation problem.

[8] All of the ecological literature on the Chaco is from Argentina. However, the history and social situations in the Paraguayan and Argentinian Chaco appear to be generally similar.

One might assume that this is because commercial ranchers simply have more demanding standards of production efficiency and scalability than subsistence cattle raisers, or are trapped in a productivist discourse that undervalues shrubs on a symbolic level, somewhat like the *espino* in Chile. However, it is also possible that commercial ranching practices *create* conditions in which cattle are underproductive in the presence of shrubs. It is generally assumed that cattle only eat grass, but in reality free-range cattle eat a very wide range of other plants as well (Molnár et al. 2020). Whether or not cattle eat shrubs and other plants depends partly on the shrubs present and their specific palatabilities: many shrubs are full of chemicals called "secondary metabolites", like the aromatic and bitter rosemary that we use to season food. Whether livestock eat these shrubs and flowering plants can depend on whether they are given the opportunity to socially learn from their mothers what to eat, which is not the case in many ranching systems which separate calves from mothers and keep cattle in feedlots for parts of the year or over periods of their lives. Some studies report that if cattle learn to mix aromatic shrubs or herbs with their other food, their digestion is improved and they gain weight faster (Provenza & Balph 1987). Economic imperatives for efficiency of production at particular scales, along with production methods that are tied to fixed properties and leave little leeway to allow cattle to select which vegetation associations across a landscape to forage in, are what seem to make a landscape with shrubs degraded.

Borneo : Degradation can be avoided, under some conditions

The last case study from Borneo demonstrates that under certain social and political conditions, multiple changing economies and changing ecosystems can manage to coexist, adapt and persist, at least until industrialized production methods that produce a single resource for a single use and a single social group, with no exploitable excesses, come to dominate the landscape.

In the kind of reflection that conservation ecologists rarely write, Putz has reflected on 40 years of economic and development changes in an area of Borneo that he visited repeatedly[9]. There, the indigenous Dayak peoples, who had long lived from hunting, gathering, and swidden agriculture in the forest, were moved off of their land and given houses in prefabricated villages in the 1980s. Their land was converted into a logging concession. They did not switch entirely to wage labor, but negotiated with the logging companies on the basis of their traditional land rights. The logging companies gave them access to the forests, which they now reached more easily on logging roads and in logging trucks. By the 2000s, the Dayak were still hunting and gathering forest products, as well as reoccupying logged areas with swidden farming, selling off their traditional land-rights to oil-palm entrepreneurs, and receiving royalties from the logging concessionaire, as negotiated through a community conservation agreement. Meanwhile, some of the previously logged areas had been reclassified as an industrial plantation. Putz notes various forms of degradation: soil erosion from heavy equipment and deforestation on steep mountain slopes, land-cover change to plantations, loss of tree cover and disappearance of seed-dispersing birds and mammals. There are, of course, concerns that this forty years of economic symbiosis between the Dayak peoples and various Indonesian entrepreneurs and companies is not sustainable. Regrowth of the logged forests, in the context of apparently high rates of defaunation, could shift the succession of forests into states unsuitable for Dayak subsistence, and equally unsuitable for continued logging. The replacement of logging concessions with forestry plantations is not encouraging either: acacia plantations produce almost no secondary resources for anyone or

[9] https://aesengagement.wordpress.com/2018/07/31/fates-of-forests-in-borneo-a-40-year-retrospective/

anything except the owner, which is compatible neither with conservation nor with the Dayak livelihoods.

Putz notes that the conservation solutions to preserve the forest that he promoted at different times over his career are situated in a socio-economic, political and legal context whose complexity and subtleties sometimes exceeded his knowledge. This is an important lesson. It is also instructive to note that indigenous peoples, when they have sufficient political rights or powers, may be able to negotiate a place for their livelihoods models, which may benefit from the roads, royalties, and markets of other models. Under the terms of the certification of sustainable logging practices at the site, the Dayak should not be able to use the forests for their subsistence. Yet they have managed to continue to do so, drawing on the kinds of discretionary capacities and local bargaining that get around rules designed to be globally applicable. Multiple economic models can coexist in ecosystems, although coexistence *per se* is no guarantor of long-term sustainability.

The state model in the context of succession

One of the problems with the state model approach to ecology is that its analytical approach is most suitable for minimizing the first and most obvious form of degradation, that is, uncoordinated demand for a resource leading to its over-exploitation. The state model, for example via Nature's Contributions to People landscape optimizations, aims to allow markets or other governance tools to rationally allocate and sustainably exploit resources. But it does so through the same mechanisms that create the other three forms of degradation. It regulates resources out of access through land-use allocation to conserved and restored areas, agriculture, industrial zones, and so on. It organizes landscapes around the production or allocation of particular resources or optimal trade-offs between them, and thus often leaves insufficient space, energy, nutrients, or ecological functioning capacity to produce other kinds of resources not valued by the state. The optimization model for the Chaco, for example, fails to provide landscape for Nivacle and Guaraní livelihoods. By ignoring the possibility of succession, the state model also reifies static economic states that may be optimized to mitigate the predicted effects of changes in climate (a background condition on the game board), but rarely considers adaptation to allow or respond to spontaneous change in the frequency, position, or identity of ecosystem states, such as shrub habitats.

I realize that my argument around what is and is not degradation, by focusing on social access to resources, may seem indifferent to what ecologists and conservationists are supposed to care about. Don't I care about species extinction, deforestation, and loss of ecosystem complexity and richness? Shouldn't I wish to protect them from conversion to resources, over-exploitation, and the destruction of life on Earth? On one level, yes: other species are beautiful and wonderous, and my experience of and ability to learn about the variety of species and ecosystems provides a profound epistemological exploration of life. On another level, I am arguing that ecological states, succession, and Nature itself do not aim to maximize biodiversity or productivity, or to ensure the maintenance of the identities of particular ecosystem states (stability or resilience). I argue that Nature has no inherent morality: it is not striving to achieve particularly abundant states, nor being ontologically thwarted by evil humans who drive it to uniformity, loss and shrinkage. I am arguing that from a pure ecology standpoint, we cannot argue that low biodiversity, low productivity and irreversibility are bad. The issue of why ecosystem states become smaller, simpler, less productive or less biodiverse, is indeed an interesting question, but to address it we need to remove the moral split between good and bad ecosystem states, and between the ecological definition of degradation and

succession[10].

Nor do I wish to give the unqualified impression that peasants and indigenous people have some kind of inherent right to continue living as they always did, and that industrial and modernized production systems are somehow inherently illegitimate resource uses. The Dayak in Borneo have adapted their traditional livelihoods practices and economy in the face of a changing landscape. Indeed, all indigenous peoples as well as non-indigenous peasant populations have always had adaptive livelihoods, and have invented new practices, technologies, and resources, both responding to and creating new ecological conditions. The difference between the case of the Dayak and the cases of the Guaraní, Nivacle, and central Chilean peasants, are that the latter have not consented, through a political process, to have their livelihoods profoundly altered through socio-economic degradation of the landscapes where they live. Their landscapes were, and are, being altered through processes in which they had or have no political representation. Degradation can be an adaptive challenge, but it is a problem only when it is a problem of social and environmental justice.

Because human economies are also part of ecology, it is not the case that the socio-economic dysfunctions are simply at the level of discourse, or simply layered on top of an independent ecology. Rather, as in the examples of shrub encroachment, central Chilean woodlands, and Bornean forests, economic systems physically interact with ecologies through resource alteration—and this is more complex than simple extraction. By affecting how cattle forage, learn, and gain weight, how certain materials (dry grass, dead leaves) accumulate or not in woodlands, whether cattle are permitted to enter woodlands to carry out ecological functions that aid woodland succession, and what kinds of resources are produced by forests that regenerate after logging, fragmentation, and animal extirpation, economies and the landscapes they create directly affect ecological processes and thus the ecological states that develop through succession. Note also that social and cultural transformations of a purely symbolic order, such as teaching Nivacle and Guaraní communities that wage labor is morally superior to their traditional livelihoods, or incentivizing central Chilean peasants to folklorize their practices as touristic spectacles, can also cause or contribute to material alterations to resource availability. Thus while degradation is, I argue, primarily a problem of what is recognized as a resource, what is valued, and who is allowed to have access to their cultural or livelihoods resources and values, it also has ecological impacts. Degradation in my socio-economic sense will thus often lead to ecosystem change. This ecosystem change might correspond to degradation in the pure-ecology sense of low biodiversity, low productivity, and short-term irreversibility, but this is by no means necessarily the case.

Bibliography

Abril, A., & Bucher, E. H. (2001). Overgrazing and soil carbon dynamics in the western Chaco of Argentina. *Applied Soil Ecology*, *16*(3), 243-249.

André, V., Pestaña, G., & Rossi, G. (2003). Foreign representations and local realities. *Mountain research and development*, *23*(2), 149-155.

Ballouche, A. 2016. Forêts *Versus* Savanes L'héritage D'un Forestier Colonial En Écologie Et Géographie Tropicale De L'afrique De L'ouest . P. 185-204 In Denis Chartier *et al.*, *Manifeste pour une géographie environnementale . Presses de Sciences Po.*

Bestelmeyer, B. T. (2014). Deforestation of "Degraded" rangelands: the Argentine Chaco enters the next stage of the anthropocene. *Rangelands*, *36*(4), 36-39.

[10] This part of the chapter is left out of this paper for our purposes.

Boix, L. R., & Zinck, J. A. (2008). Land-use planning in the Chaco plain (Burruyacu, Argentina). Part 1: Evaluating land-use options to support crop diversification in an agricultural frontier area using physical land evaluation. *Environmental Management*, *42*(6), 1043.

Bonino, E. E. (2006). Changes in carbon pools associated with a land-use gradient in the Dry Chaco, Argentina. *Forest ecology and management*, *223*(1-3), 183-189.

Bucher, E. H., & Huszar, P. C. (1999). Sustainable management of the Gran Chaco of South America: Ecological promise and economic constraints. *Journal of environmental management*, *57*(2), 99-108.

Durrell, G., & Durrell, L. (1982). *The Amateur Naturalist*. New York, Knopf.

Hernández,A., Miranda, M. D. ,Arellano, E. C., & Dobbs, C. (2016). Landscape trajectories and their effect on fragmentation for a Mediterranean emi-arid ecosystem in Central Chile. *Journal of Arid Environments, 127*, 74–81.

IPBES (2016). *The assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services on pollinators, pollination and food production.* S.G. Potts,V. L. Imperatriz-Fonseca, and H.T. Ngo (eds). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany.

Macchi, L., Grau, H. R., Zelaya, P. V., & Marinaro, S. (2013). Trade-offs between land use intensity and avian biodiversity in the dry Chaco of Argentina: A tale of two gradients. *Agriculture, ecosystems & environment*, *174*, 11-20.

Marsh, G.P. 1874. *The Earth as Modified by Human Action*. New York, Scribner, Armstrong & Co.

Molnár, Z., Kelemen, A., Kun, R., Máté, J., Sáfián, L., Provenza, F., ... & Vadász, C. (2020). Knowledge co-production with traditional herders on cattle grazing behaviour for better management of species-rich grasslands. *Journal of Applied Ecology*, *57*(9), 1677-1687.

Murgida, A. M., González, M. H., & Tiessen, H. (2014). Rainfall trends, land use change and adaptation in the Chaco salteño region of Argentina. *Regional environmental change*, *14*(4), 1387-1394.

Padonou, E. A., Bachmann, Y., Kakaï, R. G., Lykke, A. M., & Sinsin, B. (2015). Spatial distribution of bowal and differences in physicochemical characteristics between bowal and woodland soils in Benin, West Africa. *Catena*, *124*, 45-52.

Provenza, F. D., & Balph, D. F. (1987). Diet learning by domestic ruminants: theory, evidence and practical implications. *Applied Animal Behaviour Science*, *18*(3-4), 211-232.

Regehr, U., Regehr,V.,Allen, F. (2018). *Reconfiguraciones:Vida chaqueña en transición*. Fotosintesis, Paraguay.

Root-Bernstein, M., Holgado-Vargas, B., Bondoux, A., Guerrero-Gatica, M., Zorondo, F., Huerta, M. Valenzuela, Videla-Bello, A. Local ecological knowledge and forest resilience in a conservation landscape. Pre-print on Authorea

Root-Bernstein, M., Valenzuela, R., Huerta M.,Armesto, J., Jaksic, F. (2017). *Acacia caven* nurses endemic sclerophyllous trees along a successional pathway from silvopastoral savanna to forest. *Ecosphere* 8(2), e01667.

Tomaselli, R. (1977).The degradation of the Mediterranean maquis. *Ambio*, *6*(6), 356-362.

United Nations Convention to Combat Desertification (UNCCD). 2017. The Global Land Outlook, first edition. Bonn, Germany.

Zwarg, A., Schmidt, M., Janßen, T., Hahn, K., & Zizka, G. (2012). Plant diversity, functional traits and soil conditions of grass savannas on lateritic crusts (bowé) in south eastern Burkina Faso. *Flora et Vegetatio Sudano-Sambesica*, *15*, 15-24.