Article

Meadow degradation in a rural community of a protected natural area

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Abstract

In order to know the degree of degradation of meadows, as well as the social perception on how to avoid it, in the rural community Francisco Villa I, municipality of Jiquipilas, Chiapas, located in the area of influence of the protected natural area La Sepultura Biosphere Reserve. Since no similar studies in the region were found, it was considered a challenge to evaluate the degradation of the meadow from the local perspective and compare it with the technical evaluation to perceive that strategies to avoid and stop it can arise from the social initiative. The management characteristics of grazing areas and the strategies that producers would employ to mitigate the degradation of their paddocks were determined through 11 semi-structured interviews. To evaluate the degree of degradation, a probabilistic sample was selected, from 10 plots divided according to the botanical composition, in two systems of grazing areas: the naturalized one and the improved one, variables: vegetation cover [double sampling or botanal method of Tothill *et al*. (1992)], botanical composition [double sampling technique described by Haydock and Shaw (1975)] and tree inventory (Dallmeier, 1992). The analysis was descriptive, except for the variable of Vegetation cover, of Tukey's mean comparison ($p> 0.05$). Vegetation cover was higher (58%) for the naturalized grass system and lower (51.6%) for the improved one; the botanical composition was 37% of the *Cynodon plectostachyus* grass for the former and 34% of cover with the *Andropogun gayanus* grass in the latter, with 12 and 9 tree species, respectively. The level of degradation of the paddocks evaluated of the grazing areas was rated as moderate by the producers, coinciding with the technical results made.

Keywords: biosphere reserve, grazing, livestock farming, recovery of degraded paddocks.

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Introduction

The expansion of livestock farming increased at the expense of natural resources throughout Latin America. The impact on forested areas became more important in the early 60's, a time when the areas allocated to crops and grazing also increased (UI-UC/ATMO, 2018).

Extensive livestock farming, in addition to having local effects such as soil degradation and their loss of productivity, also contributes to emissions of CO_2 and other gases into the atmosphere (Pezo, 2018), in the last 50 years, the cattle population increased in Latin America, but the area under grazing only changed from 461 to 560 million (FAOSTAT, 2017), so the stocking rate increased from 0.44 to 0.75 animals ha^{-1}, values far from an optimal rate for most tropical and temperate zone meadows (Pezo, 2018).

The degradation of meadows is defined by Padilla *et al*. (2009) as a loss in their condition, product of environmental changes, understanding the condition of the meadow as the sum of parameters such as botanical composition and vegetation cover. The route to degradation ranges from losses in production, with the gradual reduction of the cattle herd, ecological changes such as alterations in biogeochemical cycles (Pezo, 2017) to social vulnerability to decision-making on the management of resources to which the producer and their family have access, such as the control of soil degradation and the consequent promotion of their recovery with the application of agroecological and economic principles (Solorio *et al*., 2017).

In Chiapas, this phenomenon is no exception, bovine production systems are based on extensive and semi-extensive grazing, because it is the most economical way to provide feed, which, together with management factors, such as burning to stimulate the growth of grasses, the use of agrochemicals, the management of the carrying capacity of paddocks, grazing intensity and interval can lead to meadow degradation (Zepeda *et al*., 2016).

In the protected natural areas of Chiapas, as in other areas in Mexico, human communities are in or around and depend on them in order to survive, for this reason, peasant knowledge and forms of significance and coexistence with nature are closely linked to the productive processes that are usually developed in areas delimited as buffer or sustainable development areas; knowing and valuing their referents can help to understand the way in which self-managed processes are generated for the construction of the sustainability approach in the production process (Barrasa and Reyes, 2011), as well as to prevent waste and deterioration (Owen, 1977), which is highly compatible with the conservation strategy that a protected natural area represents.

For all the above, the research aimed: to know the degree of degradation of the meadows for livestock use and the social perception on how to avoid it, in a rural community settled in the area of influence of the La Sepultura Biosphere Reserve in the state of Chiapas.

Materials and methods

The present work was carried out in the ejido Francisco Villa I located in the municipality of Jiquipilas, Chiapas, located in the 'La Sepultura' Biosphere Reserve, in the Sierra Madre of Chiapas, in the Southwest region of the state, between the parallels 16° 00' 18" and 16° 29' 01"

north and 93° 24’ 34” and 94° 07’ 35” west (Hernández, 1995), it includes part of the municipalities of Arriaga, Cintalapa, Jiquipilas, Tonalá, Villacorzo and Villaflores, with a total area of 167-309-86-25; 167 309 ha. The study was conducted at the beginning of the dry season between January and February.

Characteristics of study plots and sample selection

Walking tours throughout the community and interviews with the owners of each plot were carried out, to know the characteristics of the study areas (types of established grass, topography, presence of trees and cattle grazing), which determined a total of 59 plots with an average area of six hectares for livestock use. A sample size was determined with the previous information. Ten paddock plots were used to carry out the samplings, which represented 15% of the area of meadows for livestock use.

One hectare was considered as a sampling area in each paddock plot. The sample selection was of a non-probabilistic type (Hernández *et al*., 2014). According to the botanical composition, two systems of grazing areas were defined: the naturalized and the improved. In the first, with the introduction of grasses of a generation prior to the current ones considered as ‘improved’, with a predominance of African star grass (*C. plectostachyus*), while in the second, subjected to management techniques to increase productivity, the Gamba grass (*A. Gayanus*) predominated, it was also considered that in both systems there was the presence of trees, and that the topography had a slope greater than 40%. Five plots from each system were selected.

Descriptive diagnosis of meadow management in the community

To determine the management of the meadows in the community, the characteristics of the paddocks, as well as aspects of their management that could be related to the degradation of their meadows according to social perception, based on the assessment of peasant knowledge described by Barrasa and Reyes (2011), subsequently, a semi-structured focused interview was applied (Montes, 2015) to 11 producers of paddocks individually, who freely and consensually decided to participate.

Measurement of variables associated with paddock degradation

The variables measured in the paddocks of each type of grassland were vegetation cover of the paddock [double sampling or botanal method (Tothill *et al*., 1992)], botanical composition [double sampling technique described by Haydock and Shaw (1975)] and tree inventory. The sampling area was one hectare. The first two variables were performed with a visual method in a quadrant of 50 x 50, randomly thrown in a zig-zag path, with 70 repetitions. The cover consisted of writing down the quantity of soil covered by the plants within the quadrant and was expressed as a percentage.

The botanical composition consisted of writing down the name of the species within each quadrant and the visual estimation of the percentage present, the total found corresponded to the botanical composition of each study plot. The tree inventory consisted of a count of the trees present in the area, to which the data of species and diameter of stem at the height of the evaluator’s breast were taken, the latter was carried out with a dasometric tape, with the technique used by Dallmeier (1992). For this to be considered, the diameter of the tree was greater than 5 cm.

In both sites, the assessment of the categories of degradation level in which the plots are was carried out through the qualitative classification of Hernández *et al*. (2002), indicated in Table 1, who describe four levels and which were compared with the results obtained: 1) mild degradation with healthy pasture, >75% of cover, 0-25% of herbaceous weeds, strong grass with sufficient feed to cattle and soil with good filtration, provided with nutrients; 2) moderate degradation with weak pasture without nutrients and diseased, grass cover of 50-75%, invasion of undesirable and shrubby plants (25-50%), bare, eroded and compacted soil; 3) severe degradation with grass cover of 25-50%, undesirable herbaceous and shrubby 50-75%, secondary vegetation >1 m high, soil without nutrients, very compacted and eroded; and 4) very severe with paddocks areas covered with secondary forest vegetation.

The analysis of most of the variables was descriptive and was with frequency parameters and means with an Excel® spreadsheet. The exception was the variable of vegetation cover in the meadows in which a randomized block design was used, five paddocks with improved pastures and five with naturalized pastures were compared with Tukey's mean test ($p< 0.05$), using the Analest program version 2.0 (Instituto de Ciencia Animal, 1998).

Results and discussion

Descriptive diagnosis of pasture management in the community

It was found that, from the social perception, there is overgrazing in the plots studied. Each producer has, on average, six hectares and they have an average age of establishment of 13 years, in which they keep 18 animal units throughout the year (Table 1). On average, livestock areas have an occupancy time of 37 days and a rest time of 24 days [qualitative classification of Hernández *et al*. (2002)].

Table 1. Characteristics of the meadows and the management carried out in the livestock areas of a community located in the 'La Sepultura' biosphere reserve, Chiapas.

Characteristic	Results
Total area of livestock area	354 ha
Number of paddocks per producer	3 ±3.95 paddocks
Area per producer	6 ±0.8 ha on average
Age of establishment of paddocks	13 ±8.33 years
Number of AU per producer	18 ±8.9 AU
They carry out rotation of paddocks	100% do it
Rest or recovery time	23.8 ±8.5 days on average
Occupancy time	37.5 ±22.8 days on average
Aspects considered by the producer for an animal to remain in the paddock	That the paddock has enough pasture (100%)
Aspects considered by the producer to change animals from one place to another	When the pasture is finished (73%) When the grass is small (27%)
Type of production	Calf rearing (63%) Dual purpose (37%)

n= 11.

In general, for grasses, the recommended time of occupation of a paddock by cattle, in the rainy season, is considered five to seven days and the rest time of 21 to 30 days (Linares, 1991), so the results obtained in this work could indicate the existence of an overgrazing in the paddocks of this community, being the main cause of the degree of degradation found, which could have an impact on the botanical composition of the grassland, since the regrowth of the grass occurs during the first three to five days of having been grazed.

The average stocking rate in this community was 3 AU producer^{-1} and 8 AU ha^{-1}, a figure that is above the values recommended by the technical-advisory commission of rangeland coefficients (COTECOCA, 1980) which are 1.5 AU ha^{-1} and that, according to González *et al*. (2019), is a figure that indicates that overgrazing is favored, who indicated this when finding a stocking rate of 0.2 AU ha^{-1}. This could explain why the degree of cover is low (51%).

This high SR implies, in the medium term, greater risks of degradation in livestock areas, so strategies such as adjusting the number of paddocks in production units could be recommended to manage the recommended days of occupation and rest.

For this case, it would be recommended to manage on average 13 subdivisions of the area allocated to grazing, with an area of 1.4 ha each, considering, according to the climatic conditions, a rest time of 35 days and an occupation time of three days. The stocking rate could be reduced to 1.1 AU ha^{-1}.

Activities related to meadow management are shown in Table 2; in those that were related to pest problems, 18% of producers said they were combated using pesticides (mainly against the *Limax maximus* slug) and 82% admitted not doing so.

Regarding fertilization, 55% of producers do not carry it out because these inputs have a high acquisition value, while 45% of the producers who do fertilize, do it to produce more grass and do so using cattle manure and urea, in some cases as indicated in Table 2.

Table 2. Sanitary management of paddocks, presence of pests and undesirable plant species, in the livestock areas of a community located in the 'La Sepultura' biosphere reserve, Chiapas.

Characteristics	Results obtained	
Type of undesirable species present in the paddock according to the opinion of the producer	Asian crabgrass (*Digitaria bicornis*) (26%) Graceful mimosa (*Mimosa casta*) *(*21%) Green Sanburd (*Cenchrus brownii*) (16%)	Upright paspalum (*Paspalum virgatum* L.) (11%) Bullhorn acacia (*Acacia Vachellia cornigera*) (L.) Seigler & Ebinger (10%) Sleepy morning (*Waltheria indica*) (5%) There are not (11%)
Combating undesirable species	73% combat	27% do not combat
Methods used to combat undesirable species	Use of herbicide (75%)	Manually (25%)

Characteristics	Results obtained	
Type of potential pests that attack grasses	Striped grass looper (*Mocis repanda*) (20%) Slug (*Limax maximus*) (20%) There are no pests (32%)	Spittlebug (*Aeneolamia* spp.) (14%) Grasshopper (*Tettigonia viridíssima*) (14%)
Combating potential pests	Do not combat (82%)	They do combat (18%)
They fertilized	Do not fertilize (55%)	They do fertilize (45%)
They burn their paddocks	They do not burn (90%)	They do burn (10%)

n= 11.

In this regard, it is worth mentioning that when animal manure stays in the fields or is only accumulated without composting, a large amount of methane is generated; which has the potential to create a greenhouse effect at a rate 21 times higher than carbon dioxide (United Nations Climate Change, 2020), for this reason, a recommendation would be to focus efforts towards the circular economy approach proposed by Geissdoerfer *et al*. (2017), where every residue derived from grazing, such as manure, is used as a raw material and reintegrated into the cycle of matter and energy; in this case by composting to curb the effects of global climate change.

On the other hand, 90% of the producers of this community do not burn their paddocks since they mention that it is a practice that puts at risk the well-being of their meadow paddocks, eliminating pastures and some trees, in addition, this practice is restricted by the local authorities of the community and they run the risk of being sanctioned, only 10% do so and in order to clean the paddocks (Table 2).

The producers mentioned some species of grasses and trees that they would like to be able to plant in their meadows to improve the quality of their forage for their cattle; 45% of them mentioned *Megathyrsus maximus*, followed by 27% of *Sorgum vulgaris*, to create a cutting and hauling feeding system because these species have a higher yield and can be used in the dry season, the remaining 27% mention grass species such as *Cenchrus clandestinus* (Syn. *Penisetum* sp.) and *Urochloa brizantha* (Syn. *Brachiaria brizantha* Link).

These species are a good forage option to introduce into their paddocks, since they are improved species that under different associations can be used by animals, as shown by Hoyos *et al*. (2021), who considers this species as potential to improve the supply of fiber from meadows, if it is under a silvopastoral system.

As for *U. brizantha*, Cruz *et al*. (2015) show evidence that, in combination with other improved grasses, they can reach 95% of the land cover, as well as average weight gains in the animals that consumed this combination in four weeks of having been sown (Table 3). Tree species such as Primavera (*Tabebuia donnell*) and Bay cedar (*Guazuma ulmifolia*), planted in silvopastoral arrangements such as live fences, protein banks or scattered in paddocks, were the main tree species mentioned by producers as an option to reduce the effects of degradation, as well as for other uses as forage for their animals and to produce wood or firewood.

Table 3. Individual perception of the degradation of the paddocks and the possible management to prevent or minimize it, in the livestock areas of a community located in the 'La Sepultura' biosphere reserve, Chiapas.

Results obtained	
Grasses that predominate in the paddock	1st place: Gamba (*Andropogon gayanus*)
	2nd place: Star (*Cynodon plectostachyus*)
	3rd place: Giant thatching grass (*Hyparrhenia ruffa*)
Forage they would like to sow	Tanzania (*Megathyrsus maximus*) (46%)
	Sorghum (*Sorghum vulgare*) (27%)
	Cuban grass *Cenchrus clandestinus* clone Cuba CT-115 (18%)
	Palisade grass (*Urochloa brizantha*) (9%)
Tree species that they would include in their paddocks to recover them	Primavera (*Tabebuia donnell*), Bay cedar (*Guazuma ulmifolia*) and hartweg's pine (*Pinus rudis*)
How they would plant the trees	Live fences, protein bank and scattered
Area of the livestock area that is degraded	2 ha per producer average
Level of degradation in which the paddocks are	More or less degraded

n= 11.

This coincides with Sotelo *et al*. (2017), who mention that as they are nitrogen fixers, they help to enrich the content of this element in the soil, increase the productivity of the plot and improve the diet of the animals, while Pezo (2018) indicates that the presence of trees, in addition to the characteristics already mentioned, contributes to improving the resilience of the productive system (Table 4).

Table 4. Percentage of presence of species (as an indicator of botanical composition) in paddocks of two systems, in the livestock areas of a community located in the 'La Sepultura' biosphere reserve, Chiapas.

Species or type	Botanical composition (%)	Overall average
	Improved grassland system (n= 6)	Naturalized grassland system (n= 5)
Gamba grass (*Andropogun gayanus*)	34	2.4
Molasses grass (*Melinis minutiflora*)	1.4	0
Giant thatching grass (*Hyparrhenia ruffa*)	7.4	2
Bahiagrass (*Paspalum notatum*)	0.4	4.6
Star (*Cynodon plectostachyus*)	0	37
Guinea grass (*Megathyrsus maximus*)	0	0.2
Undesirable species	8.4	11.8
*Total (%)	51	58

*= the total is related to the percentage of species found by surface area during sampling, the rest corresponds to bare soil

Regarding the degradation of the paddocks, as indicated in Table 3, the producers themselves considered according to the following criteria: presence of landslides, low grass yield and presence of undesirable species under their perception, that their paddocks are in regular states of moderate degradation and that on average they have two degraded hectares, which represents 6% of the community's livestock area (Table 4).

Variables associated with paddock degradation

Vegetation cover of paddocks

Vegetation cover was different ($p> 0.05$) between the study sites, with 51.6% and 58% for the system with improved grasses and the system with naturalized grasses, respectively (Table 3). This result can be caused by the effect of nitrogen deficiency on improved pastures since it is one of the main factors that destabilizes the pasture and causes the onset of degradation.

In this sense, the higher value on the part of the system with improved grasses gives an indication that the new forage germplasm, supported by technological effort, is a better option for the sustainable intensification of livestock production, as mentioned by Pezo (2018), in this sense, the degradation becomes evident and the need for a future renewal of pastures in the area is proposed.

Botanical composition of paddocks

Table 4 shows that, in the meadow under the improved system, the *Andropogon gayanus* grass is found in greater proportion and five species of plants were found, including undesirable species, of which four were grasses, among them introduced improved and naturalized.

The species present in a smaller proportion in the same system, such as the grasses *Cynodon plectostachyus* and *Megathyrsus maximus*, as well as *Paspalum notatum* have suffered a low recovery rate after grazing, which may be the cause of the low yield that these species have had and the cause for which an introduced grass is present. It is important to make it evident that the presence of different species plays an important role in the condition of the grassland and the ecological and productive implications that these bring to the productive system and its management practices (Merchant and Solano, 2016).

In the case of undesirable species, the way they affect the condition of the meadow is because they have a faster development than grasses, so they occupy the areas of bare soil, drastically affecting the condition of the meadow (Table 4).

In the case of the other species that are consumed by cattle, their mere presence represents a competition for nutrients and space, however, being in the face of climate change and the consequent shortening of the rainy period, the plants with the most rusticity or greater potential for adaptation will be those that will settle (Pezo, 2017) and those that give the soil its characteristics that can make it more resilient to degradation.

Tree inventory

Table 5 presents the tree species found in each system and specifies the number of species found. Among the main woody species found in the paddocks in greater quantity are the cedar (*Cedrela odorata*), bay cedar (*Guazuma ulmifolia*), oak (*Quercus penducularis*), for being the most representative in the paddocks of introduced and naturalized systems. This is important as trees in paddocks areas destined for grazing areas represent diverse ecological and economic benefits.

Table 5. Tree species present in the meadows of the improved and naturalized systems, in the livestock areas of a community located in the 'La Sepultura' biosphere reserve, Chiapas.

Species		Improved system		Naturalized system	
Common name	Scientific name	Average quantity per ha	Measure DBH Average	Average quantity per ha	Measure DBH Average
Cedar	*Cedrela odorata* L.	29.4	14.78	11.2	14.33
Oak	*Quercus peducularis* NÉE	9.2	10.93	7.2	14.09
Bullhorn acacia	*Vachellia cornigera* (L.)	8.4	7.52	1.2	9.37
Hartweg's pine	*Pinus rudis* Endl.	5.6	25.47	-	-
Bay cedar	*Guazuma ulmifolia* Lam.	3.8	11.43	15.8	13.36
Pink poui	*Tabebuia rosea* (Bertol.)	1	5.93	1.2	33.8
Guanacastle	*Enterolobium cyclocarpum*	0.8	16.96	0.4	14.72
Gumbo-limbo	*Bursera simaruba* (L.).	0.6	8.42	-	-
Seagrape	*Coccoloba uvifera* (L.)	0.2	26	0.2	9.92
Willow	*Salix bonplandiana* Kunth	-	-	1.2	29.97
Brown-woolly fig	*Ficus drupacea* Thunberg	-	-	1.2	37.36
Coconut palm	*Cocos nucifera* L.	-	-	0.2	25.6
Chincuya	*Annona Ppurpurea*	-	-	0.2	16.96
Avocado	*Persea americana* Mill.	-	-	0.2	11.2

Strategies to counteract the degradation of paddocks.

In silvopastoral systems, there has been a dynamic of continuous transfer of nutrients between grasses and trees, which use nutrients for their metabolism and return them as senescent material of aerial and root biomass (Martínez *et al*., 2014), therefore the presence of tree species in paddocks offers an alternative to reduce pasture degradation and soil compaction (Roca *et al*., 2018).

These strategies are implemented by some of the producers and have been learned through the intervention of some educational institutions. For producers, the most important are to reforest, not burn and to sow pastures in areas poorly populated by plants (Table 6). These practices are easy to carry out and do not require high economic costs, which is why other practices are not implemented since most producers are low-income. A practice that was not mentioned is the increase or subdivision of grazing areas to reduce the stocking rate present and with it the risk of degradation; however, the producers interviewed did not consider it as a possible strategy.

Table 6. Strategies to counteract the degradation of meadows from the local perspective, in the livestock areas of a community located in the 'La Sepultura' biosphere reserve, Chiapas.

Activity	(%)	*Frequency	**Level of importance
Reforest	21.05	8	1
Do not burn	18.42	7	2
Sowing grass	15.78	6	3
Organic fertilization	13.15	5	4
Paloapique (fence)	10.52	4	5
Silvopastoral system	7.89	3	6
Rotation of paddocks	2.63	1	7
Sowing legumes	2.63	1	8
Level curves	2.63	1	9
Request credits	2.63	1	10
Request technical assistance	2.63	1	11
Total	100	38	

n= 15; *frequency= number of times each strategy is mentioned; **= level of importance= order given to each strategy.

The activities with less importance are to request credits and technical assistance, which would cause economic disbursements to producers and a series of procedures to which they are not accustomed to carry out.

The above coincides with Flores *et al*. (2018), who claim that overgrazing causes both ecological degradation by reducing forage and altering vegetation, while economic degradation may occur since it is not profitable to transform areas into less productive ones with the idea of producing more cattle because damage to the soil can occur and the chances of producing more meat decrease. This marks a precedent for future training in these areas, whose ecological and economic vulnerability can have an impact on the conservation of the adjacent protected natural area.

Conclusions

The results of the stocking rate, cover values, presence of undesirable herbs, botanical composition and forest inventory indicate that degradation occurs in the degree of moderate. The degradation of meadows is avoided or stopped by producers with actions that are within reach of their technological level and their economic possibilities. Social perception as well as recorded values indicate that degradation in the meadow is in the category of moderate.

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