FINAL REMARKS

The contribution of this special issue is the presentation of new information that supports a novel consideration of the environmental consequences resulting from the adoption of cattle ranching in the American continent. Several questions for future projects and lines of work may be noted, such as: 1) the relationship that livestock had with the local flora and fauna, 2) the adaptation of livestock management practices to diverse environments with a natural and human history different to that of Europe, 3) the environmental and ecological history involved in the arrival and reception of livestock, and 4) the influence that different breeds of livestock had on the structure and function of Latin American ecosystems and the landscape.

The articles included in the present debate focus on the impact of the introduction of livestock in the American continent and on the conflict that took place between the dedication of land to either raise livestock or crop fields. The arrival of livestock to the American continent was massive and fast, beginning in the first decades of the 16th century and involving all regions - from wet to dry climates, from herbaceous vegetation to scrubland to forests, and from the lowlands to the highlands. In a short period of time extensive areas dedicated to raise old-world livestock became the predominant land use in all of America, accounting for the prevalence of cows, horses, sheep, goats, and pigs, as well as *"vaqueros," "gauchos," or "charros"*. The breeds and varieties of livestock that came from various regions of the Iberian peninsula and from the North of Africa were interbred, producing new breeds and varieties, as well as new forms of management stemming from traditional animal husbandry practices of the Mediterranean and Central Europe that ultimately fused together in a mode of animal husbandry without precedent in the entire history of livestock ranching.

The possible negative effects that livestock had on the American environment are generally focused on its impact on biodiversity, which was provoked by the deforestation and fragmentation of ecosystems, the creation of grasslands, and by the voluntary and involuntary introduction of exotic species that have eventually created *novel ecosystems (emerging ecosystems)* due to the loss of soil quality (fertility, structure, erosion) and to the contamination produced by livestock manure and the immoderate use of agrochemicals. These changes occurred rapidly due to the urgency with which livestock was introduced, and the amazing reproductive success of the herds.

The conflict that ensued over the decision to dedicate land to crop fields or the raising of livestock had its origin in the colonial redistribution of land, which privileged

Bases de datos: http://polired.upm.es/index.php/pastos (España), AGRIS (Italia), CAB Abstracts (Reino Unido), CABI Full Text (Reino Unido), Catálogo LATINDEX (México), DIALNET (España), ICYT Ciencia y Tecnología (España)

the use of livestock over that of agriculture. This rivalry probably had an immediate precedent in the Mesta in Spain, where a similar dispute in the 15th century resulted in the "derrota de las mieses" (defeat of the crops), which translated to the right for livestock to graze freely between vegetation and agricultural fields. In America the presence of domesticated animals also generated conflicts without discretion between indigenous, mestizo, and peninsular farmers. In the case of tropical rain forests, livestock moved freely throughout the landscape, including between the secondary vegetation and agricultural fields, thereby linking the landscape through the interchange of species and strengthening the process of secondary succession. These phenomena may be demonstrated in the proliferation of native grass species commonly called *"grama,"* which began to appear spontaneously as they were dispersed by livestock. It is possible that living fences, or rows of trees left behind in pastures, are an answer on behalf of the indigenous farmers to impede the entrance of livestock into their crop fields. Such fences were composed of secondary rapid growth trees, such as *Bursera simaruba* and *Gliricidia sepium* in Los Tuxtlas, cambronera (*Lycium* spp.), brambles or prickly pear cactus in Los Espinales, and cabuya (fique plants) in Villa de Leyva.

In some regions the introduced or exotic species had a significant role in the shaping of the landscape, influencing, for example, the process of secondary succession that takes place in agricultural or abandoned grazing sites. In the majority of regions and countries we do not know which species were introduced directly or indirectly with animal husbandry practices and which were incorporated in the structure of the ecosystems and landscapes, and in some cases they were invasive species. This introduction of exotic species has continued up to this very date, increasing particularly after the arrival of *Bos indicus* into tropical America and with the modernization of livestock farming. These exotic species together with the modern or more recent practices are having increasingly important repercussions in the shaping of grasslands and man-dominated landscapes that are becoming part of *"emerging ecosystems" (novel ecosystems).*

The consideration that the introduction of livestock was negative for the American landscape is shared by many specialists. Particularly in regards to the introduction of bovine livestock, which were the most abundant and spread more widely. It is necessary to point out that the arrival of livestock occurred in two qualitatively different fashions, the initial event stemming from the entrance of different breeds of *Bos taurus* in the Americas, originating in the basin of Guadalquivir in the Iberian peninsula. A large quantity of cows was left to roam free in the rain forests and secondary vegetation, where they prospered and increased considerably in number. This period began in the 16th century and depending on the region, lasted until the end of the 19th and beginning of the 20th century. During this time the livestock foraged on native plants, dispersing

seeds and herbaceous plants, bushes, and trees across the landscape, thus increasing the availability of species within the rain forest and sites of secondary vegetation.

The second event began at the beginning of the 20th century when cattle ranchers began to substitute original Mediterranean breeds for those of *B. indicus* from tropical Asia, with the goal of increasing meat production in tropical America. These Asian livestock breeds were raised in man-made pastures and fed with planted grasses, the majority African in origin, which were accompanied by numerous exotic species and occurred over a large extent - in the rain forests in southern Mexico and Central America as well as the Andean region. The proliferation of this kind of livestock led to an increase in deforestation and intense fragmentation of habitats, provoking also the loss of mobility of many native species, which further increased the isolation of remnant habitats into increasingly smaller fragments, presenting an additional threat to biodiversity the fragments and presented a threat to biodiversity.

The impact of cattle ranching in Latin America should additionally be understood within the context of several other events such as: 1) the disappearance of large native herbivores between approximately 10 and 12000 A.D., 2) the large quantity of plant species that depend on frugivores for seed dispersal 3) the existence of *coprophagous* beetles, 4) the large extensions of secondary vegetation resulting from the massive abandonment of the zones of agricultural cultivation due to the reductions in the indigenous population, decimated by new European diseases, and 5) the change in the property regime and schemes of land ownership during the colonial rule.

In each region of the Americas livestock was able to take advantage of variable quantities of forage, with a distinct proportion of species dispersed by animals, which established a peculiar relationship, in which predatory species began to suffer an onslaught of parasites and diseases. In Los Tuxtlas fewer predators were present, along with a large quantity of resources that could be used as forage additionally, the region has a dominant presence of *zoochorous* plant species. In comparison with Los Tuxtlas more predators and diseases existed in other sites, like Totonacapan.

Perhaps the argument that alleges that soil deterioration was produced by cattle ranching and resulted in environmental degradation is one of the most specific. This occurred in sites where livestock were stabled and the land was over-grazed. However, considering the livestock breed of *B. taurus*, its weight, hoof size, and the wild habitat to which it was accustomed to roam, its introduction to Latin America did not result in a drastic deterioration of the soil. In this scenario, soil deterioration could also have been a product of an inadequate pre-Hispanic and colonial management.

Another cause of erosion and loss of soil fertility was due to the displacement of the indigenous population from fertile and productive lands to those that were fragile, on steep terrain, and susceptible to erosion.

Considering that the cultivated surface area in Mesoamerica was extensive and that the agricultural practices were mainly design and implemented around the seasonal use and subsequent abandonment of the land, it seems clear that productivity depended in large part on the management of the process of secondary succession or forest regrowth. This process was rooted in the recuperation of soil fertility, useful native species, and the regeneration of the rain forest or native vegetation. This kind of management led to a greater resilience of ecosystems, which explains the biodiversity currently encountered in Mesoamerica. Such biodiversity is self-maintaining, in spite of the fact that the fragments are decreasing in size; this scenario is also occurring simultaneously in other regions, such as the Amazon.

The key to a greater resilience and maintenance of biodiversity most likely rests in maintaining the connectivity of the landscape. This is demonstrated by the presence of trees in open fields, a characteristic of forested landscapes - especially of both dry and wet tropical forests. These trees facilitate the movement of frugivores (mainly birds and bats), and pollinators throughout the landscape, guaranteeing the dispersion and pollination of many species. This feature of the landscape seems to have its origin in the deforestation practiced by many indigenous farmers, in which cycles of land use as crop fields were alternated with forest re-growth in the old-field.

In this context livestock farming incorporated itself into American nature, much in the same way that frugivorous mammals and birds dispersed fruits and seeds across the landscape. Not all fruits or seeds were attainable by birds and bats due to the hardness and size of the fruit, thus livestock farming has contributed to the connectivity between fragments and secondary vegetation through dispersion of fruits and seeds.

Livestock also quickly developed a relationship with different species of coprophagous beetles across the landscape, as livestock manure and its handling by these beetles increased the fertility of the soil and also contributed to the distribution of seeds by the beetles.

In the current landscape livestock farming has resulted in numerous isolated trees, spread out throughout pasturelands – a scenario that has a striking resemblance to the landscape of the Spanish and Portuguese *dehesas*. While this may be a coincidence, it could also represent a new design that has implemented both ancient and traditional elements.

The contributions assembled in this issue and their findings opens up a new range of explanations and possibilities that should be investigated and integrated quickly in the debate, as they represent a new possibility of managing the landscape in a way that would harmonize cattle ranching with biodiversity and development.

Sergio Guevara Sada