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COLLECTIVE ACTION IN ANT CONTROL

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ABSTRACT

Leaf-cutting ants (*Atta. cephalotes*) represents a serious problem to farmers in many parts of Latin America and accounts of ants eating up a whole cassava plot or destroying one or more fruit trees overnight are not uncommon. Ants do not respect farm boundaries. Therefore, farmers who control anthills on their own fields might still face damage on their crops caused by ants coming from neighboring fields where no control measures are taken. In that sense, crop damage caused by leaf-cutting ants constitutes a transboundary natural resource management problem which, in addition to technical interventions, requires organizational interventions to ensure a coordinated effort among farmers to be solved. This paper reports on a research effort initiated by CIAT and implemented jointly between CIAT and farmers in La Laguna—a small community in the Andean Hillsides of Southwestern Colombia. The objective of the research effort was two-fold: i) to identify low cost technical options for ant control, and ii) to analyze and visualize the transboundary nature of the ant control problem and thus identify organizational options to enable collective or coordinated ant control.

CONTENTS

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1. INTRODUCTION

Leaf-cutting ants represent a serious problem to farmers in many parts of Latin America. In *La Laguna*, a community in the Andean hillsides of Southwestern Colombia, small-scale farmers ranked the damage caused by leaf-cutting ants (*Atta. cephalotes*) as one of their most serious agricultural problems.[2] Accounts both from *La Laguna* and elsewhere in Latin America (Cherrett 1986) of leaf-cutting ants eating up a whole cassava plot or destroying one or more fruit trees overnight are not uncommon. In

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[2] In a group diagnosis of agricultural and natural resource management problems, the problem of ant control ranked second to the cassava pest, (Cyclocephala sp.) among the problems identified, while in a questionnaire survey concerning crop pest and disease problems in the area, the ant control problems came out as the most frequently mentioned problem.

general, *La Laguna* farmers estimate that they lose between 20 and 50 percent of their cassava due to attacks from leaf-cutting ants. The most common control practice is the use of the chemical chlorpyrifos (an organophosphorous), known in the area under the commercial name *lorsban*. *Lorsban* is recommended to be pumped into the ant nest. However, due to cash constraints for purchasing both the pump and sufficient quantities of *lorsban*, the most common practice is to place *lorsban* around the entrances and exits of the anthill directly from the bag. Farmers complain about the ineffectiveness of this method as well as the human and environmental health problems with which it is associated.

In more than one way, crop damage caused by leaf-cutting ants is a problem related to collective action. From the perspective of the ant colony, collective action among the ants—the highly developed division of labor and the occurrence of altruistic behavior in an effort to protect the colony as a whole—is the key to explain the tremendous ecological impact that ants have. As indications of their ecological impact, ants are claimed to move more soil than earthworms, to be the principal catalyzers of energy within ecosystems, and their total weight is estimated to four times that of all vertebrates combined (Lopéz 1996). From a farmer perspective, it is the *lack* of collective action which is key to understanding the difficulties involved in controlling the leaf-cutting. Ants do not respect farm boundaries. Therefore, farmers who control the anthills in their own fields might still face damage on their crops caused by ants coming from neighboring fields where no control measures are taken. In that sense, crop damage caused by leaf-cutting ants constitutes a transboundary natural resource management problem.

Like the ant control problem, many other agricultural and more broadly natural resource management problems cannot be properly understood and solved at the plot or farm level but need to be addressed at the landscape level.

The transboundary nature of many agricultural and natural resource management problems has both technical implications in terms of experimental design and resource monitoring approaches (Ravnborg 1997), and organizational implications in terms of the need for coordination among farmers of the timing and kind of management practices employed. It means that the search for alternative solutions or management practices cannot be seen as a purely technical endeavor, taking into consideration only the technical effectiveness and the economic and financial aspects of potential solutions. Organizational aspects, that is mechanisms that stimulate and facilitate coordinated or collective management efforts at various levels, have to be included as an integral part of the alternative solutions. This paper illustrates the importance of organization in the case of ant control.

The present chapter is organized into eight sections. The following section (Section 2) gives an account of site selection and methods used. An important element in stimulating coordinated or collective resource management is to demonstrate and, if possible, visualize its need and advantages (Uphoff 1992). Section 3 describes an attempt to visualize the need for collective ant control in the case of *La Laguna*. Section 4 continues by briefly summarizing the ant control practices employed in the area prior to the search for alternative ant control methods. In response to farmers identification of ant control as one of the most important and widespread problems, the CIAT research team committed itself to assisting farmers in searching for alternative solutions, technical as well as organizational. Section 5 describes an experiment set up to test some of the potential technical solutions identified through this joint search, while Section 6 summarizes the results. One of the potential solutions tested in this experiment was evaluated favorably by farmers. Hence, Section 7 turns to describe some of the organizational problems—and challenges—encountered when seeking to implement this solution at a landscape level. Finally, Section 8 offers some tentative conclusions from this work in progress.

2. METHODS

In the beginning of 1996, CIAT's Hillsides project began undertaking 'participatory landscape-level experimentation' on what could be considered a pilot level. The basic idea was to explore the methodological implications, both for bio-physical and social and institutional research, of dealing with natural resource management problems at a landscape level rather than, as conventionally done, solely at a plot level. CIAT has a long history of undertaking both researcher-led and farmer-led on-farm experimentation, particulturaly in the municipality of Caldono in the Department of Cauca, situated in the Andean foothills in southwestern Colombia at altitudes between 1000 and 2200 meters. The area is inhabited by a multi-ethnic population, including so-called *mestizo* small-scale farmers, indigenous (both Paez and Guambiano) farmers, and so-called *white* or *caleño* settlers who bought land during the past decades which they are cultivating, often by contracting caretakers. Thus, without making claims of being representative in a strictly statistical sense, the area is characteristic of much of the medium altitude and culturally diverse hillsides of Latin America where small-scale farming dominates. It was therefore natural to start the participatory landscape-level experimentation in this area. More specifically, a contiguous area big enough to include different types of land use and users and small enough to make it possible for landscape users to meet face-to-face was selected. As many natural resource management problems relate to movements of water and soil within a landscape (though not all—including the ant control problem treated in this paper), site identification was done on a watershed basis, identifying all watersheds in the area of a size between 25 and 150 hectares. Previous research done in the area, including a census questionnaire survey undertaken in 1993 and a poverty profile undertaken in 1994 (Ravnborg and Guerrero 1996) allowed us to select watersheds with great diversity in terms of land use and land users. *Los Zanjones*, located in La Laguna, was one of these watersheds.

Los Zanjones comprises 44 hectares, subdivided among 14 individual owners, giving an average plot size of 3.1 hectares. In addition to owner cultivation, various other forms of access to land are common in the area, such as renting in land, sharecropping or employment as caretakers. Including these forms of tenure in addition to owner cultivation, *Los Zanjones* has a total of 17 land users.

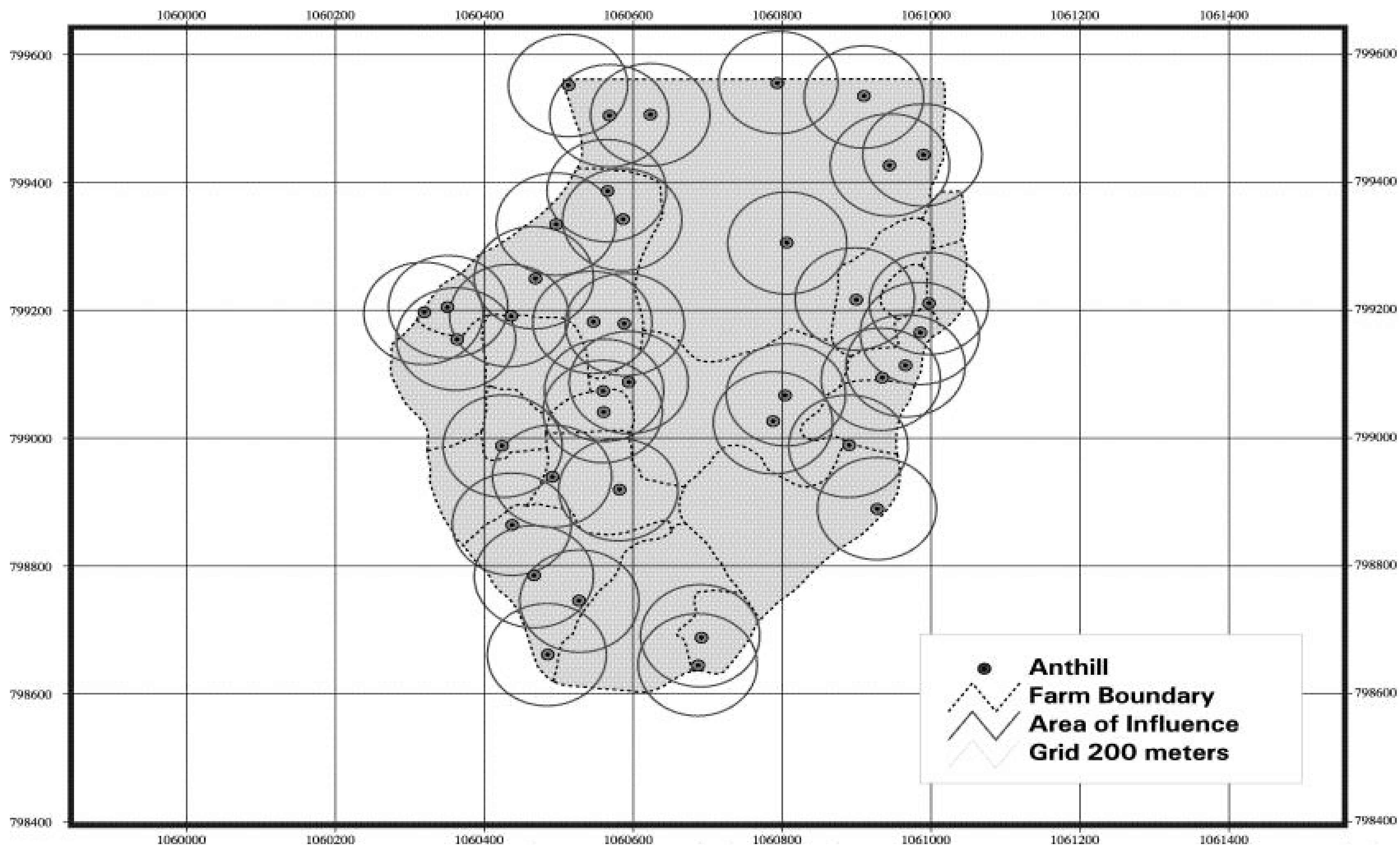
Having selected the micro-watershed, CIAT invited all land users for a series of meetings in order to explore their interest in working collectively to analyze and attempt to solve agricultural and natural resource management problems that farmers cannot solve on an individual basis. Apart from their role as organizers, CIAT researchers acted as facilitators during these meetings and various activities were undertaken, including problem identification, ranking and analysis. The meetings also served as fora within which experiments were planned and monitored, as in the present case of testing potential ant control practices. In parallel to the meetings, open-ended semi-structured interviews were undertaken on an individual basis with land users selected through contrast sampling (Ravnborg and Guerrero 1999) to examine in more detail the diversity of perceptions of natural resource management problems, interests and conflicts. A structured questionnaire survey was undertaken to provide more detailed information concerning pest and disease problems and current management practices in the area (de la Cruz and Cardona 1996). In addition to ant control, other problems such as decreasing soil quality and protection of riverbeds and springs were identified and worked on as priority problems. Throughout the period of experimentation, regular meetings were held and occasionally conversational interviews were undertaken to obtain more detailed understanding of farmers' perceptions of progress and problems.

As already mentioned, the research, of which collective ant control experimentation is part, was initiated on a pilot basis in order to explore the bio-physical, social, and institutional implications of managing natural resources on a landscape level rather than a plot level. Moreover, studies were undertaken very recently and are meant to form the basis for the design of a more comprehensive research program. Rather than final conclusions, the results reported in this paper are of an indicative nature.

3. ANT CONTROL—A TRANSBOUNDARY NATURAL RESOURCE MANAGEMENT PROBLEM

Leaf-cutting ants do not respect farm boundaries. Hence, in areas where small farms predominate, crop damage caused by leaf-cutting ants tends to be a transboundary resource management problem, which calls for coordinated or collective action to solve. Following farmers' identification of ant control as a major problem, one of the objectives of the CIAT research team working on participatory landscape-level experimentation was to find ways to visualize and to some extent quantify the transboundary nature of the ant control problem, and thus raise awareness of the need for a coordinated effort. Such an attempt was made for *Los Zanjones*. Subdivided into two groups walking through the watershed, equipped with a very detailed map (an ortho-photograph) of the area, land users conducted an inventory of major anthills. Thirty-nine major anthills or nests were identified and located in the map. Figure 1 shows the extensions of the 19 plots, overlaid by the location of the 39 major nests. On the basis of farmers' experience from following the ant tracks from the anthills in the area, the average radius of action of the leaf-cutting ants, that is the distance from the nest that the ants move to forage, was estimated at 80

Figure 1: Location of anthills, their radius of action and farm boundaries, Los Zanjones, La Laguna, Colombia


1060000
1060200
1060400
1060600
1060800
1061000
1061200
1061400
799600
799400
799200
799000
798800
798600
798400
Anthill
Farm Boundary
Area of Influence
Grid 200 meters

meters[3]. A circle with a radius corresponding to 80 meters has therefore been drawn around each nest in Figure 1 to indicate their respective area of influence. Thus, calculating from the map, each plot is potentially affected by an average of 5.5 anthills (ranging from 1 to 13) of which 3.4 anthills (ranging from 0 to 9) are located on plots belonging to other farmers—on average belonging to 2.5 other farmers (ranging from 0 to 6). In addition to the damage caused by ants that have their nest within the farm boundaries, this means that farmers can expect crop damage to be caused by ants coming from more than three nests located outside their own farm, belonging to two to three other farmers. Controlling the ants on one's own plot thus provides limited security against crop damage caused by leaf-cutting ants unless there is guarantee that the neighbors also control the ants on their plots.

4. CURRENT ANT CONTROL PRACTICE

The current ant control method employed in the area is the use of a powdered insecticide with the commercial name *lorsban*, in which chlorpyrifos is the active ingredient. In *Los Zanjones*, 88 percent of the households use *lorsban* for ant control. *Lorsban* is recommended to be pumped into the ant nest to be effective, but the most common method of application, used by 41 percent of the farmers, is to pour *lorsban* directly from the bag around

[3] It should be noted that the 80-meter action radius is a conservative estimate since leaf-cutting ants are known to cut leaves at distances up to 200 meters from the nest (Cherrett 1986).

the entrance and exit holes of the anthill (see Table 1). As soon as the ants detect the poison, they leave the old entrances and start opening new ones. The reasons stated by farmers for this sub-optimal use of *lorsban* are the lack of a pump for pumping *lorsban* into the nest, and the fact that pumping *lorsban* into the ant nest requires the use of larger quantities of *lorsban* (and is therefore more costly) compared to just pouring the powder around the holes.

Table 1: Ant control method used, *Los Zanjones, La Laguna*, Colombia

Ant control method	Percent [a] farmers using
Pour *lorsban* around the entrance/exit hole directly from the bag	41
Pump *lorsban* into the nest, using a pump	18
Apply *lorsban* directly from the bag around the entrance/exit holes, using a spoon	12
Make a hole into which *lorsban* is poured	12
Sometimes using a pump, sometimes pouring *lorsban* directly from the bag	6
Do not control ants	12
N	17 [b]

Notes: [a] The percentages do not add up to 100 due to errors of rounding.
[b] The number of farmers does not correspond to the number of land owners due to the existence of tenure arrangements others than owner cultivation, such as sharecropping and caretaker cultivation.

Table 2 shows the amounts of *lorsban* used during the period May 1996 to May 1997, as recalled by farmers in May 1997. The most frequently used quantity was between 1 and 3 kilos, used by 41 percent of the farmers. For comparison, to control an anthill by pumping *lorsban* into it requires on average three applications of 0.5 kilos, that is 1.5 kilos of *lorsban*. Figures reflect the total amount of *lorsban* used per farm, which may be to control one or more anthills, or to spray crops.

Table 2: Amount[a] of *Lorsban*[b] used in *Los Zanjones* from May 1996 to May 1997, *La Laguna*, Colombia

	0 kilos	1-3 kilos	4-6 kilos	12-15 kilos	30 kilos
Percent farmers using	12	41	24	18	6

Notes: (N=17 farmers)

a 13 farmers (76 percent) indicated use of *lorsban* only for ant control while 2 farmers (12 percent) used *lorsban* both for ant control and to spray crops. This partly explains the large quantities used by some farmers.

b 1 kilo of *lorsban* costs US$2 (for comparison, an agricultural laborer is paid US$4.5 per day).

Less than 10 percent of farmers in *Los Zanjones* use any form of protection (protective gloves or masks) when applying *lorsban*. This is unfortunate since chlorpyrifos, classified by WHO as toxicity class II, is a chemical that easily penetrates the skin.

Rather than being attributable to the chemical as such, the failure to control ants in *Los Zanjones* with the use of *lorsban* is assumed to be due to a combination of two other factors, namely the sub-optimal method of application and the fact that ant control is not coordinated among farmers. Moreover, farmers complained about the cost of *lorsban* and expressed their general environmental concerns related the use of insecticides. These concerns therefore motivated the search for alternative ant control methods.

5. ALTERNATIVE ANT CONTROL METHODS—THE EXPERIMENT

Four alternative control methods and a control (no treatment) were selected for farmer experimentation in *La Laguna* for control of existing anthills. These are:

1. agricultural lime, pumped into the anthill;
2. lime mixed with *lorsban*, pumped into the anthill;
3. gasoline, poured into the anthill and set fire in order to produce an explosion; and
4. washing powder, poured into and around the entrances/exists of the anthill.

Agricultural lime does not work directly to kill the ants. Rather, it has an indirect effect by increasing the pH of the interior of the anthill and thereby creating conditions under which the fungus cultivated by and upon which the ants feed[4] cannot survive. Thus, lime causes the gradual starvation of the ants by inhibiting their fungus cultivation. For ease of pumping and maximum effectiveness, a fine-powdered lime with 100 percent calcium content should be used. This control method was proposed to farmers by CIAT researchers, following advice from national extension workers in other parts of Colombia.

In response to initial experiences with the application of lime, farmers proposed to mix lime with *lorsban* for combined application in a proportion of lime to *lorsban* of 3:1 and to gradually decrease to zero the amount of *lorsban* added to the lime. Since *lorsban* works by directly killing the ants, farmers in this way obtain immediate ant control while waiting for the

[4] Leaf-cutting ants do not directly feed on the leaves they cut, but on a fungus cultivated in the nest on the basis of the leaves.

effect of lime to build up. In the experiment, the average ratio of lime to *lorsban* was 6.33:1, calculated over all the applications.

Gasoline works by exploding and thus physically eradicating the anthill. This method was proposed especially by young, male farmers.

A fourth method proposed by female farmers was the use of washing powder, poured into and around the anthill. Presumably, alkaline washing powder has an effect similar to that of lime, namely to increase the pH of the anthill, thus inhibiting the growth of the fungus on which the leaf-cutting ants live.

Farmers were asked to volunteer for participating in the experiment, each with one anthill. Fifteen anthills[5] were included in the experiment, and by way of a lottery, a treatment assigned to each anthill, resulting in three replications per treatment. After testing several methods of evaluating anthill activity,[6] a relatively simple method was chosen: all holes (entrances and exits to the nest) were closed following the treatment. After a period, say of two

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[5] Due to the inclusion of controls (no treatment) two farmers insisted of participating with two anthills in the experiment. Thus, a total of 13 farmers participated in the experiment.

[6] In addition to the method of counting holes, two other methods were tried out. The first method, proposed by Fowler et al. (1993), consists of cutting drinking straws of different colors into pieces of 2.5-3.0 mm and bathing or impregnating these pieces in orange juice or mashed banana. These were placed on plates around the entrances and exits of the anthill, and the number taken into the anthill was used as an indicator of activity. However, for the ants to leave any little pieces of impregnated straw, the number of pieces placed around the nest had to exceed 1,000, something which made this method a very tedious, time-consuming, and thus impractical for farmer evaluation. The second method was excavating the nest and counting the number of healthy and destroyed 'garden cells', that is cells or chambers containing the fungus. This method was employed occasionally, but as a regular evaluation method it cannot be recommended since the ant nests can be very deep—up to five meters.

weeks, the number of holes which have been (re)opened were counted. Application and/or monitoring visits to the anthill, that is counting of (re)opened holes, was recommended to be undertaken every fortnight but in practice, the interval between individual applications/monitoring varied from a week to a month. The periods of application of the various techniques were uniform (with the exception of the interval between the applications around Christmas), except of course for the cases where the anthill had been effectively controlled before the last application/monitoring date. The last application/monitoring date was the same for all treatments.

In addition, a fifth control method was proposed by CIAT researchers to prevent young queens from establishing new anthills. The young queens usually leave the anthill in the first days of the rainy season. In *Los Zanjones*, it is some time in late October/early November. After fecundation, the queens seek to dig themselves into the ground in order to establish a new nest. The period from when the queens leave the old nest until they establish new ones only lasts a couple of days. As a control measure, a competition was announced in *Los Zanjones* among the children, awarding of prizes just before Christmas to those who collected the most young queens.

6. RESULTS FROM THE EXPERIMENT

Table 3 shows the results of the experiment using the four treatments mentioned above, measured as the initial number of entrance and exit holes to the ant nest and the number of holes (re)opened after each application or monitoring visit over the five-months period covered by the experiment. It should be noted that the anthill activity varies over the season as well as with the age of the anthill. Thus, even without any treatment, the number of holes can be expected to change. The table shows that lime mixed with *lorsban* and gasoline were the two most effective treatments, reducing the number of holes by 95-100 percent.

Table 3: Results from ant control treatment, La Laguna, Colombia

Treatment	Anthill number	Number of holes at first application/monitoring visit	Number of holes at last application/ monitoring visit	Total number of applications	Percent reduction in number of holes
Washing powder	1	44	7	7	84
Washing powder	2	135	20	9	85
Washing powder	3	25	43	9	(-72)
Lime	4	109	1	10	99
Lime	5	257	18	9	93
Lime	6	22	26	9	(-18)
Lime+*lorsban*	7	70	3	7	96
Lime+*lorsban*	8	25	0	3	100
Lime+*lorsban*	9	13	0	4	100
Gasoline	10	8	0	2	100
Gasoline	11	35	0	2	100
Gasoline	12	102	0	3	100
Control	13	30	6	N.A.	80
Control	14	8	6	N.A.	25
Control	15	17	9	N.A.	47

N.A. Not applicable

Table 4 summarizes the costs of the treatments and shows that while least effective, the most costly treatment was the use of washing powder with an average cost per anthill of US$11.76. On the other hand, the use of lime mixed with *lorsban* was the cheapest, with a total average cost per anthill of between US$5.36 and US$5.60, depending on the type of lime used.[7] This is the same cost as calculated for the use of *lorsban* if pumped into the anthill (US$5.56). For cash constrained farmers, however, the composition of the cost is important. While both the use of washing powder and gasoline have high input (cash) costs (US$6.86 and US$8.05, respectively), lime mixed with *lorsban*, and particularly lime (*cal viva*) alone, have relatively low input (cash) costs (ranging from US$0.56 for *cal viva* alone to US$1.15 for *supercal* mixed with *lorsban*). Lime alone has higher labor costs because of the need for more applications. The input cost calculated for the use of *lorsban* pumped into the anthill of US$2.89 is somewhat above the input costs for lime and lime mixed with *lorsban*.

Table 4: Average total costs per anthill of different ant control treatments (US$—1998 prices)

Treatment	Input costs[a]	Labor costs[b]	Total costs
Washing powder	6.86	4.90	11.76
Lime (*cal viva*)	0.56	8.89	9.44
Lime (*supercal*)	1.11	8.89	10.00
Lime (*cal viva)* + lorsban	0.97	4.44	5.36
Lime (*supercal*) + *lorsban*	1.15	4.49	5.60
Gasoline	8.05	2.06	10.11
Lorsban pumped into nest *(calculated; treatment not included in experiment)*	2.89	2.67	5.56
Queen-catching competition	1.20–2.41	N.A.	1.20–2.41

Note: [a] calculated on the basis of retail prices at the local markets.

[7] Two types of fine-powdered lime with a 100 percent calcium content are available in the area: one called supercal which is available in 10 kilo bags at a cost of US$2.22 (or US$0.22 per kilo) and another called cal viva which is available in 50 kilo bags at a cost of US$5.55 (or US$0.11 per kilo). Although more expensive per kilo, ease of transport, local availability, less risk of storage losses and a smaller cost per bag make farmers prefer supercal to cal viva.

[b] calculated on the basis of the local payment for an agricultural day-laborer, corresponding to US$0.6 per hour.

With respect to the competition collecting young queens during the days when they leave the old nest in order to establish new ones, a total of 4,616 queens were collected between the twelve participants in the competition. The number of queens collected per person ranged from 75 to 1,897. Even if not collected, far from all of these queens would have managed to establish new nests: on average, only 0.5-1 percent of all young queens manage to establish new nests. This means that by way of the competition, between 23 and 46 new ant nests were avoided. The total cost related to this method, that is the prizes given to the winners as well as consolation prizes, was US$55.38, corresponding to between US$1.20 and 2.41 per avoided anthill, depending on the exact number of new nests avoided. The following year (1998), very few queens left the anthills, probably due to a combination of the fact that a considerable number of the anthills had been controlled and that 1998 was a very wet year caused by the climatic phenomenon called *el niño*, and the queen catching competition was therefore not . However, inspired by CIAT's work on collective ant control, mid-1999 an association of extension workers employed by a range of governmental and non-governmental organizations in Río Cabuyal—a 7,000 hectare watershed of which *Los Zanjones* forms part—decided to form a sub-committee to deal specifically with ant control. As their first joint initiative, they decided to launch the queen catching competition among children in 10 villages in Río Cabuyal. Twenty-three villages signed up for the competition in 1999, which resulted in the capture of more than 100,000 queens by October 15, 1999.

In an open-ended evaluation, farmers included both cost and effectiveness in terms of controlling ant activity in their assessments of the different methods. The use of washing powder was discarded both due to its low effectiveness and its high costs. In addition, farmers included a third, environmental, aspect into their assessment. The use of lime and particularly lime mixed with *lorsban* were evaluated positively because, apart from cost-effectively controlling ants, they were perceived to improve the soil which in the area is rather acid (pH around 5). An example was mentioned of a large anthill, which had been completely bare of vegetation for many years. After being treated with lime, which managed to put an end to the ant activity, vegetation emerged on what had been the anthill. This effect was attributed to the lime. The use of gasoline, on the other hand, though effective and liked, particularly by the young, male farmers due to the excitement involved in its application, was discarded as a feasible control method by the same young, male farmers. The reason given was the high cost of restoring the soil afterwards in terms of nutrients, soil life, and structure where the explosion had occurred. Also, compared to the current practice of applying *lorsban* alone, the use of lime mixed with *lorsban* was preferred, primarily on environmental grounds, since it used fewer insecticides.

The use of lime mixed with gradually decreasing amounts of *lorsban* was consequently the treatment evaluated most favorably by farmers, and considerations began on how to initiate ant control on a collective rather than an individual basis.

7. TOWARDS COLLECTIVE ANT CONTROL

Testing alternative technical methods of ant control constitutes only part of the solution to the ant control problem and the participatory landscape-level experiment initiated in *Los Zanjones*. An equally important part of the solution lies in the identification of mechanisms to facilitate the adoption of promising ant control methods in a coordinated fashion. It is important to stress that undertaking ant control in a coordinated fashion does not imply that the actual treatment, i.e. the pumping of lime and *lorsban* into the ant nest, should be done collectively. Rather, collective action is necessary to ensure that all anthills are treated simultaneously. Not surprisingly, this part of the ant control problem has in many respects proved to be the most difficult to solve, and still has to be completed. Though not all equally successful, this section describes some of measures taken and experiences gained in the joint efforts between farmers and researchers to stimulate collectively coordinated ant control.

In a meeting held on the technical evaluation of the various ant control methods, farmers decided to use part of a fund established by CIAT (using an IDRC grant intended to facilitate collective management of watershed resources) for purchasing a pump to be shared between the 17 farmers in the area for application of lime mixed with lorsban. The decision was made that the pump should rotate between farmers, who each could use it for one day every two weeks. This decision was implemented and the pump has been rotating, at least to some extent. Two problems have, however, been encountered. First, there has been a problem of maintenance. Some farmers did not get the right type of very fine powdered lime, but were persuaded by agricultural supplies dealers to buy a more coarse type, which apparently damaged the pump and thus discouraged farmers from continuing lime-lorsban ant control. This problem has now been resolved. The pump has been repaired, and in mid-1998, a survey was conducted at adjacent local markets to establish the commercial names of the feasible kinds of fine-powdered lime (and the ones to be avoided), as a guide to farmers when they make their purchases. Thus, there have been no further incidences of pump breakdowns.

The second problem, which still has only been partly resolved, relates to the difficulties of transporting the pump from one place to another in the rather hilly watershed. The system initially proposed by farmers was that the pump should always be returned to the same person, the pump caretaker. The advantages of this system are that the pump caretaker assumes responsibility for the pump and everyone knows where to find the pump. The drawback, however, is that it is always the same group of farmers, namely those living at some distance from the pump caretaker, who have difficulty getting access because they have to walk uphill or downhill to get the pump. In response to the problem of transporting the pump, farmers decided to purchase a second pump with the fund, and this has somewhat eased the problem of transportation. Moreover, the system of having the pump returned to the pump caretaker after every use has gradually been relaxed and evolved into more of a rotational system. However, this has created an information problem, making it difficult for farmers to locate the pump. A local field worker employed by CIAT has, to a large extent, stepped in to help farmers locate the pump. Finally, a number of the more resourceful farmers have decided to purchase their own pump, which has increased the availability of pumps in the area to all farmers. The cost of the type of mechanical pump used in the area is approximately US$55.

The second decision taken by farmers relates to the organization of work. Pumping lime into an anthill is hard work and lime can get damp if stored for a longer period during the rainy season. However, it is only commercially available in bags of minimum 10 kilos, while each application only consumes around half a kilo. For these reasons, farmers suggested subdividing themselves into working groups of two to four neighboring households, who would collaborate in undertaking applications as well as purchasing of lime collectively. Six groups were established, each of which decided upon different arrangements for sharing input purchase and work. However, only one group, consisting of two Guambiano farmers (a man and a woman) and one female mestizo farmer, has succeeded in dividing the purchase of inputs between them and jointly treating the anthills on a fortnightly basis. The remaining groups managed in varying degrees to buy inputs and work together, but due to problems of cooperation, lack of time, and unwillingness of some to undertake ant control, many farmers ended up doing the ant control on an individual basis. Thus, some farmers still complain that undertaking the applications *alone* is hard work.[8]

Encouraged by CIAT researchers, farmers made a third decision that each should fill out a form after each application or monitoring visit to an anthill, indicating the number of (re)opened holes and, if relevant, the type of application undertaken. Moreover, all anthills in *Los Zanjones*, whether receiving treatment or not, should be located in a map—the same map as the one used for the anthill inventory of which each farmer got a copy—and monitored. These two measures combined would enable a more global monitoring of the successfulness of ant control for the whole micro-watershed. The local field worker employed by CIAT has provided initial assistance to farmers in locating the anthills in the map and in filling in the monitoring sheet for each anthill. Combined, these maps depict approximately 90 anthills in *Los Zanjones*, including smaller anthills. However, farmers have complained that they found the monitoring sheet difficult to complete, partly because it involved the use of codes to identify the anthills; partly because by including all anthills and not just the major ones, the number of anthills to monitor became cumbersome to manage; and partly because they did not feel comfortable in writing and were afraid of making mistakes. The monitoring sheet has been revised so as to avoid the use of codes, but ways to overcome farmers' uneasiness with respect to writing and the great number of anthills to be monitored still have to be found. Since monitoring change is so central to the understanding of many transboundary natural resource management problems, including the problem of ant control, the development of monitoring systems which can be managed and analyzed by farmers themselves remains an important challenge to participatory landscape-level research.

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[8] Each application implies an average of half an hour just for pumping in addition to which has to be added time for carrying the pump and the lime to the ant nest.

Fourth, and from the point of view of collective action most important, farmers who had participated in the experiment and/or the meetings concerning ant control, decided to encourage farmers who hitherto had not participated to undertake ant control. This decision was made in view of the perceived importance that all anthills should be controlled simultaneously to obtain effective protection against crop damage caused by leaf-cutting ants. Initially, enthusiastic farmers tried to convince their neighbors to undertake ant control, but with little luck. This was in 1997 before the mapping exercise of the major anthills and their radius of influence (Figure 1) had been completed. Thus, farmers did not feel that they had come any closer to a solution of the ant control problem. Among the reasons encountered were that some farmers did not feel economically affected by the ants because their land was lying fallow or was planted with a crop, like beans, which is not attacked by the ants, or that the farmer was sharecropping or taking care of somebody's farm and unless the owner gave his acceptance and/or paid for the inputs, the sharecropper or caretaker could not undertake any ant control. On the other hand, there were examples of farmers who had their crop damaged by ants coming from neighboring fields and subsequently trespassed into the neighboring field to undertake ant control themselves.

In 1998, farmers decided to try another way of encouraging ant control to be undertaken more globally throughout *Los Zanjones*. They launched a competition. Over a period of three months (the time it takes on average to effectively control an anthill using lime mixed with *lorsban*), the control of anthills in the area would be recorded and a winner, that is the person who had controlled the most anthills on his or her own as well as on fields belonging to neighbors, would be found. The reward would be a *minga*, that is a labor party at the winner's land, in which the workers would be farmers who had entered themselves in the competition and the lunch would be paid by the fund established by CIAT. To identify a winner, farmers developed a scoring system and the farmer with the highest score would be the winner. Scores were allocated on the following basis:

For every anthill controlled on own farm	5 points
For every anthill controlled on neighbor's farm (with the permission of the neighbor)	10 points
For every anthill a farmer could convince a neighbor to control (based on consent between the 'convincer' and the 'convinced' that this was what happened)	20 points
For every anthill controlled in groups, every member of the group receives	20 points

Only about half (9) of the farmers participated in the competition. However, through the competition, an additional four farmers were convinced to undertake ant control and all participants in the competition got permission from their neighbors to control anthills on their land. Despite favoring ant control in groups, the scoring system did not manage to encourage farmers to do so. Only three of the participants undertook ant control in groups. Participants in the competition collected between 5 and 180 points and the winner had managed to control 14 anthills on her own farm, seven at a neighbor's farm and, in addition, she had managed to convince one of her neighbors to control some anthills on his farm. The fact that all competitors participated in the *minga* at the winner's farm provides an indication of their commitment and their recognition of the efforts of the winner. In total, 56 anthills or approximately two thirds of the estimated total number of anthills in the area were controlled through the competition.

Thus, the competition as such and the fact that farmers had developed a stronger sense of the transboundary nature of the ant control problem which helped to strengthen their arguments to convince neighbors to take up ant control, turned out to be an effective means of stimulating a coordinated ant control effort. As a somewhat ironic indication of success of the coordinated ant control efforts as part of their collaboration with CIAT, farmers in *Los Zanjones* today do not wish to continue their work in ant control because they no longer perceive it as a major problem (although they do recognize the importance of controlling remaining anthills). Instead, they wish to embark upon other problems such as land use around riverbanks and springs, and erosion control which also require coordinated efforts.

8. CONCLUSION

Technical designs are rarely sufficient to solve transboundary natural resource management problems. The case of crop damage caused by leaf-cutting ants described in this paper illustrates that, although technically feasible ant control methods were developed, it was not until a mechanism was identified which managed to encourage a significant proportion of the farmers of *Los Zanjones* to simultaneously control their ant nests that progress was made in effectively limiting the ant activity. Thus, the case of participatory experimentation to solve the ant control problem reported in this paper has been successful in the sense of having significantly limited the crop damage caused by leaf-cutting ants in *Los Zanjones* as well as in demonstrating the transboundary nature of the ant control problem and the importance of collective action.

Yet coordination is cumbersome, particularly in groups that are so heterogeneous in terms of livelihood strategies (day-laboring farmers, small-scale farmers, sharecroppers and caretakers and absentee landlords), ethnicity, and resource endowments as are the land users of *Los Zanjones*. Heterogeneity can contribute to lack of trust and mutual understanding within the group and lack of experience working together. The multi-faceted relationships between neighbors can also create fears that encouraging someone to undertake practices such as ant control might be taken as a reproach and thus endanger future relationships and perhaps block for future favors—all of which hamper communication. Unfortunately, heterogeneity is the rule rather than the exception. The solution to many natural resource management problems depends upon the coordinated efforts of diverse, rather than homogeneous, land users and their ability to negotiate conflicts between short-term *versus* long-term interests, as well as between individual *versus* collective interests.

In the case of *Los Zanjones*, CIAT has been instrumental in overcoming many of the organizational difficulties involved in coordinated ant control, such as organizing meetings, facilitating the rotation of the pump, undertaking a market survey to establish the types of lime compatible with pumping, and pushing and partly conducting the monitoring of ant control. The participatory experimentation initiated and supported by CIAT to encourage collective ant control shows that with third party organizational support, it is possible even in heterogeneous groups to achieve coordination among individual farmers and thus achieve results—in this case, effective ant control—which critically depends upon such coordination. Inspired not only by the technical results with respect to the use of lime mixed with *lorsban*, but also by the organizational lessons in terms of the importance of coordinating the ant control of the individual farmers, an association of extension workers employed by a range of governmental and non-governmental organizations have decided to undertake a joint effort in ant control in the 7,000 Río Cabuyal watershed of which *Los Zanjones* is part. Still, more effective means to support coordination and stimulate farmers themselves to eventually assume the responsibility of organizing their collective efforts, not only in ant control but more widely in natural resource management, would need to be explored. This constitutes a major task for future research into the importance of collective action in agricultural development and natural resource management.

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