21

Monitoring Settlement as Part of an Integrated Model of Aquatic Ecology

The Onchocerciasis Control Programme of West Africa

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Since the mid-1970s, the issue of environmental monitoring has been at the forefront of most major vector-borne disease control programs. To date, however, the traditional focus of these monitoring efforts has been to minimize the impact of current and projected pesticide use. Far less attention has been focused on environmental changes set in motion by the successful impact of these pesticides in reducing the threat of disease. This chapter explores some of the long-term environmental costs of this myopic vision of environmental impact for the aquatic ecology of the affected river basins and makes recommendations for how these costs can be avoided in similar types of disease control efforts in the future.

These questions are examined for one of the most successful disease control programs ever launched in sub-Saharan Africa: the Onchocerciasis Control Programme (OCP). Since 1974, the OCP has coordinated a massive international effort to control river blindness in an 11-country area of West Africa. The OCP is an appropriate focus because it is one of the rare disease control programs that did attempt to address the issue of spontaneous new lands settlement as part of its initial definition of environmental impacts from 1974 through 1980. After this promising start, however, the environmental mandate of the program was redefined to focus exclusively on the larvaciding program. One result was to postpone the discussion of the environmental impact of the resulting new lands settlement until the indirect environmental impacts of the settlement in terms of extensive forest clearance and pesticide use had begun to affect invertebrate and fish populations. The emerging evidence that accelerated rates of settlement were having major environmental impacts led to a more broad-based concern with the environmental impact of uncontrolled spontaneous new lands settlement after 1994.

Some of the factors that contributed to the evolution of the OCP's institutional mandate for environmental monitoring are reviewed. The impact of these monitoring efforts in three relatively distinct time periods (1974–1980, 1980–1994, and 1994–present) is considered. The final section summarizes the lessons learned from this analysis about risks of excluding settlement from a more broad-based model of environmental impact and some of the challenges that one is likely to encounter when attempting to develop new models of the aquatic environment that incorporate settlement as an active change agent.

Early Design and Medical Impact of the Onchocerciasis Control Programme

The Aquatic Ecology of River Blindness and Larvaciding

The high incidence of onchocerciasis (river blindness) is considered to be one of the principal reasons that the river basins in West Africa's Sudano-Sahelian region have remained sparsely inhabited despite high population densities in adjacent zones.[1] This highly specific geographical concentration of the disease is related to the fact that the larvae of the black fly vector *(Simulium damnosum)* that transmits the disease-causing microfilariae of the worm *Onchocerca volvulus* can breed only in areas with fast-flowing, aerated water. The infected river basins include some areas with a high potential for agricultural production in one of the most drought-prone areas of West Africa. Therefore, the international donors who supported the control program anticipated that controlling the disease would help stabilize agricultural production.

When the OCP began in 1974, there was no acceptable mass treatment for onchocerciasis once the microfilariae, or worms, had penetrated an adult body.[2] As a result, the early program focused on interrupting the transmission of the parasite for longer than the longevity of the adult worms in a human host (estimated to be about 14 years). The plan was to destroy the larval stages of the black fly vector through aerial application of insecticides at the black fly's riverine breeding sites (Calamari et al. 1998a, 1998b). Aquatic-stage development from egg to pupa is around 1 week; hence, insecticide treatment was undertaken weekly. At the peak of larvaciding activities during the early years 1986–1991, about 50,000 km^2 of river were treated in an area of over 1 million km^2.

Medical Impact of Control (1974–present)

By the end of 1979, 18,000 km² of river basin areas had been treated and were under continuous surveillance, and disease transmission was effectively reduced in the core control zone, which covered 764,000 km² in seven countries—Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali, Niger, and Togo (Figure 21.1). It soon became clear, however, that the flight range of the black fly was greater than what had been thought, and the aerial spraying program was expanded to include a total of 1.3 million km² and four additional countries (Guinea, Guinea Bissau, Sierra Leone, and Senegal) after 1986–1987. These countries are referred to as the southern and western extension zones; with their addition, the number of countries affected by control totaled 11 (Figure 21.1).

By 1992, the transmission of the disease had been interrupted in the core control zone except for a small number of foci where transmission continued at a low level. The effect of the interrupted transmission was reflected in comparisons of the prevalence of microfilariae in skin samples in the precontrol period (1974) and in 1992–1993 (Figure 21.2).

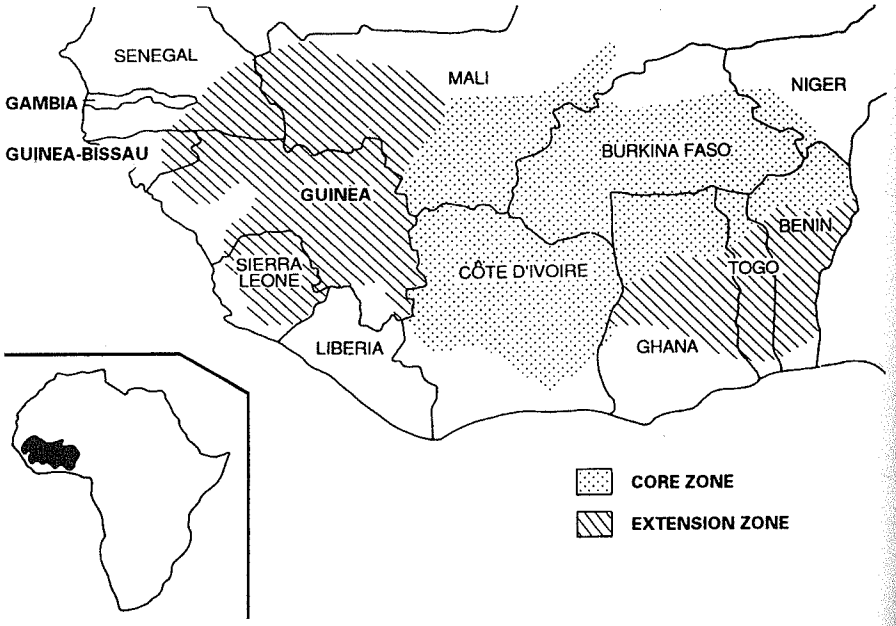
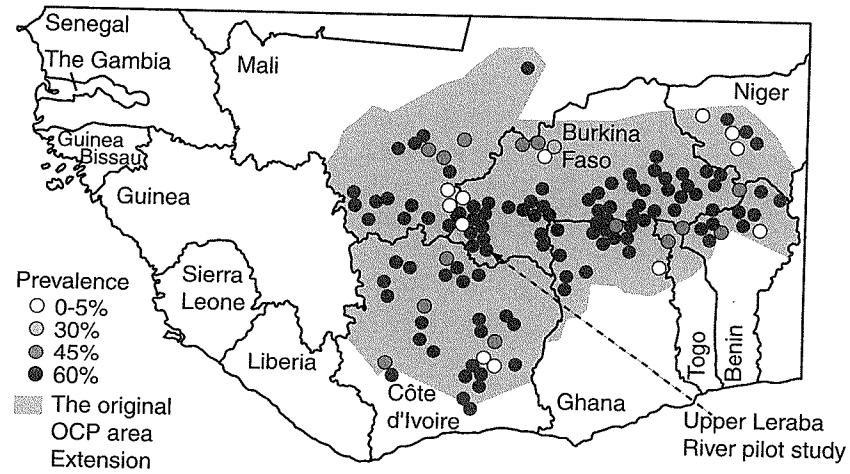


Fig. 21.1. The Onchocerciasis Control Programme core and extension zones (adapted from McMillan et al. 1992).



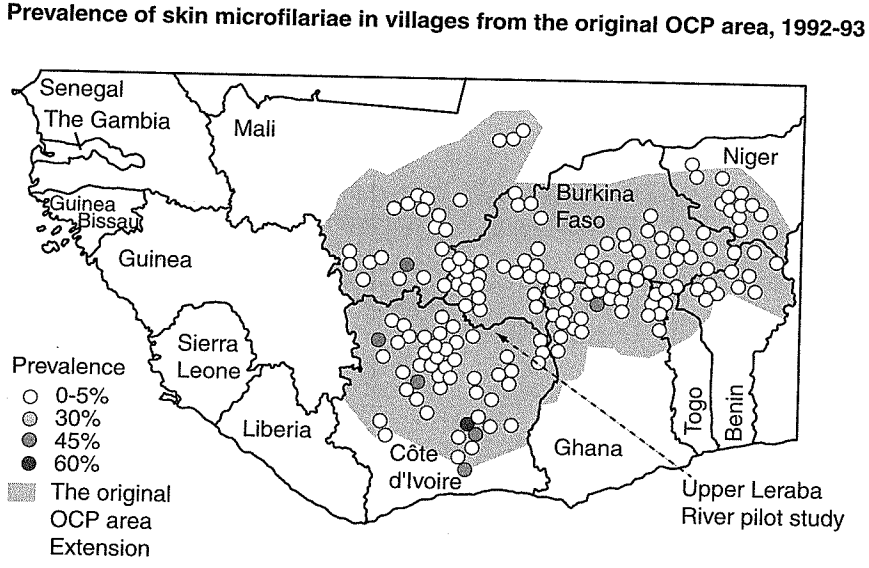


Fig. 21.2. The prevalence of skin microfilariae in villages from the original Onchocerciasis Control Programme in the precontrol period (1974) and in 1992–1993.

A major turning point in the control program was the discovery in the mid-1980s that a single oral dose of the microfilariacide ivermectin (registered name, Mectizan) would kill the microfilariae but not the adult worms. Later large-scale community trials to monitor adverse reactions to the medicine led to the conclusion that ivermectin was sufficiently safe for large-scale mass treatment and that the annual dose could also control for eye morbidity. Since late 1987, when the drug was first donated to the OCP by Western drug producers, a series of mass distribution programs has been organized.[3] The ivermectin distribution program significantly increased the potential for sustaining control, but it was insufficient, in and of itself, to maintain control, given the logistical difficulties of reaching the entire population living in these isolated river basins. For this reason, the OCP has continued a reduced program of larviciding that is expected to stop completely by the end of 2002.

Early Mandate and Activities of the OCP Ecological Panel, Including Settlement and Larvaciding: 1974–1980

Mandate and Institutional Framework for Environmental Monitoring, 1974–1980

Since 1972, when the very first planning meetings of the OCP Committee/Committee of Sponsoring Agencies (CSA) met, the issue of environmental monitoring has been central. One highly innovative aspect of this initial conception of environmental monitoring was that it addressed both the direct and indirect impacts of the larvaciding program on the aquatic environment and the risk of uncontrolled spontaneous settlement. This strong concerted focus on environmental monitoring in the design phase of the control program was greatly influenced by the DDT scare, which led to progressive banning of DDT in Europe and the United States from 1972 to 1974. The same initial conception of environmental impacts appears to have been strongly influenced by the first examples of comparative research on the environmental impacts of spontaneous settlement in Latin America (Nelson 1973) and the large Mossi immigration to Burkina's southwest, which river blindness control was expected to accelerate (Rouch 1956, 1958, 1960, 1961, Gregory 1974a, 1974b, Remy 1975, Benoit 1973a, 1973b, Benoit and Lahuec 1975).[4]

This broad vision of environmental impacts was translated into the administrative structure of the program. The first OCP budget included a financial line for consultant hydrobiologists to collect baseline data for future assessment of the effect of the vector control operation. The same budget foresaw the creation of an independent Ecological Panel comprising leading world experts who would "study the ecological problems connected with the Programme and with the associated economic development projects" and propose to the OCP Steering Committee measures "to ensure effective protection of the environment" (Samba 1994:4).[5] The panel was given three official functions. The first was to organize a long-term monitoring program of the aquatic invertebrates and fish assemblages at selected sites. The second was to identify the OCP's criteria for selection of pesticides for operational use and to determine the conditions by which insecticide use could be optimized in relation to seasonal and environmental factors in different areas on the basis of laboratory and field-based ecotoxicological studies. The third, which is as innovative today as it was then, was to review the nature of the agricultural development process being undertaken and proposed in areas liberated from onchocerciasis to identify the environmental and human ecological implications of such development.

By 1975, the OCP, acting on the recommendations of the Ecological Panel, had developed a strict system for monthly monitoring of the first generation of organophosphate (temephos) pesticides on invertebrate and fish assemblages in six basins in Côte d'Ivoire, four basins in Ghana, two major river basins (the Red and the Black Volta), isolated other rivers, and fish markets (OCP/EP 1976:Annex 4, p. 1). Another major achievement was the identification and pretesting under field and laboratory conditions of alternative backup pesticides that could be used after evidence of resistance to the first control agent (the organophosphate temephos) was detected in the late 1970s.[6] To determine the most representative taxa to be used as markers in these studies, the panel oversaw the design and implementation of a massive series of baseline studies on the composition of the freshwater fauna. The same initial period coincided with the development of a standardized computerized data-recording system, with precoded forms, that made it possible to coordinate these data-collection and analytical activities among the three monitoring groups based in Ghana, Côte d'Ivoire, and Burkina (OCP/EP 1975:5).

The initial composition of the independent OCP Ecological Panel was concentrated on the scientific disciplines and issues associated with the larvaciding program. However, the panel soon made recommendations for strengthening the types of socioeconomic planning needed to reduce the negative environmental impacts of the spontaneous settlement into the zone.[7] By mid-1974 (the second meeting of the Ecological Panel), the panel's membership had been expanded to include an anthropologist

(Thayer Scudder) with extensive settlement experience as the UNDP representative (OCP/EP 1974b). In response to the panel's recommendation, the World Bank initiated a meeting, held in Washington, D.C. in December 1974, during which specialists from UNDP, FAO, and the World Bank agreed on a basic settlement planning methodology (referred to as the Methodology). The Methodology was eventually adopted by and funded in five of the original seven OCP countries.[8] At the same meeting, several OCP donors (IDA, UNDP, USAID) agreed to fund specific components of the follow-up planning put forward by the five core control countries who subscribed to the Methodology. In 1975, five of the seven core control countries (Benin, Ghana, Mali, Togo, Burkina) received an initial US$0.5 million grant from UNDP that several of them used to implement the resulting national plans (Burer 1977). In early 1976, the OCP hired an economist to head up a small "economic unit" whose role was "liaison with the National Committees for Onchocerciasis" (OCP/EP 1976:Annex 1, 2).[9] The unit's staff was gradually expanded to include by 1977 a Ph.D. anthropologist with extensive research experience in classic anthropological research in West Africa and one other general social scientist.

More Restricted Mandate of the Ecological Panel: 1980–1994

By May 1976—scarcely 2 years into the program—it was possible to see a progressive narrowing of the OCP's conception of ecological monitoring to a focus that was almost exclusively on larvaciding.[10] This narrower mandate became official when the OCP announced that the Ecological Panel would be restructured as part of a more broadly based reorganization of the OCP designed to decrease costs and increase the long-term sustainability of the control program in 1980. After the reorganization, the Ecological Panel became the Ecological Group with a more restricted mandate that focused exclusively on examining "the ecological impact on the environment of the use of insecticides in the Programme" (Samba 1994:24). The same reorganization "disestablished" (Samba 1994:24) the role of the Economic Development Advisory Panel (EDAP) and placed the responsibility for monitoring settlement trends and follow-up planning with the OCP Committee of Sponsoring Agencies (CSA).

The decision to narrow the focus of the program's environmental monitoring was in response to several factors. The first was the perceived need to gear up a much more intensive program to field test a wider range of environmentally sensitive backup pesticides. The second was the program's frustration with the limited response they were getting from

foreign donors and the national governments for follow-up investment in the zone. Whereas the medical control program was financed through a centralized fund donated by various interested countries, there was no central mechanism for financing the national proposals to carry out the follow-up development methodology that had been proposed by the joint FAO/UNDP/World Bank Report. Therefore, implementation of the follow-up proposals to deal with settlement depended largely on each donor country's particular interest (Burer 1977). Consequently, individual countries could not take simultaneous action on various components of the methodology. Even when they had money—such as the UNDP funds that were available in 1975—there were major delays. The first Status Report on Economic Development of the Onchocerciasis-Controlled Areas concluded that (Burer 1977:6): "If the use of UNDP funds, which were available even before the countries' acceptance of the Methodology, is a yardstick for each country's absorptive capacity, then Benin, Ghana and Mali, with 70%, 100%, and 100%, respectively, undisbursed at early 1977, do not seem to have the proper mechanism for accelerating economic development."

Faced with huge development problems in their areas of existing settlement, few countries were interested in investing in the development of the sparsely populated river basins. The chief exception was Burkina Faso, where follow-up planning for the valleys was a development priority from the start. Burkina's strong interest in follow-up planning can be attributed to its extremely high population densities and the fact that the affected river basins were generally thought to be potentially some of the most agriculturally productive areas in the country.

Under this revised mandate for environmental monitoring, the OCP continued to invest heavily in ecotoxicological and environmental monitoring and staff training to support the larvaciding programs. The OCP conducted an extensive battery of ecotoxicological studies on all the pesticides they anticipated using (Figure 21.3). On the basis of those studies, the OCP was able to develop a risk assessment for every new larvacide.[11] This research was critical in saving the control program after the development of insect resistance to temephos. After the development of insect resistance to another organophosphate (chlorphoxim) was detected in 1981, the OCP adopted a strategy of rotational use of different classes of insecticides, with different modes of action, to prevent the development of further resistance (Calamari et al. 1998a, 1998b) (Figure 21.3).

Parallel to its basic scientific research, the OCP trained a number of national entomologists and other scientists along with the international

scientists in the OCP in environmental monitoring techniques. By 1987, almost all of this research was being performed by national hydrobiologists with support from the program. These monitoring activities continued to support applied, longitudinal research to identify any changes in fish assemblages and the species complexity or eating patterns of the invertebrates, which, low on the food chain, are considered to be the best indicators of environmental damage (Figure 21.3).[12]

Ten years of monitoring the use of organophosphate insecticides and the biological insecticide *Bacillus thuringiensis* showed biological variations in the river fauna that were considered acceptable (Leveque et al. 1988). On the basis of those results, the Ecological Group decided to reduce the number of stations and concentrate on sites where new insecticides were applied. The protocol pursued from 1986 to 1994 provided for monthly or bimonthly sampling in selected sites to monitor the invertebrate fauna (OCP 1994:57). Fishes were sampled on a bimonthly basis, but nonprotocol interventions were provided for cases in which an abnormal rate of fish or invertebrate mortality was observed.

A 20-year evaluation of OCP monitoring data over a period when different groups of chemical substances were used showed greater effects of the insecticides on the invertebrate fauna, particularly the rarefaction of a few taxa and, for example, in the case of permethrin, a biomass reduction. The same studies also demonstrated the ability of the aquatic biota to recover. Therefore, the reports concluded that the taxonomic and functional variability in nontarget invertebrate fauna were compatible with the range of biological variation that would normally occur in these river systems (Calamari et al. 1998a, 1998b).

Although the 20-year analysis concluded that the larvaciding had had no effects on food availability or on the feeding habits of the fish, the studies did show some variation in the biomass and richness of fish species. The variation in those parameters was correlated with the hydrological patterns of the rivers; that is, they were affected by drought, rain, and so on. On the basis of these research results, the OCP decided to introduce a new satellite transmission network for recording water discharge that allowed for in-time management of hydrological data in the treatment of the rivers as a strategy for minimizing any indirect long-term impacts treatment might have on the fish population.

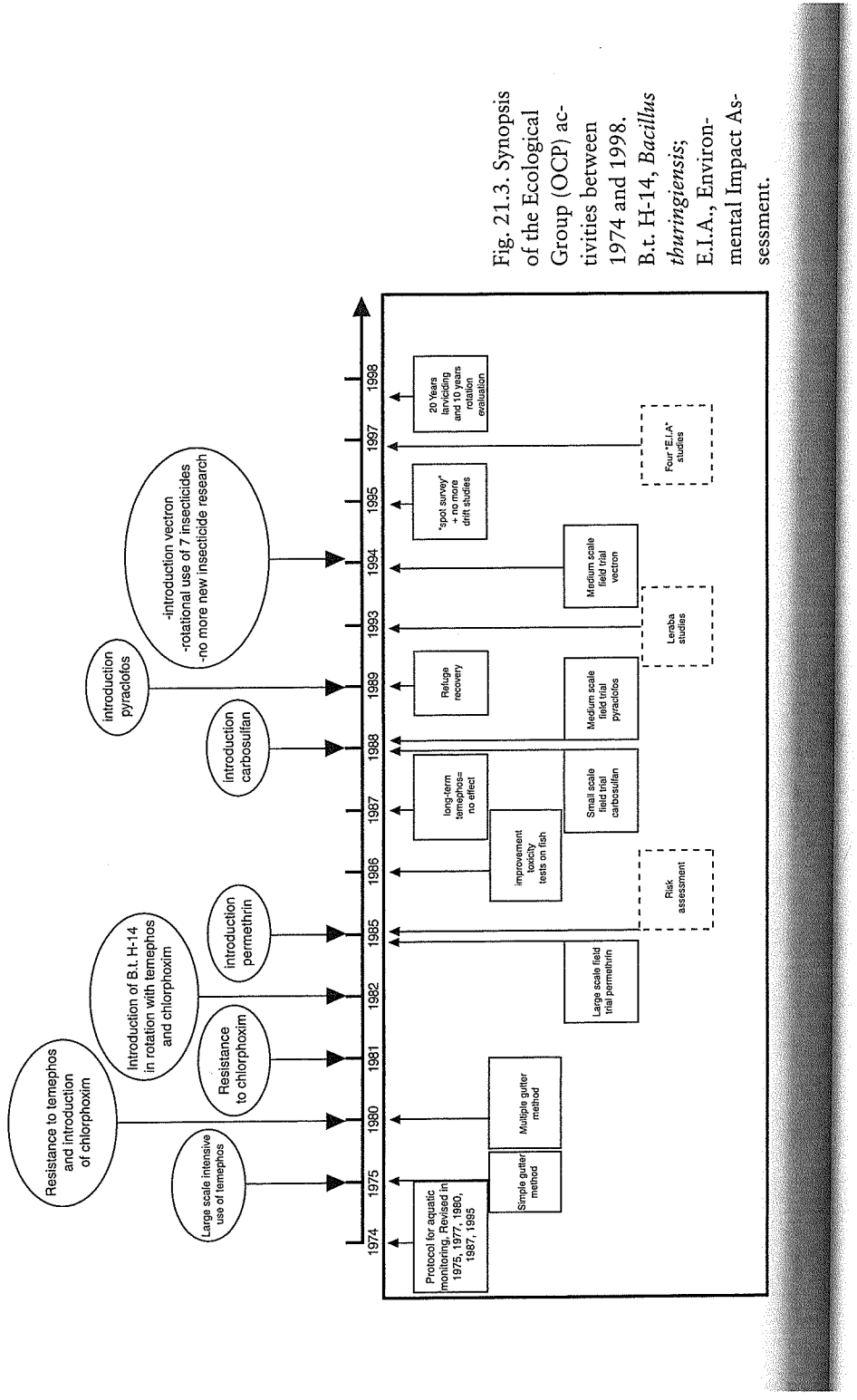


Fig. 21.3. Synopsis of the Ecological Group (OCP) activities between 1974 and 1998. B.t. H-14, *Bacillus thuringiensis*; E.I.A., Environmental Impact Assessment.

Parallel Research on New Lands Settlement: 1980–1994

Sociological and Geographical Research

The same reorganization that refocused the OCP's environmental monitoring efforts exclusively on larvaciding placed responsibility for follow-up planning for settlement under the OCP's Committee of Sponsoring Agencies (CSA). In contrast to the activities of the Ecological Group, however, the CSA's activities did not benefit from any sort of line funding from the regular OCP budget. This lack of core funding or lead responsibility on settlement monitoring affected the degree of continuity in the research.

Once the first baseline studies under the initial grant from UNDP had been completed, there was almost no regionwide research until preparations started for the 10-year report on the program. In connection with this report, individual consultants (and research groups such as the AVV, Autorité des Aménagements des Vallées des Volta [Volta Valley Authority] in Burkina Faso) received small grants from the OCP to prepare reports on settlement trends in their own countries. The reports were interesting and showed great diversity between and within countries in terms of the speed and patterns of new lands settlement. The utility of the exercise was marred, however, by the lack of any consensus on what the key issues were or how they might be measured.[13]

One of the major recommendations of the official 10-year review of settlement and development (OCP 1986) was the need for better information on the river basins' soil, forests, drinking and irrigation water resources, and current settlement processes. In contrast to the larvacide monitoring efforts that were administered or at least supervised by one of the main divisions of the OCP, the settlement studies were funded by a single donor (UNDP) and executed by subcontractors with little direct connection to the program other than office space. The first was an inventory of preexisting data funded by the World Bank and executed by WHO/OCP through Huntings Technical Services Ltd. (1988a, 1988b, 1988c, 1988d). The second was a comparative study of settlement processes and policy options funded by UNDP and executed by the World Bank through the Institute for Development Anthropology. The latter study, which is referred to as the OCP Land Settlement Review (LSR), included case study research at 16 sites (Figure 21.4). Unfortunately, a comparison of the map of the LSR study sites with the major sites monitored by the Ecology Group and Panel since 1974 shows very little overlap and almost no functional communication between the research activities (Figures 21.4 and 21.5).

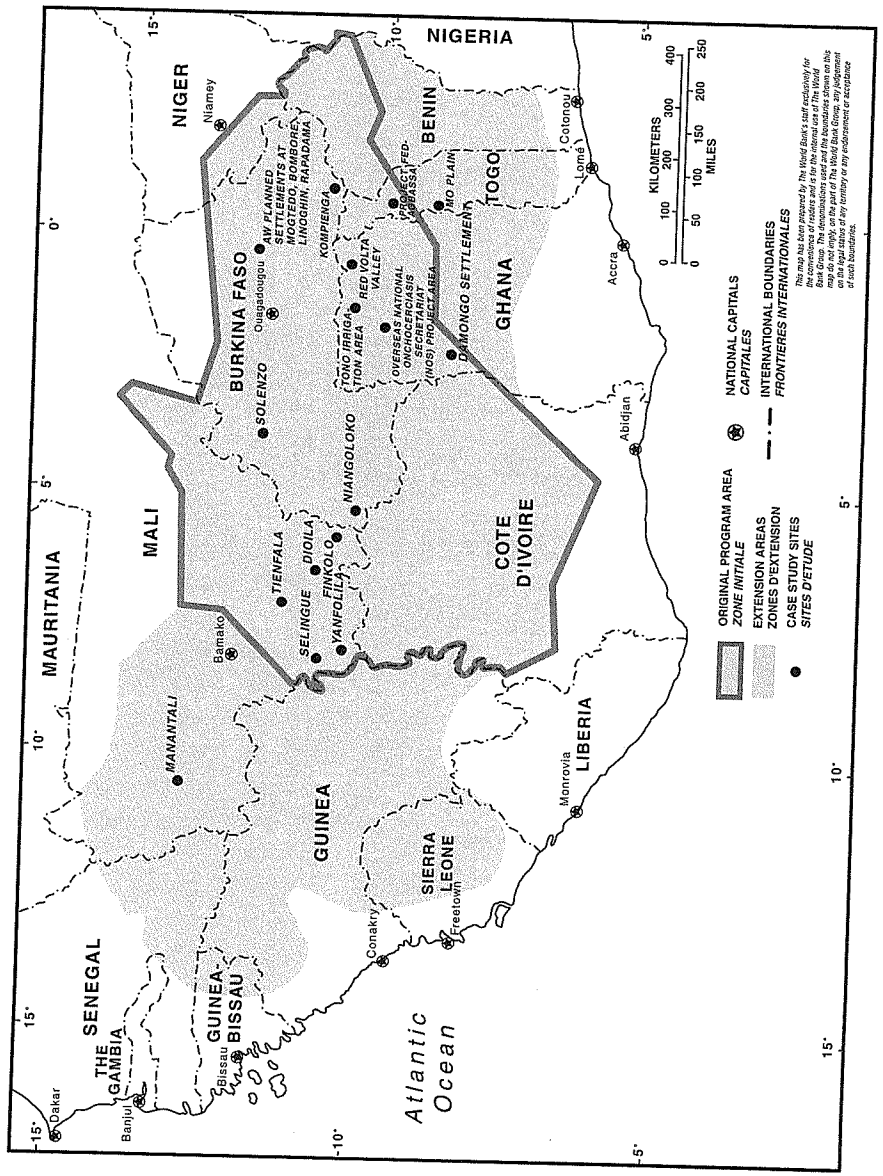


Fig. 21.4. The Onchocerciasis Control Programme and case study sites in Burkina Faso, Ghana, Mali, and Togo. (Adapted from the World Bank Group 1992.)

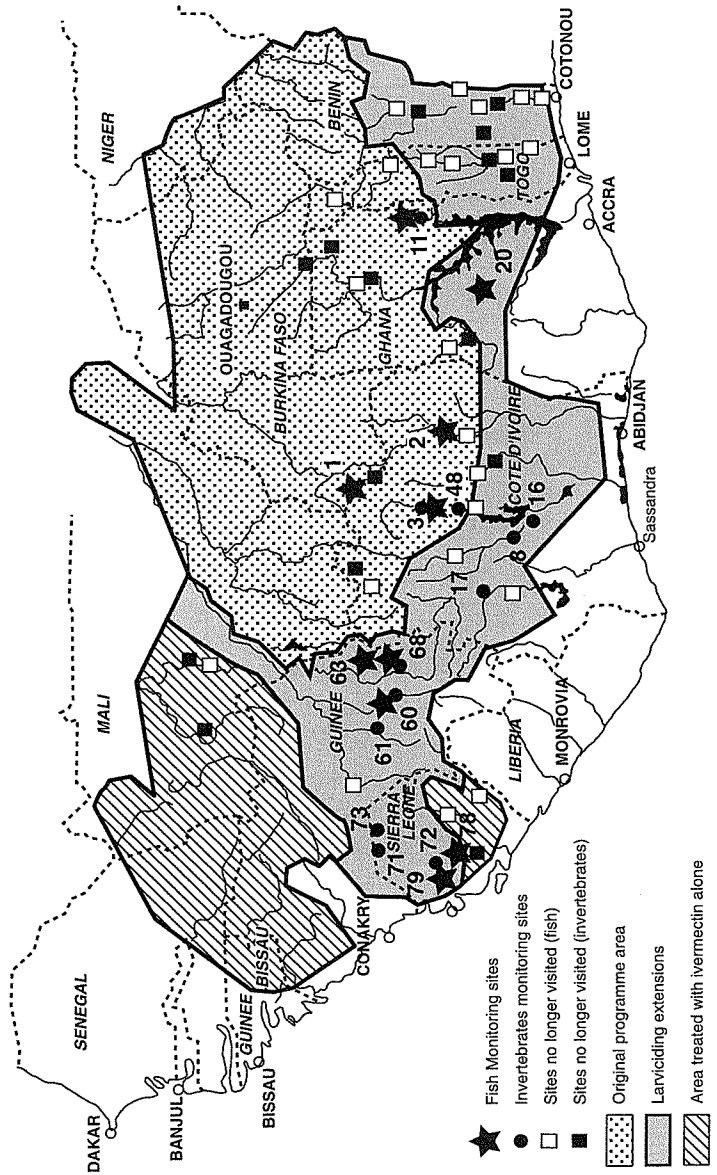


Fig. 21.5. The Onchocerciasis Control Programme area and the location of invertebrate and fish monitoring stations.

The LSR showed several instances in which new lands settlement had a dramatic impact on economic development (McMillan et al. 1992b, 1998). This success could be measured in a variety of ways including the increased food and cash crop production, non-farm employment, and activity of market networks. The review recorded a substantial increase in settlers' living standards including measurable increases in livestock as well as net improvements in housing quality and transportation.

While it is important to emphasize the economic potential of the land settlement resulting from the successful control of onchocerciasis, it is equally important to be cautious. This is because the long-term economic potential of this type of new lands settlement is not easily realized in isolated high potential but problem prone river basins that have very limited access to markets and basic infrastructure (McMillan et al. 1998). The net effect of this lack of infrastructure and services has been to encourage settlers to plant the largest area possible. The settlers give little attention to sound natural resource management and, when the soil productivity starts to drop, the wealthier, more entrepreneurial settlers are likely to move again (McMillan 1995, McMillan et al. 1998). Farm management data from 15 of the 16 sites covered by the OCP LSR showed that despite the control program's success in opening up new land, the farmers moving back into these areas were successful in increasing and stabilizing their incomes at only 5 of the 15 sites.

The high rates of unassisted spontaneous settlement in many of the river basins were associated with a net acceleration in the deforestation rate and with increased pressure on protected forests, many of which had been created in the river basin areas that had high agricultural potential. Other effects were increased pressure on natural wildlife reserves, which were also often located in river basins (McMillan et al. 1992b), and increased pressure on the Sahelian and Sudano-Sahelian pastoralist systems. The pressure on pastoralist systems increased because agriculturalists were settling on land that used to be one of the principal areas of rainy-season pasture and transit to coastal markets (Nana and Kattenburg 1986, Sowers 1986, Akwabi-Ameyaw 1990, McMillan 1995, McMillan et al. 1992b). The latter resulted in a steady increase in land-tenure disputes between agriculturalist and pastoralist immigrants that culminated in a series of border disputes in 1988–1989 and the formation of several international commissions focused on resolving these issues in the early 1990s (McMillan et al. 1993). On the basis of analysis of the 16 study sites and other longitudinal studies in the AVV and Mali, the LSR team developed a model of settlement trends and a series of recommendations to

predict this new lands settlement, which, they pointed out, was following classic trends observed for spontaneous settlement worldwide (McMillan et al. 1992b, 1993).

Ecological Monitoring Group's Independent Case Study of the Leraba Valley: 1993

A key turning point in the study of OCP-related environmental impacts came from the hydrobiological monitoring team's identification of a number of stress factors that were not associated with OCP vector control operations at a few of the monitoring sites in the late 1980s (Calamari 1998a, 1998b). Some of the best evidence of this phenomenon was at the Leraba Bridge monitoring station along the Burkina–Côte d'Ivoire border, where there was no indication of a rapid recovery of the fish fauna after the cessation of vector control (Baldry et al. 1995). However, the relatively constant levels of fish condition and species richness over the period 1975 to 1993 implied that the aquatic ecosystem was in a healthy state. Early efforts to explain these aquatic impacts led the group to emphasize the role of new lands settlement and the development activities associated with these settlements, such as increased agrochemical use, deforestation, and soil erosion. These research results led the Ecological Group to recommend a series of more long-term intensive studies of the ecotoxicological and ecological impacts of settlement on the aquatic and terrestrial environments. At the time, however, this type of research was considered outside the prerogative of the OCP's environmental mandate. For this reason, a small group of international and OCP scientists associated with the Environmental Group were forced to seek outside support from the Netherlands government to conduct a more intensive analysis of the ecotoxicological and ecological impacts of human activity in the Leraba Valley.

The team used simple types of data, much of which already existed (e.g., fish and invertebrate monitoring studies, demographic studies from the government, reports from the OCP LSR, old aerial photographs, and more recent Landsat photos). Using these data, the team was able to construct an ecological profile of the zone in three critical time periods: 1973 (before control), 1983 (9 years after control started), and 1993 (20 years later).

When the OCP began its control operations in 1974, the Leraba Valley had particularly high infection rates (see Figure 21.2). From an epidemiological point of view, many of these settlements were classified as "frontline villages" (Calamari et al. 1998b:52).[14] What little cultivation there

was tended to be isolated smallholdings with almost no permanent villages.

By 1983, four new villages had come into existence, and there was a 300% increase in the area of land utilized (30% of the total area versus 5% in 1972) (Figure 21.6). By 1993, as much as 75% of the original (pre-1974) savanna woodland had been destroyed or was becoming deforested (Calamari et al. 1998a, 1998b). The new settlers were attracted to the Leraba basin by the area's high potential for commercial cotton production, and a downturn of economic options for Burkinabe in the neighboring Côte d'Ivoire gave them incentive to migrate. Cotton production, however, was associated with a substantial increase in fertilizer and pesticide use. The ecotoxicological risk analysis of the most commonly used cotton protection pesticides indicated that, at the existing levels of concentration, there was probably not an immediate cause for concern. The team concluded, however, that if one used the more stringent requirements established by the European Union Scientific Advisory Committee on Toxicology and Ecotoxicology, these levels of concentration might have been exceeded for several days after each pesticide treatment. They recommended that these levels "should therefore be viewed as an early warning sign" (Calamari et al. 1998b:49). The same pilot study showed that the human and livestock populations (and the organic substances and nutrients emanating from them) had a very localized impact on the aquatic environment that was quite visible from the team's standard hydrobiological measurements of fish and invertebrates (Calamari 1998a, 1998b).

What distinguished the Leraba Basin Pilot Project from earlier studies on settlement was its ability to link the physical processes of spontaneous new lands settlement that had been discussed in the settlement research to some of the ecological phenomena being monitored by the programme. (The physical processes were measured in terms of deforestation, settlement numbers, and crop production patterns. The ecological phenomena were, for example, faunal composition and density and toxicity levels.) The policy impact of this work was to bring settlement back into the fold of the OCP leaders' and supportive donors' mainstream environmental concerns. The same reentry of settlement as a mainstream environmental concern seems to have sparked the foreign donors' willingness to read and discuss the results of the OCP LSR, which had been published but never widely reviewed or discussed.

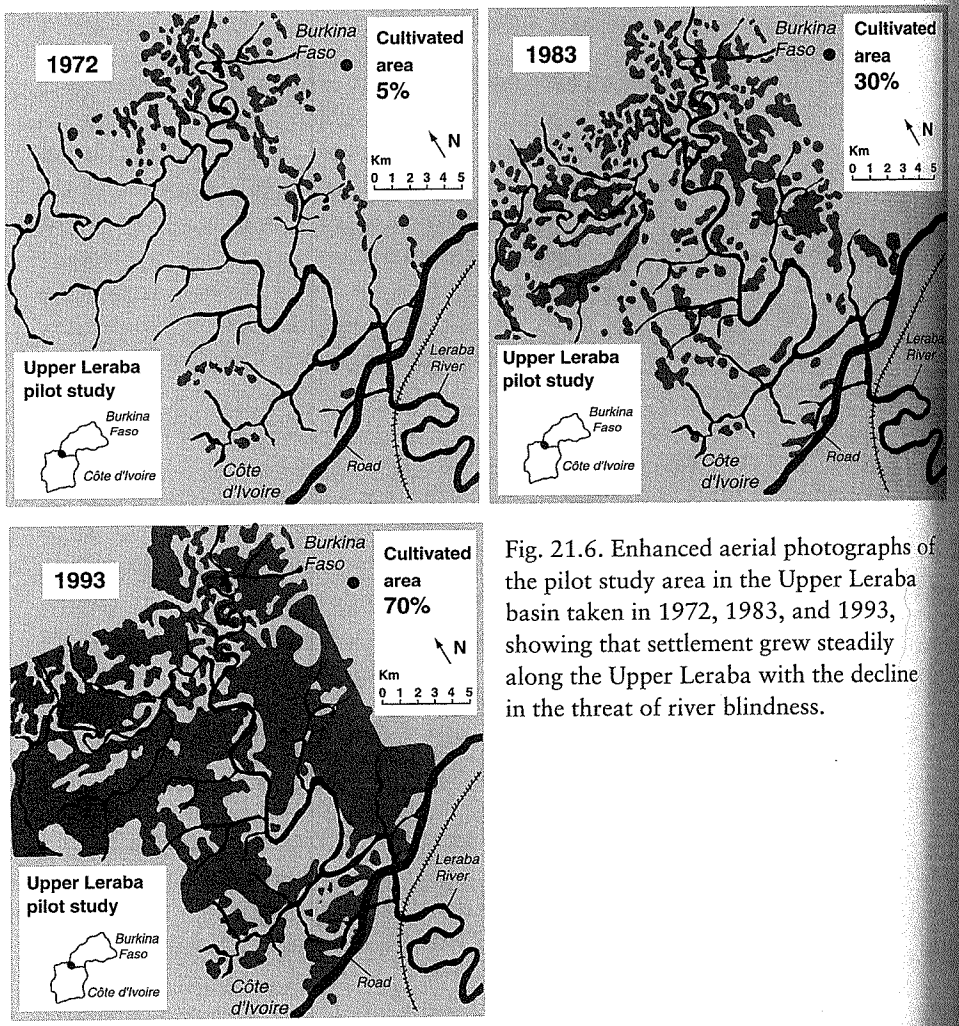


Fig. 21.6. Enhanced aerial photographs of the pilot study area in the Upper Leraba basin taken in 1972, 1983, and 1993, showing that settlement grew steadily along the Upper Leraba with the decline in the threat of river blindness.

Re-Merging of Settlement and Ecological Monitoring Concerns: 1994–Present

The growing donor concern with the environmental impacts of OCP-related new lands settlement induced the World Bank to organize the first Ministerial Meeting on Sustainable Settlement and Development in the OCP Program Area in Paris, in April 1994 (Elder and Cooley 1995). The meeting provided a forum for the presentation of the Leraba Pilot Project as well as the major conclusions of the OCP LSR. The major output of this

conference was revision of the recommendations of the 1988–1990 OCP LSR. The final product was a list of 15 planning guidelines that were officially ratified by two cabinet ministers representing each country (Elder and Cooley 1995). The process of formally voting on and adopting the guiding principles gave the guidelines the high-level national government and donor support that was needed for the principles to be acted on. Another major conference output was the decision to make the FAO the lead agency on follow-up planning. Since that time, the FAO has coordinated a series of low-cost workshops and planning missions to assist country governments with development of proposals for follow-up investment in areas undergoing active new lands settlement.

To develop a wider debate on settlement impacts, the Ecological Group raised a number of points in the report of its nineteenth meeting in 1998 (OCP 1998, in Calamari et al. 1998b:58) that are reminiscent of the published results of the meetings of the first phase of the Ecological Panel (1974–1980) and the LSR (1993–1994).[15] The group also recommended a review of settlement research and planning models "over the last quarter of a century, drawing upon national development reports, country reviews by international organizations and proceedings of the Ministerial Meeting on Sustainable Settlement and Development of the OCP Area" (Calamari et al. 1998b:59). Although this is a positive step, there is a real risk of recreating a great deal of the preexisting social research and policy analysis in the zone because there is little evidence that many members of the group have actually read much of the extensive preexisting literature on settlement processes and development experiences in the zone, most of which was written by anthropologists and social geographers.

Conclusions

The OCP has been highly successful in achieving its goals for reducing onchocerciasis as a threat to more intensive settlement and development of river basins in the Sudano-Sahelian areas of West Africa. Moreover, the larvacides used to achieve this success have been consistently monitored and adjusted in ways that minimized the direct environmental impacts of the control measures. Unfortunately, the program has been much less successful in monitoring and responding to the environmental impacts associated with spontaneous new lands settlement. The same extensive new lands settlement has failed to galvanize the types of sustainable, intensive agriculture that were envisioned when the program was designed.

The OCP provides clear evidence that the mere fact of conceptualizing

a wider, more inclusive vision of environmental impacts is not enough. The original OCP vision foresaw the need to monitor and respond to both the potential larvaciding and settlement impacts. This double vision was not, however, carried over into the program design or finance. Until 1994, neither the OCP nor any single donor that supported it had direct responsibility for monitoring or responding to the settlement impacts of control. This situation contrasts with the OCP and supporting donors' (e.g., UNDP, the World Bank, USAID, FAO, World Health Organization [WHO]) assumption of full, direct institutional responsibility for the design and local impacts of larvaciding. Therefore, implementation of any follow-up planning to deal with settlement (such as those guidelines developed under the initial UNDP planning grants) depended largely on each donor country's particular interest in financing it in part or entirely. Given the gross difference in costs (US$1 per beneficiary for control vs. US$3,000–12,000 per beneficiary family for follow-up investment in roads and basic infrastructure), donors were far more interested in funding the control program than in facilitating development in the areas where control had been established.

It is clear that foreign donors are unlikely to have the same level of enthusiasm for follow-up investment that they have for control. It is equally clear that no international donor will be willing to undertake an investment—for control, for instance—that is seen as having a host of highly negative and irreversible environmental consequences. Because of the creation of several international guidelines regulating pesticide use on international projects in the early 1970s, this issue had to be considered up front. In contrast, the World Bank and OECD (Organization for Economic Cooperation and Development) guidelines and review processes that were designed to reduce the negative environmental and social consequences of development-induced resettlement were not fully operational until the mid-1980s (Cernea 1995). The perceived marginality of new lands settlement concerns from the mainstream environmental agenda of disease control had several effects. The settlement specialists were quickly wiped off the mainstream institutional oversight committees (after 1980) and had no centralized funding structure. There was only a sporadic base of hired consulting talent (despite the considerable number of talented people working on these issues), and there was no solid, sustainable network for the exchange of information on settlement issues (Table 21.1).

Table 21.1. A comparison of internal and external pressures and support for environmenta monitoring of the settlement and larvaciding components of the OCP (1974–present)

Support	Environmental monitoring	
	Larvacide impacts	**Settlement impacts**
International guidelines (World Bank, OECD, etc.)	1972–1974	mid-1980s
Comprehensive baseline assessment studies done under supervision of OCP specialists	Yes	No
Centralization of funds accorded to this function under OCP control	Yes	No
Regular biannual and annual meetings and publications to harmonize methodologies and compare research results between countries	Yes	No
High-quality international and national researchers associated with oversight functions	Yes—for sustained periods (10–20 years)	Hired sporadically for specific studies
Longitudinal monitoring over time	Fixed sites for fish and invertebrates	No deliberate identification of sites to monitor outside studies by individual scholar

Recommendations

1. Encourage collaborative social and biological research, theory, and model building.

Once human settlement is "front and center" in an ecological cost-benefits model, the costs of compensatory land-use planning, human capacity development, and infrastructure investments should be factored into the up-front calculation of environmental and development costs. This is a major omission that needs to be addressed through interdisciplinary model building and the inclusion of new lands settlement as an active agent to consider as part of the routine environmental reviews for bilateral and multilateral development assistance.

2. Strengthen geographic research and analysis of longitudinal settlement trends.

One of the most valuable lessons to be gleaned from 25 years of OCP research on ecological impact and settlement trends is the tremendous power of hard numbers on geographical trends. Especially important was the huge visceral reaction that was elicited by the Leraba study's evidence for accelerated deforestation rates. The shrewd cross-disciplinary linking

of data with longitudinal data from the aquatic monitoring studies gave a macrotheoretical "context" that had been missing from the Land Settlement Review's comparative research on settlement processes. The combination of these three (geographical analysis of settlement trends in the Leraba basin, aquatic ecological monitoring in the Leraba basin, and policy recommendations based on a comparative analysis of settlement processes at 16 sites in four countries) provided the type of evidence needed to convince the major donors and the national governments that there was a need for special policy guidelines for the zone. The problem is that this evidence came so late in the process (20 years after control started) that the most accessible valleys had already been settled. Recent developments in Landsat imaging have dramatically reduced both the cost of this type of geographical analysis and the time it takes to conduct it.

3. Encourage longitudinal research and low-cost research methodologies that introduce a longitudinal perspective into more broadly based survey research.

Another important lesson to be learned from the OCP LSR is the critical importance of longitudinal research. Even case studies that are not actually chronologically longitudinal (i.e., were not actually conducted at different points in time) but that rely on preexisting data sets to provide a longitudinal perspective can be very useful. One of the best examples is the Leraba case study's use of earlier aerial photographs (Baldry et al. 1995). Another cost-effective rapid-assessment technique for chronological reconstruction involved interviewing village leaders to identify the households within a particular geographical unit of the village that were identified as "immigrant" at three sites associated with the LSR in Burkina (McMillan et al. 1992a).

4. Encourage the types of centralized documentation, on-the-job and regional research networks that are necessary to share monitoring results over time.

Another major lesson to be learned from the success of the OCP Ecological Group was the importance of training and supporting national research counterparts. By 1986, almost all invertebrate and fish monitoring activities were being coordinated by national teams. These same hydrobiological teams were involved in research networks and conducted collaborative writing projects that facilitated the regular exchange of research results and publications across national borders. One result of this

up-front, sustained investment in human capital was to galvanize an entire regional process that moved together. In contrast, from 1974 to 1994 there was never any sustained attempt to link national efforts to monitor the economic, social, and environmental impacts of settlement trends beyond the case-by-case information exchange between the head of the OCP economic unit and specific scholars.

One example of best practices for national training to strengthen research and public policy on settlement concerns was the AVV Project in Burkina, which actively encouraged undergraduate- and graduate-level research on settlement trends in river basins covered by its planning. Over time, this practice created a number of high-quality case studies and a cadre of Burkinabe and foreign researchers familiar with the OCP settlement issues. This national and international leadership ended up playing an important role in facilitating the country's shift from the original model of top-down sponsored settlement to a better adapted model of "assisted spontaneous settlement" and the new national program of community-based land management (*Programme National du Gestion des Terroirs Villageois,* or PNGT) (Guyon 1986, McMillan et al. 1993, 1995).

The types of intersectoral collaboration in environmental planning that are advocated in this chapter have been popular since the 1970s. The need for interdisciplinary collaboration was reiterated by the 1992 Earth Summit's call for development that meets the needs of the present without compromising the ability of future generations to meet their own needs and for a linking of development, environment, and health as a single issue. To date, however, there have been very few practical realizations of this type of interdisciplinary approach to either environmental planning or monitoring.

In this chapter, some of the key institutional and disciplinary issues that impeded the Onchocerciasis Control Programme's willingness and ability to address these interrelated issues have been discussed. A series of concrete recommendations for how to avoid this type of interdisciplinary divorce in future programs has been formulated on the basis of an analysis of the factors that contributed to and detracted from the integration of these issues in the OCP. It is not argued that the current high rates of deforestation and extensive settlement could have been avoided but that the OCP's negative environmental impacts could have been reduced had the Ecological Panel/Group provided a higher level of informed, consistent oversight and monitoring.

Notes

1. The inhabitants of the most severely infected river basins followed a cyclical migration pattern, leaving the valley in response to the disease, then returning again when the poor inland soils could no longer support their numbers (Hilton 1960, Hunter 1966, Hervouet 1977, 1978, 1980, 1983, 1990, Marchal 1978). Williams (1974:78) provides a graphic description of the gradual demise of a village in a badly infected area: "One-tenth to one-half of the men may be partly or totally blind. Brides, traditionally drawn from neighboring villages, refuse to leave home. The younger men start to leave, to get out before they in turn go blind. As the population shrinks, the rate of bites per person increases. The village takes on the aspect of death. The children, rough stones in hand, listlessly scratch arms and legs that already itch with worms. As their sight is so far unimpaired, they act as human guide dogs for the already blind. The village compound of beaten earth, once well swept, is scattered with old animal bones and cornhusks. The expanse of millet and sorghum fields gradually contracts. When the last old people die, so does the village."

2. The root cause of the disease is the threadlike worm *Onchocerca volvulus*. The adult worms have an estimated life of 14 years in the human body, where they inhabit the subcutaneous tissues, causing raised nodules. Each female worm produces millions of microscopic microfilariae, which live for about 2 years. The microfilariae migrate in the epidermis, causing itching, skin depigmentation, and, eventually, eye lesions that can result in blindness. The disease is transmitted to humans by the bites of the female black fly (*Simulium damnosum)* carrying the infected larvae. The flies become infected when they pierce the skin of an onchocerciasis sufferer and ingest microfilariae along with blood. Most of the microfilariae thus absorbed are digested, together with the blood meal, but a few eventually penetrate the wall of the fly's stomach and settle in its thoracic muscles. There, after passing through three larval stages, the microfilariae migrating into the salivary glands become larvae capable of infecting a human host. The complete cycle of insect reproduction requires only one week. Even though the disease requires repeated bites, even a person who spends less than a year of continuous habitation in an infected zone may exhibit microfilariae produced by the adult worm in their epidermis. A slight infection produces very mild symptoms that generally pass unnoticed. A heavy infection is acquired only after a long period of exposure to infected bites. In areas where the infection was most serious, a high percentage of the villagers would exhibit eye difficulties, and an average of 20% would be blind.

3. Ivermectin distribution is carried out at varying levels in all countries participating in the OCP but mostly those in the western and southern extensions (Figure 21.1). In the original control area, it is distributed only at specific disease foci (Figure 21.2). In the southern extensions and part of the western extension, both ivermectin distribution and larvaciding are used; in Sierra Leone and the northern part of the western extension, only ivermectin distribution is used.

4. Most of the reports by individual scholars were available in draft form by 1974 and as sections of a large multivolume series, *Enquête sur les mouvements de population à partir du pays Mossi* (Ancey 1974, Capron and Kohler 1975, Lahuec 1970, Lesselingue 1975, Remy 1975).

5. The members of the OCP Steering Committee are appointed by individual agencies represented in the Steering Committee/Committee of Sponsoring Agencies and by the United Nations Environment Program (UNEP).

6. Given the fact that not all of the 14,000 km of rivers in the core control zone would be treated, the OCP decided that the monitoring efforts should be made above and below the application site as well as at untreated comparison sites (OCP/EP 1974a:3).

7. The panel urged that rational programs for water and related resources be coordinated by the seven countries concerned, the Specialized Agencies, and the donor countries. The panel viewed the subsequent development of these vector-free areas as inextricably related to the *Simulium* control program insofar as their environmental and human ecological implications were concerned (OCP/EP 1994b:2). The same initial meeting concluded that "early attention must be given to the sociological and land-tenure problems likely to be associated with repopulation and settlement of the onchocerciasis-free areas; . . . that its [the panel's] membership should be strengthened in the area of social/cultural anthropology and land tenure; [that UNDP] would give consideration to nominating a consultant in these subject areas possessed of first hand knowledge of the control area [to the panel]; [and that] . . . certain research funds will be available and that these could be used to support needed socio-cultural studies" (OCP/EP 1974a:4–5).

8. The first phase of the Methodology involved the establishment of a data bank on natural and related resources. The Methodology was designed "to prevent uncontrolled and irreversible exploitation of one of West Africa's few remaining natural resources" (Burer 1977). The data bank was supposed to consist of (1) basic maps on land use, climatology, surface water and groundwater, and land suitability and (2) an inventory and evaluation of existing socioeconomic studies. Satellite images were to be used to produce the basic maps (Burer 1977:7). The goal of the Methodology was to "lead to the preparation, at each national level, of: (i) an inventory of natural resources (the data bank); (ii) a broad long-term development plan; and (iii) a number of specific investment projects" (Burer 1977:1).

9. The initial functions of the Economic Development Unit were defined as "(a) To collect and collate baseline data from all sources within and without the Programme area, relating to the zones to be cleared of onchocerciasis. (b) To maintain an up-to-date record of all development actions planned at the national and regional level within the Programme area. (c) To assist in the actual arrangement on the ground for missions and in the preparation of background data. (d) To maintain close contact with the UNDP Resident Representatives, with the representatives of the United Nations Agencies within the seven countries, and with the

representatives of the banks and technical assistance missions working in the Programme area" (OCP/EP 1976:Annex 1, p. 2).

10. One of the first signs was the unwillingness of the organizers of the first Economic Development Advisory Panel to consider attendance by an "outside" member of the Ecological Panel (in this case the UNDP settlement expert). By the fifth meeting of the Ecological Panel (September 1976) the UNDP settlement specialist had been replaced by a senior technical advisor from UNDP who had no specialized knowledge and no experience in settlement research or public policy (OCP/EP 1976:Annex 1, p. 1).

11. The studies were first conducted under laboratory conditions then later in the semi-field using a simple gutter then a multiple gutter methodology and field pilot trials. This research enabled the program to determine that B.t. H-14 was the most selective and least environmentally damaging larvacide of the seven insecticides used in rotation and to adjust the concentrations of the other six to minimize their impact.

12. Seven insecticides are currently used. Six of them are formulated as emulsifiable concentrates (temephos, phoxim, pyraclofos, permethrin, etofenprox, and carbosulfan). The seventh is a liquid concentrate of a biological insecticide, *Bacillus thuringiensis* H-14 (B.t. H-14). The rotational use of insecticides has been particularly effective, with only limited resistance to the organophosphates currently in use, while the susceptibility of the *Simulium* populations to other classes of compounds remains unchanged (Calamari et al. 1998a, 1998b).

13. The chief exceptions were in Burkina and Ghana. In Burkina, the OCP was able to contract with the AVV to prepare a much more comprehensive analysis of both spontaneous and sponsored settlement trends (AVV 1985). In Ghana, the unit contracted with four researchers who had extensive fieldwork experience in the valleys or were associated with the National Onchocerciasis Secretariat (Benneh et al. 1985). A third exception was the first comprehensive geographical analysis of settlement trends by a team of researchers connected with ORSTOM acting as an independent contracting agent (Clanet 1983, Herouvet et al. 1984). The ORSTOM study showed that, although overall the valleys had experienced an accelerated rate of new lands settlement, there were important differences both between and within the valleys in terms of settlement rates and patterns. In general, the valleys north of 11° latitude—which were the areas with the easiest access to the more densely settled areas that sent large number of immigrants—experienced much more active resettlement than those to the south (Clanet 1983, Herouvet et al. 1984). Similarly, the river basins associated with regional development programs, such as the regional cotton projects in Burkina's southwest, and with major urban settlers attracted projects much more actively than areas outside the influence of these zones. The only areas in the White Volta (Nakambe) experiencing active resettlement were those near the AVV-sponsored settlements.

14. The disease was hyperendemic (prevalence rate >60%) in the north of the basin, mesoendemic (prevalence rate 40–60%) in the west of the Leraba Valley,

and hypoendemic (prevalence rate 40%) in other parts of the basin (Calamari et al. 1998a, 1998b).

15. These points included (1) the necessity of identifying the type and potential magnitude of the most critical environmental risks that may be associated with settlement and the exploitation of natural resources; (2) the desirability of developing homogeneous technical guidelines on issues such as (a) the use and application procedures for agricultural chemicals and biological control agents; (b) the choice of the most appropriate land-use practices; (c) the extent to which savanna resources can be exploited without resulting in serious woodland depletion; and (d) the options for managing the riverside fringing forests that play key roles in the stabilization of river banks and the protection of aquatic ecosystems.

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