An Explanation of the Bolivian Highlands Grazing ⇄ Erosion Syndrome

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Abstract

Highland Bolivia is naturally subject to heavy erosion. However the situation is exacerbated by the presence of denuded ranges. Apparently, the large bands of (mainly) sheep and goats, which are the cause of overgrazing, are on or close to the biological limit of the range resource. Why this should be so has been a mystery to outsiders, since all available grazing is subject to private or communal control. The notion that an adequate explanation can be found in free competition for a common property resource is rejected mainly because what appears to be common rangeland really is not. An explanation for overstocking is found in a complex of factors linked to culture and tradition as well as to agronomic forces. Typical pressure for families to maintain herd sizes is reinforced by little preception of erosion as a threat to subsistence and by lack of forage alternatives in bad years. Even at the community level, therefore, there appears to be little incentive voluntarily to reduce grazing. Three nonvoluntary control options are discussed, but all would be difficult to introduce. This "case study" is an illustration of the kind of background knowledge that must be developed in order to combat erosion in third-world settings.

About 220,000 rural families make their home in the highlands of Bolivia. Most of them are Aymara or Quechua Indians who depend, for a large share of their living, upon the output of mixed enterprises involving cultivation of several small plots and ownership of various types of animals.

A typical family owns one or two oxen, a cow, and 15 to 35 sheep. Often a burro is kept as a pack animal, and one or two pigs are fattened each year. A rabbit or two, plus a dozen chickens, round out the animal inventory. The main crops are potatoes (including bitter varieties that are frost-resistant), quinoa (*Chenopodium quinoa*), oca (*Oxalis tuberosa*), broad beans (*Vicia faba*), and barley. At some lower elevations or in sheltered spots, wheat or maize can be grown.

The highland may be visualized as an oval-shaped area extending from Lake Titicaca towards Argentina. These lands, covering about 210,000 km^2, have elevations above 3,000 m. The western north-south segment, the Altiplano, lies between two giant mountain ranges and covers about 142,000 km^2. Passes through the eastern range lead to a series of high valleys (comprising the eastern north-south segment) that rapidly fall away from the average Altiplano elevation of over 4,000 m.

All of the highland areas are marked by a pronounced dry season, which lasts over half the year. Rainfall of up to 450 mm is concentrated in the summer months of December, January, and February, and hail is always a threat. In the highest parts of the valleys, and in various places in the Altiplano, it is possible to have frost every month of the year. Erosion is extensive, and cultivated soils lack basic nutrients (Leyters 1963; Grover 1974; Whitaker and Wennergren 1976; Parker 1975; Carter 1964; Parker 1975b; and Wood 1975).

Under such conditions agriculture is difficult and risky. Nevertheless, an adaptation to the natural environment originated by the earliest inhabitants has persisted with little modification to the present day. The Incas and their predecessors took advantage of a relative freedom from pests and diseases, reliable rainfall, and considerable open range that could support a llama (*Llama glama*) population required for pack animals. Plants were domesticated that proved to be good human food and energy sources (notably potatoes). In addition, efficient technology, recognizing the value of legumes, crop rotation, and irrigation was institutionalized (Aitken 1975; Wood 1974; and Prescott 1951).[1]

While the risks to individual *campesinos* from hail or frost damage are substantial, the overall system is stable and has sufficed to supply the evolving needs of rural people plus a major share of basic staples for urban dwellers for a great length of time. Naturally, with the general growth of population, there has been a concomitant increase in demand for crop and livestock output, especially from the better lands. In many locations, these have been extensively subdivided; but ignoring specific counter examples, land resources are still substantial for even the best are not cropped each year except in certain locations (Carter 1964).

The picture for animal production is considerably different: grazing areas are "cropped" each and every year, and the large numbers of (especially) sheep and goats overgraze to such a degree that denuded ranges are probably the most obvious indication of pressure on agricultural resources (Parker 1975; USU Advisory Group 1975; and Stevens 1975). The opinion has been expressed that the population of scrawny sheep and goats is about at a biological limit (Michaelson 1975) and that excessive numbers make range improvement very difficult, if not impossible (Draper 1973).

The other side of the coin is the extent of the erosion everywhere apparent (see Figs. 1,2, and 3). These effects are most obvious in the high valley areas, but the Altiplano itself is not immune because it is broken by low hills and undulations in

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The interpretations and conclusions presented in this paper are based upon specific field interviews and experiences of the authors in Bolivia during the period 1971-1977.

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[1] The Spanish introduced some old world crops, but of these only barley is hardy enough for the Altiplano; wheat is only grown in protected areas or at altitudes closer to 3,000 m. In contrast to the continued heavy reliance upon indigenous flora, introduction of old world fauna has had a big impact. Prior to the Spanish conquest, only the llama (*Llama glama*), alpaca (*Llama pacos*), dog (*Canis domesticus*), and guinea pig (*Cavia cobaya*) had been domesticated. The presence of bovines, especially, has allowed substitution of animals for human tillage power.

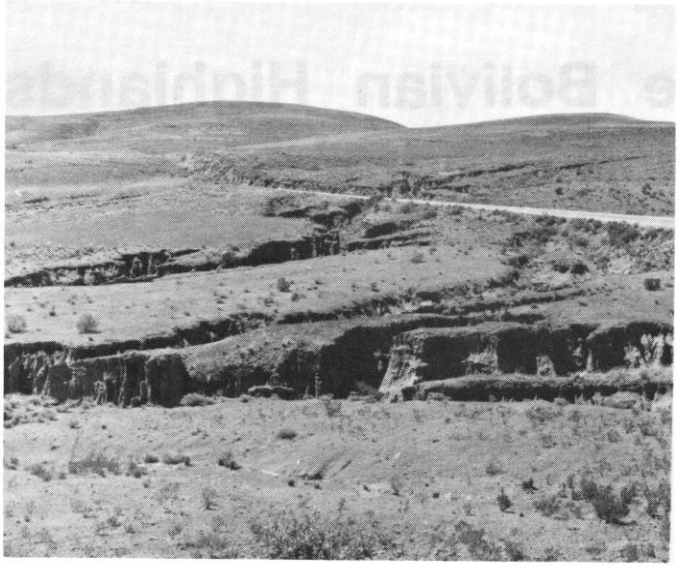

Fig. 1. *Erosion on the rangelands in highland Bolivia.*

every direction.

It is the well-known interrelationship between heavy grazing and erosion that provides the focus of this paper. In highland Bolivia, overgrazing persists in an institutional setting that might be expected to rule it out: all highlands lie within defined village boundaries (none are "government" owned); there are strong traditions of mutual endeavor and problem solving. An outside observer must therefore ask, "If villagers cooperate in so many ways, why don't they control grazing in the common interest?" In this paper we explore some answers to this question.

Is Overgrazing the Consequence of Competing for Common Property Resources?

In order to set the stage for our explanation of the Bolivian grazing⇄erosion syndrome, it is necessary to deal with a conjecture that might be made by any observer familiar with the history of range management in North America: grazing lands within village boundaries are being treated as a common property resource. If this were true, no further explanation would be necessary for observed over-exploitation of the range resource. Certainly, when one observes what appear to be absence of grazing controls and general lack of management, it is easy to make such a judgement (Whitaker and Wennergren 1976). Nevertheless, for the conjecture to be valid it must be possible to show that, even though villagers cooperate or are regulated in many ways, for some reason they are not constrained in active competition for grazing resources. Or, to put it another way, falsification of the common property explanation requires merely a demonstration that patterns of village cooperation do not break down in competitive rangeland use and/or that there are controls over rates of individual family utilization. In this section we made such a demonstration so that the way is cleared for consideration of our alternate explanation for overgrazing.

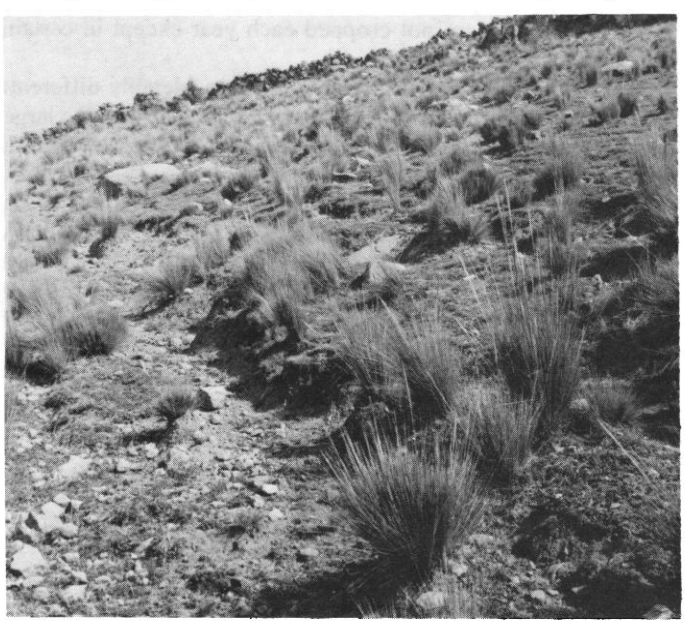

Fig. 2. *A typical scene showing overgrazing and early stages of erosion.*

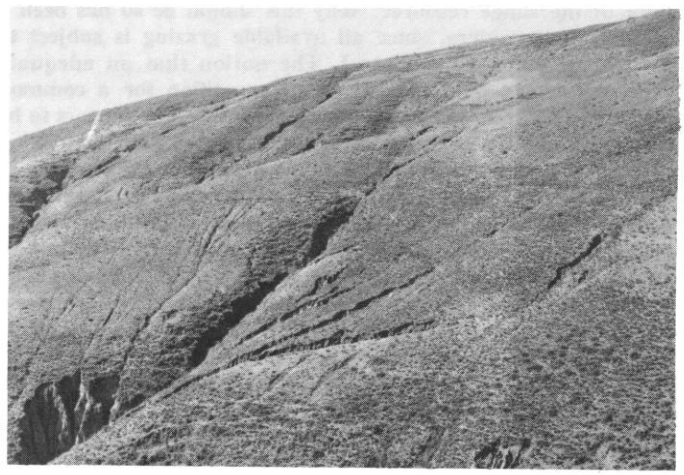

Fig. 3. *Much of the farmland in highland Bolivia is on steep terrain. The lighter patches are fallow fields that may not be farmed again for 10-20 years, but are grazed every year.*

Since Bolivian experiments to control runoff with heavier groundcover are virtually nonexistent, there is no way to be certain of the degree to which erosion might be slowed by management techniques. All that can be assumed is that more vegetation would help (Parker 1974). What is known is that native species will recover very rapidly if protected (Parker 1975a; Parker and Alzerraca 1974; Parker 1974) (see Fig. 4). Also, some nutritious species, previously thought to be extinct, could enhance the quality of available forage if they were allowed to make a comeback (Parker and Alzerraca 1974; and Parker 1975a). As things stand, little benefit can be obtained from this knowledge in the absence of reduced animal numbers or controlled grazing. Based on United States' experience, we would not expect either action to be voluntarily selected.

In the early days following the white man's settlement of the American West, private persons grazed cattle and sheep more or less to the extent individually desired. Time passed, rural populations and animal numbers increased, and various strategies were employed to maintain first-come-first-served exploitation of the available forage. Overgrazing removed the plant cover from large areas, water runoff was not controlled as previously, and a considerable erosion on land resource destruction occurred. Since it was in no one person's interest to introduce protective measures on the common lands, all the classic symptoms of external effects associated with use of a

Fig. 4. *Bolivian* campesinos *compare the height and density of native range grasses under the cage with those outside the cage while the Extension Agent explains the importance of controlled grazing.*

common-property resource eventually became evident: private costs were below social costs, and the resources were overexploited.[2]

The grazing $\rightleftarrows$ erosion syndrome was broken in the United States when the federal government elected to restrict private entry to common lands by granting individual controlled use rights to defined areas. A system of range permits, plus annual fees, was the way chosen to minimize external effects and set in motion forces and actions that might eventually lead to a reversal of the trend in erosion and other environmental decay. About 40 years have passed since controls were introduced, along with other reclamation measures such as revegetation. Today, most public or common grazing land may be said to be in fairly good condition from a revegetation standpoint, and erosion has been slowed.

Thus, in the United States' experience, it is possible to study the grazing $\rightleftarrows$ erosion syndrome in a particular cause/effect setting and one way of breaking it. In the Bolivian situation, the syndrome certainly exists, the results are the same, but what about the cause? Does the common property notion fit the Bolivian setting? Our answer is *no* because of what can be said about village cooperation, social controls, and actual access to common land. The social factors are dealt with in the remainder of this section and the question of access is taken up later.

Cultural Stability, Cultural Predictability, and Order

The degree to which highland *campesino* lives are structured is somewhat dependent upon whether, before the Agrarian Reform of 1953, their community was part of a "free" Indian village or fell within the boundaries of a hacienda. These latter villages were the source of tenant farmers (*colonos*). In the first case, following the Spanish conquest, the age-old system of Inca tribute was turned into a taxation system, into support of churches, or even eliminated at the lowest levels (Carter 1964; Dorsey 1975). In the latter case, the tribute system was bent to the end of supporting a hacienda operation by supplying free labor to the *patron*. In the case of either, however, there was little change in the traditional structure of community hierarchical public offices, through which any tax or labor tribute was extracted.

These offices continued to be positions of greater or lesser responsibility to the community as a whole and conferred particular stature and authority on the holders. Naturally, within the hacienda system, the patron reserved certain appointment powers to himself, but never 100 percent. According to Carter (1964), Dorsey (1975), and our own research, these offices still exist, and the competition for them and the attached social status and power is keen.[3] The authority of each office is exercised towards communal ends; family groupings of bilaterally reckoned kindred (*ayllu*) must respect such authority.

An awareness of *ayllu* and community responsibility, reinforced by the idea that those who have "given" the most must be accorded the highest status, is ingrained from early age. This creates a desire for acceptance, and for belonging, that is not easily outgrown. Individuals see and refer to themselves as members of a known *ayllu*. In this way, individuals experience a sense of community, the most outward expression of which is a tradition of mutual aid (Carter 1964; Chirinos 1975). Such aid takes many forms: gifts of food or animals to those who suffer unusual loss or are unable to provide for themselves, labor exchange, working for hire to obtain desired seed or other special products, arrangements to combine excess seed with excess land, and other types of sharecropping. Most of this cooperative and mutual aid is confined within *ayllus*. Finally, each community maintains a separate entity by adhering to endogamous marriage rules. Among the Aymara, for example, 75 to 85 percent of all spouses came for the community itself, and the same holds true for 50 to 75 percent of all Godparents (Carter 1964).

> Community members generally do not find [social and economic] security outside the local community, therefore, the outside world is viewed as a world of danger and risk. . . . A member of the Indian community is taught that independent action in the environment of the Andes is doomed to fail, and that only communal action is successful. (Aitken 1975)

Social Sanctions and Grazing Control

None of the above suggests that whole communities would allow some families or family groups to gain so much access to common forage that others would be unduly harmed. In fact, our field research reveals that all kinds of mechanisms are employed to eliminate or minimize first-come-first-served family competition. These vary from limitations on absolute animal numbers to preseason range inspections to set the number of weeks or months of allowable grazing. Sometimes grazing is confined to certain hours of the day. Even in cases where there seem to be no controls (Dorsey 1975), the village leaders will say, "No one uses more than they need." Elders also imply limitations when they say, "Families cannot afford more animals than the [base property] will support during nongrazing periods."

The concept of seeking status is not equivalent to the notion of one family trying to get ahead of another economically:

"Suppose a rich family increased its use of the common range very greatly, what would happen?"

"They wouldn't try."

"Let's put it another way. Suppose some family tried to graze animals beyond their needs?"

[2] Social cost includes all private grazing costs plus the costs of floods or mudslides, or insurance against such calamities, reduced grazing in the future, etc.

[3] Candidates must bear the expense of gifts, shrines, and fiestas associated with particular offices. This is very expensive and in extreme instances the cost can reach $1,000. The ladder of community offices moves up from dance group leader, defender of crops from supernatural or ordinary threats, school mayor, major fiesta sponsor, plus repair of the community chapel, to *Jilakaata* or headman. In addition, on haciendas there were several additional tribute labor posts, some of which were sought after since they conferred special rights or were recompensed with extra food (Carter 1964).

[4] "Natural resources are important only inasmuch as they are contained within one's small, almost private world. Tragedy to a neighboring community is looked upon with complete indifference." (Carter 1964).

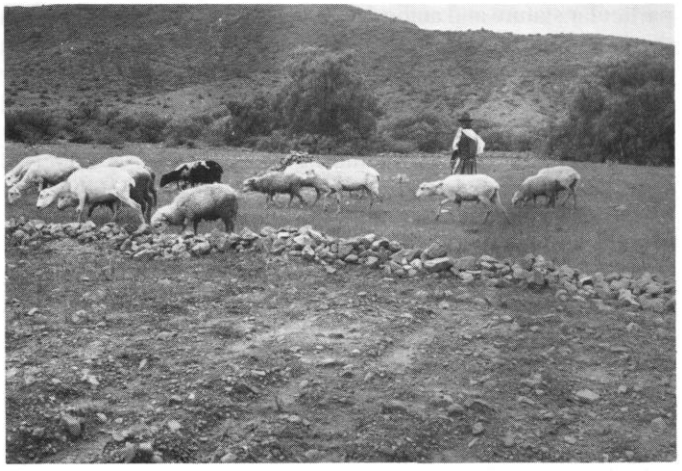

Fig. 5. Criollo *sheep get much of their feed from idle farmland.*

"The Council would caution them."

"Suppose all of a family's sheep suddenly died. Would other families increase their own herd size to take advantage of the 'additional' feed?"

"No. If the family has money, it can buy replacement animals, otherwise all the rest of use would contribute from our herds so the family could again build up its flocks."

Responses such as the above are encountered in free as well as ex-hacienda communities. They indicate that overgrazing, due to unfettered competition for available forage, is minimal. Any strictly grazing land is better visualized as though it is under single ownership because it is all subject to common management decisions or overlapping private rights.

Factors Favoring the Syndrome

To show that *campesinos* do not treat grazing lands as a common property resource does not alter the fact that the grazing erosion syndrome exists. It just means that over exploitation of any actual common land is being carried on collectively rather than competitively. Since private lands or private grazing rights appear to be over exploited as well, there have to be other explanations for lack of private or collective use control—either families or communities do not care (not very affected) or they have little choice. It seems that both of these elements (forces) are in operation simultaneously via demand for animals and through tolerance or acceptance of erosion.

Pressures for Large Herds

A large percentage of barley is harvested as hay. This feed source, plus the better (usually family-owned) pastures, are reserved for cows, oxen, and burros. Pigs are allowed some free forage but also share various food scraps, crop residues, and some grain along with any chickens, guinea pigs, or rabbits. Sheep (goats) receive no supplemental feeding beyond what they obtain from grazing. (In higher, rougher, and more remote areas, llamas take the place of sheep.) It is this deliberate allocation of available animal feed that results in most blame being place on sheep for overgrazing; they are the particular type best able to survive where grazing resources are already the most run down.

If there were a big market for mutton, we would have an obvious and satisfactory explanation for the pressure on grazing resources. But beef is far and away the meat most consumed in urban and semirural areas and even in rural areas by non-Indians. Mutton enjoys a restricted but steady sale mostly in rural markets. As a consequence, it is easy to form the impression that mutton sales are inconsistent with overall flock sizes (Draper 1973).

Actually, emphasis on the lack of markets masks the real role sheep and goats play as meat producers. While rural consumption per capita is certainly not large (LeBaron 1976; Anonymous 1960; and Michaelsen 1975), when translated into live animals, it amounts to about 5 to 11 head per year per family. This quantity, on the average, must come from a flock of 15 to 35, with a reproduction rate of less than 50 percent (Hoopes, 1974; Wood 1975a). Under the circumstances, family direct consumption, donations to fiestas, and some sales may represent something like a maximum offtake rate. In short, large flocks are required to support even minimal home consumption.

Moreover, flocks are always subject to disease or might be reduced by some other natural disaster. The best way to hedge such risk is with larger numbers because it's better to lose 30 percent of 20 than 30 percent of 10.

When these observations are combined with the well-known function that flocks perform as an emergency food or cash source during bad crop years (Urioste 1976; Michaelsen 1975), an important share of the reasons for pressure on grazing resources is explained.

Of course, the flocks confer many other advantages on owners. Some wool can be sold. The remainder, plus milk, is utilized directly. Since the flocks are tended during the day by women and children, such products are a kind of low cost dividend from a capital asset immune from inflation. And, in the odd case where "underutilized" forage is available, flock sizes can increase and wealth accumulates.

One of the most important dividends is manure. This is carefully gathered and used to fertilize the annual potato crop.[5] To make the task easier and to mesh with other female chores, the flocks never graze over 8 hours per day and are penned each night. Under this system, small amounts of widely scattered plant nutrients are concentrated in the spots where they are most needed. Little scrawny animals seem perfectly adapted to the gleaning task, and large numbers simply facilitate the process of searching out whatever forage is available (see Fig. 4).

As endogamous families seek the benefits of animal ownership, there can only be one result: pressure on range resources. This is a community-wide pressure that is expressed (as we shall see) mainly through recognized family rights to particular grazing areas.

In opposition to these pressures for maximum herd sizes must set the obvious erosion control mechanism of reducing animal numbers. Indeed, numerous suggestions have been made to this effect. The main inducement cited is that fewer, better animals would be just as productive of meat and wool (Draper 1973; Wood 1974; Stevens 1975; Allred 1973). While there is some evidence that such inducements might have an effect (Wennergren 1974; Wood 1974), they only seem to be partially related to the main benefits of animal ownership. Would manure production go up or down? Would it be less convenient (harder to store meat) if animals were killed half as often? Would larger, more exotic animals introduce marketing problems for the *campesinos*? How would improved animals respond to disease or climate over the long run? Better animals would have to have better forage (Michaelsen 1974, 1975; Wood 1975a; Hoopes

[5] Bovine manure is often reserved for fuel (Carter 1964; and Dorsey 1975).

[6] In fact, complete grazing is desirable because in the absence of any possibility for "green manure" plowdown, failure to graze the annual growth would result in a loss of some nutrients.

1974). Where would it come from? The answers to such questions are still imperfectly known or have not been effectively demonstrated to *campesinos* (Allred 1973; Michaelsen 1975a, 1975b). *Campesinos* seem to lack knowledge of basic plant physiology and do not understand that allowing pastures to regain vigor would result in great production on a sustained yield basis (Parker 1975a, 1975b; Michaelsen et al. 1974).

Again, all that can be concluded is that there continue to be strong reasons for herd sizes to press on forage resource limits. These pressures represent one measure of *campesino* lack of choice; they add up to little incentive to voluntarily change husbandry practices.

Interrelation of Erosion Perception and Management Practices

There is an important sense in which individual communities do not worry about the link between overgrazing and erosion, and this is because ordinarily erosion is not a threat to their basic subsistence food system. At the same time, on the strictly nonarable grazing lands, natural forces trap the *campesinos* into erosion-inducing practices. To appreciate how seemingly self-destructive results can exist simultaneously, we need to understand something of highland farming practices and how they augment grazing resources. It is then possible to identify further the role played by lack of choice.

Pattern of Land Management

The special ways in which erosion, due to overgrazing, may not be a village problem are found in the general system of tenure and land management that prevails to a greater or lesser degree throughout the highlands. In a given community there may be: (a) house plots; (b) other agricultural lands; and (c) open grazing land. These divisions have a somewhat different meaning depending on whether a free or ex-hacienda community is being discussed. In free communities, the house plots (*sayaña*) are the real focus of extended family activity, and more than one house is found on a plot. Surrounding any group of house plots are three or four large arable chunks (*aynokas*) that appear to be communally worked but which are actually subdivided into many small plots (*leguas callpas*), rights to which are held by

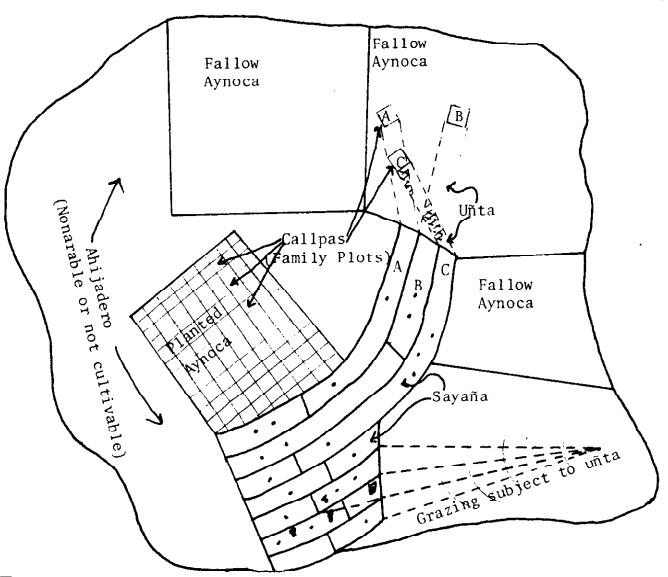

Fig. 6. *Typical land-use pattern of "free" Indian* sayaña/aynoka *complex or subzone within a larger community on the Bolivian highlands. Each* sayaña *is partly planted and partly fallow. Grazing rights on one fallow* aynoca *for* sayañas *A,B, and C are shown. These overlapping rights (*untas*) crisscross in all directions into* ahijaderos *and fallow* aynocas.

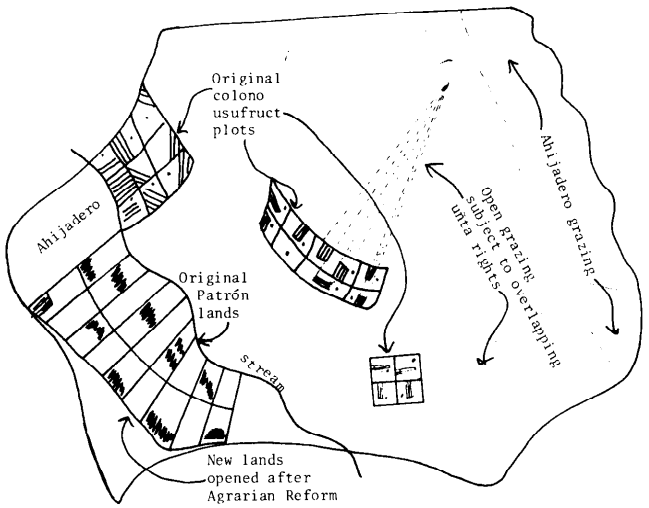

Fig. 7. *Typical land-use pattern of ⅓ or ¾ of the total area of an ex-hacienda in Bolivian highlands showing individual family control of fallow/planted areas. Families have grazing rights on their own fallow plots as well as various overlapping* unta *in open grazing areas. They have other grazing rights in* adijadero *or commonly managed land.*

nearby families. In addition, there may or may not be *ahijaderos*, that is, common rangelands as well as open range subject to group rights. Each *sayaña/aynoka* complex represents a subzone within the community. On the *sayañas*, extended families do as they plese, but all the many *leguas callpas* within an *aynoka* will generally be sown to a single crop or the whole *aynoka* will be left fallow.

Figure 6 is a generalized plan of such a community. Several communities make up a village. Villages vary in size, but a not unusual example on the Altiplano would include 8,000 hectares total land, 25,000 sheep, 2,000 oxen, 2,000 cows, and 1,000 families. In contrast, even large ex-haciendas in the valley areas would encompass no more than 2,000 hectares and 100 ex-*colono* families.

In ex-hacienda communities, the tenure pattern varies according to region. On the Altiplano many landlords reserved less than 30 percent of the arable land to themselves. The great bulk was left in usufruct to the peasants either in their *sayañas* or in *aynokas* and open grazing grounds (Carter 1964). In the high valleys, the proportions were reversed, and, in extreme cases, the landlords maintained rights to as much as 93 percent of the arable land (Dorsey 1975). Another difference related to the high valleys section is that cultivated fields analogous to *aynokas* contain the larger or main pieces worked by the individual families. While the importance of *ayllu* is less pronounced, each family or group manages its allotment as it desires. These fields, therefore, exhibit an everchanging checkerboard pattern of fallow and worked plots (Fig. 7). In many cases, the amount of land each family has to cultivate is greater than what their fathers or grandfathers had due to distributions of portions of the hacienda worked exclusively for the *patron* prior to the 1953 Agrarian Reform. Even so, a typical high valley holding for ex-*colono* families would not be over 5 hectares.

The more fertile or accessible the land within any community, the less it is given over to any kind of open pasture. Where land and climate are favorable, such as near Lake Titicaca, an entire community may have no non-arable, com-

mon land. In such cases, grazing resources consist entirely of volunteer growth on fallow lands or meadows owned by individual families. As the other extreme, in some valleys where land quality and rainfall are deficient, 80 percent or more of the land is usable only for grazing.

All grazing on *sayañas* or house plots is exclusive to the family owners. In the valleys, exclusive rights also include plots in larger arable land extensions that are not subject to the *aynoka* system of controlled rotational cycles.

On fallow *aynokas* or certain grazing lands, a family's grazing right (*unta*) is often dictated by a line of sight relationship between their *sayaña* and the location of their several *leguas callpas* in a fallow *aynoka* or to a common meeting point on a hill top or middle of a bog. Because of this, it is possible that a family's *callpa* may lie under someone else's *unta*, and the family must share the grazing on the *callpa* while it is in fallow (Carter 1963) (see crosshatched areas in Figures 6 and 7). Management of open grazing *behind* a hill (see Fig. 7) would be determined by the community and the decision would likely be for common use. This common land would be called an *ahijadero*, and utilization would be subject to the general sanctions already described, including the possibility that the use would be assigned to only certain family groups. If another subcommunity were to lie behind the hill (a most likely possibility), and the subboundaries crossed the hilltop, the "far side" grazing would all be subject to private *untas*.

To summarize, community grazing and farming systems are separate and animal management is not allowed to interfere with obtaining a community's basic subsistence. The latter is tied to the cycle of annual crop sowing, cultivation and harvest. It is this separation that paves the way for a reduced perception of erosion threat at the community level.

What needs to be stressed about animal management in general is the rather high percentage of total grazing resources that are under private control or under definite sharing arrangements. Only that part of grazing on true *ahijaderos* is excluded and, as we have seen, various community sanctions are in operation or can be invoked to limit inter-family competition on these communal lands. This clinches the earlier argument that the notion of first-come-first-served competition for grazing resources is of limited usefulness in the Bolivian context.

Another important point to recognize is the key role played by fallow farm lands (within *aynokas* or *sayañas*) in providing animal forage. Some of the fallow periods last 2, 4, 7, 10, or even 20 years! Since such lands are not plowed until ready to go back into 2 to 4 years of crop production, during fallow periods animals graze whatever volunteer growth is available. Indeed the very fact that these lands eventually will be plowed means that heavy animal use of such areas is not important from the standpoint of maintaining the grass resource (sustained yield). This is not to say that grazing fallow lands might not lead to erosion, only that on such lands goals of sustained yield and erosion control do not go hand in hand.

In the case of non-arable grazing land, as we have seen, heavy animal use is not so important because these ranges are automatically outside the basic food production areas. Finally, turning to potentially arable land, all that needs to be said is that if a decision is made to open a new *aynoka*, this is a simple matter of clearing off the rocks and plowing. Whether or not such land has been previously overgrazed is of little consequence. Naturally the new *aynoka* will not be placed in a location that has been subject to heavy erosion.

Lack of Choice

Some years are drier than others, especially in the high valleys. In such years, there is a natural tendency to hold animals on ranges or pastures for a longer time. This tendency is greatly magnified by the fact that there is no way to purchase supplemental feed. None exists. In the United States, supplemental feeding is an alternative in bad years. In the Bolivian highlands, the alternative to extended grazing is animal starvation. Thus, even if there were general community agreement to control grazing on open lands, the cumulative effects of heavy grazing in the dry years will dampen the oscillations in annual regrowth toward some land/animal biological limit. It seems that the same tendency must prevail for all private or shared grazing. The only difference would be that a lot of the better pastures are 'private' and are subirrigated and have greater capacities to recover from one season to the next.

In the worst years, some animals will die. The Indians long ago learned to live with this possibility; sometimes the hand of fate moves against them, and this is accepted as a natural part of their lives (Aitken 1975; Carter 1964).

Conclusion

A large share of grazing in the Bolivian highlands is obtained from fallow farmland. Any control over erosion of these lands will have to include special tillage practices. These might begin with educational programs in contour plowing or other reclamation techniques. Another, sometimes important, share comes from private pasture lands. The possibilities of regulating their use would be limited. However, often these lands are quite valuable and demonstrations of benefits of better management practices surely should be conducted. The only lands that really could be made the object of grazing control would be open community lands, whether *ahijadero* or subject to *unta* rights. In some areas, such as the southern Altiplano, these are extensive and represent the main community economic resource. In other areas, the importance of open grazing shows great variation.

Collective overgrazing of ranges, fallow land, and pastures is due to: (1) the incentive to keep large herds for family benefit and security even though animal product markets are limited; (2) the fact that erosion at the community level is not perceived to be much of a threat to the basic food production system; and (3) the cumulative consequence of the natural desire to prevent animal starvation during dry periods.

A strictly voluntary system to cut back grazing would require that the long-run benefits be greater than at present. We have already questioned this possibility. There is no way to get cheaper fertilizer. There are no developed markets for *increased* supplies of mutton from fewer but improved animals (possibly more wool could be sold). There is no easy way to replace the cheap meat and security against crop failure that the current herds represent. These are the kinds of constraints that face any actions that might be implemented to obtain new or additional benefits from production of higher quality sheep and goat products.

On the other hand, it is not clear just how to introduce nonvoluntary controls to help reduce erosion. Any control scheme contains pitfalls. In Figure 8 we show possible consequences of three broad options. In Option A (with no restriction in animal numbers over the long run) a straight cutback of grazing would require an alternative feed source. This would have to be obtained from *descanso*, that is, fallow, lands and would involve breaking into the historic pattern of basic food

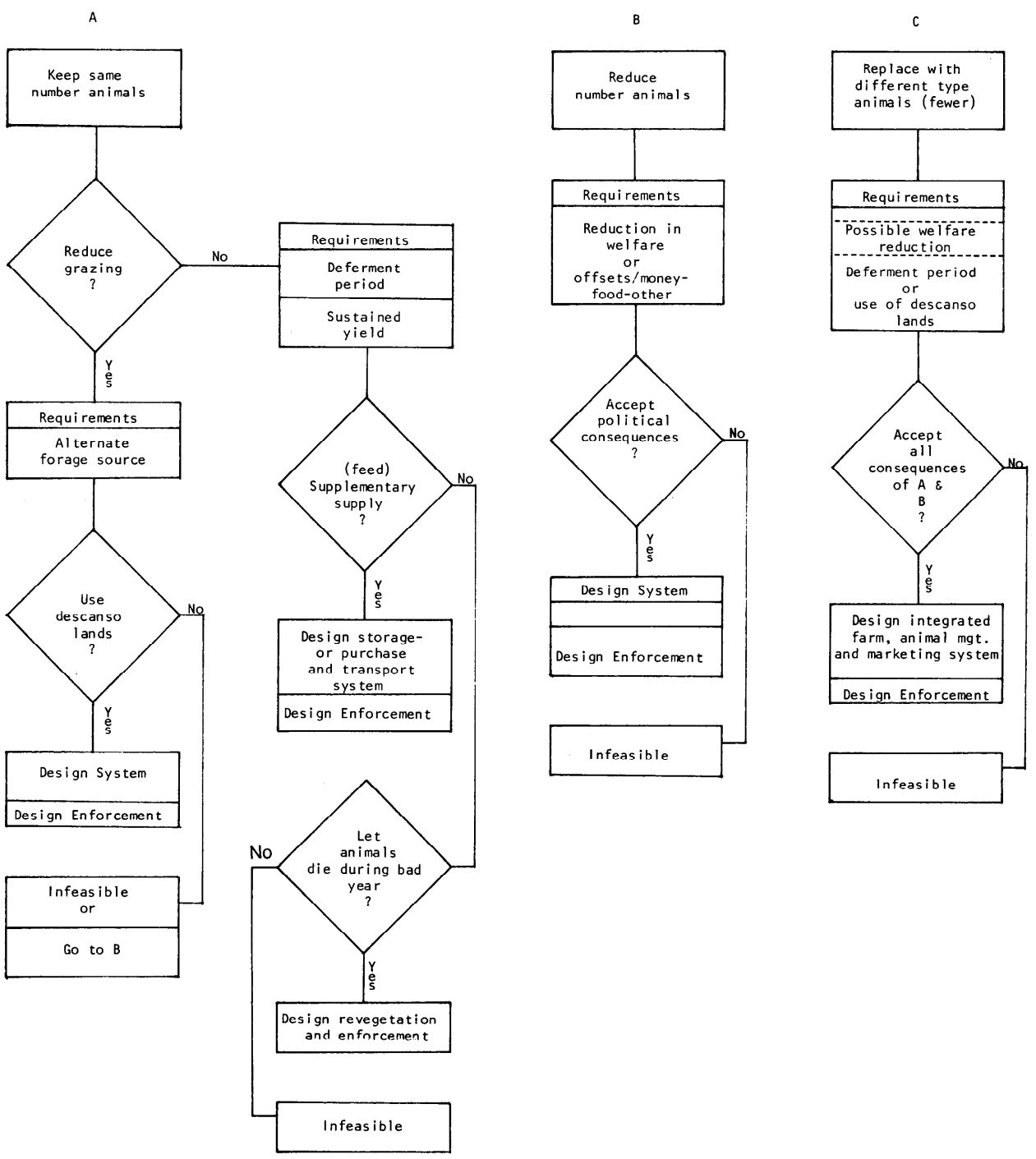

Fig. 8. *Some requirements and consequences of selecting grazing control options in the Bolivian highlands.*

production. Such a program would require very careful design and execution.[7] The other general line of action under Option A would involve the usual revegetation, deferred grazing, and subsequent management on a sustained yield basis to carry as many or somewhat more animals that at present. Unless there is an emergency feed storage supply for bad years, some animals will die (or the program will oscillate back down to an overgrazed condition due to the natural effects of dry/normal cycle as discussed earlier). Thus an analysis of Option A is likely to lead to an infeasible conclusion.

Option B assumes a legal degree to reduce animal numbers. This means an automatic reduction in family living standards unless the order is coupled with some system of money/food/-material offsets and transfers. The big question would be whether a government would be willing to accept the political consequences. An affirmative answer would require an especially tough and expensive enforcement mechanism.

Some form of Option C has been written about in the past but without any clear statement of probable consequences (Draper 1973; Stevens 1975; Allred 1973; Wood 1974; Michaelson 1975; Michaelson et al. 1974; Wood 1975). In our view, Option C, unless accompanied by some definite markets for the "new"

[7] Wood (1975b) advocates seeding fallow (*descanso*) lands to grasses and legumes during the long periods they are out of production. The economics of such a practice have never been worked out.

products, might well involve, to a greater or lesser degree, *all* the administrative difficulties of Options A and B!

In short, it is going to require some very clear thinking and possibly some tough action to finally break the grazing ⇄ erosion syndrome in the Bolivian highlands. Only government leaders with tremendous political courage will ever put income-reducing edicts into practice in order to fight erosion!

No doubt the 1978 international conference on rangeland management has stimulated papers on the potential valuc of animal grazing in a world moving towards food shortages. In many situations, animals are the most efficient users of thin and weak vegetative growth. Unfortunately, such situations are often coupled with erosion and secondary effects reaching far beyond the animal "cultivators." We see an increasing demand for new and effective range management skills suitable for situations much different than those in the western United States.

Our research experience in the Bolivian highlands is just one example of how important it is to have some understanding of the social and economic forces at play in underdeveloped situations before a suitable technological fix can be devised.

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"Grasses and Grasslands" Symposium

Nine nationally known scientists have been invited to present the essential aspects and significance of different facets of grass taxonomy and ecology at the 30th Annual Meeting of the American Institute of Biological Sciences at Oklahoma State University, Stillwater, in August, 1979. Representative topics include major trends of evolutions in the family Gramineae, human interference in grass systematics, systematics and evolution of the Triticeae, interactive processes in grassland ecosystems, and the role of small herbivores in grasslands. The symposium is sponsored by American Society of Plant Taxonomists, Botanical Society of America, and the Ecological Society of America.