WWF PROGRAMME OFFICE ZIMBABWE

WILDLIFE ELECTRIC FENCING PROJECTS IN COMMUNAL AREAS OF ZIMBABWE - CURRENT EFFICACY AND FUTURE ROLE

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EXECUTIVE SUMMARY

As rural populations have increased, the conflict between wild animals and people has become more acute. Various strategies ranging from selective hunting to offering rural communities' incentives have been tried to resolve this problem. None have proved to be successful, and attention has now focused on the erection of physical barriers, particularly electrified fences.

This technology was first used in the 1960's to control domestic livestock, but as the technology advanced, it was applied to control wild animals. In Zimbabwe, electric fences have been used since the 1990's to control elephant and buffalo. When first installed, such fences appear to reduce crop damage, however, the systems deteriorate over a period of time, primarily as a result of a break down in the institutional/management capabilities at the community level.

This report investigates the status of electric fences in the communal areas of Zimbabwe and accesses their efficacy and future role in controlling problem animals.

The Human-Wildlife Conflict in Zimbabwe

The conflict between humans and wild animals takes on three forms defined as "a hard edge" where people live adjacent to a wildlife refuge, "isolated settlements" where people are surrounded by wildlife habitat and a "mosaic" where settlements occur more frequently. Conflicts occur in these situations throughout the year but are more frequently where crops mature (February to March). Elephant are seen to be the primary problem around; however various studies have shown that small animals and insects are responsible for greater levels of damage than elephant.

The policy to deal with those dangerous animals (or problem animal control (PAC), was to selectively shoot these animals, and deliver the meat to the affected people. Ideally this was the responsibility of the Department of National Parks and Wildlife Management (DNPWLM). With the advent of the Communal Areas Management Programme for Indigenous Resources (CAMPFIRE), this responsibility was transferred to the Rural District Councils (RDC).

Under this programme, many wild animals have a commercial value, from which rural community's benefit. RDC's have therefore adopted various strategies to control problem animals amongst which is an increased use of electric fencing. The rationale often quoted for the use of electric fences has been that this leads to a reduction in crop damage. However, closer examination of the social issues has revealed that in addition to a reduction in the destruction of personal property, personal safety is a significant factor. Furthermore, there are a number of "opportunity costs" associated with living with dangerous animals.

Rural communities therefore believe that fencing projects can solve many of their problems, and after advance convincing arguments as to where and why fences should be erected in their areas. Various NGO's have assisted communities to implement fencing projects, and five strategies have been identified. These are: -

- Model 1 - Extended Full Barrier Fence
- Model 2 - Partial Interface Fence
- Model 3 - Community Protection Fence
- Model 4 - Small Group Ownership Fences
- Model 5 - Crop Protection Fence

Model 1, 2 and 3 are the most widely used, and approximately Z$5.5 million has been spent on the erection of 500km of electric fencing in Zimbabwe. These fences have been erected in eight districts at an average cost of Z$10 900/km, with the longest fence in the Binga District (182km).

Efficacy of Existing Electric Fences

With the help of NGO's, a "Problem Animal Report" was developed to monitor the efficacy of the fences shortly after they were commissioned. Unfortunately, this system has not been maintained in all districts and thus it is difficult to analyse and compare quantitative data. Instead, this report has had to rely on verbal and written sources from people directly involved with fencing projects. Nonetheless, these sources of data do provide a reliable record of the destruction and frequency of problem animal activity. In contrast, it is relatively easy to assess maintenance problems simply by physically examining the status of the fence.

The evidence gathered during this study suggests that initially problem animals such as elephant are controlled by almost all fence models. Furthermore, encircling fences appear to be more effective than deflecting fences even when not properly maintained. The problems appear to arise after the fence has been in place for some time, in some cases as early as 18 months after commissioning, in others as late as six years. During this study, approximately 43% of the fences examined were not working at the peak of the challenge period, and only three recorded voltage levels approaching the required level (3.5 - 5.5kv).

The reasons for this are complex but can be linked to institutional problems as well as problems caused by animal adaptation, theft of equipment, and poor maintenance. Of these, theft is probably the most important, followed by administrative and institutional problems relating to the supervision of fence maintenance workers.

Maintenance Costs of Electric Fences

The concept of an electric fence, and the technical equipment appear to be uncomplicated. However, they require meticulous care to detail if they are to work to optimum efficiency. Most components (solar panels, energizers, batteries, fence posts, wire and insulators) are available locally. Labour requirements and mainte3ance costs are not significant, resulting in an average maintenance cost of $1 650/km/year in a communal land environment. However, when this is related to Ward or RDC budgets, it is feared that these institutions are spending approximately 30% and 43% respectively of their CAMPFIRE revenue on fence maintenance. Labour costs make up approximately 61% of these costs.

In contrast, the cost of maintenance per kilometre in the private sector is approximately $2260/km. The key issue here is that even though considerable funds are being spent on maintenance, this does not guarantee that the fences will be 100% in working order, even in the private sector.

Within the communal land environment, the problems and successes of electric fencing projects were evaluated based on: -

- Efficacy relative to the concept model of the fence
- Technical problems
- Financial problems
- Community problems

This analysis revealed that the issues were complex. Deflecting fences (Model 1 and 2) had proved to be partially effective, but difficult and costly to maintain. Model 3 fences (Community problem fences) were the most common, and this design was appealing to both planners and residents. However, some schemes had become too large, and thus inherited all the problems associated with deflecting models. Politically some communities have rejected this model as they feel very strongly about being encircled by a fence. For this reason, it has not been possible to fully test the effectiveness of Model 4 (or Household Fence) schemes.

Technically, rural communities have not yet fully grasped the importance of the constant attention to detail. As a result, the power unit, which costs less than 3% of the overall capital cost of the fence, is responsible for 50% of the subsequent problems. Financially, electric fences are a heavy drain on Ward and RDC budgets. Financial planning is seldom considered during the design phase with the result that the projects are often undercapitalised. Add to this the unrealistic expectations of rural communities regarding the appropriate use of electric fences, particularly in attempting to control all species rather than selected species such as elephant. The net result is that supervision of maintenance is allowed to lapse with the result that the fence becomes ineffective.

Cost: Benefit of Electric Fences

Given the problems associated with electric fences, donors have insisted that a cost: benefit analysis is undertaken before the project is approved. Several such analyses have been attempted however there are several constraints associated with obtaining reliable data.

Furthermore, it is possible to "manipulate" the data in order to arrive at acceptable rates of return. The key problem is that it is extremely difficult to show conclusively that an electric fence will result in substantial increase in crop production. Furthermore, it is not possible to factor in the human safety aspect nor is it possible to assess "hidden costs" such as "down time" when the fence is not working.

One approach to resolving these issues attempts to qualify the level of benefits one should attain in order to justify a predetermined rate of return i.e. how many tons of maize would have to be destroyed in order to justify the expense of a fence. Another approach attempts to calculate the overall maintenance costs as a factor of the gross construction costs. Using this approach, the percentage maintenance costs vary from as low as 3% for Model 1 to as high as 20% for a Model 4 fence. The implications of this are that communal land fencing programmes will have to substantially increase the annual maintenance budgets if they are to persist with Model 1 type fencing projects.

Most communal land fencing projects have opted for Model 3 type fences that offer a compromise between personal safety and crop protection. To improve the effectiveness of these fences will require local authorities to invest greater amounts in construction and maintenance costs and improves their management. The financial implications of such a strategy will be to further strain the already stretched budgets. The alternative is to move away from using Model 1,2, and 3 type fences and adopt Model 4 and 5 type fences. These models have not yet been fully tested however and will be difficult to implement given the fact that local authority and communities believe that full barrier fences are more effective.

In conclusion, there is no doubt that electric fences are effective in controlling the movement of dangerous animals such as elephant, particular when new. However, the lack of institutional, financial and technical capacity at district and local level often results in fencing projects becoming inoperable after a period of time.

To break this cycle will require local communities and authorities to adopt new strategies. One option is to move away from extended barrier system and transfer as much of the responsibility for dealing with problem animals to individuals, through the implementation of fencing schemes at the household or village level.

1 INTRODUCTION

Bell (1984) has described the man-animal conflict as *'a rolling zone of attrition in which wildlife has generally been eliminated but utilised in the process'*. To check this progressive erosion of wilderness areas and to stabilise the man-animal interface, five broad strategies have been used over the years. These are:

- Raising the human tolerance threshold
- Deterrence of animals
- Removal of animals
- Removal or modification of animal habitat
- Construction of physical barriers

All the above five strategies have in some form or at some time been applied in Southern and Eastern Africa to control or prevent damage to humans and/or crops, particularly by elephant. This is because rural communities perceive the threat from large mammals to be far greater than from smaller animals such as rodents and baboons, and vast sums of money and time are being spent in trying to solve this problem. Of these, the construction of physical barriers, and more particularly electrified fences, has attracted the most attention in recent years.

The available literature on the human/animal conflict in Africa frequently refers to the potential of electric fencing as being a possible permanent solution to the problem. The first recorded use of electric fencing was to contain prisoners of war in World War One! Electric fencing was initially used on domestic mammal species in the 1960s and gradually applied to wild species as it advanced technologically (McKillop and Sibly 1988). Electric fences are cheaper to construct than conventional fences because they are not required to be robust impenetrable barriers (Gallagher 1989). They rely for their effectiveness on animals changing their behaviour as a result of receiving shocks. The behavioural change, when applied to animals that have been shocked, is called "conditioned avoidance". Animals that avoid a fence but have never touched it may be showing "socially learned avoidance" by copying other conditioned animals (McKillop and Sibly 1988). The persistence of negative conditioning by electric fencing is what interest's wildlife managers.

Electric fencing has been used in Zimbabwe to control the movement of elephant and buffalo in communal land areas in the 1990's. Initially these fences were seen to be the answer to control problem animals and reduce the conflict between humans and wild animals. However, planning and implementing electric fence programmes in a communal environment has exposed a variety of institutional and management issues which have directly impacted on the effectiveness of such fences.

Initially the fences appear to meet the objectives of reducing crop damage and the destruction of wild animals. However, all too often, many of these fences fail as a result of a breakdown in institutional/management capabilities at the community level. Furthermore, some local districts have developed alternative management strategies that do not rely on electric fencing. In such cases, the very high capital and recurrent costs of electric fencing probably cannot be justified.

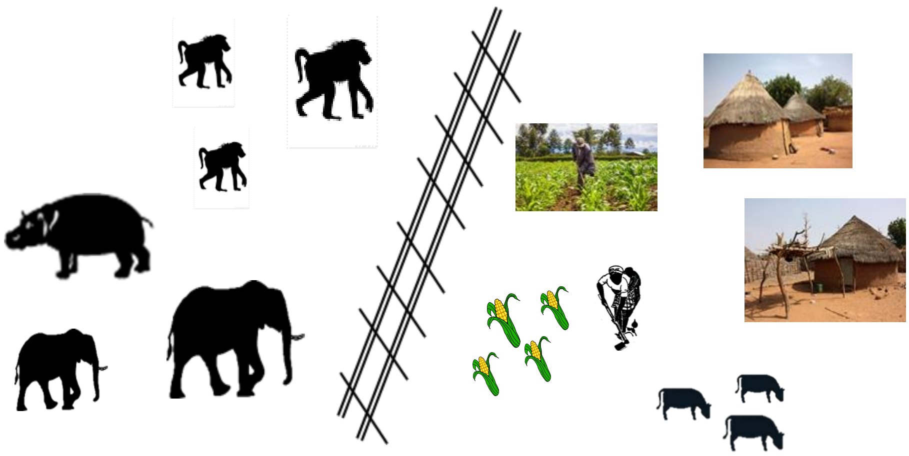
The purpose of this report is to investigate the status of electric fences in the communal areas, and to develop a framework for use by RDCs, wards and donors to assess the efficacy and future role of fencing projects.

1.1 CHARACTERISTICS OF THE HUMAN - WILDLIFE CONFLICT IN ZIMBABWE

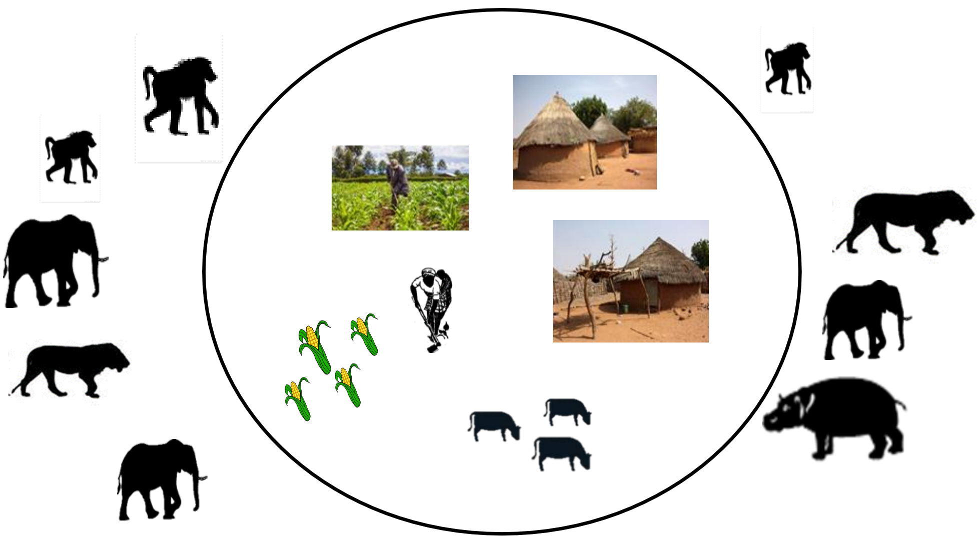
There are several types of interface between human settlement and wildlife range in savanna areas of Zimbabwe. Broadly speaking, such interfaces take three forms: "a hard edge" (where human settlement and wildlife habitat are divided by a long, clear boundary), an "isolated settlement" (where people live surrounded by wildlife habitat) or a "mosaic" (where settlements and wildlife habitat are irregularly interspersed; Hoare 1995; WWF 1997, Fig. 1). In CAMPFIRE[1] districts incidents of human - wildlife conflict can occur in any of these settlement configurations. The types of problem incidents include damage to crops or grain stores, killing of livestock and direct threats to people's safety.

Figure 1: Various interfaces between wildlife and people

HARD EDGE

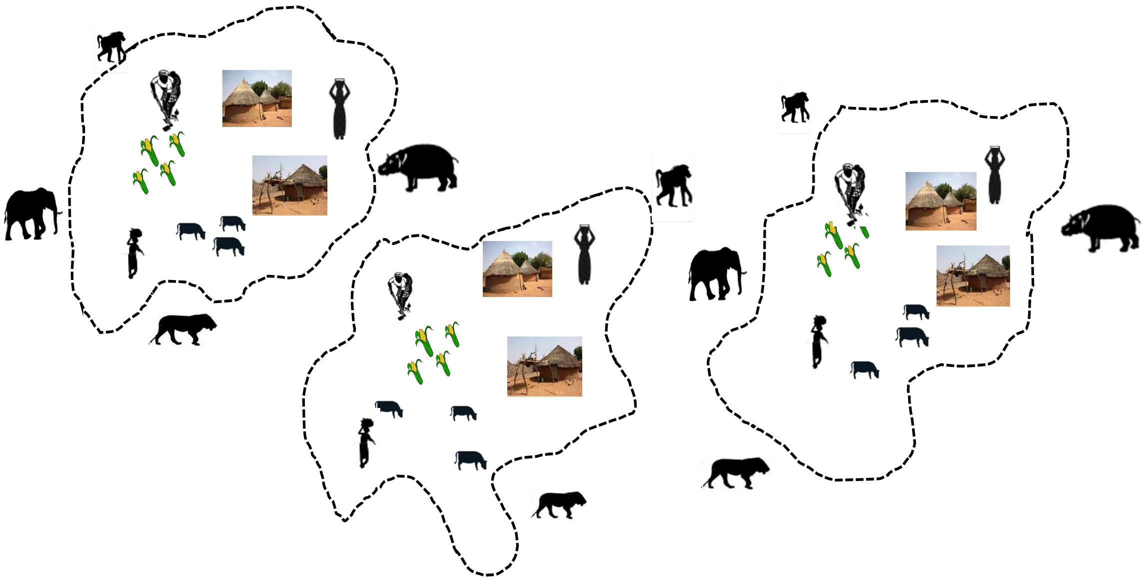


ISOLATED SETTLEMENT



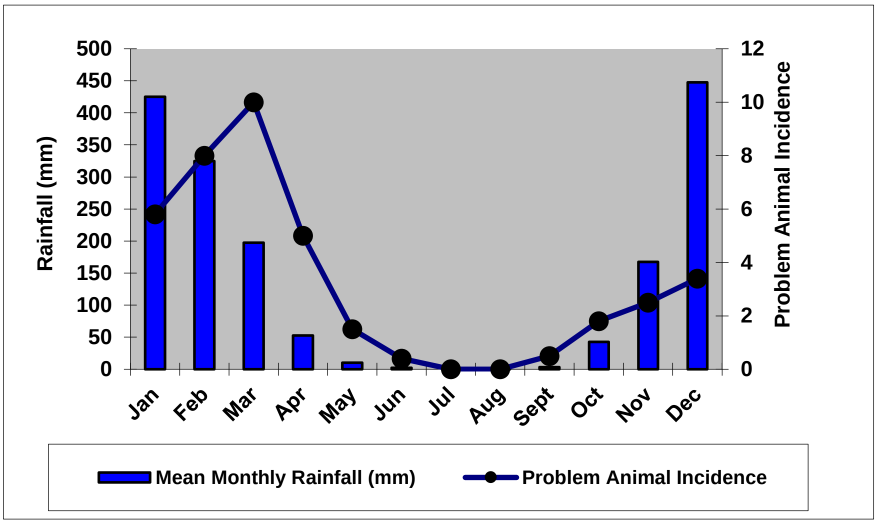
[1] CAMPFIRE is the acronym for the "Communal Areas Management Programme for Indigenous Resources".

MOSIAC



Conflict incidents can occur throughout the year but typically show a definite seasonal peak in the late wet season (February, March, April) when crops are maturing (Hoare and Mackie, 1993, Figure 2).

Figure 2: Annual pattern of problem animal activity in communal lands of Zimbabwe



This is because by far the most common type of problem animal incident involves "crop raiding", especially where elephants occur near to human settlement (Figure 3). However, there is growing evidence that the level of crop damage attributable to the large mammals (elephant, buffalo or hippo) is often relatively small both in terms of quantity and economic value when compared to the damage caused by small mammals and insects.

A study in Malawi quantified the level of total damage by elephants on farms around a national park as amounting to only 4% of damage inflicted by bushpigs (Deodatus and Lipiya, 1991). In another study in Malawi where very high densities of elephants are found adjacent to densely populated and heavily cultivated human settlement, elephant damage affected 9% of the crops (Bhima 1998). In Zimbabwe, Wunder (1996) investigated the effects of nine pests affecting food crops in a rural community. This study showed that crickets and birds were the two most damaging agricultural pests, and elephant and hippo were ranked fourth and fifth respectively. Yet when interviewed, the people in this community did not even include birds, rodents or insects in their definition of a "problem animal".

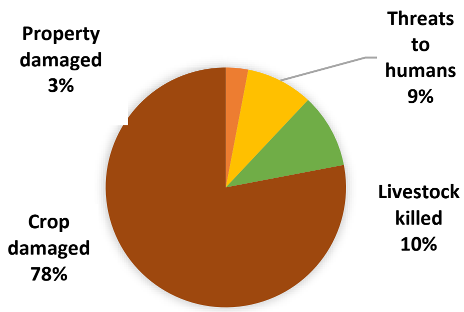
Small animals such as bushpigs, monkeys, baboons and birds can survive in small refuges around human settlements and cause problems at any time. Larger problem animals need refuges outside the settlement area and generally cause seasonal problems (Bell 1984). Livestock killing by large carnivores (*e.g.* lion, leopard, hyena and crocodile) tends to be sporadic and less predictable.

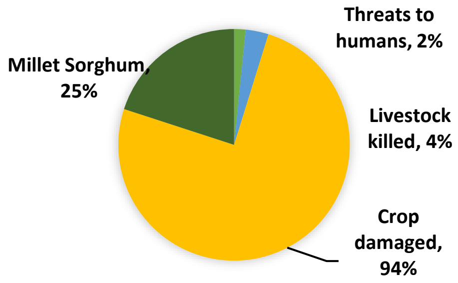
The unfortunate characteristic of damage in rural communities from large problem animals is that a few people are seriously affected while many others are often only lightly affected. The devastation caused to food supplies in a few households by elephants or lions for example, makes the problem of these animals seem much more dramatic than that of quelea, mice or crickets which by contrast rob very many households of large amounts of food in a far less obvious manner. Since existing fences have been designed to treat communities as a whole, rather than those individuals afflicted by problem animal activity, in a typical, semi-arid CAMPFIRE area of Zimbabwe it would probably be impossible therefore to demonstrate that a protective fence results in increased crop production within a subsistence farming community.

Figure 3: Typical problem animal incidents in communal lands after a one year period

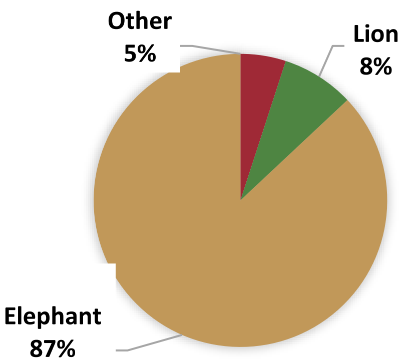
Binga District (N=337)	**Nyaminyami District (N=337)**

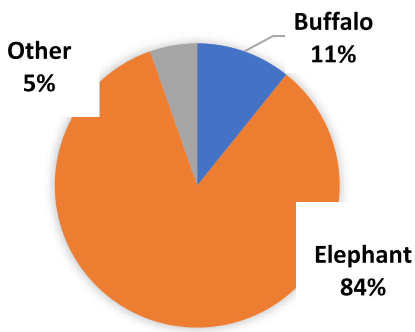
Type of Damage



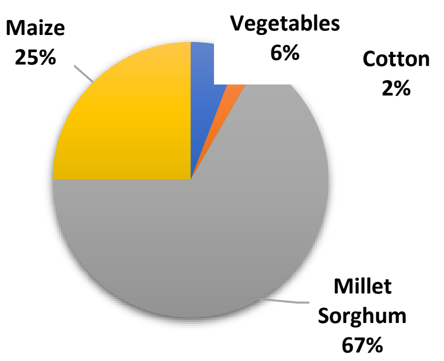


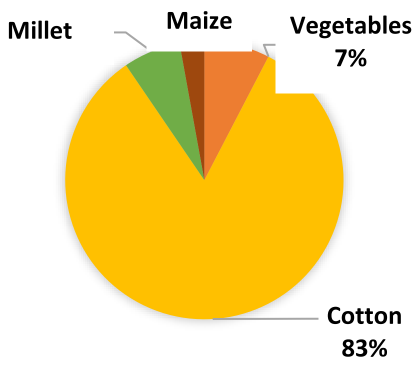
Species Involved





Crops Affected





1.2 POLICY RELATING TO PROBLEM ANIMAL CONTROL IN ZIMBABWE

In cases where rural people need assistance with the control of problem animals from an outside agency, the associated operations are termed "problem animal control" or "PAC". PAC in Zimbabwe is mainly concerned with the larger, more dangerous species, and in the past was synonymous with control shooting of the larger problem animals. The provision of free meat from PAC on crop raiding elephant and buffalo became "institutionalised" as a palliative from Government wildlife authorities to affected people.

Prior to the development of CAMPFIRE, the Department of National Parks and Wildlife Management (DNPWLM) carried out such PAC in all areas. By delegating "Appropriate Authority" status to Rural District Councils (RDCs), the CAMPFIRE districts have assumed responsibility for all aspects of wildlife management, including PAC. At first this was not initially appreciated, and some sectors of the rural community felt that although they could derive benefit from the newly decentralised system which allowed some wildlife utilization, the DNPWLM was still obliged to provide them with PAC services. However, the Director of the DNPWLM clarified its position in a letter to all RDCs with Appropriate Authority in 1993. This letter unambiguously explained that all such districts were responsible for their own PAC, and that they could either set up their own PAC units or hire the DNPWLM or someone in the private sector to do their PAC.

This policy was recently reversed by the DNPWLM that insisted that it carry out all PAC. In practice, this policy has not been implemented. However, in some cases, both the Council and the DNPWLM are engaged in problem animal control resulting in an increase in the number of animals being shot.

The dilemma facing the RDCs now is that under the CAMPFIRE programme, many wild species have some exploitable value, even if individuals of that species are sometimes problem animals (Taylor 1993a; b). They are also faced with the problem of raising the tolerance levels of local communities towards wildlife, particularly elephant. In fact, by accepting "Appropriate Authority" status, the RDCs have been placed in a position very similar to that in which the government agencies were before they decentralised their responsibilities.

The RDCs have therefore adopted a much wider range of options to control pest species among which is the increased use in the last seven years of physical barriers, such as electrified game fencing.

1.3 REASONS FOR THE USE OF ELECTRIC FENCING

Because many problem animal incidents involve crop damage (Figure 3), it is often supposed that the purpose of electric fencing in communal lands is to reduce crop damage in subsistence farming areas. In this way the tolerance levels of local communities towards the larger problem animals can be raised, particularly if the animals are of economic value.
However, it appears that the widespread animosity to large mammals among rural people, even those who suffer very few direct problems, is probably due to a combination of the potential for these animals to be aggressive and dangerous to people as well as destructive to property. Rural people tend to believe that they can "control" smaller animals (such as bushpigs) by scaring them away or hunting them down whereas large, dangerous animals such as elephant present them with problems that seem much more difficult and conspicuous to deal with.

Personal safety has emerged as a significant reason in the enthusiasm among rural people for fences. This may be because the so-called "opportunity costs" of living with dangerous wildlife can be quite considerable (DHV, 1992).

Opportunity costs are those indirectly related to dealing with problem animals and are difficult to quantify. Examples are:

- Reduced school attendance in areas where dangerous animals occur
- Safety problems when moving about after dark
- Decreased employment opportunities because of the need to deter wildlife
- Competition for water sources
- Sleep deprivation while defending crops at night
- Increased exposure to malaria

Rural people in Zimbabwe have regarded fencing as something of a panacea for all their problems associated with living with wild animals (Tavengwa 1997). Many rural people believe electric fencing will deter virtually all problem species from entering settled areas almost all the time. Many probably also see fencing as an aid in preventing domestic livestock from entering into and damaging crops. People also generally believe a fencing project, which is expensive and paid for by donors, does bestow some local prestige in terms of enhancing rural development. The fact that some employment will result from electric fencing further increases enthusiasm for such projects.

There is, however, a minority who sees fences in a negative light. These people may regard a fence as a "psychological" barrier that denies them access to resources beyond the fence (e.g. hunting, cattle grazing or agricultural expansion). This is particularly the case where fences are designed to encircle a settlement. In contrast, there are those who see a fence as delineating a land use boundary (i.e. cattle grazing) and attempt to influence the positioning of the fence in order to extend the particular land use rather than using the fence for its specified purpose.

Because electric fencing is perceived to benefit communities through a combination of improved security, easier crop production and increased rural development, it ranks as one of the priority items on the list of requests for financial assistance in many CAMPFIRE areas. Unfortunately, without previous exposure to new technological applications, rural communities have little appreciation of the opportunity costs, cost ceilings, construction limitations, technical requirements, maintenance regimes or likely effectiveness against animals that must be expected from an electric fencing project.

NGOs involved in the CAMPFIRE programme have invested a great deal of time and effort into training and technical support to overcome these problems. However, only recently has a booklet been produced to explain the suitability and use of electric fencing in simple, user-friendly terms to rural communities (WWF 1997). Despite this input, proposals submitted by CAMPFIRE districts for fencing still show little connection between the scale and nature of the actual problem due to wildlife, and a proposed solution to control it, using a barrier.

Few communal land fencing projects have undergone detailed cost-benefit analysis prior to implementation. However, although this is seen as a necessary procedure and is now being repeatedly recommended by NGO's assisting CAMPFIRE, there are problems associated with this type of analysis. These are discussed in detail later in this report.

1.4 CONCEPT MODELS FOR COMMUNAL LAND ELECTRIC FENCING IN ZIMBABWE

Various "concept models" have been proposed for electric fencing in a communal land situation in Zimbabwe (Mackie 1992; Hoare 1995; WWF 1997, Figure 4). These are[2]:

a **Model 1 - Extended Full Barrier Fence**: Examples of such fences are those located along the boundary of national parks. Usually government departments construct these Foot-and-Mouth Control fences in order to restrict the movement of buffalo into cattle producing areas.

[2] Other examples include strategic fencing for particular species with known restricted movements *e.g.* river front gardens bothered by hippo or low specification fences such as lion-proof bomas for livestock.

These fences are constructed in such a manner to allow certain animals to either step over or jump the fence (*e.g.* elephant, kudu, eland). An example of such a fence can be seen along the boundary of Hwange National Park and the adjacent communal lands of Tsholotsho and Hwange. In other areas, the height of the fence is extended and electrified in order to control the movement of elephant. Examples of this can been seen along the Chirisa Safari Area boundary in Gokwe South District.

b **Model 2 - Partial Interface Fence (may incorporate natural barriers):** Extensive open ended fences up to 30km in length that may incorporate natural barriers such as steep escarpments. The purpose of these fences is to reduce and not eliminate crop raiding problems altogether by "deflecting" problem animals away from human settlement. An example of such a fence is the Nenyunka Fence in Gokwe North District and Negande Fence (Nyaminyami District).

c **Model 3 - Community Protection Fence**: Extensive complete enclosures with dwellings, crop fields and some community infrastructure inside (*e.g.* schools, clinic, water points). Examples of such fences include the Tyunga Fences (Binga District), and Masoka Fence (Guruve District).

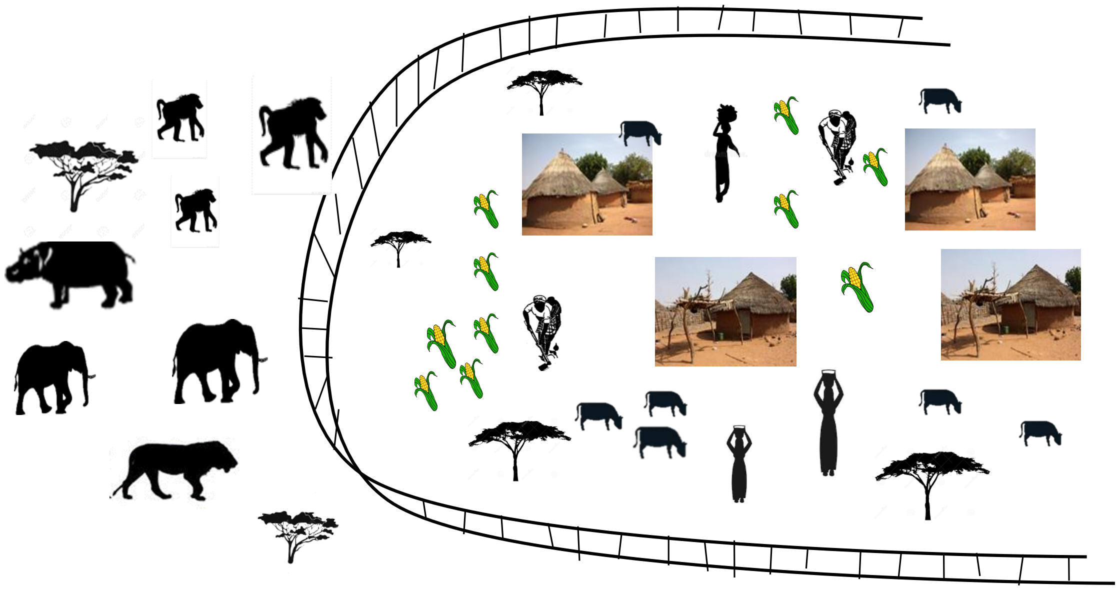
d **Model 4 – Small Group Ownership Fences**: These are individually owned fences that enclose the fields and dwellings of a family or a group of families. It was first implemented in Simchembu (Gokwe North) in 1995 and has recently been implemented in the Mazarabani District.

e **Model 5 - Crop Protection Fence**: Usually a fence encircling an irrigation scheme where the dwelling areas are outside and only irrigated crops are protected inside a fence (*e.g.* Gatche Gatche Irrigation Scheme).

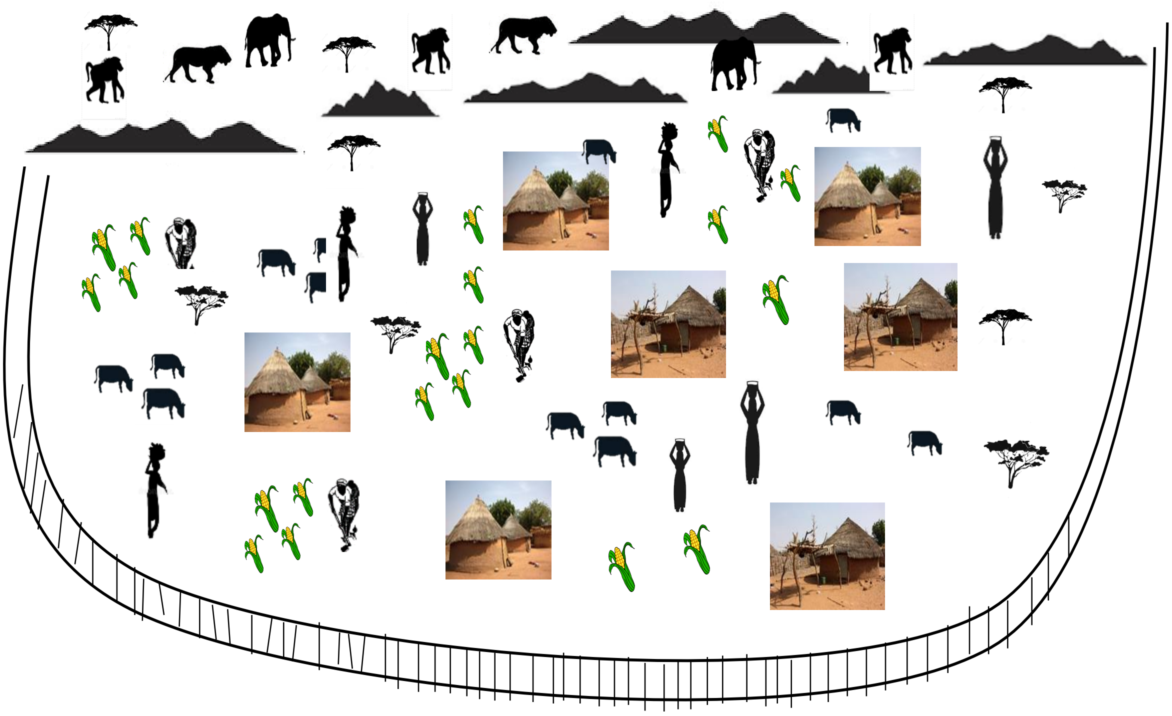
Models 1, 2 and 3 have been the most widely used. There are a few examples of Model 5 while the Model 4 arrangement has not been widely tested in Zimbabwe. The planning process involved in electric fencing projects is extensively discussed in a document whose specific target for readership are rural people in CAMPFIRE districts (WWF 1997).

Figure 4: Various "concept models" of fencing projects to deter problem wildlife

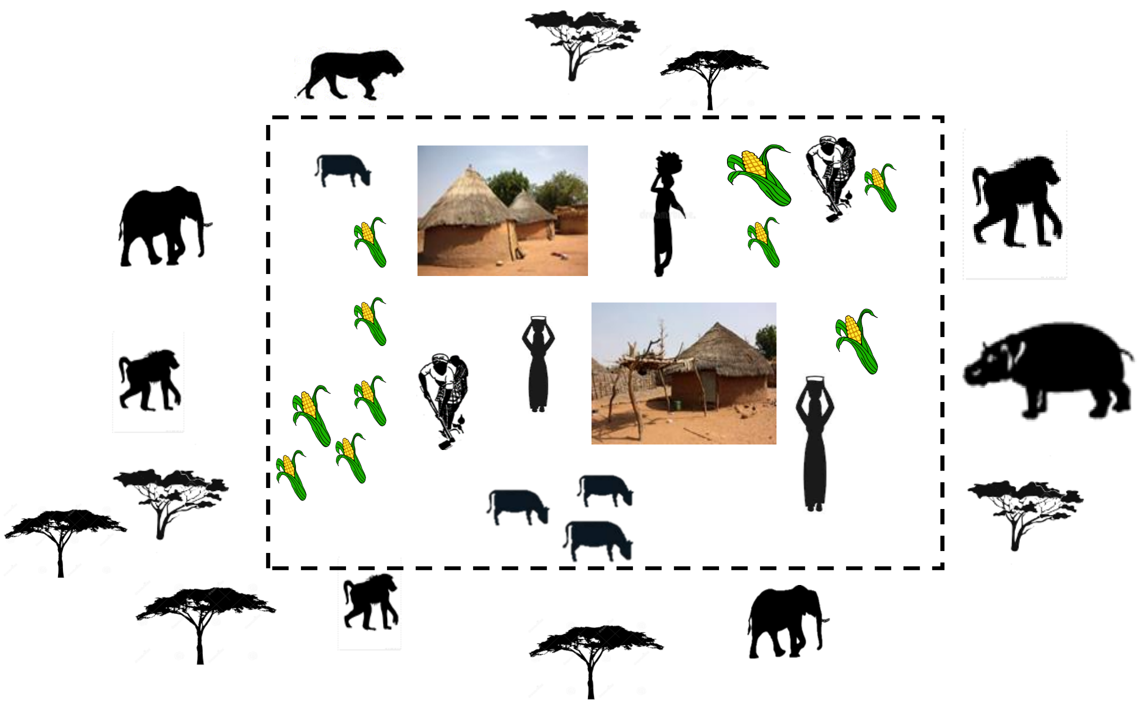
Model 1: Extended Full Barrier Fence



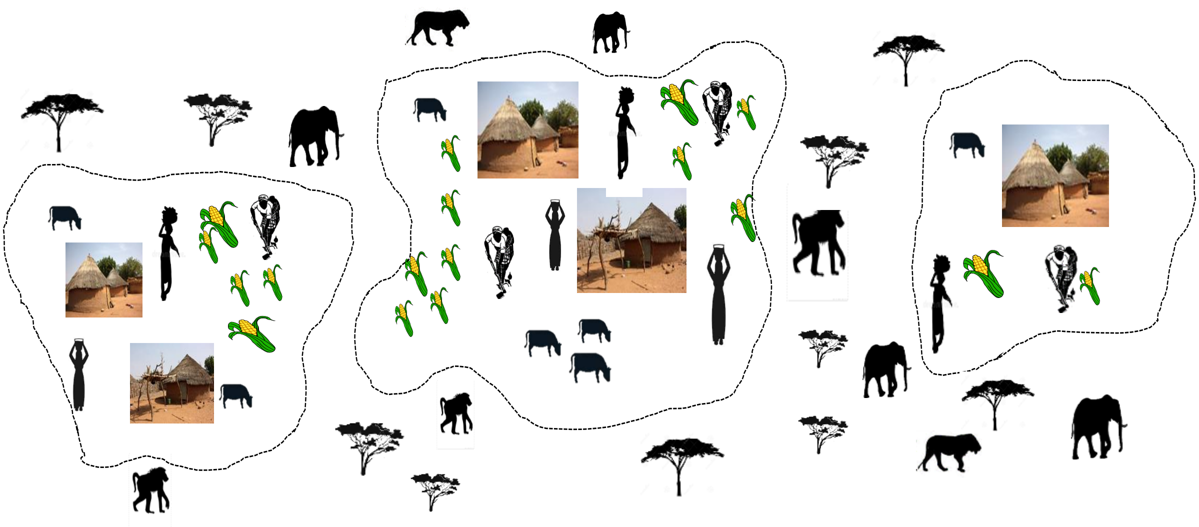
Model 2: Partial Interface Fence **(may incorporate natural barriers)**



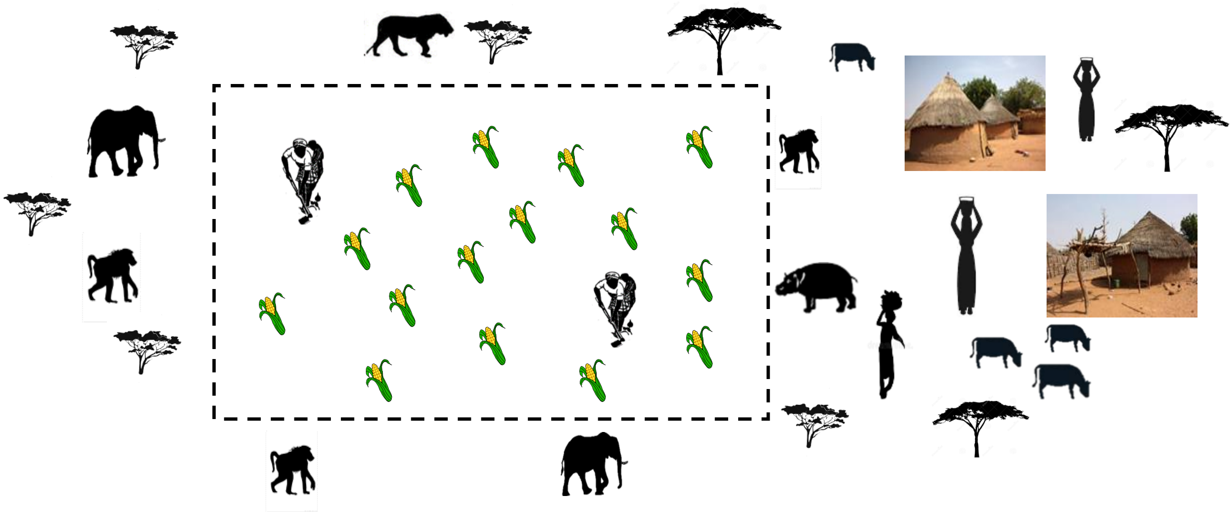
Model 3: Community Protection Fence



Model 4: Small Group Ownership Fence



Model 5: Crop Protection Fence



1.5 FUNDING SOURCES FOR FENCING PROJECTS

The cost of electric fencing is relatively very high when the rural economy of communal lands is considered (Hoare and Bond 1994). Approximately Z$5.5 million has been spent on erecting 500km of electric fencing in Zimbabwe's communal lands between1990 - 1997 at a cost of approximately Z$10 900/km (Table 1). The capital expenditure has come mostly from international donor agencies. The United States (USAID) programme is by far the largest donor, supporting projects in Binga, Bulilima-Mangwe, Nyaminyami, and Tsholotsho districts. The Netherlands Embassy has sponsored two projects in Muzarabani district while aid agencies from Germany (GTZ), Denmark (MS) and New Zealand have sponsored smaller electric fencing projects in various parts of the country. One project in Gokwe North obtained part funding from a mining company (Rio Tinto Zimbabwe) while a safari operator entered into a joint venture with the Rural District Council on a fencing project in Binga district. There are no examples where a Rural District Council or community has met the entire construction cost of an electrified fence (although Tsholotsho RDC invested approximately $200 000 in clearing the trace line of their fence).

Table 1: Inventory of communal land electric fencing constructed between 1991 and 1997 in eight CAMPFIRE Districts

District	Wards Involved	No of Projects	Fencing Length (km)	Total Cost (Z$)	Cost per Kilometre (Z$)	Target Species
Binga	3	9	182	1 569 000	8 620	Elephant, buffalo, hippo
B/Mangwe	2	1	35	646 000	18 457	Elephant
Gokwe	3	3	54	507 000	9 388	Elephant, buffalo
Guruve	1	1	22	38 000	1 727	Elephant, buffalo
Hwange	1	1	32	296 000	9 250	Elephant
Nyaminyami	1	1	18	157 000	8 722	Elephant, buffalo, lion
Muzarabani	3	6	86	1 565 000	18 197	Elephant
Tsholotsho	2	1	71	675 000	9 507	Elephant
TOTAL	**16**	**23**	**500**	**5 453 000**	**10 906**	

The cost of installation of these fences varies considerably from $2 111/km in Guruve to $18 457/km in Bulilima-Mangwe. These variations reflect the costs associated with the location and the terrain in which the fence is being constructed.

However, the actual costs of construction have remained constant between 1991 and 1997. This is seen in Table 2 where the construction costs in two districts have not altered significantly during this period[3].

Of interest here is the fact that the cost of installing fences in relatively flat terrain such as that found in the Binga District is substantially lower than the costs associated with construction in rugged terrain in Muzarabani.

Table 2: Installation costs of communal land electric fencing in two districts between 1991 - 1997 in relatively flat terrain (Binga) and rugged terrain (Muzarabani).

Year	**Cost per kilometre installed (Z$)**	
	Binga District (flat terrain)	**Muzarabani District (rugged terrain)**
1991	4 104	-
1992	-	13 473
1993	6 985	18 521
1994	8 720	16 555
1995	-	-
1996	10 000	14 733
1997	-	15 457

1.6 ASPECTS OF FENCE PLANNING AND IMPLEMENTATION IN ZIMBABWE

A fence project has several phases (Mackie 1992; WWF 1997): proposal, planning, funding arrangements, contract preparation, tendering and award, erection, technical maintenance and monitoring. Generally local NGOs have assisted districts individually in their feasibility assessments and proposal formulation, sometimes also acting as a conduit and management agency for the capital funding i.e., dealing with tenders and fencing contractors. Private sector contractors in Zimbabwe who have successfully tendered for communal land fencing projects have often been contractually required to:

(i) employ construction labour from the local community involved, and
(ii) train local fence minders during the construction phase for future maintenance work.

Although most funding is disbursed during construction, the contractor may only receive a final payment once a specified period has elapsed in which no faults can be ascribed to the workmanship.

After construction the RDC may elect to manage the fencing project or may cede this responsibility to the ward or wards involved. Recurrent expenditure on fence minders and equipment required for repairs has not been provided by donors and has become the responsibility of the district at either RDC or Ward Wildlife Committee (WWC) level to fund out of their own resources, i.e., their CAMPFIRE revenue.

As discussed above, rural communities believe that electric fences will solve all their problems related to problem animals. Their expectations are usually unrealistic, and planners must be

[3] The estimated cost/km of constructing a Foot-and-Mouth Control fence modified to control the movement of elephant in the Omay Communal Land in 1996 was $42 700/km. Commercial companies are quoting Z$22 700/km in the September issue of *The Farmer* magazine.

aware of this if the objectives of the fence are to be achieved. These objectives may be summarised as follows:

a. Reduce crop losses (this is the most pressing issue perceived by the people, regardless of whether in economic terms it is significant).
b. Reduce human injury and deaths from wild animals.
c. Decrease the human impact on the environment (reduce PAC, decrease illegal hunting).

In planning the implementation of physical barriers, it is important therefore that the target communities are made aware of all the implications. The construction of a barrier such as an electrified fence is a complicated development for rural communities, and the success of the fencing programmes depends on the concept being accepted by the communities. Five steps in implementation of fencing projects have been developed in Zimbabwe (Mackie 1992, WWF 1997). These are: -

a. Concept (including resource survey and socio-economic survey)
b. Planning (discussing all options)
c. Funding and tendering
d. Trace line marking and construction
e. Maintenance and Monitoring.

The communities should be directly involved in all these stages, although in practice the concept and planning stage is usually done at Council level prior to discussing the issues at a community level. Funding and tendering is the responsibility of the Council and it is only at the stage of line marking and maintenance that local communities become more actively involved.

It is also important that the contractual obligations of the contractor be thoroughly worked out in advance of the construction phase if the fencing project is to be a success. Once the fence becomes the responsibility of the Council (or Ward), the maintenance of the fence is the crucial link determining whether the fencing project will be successful in the long term. It is at this stage that the full implications are least understood or appreciated by Councils or rural communities.

Most Councils have been very slow or reluctant to pay fence minders, and the most successful fencing project are those in which a full time supervisor is employed. There can be absolutely no compromise with electric fence maintenance. For animals to be properly 'conditioned', voltage above four, preferably five kilovolts, must always be maintained. Therefore, patrolling of the entire length of fence DAILY THROUGHOUT THE YEAR is required and minders must have proper tools and materials to effect repairs immediately.

However, there is a tendency for maintenance to lapse in the dry season in the belief that the deterrent is only needed in the crop growing season. Elephant, who will continually test a fence, will cease to respect such a barrier and tear down the flimsy structure even when the current is restored.

1.7 ALTERNATIVES TO ELECTRIC FENCING

Because of the cost and intensive management associated with electric fencing in the communal land situation, the question of alternatives to electric fencing often arises (Hoare 1992a). Our current knowledge of problem animal management in Africa strongly suggests that electric fencing is only one of a "suite" of measures which can be used to ameliorate the negative impacts of wildlife on people (Hoare 1995). Electric fencing can never be universally applicable or affordable in the communal land situation. Even where circumstances allow it to be used, it should not be relied upon as the only measure in PAC. Therefore, seeking a single "alternative" is contra-indicated. Intelligent choices must be made as to which wildlife control measures can be combined in which locality.

The strategies adopted prior to the development of electric fencing were either cheap to implement and/or exacted high social and environmental costs. Where this involves small mammals, they were reasonably effective, but where large and potentially life-threatening animals were involved, rural communities were quick to point out that it was the responsibility of the wildlife authorities to solve the problem. To achieve this, wildlife authorities have tried a variety of methods including:

- Monetary compensation schemes
- Revenue sharing schemes
- Direct active deterrence (shooting, fire, noise)
- Disturbance (using shotguns to frighten animals)
- Removal of animals (control shooting to "teach" animals not to raid fields)

None of these methods have provided long-lasting solutions primarily because they did not address the cause of the problem. The general consensus was that this could only be achieved by erecting some form of physical barrier that would not require the permanent presence of humans in order to make it effective and would prevent large mammals from entering settlement areas.

A variety of methods have been used to achieve this. These included:

- **Establishing barrier crops**: For example, spiny plants such as sisal and cacti were planted around smallholder plots in Kenya. Although cheap and relatively maintenance free, the general constraints are the size and slow establishment of the barrier needed, and the marked variation in growth vigour even in apparently identical circumstances. Furthermore, elephant ate the plants (sisal for example).

- **Moats/ditches/trenches**: Elephant trenches have been dug in various parts of East Africa such as Meru National Park and in the Aberdares, Kenya and in the Lengwe National Park, Malawi (Bell 1984). However, they have achieved very limited success, and have not been used extensively in Zimbabwe or South Africa. The major constraint to ditching is that it is seldom possible to construct a moat around entire crop boundaries because of the soils or terrain. The technique is also unsuitable in sandy, swampy or rocky soils and in hilly, steep terrain. Ditches that interrupt drainage systems cause considerable soil erosion and are liable to siltation and bridging or refilling with the spoil. When inundated they are no longer a barrier to elephants and create artificial stagnant bodies of water that may become health hazards. They require extensive maintenance by large numbers of labourers as elephants learn to cave in the sides and are able negotiate all but the most difficult obstacles. Combinations of trenching with fencing or barbed wire is an expensive option but is only effective over short distances such as around tourist lodges and water pumps.

- **Conventional fences**: In this context 'conventional' means non-electrified high-tensile steel fencing. One example of a successful elephant-proof conventional fence is the Armstrong Elephant Fence built in the 1950's around the Addo National Park in South Africa. It consists of railway line posts embedded in concrete and strung with thick mine cable. However, the estimated cost for erecting a fence to these specifications is approximately US$20 000 per kilometre that is prohibitively expensive for other situations in Africa. In Zimbabwe, the Department of Tsetse Control constructed two-metre high, 12 strand fences to control wildlife movement. These fences were patrolled and animals breaking though the fence were hunted down and shot. This strategy was abandoned because of the costs involved and the unacceptably high number of animals that were destroyed.

Factors such as lower population pressure around protected areas, less reliance on small-scale agriculture and the development of the CAMPFIRE approach has led Zimbabwe to avoid park boundary fencing such as that being considered in more densely populated countries like Malawi and Kenya. Those Park boundaries that have been fenced (Hwange, Matetsi, Gona re Zhou) have been done so by the agricultural authorities for veterinary control reasons, mostly to control the movement of foot and mouth carrying buffalo into cattle producing areas. In all cases it can be said that these fencing programmes have not been completely successful despite considerable maintenance programmes[4].

[4] It is of interest to note that the Department of Veterinary Services attempted to electrify certain sections of the Foot-and-Mouth Control fences, but abandoned this approach when maintenance proved too difficult.

2 ELECTRIC FENCING PROJECTS IN CAMPFIRE DISTRICTS

An inventory of electric fencing projects in communal lands shows that in the period 1990 - 1997 inclusive, a total of 500km of electric fencing has been constructed in eight CAMPFIRE districts at a cost of nearly $5.5million (see Table 1). Many more projects have been proposed and discussed but for diverse reasons have not been implemented. There are five target wildlife species against which the existing fences have been erected, the principal one common to all 23 projects, being elephant.

Binga District - 182 km

Binga District has the greatest length of electric fencing of any communal land district (182 km) involving three wards in the wildlife areas in the east of the district, Tyunga, Nabusenga and Nagangala. The programme started in 1991 in Tyunga with two encircling fences around the Tonga settlements of Sinagatenke and Siamupa. By 1994, three additional neighbouring settlements were separately encircled viz. Sinamwenda, Sinamusanga and Llunga. In 1995/6 the Safari Operator, under an agreement with the RDC, erected approximately 100km of electric fencing to secure the Songo wildlife area to the north of the large Siabuwa settlement and to simultaneously try to prevent problem elephant incursions into Siabuwa. At about the same time, the community in the south of Nabusenga ward procured funding from the Danish Association for International Co-operation (MS) to construct an 8km fence in Nabusenga ward in an east-west direction at the base of the Chizarira hills. This is the only example of an electric fence being constructed by the affected community themselves. It has been erected to an acceptable standard to deter elephants in an area of low - medium challenge. This short fence was extended through funding from Zimbabwe Trust and is now over 20km long.

Muzarabani District - 86km

Between 1992 and 1997, Muzarabani District installed an extensive electric fencing programme that is a somewhat atypical of a CAMPFIRE district because a large part of its main wildlife area, the Mavuradona Wilderness Area (MWA) and Great Dyke State Land (GDSL), borders commercial farmland. As such, the initial moves to contain elephants within the MWA/GDSL were taken by commercial farmers who were suffering elephant damage to crops. In successive projects, almost the whole of the southern MWA/GDSL boundary has been fenced, protecting the Centenary and Horseshoe commercial farming areas as well as Chawarura ward in Muzarabani and Mutota ward in neighbouring Guruve. To the north of the MWA mountains lie the Muzarabani Communal Land wards of Hwata and Gutsa on the Zambezi valley floor. Two villages here have been the first places in the country to accept the idea of very small encircling electric fences, individually owned by smallholder farmers (i.e. Model 5, see Figure 4). The first of the intended 30 or so of these projects are in the construction phase at the time of writing.

Tsholotsho District - 71km

Five wards in Tsholotsho district (Wards 4, 3, 2, 1 and 7) have a very long combined frontage with the Gwaai Forest Land and Hwange National Park where bordering communities have endured longstanding problem animal activity. The first phase of their electric fencing project underwent a comprehensive environmental assessment (Hoare and Bond 1994) and was implemented in 1994. At 71 km it is one of the longest electric fencing project in Zimbabwe's communal lands and was built with assistance from Zimbabwe Trust and funded under the USAID NRMP Phase I programme. The RDC wants Phase II to continue southwards to join the fence in Bulilima-Mangwe district at the Nata river.

Gokwe North District - 54km

In the extreme north-west corner of the district there are electric fences in Nenyunga, Madzivazvido and Chireya wards which together demarcate a wildlife "corridor" stretching east-west from the western (Sengwa river) boundary of Chizarira National Park. All are open ended, following the agricultural / natural woodland interface and joining steep escarpments to utilise the extending effect of natural barriers. A local mining company, Rio Tinto Zimbabwe, donated funding for the initial project that was subsequently extended with some ward-derived CAMPFIRE funds in Nenyunga. WWF was the agency supervising the implementation of fences in the district.

Bulilima-Mangwe District - 35km

Electric fencing in Bulilima-Mangwe district consists of a 35km straight fence running from the Botswana border through Bambadzi and Makulela wards and terminating at the Nata (Amanzamnyama) River boundary with Tsholotsho district. There is one major crossing on the Tegwani river. The purpose of the fence, which was subject to a brief environmental assessment (DNR 1995), is to prevent elephants entering "frontline farms" bordering the wildlife area in the north-west of the district, from which all CAMPFIRE revenue originates. There are 11 gates in the fence through which cattle are permitted to enter the wildlife area up to the point where a parallel cattle fence has been erected. The RDC specify that these cattle should be herded and returned to settlement areas at night, but this ruling is largely ignored. People are permitted to enter the wildlife area to collect some local produce (e.g., thatching grass). This fence was funded through the USAID NRMP in 1996.

Hwange District - 32km

Electric fencing in Hwange involved the upgrading of a Veterinary Control Fence on the boundary between the Hwange Communal Land and Sikumi Forest Land. Electrified outrigger brackets were attached to an existing steel fence to try to prevent elephant excursions from the protected areas into communal land. This project was subject to a brief environmental assessment (Timberlake et al 1993) and funded through the USAID NRMP Matabeleland programme.

Guruve District - 22km

This is the oldest electric fence in the CAMPFIRE programme. It was established in 1990 in Kanyurira ward and encircles the small Kanyurira chieftaincy at Masoka in the Zambezi valley.

Nyaminyami District - 18km

WWF assisted with the technical and financial arrangements to erect an electrified fence around Negande A and B wards in the Omay Communal Land. This fence also uses an escarpment area as a natural barrier to prevent elephant movement into the settlement areas, however, the fence is open ended thus reducing the impact of this fence. At the time that this fence was constructed, these wards were not heavily settled, and most people were not affected by problem animals (according to their Problem Animal Reports (PAR's). However, the construction of the fence appears to have re-directed the PAC problem to areas where it did not exist previously (Mackie pers. comm).

A small Model 5 fence was erected around the Negande irrigation scheme in 1989. It was severely damaged by flooding in the early 1990's and subsequently experienced maintenance problems but has been reasonably effective in keeping animals out of the small area of irrigated crops.

In the period 1994 - 1997 some very large electric fencing projects were proposed, encircling three other chieftaincies, but were never brought to fruition. This was due to widespread disagreement between the externally based funding agency - the European Union (EU) and a local implementing agency - Agricultural and Rural Development Agency (ARDA).

2.1 COSTS AND SPECIFICATIONS OF EXISTING COMMUNAL LAND ELECTRIC FENCING PROJECTS

As previously mentioned, the costs of electric fencing in Zimbabwe varies with location, although the costs do not appear to have escalated over a period[5]. Over the entire eight year programme (1990-1998) the average cost per kilometre of electric fencing is Z$10 900 (see Table 1), however this figure should be regarded with caution because enormous exchange rate changes and very high domestic currency inflation could alter this significantly in future. More reliable indices of the capital cost of fences may be the cost per km^2 of land protected or the cost per household benefiting. These were calculated for five of the earliest fences (Table 3).

Table 3: Details of five communal land fencing projects in Zimbabwe

LOCATION	Guruve MASOKA	Nyaminyami NEGANDE	Binga TYUNGA	Gokwe N NENYUNGA	Gokwe S SENGWA
Model	3	2	3	3	2
Fence Type	Encircling	Partially Encircling	Encircling	Partially Encircling	Deflecting
Interface	Isolated Settlement	Isolated Settlement	Isolated Settlement	Mosaic	Hard Edge
Target Species	Elephant Buffalo	Elephant Buffalo Lion	Elephant Buffalo Hippo	Elephant Buffalo	Elephant
Fence Length	22 Km	18 Km	23 Km	30 Km	21Km
Protected Area	25 Km^2	44Km^2	22 Km^2	88 Km^2	100 Km^2 partially
No Households	120	513	256	884	Unknown
DESIGN					
Wires	5	7	5	5	2
Poles	Wooden	Wooden	Steel	Steel	Wooden/Steel
Height	1.8m	1.8m	1.7m	1.8m	1.8m
Electrics	3 In-line +ve	4 In-line +ve	3 In-line +ve	2 Offset +ve	1 In-line +ve
Completed	Aug 1990	Sept 1991	Nov 1991	May 1992	Oct 1992
Cost/Km	US$500	US$1 185	US$1 368	US$1 476	US$495
Cost vs. Protection Indices					
Cost/Km^2 Protected	US$440	US$484	US$1 430	US$503	US$104
Cost per Household Protected	US$91	US$41	US$123	US$50	N/A

The area of land protected by these five fences varies from 22km^2 to over 100km^2. The cost of protecting these areas therefore ranges from US$104 in Gokwe South to US$1 430 in Binga (Table 3). When these data are applied to households, the costs are reduced considerately to as low as US$41/household. Although these investments appear to be insignificant, the picture changes when one considers that these fences are often not achieving their objectives because of institutional and technical failures.

[5] This may be a result of using locally produced components instead of more costly imported products.

3 ASSESSMENT OF EFFICACY OF EXISTING ELECTRIC FENCING PROJECTS IN COMMUNAL LANDS

Evidence to evaluate the efficacy of existing fence projects comes from several verbal and written sources. These are:

- Fence minders
- Community members
- CAMPFIRE personnel in areas affected by problem animals
- Written problem animal reports (PAR), when available.

Most PAR schemes were initiated only at the time fences were being installed (1990 - 1994) or after their completion, so previous quantitative data for comparison is often lacking. Some districts have not kept up PAR monitoring schemes after the trainers withdrew. Verbal evidence of the local scale of the problem and records of problem animal control (PAC) operations can provide reliable evidence for evaluating a change in the number of incidents due to problem wildlife species if PAR data are lacking. Whilst there is sometimes a tendency among farmers to exaggerate the levels of damage to their property once a problem incident has occurred, rural people generally provide very reliable information on the distribution and frequency of problem animal activity.

Maintenance problems are relatively accurately assessed by:

- Visiting and noting the state of repair of fences
- Questioning fence minders
- Speaking to ward wildlife committee members and RDC officials
- Examining minutes of fencing workshops held in CAMPFIRE districts.

3.1 DETERRENCE OF PROBLEM SPECIES

Problem species behaviour at electric fences, common to all mammals, has been described in Britain (McKillop & Sibly 1988) and the requirements for controlling a range of African species with fencing have been noted by Hoare (1992a). These are discussed below.

Elephant: Evidence suggests that generally very good control of elephant movement can be achieved with electric fencing in a variety of situations in rural Zimbabwe, as long as fences are in good working condition. There is evidence that shocking by an electric fence can "negatively condition" most elephants against entering human settlement for some time. However, certain locations have very persistent and adventurous individual problem elephants that will continually test an electric fence and try to find new ways of disarming it.

Buffalo: Buffalo are relatively easily controlled by electric fences, mainly because they mostly exhibit herding behaviour and lack of persistence at an obstacle. Other than where fence maintenance standards have been allowed to lapse (*e.g.*, in Guruve and Nyaminyami) buffalo are fully controlled by the existing fences.

Hippopotamus: At river crossings, hippos can swim under fences but when on land they are easily controlled by simple, low height electric fences. Three encircling electric fencing projects in Tyunga ward, Binga have much reduced the incidence of hippos raiding crops planted close to the edge of an inlet on Lake Kariba.

Large Carnivores: Very poor control is being achieved against these species (lion, leopard, hyena) using electric fencing because they can climb over, dig under or squeeze through small gaps in fences (Hoare 1992a). In Tsholotsho, where carnivore incidents are common, problem incident levels from lion and hyena in areas bordering Hwange National Park remain little changed after construction of electric fencing which mainly targets elephants.

Bushpigs and Primates: Bushpig are a very problematic species but tend to prefer wetter parts of the country. Therefore, in the present project areas that are fairly arid, they are not too serious as an agricultural pest. Present electric fencing is virtually useless against both nocturnal bushpigs and diurnal primates.

3.2 REDUCTION OF PROBLEM ANIMAL INCIDENTS

Poor record keeping precludes the use of reliable data to substantiate the hypothesis of a universal decrease in problem wildlife incidents in rural areas protected by fences. There is, however, quantitative evidence from a few sites and good verbal evidence from most sites that a marked decrease did indeed occur (Tables 4 - 6 and Figure 5). Available evidence shows that control of the main problem species (elephants) is achievable with almost all fences but is consistently better with encircling than deflecting or open-ended fences. Buffalo and hippo incidents can be reduced because, lacking the persistent and innovative behaviour seen with elephant, they are deflected relatively easily from reaching a food target. Carnivores, bushpigs and domestic goats are very poorly controlled by any electric fence of the current design.

Table 4: Elephant controlled by existing communal land electric fences when maintenance is satisfactory

District (Project)	Km Length	Type of Fence	Elephant Challenge Level	Elephant Control Level	Comments
B-MANGWE					
Bambadzi	15	Deflecting	Low	100%	
Makulela	20	Deflecting	Medium	Nearly 100%	Funnelling around end of fence
BINGA					
Sinagatenke	23	Encircling	High	100%	
Siamupa	9	Encircling	High	Nearly 100%	Occasional entry at river crossings
Sinamwenda	6	Encircling	High	100%	
Sinamusanga	11	Encircling	High	100%	
Llunga	17	Encircling	High	100%	
Karungwizi	8	Deflecting	High	Nearly 100%	
GOKWE NORTH					
Nenyunka	31	Deflecting	High	Fair	Funnelling around end of fence
Madzivazvido	15	Deflecting	Medium	Fair	Funnelling around end of fence
Chireya	8	Deflecting	Medium	Unknown	Never maintained properly
GURUVE					
Masoka	22	Encircling	High	100%	

District (Project)	Km Length	Type of Fence	Elephant Challenge Level	Elephant Control Level	Comments
MUZARABANI					
Centenary	19	Deflecting	Medium	Nearly 100%	Funnelling around end of fence
Horseshoe	23	Deflecting	Medium	Nearly 100%	Funnelling around end of fence
E. Mvuradona	15	Deflecting	Medium	fair	Funnelling around end of fence
Musengezi	15	Deflecting	Medium		
Utete	14	Deflecting	Low		Funnelling around end of fence
TSHOLOTSHO					
Ward 3	45	Deflecting	High	Good	Some elephants disarm fence
Ward 2	26	Encircling	Low	100%	Low challenge

Table 5: Performance of an encircling-type electric fence in first year (Tyunga Block 1 fence, Binga District, 1991 - 1992)

Species	Elephant	Buffalo	Hippo	Bushpig	Kudu	Other	Total
FENCE BREAKS							
Number of breaks	19	24	6	0	12	3	64
% of breaks	30%	37%	9%	-	19%	5%	100%
DAMAGE INCIDENTS							
Inside of fence	0	0	5	0	0	0	5
Outside of fence	132	0	8	2	0	0	142
% of damage	93%	-	6%	1%	-	-	100%

* Design: Six strand fence with alternating +ve and -ve wires
* Length: 23 km long and encircling
* Fence breaks are repaired; damage incidents are reported problem animal incidents

Table 6: Effectiveness of a well-maintained community enclosure (Model 3) fence over 3 years. (Tyunga Block 1 fence, Binga District)

SEASON	ELEPHANT ACTIVITY OUTSIDE FENCE	ELEPHANT ACTIVITY INSIDE FENCE
1991 / 2	132 Crop Damage Incidents	No Crop Damage
1992 / 3	27 % of Fields Damaged	No Crop Damage
1993 / 4	43 % of Fields Damaged	No Crop Damage

Quantifying the effectiveness of fences (*e.g.* as in Thouless and Sakwa, 1995) is expensive, time-consuming and logistically difficult. Table 5 and Figure 5 give quantitative data on two different kinds of fence that were reliably monitored in the first year after construction. These examples substantiate the subjective judgements appearing in Table 4 as "elephant control level" which had to be based largely on interviews with people. Table 4 therefore reflects the performance of new communal land fences (*i.e.* before maintenance problems affect fence efficiency) or those that are always carefully maintained.

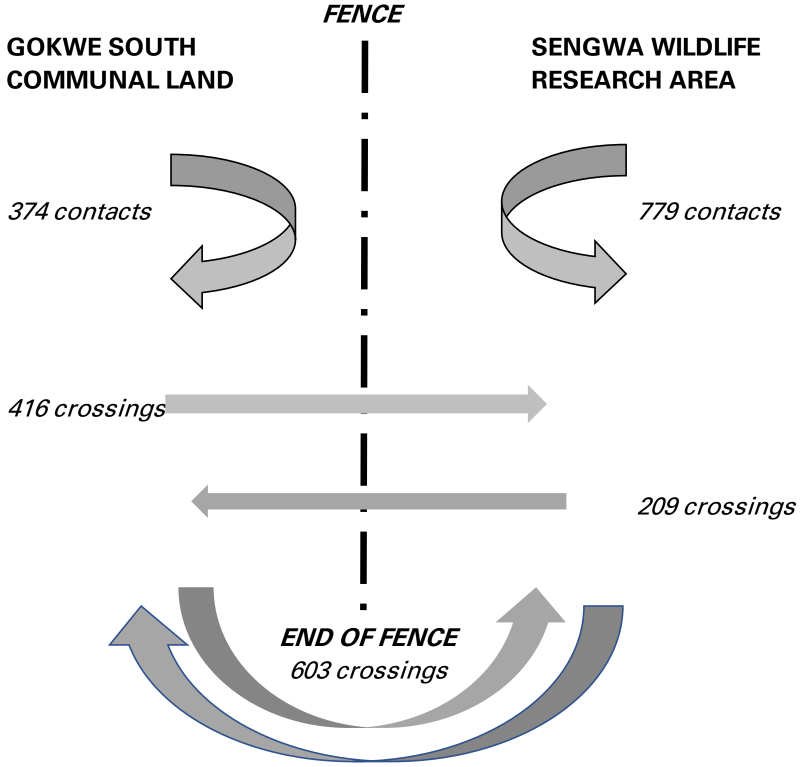
The major issue here is that local communities agree that where problem animal activity is measured, encircling fences are more effective deterrents than deflecting fences, even where both suffer from poor maintenance. Encircling fences are closer to human settlement and people can use alternative deterrent if they are under threat from problem animals breaking through the barrier because it is badly maintained. With a deflecting fence, even if it is well maintained, a relatively high level of problem animal activity persists, particularly from elephants.

This point is illustrated in Figure 5 (a) where elephants leaving a protected area mostly preferred to walk around the end of the fence after dark to enter the communal land. On returning to their daytime refuge however, when they may have felt more "exposed" to retaliation by people, many broke through the electrified fence itself. In this area most crop raiders are large adult bulls which employed a variety of ingenious methods to disarm the inadequately designed electric barrier.

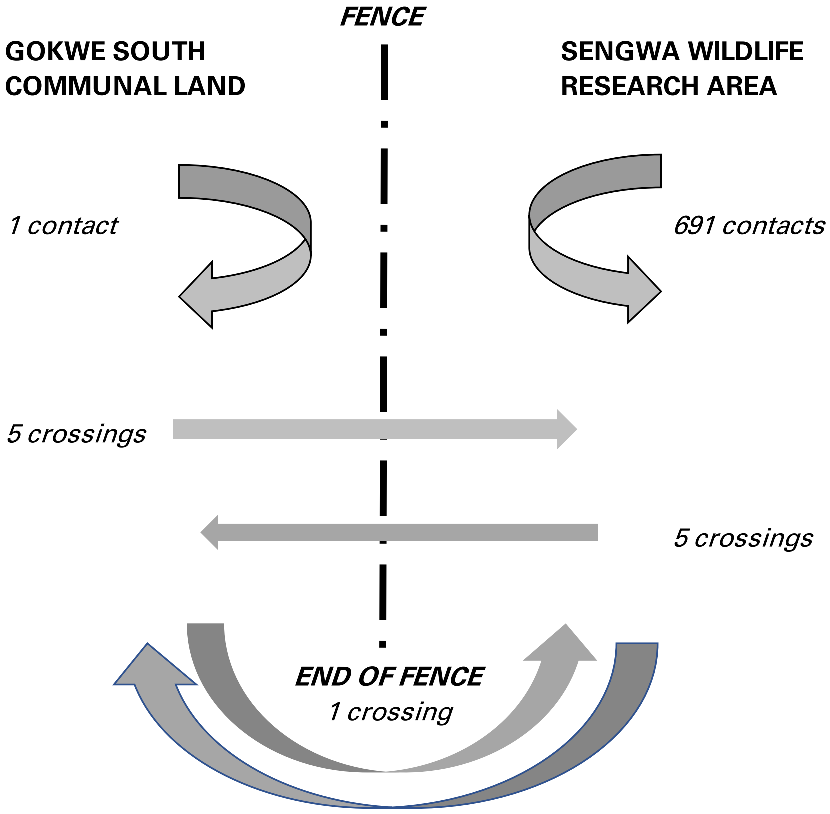
It is not possible to state when a fence will become ineffective against problem animals. As can be seen from the case studies and the analysis of linkages between different causes of maintenance problems, this can be anywhere from one to six years after construction.

Figure 5: Comparison of the performance of a full barrier fence (Model 1) against elephant and buffalo showing numbers of animals which turned back (contacts) versus number of animals which successfully crossed (crossings) during one year (1992 - 1993)

ELEPHANT



BUFFALO



3.3 DECREASE IN DESTRUCTION OF PROBLEM ANIMALS

Several factors likewise preclude a clear quantitative hypothesis being expressed about a decrease in the destruction of problem animals due to fencing protection of human settlement. These are the relatively small areas protected by fences and poor locational information on PAC killings.

In areas where encircling fences are used and maintenance has been good there has been a localised decrease in PAC killings (*e.g.,* Tyunga, Binga and Masoka, Guruve). With long, open-ended fence programmes, the deflecting effect of fences may even "funnel" more animals, especially elephants, into a smaller area of human settlement. Rural communities may regard such problem animals as even more recalcitrant than usual since they apparently fail to be contained by a fence. Ironically, in these circumstances a fence may exacerbate both problem incident levels and PAC killings or at least fail to cause a noticeable decrease.

This has been observed in Muzarabani district where gradual extensions of electric fencing over a long wildlife-human interface have not led to a decrease in PAC elephant killings. Unfortunately, the time span here is too short (three years), the numbers of elephant shot is small (nine animals), and the movement patterns of elephants in this area are complex, so this situation should be treated with caution.

3.4 ASSESSMENT OF CURRENT PROBLEMS WITH COMMUNAL LAND ELECTRIC FENCING

Random voltage checks were made on several communal land fences during this study to determine whether the fences were working effectively at the peak of the crop raiding period (March 1998). The results of these checks are summarised in Table 7.

Table 7: Voltage checks on communal land electric fences, March 1998. For control of large wild species voltage should be above 5.0 kilovolts (5 000 volts).

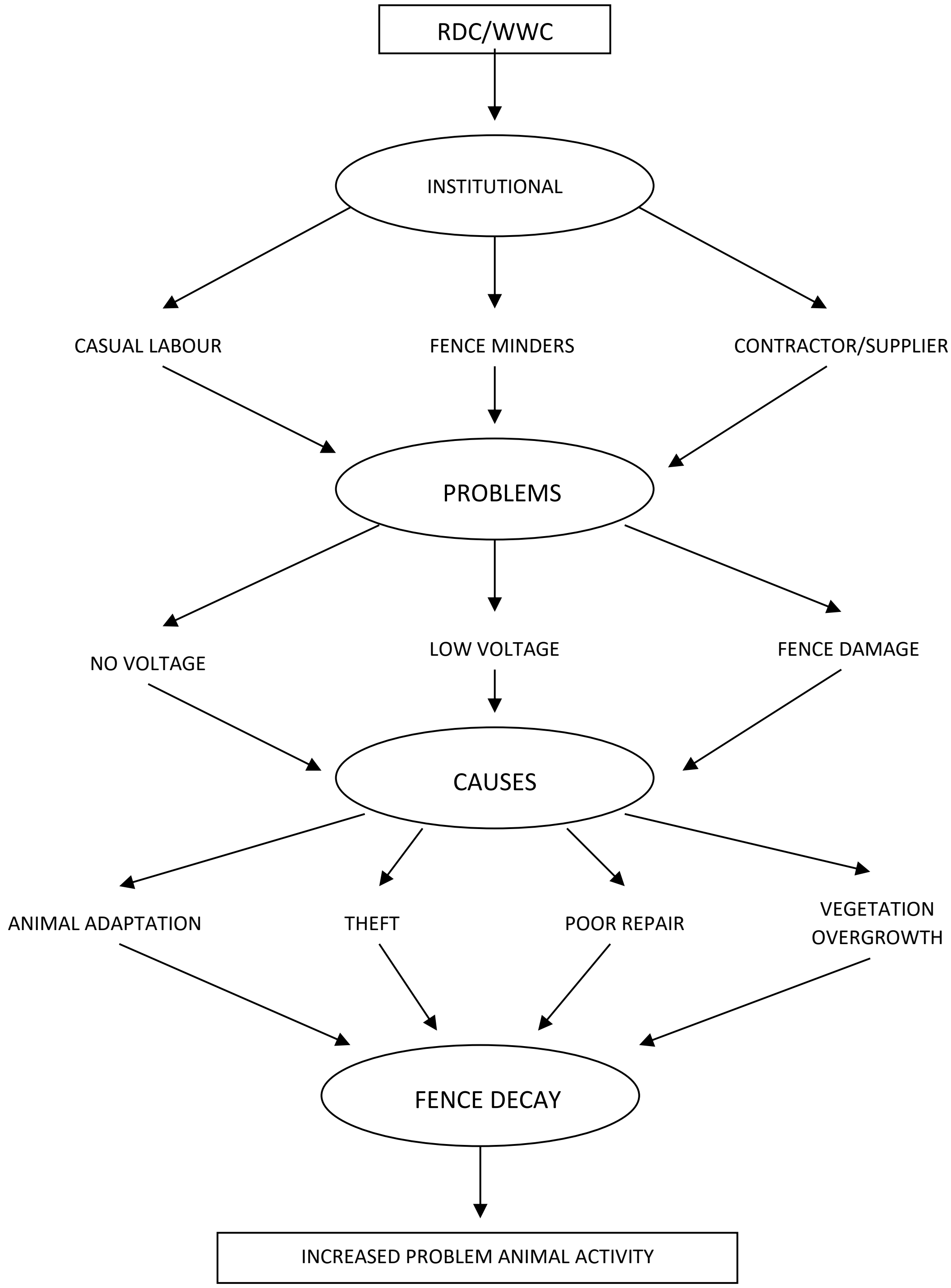
District	Location	Voltage (kV)	Comment	Clearing of Line
BINGA	Tyunga Block 1	0	8 km removed by flood February 1997	Overgrown
	Tyunga Block 2	1.9	Flood damage at rivers	Fair
	Karungwizi	0	Energizer failure July 97	Good
B - MANGWE	Bambadzi	3.5	Reading at Energizer	Poor
	Bambadzi	1.2	< 1km from Energizer	Poor
	Makulela	4.0	Reading at Energizer	Fair
GOKWE NORTH	Sengwa River	5.5	Reading at Energizer	Fair
	Main Tar Rd	0.9	Panel thefts	Good
	Champapara	2.2	Panel thefts	Fair
GURUVE	Masoka west	1.3	Reading at Energizer	Poor
	Masoka access	0.9		Poor
	Masoka airfield	0	Rotting wooden poles	Good

District	**Location**	**Voltage (kV)**	**Comment**	**Clearing of Line**
MUZARABANI	Horseshoe	0	Commercial farmer	Overgrown
	Chawarura	0.4		Poor
	Hwata	0	Smallholder	Overgrown
NYAMINYAMI	Negande A	0	Panel theft	Fair
	Negande B	0	Panel theft	Fair
	Chiwa valley	0	Panel theft	Overgrown
TSHOLOTSHO	Ward 3	0.6	Reading at Energizer	Overgrown
	Park boundary	0.5	Vet fence modification	Poor
	Ngamo flats	0		Overgrown
MEAN VALUE		**1.25**		

To control large wild animals, the voltage should be above five kilovolts (5 000 volts). The mean value recorded from the 21 fences visited was 1.25kV. Approximately 43% (9 out 21) were not working at all, whilst the remainder carried between 0.4 and 5.5kVs. Only three fences recorded voltage levels approaching the required level (3.5 - 5.5kV) at the energizers, but this level dropped off significantly within one kilometre of the energizer and thus rendering the fences ineffective.

The following flow diagram attempts to identify the reasons for this. Essentially, the responsibility for the fence rests either with the RDC or the WWC. These institutions are responsible for the supervision of the maintenance crews (casual labour, fence minders, contractor/supplier). The problems encountered by the maintenance crew can be summarised as either no voltage, low voltage or fence damage. The causes of these faults can be any combination of animal adaptation, theft, poor state of repair or overgrown vegetation along the lines. The net result is that the fence decays and the incidence of problem animal reports (PAR) increased (Fig 6).

Figure 6: A flow diagram illustrating the problems and causes leading to fence decay.



3.5 THEFT OF EQUIPMENT

Theft of solar panels, energizers and batteries is one of the most serious threats to the operation of communal land electric fencing projects in Zimbabwe. Only two of the seven districts reviewed have not suffered such thefts (Table 8). There appears to be a thriving black market in second hand solar panels and batteries that are now regularly stolen from rural schools, missions, telecommunications installations and electric fences. The Posts and Telecommunications Corporation (PTC) recently reported that losses of solar panels had cost $152 000 country wide (Herald 1998). In Gokwe North, three solar panels were stolen from the Nenyunka fence on the same day![6] Energizers have been stolen but less frequently than solar panels or batteries, presumably because their subsequent use is much more restricted and more obvious.

Table 8: Thefts of equipment from Communal Land electric fences

District	Year	Solar Panel	Energizer	Battery	Wire
Binga	1996	1	1	1	-
B - Mangwe	-	-	-	-	-
Gokwe North	1995 1996 1997	1 2 3	- 1 -	- - 1	- - -
Guruve	-	-	-		
Nyaminyami	1995 1997	1 1	1 1	- -	++ ++
Muzarabani	1996	4	2	-	++
Tsholotsho	1995 1997	1 1	1 -	1 1	- -
TOTALS		**16**	**7**	**4**	

Most fences have power units installed in remote places far from any dwellings and although they are often enclosed in protective metal boxes or cages, thieves have ample time to work on removing them. Even in the commercial sector where management is generally good, the theft of solar panel is a major problem. Save Conservancy lost more than 10 panels on their 300 kilometres of fence before securing them in cages, electrified boxes or concrete rooms. Some were stolen despite guards employed to live at the site of the fence energizer! Hippo Valley Estates changed to mains energizers for all their 190 kilometres of fencing because of constant theft of solar panels.

The consequences of removing the power units from a fence results in the remaining power units having to "double up" and therefore powering lengths of fence in excess of their capacity. The voltage in the whole fence then drops, allowing problem animals to breach the barrier. This situation has occurred in Nenyunka, Gokwe North where a large group of elephants has taken up residence inside the fence and is devastating the community's crops. In Nyaminyami, even though one power unit has been recovered and the suspect arrested, the Ward Wildlife Committee (WWC) do not want to re-install it in the same place for fear of it being stolen again. The fence is therefore not working at the time of peak challenge by problem animals.

6 Theft of solar panels from institutions such as schools and clinics has also recently featured on the main news televised to the nation.

3.6 ADMINISTRATIVE AND INSTITUTIONAL PROBLEMS

A chain of command exists in the maintenance of an electric fencing project. A weak link in this chain of command will prejudice the whole operation of the project, whether maintenance is RDC based or Ward based. Some of the more common problems encountered were:

(i) Delays in paying salaries to maintenance workers

This was a common complaint heard in RDC controlled projects. Furthermore, in some cases the RDC claimed that it had hired casual labour to clear fence lines but when fence minders were asked about the arrangement, they denied that any casual labour had been employed.

(ii) Delays in the disbursement of revenue from RDC to Wards

This was also a common complaint. The most talked about example is that pertaining to the Guruve RDC. In this instance alleged corruption at Ward and RDC level resulted in the disbandment of the WWC and the RDC in 1997. The interim RDC administration has forbidden the WWC to operate its own bank account (something it was able to do for several years) with the result that it must request the RDC for money. The net result is that allowances for fence line clearance or providing fence minders with tools and essential repair items are now not being paid timeously.

Simple administrative deficiencies such as these can cause a "cascade effect" on a fence project. The flow chart (Figure 6) shows the general progression of fence management problems and illustrates the variety of cross-linkages that can occur between the details of fence maintenance. The whole or parts of the following sequences of problems were seen in the course of this investigation:

- Failure to pay workers ➔ vegetation overgrowth in places ➔ voltage loss ➔ problem animal penetration.
- Failure to pay workers ➔ vegetation overgrowth in places ➔ dry season fires ➔ damage to insulators and poles ➔ repair requirements outstrip maintenance budget.
- Theft of power unit ➔ total or partial voltage loss ➔ reduced patrolling by fence minders ➔ theft of wire for snaring ➔ penetration by problem animals and destruction of remaining fence.
- RDC decision to divert CAMPFIRE ward revenues to central projects ➔ theft replacements exceed ward revenue ➔ voltage loss on fence ➔ penetration by problem animals and destruction of remaining fence.

The cascade of problems can continue and affect the whole attitudinal structure of local wildlife management. For example:

- Fence maintenance deficiencies ➔ needless destruction of problem animals ➔ provision of free meat to the community ➔ reduced incentive to maintain an ailing fence.

3.7 SUPERVISION OF MAINTENANCE WORKERS

Each level of maintenance in electric fencing requires supervision because the momentum in routine duties has to be sustained daily. Fence minders operate in remote areas and can easily be absent for short periods without detection. The employment of a fence supervisor (as in Nenyunka Ward, Gokwe) who earns slightly higher wages and is paid an allowance for a bicycle is one way of trying to improve fence maintenance.

3.8 TECHNICAL DEFICIENCIES

Most communal land electric fences are designed to carry three or four live wires. The lowest strand is usually less than 30cm above the ground. Why the majority of fences are constructed this way when the target species are large bodied, is not immediately clear. There are three possibilities:

(i) communities believe that these fences could deter all species, even carnivores and bushpigs or
(ii) communities wanted an easy way to stop domestic species (*e.g.*, goats) from entering fields or
(iii) the fence is designed to avoid having the top strand positive.

The net result of this design is that most of these fences carry poor voltage levels (see Table 7). The main reason for this was the presence of vegetation that provided a pathway for the electrical current to leak from these low positive wires into the ground.

The solution to this problem is to disconnect the power to all live strands below one metre above ground, if adequate vegetation clearance cannot be achieved. This will mean that the fences target large-bodied herbivores only and have a better chance of remaining effective against them.

3.9 ANIMAL ADAPTATIONS

Elephants are highly mobile and intelligent so there are a number of particular problems in controlling this species with electric fences. For example, elephants can use their tusks to disarm live wires because ivory is a good insulator, and they often use their feet and trunks against non-electrified parts of a fence, *e.g.* the posts and droppers (Thouless and Sakwa 1995). Other problems that have been encountered in Zimbabwe include:

- From available evidence it has been proposed that certain individual elephants may be "habitual" problem animals (Anon 1998; Osborn and Welford 1996; Hoare 1995; Hoare 1997) or "habitual" fence breakers (Thouless and Sakwa 1995). Good anecdotal evidence from Gokwe North, Gokwe South and Tsholotsho districts substantiates this view. In these locations, elephants have a protected area refuge close to human settlement so certain individuals have become particularly regular, persistent and adventurous crop raiders.

- Bull elephants are mostly responsible for problem incidents. Fences must be at least 1.8 m high to stop large bull elephants from stepping over the top wire. Due to undulations in the ground, some sections of a 1.8m fence can fall well below this height, so it may be safer to specify at least a 2m height in the construction and tender requirements.

- Fence standards must be close enough together to stop elephants disarming a fence by pressing live and earth wires together. In Tsholotsho and Gokwe South where the Veterinary department buffalo control fence was extended upwards and electrified, elephants have managed to deliberately short out the current in this way and step over the barrier. Because the extension is of weaker metal construction than the very robust base fence, individual elephants have also learnt to bend the extension over to reduce the height of the barrier, and then step over.

- An exception to this requirement for fence height is found where problem elephant groups contain juveniles that cannot step over a fence. In western Beit Bridge for example, the districts' elephant population has been harassed and consequently moves around in large groups which contain cows and small calves. A standard 1.1m high cattle fence with the top strand electrified, successfully stops these elephants from entering irrigated wheat, citrus and cotton fields.

- Where electric fence projects have been designed as "open ended", problem elephants have moved along the fence line and become "funnelled" into settlement at the open end. This has happened with fences in Gokwe North (Nenyunka), Nyaminyami (Negande A) and Muzarabani (Chawarura). This was not anticipated in the planning of many existing electric fencing projects and is one of the most fundamental problems being experienced in the whole electric fencing programme.

3.10 Fencing Workshops

NGOs and RDCs involved in CAMPFIRE programmes have recognised for some time that fence maintenance in communal land projects is experiencing problems. The minutes of fencing workshops and the correspondences flowing between NGOs and RDCs are particularly illuminating in this regard. The following are problems identified by the workshop participants at two recent workshops:

Gokwe North, February 1996 (WWF 1996a)

- Late pay for fence workers
- Delay in providing fencing materials
- Fence minders not sure of what to do
- Energizers not strong enough
- Energizers not working at night
- Elephants get caught in fence corners
- Elephants passing through main road gap
- Trees fall on fence
- Community failing to clear grass on fence line
- Animals break into settlement area

Bulilima-Mangwe, January 1997 (Zimbabwe Trust 1997)

- Housing for fence minders inadequate
- No supervision for fence minders
- Wrong tools for fence minders
- Fence checking not done daily
- Fence minders not filling in report forms
- Fence at river crossing not in place
- Inadequate grass and bush clearing
- Fence touching anthills in places
- Gates not locked
- Livestock grazing in prohibited area behind fence

4 CHARACTERISTICS AND COSTS OF ELECTRIC FENCE MAINTENANCE

The concept of an electric fence to control the movement of animals appears to be simple, and the technical equipment uncomplicated (Figure 7). In practice however, electric fences require meticulous care to detail if they are to work to maximum efficiency. This requires a high level of management, contrary to common beliefs that once the fence is installed, it will look after itself. The following summary illustrates this point.

4.1 COMPONENT LIFE AND COMPONENT FAILURES ON ELECTRIC FENCES

Solar Panels: Solar panels should have a life of at least 20 years. Imported and locally manufactured models are available, the former being more expensive but superior. The only maintenance required is to keep the upper glass surface clean. The rate of conversion of the sun's energy to electricity by a solar panel is inefficient (of the order of 6%), so anything which obscures full sunlight will decrease the panel's output. In addition, the output of the panels is decreased depending on whether they are self-regulating, or they require a regulator. As previously mentioned, the greatest problem involving solar panels at present is their extreme vulnerability to theft.

Energizers: Energizers manufactured in Zimbabwe are satisfactory for local conditions. Energizers should in theory have a long and trouble-free life but conditions in this country have shown that they can experience problems periodically. Any wire fence attracts lightning because it is in effect a large radio aerial (R. Barrett pers. comm). All energizers should therefore be protected from direct lightning strikes coming through the fence wire by a lightning kit (a choke plus a lightning diverter). This system is effective but not fool proof. Lightning can also enter the energizer via its own electrical earthing system. This can come from a lightning strike some distance away and is known as an "induced strike". If a severe electrical surge from either lightning, or a mains power variation in the case of mains powered energizers, enters the energizer, it blows a fuse which can be replaced locally. Unfortunately, though, further damage often results from a lightning strike, requiring the energizer to be removed from the field site and sent for repair by a specially trained technician.

Electrical failure will also occur if the battery which is being charged by a solar panel is fully discharged or if the energizer - battery connections are in poor condition.

Batteries: Standard heavy-duty 12-volt automotive batteries are adequate for electric fencing. In the marketplace there are many models of imported and locally built batteries, so the quality and prices vary. Lead-acid batteries kept in locked steel boxes under very hot conditions in the field do experience increased loss of the liquid electrolyte and therefore require constant attention to attain their specified lifespan. "Deep cycle" batteries that can withstand repeated discharge and recharge are recommended for electric fences. Batteries can be overcharged or undercharged when linked to a panel, but a device called a "solar regulator" should avoid this. It is sometimes difficult for solar panels to bring a battery back to full charge if it has been fully discharged. Prolonged overcast weather, for instance, results in poor charging and a very flat battery may have to be removed for charging at a mains supply. Reduced battery life caused by irregular charging cycles and battery theft are constant problems plaguing the existing communal land projects.

Fence Posts: All except two of the earliest communal land electric fences are constructed with steel poles. Termite-protected wooden poles (used in Nyaminyami and Guruve), have a shorter life but do have the advantage that temporary repairs can be affected using locally cut hardwood poles. Steel poles should have a long life but on some projects were seen to be suffering from surface corrosion. Maintenance must be very good on a steel fence since a live wire accidentally touching a steel post or dropper results in a "dead short": the current runs straight to ground and the remainder of the line is de-energized. A recent innovation is the use of highly flexible plastic "insulated droppers" which serve both as wire spacers and insulators. These unfortunately are still too expensive for use on large scale fencing projects such as those in communal lands.

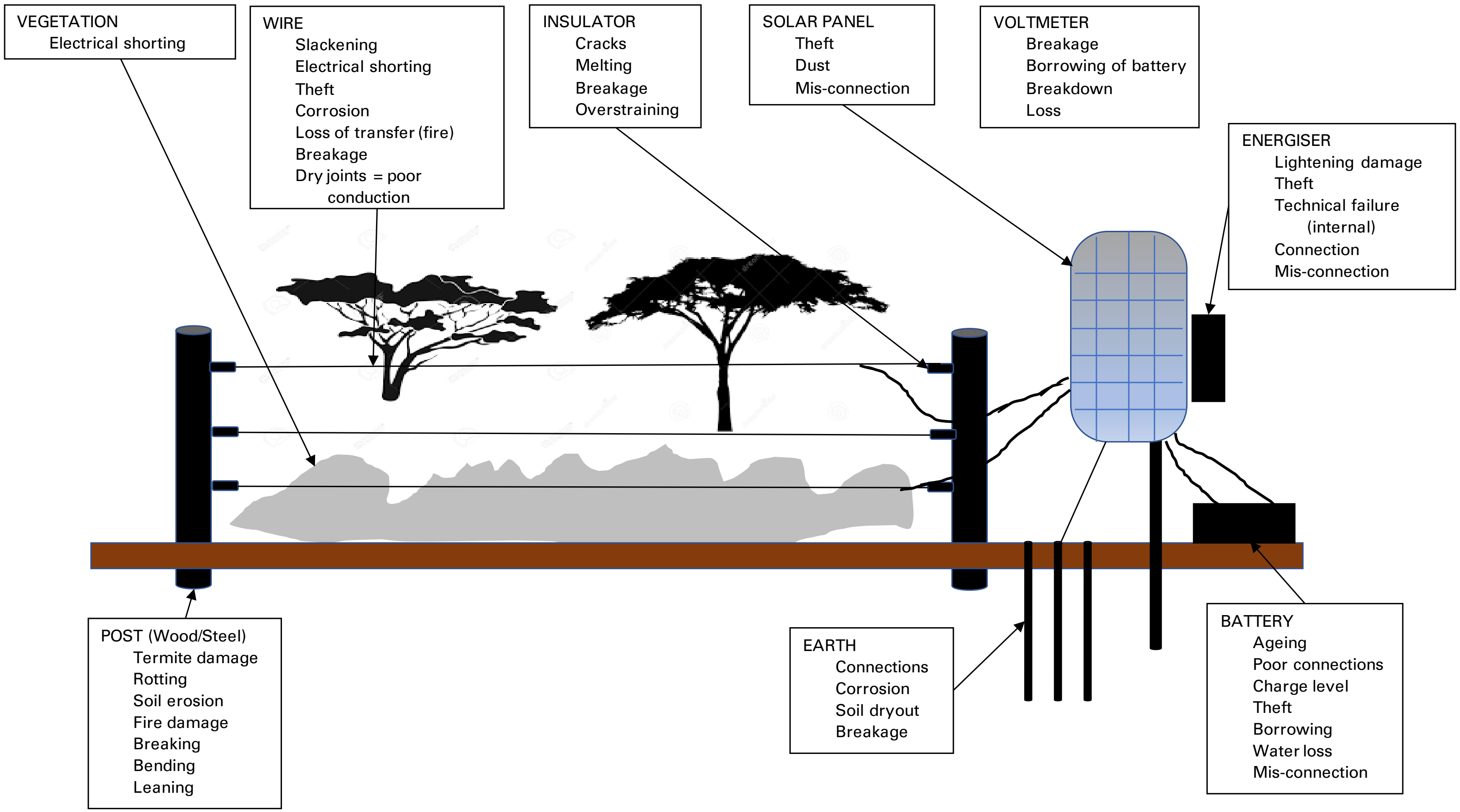
Wire and Insulators: Only galvanised high-tensile wire should be used for construction and repair of main strands in electric fencing. Wire bends and joins should be made in such a way as to avoid damaging the outer galvanising (zinc) layer. The outer zinc layer is a better electrical conductor than the inner core of iron. Post insulators on early electric fencing projects experienced many breakages. Subsequent designs changed to bobbin insulators that are stronger under the tension produced by animals contacting the wire. The method of attaching bobbin insulators to posts has been found to be important in fence maintenance and various methods have been tried. Wrap around rubber with a wire tie is a poor method as is a curved metal extension peg coming off the post. The simplest and best method is a straight nail (on a wood post) or a bolt and nut (on a steel post). Insulators manufactured in Zimbabwe are now of acceptable quality.

4.2 SOLAR VERSUS MAINS ELECTRICITY SUPPLY

The solar panel-energizer-battery system is an inherently inefficient arrangement when compared to a mains electricity supply for a fence energizer since the solar technology contributes more than 50% of the maintenance problems in the communal land situation (R. Barrett personal communication). Nonetheless, in the absence of mains power supply, it obviously must be used. Theft and maintenance problems have been drastically reduced on some commercial farms (Beit Bridge, Centenary, Chiredzi and Kariba) which are able to use the mains electricity supply.

Mains electrical supply also delivers a higher energy source and is therefore more efficient than a battery supply. Furthermore, it is more tolerant of shorts and leakages caused by vegetation touching the live wires (in fact, mains energisers burn the grass as it grows).

Figure 7: Potential problems with electric fence components



4.3 LABOUR REQUIREMENT

Communal land electric fencing projects all employ fence minders whose job it is to patrol fences daily and carry out repairs of a routine nature. The usual causes of fence damage are:

- Animal touches or crossings
- Falling trees or branches
- Growing vegetation contact with live wires
- Soil movement affecting poles
- Broken wire strands

The length patrolled per man decreases with rough terrain or heavy animal challenge. In the existing projects the distance per man per day varies from 4km (Binga) to 7km (Tsholotsho). In addition to carrying wire and insulators, fence minders should be equipped with the following tools:

- Wire tensioner
- Pliers
- Screwdriver
- Spanners
- Voltmeter

They may be employed at full time rates (Bulilima-Mangwe) or part time rates (Nyaminyami) and be supplied with uniforms (Guruve). The labour budget is the largest component of maintenance costs on both communal and commercial electric fences (72%, Tables 9 - 11).

Table 9: Current maintenance costs on six Communal Land electric fences

		Percentage of Annual Fence Budget 1997				
District	**Total Budget (Z$)**	**Fence Minders**	**Casual Labour**	**Repair/ Maintenance**	**Replace Thefts**	**Cost per Km per year (Z$)**
BINGA (Karungwizi)	10 000	60%	0%	40%	0%	1 130
B-MANGWE (North West)	80 000	73%	15%	12%	0%	2 280
GOKWE NORTH (Nenyunka)	47 000	45%	10%	45%	Not yet replace d	1 520
GURUVE (Masoka)	47 000	62%	19%	19%	0%	2 610
NYAMINYAMI (Negande)	14 000	57%	7%	36%	Not yet replace d	800
TSHOLOTSHO (Hwange NP)	97 000	67%	15%	10%	8%	1 490
Average		**61%**	**11%**	**28%**		**1 650**

Table 10: Maintenance costs of Communal Land electric fences relative to revenues

District (Project)	Maintenance Level	Maintenance Budget 1997 (Z$)	Km of Fence	RDC Management Revenue 1997 (Z$)	Ward Revenue 1997 (Z$)	% used for Fence Maintenance	
						WARD	**RDC**
BINGA (Karungwizi)	WARD	10 000	8	-	59 500	17%	
B-MANGWE (North West)	RDC	80 000	35	173 700	-		46%
GOKWE NORTH (Nenyunka)	WARD	47 000	31	-	89 400	53%	
GURUVE (Masoka)	WARD	47 000	22	-	528 800	9%	
NYAMINYAMI (Negande)	WARD	14 000	18	-	35 000	40%	
TSHOLOTSHO (Hwange NP)	RDC	97 000	71	241 700	-		40%
Average						**30%**	**43%**

Table 11: Employment of fence minders on Communal land electric fence projects

District (Project)	Maintenance Level	Total Km of Fence	Km per Fence Minder	Fence Minder Wages (Z$/ mth)	Maint. Cost 1997 (Z$)	Proportion of 1997 Budget on Fence Minders
BINGA (Karungwizi)	WARD	8	4	200	10 000	60%
B-MANGWE (North West)	RDC	35	5	700	80 000	73%
GOKWE NORTH (Nenyunka)	WARD	31	5	200	47 000	45%
GURUVE (Masoka)	WARD	22	5.5	475	47 000	62%
NYAMINYAMI (Negande)	WARD	18	4.5	105	14 000	57%
TSHOLOTSHO (Hwange NP)	RDC	71	7	500	97 000	67%
Mean value			**5**	**475**		**61%**

4.4 LINE CLEARANCE

Keeping the fence line clear of vegetation is vital for good electric fence performance. Grass growth is especially rapid in the wet season and virtually all communal land projects suffered from clearing deficiencies at this time (see Table 8). There are two ways that vegetation clearance is done in the communal land projects: either casual labour is employed for specified periods or nearby community members are organised into teams on "field days". In some districts, the community members get a nominal fee for this labour. Some commercial land projects (Centenary, Save Conservancy, Kariba) use herbicides on the fence line to reduce the labour requirement.

4.5 CASE STUDIES OF MAINTENANCE COSTS

Six case studies of maintenance costs were conducted using data from 1997. Two of these projects (Bulilima-Mangwe and Tsholotsho) were managed by the RDC and four were managed at Ward level (Binga, Gokwe North, Guruve and Nyaminyami, Table 9). The breakdown of expenditure shows that in 1997 an average of 72% of the overall budget was used on combined labour costs *i.e.* fence minders plus casual labour. The remainder of the budgets was used on direct costs of the items required for routine repair and maintenance. This includes costs of repair of faulty energizers, replacement of batteries, wire, insulators and posts, supply of tools, trips to obtain these supplies in town *etc.* The range of expenditure on this equipment varied widely across projects (10% - 45%) with the mean below one third of the total (28%).

4.5.1 Economic Consequences of Maintenance Problems

The following are examples of the consequences of maintenance deficiencies observed during this study. Figures for the replacement of equipment thefts were only available in one district (Tsholotsho) because two others, which have suffered thefts, have not yet replaced the stolen items.

a. In Gokwe North the revenue allocated to Nenyunka ward ($ 89 400) was later reduced by the RDC who took a decision to spend 50% of all CAMPFIRE revenue in 1997 on a high school project in the district capital. This means that only $44 700 is available in Nenyunka ward to spend on all CAMPFIRE-related projects. The annual maintenance of the fence alone is approximately $47 000 per year (Table 10). In addition, this fence has had three solar panels and one battery stolen in January 1998. At current prices these will cost approximately $21 500 to replace with the result that there is little chance that the ward itself will be able to rejuvenate its fence without outside assistance. With the remaining power units having to more than double up on their capacity, the fence voltage has dropped to levels insufficient to deter elephants. Fence crossings by animals doubled in each successive month after the theft incidents, and a group of elephants has since taken up residence in a refuge of thick bush occurring between crop fields inside the fenced area. These animals devastate crops during regular nightly forays into people's fields.

b. In Negande ward (Nyaminyami district), 40% of the ward revenue is spent on the fence. All sections of the fence now have zero voltage because of theft of solar panels and energizers (Table 9), and replacement of the stolen components alone will consume all the remaining 60% of present revenue. The WWC are reluctant to re-deploy the recovered equipment to its previous site so the fence remains without any power. Therefore, fence minders with little to do have been put on half time and do not patrol daily. This in turn means that thefts of wire occur to make snares and the fence deteriorates rapidly. Snaring and the probable increase in PAC from a non-functioning fence affect local wildlife populations, so the whole CAMPFIRE programme in the ward is potentially undermined.

5 PRIVATE SECTOR ELECTRIC GAME FENCING

A survey in 1991/2 revealed that fencing is widely employed in private sector game management in Zimbabwe (Hoare 1994). There were 167 respondents to the questionnaire survey sent through the Wildlife Producers Association (WPA - a division of the CFU) who at that time collectively managed 2 446 km of game fencing, 1 012 km (41%) of which was electrified. The then rapid growth of the private sector wildlife industry was reflected by a further 1 394 km of game fencing under consideration and 944 km of cattle fencing having been recently removed.

The reasons for controlling private sector wildlife with fences have differed from those in communal lands. In commercial farmland the primary objective is to enclose a range of exploitable wildlife species whereas in communal farmland it is to exclude a few wildlife pest species. There are, however, cases where commercial sector enterprises wish to exclude similar species to communal land situations and these examples have been used in this study for comparative purposes (Table 12).

Table 12: Maintenance costs on commercial land electric fences (1997)

Location (Property)	Target Species	Annual Maint. Cost (Z$)	Km of Fence	Maint. Cost per Km per Year (Z$)	Comment
KARIBA (Charara Estates)	Elephant Buffalo Hippo	50 000	5	10 000	EXCLOSURE high investment irrigation business, elaborate design, mains powered
BEIT BRIDGE (Gem Farm)	Elephant	7 000	10	700	EXCLOSURE very simple design, mains powered
CENTENARY (Ruindi Estate)	Elephant	8 250	11	750	EXCLOSURE "communal land" design, solar powered
TRIANGLE (Hippo Valley Estates)	Elephant Buffalo	400 000	190	2105	EXCLOSURE robust design, mains powered
CHIREDZI (Save Valley Conservancy)	Elephant Buffalo Rhinoceros Antelope	257 000 213 200	116 82	2 216 2 600	ENCLOSURE Double game fence Very elaborate and robust design
Average				**2 260**	

A similarity between electric fencing projects in the two sectors is that both have experienced solar panel thefts (at least 10 panels were stolen from the Save Valley Conservancy fence). Differences are that private sector electric fencing projects now employ mains power whenever possible and the fences tend to be of a more elaborate design. Maintenance standards are generally higher and more consistent in the private sector for two main reasons: a supervision structure within the workforce and the lack of interruptions to maintenance funding.

Costs of maintenance per kilometre on large private sector electric fence projects (Table 12) are generally higher ($2 260/km) than on communal land fences ($1 650) but some small projects run from individual farms are considerably lower. The reason for this is probably fourfold:

(i) Longer stretches are patrolled per fence minder (10 -11 km as opposed to an average of 5 km in communal lands) which saves wages.
(ii) Less maintenance problems occur due to rapid decision making and good financial management.
(iii) Commercial sector is better able to finance the maintenance costs.
(iv) Commercial sector has a greater sense of "ownership" of the fence and is therefore willing to spend money to make it work and achieve its objectives.

All private sector projects studied had fence minders patrolling sections on foot except Hippo Valley Estates where fences are checked daily by one worker on a motorcycle. This person does voltage checks every kilometre and reports maintenance problems to a central office who then dispatch a mobile maintenance team by vehicle if necessary.

6 REALISATION OF PURPOSE BY COMMUNAL LAND ELECTRIC FENCING PROJECT

The problems and successes of the present communal land electric fencing projects have been evaluated according to the following criteria:

- Efficacy relative to "concept model" of fence
- Technical problems: efficacy of existing physical designs
- Financial problems in existing projects
- Community problems in existing projects

6.1 EFFICACY RELATIVE TO "CONCEPT MODEL" OF FENCE[7]

Model 1: EXTENDED FULL BARRIER FENCE

These fences have not been particularly successful due to "open endedness" and resultant funnelling of elephants towards the end of the barrier. These fences have been installed on the boundaries of wildlife refuges (*e.g.* in Tsholotsho, Gokwe South, and Muzarabani). Maintenance of the long fences is a particular problem because they are often far from settlement areas. Logistically this presents problems to the RDC and/or WWC. It also appears that a feature of dealing with a long-standing protected area is that some animals, particularly elephant, have become extremely persistent and regular crop raiders of "frontline" farms. These animals, found on the edges of such permanent refuges, have learnt to disarm fences or move around the ends of them. Such animals are inevitably shot on PAC thus defeating the object of the fence.

Model 2: PARTIAL INTERFACE FENCE

These projects have performed below expectation. Natural barriers were incorporated into the design in order to increase the area of settlement to be protected with the available funding. It was not known at the time how effective this practice would be. However, it is now been shown that elephants can negotiate natural barriers, such as escarpments, or have been "funnelled" around the ends of these fences. Furthermore, the sense of community ownership is less than with encircling fences and the distance of fences from habitation has made these projects particularly vulnerable to equipment theft, and difficult to maintain.

Model 3: COMMUNITY PROTECTION FENCE

This is the most common fence in communal lands at present. The idea of enclosing a whole community with its local infrastructure is very appealing both to planners and residents and has been proved to be very successful if maintained properly (Table 4). Unfortunately, these projects have tended to become too large and have experienced serious maintenance problems (thefts, inadequate line clearance, fence minders failing to patrol daily, *etc.*). In addition, some communities feel very strongly about being encircled by a fence and have rejected this model outright. In other projects, the local community has encompassed areas of non-agricultural land which have become refuges for problem animals that have breached the barrier. Removing animals from these refuges becomes exceedingly difficult.

[7] See Figure 4 for examples of these models.

Model 4: SMALL GROUP OWNERSHIP FENCE

These fences have not been in place for long enough to be tested under field conditions. Several technical support personnel believe that many of the current problems with communal land fences could be overcome with this model. Firstly, the layout is encircling, and this has been proven. Several such projects, encircling individual households in the "frontline areas" of problem animal attack should create an effective barrier to problem species. Secondly, capital costs are low because designs can be very basic and can even be re-erected seasonally. Thirdly, maintenance deficiencies and thefts should be minimised by the enhanced security and sense of full ownership provided by the presence of a resident family. In Muzarabani 29 farmers paid a fee of $600 in 1996/7 to qualify to receive subsidised electric fencing equipment from a donor. As at March 1998 no individual fences had been erected. The reason for this, given by some of the scheme's participants, was the lack of time to assemble enough locally cut poles. A less obvious reason for the apparent lack of acceptance of the Model 4 concept may be that this arrangement does not decrease the travel restrictions to and from neighbouring villages *etc.* imposed on people by problem animals. Personal safety is an important consideration that Model 3 caters for more efficiently.

Model 5: CROP PROTECTION FENCE

Electric fences (enclosing irrigated gardens, water sources or other vital structures), are generally successful but few communal land examples exist at present. The private sector equivalent of Model 5 electric fencing is seen around safari camps, game holding bomas *etc.* These are generally very successful.

The small size of these projects infers that they should be less prone to maintenance problems. However, unless the "ownership" of the fence is clearly defined, there is a tendency amongst rural communities not to maintain the fence and the system collapses. An example of this problem is seen with the Gatche Gatche Irrigation Scheme where the RDC has had to take over the responsibility for maintenance rather than leave it up to the members of the irrigation scheme. Another problem associated with these fences is the difficulty of obtaining finance for a project that apparently benefits only a few people. An example here is the CIDA - funded irrigation scheme under Chief Nibiri in Nyaminyami. This scheme has remained dormant for several years because of the lack of agreement as to who can use the scheme.

6.2 TECHNICAL PROBLEMS - EFFICACY RELATIVE TO PHYSICAL DESIGN OF FENCE

The solar power system used in communal land electric fencing is constantly vulnerable to collapse from the slightest technical or institutional problem. Constant attention to detail is required to keep lead-acid batteries in peak condition. Solar panels are continually at risk from theft. Energizers fail periodically from induced lightning strikes or battery problems and prompt repair is not always possible.

It is pertinent to note that the power system costs less than 3% of the capital cost of the average electric fence but gives far in excess of 50% of the subsequent problems in the communal land situation.

Inadequate vegetation clearance on fence lines is almost universal among existing projects. Even some projects in the private sector suffer from serious overgrowth of vegetation. In the wet season it is very difficult to keep up with grass growth on fence lines but with appropriate planning and effort this predictable problem can be contained.

Current designs of electric fencing in communal lands probably *try to control too wide range of species* and as such are constructed with too many strands of wire. Live wire at low height (*i.e.* 20 - 75cm above the ground) facilitates leakage of current through uncleared vegetation. This exacerbates maintenance problems. The great variation in size and behaviour among problem wildlife means that all potential problem species in communal lands cannot be controlled by one design of fence. The only "universal" wildlife fence is the type used on conservancies, which is prohibitively expensive for communal lands. Evidence from Asia (Schultz 1998) and Africa suggests that elephants can be deterred from entering crop fields with fences containing only one or two strands of wire. Communal land electric fencing should concentrate on simple designs, which can deter the large herbivore pest species only. Also, any fence is never 100% effective 100% of the time against all individuals of a target species. Occasional breaches will occur and must be expected, even on the best-designed and maintained fence.

The combined effects of all these problems related to power output is manifested in extremely low voltage levels (Table 10), insufficient to discourage determined problem animals. Power fencing without power is doomed because it is too flimsy to constitute a physical barrier on its own and so it will undergo a rapid spiral of decay (see Figure 7).

Incorrect positioning of a fence can be catastrophic. In Tyunga, Binga, 8 km of one electric fence was swept away by the Sengwa River flooding onto a large alluvium in 1997. Up until this time, this was one of the CAMPFIRE programme's most successful fences in terms of maintenance standards and design. It therefore was successful against high challenge by problem animals. However, the community were warned by the planning agency in 1991 not to fence large alluvial terraces but refused to leave their best agricultural soils unprotected. Now the ward budget is insufficient to replace this fence and problem animals have unrestricted access to crop fields. This was the CAMPFIRE programme's most successful fence.

The fencing project at Masoka in the Guruve District incorporated a thicket and natural pan that were key resources for wildlife in the area. By denying access to these resources has led to problems for the local community. Initially the Masoka community attempted to attract animals into the fenced area, and then tried to capture animals that were trapped inside fence.

6.2.1 Financial Problems

The communal land electric fencing projects are expensive to maintain. In most areas, fencing projects are placing a heavy financial drain on revenue that cannot be attributed to inflation alone. The future financial demands of fence maintenance were seldom considered adequately at the project planning stage. There are four main reasons for the financial problems being experienced in existing projects:

Thefts: Provision for replacing stolen components was not made when communal land fence projects were conceived. This was a serious omission, but one which has only been possible to identify with hindsight. Reluctance to re-deploy the power units in the same locations for fear of renewed theft (*e.g.,* Negande, Nyaminyami) or inability to replace them with existing budgets (*e.g.* Karungwizi, Binga; Nenyunka, Gokwe) completely sabotages an electric fencing project.

Inadequate resource base to generate enough CAMPFIRE revenue: Where wards generate high revenue (*e.g.,* Masoka, Guruve) the financial demands of a small fence project can be relatively easily met. Several wards with existing electric fencing do not have the resources to generate enough revenue to meet fence maintenance costs. For example, in Nyaminyami district, ward revenue is allocated based on safari hunting and relatively few successful hunts take place in Negande ward which has an unrealistically large fence budget.

Restriction of CAMPFIRE revenue to wards: In some cases, ward revenue has been restricted by RDCs diverting it for other projects (*e.g.,* Gokwe North) or disallowing wards to manage their own bank accounts (*e.g.,* Guruve). The effectiveness of fence projects in these areas has been severely prejudiced by such actions.

Overspending: Both RDC-managed and ward-managed fencing projects tend to spend heavily on some of their budget lines, especially those involving fence minders salaries and benefits (*e.g.,* Bulilima-Mangwe, Guruve). In some projects (Binga; Guruve) unnecessary, expensive trips to town are being made for the repair of equipment or purchase of spare parts. This appears to be due in some cases to abuse of the budget by individuals or in other cases to a genuine lack of understanding of repairs that could be achieved in the field.

6.2.2 Community Problems

Unrealistic expectations were created regarding the use of electric fencing. CAMPFIRE administrative personnel had no previous exposure to the pitfalls of electric fencing (construction limitations, technical requirements, maintenance demands or likely effectiveness against animals) before projects were instituted, despite much NGO support. Even if they did begin to appreciate these, which for anyone is very difficult without the practical exposure, they would still want to enhance their own reputations amongst communities by facilitating popular projects. Administrators believed communities' assurances that the latter could achieve adequate maintenance standards without anybody involved having seen it or tried it in a real life situation. A fence to a rural community often implies a robust barrier (like a veterinary control fence) but an electric fence is an inherently flimsy structure requiring a constant, almost obsessive level of attention to detail.

Where open-ended fences have been only *partially effective* and the community has simultaneously allowed maintenance to lapse, a complex situation arises. Technical people ask the community how they can expect further funding to be forthcoming to extend the fence when they have allowed the present one to fall into disrepair. The communities counter this by arguing that only when the fence is fully enclosing can it be seen to work and then it will be properly maintained. A stalemate exists and the fence gradually decays (*e.g.,* Negande, Nyaminyami).

Expansion of dryland cropping, or cattle grazing may be perceived to be restricted by a fence project. At Masoka, Guruve some of the community has expanded beyond the existing enclosure fence, citing lack of arable land inside as the reason. In Bulilima-Mangwe cattle owners ignore an RDC directive which only permits herded cattle in the wildlife area beyond the fence in daytime. Cattle are left to wander at will and use an unfenced dry river-bed to return to the settlement areas. The buffer zone concept in ward 3 in Tsholotsho is meaningless. It is supposed to create an undisturbed zone against Hwange National Park and so encourage utilisation of wildlife emigrating from the park but is used as a cattle grazing area all the year round.

7 COST:BENEFIT METHODOLOGY FOR FINANCIAL ANALYSIS OF ELECTRIC FENCES

The terms of reference call for the development of a simple cost:benefit model for financial analysis of electric fences, and to project the likely costs and benefits over the next 10 years for different designs. These issues have been addressed in a booklet developed by WWF that deals with electric fencing projects under its Wildlife Management Series (WWF, 1997). A chapter within this booklet discusses the steps required to undertake a "do-it-yourself" cost:benefit analysis of an electric fence. Rather than repeating the cost : benefit model here, this section instead examines some of the constraints associated with undertaking such an analysis. Furthermore, the relationship between fence design, personal safety and crop protection is examined. Finally, the financial implications of various maintenance regimes on district/ward budgets is discussed.

7.1 CONSTRAINTS ASSOCIATED WITH COST : BENEFIT MODELS FOR ELECTRIC FENCES

Donors assessing fencing proposals now insist that a cost:benefit analysis be undertaken to support the project. This is regarded as being necessary because of the the high costs associated with these projects. However, developing a reliable cost:benefit analysis is not a simple task since it is not always possible to acquire the necessary data. Furthermore, it is relatively simple to "manipulate" the data in order to arrive at an acceptable rate of return.

7.1.1 Data Constraints

In order to build a cost:benefit model, it is necessary to gather baseline data on the benefits and costs associated with the construction, operation and maintenance of the fence. Some of these data are quantifiable, however there are certain data that are crucial to the analysis that cannot be valued or quantified.

a **Benefits**:

Benefits that can be quantified include:

i Reduced crop losses of maize, cotton, sorghum, millet, vegetables.

ii Reduced stock losses of cattle, donkeys, goats.

iii Reduced destruction of economically important wildlife (*e.g.* elephant, buffalo, lion, leopard).

iv Reduced cost of undertaking problem animal control activities (*e.g.* hunting).

Those benefits that are difficult to quantify or attach a value to include a number of important "opportunity costs". Examples include:

i Reduced exposure to sickness (*e.g.* malaria)

ii Improved attendance at school.

iii An increase in time available to undertake other tasks.

iv Increased personal safety.

Of these parameters, the increased personal safety that accrues to the local community as a result of an electric fence curtailing the movement of dangerous animals into a settled area is a crucial factor that drives many electric fencing programmes. Hoare and Bond (1994) encountered difficulties in securing baseline data on crop and livestock damage as well as the lack of reliable financial records on the cost of maintenance. Similarly, it was difficult to gather reliable data with regard to the cost: benefit analysis of the proposed North Gokwe electric fence (Price Waterhouse 1997).

To a large degree, this situation still prevails despite inputs of NGOs to develop appropriate "Problem Animal Reporting" systems (although there are data available reflecting maintenance costs). It is therefore difficult to undertake these analysis without several years of data that monitors the significance of crop damage.

b **Costs**

The quantifiable costs associated with an electric fence are relatively simple to obtain. These can be identified as:

i Maintenance costs comprising labour and transport.

ii Replacement of equipment (solar panels, energizers, batteries, wire, poles, insulators).

iii Replacement of maintenance equipment (pliers, voltmeters, wire strainers)

iv Casual labour for fence clearing.

v Value of animals destroyed in the fence (impala, kudu, giraffe).

vi Value of animals snared from wire stolen from the fence.

There are also "hidden costs" that are not immediately obvious. For example, there is a cost attached to the "down time" when the fence is not working or when problem animals are still able to cross the fence and destroy crops.

7.1.2 Methodology Constraints

The approach used in the past to deal with these issues was to assume that the annual maintenance cost was a percentage of the gross construction cost. Various maintenance regimes ranging from 5% per annum to 15% per annum of gross construction costs have been used in the analysis.

The approach used to undertake a cost:benefit analysis has been to assume a desirable rate of return, and then determine the benefits needed to attain the rate of return. This approach, called "how much or what value", was used by Hoare and Bond (1994) to assess the cost:benefit of the Tsholotsho fence. They calculated that if the maintenance costs were 5% of the construction costs, an equivalent of 187 tonnes of maize and 323 tonnes of sorghum had to be "saved" in order to achieve a 20% Internal Rate of Return. Clearly greater savings of maize and sorghum would be necessary if the maintenance costs were higher.

This implies that elephants would have to destroy 187 tonnes of maize and 323 tonnes of sorghum annually in order to justify the expense of the fence. To produce this quantity of crops in Tsholotsho would require 124 - 184 ha of land. Assuming that each household tills approximately one hectare of land, this implies that the crops of 124 - 184 families would have to be totally destroyed each year.

Although the data are not available, experience has shown that this level of destruction is not common in communal areas. Furthermore, crops are often destroyed that are unlikely to yield high levels due to other factors such as drought or other pests. Placing a value on the level of food security is therefore extremely difficult in these situations.

7.1.3 Level of Costs

As discussed above, annual maintenance costs have been calculated by assuming that these are a percentage of the gross construction costs. For example, if the construction cost is $10 000/km, the annual maintenance cost could be $1 000/km/year or 10% of the construction costs.

The following table examines the relationship between model design, construction costs and percentage maintenance costs (Table 13).

Table 13: Relationship between model design, construction costs (Z$) and percentage maintenance costs (Z$). Note all figures bin 1998 Z$

Fence Model	**1**	**2**	**3**	**4**	**5**
Construction cost/km (Z$, 1998)	47 880	21 330	26 568	8 910	3 060
Percentage Maintenance Costs (Z$)					
3%	***1 436***	640	797	267	92
4%	***1 915***	853	1 063	356	122
5%	2 394	1066	1 328	445	153
6%	2 873	1 280	***1 594***	535	184
7%	3 352	1 493	***1 860***	624	214
8%	3 830	1 706	2 125	713	245
9%	4 309	1 920	2 391	802	275
10%	4 788	2 133	2 657	891	306
15%	7 182	3 200	3 985	***1336***	459
20%	9 576	4 266	5 314	***1782***	612

During the course of this study, spot checks made on various communal land fences confirmed that 43% were not working (see Table 7), and that the average maintenance costs are $1 650/km (see Table 9). This implies that the maintenance costs are between 3% and 4% of the gross construction costs of a Model 1 fence, 6% to 7% of a Model 3 fence and 15% to 20% of a Model 4 fence(see Table 13).

The fact that many of these fences were not working suggests that at this level of funding, the maintenance is inadequate and will have to be increased if the situation is to improve. In the commercial sector, where annual maintenance costs are approximately $2 260/km (see Table 12), which is equivalent to 5% to 6% of the gross construction costs of a Model 1 fence, fence maintenance is slightly improved, but still not 100% perfect (the exception being Charara Estates which spends $10 000/km on fence maintenance to prevent elephant from entering its banana plantation).

The alternatives for communal land fencing programmes is therefore to substantially increase the amount of money spent on maintenance in order to improve their management if they intend to persist with Model 1 designs, or to change to less expensive designs such as Models 4 and 5. The implications of this are discussed in the following section.

7.2 THE RELATIONSHIP BETWEEN FENCE DESIGN, PERSONAL SAFETY AND CROP PROTECTION

The major motivation in planning a fencing project is to alliviate the destruction of crops by animals such as elephant. As discussed earlier, five options have been tested by planners, with a Model 1 fence being the most costly to construct and maintain. Figure 8 examines the relationship between fence design, personal safety and crop damage.

There are three main factors to consider when evaluating the different types of electric fencing projects against each other. These are:

- The cost of construction and maintenance
- The level of personal safety achieved
- The level of crop protection

The construction cost (to be met by the funding agency) and the maintenance cost (to be met by the RDC or Ward out of CAMPFIRE revenue) increases with increasing fence length. (Models 5 to 1, Figure 8)

The effectiveness of crop protection and personal protection are inversely related to each other across all fence models. This is illustrated in Figures 8a - 8c.

a **Construction and Maintenance Costs:** The construction and maintenance costs increase with increasing length. Thus, the full barrier long fences (Model 1) are substantially more expensive to construct and maintain than the Model 5 fences. (See Figure 8) because of costs such as length of trace line, line of access roads, transport costs, number of minders employed, amount of construction and maintenance materials required *etc.*

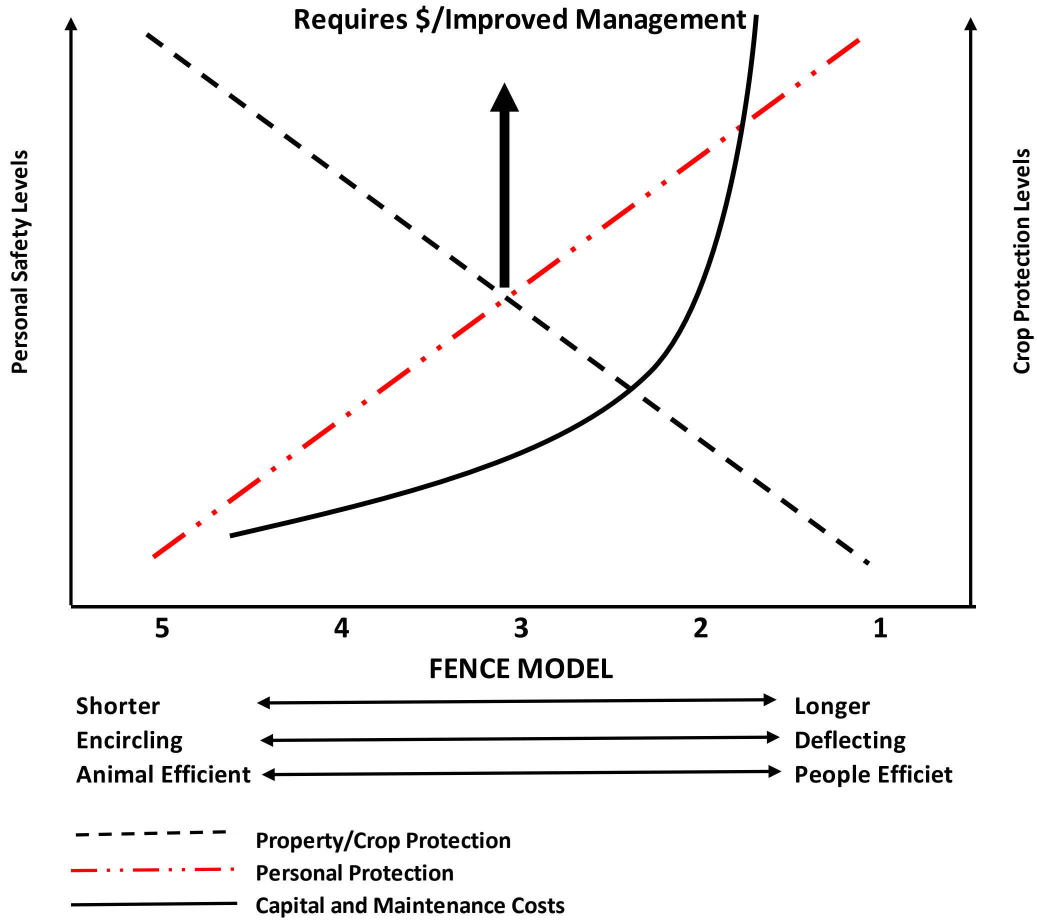
b **Crop Protection:** The shorter encirling fences (Model 4 and 5) are able to afford greater protection to crops since these fences are easier and less costly to maintain. However, this type of fence does not offer a high level of personal protection. (See Figure 8a).

c **Personal Safety:** In contrast, Model 1 and 2 fences afford a greater level of personal safety to local communities than a Model 5 fence. This is because the barrier type fences are effective in keeping the majority of PAC animals out of settlement areas which in turn allows local residents in these areas to move about relatively safely. However, it is known that these types of fences are difficult to maintain and animals are able to cross the fence. (See Figure 5). When this occurs, the crops are just as vunerable to destruction as when no fence exists. (See Figure 8b).

The intercept of the two lines equates to a Model 3 fence design that appears to offer equal crop and personal safety (Figure 8c). It is not suprising, therfore, that this model is the most commonly used in the communal land environment. This design is essentially an encircling fence that has been extended to enclose a large area.

However, there is a tendency with this design to inherit all the disadvantages of the Model 1 and 2 fences (too long, difficult to access), and does not capitalize on the attributes of the Model 4 and 5 fences (easy to maintain).

Figure 8: Relationship between fence design, personal safety and crop damage



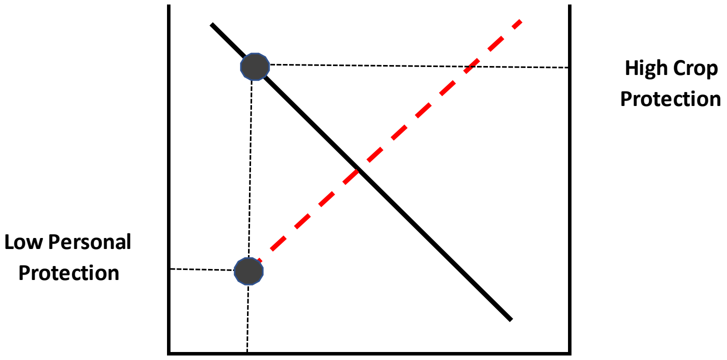


Figure 8a: Model 5 Fence - Crop Protection Fence

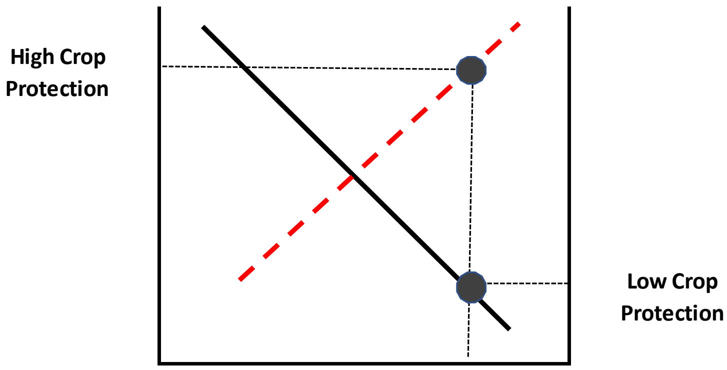


Figure 8b: Model 1 Fence - Partial Interface Fence

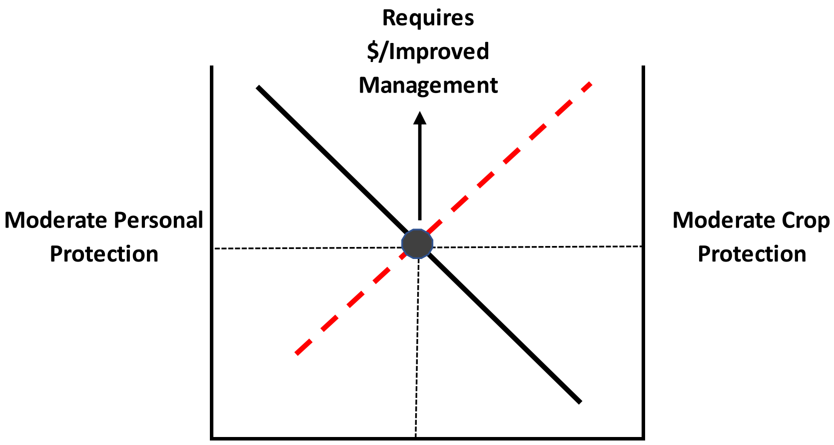


Figure 8c: Model 3 Fence - Community Protection Fence

In order to make the Model 3 design more effective (*i.e.* move the intercept point upwards to improve crop protection and personal safety), it will be necessary to improve the effectiveness of the fences through:

- Investing greater amounts in the construction and maintenance of the fences.
- Improve institutional and maintenance management.

This will require the construction of more robust fences than are currently being used, and a greater dedication to fence supervision and maintenace. The net result will be increased spending on fence maintenance.

7.3 FINANCIAL IMPLICATIONS OF MAINTENANCE REGIME ON DISTRICT/WARD BUDGETS

The data available suggests that wards and RDCs are committing between 30% and 40% of their revenues on fence maintenance (see Table 10, and that average cost is $1 650/km/year. It has also been shown that at this level of maintenance, many of the fences are not working or are difficult to maintain. As a result, these fences are not achieving their objective of reducing crop damage, particularly the Model 1 and 2 fences.

One must therefore question whether the construction and maintenance of such fences is warranted. Furthermore, an underlying principle of the CAMPFIRE programme is that local communities will benefit from the sustainable use of their wildlife, and thus improve their living standards. The fact that wards and RDCs are using up to 40% of their CAMPFIRE (and other revenues) to maintain these fences appears to undermine this principle.

To assess the financial implications of various maintenance regimes on district/ward budgets is therefore difficult given the fact that:

- The current expenditure appears to be insufficient to maintain Model 1, 2 and 3 fence designs.
- Model 4 and 5 fence designs have been insufficiently tested under rural conditions.

Wards and Districts are therefore unlikely to benefit from the current strategies of using Model 1 to 3 fence designs unless they are able to invest greater amounts in the maintenance of such fences. The level of this increased investment is difficult to determine at this stage but may be three times the current level. If this were the case, the majority of the wards and RDCs could not afford the electric fences in their districts.

Under these circumstances, it is difficult to determine what benefits can accrue to districts, wards and local communities in the long term. Should the cost of maintaining these fences continue to escalate, it must be assumed that the benefits will decrease. It must also be assumed that the wildlife populations, particularly elephant, will not benefit as the tolerance levels of local communities towards these animals declines and conventional measures (*e.g.* shooting) continues or increases.

The only option that has not yet been fully explored is to invest in alternative designs, particularly Models 4 and 5. At present, local communities (and local authorities) believe that full barrier fences are more effective than Model 4 or 5 type fences. To change this attitude will be difficult unless it can be demonstrated that Model 4 and 5 type fences are effective in reducing the level of crop damage.

8 EVALUATION OF ELECTRIC FENCE PROPOSALS

Despite the institutional and management problems associated with electric fences, rural communities still insist that electric fences be constructed to improve personal safety and reduce the incidents of crop damage. In this section, an attempt is made to identify those factors to be taken into consideration to assist donors, RDCs and NGOs in assessing the merits of fencing proposals presented to them.

8.1 ISSUES TO BE CONSIDERED WHEN EVALUATING ELECTRIC FENCE PROPOSALS

a. Baseline Data:

- Are long-term "Problem Animal Records" available?
- What is the value and/or quantity of crops/personal property destroyed by various species?
- How many people have been affected?
- What species are responsible (this to include small mammals {rodents, primates, bushpigs, goats} as well as birds)?
- How many households will benefit from the fence?
- What area will be protected by the construction of the fence.
- Does the protected area need to be expanded in future?
- What are the costs of PAC operations?
- What is the value of animals destroyed on PAC?
- Have alternative methods of PAC been explored?
- Have alternative methods of fence models been considered?
- What are the opportunity costs and how important are they in the affected areas?

b. Institutional Issues:

- What is the purpose of constructing the fence (crop protection, personal safety, other)?
- Who will be responsible for the planning, design, implementation and maintenance of the fence?
- Describe the level of community involvement in the planning process.
- Describe the training programme of the fence maintenance crew.
- Does the fence affect other institutions (national parks, neighbouring districts, wards etc) and have these been consulted?
- Will other institutions/agencies share any responsibility for the design and maintenance of the fence?

c. Fence Design:

- Describe the wildlife interface type (park boundary, isolated villages, mosaic) and length.
- Describe type of terrain.
- Provide detailed description of the fence design.
- Describe the objectives of the fence in terms of its local effects and identify the species that it is to control.

d. Fence Maintenance:

- What are the present and future revenue resources of the RDC/Ward?

- How much revenue will be allocated to fence maintenance ($/km/year)? How will this be guaranteed adequate against inflation?
- If wards are to be responsible for fence maintenance, what revenue allocation scheme is used by the RDC?
- Describe in detail the maintenance arrangements to be employed (RDC employees, ward employees, private sector contract, individual, etc) as responsible for purchasing duties, electrical maintenance, line clearance, *etc.*
- How does the RDC/Ward intend to protect the key equipment?
- Provide a detailed description of the staffing of the maintenance crew, including proposed salaries, equipment, condition of service (housing, transport, leave, uniforms, tools, any allowances, etc).
- What contingency plans have been made to replace equipment (solar panels, wire, energiser, batteries). *e.g.* theft insurance, contingency funds, *etc.*
- Can work contracts be linked to revenue pay-outs?

e. Cost Benefit Analysis:

- Has a cost benefit analysis been undertaken?
- Provide a detailed description of the assumptions used to develop the cost-benefit analysis, including data source.

f. Environmental Factors:

- Is the proposal supported by an Environmental Impact Statement?

8.2 SUMMARY OF EVALUATION QUESTIONS

1. Does the baseline data (a) indicate that the scale and nature of the problem is enough to consider investing in fencing?
2. Does the institutional (b) capacity exist to sustain such a project?
3. Has an appropriate design of project (c) been chosen?
4. Are there adequate financial resources (d) and arrangements to guarantee maintenance requirements can be met?
5. How does the cost benefit analysis (e) done by the funding agency compare with the cost/benefit analysis undertaken by the affected people?

9 CONCLUSION

The technological capability of electrified fencing is not in doubt and its use to control large mammals has been demonstrated in Africa. Because human-wildlife conflict involves political and social considerations at an individual level, resolving the problems cannot be seen as a matter of providing short-term technical solutions to whole communities whose decision making is still largely constrained by a district authority. Electric fencing can never be universally applicable to human-wildlife conflict in African savannas and must remain fairly site specific in application, where the scale and nature of the circumstances justify both its initial use and subsequent efficient operation.

In community based natural resource management (CBNRM) programmes like CAMPFIRE, new ideas should try to be politically, ecologically, technically and financially sustainable. Site specific factors, relating to both human communities and their problem animals can confound efforts to generalize about the use of electric fencing across Zimbabwe. Nevertheless, a cautious generalization must be attempted. Electric fencing to protect rural communities is, in general, politically accepted and not ecologically detrimental. Technically, in some of its present forms it may be inappropriate to the level of management skills available in the administrative institutions in rural Zimbabwe. Likewise, in some of its present forms, electric fencing may be placing a heavy financial burden on benefits generated from the current use of local natural resources.

Most electric fencing projects in Zimbabwe's communal lands, when new, have resulted in marked reductions of wildlife-related problems. This early success, however, has apparently instilled a sense of false security in the administration of such projects. Both districts and wards often lack the institutional, financial and technical discipline and organisation to maintain the level of attention to detail demanded by the daily maintenance of electric fences. The "cascade effect" of the entwined institutional, financial and technical problems observed in most existing electric fencing projects has created a situation where, after some years of operation, most of them are "stuck" in a partially functioning state.

In the period under review, planning authorities at district level have tended to opt for large fencing projects that would "fence wildlife away from people". Because electric fencing had been proven technologically, they believed that it could be used extensively, the only limitation to its application being sufficient capital funding. There was also an assumption that the twin objectives of crop protection and increased personal safety would be simultaneously and equally well met by any kind of fence.

Model 1 and 2 projects which demarcate a long boundary between wildlife and agricultural land use and thus apparently would benefit many people, embody an inherently simple and politically acceptable concept which district level planners and rural subsistence farmers readily support ("people efficiency"). On the other hand, small encircling Model 4 and 5 type projects which are "animal efficient" by fencing a relatively small number of wild animals away from small areas, appear to resolve the problem only for a limited number of people. This is something that District level planners find politically difficult to incorporate in CBNRM programmes. In addition, this concept is difficult to "sell" to subsistence farmers who don't believe that such fences will prevent problem animals from destroying crops.

For deflecting fences, financial constraints have made Model 2 a compromise for the desired Model 1 approach. Model 2 projects have performed consistently poorly because they have transferred problem animal activity to their extremities and have not allowed adequate supervision of maintenance workers. In encircling fence projects, the compromise has been to adopt a Model 3 fencing strategy but extend the boundaries to enclose as much human settlement as possible. The present study has shown that a Model 3 approach is also an unsatisfactory compromise. It does not allow high levels of either personal or crop protection, places a heavy and continual financial burden on resources at the level of a CAMPFIRE ward and is equally as susceptible to serious and intractable maintenance problems as are Models 1 and 2.

The characteristics of problem animal damage show that many people in any area are very little affected while a small number do suffer serious problems. Existing electric fences have been designed to treat communities as a whole, probably because the perception of improved personal security for the majority carries more weight of opinion than the plight of those whose property is directly damaged by problem animals. But under hopelessly deficient maintenance by district and ward level institutions, the present fencing projects, after some years of operation, decreasingly provide benefits of any kind in an affected community.

It is therefore appropriate to transfer much of the responsibility for dealing with problem animals entirely back to the people among which problem animal activity directly occurs. This should be attempted at as small a scale as possible, preferably at the level of the individual household. The downside of coexistence with dangerous wild species should be addressed at the same scales as those at which the benefits from wildlife in CBNRM programmes are supposed to accrue, i.e. mostly at the level of an individual household.

If RDC's and Wards want to persist with Model 1, 2 and 3 types schemes, it will be necessary in existing projects to: -

a. experiment with contracting out the routine fence maintenance to private sector organisations. Two private sector fencing contractors have already indicated their willingness to explore this possibility by providing supervision to teams of locally resident fence minders. Continuing external financial support for wards to maintain their fences would not appear to be a sound concept in CBNRM thinking and is therefore contra-indicated.

b. If CAMPFIRE communities wish to continue to propose the further use of Model 1, 2 or 3 schemes in future, and funding agencies are prepared to support them, these fences will have to contain much greater capital investment to make them more robust wildlife barriers which rely far less on electrification. This will decrease their vulnerability to maintenance deficiencies affecting the power supply. Alternatively, if electric fencing is to continue to be used as the major deterrent, it will be necessary to greatly improve the level of supervision and management of maintenance crews which will require a greater commitment of RDC/Ward funds than the present levels.

The alternative is to encourage a shift towards Model 4 and 5 electric fencing schemes. The current institutional, financial and technical inputs will be substantially reduced by encouraging individual responsibility for the problem. Several "animal efficient" barriers strategically placed in the frontline of problem animal activity will have a good chance of becoming "people efficient" on a human-wildlife interface. This strategy may also prove more efficient in accommodating the short and long-term aims of the CBNRM programmes in the communal areas of Zimbabwe.

10 BIBLIOGRAPHY OF WILDLIFE FENCING

AfESG (African Elephant Specialist Group) 1995. Working Group Recommendations on Human - Elephant Conflict, AfESG Meeting Mombasa 1994 Pachyderm 19: 64-72

Barrett Electronics Ltd 1997. Barrett Electro-fencing Manual

Barrett Electronics Ltd 1997. Notes for Fence Minders

Bell, R.H.V. 1984. The man-animal interface: an assessment of crop damage and wildlife control. In Conservation & Wildlife Management in Africa, (Eds Bell R.H.V. & Mcshane-Caluzi E.) US Peace Corps, Malawi: 387-416.

Bhima, R. 1998. Elephant status and conflict with humans on the western bank of Liwonde National Park, Malawi. Pachyderm 25 in press.

Deodatus F.D. and Lipiya A.K. 1991. Public Relations and Crop Protection Electric Fencing, Kasungu National Park, 1990. FAO Field Document No.19, Dept of National Parks & Wildlife, Malawi. 19pp.

DHV Consultants 1992. Environmental Impact of the Proposed Fencing Programme in Kenya. Elephant & Community Programme, Phase 1. DHV Consulting / Price Waterhouse Harare. 103pp.

DNPWLM (Dept of National Parks & Wildlife Management) 1993. An open letter from the Director to all District Councils with Appropriate Authority for Wildlife in Zimbabwe: Problem Animal Control. 5pp.

DNPWLM 1994. Proceedings of Seminar and Workshop on Safari Operations in Communal Lands, Bulawayo, October 1994. (Ed. M.A. Jones)

DNPWLM / WWF 1995. Aspects of wildlife management in the communal lands of Zimbabwe Proceedings of a CAMPFIRE workshop for Rural District Councils with appropriate authority Hwange Main Camp, December 1994 (Ed. R. Taylor and I. Bond).

DNR (Dept of Natural Resources, Ministry of Environment & Tourism) 1995. Environmental assessment of the solar powered electric fence: Maitengwe Communal Land, Bulilima-Mangwe District.

DNR 1995. Environmental impact assessment of proposed electric fence for Omay, Kariba. DNR Chinhoyi.

du Toit, R.F. 1992. Fencing in wildlife conservancies. In 'Proceedings of a seminar on fencing as a management tool in Zimbabwe's wildlife programmes' (Ed Hoare R.E.) DNP&WLM, Harare.

Eltringham S.K. 1990. Wildlife carrying capacities in relation to human settlement Koedoe 33(2): 87-97.

Foggin C.M. & Hoare R.E. 1994. Fence inspection of the Save Valley Conservancy. Dept of Veterinary Services, Wildlife Unit Unpublished Report, 8pp.

Gallagher Ltd New Zealand 1989 8th International Power Fence Manual.

Gallagher Power Fence Ltd, Zimbabwe Construction of Power Game Fencing

Hawkes R.K. & Madzudzo E. 1993. Electric Fencing in Tsholotsho CASS Typescript.

Herald, The 1998. Thefts, repairs cost PTC over $1.2m. The Herald 4th April 1998.

Hoare R.E. 1992a. The present and future use of fencing in the management of larger African mammals. Environmental Conservation 19(2): 160-164.

Hoare R.E. 1992b. Wildlife Fencing as a Management Tool for Protected Areas in Africa. IUCN Parks 35--39.

Hoare R.E. 1992c. Research into and monitoring of the effects of wildlife fencing. In 'Proceedings of a seminar on fencing as a management tool in Zimbabwe's wildlife programmes' (Ed Hoare R.E.) DNP&WLM, Harare.

Hoare R. E. 1992d. Veterinary control fencing in Zimbabwe: current status and possible effects on the wildlife industry in the light of present knowledge of Foot and Mouth Disease.

Hoare R.E. 1994. Wildlife Fencing Research Project. Final Report. Zimbabwe Trust, Harare

Hoare R.E. 1995. Options for the control of elephants in conflict with people. Pachyderm 19:54-63.

Hoare R. E. 1997. The effects of interaction with people on elephant populations of the Sebungwe region, Zimbabwe. D Phil Thesis, University of Zimbabwe

Hoare R.E. and Bond I. 1994. An Environmental and Socio-economic Review of the Tsholotsho Communal Land Wildlife Fencing and Buffer Zone Project. Zimbabwe Trust Report, Harare.

Hoare R.E. and Mackie C.S. 1993. Problem animal assessment and the use of fences to manage wildlife in the communal lands of Zimbabwe. WWF Multispecies Project Paper No.39 WWF Programme Office, Harare.

Jansen D. 1992. Economic Evaluation of Fencing Projects. In 'Proceedings of a seminar on fencing as a management tool in Zimbabwe's wildlife programmes' (Ed Hoare R.E.) DNP&WLM, Harare.

McKillop, I.G. & Sibly, R.M. 1988. Animal behaviour at electric fences and the implications for management. Mammal Review 18(2):91-103.

Mackie C.S. 1992. Implementation of fencing projects in communal lands. In 'Proceedings of a seminar on fencing as a management tool in Zimbabwe's wildlife programmes' (Ed Hoare R.E.) DNP&WLM, Harare.

Mkanda F.X. 1992. The effects of inadequate fencing along the eastern boundary of Kasungu National Park, Malawi. Nyala 15(2): 63-68.

Osborn F.V. & Welford L.A. 1996. Living with elephants: a manual for wildlife managers in the SADC region. Dept of National Parks Malawi /USAID Regional centre for Southern Africa

Price Waterhouse, 1997. Cost benefit analysis of proposed North Gokwe electric fence.

The development programme for Communal Areas in Kariba District. Omay. Land the project and Kenyati/Gulshe Gatihe Projects Phase II

Schultz B. 1988. Construction and Maintenance of Power Fences for Indian Wildlife. FAO Field Document No.8, Wildlife Institute of India, Dehra Dun. 70pp.

Tavengwa T. 1997. Communities demand electric fences to keep wildlife away Campfire News 15/5/97: 6

Taylor, R.D. & Martin, R.B. 1987. Effects of veterinary fences on wildlife conservation in Zimbabwe. Environmental Management 11(3):327-334.

Taylor R.D. 1993a. Wildlife Management and Utilisation in a Zimbabwean Communal Land: A Preliminary Evaluation in NyamiNyami District, Kariba. In Proceedings of 3rd International Wildlife Ranching Symposium, CSIR Pretoria, South Africa.

Taylor R.D. 1993b. Elephant Management in NyamiNyami District, Zimbabwe: turning a liability into an asset. Pachyderm 17: 19-29.

Thomas S. 1992. Institutional preparation for fencing projects in communal lands. In 'Proceedings of a seminar on fencing as a management tool in Zimbabwe's wildlife programmes' (Ed Hoare R.E.) DNP&WLM, Harare.

Thouless C.R. and Sakwa J. 1995. Shocking elephants: fences and crop raiders in Laikipia District, Kenya. Biological Conservation 72: 99-107

Timberlake J., Makuku S., Rundzuna J. 1993. Environmental Impact Assessment for Electrification of Sikumi Forest Game Fence. Forestry Commission Bulawayo, Typescript 7pp

Woodley F.W. 1965. Game defence barriers. East African Wildlife Journal 3: 89-93.

Wunder M. B. 1996. Of elephant and men: crop destruction in two CAMPFIRE communities in the Zambezi valley, Zimbabwe. Unpubl. D.Phil thesis. University of Michigan.

WWF 1996a. Report on Problem Animal Management Workshop, Nenyunga 27 & 28 Feb 1996. Typescript.

WWF 1996b. Problem Animal Reporting. WWF Wildlife Management Series, Booklet No.1

WWF 1997. Electric Fencing Projects. WWF Wildlife Management Series, Booklet No.2

Zimbabwe Trust 1995a. A basic checklist for electric fences. ZimTrust Box 4027 Harare

Zimbabwe Trust 1995b. Infrastructural Maintenance System : Electric Fences

Zimbabwe Trust 1997. Letter from Technical Officer to CEO of Bulilima-Mangwe RDC

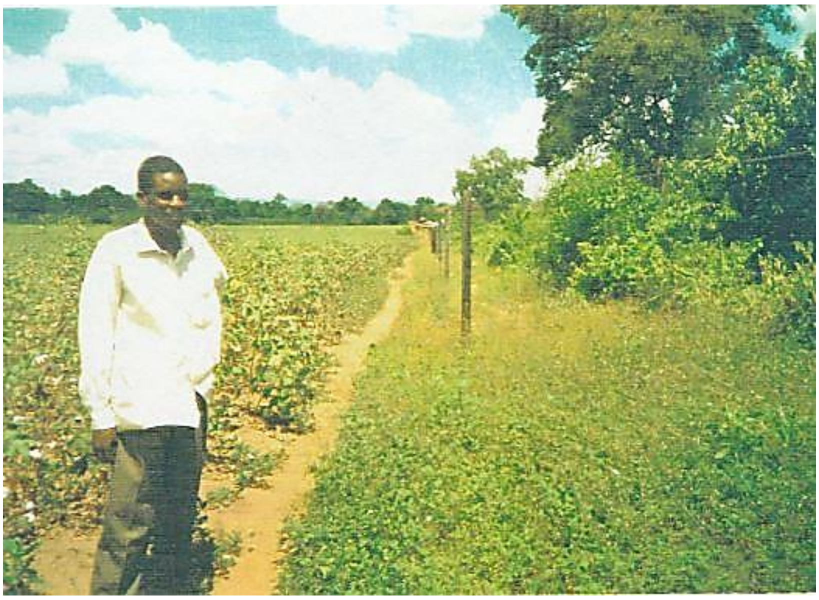


Plate 1: An example of overgrowth of vegetation on an electric fence line, Kanyurira Ward (Masoka), Guruve District

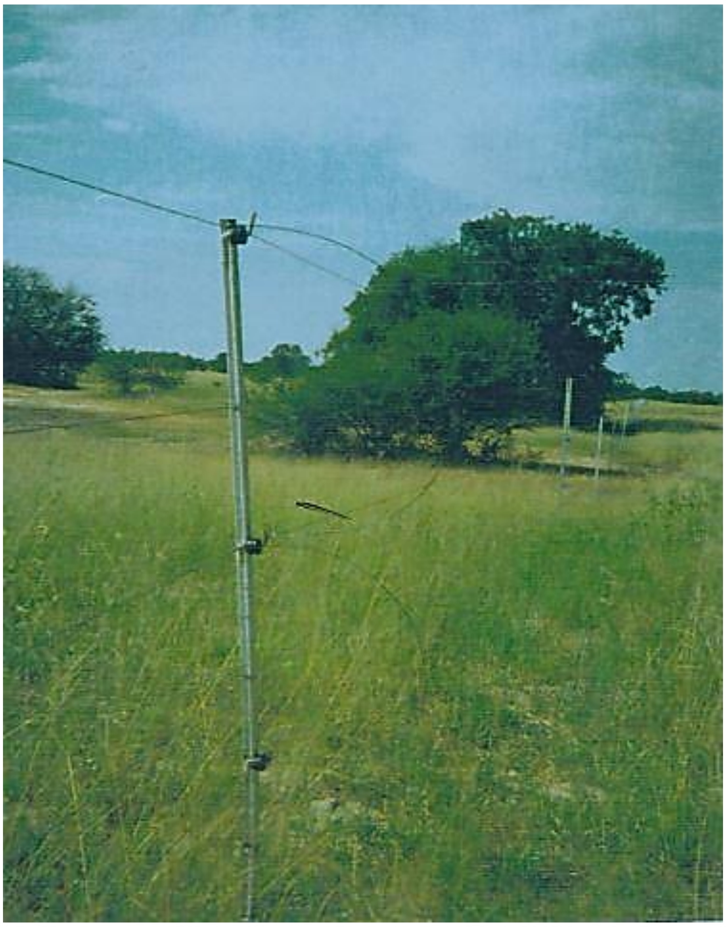


Plate 2: An example of overgrowth of vegetation on an electric fence line. Ward 3 (Ngoma), Tsholotsho Communal Land

Plate 3: An example of overgrowth of vegetation on a fence line, Songo wildlife area, Binga District

Plate 4: Example of a well-cleared line, Tyunga Ward, Binga District. Large sections of this fence are not working due to flood damage. Note low tension of fence wires caused by animal damage as a result of no electrical current.

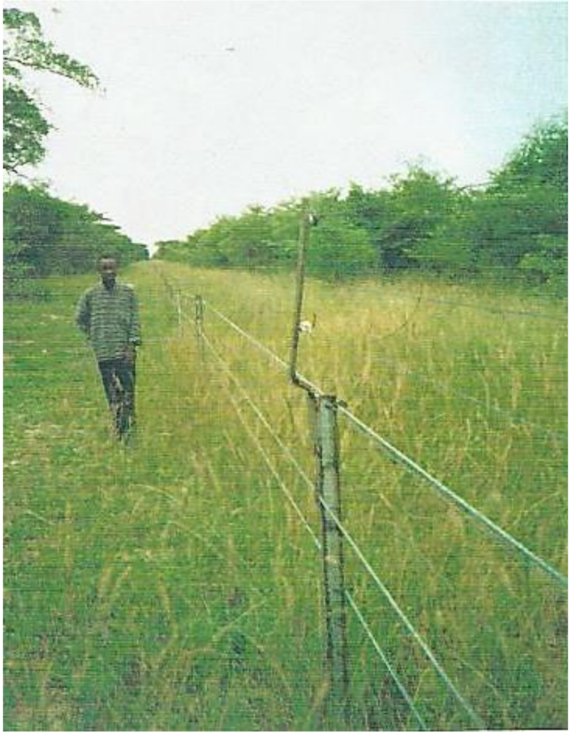


Plate 5: Example of cost-cutting measures used to modify an existing veterinary control fence, Tsholotsho Communal Land. Elephants have rendered this fence inoperable after bending the steel extensions carrying the electric wires.

Plate 6: To reduce costs, material from old tyres is used as electrical insulators around trees (Gokwe North Communal Land)

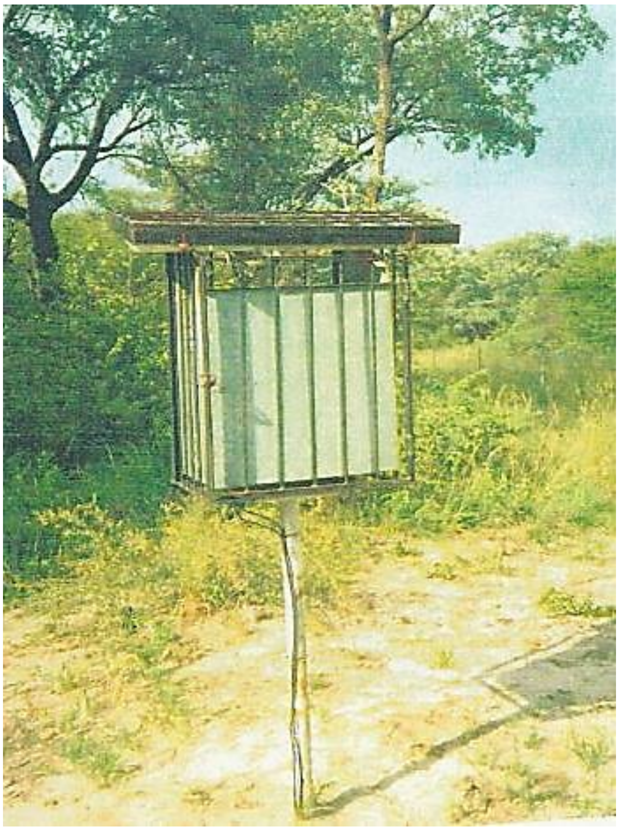


Plate 7: An example of a protection box from which solar panels and energisers have been stolen

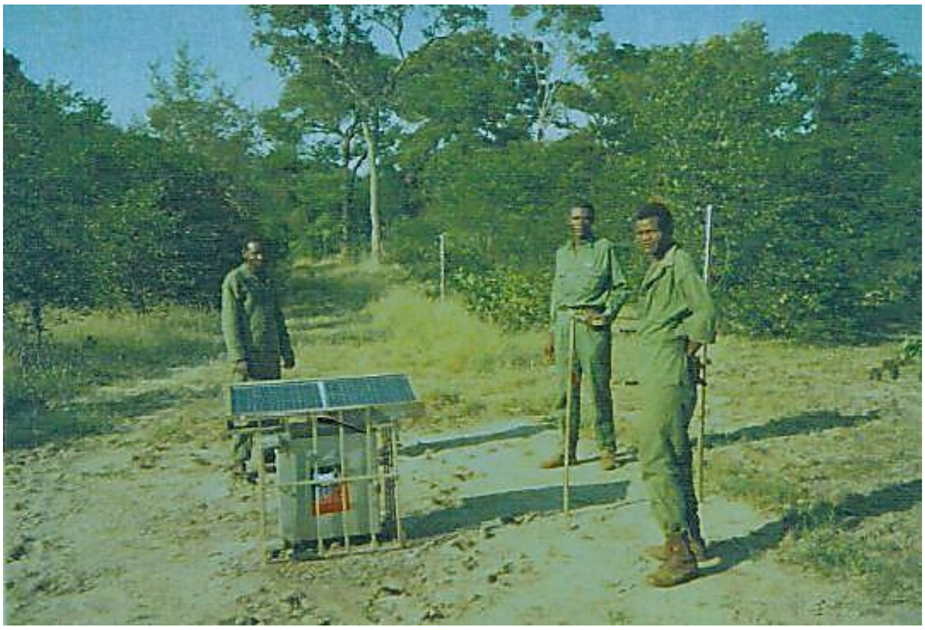


Plate 8: An example of a secure protection box that is adequately guarded and from which equipment has not been stolen. Note the overgrown fence line.

Plate 9: Illustration of a protected energizer and panels on a commercial game ranch

Plate 10: Two metre high electric fence carrying six live wires. Note cleared service road and lack of vegetation

Plate 11: River crossings present problems for electric fencing. In this case, a "curtain" is being constructed to accommodate flash floods.

Plate 12: Double electric fencing surrounding a conservancy.

Plate 13: Traditional Grain silo (or *Dura/Tsapi*) destroyed by elephants searching for maize

Plate 14: Maize crop partly destroyed by elephants