Traditional Ecological Knowledge:

A Collection of Essays

Edited by Robert E. Johannes

IUCN – The World Conservation Union

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November 1989

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Prepared and published with financial support from the Commission of the European Communities, and by the Government of France.

Published by: IUCN, Gland, Switzerland and Cambridge, UK.

Produced by: IUCN Publications Services Unit on desktop publishing equipment purchased through a gift from Mrs Julia Ward.

Citation: Johannes, R.E. (Ed), (1989). *Traditional Ecological Knowledge: A Collection of Essays.* IUCN, Gland, Switzerland and Cambridge, UK. 77pp.

ISBN: 2-88032-998-1

Printed by: Unwin Brothers Woking, The Gresham Press, Old Woking, Surrey.

Cover photograph: Part of a rock painting by the San or Bushmen dating from 1200-1500AD © Musée de l'Homme, Paris.

Available from: IUCN Publications Services, 219c Huntingdon Road, Cambridge CB3 0DL, UK; or Avenue du Mont-Blanc, CH-1196 Gland, Switzerland.

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FOREWORD

IUCN is pleased to publish this collection of articles which originate from the working group on Traditional Ecological Knowledge of our Commission on Ecology. This book does not presume to be an authoritative review of the state of knowledge in the field. It is, rather, a collection of free essays which offer fascinating glimpses of the deep understanding and practice of "ecology" displayed by traditional societies on different continents.

Traditional ecological knowledge is a unique, essential resource for humanity as a whole. That it is now seriously endangered by widespread assaults on the Earth's last remaining natural habitats, and by the fast disintegration of the social web of traditional societies, should be of concern to everyone. For its loss would mean the disappearance of ecological wisdom acquired over thousands of years of direct human contact with nature.

This volume intends to stimulate reflection and action. It will encourage dialogue between ecologists and anthropologists, and broaden the realization among researchers that traditional knowledge has a major contribution to make to the development of modern environmental science. At the same time it conveys the powerful message that tapping the source of such knowledge cannot be for the mere benefit of science, agrobusiness, and pharmaceutical industries. Returns must accrue first of all to indigenous populations - current inheritors of such information.

Finally, it is more than time that resource managers and development practitioners recognize the significant role of traditional people in the sustainable management of natural resources. A partnership with indigenous populations, taking into account their perspectives and future well-being in the formulation of development policies, is a moral, as well as environmental, imperative.

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TRADITIONAL ECOLOGICAL KNOWLEDGE: A COLLECTION OF ESSAYS

INTRODUCTION

Robert E. Johannes

Imagine people who confidently assume they can best describe and manage the natural resources of an unfamiliar region alone - ignoring local hunters who know every cave and waterhole and the movements and behavior of a host of local animals - overlooking the farmers who know the local soils, microclimates, pests and seasonal environmental changes - disregarding the native fishermen who know the local currents and the movement and behavior of the marine life in their waters. Such, historically, has been the custom of most environmental scientists and natural resource managers working in unfamiliar environments.

On the face of it the practice seems absurd. But most biologists have not been trained to seek knowledge through direct interaction with "laymen"; they are trained to go first to books, then directly to nature for their answers. When they extend their research to lands inhabited by traditional non-western societies, their past habits seem to render them oblivious to the fact that, here, much important environmental information can be found in the heads of local people.

Evidence of the richness of that information certainly exists. Conklin (1957) found that the average adult among the Hanunoo – a tribe in the Philippines practising swidden agriculture – recognized 450 animal types and 1600 plant types. He stated, "partly as a result of this great interest in plant domestication and detailed knowledge of minute vegetative differences, native categories outnumber by more than 400 types, the taxonomic species into which the same local flora is grouped by systematic botanists" (Conklin 1957). Similarly, Johannes and Hviding (unpublished) have found that the fishermen of Marovo Lagoon, New Georgia, Solomon Islands, classify fish schools and other aggregations into more than 20 different types, based on the shape and movement of the school, the movements and behaviour of individual fish within it, and the purpose of the aggregration (hunting for food, feeding, resting, spawning etc.). No classification of equivalent richness can be found in the marine biological literature.

But the attitude of many biological scientists and natural resource managers to traditional knowledge has frequently been dismissive. Chambers (1980) in discussing tropical agriculture research and development states, "the most difficult thing for an educated expert to accept is that poor farmers may often understand their situations better than he does. Modern scientific knowledge and the indigenous technical knowledge of rural people are grotesquely unequal in leverage. It is difficult for some professions to accept that they have anything to learn from rural people, or to recognize that there is a parallel system of knowledge to their own which is complementary, that is usually valid and in some aspects superior".

This attitude has begun to change. The value of traditional environmental expertise is rapidly gaining recognition. And for a small but growing number of environmental researchers, scientific interviews and participant observation – activities more often associated with social scientists – have become essential research tools. Important discoveries are being made in this area, not only by biologists, but also by ecologically sensitive social scientists. This volume is a compendium of some of their findings.

Just how recent are these changes in attitude is indicated in H.T. Lewis's study of the traditional use and management of fire when he notes that apart from the work of a limited number of researchers, "... techno-ecological studies on hunter-gatherer uses of fire were not begun until the 1970s". The consequences of remaining unaware of the ability of traditional peoples to manipulate the resources provided by natural environments can be seen in Australia where, in recent decades, shrub encroachment has been choking pasture production in semi-arid range-lands. Ralph (1985/6) states, "It now appears that one of man's first and most important tools, fire, is the crucial factor that has been lacking during this period". Australian Aborigines have, for centuries, been well aware of the values of controlled burning. One early European observer remarked, "The dexterity with which they manage so dangerous an agent as fire is indeed astonishing" (Stokes 1846). Even less well known until recently is the fact that North American Indians were also highly adept at using fire for environmental management. Lewis studied how both groups use fire, and in this volume provides a fascinating account of the knowledge and skill involved and the possible contemporary applicability of their management techniques.

The ability of the native hunter to detect and interpret the behaviour of his prey using signs invisible to the unitiated, has been widely celebrated in fiction. Here Nicholas Blurton-Jones and Melvin Konner reveal it in fact, describing the sophisticated and subtle knowledge of their prey possessed by the !Kung hunters of the Kalahari. Through analysis of their discussions with the !Kung, Blurton-Jones and Konner are led to the conclusion that these people "seemed very objective in their descriptions" of animal behavior. Such kinds of knowledge, they argue, could be very useful "in helping to assess the importance and exploitation of a particular area or resource by local people and the likely conservation costs of their continued use of the area."

Shultes reviews research on the extraordinary range and academic and practical value of traditional plant medicines in South America. He also makes a point of general importance in ethnoecological research, namely, that more effort should be made to ensure that the peoples who volunteer their traditional knowledge to researchers receive a proper share of the resulting benefits.

Traditional knowledge is not limited to terrestrial environments. Many traditional societies depend on the sea for their survival. Pacific Islanders, for example, draw on a vast reservoir of knowledge of the behaviour and movements of the marine animals they observe and catch. Much of that knowledge is new to science. Johannes discusses some of the information learned from the expert native fishermen of Palau, Micronesia, and assesses its value for contemporary fisheries managers.

Another study from Micronesia is by Falanruw, developing a similar theme in her examination of the agricultural system of the people of Yap Island. Whereas some farmers use considerable amounts of energy in the form of fossil fuels and fertilizers, and others use mainly manual labour, the Yap Islanders employ nature to do much of their agricultural work for them.

Richard's case study of traditional rice farming strategies in Central Sierra Leone, focuses on the prolonged efforts of agricultural authorities to substitute irrigated wet rice cultivation for traditional shifting cultivation of dry rice. These efforts betray an ignorance of ecological (and economic) realities of which the local farmer is well aware. Here, says Richards, "virtue and profit reside in attempts to hitch a ride upon, rather than to over-ride and forcibly control processes observed in nature."

In the final contribution in this volume, Dahl examines the scope of traditional Kanak knowledge of the environment and of their approaches to environmental conservation and management in New Caledonia, insofar as these can be determined from published sources. He observes "how little has been preserved or recorded" although available evidence points to the rich heritage there must have been.

None of the authors of these articles suggests that we should renounce scientific approaches to resource management and let tradition lead us back to an idyllic land. Richards (1980) states that 'a sentimental belief in "traditional values" and a conviction that the "people know best" without knowing why and under what circumstances, will be ... unhelpful'. The romantic and uncritical espousal of traditional environmental knowledge and natural resource management is an extreme almost as unfortunate as that of dismissing it. Traditional peoples have not lived in some preternatural state of harmony with nature. Some of their abuses of natural resources have been substantial.

Some claims regarding the environmental wisdom of traditional cultures have been so exaggerated and uncritical that they have provoked a backlash. To counteract these excesses, some writers now dwell singlemindedly on examples of bad natural resource management among traditional peoples, advancing the opposing notion that traditional environmental practices were basically unsound (e.g. Diamond, 1987). The truth lies between these extremes; wise and unwise environmental practices coexist in many, if not most, cultures. The existence of the latter practices does not diminish the importance of the former.

The value of traditional environmental knowledge and management practices should thus not be taken for granted. Some relevant traditional beliefs are incorrect or misdirected. This is hardly surprising; the history of Western science is likewise a chronicle of mistakes as well as successes. Superstitions sometimes over-ride objective observations. Beliefs that declining fish catches or crop yields are due to sorcery or failure to propitiate the gods will, in some cultures, divert attention from the real, and sometimes correctable, causes. Tabooing the hunting of a sacred species may result in increased pressure on some other more easily depleted species.

Local interpretations of natural history phenomena may be at odds with established facts. For example, some Pacific Island fishermen believe that one species of sea snake breathes poison into the water, because small fish in obvious physical distress are often seen to emerge from a crevice in a coral reef after a sea snake has explored the crevice. In fact, the snake bites the fish after cornering it in the crevice, then withdraws and waits for the fish to emerge and go into shock before grasping and consuming it. Because the fangs of this snake are too small to enable it to inject venom into humans, the fishermen are unaware of its venomous bite. Thus, while their observations are accurate, their interpretation of them, although reasonable, is not. But by dismissing too readily such false interpretations of natural phenomena, the researcher is in danger of overlooking the value of the empirical knowledge underlying it.

The difficulties of investigating and evaluating traditional knowledge should not be underestimated. Biological truths are sometimes embedded in a matrix of myth and are thus difficult to discern. Ideally, traditional knowledge concerning natural resources should therefore be recorded and evaluated by scientists who possess not only an appropriate background in ecology and resource management, but also anthropological skill in translating information from one culture and language to another.

It is also important to choose the right informants. For example, in discussing traditional knowledge of natural resources possessed by the Mbeere people of Kenya, Brokensha and Riley (1980) state: "They are familiar with ecological consociations – the combinations of climate, soil, slope altitude and human occupation. But this familiarity varies between groups of people as well as between individuals within groups. Generally, the best information about the small annual herbs is obtained from older women; herd boys, being always hungry and also experimental, are experts on the range of wild edible fruits; and honey-collectors show the most detailed knowledge of flowering sequences, and indeed know most differential characteristics of their local plants. Yet even within one group, one individual will stand out because of keen powers of observation, prodigious memory, curiosity and intellect". Older people often possess greater detailed knowledge of local resources, and almost always provide the best information concerning changes occurring over long periods of time.

In cases where circumstances do not permit personally verifying the information one receives, informants can at least be screened for their reliability. I generally do this by asking two sets of questions. One group sounds plausible, but consist of questions to which I know the informant cannot possibly know the answers. A forthright "I don't know," in response to such questions is an encouraging sign. I also ask questions to which I already know the answers.

Some traditional management systems may have worked well because of low human population densities. They cannot be expected to solve today's resource management problems where demands on resources exceed their productive limits. For example, however apt Pacific Islanders management of their traditional fisheries might have been when their populations were low, their populations today are burgeoning, and no form of management can re-create the miracle of the loaves and fishes. Moreover, developmentmay ggenerate novel disputes over natural resources which traditional forms of conflict resolution cannot settle (e.g. Johannes, 1982).

These cautionary comments nothwithstanding, the potential for the application of traditional environmental knowledge to the management of soils, crops, forests, water resources, wildlife and fisheries is, quite simply, vast. Such information must not only be collected and verified. It must also be blended with more technical forms of biologial research – population dynamics, population genetics, physiology, soil chemistry and microbiology, before it can be put to best use. This is no small matter. But the rural farmer, hunter or fisherman can often identify to the scientist which questions to ask about the environment, and where and when to look for the answers in order to focus research on significant local environmental phenomena.

Conklin (1957) and others have shown, for example, that indigenous knowledge concerning the distribution and characteristics of different soil types and the plants associated with each can provide effective shortcuts for researchers investigating the local resource base. Local knowledge may facilitate in a few days soil surveys and mapping that would otherwise take months (Howes, 1980).

Traditional knowledge is disappearing as a consequence of westernization, industrialization, urbanization and the accompanying alienation of the young from their traditions. Young members of the educated elite whose formal education is often obtained far from their own communities are among the people in these cultures who know least of such knowledge. Ironically, it is these very people who will be most responsible for influencing patterns of natural resource use in their communities in future years. Their technical and political sophistication cannot possibly be put to best use without the knowledge of their natural resources possessed by their elders. Educational institutions should therefore help retain such knowledge. Its absence from their curricula amounts to a tacit assertion that it is no longer worth learning.

Courses on traditional and contemporary uses of natural resources should be made widely available in institutes of learning, particularly in the developing world. Consideration might be given to making such courses mandatory for all students – not just biology, agriculture and fisheries students, but for students of law, business, engineering, political science, liberal arts and education. All of them need to understand the limits of their natural resources, for within few years they will be the ones who make the important decisions concerning the uses to which these resources are applied.

Research projects to record traditional environmental knowledge and environmental management practices, and to a lesser extent to test them rigorously, are scattered thinly throughout the world. The amount of manpower and money devoted to such work is expanding, but not nearly fast enough.

As an educational requirement to help remedy this situation, primary and secondary school and university students might be asked to submit reports describing local knowledge concerning natural resources or traditional resource-use patterns. In some countries these activities might be carried out during term breaks when students return to their villages. Here they would have an opportunity to learn from their elders and thereby gain a renewed interest in and respect for traditional knowledge. Copies of their reports could be kept in a permanent collection, which could grow to become large and unique sources of traditional knowledge and serve as sources for laters researchers.

Traditional knowledge is being lost very rapidly as its possessors die. Recording it is thus a truly urgent matter. Allowing it to vanish amounts to throwing away centuries of priceless practical experience. To record it with care and in the interest of its possessors – not just for the economic benefit of industrialized societies – is essential.

A PARABLE OF FIRE: HUNTER-GATHERERS IN CANADA AND AUSTRALIA

Henry T. Lewis

It is mid-April, early spring in the boreal forest region along the border of northern British Columbia and Alberta. The year is 1948. An Indian trapper is returning to one of his two line cabins for the furs that represent a part of his winter's work. With snow gone from meadows and parts of the forest, he travels on horseback and leads a packhorse rather than going by dogteam and sled. Though there may still be several late season snowfalls with the ground frozen for several weeks to come, the previous summer's grasses on the meadows and small prairies are already dry. Conditions are right for setting fires.

At the first of the meadows he dismounts and leads his horses along the western edge where, under the nearby cover of brush and trees, plants are moisture-laden and there are still large areas of snow. Stopping, he lights a match and places it in the fringe of dried grasses. Pulling up a tuft of grasses he ignites it from the fire, carries it a few metres further where he sets a second, then a third fire, ignites another handful, and continues the process until a string of fires is moving with a morning breeze towards the eastern edge of the meadow more than a kilometre away.

The grasses have hardly begun to burn in a single line – in some places a few centimetres high, in others a metre or more – by the time the trapper remounts, picks up the trail to his line cabin, and disappears along a forest trail. During the day, he will set identical fires on six other meadows, the largest of which is five square kilometres, the smallest less than one. A trail of smoke marks his progress through the forest, none of which he bothers to watch and all of which die out within a few hours as they reach the damper edges of forest growth.

His overt casualness, even apparent carelessness with fire gives no hint as to his comprehensive understanding of how fires behave at specific times and places, or his acute awareness of the variable and manageable impacts that burning has on individual species and interrelated communities of plants and animals. Nonetheless, the factors that he considers (e.g. the seasonality of burning, the frequency of burning, the time of day, the size of areas burned, the kinds of grasses and forbs, the relative humidity of adjacent fuels, natural firebreaks, wind and slope) are the same elements that are today weighed by environmental agencies in managing grasslands, brushfields and forests through controlled burning. Only in the event of unseasonably hot, dry weather will wildfires occur at this time of year. These are normally the consequence of ignorance or carelessness on the part of people in the north who do not understand the technology and ecology of fire, which today, in the 1980s, includes nearly all Whites and most Indians.

The trail he takes is hardly more than a deer track and only the trapper and the occasional hunter from his village know and make use of it. The line of traps that he exploits during the winter follows a zig-zag course which more or less runs next to and irregularly recrosses a drainage channel that is alternately a stream, grassy slough, and series of beaver ponds. Traps are set at appropriate places within the drainage and nearby forest to harvest the fur bearing species that either live in the water and grass habitat or else come there from surrounding forests – beaver, muskrat, snowshoe hares, wolves, lynx, coyotes, wolverines, otter, fisher, marten, mink and weasels. At the same time, the most important game animals – moose, elk and deer – also frequent these areas to exploit the growth of fire-maintained grasses and shrubs. In addition to animals hunted and trapped, these grass habitats support great numbers of voles and mice, the prey of both large and small carnivores. As with open meadows, these grass corridors are regularly maintained by prescribed burning, and the trapper is well aware of the life cycles of these species, the various predator-prey relationships, and how the environments of the animals involved can be managed and, for Indian hunter-gatherers, even improved upon by the selected, careful use of fire for maintaining a greater diversity of micro-habitats at various stages of succession.

Because the grasses along the creeks and sloughs are still damp at this time, he will leave a series of smouldering fires that act as delayed fuses. Several times during the day he starts a fire within a grassy area in which he has placed the ends of four or more logs, each a spoke radiating into the surrounding, still moisture-laden, detritus vegetation. In a few days, when the matted grasses have dried sufficiently, the flames will spread out from one or more of these incendiaries and irregular sections of the drainage will be safely burned. As in open meadows, fires do not carry into nearby stands of healthy, still dampened forest.

If the grass corridors and forest openings are not sufficiently burned at this time, conditions may still be safe for setting spot fires when he returns in one or two weeks for the spring muskrat hunt. At the same time, he will also hunt the moose, elk and deer that come to recently burned grasslands to feed on the new growth of shrubs and grasses, a growth that emerges two to three weeks earlier than in unburned areas. It is the biological and climatic circumstances of particular sites, all of which can vary widely, that determine the time for burning; calendrical dates are essentially incidental to the interpretation of localized conditions.

It is almost dark when he reaches the cabin located at the eastern side of a fairly large meadow. After lighting his stove he goes outside and sets a number of small fires in the grass surrounding his cabin. They flare briefly but, in the absence of a wind and with the cool damp of the night setting in, go out after having burned little more than a hectare. In the morning he sets off for a nearby lake to shoot muskrats and ducks, and, after obtaining enough for his short-term needs, he again starts fires, this time in the belt of drier grasses surrounding the lake. This line of fire ignites neither forest cover nor the damp reeds and grasses along the immediate shoreline. However, when he returns in two weeks these blackened edges will fire-guard the adjacent forest when he burns the shoreline vegetation to stimulate the growth of the roots and stems of reeds and water tolerant grasses that will later be fed on by waterfowl and muskrats. Though ducks and geese are already migrating, shoreline burning is completed before nesting begins, an important consideration since large numbers of ducks will be taken around lakes and ponds throughout the summer and early autumn.

By mid-morning he is ready to leave for the second cabin. Before setting off he rides to the opposite end of the meadow and sets a line of fires in the same way as the previous day. He departs well before the flames reach the scorched ground which now fire-guards his cabin. At noon, he skirts the edge of a windfall forest, an impenetrable mass of downed and dead trees, the remnants of an eighty-year old forest levelled by a storm during the previous summer. More than three square kilometres overall, it now blocks off a portion of his trapline route and forces him to make a difficult traverse across an area of muskeg, one of the numberless bogs of grasses, mosses and stunted black spruce that make up the boreal forest.

With the dead vegetation of the windfall area relatively drier than the surrounding live forest, he sets fires that burn irregularly and unevenly to the surrounding stands of forest growth. Additional spot fires, fire-guarded by the areas he now burns, will be set in two weeks. Subsequent spring fires over the next two years or more will eventually clear off the tangle of dead trees, initiate new and more productive stages of growth, and reduce the fire hazards that these areas create.

Within the windfall he notes that there is a small drainage which, decades before, had been dammed by beavers at several places, but which was subsequently abandoned as the surrounding forest aged. With a newer growth of aspen, birch, and willows, the trapper knows that beaver will return in about five years and he can extend his trapline to include the ponding areas that will then be occupied by muskrat as well as beaver. With repeated annual burns, several places within the windfall area – those having the appropriate combinations of trees (white spruce and aspen), understorey growth, and soils – can be converted into meadows while most of the area is allowed to return to forest. Because the vegetation of windfalls is more likely to ignite from lightning storms during the heat of late summer and then spread wildfire into younger and more productive stands of growth, the trapper also sets fires within deadfall sites during this safer period to provide added fire protection.

By the end of his trip, having covered an irregular distance of some 180 kilometres, the Indian trapper will have set many more fires. In addition, a smaller number of meadows will be fired in late autumn, in areas and at sites that he may not or cannot reach in the spring. In these instances he takes advantage of the early snows that melt in open areas but remain to provide some protection for surrounding brush and trees.

The overall pattern of burning acts to maintain a greater variety of habitats and corresponding stages of reproduction. Until the enforcement of fire exclusion laws throughout the first half of this century, the Indians of northern Canada were able to maintain and manage a greater diversity and productivity of preferred plants and animals than would have occurred under natural conditions. At the same time, these humanly influenced fire mosaics reduced the frequency and intensity of summer wildfires that are characteristic of today's over-protected forests.

A month or two after the onset of firing in Canadian boreal forests, a strikingly similar series of events take place in the tropical savannas of northern Australia. The historical timing is different in that within remote regions of the continent Aborigines have been able to maintain much of their traditional fire technology in the face of the great changes that have influenced other aspects of their lives. In this instance, two Aborigines drive a small four-wheel-drive truck across a burnt strip of grass, variably 2-10 metres wide, that separates a stand of monsoon jungle forest from a nearby floodplain. The burnt strip was fired three weeks earlier, shortly after the end of the wet season, at a time when the floodplains were still partially inundated and the jungle much too humid to burn. Now a new growth of grasses ("green pick") has already emerged and shows signs of being grazed by kangaroos and wallabies. In the meantime, a broader band of floodplain grasses, 100 metres or more wide, has matured and dried. The Aborigine on the passenger's side of the truck drops several lighted matches into the dry grass. These fires burn from the previously fired strip towards the slightly lower and moister portions of the floodplain where they slowly go out in the greener and moister grasses.

In another month, similar fires will be set at the new margin, burn further into the plain, with this pattern of staggered burnings repeated until all or most of the grasslands are fired prior to the onset of monsoon rains in mid-December. In some areas, where soils and moisture result in a rapid recovery of plant growth, fires will be set two or even three times in a single dry season, and each time a new, artificially induced growth of grasses will follow.

As the two Aborigines are well aware, the exclusion of fire from the stand of tropical foliage, on the one hand, and its repeated application to nearby grasslands on the other hand, are not unrelated. In a few days, once the new growth or "green pick" has begun to emerge, the two men will come back here to hunt the wallabies and kangaroos that emerge from the forest to feed during the early morning and evening. The Aborigines are also well aware that the monsoon jungle community of plants is more easily damaged by wildfire and can be reduced in size by late season conflagrations. In addition to their concern for this less fire-tolerant community type and the animals that use it for shelter and concealment, monsoon forest stands have ritual and totemic significance which require that they be fire-guarded.

However, the exclusion of fire from monsoon jungles is not entirely absolute and the Aboriginal hunters may return to this stand slightly later in the dry season to set a low intensity ground fire that, under selected conditions, will burn no more than a few inches in height. These occasionally-lit fires, set every 5-10 years, are necessary to clean up leaf litter which, over time, can conceal and inhibit the growth of yams.

Like their northern Alberta counterparts, Aboriginal hunters and gatherers are well aware that plants and animals are not merely adapted or not adapted to fire. Rather, they recognize that fires have multiple effects on individual species and on communities of plants and animals depending upon the circumstances of time, place, frequency, and intensity. For them, fire is not a single entity. It is not an undifferentiated force that is consonant in its effects. Instead, it is recognized as a multidimensional tool of great value that is inherently neither good nor evil, only potentially so in how it is used and, also, not used.

Further along the rough track the hunters skirt an area of paperbark swamp which, like the jungle, is susceptible to late, dry-season fires and which must also be fireguarded with a fringe of burnt grass. Here too the understorey is occasionally burned, every 5-10 years, in order to remove accumulated litter. These fires are set after water in the swamp has receded and vegetation is dry enough to carry a fire but not so highly flammable as to damage paperbark trees and other less fire-tolerant plants.

Away from the swamp the truck stops within an area of eucalypt dominated open-forest. The canopy of trees (15-19 metres) partially shades a mixed understorey of shrubs, palms and grasses. The dominant grass is an annual sorghum which grows to a height of 1-2 metres, is highly flammable, is blown down during high winds in March (the "knock'em down storms"), and is a poor source of nutrients for either game or domestic animals beyond the early stages of growth. In terms of the Aboriginal calendar, which is based upon changes in seasonal indicators, it is now the "cold weather season", marked by the arrival of cool, south-easterly winds and somewhat lower temperatures. For the next four to six weeks fires will burn out during the night resulting in a patchy mosaic of burnt and unburnt stands of understorey growth, while the overstorey of trees is little affected by ground fires at this time of year. Progressing throughout the season, this mix of burnt and unburnt sites provides a range of habitat types, at staggered stages of annual regrowth, within which animals can find a much greater diversity of resources and micro-environments than would or could occur under natural conditions.

The two hunters note the variations in plant growth and the places within the tall open forest, where wallabies and kangaroos are most likely to hide. All of the area has been burnt at least once in the past five years with up to a third of it fired during any season. On this day the hunters have come first to check out a site burnt only the day before by a group of women who were digging for yams. It is a small burn which covers only two hectares. The hunters hope to find wallabies or kangaroos that will be scratching the blackened surface for wild yams and other roots. Unfortunately, their approach has startled a flock of sulphur crested cockatoos whose raucous yells alert other animals to the human intrusion. The only ground animal present, a large goanna that has come to feed in the area, is gone before the hunters come in sight. The tracks and droppings of wallabies are visible, as are signs of their scratchings, but they have moved some distance and their tracks are more difficult to find beyond the limits of the burn.

The two hunters drive further into the forest, stopping just short of an area of relatively old growth; it has been five to six years since it was last burned. The truck is parked in a small sandflat, upwind of where they will now set a hunting fire. Stripping long pieces of bark from a "stringy bark" eucalyptus, they ignite their firebrands, take their rifles, and set off in different directions, touching off the grasses and shrubs as they walk. Fifteen minutes later they have come together again, having created a circle of fire more than 25 hectares in size. Dropping their torches and staying several metres apart, they walk back towards their starting point keeping within the ring of fire. The flames that have started frome the original position are moving towards them. Ahead of the fire move two wallabies, somewhat disoriented by the smoke and crackle of flames. The most agitated of the two suddenly dashes forward and into the line of sight of one of the hunters. His shot both kills it and alerts the second wallaby of the greater danger. Finding an opening in the fire, it dashes into the forest.

After loading their kill into the truck they drive several kilometres inland where they stop at the base of sandstone cliffs, a rocky escarpment that separates the lower and more productive lowlands from the interior and drier areas of woodland. The land atop the escarpment is rough and deeply fissured, an area not easily traversed. Their aim here, however, is to force the animals to come down to them. Again, fire is the primary tool involved.

Parking near the base of the cliffs the two hunters set off in opposite directions, each heading for clefts that cut several hundred metres into the escarpment. When they can no longer proceed up the crevice without difficulty they light matches and set fire to the strands of spinifex grass that lead to the top of the cliffs. The fire literally jumps from one clump to another of these extremely dry and most flammable of grasses. As the fire reaches the top, the afternoon winds, coming from inland, carry the flames back towards the leading edge of the escarpment. However, even before the fire has crested the hunters are seeking out the trails that the animals will use for escape. The grassy fuels on the escarpment burn with considerable intensity and the flames are less easily avoided than are those in the more shaded lowland forests. This forces the large marsupials caught within the limits of the fire down the precipitous trails along the face of the cliff. Between them the hunters shoot two: a kangaroo and a wallaby.

By the time they return to their camp, an "outstation" that their group will occupy for the remainder of the dry season, it is already getting dark. Smoke from fires set by another hunting party and several set by women collecting plants and hunting goannas are visible. Fires will continue to be set in the open forests until mid-August, longer in the drier woodlands, and sporadically in the central parts of the floodplains until the onset of monsoon rains. Lightning storms will herald the change of seasons for several weeks before that. However, few if any fires will occur from lightning, primarily because hunters and gatherers – and over the past one hundred years, cattlemen – have precluded the build-up of fuels.

For the Aborigines this fire management of their environment involves more than mundane, practical considerations. Habitats that are overgrown and susceptible to conflagrations are considered to be "dirty" or "wild places" where people have neglected or foresaken their responsibilities to take care of them. As the examples from northern Alberta and northern Australia demonstrate, viewing technology, in this case *fire technology*, only in terms of tools and techniques overlooks the considerable technological *and* ecological knowledge that a people must have in order to regularly and effectively manage the distribution and abundance of plant and animal resources. In this respect, a technology of fire is pre-eminently the understandings that people have about when, where, how and under what circumstances to burn or not to burn. This is coupled with the ecological knowledge about the variable effects that different types of fire have across a range of habitats and the diversity of species therein. Whether a people use fire drills, matches or butane lighters makes little difference in terms of the overall technology.

Until recently scientists had very little interest in, much less an understanding of, the all-but-universal practices whereby hunting-gathering peoples employed fire to influence the distribution and productivity of plants and animals [(1)]. Though frequently noted in historical and archival record, prior to the 1970s only a very limited number of researchers argued that habitat burning was ecologically or technologically significant, the best known works being those of Day (1953), Sauer (1944, 1947, 1950, 1975), and Stewart (1954, 1955, 1963). Despite these few summaries about the widespread instance and the general effects of burning practices, no ethnographic studies were made which demonstrated how specific groups of hunter-gatherers understood and acted upon the effects of habitat fires or how prescribed burning was integrated into the overall technology and ecology of foraging. Apart from sometimes asking (or in some cases merely inferring the reasons) *why* fires were set, techno-ecological studies on hunter-gatherer uses of fire were not begun until the 1970s.

The failure of anthropologists to consider fire as a serious topic of research was undoubtedly influenced by the evolutionary view that hunter-gathering peoples did not manipulate the resources provided by natural environments.

The conscious, controlled management of resources, it was argued, originated with the domestication of plants and animals and the "Agricultural Revolution". With the single exception

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(1) *Not surprisingly, there is little or no information about the use of habitat fires by Inuit in the Arctic nor by hunter-gathers in tropical rainforest. For instance, the so-called Negritos in the Philippines are reported to make use of fire in monsoon areas (Brosius 1981) but not in true rainforest regions (Jean T. Peterson and P. Bion Griffen, personal communications).*

of Omer C. Stewart (1951, etc.), anthropologists were scientifically naive about the ecological role of fire and the significance that fires could have for hunting-gathering technologies. Earlier descriptions and comments about fire (e.g. Hough, 1926) were essentially restricted to considering the ways that people made and used fire for domestic purposes with the result that it was fires of the hearth rather than those of the field that interested anthropology. Even much more recent publications about "pyrotechnology" have largely ignored the uses of habitat fires (De Jesus 1984, Perles 1977). As laymen to the subject, anthropologists seemed to have fully accepted the official and popular injunctions which indicated that environmental fire, inevitably viewed as "wildfire", was a highly disruptive and an essentially destructive force.(2)

However, following from and largely inspired by studies in fire ecology, we now know much more about the short-term and long-term effects of using fire to facilitate hunting-gathering adaptations. Most important for field studies in anthropology, this knowledge provides the background for asking meaningful questions about the networks of cause-and-effect that follow from using and alternately withholding fire, and not just "why" a fire was set. A recent spate of publications on North American Indians and Australian Aborigines has begun to correct the older, simplistic views of hunter-gatherer uses of fire.

Virtually all of the work on hunter-gatherer practices of burning have come from North America and Australia, for which summaries and related bibliographies can be found in publications by Hallam (1985) and Lewis (1985a) on Australia and Lewis (1982a, 1985b) on North America. A most comprehensive bibliography for both continents can be found in an unpublished MA thesis by Reid (1987). Though there are also numerous references to hunter-gatherer uses of habitat burning in Africa, India and South America, our understanding of practices outside North America and Australia is still very limited. However, unless foragers in other parts of the world were singularly inept in their understanding of the multiple roles of and potential for using fire, there is no reason to believe that such practices elsewhere are significantly or functionally different from those employed in North America and Australia.

Despite the marked differences between the Canadian boreal forest and the tropical savannas of northern Australia, the "parable" described for Indians and Aborigines is, at one level of comparison, an example of "convergent evolution". Both Indians and Aborigines make similar evaluations of how fires are employed with respect to the seasonality of burning, the frequency with which areas are fired, and – by understanding environmental conditions and the "behaviour" of fire – the intensity of a particular burn, all of it involving prescribed arrangements that are significantly different from natural fire regimes in both continents.

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(2) *Anthropologists did not question Euro-American cultural injunctions (or laws) against the uses of habitat fires as these applied to hunting-gathering societies. On the other hand, we have frequently invoked charges of cultural bias, or "ethnocentrism", when other, much more esoteric aspects of primitive life are denigrated. Yet popular pronouncements about the dangers of fire, officially propagandized by the anthropomorphic figures of "Smokey the Bear" and "Bambi", are no less part of Western culture than are the current beliefs espoused by some conservation groups that indigenous hunting and trapping practices are "inhumane" and constitute a threat to "endangered species".*

Considerations of seasonality, frequency and intensity are made relative to the conditions of specific habitats plus the plant and animal resources involved. In northern Canada, natural fires (e.g. lightning fires) are primarily restricted to late summer (mid-July to late August), though lightning fires can and do occur earlier or later than this. In contrast, Indian fires were almost always set over a short period in spring, with a few ignited in the autumn. The vast majority of natural ignitions occur when fire hazards are greatest, unpredictable in effect, uncontrolled as to extent, and can cause significant short-term and even long-term disruptions to hunting-gathering activities. Indian fires in northern Alberta are set during times when burning can be contained by using natural fire controls, whether at the beginning or the end of the growing season, and which serve both specific (short-term) and generalized (long-term) goals.

In northern Australia lightning storms occur at the end of the dry season and just before the onset of monsoon rains in December, whereas Aboriginal fires are initiated in early May and continue until mid-August.

Both Indians and Aborigines employ fire to facilitate the growth of those plants they consume directly, and those that are consumed by the animals that they and animal predators hunt.

The frequency with which areas are burned or left unburned is influenced by how resources are positively or negatively affected. For the Indians of northern Alberta, fires are normally set each year in "tall grass" meadows, areas with solonetzic soils where fire has become an important factor for maintaining forest openings and small prairies (Reeder & Odynsky 1964). In areas of sandy soil, with a lighter, less fire-tolerant cover of growth, fires are set less frequently and are spaced over longer periods to allow the recovery of vegetation.

Whereas streamside areas, especially along traplines, are regularly fired each year, a site that beaver have begun to occupy will not be burned for three to five years in order that aspens and willows will develop sufficiently to provide food for the beaver. Reeds and other estuarine grasses around lakes and ponds are burned each year to improve that habitat for both muskrats and waterfowl. Forested areas, on the other hand, are normally fired only when aged trees have toppled and the area is no longer productive or passable. These "windfalls" make up forest sections that are fired every 70-90 years.

The intensity of fires is in turn affected by the factors of seasonality and frequency in that a fire set late in the burning season within an older stand of vegetation will burn much hotter than one set earlier within a more recently burnt stand of vegetation. Obviously, other considerations are involved as well: the time of day, the strength of wind, the direction in which a fire is set (with or into the wind; up or down slopes), the kind of vegetation, the relative dampness of vegetation, the size of an area, and general weather conditions are all localized and immediate variables to be considered. And these too are frequently influenced by such things as the value of the resources and areas involved, the number of people available in case backfires have to be set, or the fact that, imperfect as conditions may be at the time, they may worsen later on.

From the standpoint of both short-term and long-term adaptations, the major difference between man-made and natural fires is the fact that the former are selectively set. From the standpoint of human adaptations, natural fires are completely random and any benefits are entirely fortuitous, while having the great potential for disrupting rather than faciliating the goals of hunting and gathering. Prescribed fires are set in selected areas, under preferred conditions, involving a range of resources, while providing much greater measures of predictability and security.

The resulting overall environmental patterns of hunter-gatherer burning also show cross-cultural regularities. As indicated for northern Australia, controlled burning results in a distinctive mix of variably aged sites within a habitat type (e.g. tall-open forest and eucalypt woodlands), the clear burning of other areas (e.g. floodplains), and the regular protection and exclusion of fire from some habitats (e.g. rainforests, paperbark stands and mangrove swamps). Altogether, this results in a pronounced fire mosaic, infinitely more pronounced than could or would occur under natural fire conditions. In northern Alberta the mosaic is a mix of naturally burnt forests, with only the occasional burning of windfall areas, and a more pronounced pattern of maintaining "fire yards" (prairies, meadows and smaller forest openings) and "fire corridors" (sloughs, streamsides, lakeshores and trails).(3)

As with other aspects of "folk ecology" where so-called primitive peoples have discovered similar solutions to like problems of adaptation, hunter-gatherer uses of fire provide important examples of human-environmental interactions. However, in more than any other way, the technology of fire represents man's earliest and, until recent historical times, the most pronounced influence in "humanizing" the natural world. These practices would perhaps now best serve the interests of conservation agencies and the concerns for preserving and maintaining parts of our "natural" environment. I hope that anthropologists and others would attempt to gain further insights and comparative examples in Africa, Asia and parts of Central and South America where remnant populations of hunting and gathering peoples still carry on this most ancient yet modern human strategy.

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(3) *A more detailed description and comparison of maintaining "fire yards" and "fire corridors" can be found in Lewis and Ferguson (1986).*

!KUNG KNOWLEDGE OF ANIMAL BEHAVIOUR

Nicholas Blurton Jones and Melvin J. Konner

The investigation reported here concerns both !Kung knowledge of animal behaviour (ethnoethology), and their methods of acquiring and organizing this knowledge. Our original paper (Blurton Jones and Konner 1976) compared !Kung data and methodology with the data and methodology of Western ethologists, as described for instance by Tinbergen (1963). The investigation originated in the field partly as a result of a coincidence: an interest in animal behaviour led to a question from Blurton Jones which aroused a lively response from some !Kung. This gave Konner the idea of investigating their interest further.

The !Kung San live in north-western Botswana and north-eastern Namibia and have been the subject of extensive studies such as Howell (1979), Shostak (1981), Lee and DeVore (1976), Lee (1979 and 1984). At the time of these studies many of the !Kung were living by hunting and gathering, and a good number had added goat herding or work for their pastoralist neighbours to their foraging. Foragers have lived in this area for some thousands of years, and it seems that the !Kung are not a refuge population of people who fled into the Kalahari in recent centuries (Howell 1979). As argued by Schrire (1980), it would be wrong, however, to think of the !Kung as isolated relics of Stone Age man. They have been exposed to and influenced by the outside world in several ways in the last two hundred years, and, prior to that may have had episodes of living as pastoralists or agriculturalists.

!Kung subsistence activity shows a fairly marked differentiation according to sex. Women forage for plant foods bringing in some 58 per cent of the calories fairly steadily and predictably. Men hunt, with greatly varying success. Although women observe tracks and animals and report their observations to men, we confined our investigation of !Kung knowledge of animal behaviour to discussions with adult men. This study was a peripheral activity for both of us. Konner's primary research was on infancy and early child development. Blurton Jones also worked on children's behaviour while in the field with Konner, and subsequently worked on Howell's data on birth spacing. Neither of us has returned to the topic of !Kung knowledge of animal behaviour.

Methods and Procedures

In August and September 1970, Blurton Jones visited Melvin Konner and Marjorie Shostak during their field work. Besides investigating topics of mutual interest in child behaviour, Blurton Jones and Konner participated in a series of discussion groups on animal behaviour with five or six !Kung men in each group. In all we held six discussions in three villages, each of which lasted two to three hours during the evenings. Before the meeting we would plan a general line of questioning, and during the meeting Blurton Jones would raise a question on animal behaviour which Konner would translate to the !Kung. The !Kung, in turn, would then discuss the matter. One or more individuals might volunteer information, at which point Konner would translate back to Blurton Jones, and both authors would enter replies in their notebooks. One discussion was completely tape-recorded.

Once under way the discussions proceeded at a good pace. It was notable that the participants found the exercise interesting and showed little sign of tiring of the topic. The atmosphere was more like a lively seminar than an interview. As a precaution against misunderstanding, a !Kung man experienced in working with anthropologists and particularly with Konner and Shostak, participated in each meeting and, where necessary, retranslated from the idiosyncratic language of the older men into a more familiar !Kung.

If we are to use traditional societies as sources of useful knowledge about wildlife we need a way to evaluate this knowledge. We probably need to do this afresh for each culture we interact with. While the !Kung seem to be remarkably objective and knowledgeable, others may not be. Indeed recollection of English country people suggests that their knowledge of wildlife was as patchy, unreliable and fantasy-laden as that of the most sentimental pet-owner. And the first reaction of an anthropologist would be cautious. He would point to the different reality that goes with a different culture, and warn that there are myths and mythical knowledge about animals as well as everyday knowledge about them. In addition, he would warn of the almost universal wish of people to impress anthropologists and other visitors. We tried to guard against these problems by comparing what the !Kung told us with what professionally trained scientists had already reported. It could have proved impossible to make such comparisons, but as it happened, !Kung everyday knowing seems very similar to the trained scientists' way of knowing and describing. Thus, we were able to make the comparison and to show in what areas the !Kung are knowledgeable (in our terms). Of course the !Kung have a rich mythology involving animals which others have recorded.

In our questioning, we therefore concentrated on establishing how much the !Kung knew about animal behaviour, with a view to checking this against existing knowledge of trained scientists. Incidental to this, many hints emerged about how they know and find out about behaviour, and, to some extent, how they explain it. Consequently, we were able to make a comparison with modern ethology, the science of the behaviour of animals. In practice, establishing the precise points of comparison of knowledge and methodology was often difficult since the !Kung appear to know a good deal more about many subjects than do the scientists. Because of this we often cross-examined them on data that were new to us, and, in so doing discovered interesting features of their methods for finding out about behaviour and their attitudes toward observation and towards the nature of facts.

Comparison with findings of trained scientists also enabled us to check against "tall stories". Blurton Jones's knowledge provided an immediate stimulus to cross-examine any statement which contradicted or extended the better-known scientific findings. Some !Kung observations which we refused to believe were later proved correct when subsequently checked with ethologists who have worked in Africa.

Objectivity of Observation

It became evident early in the study that the !Kung were very careful to discriminate data from theory and interpretation, and, even more so, to discriminate observed data from hearsay. Data are obtained from directly observed behaviour, or based on behaviour inferred from tracks. They seem to place equal confidence in both sets of observations although they always distinguish the two data sources. A further distinction is made between, on the one hand, behaviour that they have seen or reconstructed from tracks and, on the other hand, behaviour that they think may happen, or that somebody claims to have seen.

The features of the discussion which led us to believe that they discriminate between observation and hearsay are of several kinds:

1. **They admit ignorance very readily.** Often after a question there would be a long silence, or the reply of "I don't know" from each participant. This was distinct from a response to an unclearly phrased or unclearly pronounced question, when always some attempt was made to have the question repeated and to find out what was being asked. Some remarks from the notes on the seminars support this view: One man said that he had heard of people who have seen kudu fighting, but he himself never had. When asked whether newborn buffaloes *(Syncerus caffer)* stayed with their mothers or were hidden, one man replied that because buffaloes are so dangerous, he had not looked to see where the babies were, "Since buffaloes kill you, you don't go after them". And at another village where they have on occasion gone after buffaloes, when asked whether baby lions' eyes were open at birth, they laughed and said, "If you go over and look, won't you be dead?".

2. **They argue about generalizations based on scant data and will disagree but will try to reach an answer.** On the subject of newborn buffaloes: one man suggested that buffaloes are like cows, so would be unlikely to hide their babies; someone disagreed with this suggestion, and a discussion ensued about what would really happen with the buffalo. The discussion produced more observations; and, eventually, once the problems of measuring time were resolved, agreement was reached on the fact that the newborn buffalo follows the mother from very early in its life. Someone suggested that lions spot and follow the tracks of their prey, and that they know which animal they are following, whereupon others disagreed as to whether the lion knows which track belongs to which prey. Although this is clearly not a field in which it would be easy to obtain a correct answer, the fact that a guess at this is not acceptable is some evidence of a distinction between fact and fiction. (It certainly contrasts with the country people among whom Gilbert White (1789) attempted to discern the truth about the English countryside).

After a detailed description of the behaviour of the honey guide, a man suggested that the honey guide sometimes leads leopards to honey. This suggestion was then qualified by the objective statement that if you are following the bird you sometimes see a leopard. The statement was taken up immediately and negated by someone who claimed that the bird leads people to leopards, not leopards to the honey. It would seem to us very likely that, as the behaviour of the honey guide is probably based in part on a mobbing response to large animals, it may indeed lead people to leopards by the same rather fortuitious way in which it leads them to honey.

In the same discussion, the men said they did not know whether the honey guide leads the honey badger *(Mellivora capensis)* to honey, despite the suggestion that this is so is widespread in the literature, and the !Kung know that the honey badger eats honey.

In another discussion there was a striking rejoinder by an elderly man that his colleagues should speak only if they have seen things happen. This was provoked by one man's speculation that children could be killed by fires. Since children often get quite badly burned, and sometimes fall ill as a result this was a reasonable speculation. But our informants knew of no actual case of a death from burning.

3. They are able to report new data and do so without pressure. We asked if lions ever eat elephants; this provoked laughter until one elderly man said that they sometimes take baby elephants, an observation which gained him many amazed and admiring looks. He then proceeded to describe how he had seen the body of a dead elephant baby, and the body of a dead lion, and sets of tracks which had suggested to him that the lion had killed the baby elephant, and the mother elephant had come and killed the lion.

During the questioning about kudu *(Tragelaphus strepsiceros)* fighting, a young man described how he came across two males with their horns interlocked, pushing at each other, and then added that he shot them, they separated and died. Another man imitated the sound of kudu fighting and described this as something to listen for when stalking them for a kill. Someone else did an accurate imitation of the ungulate facial expression which ethologists call "flehmen", when describing the courtship of eland (in "flehmen" the head is raised and the lips are curled back, exposing the ducts to Jacobsen's organ, an olfactory organ).

The frequent imitations, both accurate in sound and convincing though not necessarily morphologically accurate in gesture, formed a large part of the descriptions (as, indeed, in many ethological discussions!). In fact, many of them seemed to take great delight in lengthy, detailed, and very gripping, even to the non-!Kung speaker, descriptions of events they had seen. The non-verbal arts of the story teller are very much in evidence, but as far as we can see they did not take licence with the facts. These descriptions also often include considerable detail, as illustrated for example by a description of the method by which a leopard kills an animal: the leopard sees the animal and, semi-concealed, crawls slowly toward it until it is lying down four to five yards away; then it springs and grabs the prey at the throat – its forepaws over the victim's shoulders and legs around its waist. Then winding its tail around the hind legs of the animal (they say the leopard's tail is very strong), the leopard bites the prey in the throat.

4. They will disbelieve each other and on occasion seem to expect scepticism of each other. For example, when somebody said that he had heard that elephants bury their babies up to their neck in the sand, everybody laughed uproariously at his gullibility. A man who described once having seen tracks of ten leopards together at one gemsbok *(Oryx gazella)* kill said that he went back and brought people out to see the tracks because otherwise they would not have believed him. When they came to inspect the tracks themselves, they confirmed that he was correct in his interpretation.

5. Their response to being asked how they know a particular fact is never defensive. It typically leads to a long and careful description of the observations or of the tracking evidence. For instance, we challenged a description of the hunting conduct of a pair of lions. A man had described how the lions approached together to a certain distance and then split up. One advanced directly a short way and then laid down to wait, while the other encircled the prey and then pounced on it, whereupon the waiting animal rushed up and joined in the attack. We questioned them on the evidence for the timing of the relative acts, and this question was met by careful description of the tracking evidence since nobody in this particular group had seen such an event. The tracking evidence for the paths taken by the two animals is clear enough; the evidence for relative timing of the attacks is that the subsequent tracks of the animal who lay down are not those of a lion stalking near to the prey nor of one about to leap at its prey, but were the tracks of a lion running leisurely in an erect posture. We were anxious to follow up a description which we obtained in two separate villages from unrelated people of the way lions go about eating an animal they have killed. In particular, we were told that they do not eat the intestines but remove and bury them. This was such a surprise to us that we cross-examined them closely, only to find them obstinate in this view. There were two men who claimed to have watched lions doing this, and we found it hard simply to disbelieve them. We were also told, but now with some impatience, that people use this knowledge to get intestines which they, unlike lions, eat. We found people in both villages who had gone to the site after the lions had moved away and had dug up the intestines to take home.

Direct observations were also convincing for the immense amount of detail that was given, a point to which we will return when discussing the reasons for !Kung interest in animals. We also challenged a further incredible elaboration of lions' fastidious feeding habits, and although we cannot fault the !Kung's answers, at the same time we can scarcely believe the descriptions they gave us. They said that if during its careful dissection of the intestines from its prey, the lion breaks the intestines and lets their contents spill onto the carcass, it then will not eat the meat and often, indeed, will leave the entire carcass. They simply answered our general challenge by saying that if the lion has gone away, one is likely to see faeces on the carcass; but, on the other hand, if the lion has removed intestines and is still there and one frightens it away, one never finds faeces on the meat. Up to and excepting the abandonment of fouled carcasses, all these observations have been confirmed by ethologists' reports, either from the Serengeti in Tanzania (Schaller 1972) or from the Hwange Reserve in Zimbabwe (Douglas-Hamilton, personal communication to Blurton-Jones, 1972) and by naturalists' reports from elsewhere (Guggisberg, 1961; Stevenson-Hamilton, 1954).

During descriptions of the calf-raising practices of various ungulates one man explained how the data for kudu could be obtained easily if one tracks the mother until finding the remnants of the birth. Then one observes the two pairs of tracks going together for a short time, then divide in two directions. If one follows the baby tracks, one can find the baby hiding there.

6. The only reports which contradicted our argument that the !Kung were quite objective in their reports of behaviour are as follows: A man said that the kudu young is always hidden by the mother, and then said that the mother hides it and goes off to eat until she has enough milk, whereupon she returns to feed the young animal. The basic facts behind this description seem to be very clear, and this is, indeed, one common way in which ungulates care for their young. However, the confusion of observation of spaced feeding with the causal suggestion that she eats all this time to produce enough milk is different from most of the !Kung remarks and uncharacteristic of their usual distinction between observation and interpretation.

When somebody said that he had heard that elephants bury their babies up to their necks in the sand, although it led to general laughter, it did result in one man, again uncharacteristically, saying that he had seen this. On cross-examination it turned out that he had seen a pile of sand and a lot of tracks of elephants with young, whereupon he wisely had given in to the !Kung view of elephants with young and had run away without stopping to examine the pile of sand.

The discussion mentioned above of whether buffalo calf-raising resembled that of cows was also an example of !Kung non-objectivity in that the person who suggested this possibility was at least speculating, though we felt that he regarded this as speculation and not as definitive statement on buffalo calf-raising. Indeed the examples which we quoted as giving rise to argument also seem to imply a failure in objectivity in the person who made the statement.

We conclude from this summary of !Kung observational approach that their efforts resemble the approach of contemporary ethology; as regards attention to detail, distinguishing data from hearsay, and general freedom from inference. In these respects their observations are superior to those of pre-Darwinian naturalists, and very sophisticated indeed when compared with the legion of animal behaviourists among Western hunters, gamekeepers, and pet owners.

Aside from being very knowledgeable, the !Kung men seemed very objective in their descriptions. They appeared to discriminate quite sharply between fact (things you had seen animals do or interpreted from their tracks) and surmise (things you thought might happen or that other people said happen).

Bird Behaviour

Most of the above concerned mammals. Although we asked very little about birds, unless sometimes trying to collect !Kung names for those illustrated in our books, their knowledge appeared to be extensive. As indicated above, they do describe accurately the mobbing behaviour and inadvertent leading behaviour of the honey guide, although without apparent grasp of the motivational issues involved. However, Konner did hold one seminar on bird behaviour, with the help of Peter Jones, a British ornithologist working for the Botswana Government. There was only one such seminar, and it focused on the behaviour of passerines, especially quelea (Quelea quelea). It did not, however, generally inspire a level of confidence in !Kung knowledge comparable to what we were accustomed to in discussions of mammalian behaviour. Still, one anecdote is noteworthy.

Subsequent to the bird behaviour seminar Konner, Shostak, and Jones were travelling with two !Kung men by Land Rover. Knowing of Jones' interest in quelea (he had been retained by the Government to explore possible solutions to the serious quelea pest problem), the two men pointed out a low stand of thorn bushes which, at a distance, looked like any other but which, on close examination, proved to have been stripped of leaves on the distal few inches of their branches. The men said that this had been done by quelea, which were in the habit of preparing bushes in this way and then returning after a few days to rest on the ends of the branches. This observation, which was unknown to Jones, and which proved to be correct, enabled him subsequently to improve greatly the efficiency of his investigation and to collect at an early stage of the nesting cycle specimens previously inaccessible to him (Peter Jones, personal communication).

!Kung Ecological Understanding

The !Kung do seem to have some rudimentary views on ecology. The group sizes of kudu were held to depend entirely on the number of kudu in an area, and to be extremely variable with respect to season and locality. They argued that game tends to avoid areas where there are cows and people, although they explain this by their being frightened by cows rather than in terms of the lack of grass where cows graze. Indeed in the case of the kudu they may be justified because this species predominantly feeds on leaves (as the !Kung told us) and is one game species which has increased even during the recovery of cattle from the Rinderpest epidemic.

"Non-rational" Beliefs about Animals

Besides the practical knowledge of animals that we have discussed, the !Kung have a rich mythology about animals, including stories of a mythical remote past. These were never referred to in our seminars, though on other occasions Konner discussed these matters with people, and Biesele (1976) has made a careful study of them. The two areas seem to be completely different compartments of intellectual life.

A number of non-rational beliefs about animals may also be enumerated, but these seem to play a small role in day-to-day !Kung life and in their interactions with animals. Bird possession is the only one people treat quite seriously. In other words, such beliefs do not interfere with the study of animal behaviour. They seem to exist in a domain of the mind quite separate from ethno-ethological knowledge.

Bird possession: Infants are sometimes said to be "possessed" (an unsatisfactory translation) by predatory birds which they see while sleeping. A parent recognizes that the infant has seen the bird because it clenches its fists at that moment in its sleep, like the bird closing its talons. After this an elaborate ritual must be performed daily to prevent the child's death, and some infant deaths are attributed to such possession.

In our 1976 paper we commented, under the heading of non-rational beliefs that millipedes "are for some reason treated with utter revulsion and never touched under any circumstances, because of their alleged smell". While we were preparing this revised paper Johannes (personal communication) pointed out to us that several millipedes indeed have stink glands, which secrete a possibly caustic mixture of hydrocyanic acid, iodine and quinone. While this shows how predisposed we anthropologists are to impute non-rationality to others instead of ignorance to ourselves, we remain stubbornly confident about the next example. A large caterpillar seen only in the rainy season is said to cause malaria.

!Kung Explanations and Methodology

When asked why an animal did what it did our !Kung experts often fell silent. At best they offered a few anthropomorphisms. Some were also motivational tautologies – lions eat a lot of wildebeeste because lions like the taste of wildebeeste.

In the philosophy of science it is usually supposed that the purpose of a theory is to predict events in the future or in novel situations. One might have thought then that there would be great survival value for the !Kung to have powerful theories about animal behaviour. The perfect theory would allow one to predict even more of the behaviour of every animal in every situation, and perhaps to contrive situations which maximize hunting success. But the !Kung with whom we talked did not seem to be great theorists. They simply loved to know about what animals do. Perhaps the theory of behaviour they use, an introspective, anthropomorphic interpretation, is adequate or even better than adequate. We know cases where they emphasize a similarity to people – "Wild dogs are like people, if there are a few they are afraid, if there are many they are not afraid." So they are clearly aware that some animals react like people in some respects, but that others do not. They are clearly aware of, and act according to species difference. "Be careful, its a gemsbok, not a kudu, you know." (Gemsbok charge, kudu do not.)

In several ways the !Kung show the ability to apply themselves intellectually to the subject. Some discussions, like many a University ethology seminar, were rescued by a participant making the important point of discourse embodied in the following quote: "You were talking about its colour; we were talking about its meat; if you want to talk about colour, then this animal is different." This remark incidentally capped a highly convincing demonstration that the !Kung were able to use a number of different classifications of animals and to move from one classification to another readily, an ability that is supposed to be little developed in "primitive" people. (See Bruner et al. 1966)

Much of their knowledge is utilized in a simple way. For example, only gemsbok among antelope can be successfully hunted with dogs, because only they will consistently stand and fight the dogs, rather than flee. But many items of fact must be integrated in a complex way with all the other rapidly changing variables of the hunt. Typically, in the course of following an animal, a working hypothesis as to its position or condition will be advanced and then tested continually against the spoor. For example, Konner accompanied a man returning from an unsuccessful kudu hunt. It was early afternoon. They began following a gemsbok spoor which, the man said, was made the same morning. After about twenty minutes the man stopped and said, "No, it was made last night", and abandoned the spoor. Asked what made him change his mind, he indicated a single gemsbok hoofprint with a mouse track superimposed on it. Since mice are nocturnal, the gemsbok print must have been made during the night.

If two or more men are hunting together, they will discuss, within the obvious noise restriction, the evidence bearing on the working hypotheses, and argue in a way not dissimilar to the discussions in the seminars. Konner observed a zebra hunt in which the working hypothesis, that the zebra was wounded high on the body, had to be abandoned when a man showed that grass, which had been bloodied near its high tip, had first been bent to the ground by the passing animal, bloodied by its foot, and then returned to the upright position after the animal passed. Thus the hypothesis of a wound in the foot was still sufficient to account for the data.

Such an intellective process is familiar to us from detective stories and indeed also from science itself. Evidently repeated activation of hypotheses, trying them out against new data, integrating them with previously known facts, and rejecting ones which do not stand up, are not habits of mind restricted to professionally trained scientists and detectives. !Kung behaviour indicates that, on the contrary, the very way of life for which the human brain evolved required such intellectual processes. That they are brought to impressive fruition by the technology of scientists and the leisure of novelists should not be allowed to persuade us that we invented them.

Conclusion

The !Kung proved to be highly knowledgeable and accurate about observable behaviour of animals. They support the argument by Johannes (1984) that traditional societies may be a valuable source of knowledge. But they were really not very informative about animal ecology. This might be disappointing but conservationists should be consoled by the fact that the !Kung indicated some sophistication about their own ecology (as indeed do other traditional societies – see for example Western 1977, 1979). !Kung appreciated the trade-offs involved in having a larger pastoralist population nearby. Game became less numerous, but other opportunities were presented by the pastoralists (work, payment in milk or grain) that seemed to be regarded as a reasonable exchange. The consequences of new boreholes were understood (not just more water for !Kung but more cattle and less game).

People's knowledge of their own and their neighbours' ecology might be very useful in some conservation situations, for instance in helping to assess the importance and exploitation of a particular area or resource by local people and the likely conservation costs of their continued use of the area.

The degree of threat to conservation from local people may depend very much on their economy-ecology. Pastoralists in East Africa are sometimes regarded as somewhat harmful to conservation. But swidden horticulturalists in forests who also hunt but move on, may actually take a very limited toll on the wildlife. They may be bitterly opposed to rapacious industrial forestry. Conservationists should ardently support the land rights of such people. The few remaining hunter gatherer cultures probably take even less toll, and also have a vested interest in keeping cattle and foresters out.

We found our animal behaviour discussions with the !Kung chastening at many levels. The sheer volume of knowledge is breathtaking. They laughed to hear that there are people who think that the spotted hyena only scavenges; they know that lions sometimes scavenge from hyena kills; and so on and on. The accuracy of observation, the patience, and the experiences of wildlife they have had and appreciate are enviable. The sheer, elegant logic of deductions from tracks would satiate the most avid crossword fan or reader of detective stories. The objectivity is also enviable to scientists who believe that they can identify it and that the progress of science is dependent upon it. Even the poor theorization of our !Kung left one uneasy; their "errors" are exactly those still made today by many highly educated, trained scientists (tautological theories of motivation, inadequacies in application of natural selection theory). Just as primitive life can no longer be characterized as nasty, brutish and short, it cannot be characterized as stupid, ignorant, or dominated by superstition.

REASONS FOR ETHNOBOTANICAL CONSERVATION

Richard Evans Schultes

This paper is adapted from a lecture delivered at the IV Latin American Botanical Congress, Medellin, Colombia (July 1986)

In the few parts of the world still not affected by fast encroaching civilization, there exists a wealth of information on the properties of plants that is still available to us. It will not long be there for us to salvage. It has been built up by peoples in primitive societies over millennia by trial and error, for they have had to rely on their ambient vegetation for their foods, medicines and all the other necessities of life.

When our civilization arrives with roads, missionary activities, commercial interests, tourism or otherwise, the products of our culture are rapidly adopted and, often even in one generation, replace what has for hundreds of years been a part of their culture. This erosion of native ethnobotanical knowledge and use is nowhere more rapid than in the realm of biodynamic plants – medicinal, narcotic and toxic species (Schultes and Hofmann 1979 and 1980).

There have long been two strongly divergent poles in our evaluation of the worth of ethnobotanical studies. Many investigators have been carried away with enthusiasm that native peoples have had some special intuition which permitted them to seek out "nature's secrets". Others have cast aside or denigrated all native folklore as not worthy of serious scientific attention. Naturally, both points of view are extreme and are unwarranted.

Recently, the realization that the aboriginal knowledge of plant properties is of both academic and practical value has matured. And various investigators in sundry fields have recognized the need to save native plant lore before it is entombed with the culture that gave it birth.

The Brazilian chemist, Otto Gottlieb, for example, wrote in 1979: "Since Indians in the Amazon are often the only ones who know both the properties of the forest species and how they can best be utilized, their knowledge must be considered an essential component of all efforts to conserve and develop the Amazon".

Davies (1977) wrote similarly: "The tragedy is that the Indian is one of the main keys to the successful occupation of the Amazon and as he disappears his vast wealth of knowledge goes with him".

Interest in ethnobotany goes beyond these and other similar statements. The Society for Economic Botany and its journal *Economic Botany* have become increasingly dedicated to ethnobotany. The Society for Ethnobiology has recently been established and is publishing its own journal. The highly successful *Journal of Ethnopharmacology*, now only in its 15th volume, enjoys worldwide circulation. Europe has several publications specializing in the study of medicinal plants used in native pharmacopoeias. Some governments – especially Mexico, China and India – are fostering the scientific study of native remedies. The newly organized Society of Ethnobotanists of India has just published a most useful *World Directory of Ethnobotanists*, an up-dating of a *Directory of Ethnobotanists* produced in 1976 by the Ethnobotanical Laboratory of the University of Michigan at Ann Arbor; the number listed has increased from 150 to 490. Various congresses, meetings and symposia are including sections devoted to ethnobotany. Under the sponsorship of the Plant Programme of IUCN and WWF-US, the Botanical Museum of Harvard University has set up a subgroup on Ethnobotanical Conservation, the purposes of which are to knit together specialists in the many disciplines associated with ethnobotany on a wildlife basis and especially to encourage the conservation of ethnobotanical information in imminent danger of extinction.

Any denigration of native folk medicine is not supported by the contents of Western pharmacopoeias nor by the history of some of the most recently discovered drugs from the plant kingdom that have revolutionized the practice of modern medicine: the curare alkaloids; penicillin and the many other antibiotics; cortisone and the steroids; reserpine; vincoleucoblastine; the *Veratrum*-alkaloids; podophyllotoxin; strophanthine; physostigmine; and other new therapeutic or research agents (Schultes and Farnsworth 1980).

Nor is this denigration supported by chemical and pharmacological investigations of native medicinal plants under current study (Schultes and Swain 1976). One excellent example is the statistical analysis of a number of medicinal plants employed by the Aztecs. Most of them have been shown pharmacologically to produce the effects that the Aztecs claimed; four possibly could have the properties reported by the Indians; five – only twenty per cent seem unable to induce the physiological activities attributed to them in the native medicine (Ortíz de Montellano 1975). A further example is the recent ethnopharmacological analysis of the loganiaceous genus *Buddeja*: a high degree of correlation exists between the wide spectrum of native medicinal uses and what is known of the chemical composition of this genus of 100 species of the tropics and subtropics of both hemispheres (Houghton 1984). Similar correlations in the few groups of plants that have been ethnobotanically studied can be cited.

It is clear that modern science can no longer afford to ignore reports of any aboriginal uses of plants simply because they seem to fall beyond the limits of our credence. On the contrary, these uses should stimulate examination under the impartial searchlight of modern scientific analysis (Schultes 1983).

Several plant explorers of the past century – von Martius and Spruce, for example – were of the opinion that the Indians of the Amazon utilized a limited vegetal pharmacopoeia. In his field notes on *paricá* – the hallucinogenic snuff prepared from *Anadenanthera peregrina* – Spruce wrote: "Throughout the Uaupés, this is almost the sole medicinal agent employed ... I have never known any other remedies applied except occasionally the milk of some tree (and they are not particular as to the species) by way of plasters in the case of some wound or internal pain". In another context, Spruce reported: "Among the native tribes of the Uaupés and of the upper tributaries of the Orinoco, niopo or paricá is the chief curative agent" (Spruce 1873).

Von Martius had the same opinion as Spruce. He wrote: "of external applications, I have seen only the following. For a wound or bruise or swelling, the milky juice of some tree is spread thick on the skin where it hardens into a sort of plaster and is allowed to remain on until it falls of itself. Almost any milky tree may serve, if the juice be not acrid; but the Heveas (India-rubbers), Sapotads and some Clusias are preferred. Such a plaster has sometimes an excellent effect in protecting the injured part from the external air".

It is not easy to reconcile this opinion of one of the greatest of field botanists who spent five years in the north-west Amazon with my own observations over the past 40 years amongst numerous tribes of the same region. There are, however, several possible reasons. The Indians recognize in general two "kinds" of medicines: those with purely physical effects – and these are known and used by members of the tribe who might be called regular practitioners or the ethnopharmacologists of the tribe who do not resort to magic or superstition but who possess a wide knowledge of the flora and the properties of a great number of species; and the plants with psychic effects – usually the hallucinogens, which are considered to be sacred and which the medicine-man or payé manipulates. Spruce himself stated: 'I have never been so fortunate as to see a genuine payé at work With the native and still unchristianized tribes I have for the most part held only passing intercourse during some of my voyages. Once I lived for seven months at a time among them on the river Uaupés, but even there I failed to catch a payé. When I was exploring the Jaguarato cataracts ... news came that a famous payé ... would arrive that night and remain until next day; and I congratulated myself on so fine a chance of getting to know some of the secrets of his "medicine"'. He did not reach the port until 10 p.m., and when he learned that there was a white payé (meaning myself) in the village, he and his attendants immediately threw back into the canoe his goods ... and resumed their dangerous voyage ... in the night-time. I was told he had with him several palm-leaf boxes containing his apparatus ... I could only regret that his dread of a supposed rival had prevented the interview which to me would have been full of interest; the more so since I was prepared to barter with him for the whole of his materia medica, if my stock-in-trade would have sufficed" (Spruce 1873). Spruce, like most botanists engaged in making general collections of the flora, probably could not devote much attention to time-consuming ethnobotanical research, and in view of his incomparably complete collections of that strongly endemic flora, science is the richer because he spent most of his efforts in floristic botanizing (Schultes 1983).

For fourteen years – 1941 to 1954 – I was able to live permanently in the north-west Amazon, and I have briefly visited the same region almost annually since 1954, making a total of 24,000 plant collections. Of these, there are notes on the aboriginal uses as medicines, narcotics and poisons of nearly 2000 species. Certainly many uses escaped my attention and will be discovered by future investigators, if they can in some way beat the rapidly advancing acculturation and loss of native plant lore. I have incorporated reports of plant uses from this region collected by some of my students and colleagues and from herbarium reports.

The flora of the Amazon is extensive – with probably some 80,000 species. One expert has estimated that nothing is known about the chemical composition of 99.6 per cent of the Amazon's flora. Certainly almost all of the biodynamic species for which I have notes have never been chemically analyzed. Some of the uses may be of little or no practical value, but for many it is possible to see or appreciate their physiological effectiveness. Few may actually be curative, but an appreciable number probably are alleviative. Whatever the case may be, if a plant has any physical activity it indicates the presence of at least one active chemical constituent. We should know what these constituents are: they may not be of any value in our Western pharmacopoeias; they may find wholly different uses in our technology; a few may yield drugs for modern medicine to treat the same conditions for which they are applied in primitive societies. And many species hold promise of the discovery of new chemical compounds, for it is now realized that unstudied tropical flora as rich as that of the Amazon represent a vast emporium of unknown chemical compounds awaiting discovery.

What can we say about some of the interesting and promising biodynamic plants of the north-west Amazon? Included now in my ethnopharmacological notes and those of several of my students and colleagues are at least thirty-two species, the uses of which suggest possible cardiovascular activity; ninety are involved as probable major ingredients of arrow poisons; twenty-seven seem to be insecticidal or insect-repellent; fifty-seven are employed for their ichthyotoxic properties; four are valued as presumed oral contraceptives; more than eighty-five are taken as vermifuges; over hundred are believed to be febrifuges; a few are styptics; two dozen are applied to clean or hasten the healing of infected sores and wounds; five or six, it is claimed, relieve conjunctivitis; six are said to be stimulants; eleven are esteemed as hallucinogens or narcotics: and so the list could continue.

It is probable that there are few regions in the world where the indigenous populations possess a fuller acquaintance with the properties of their plants. The region is sparsely populated by numerous tribes of very diverse origins, cultures, languages and methods of using bioactive plants. Until recently the area has been by nature isolated and protected from external penetration, since rapids and waterfalls have rendered navigation impossible. Furthermore, the region is floristically the most variable and the richest in the Amazon Valley. All of these factors have tended to contribute towards the extreme ethnopharmacological wealth of the north-western sector of the hylea.

The appreciation and utilization of plants for medicinal purposes, however, varies significantly from tribe to tribe. Some – the Colombian Sionas, Kofáns, Witotos, Boras, Yukunas, Tanimukas, Kubeos, Tukanos, Barasanas, Makunas, Kuripakos, Puinaves and certain tribes of Makós, for example, have rich pharmacopoeias. Other groups – the Waoranis of Ecuador, living in the same species-rich forests – have a dearth of plants therapeutically employed: intensive research indicates that they use ony thirty-five species, thirty of which are valued in treating only six conditions (Davis and Yost 1983); while their neighbours, the Kofáns, have at least eighty species for twenty-seven different ailments.

An interesting and possibly significant aspect of the medicinally used plants in the north-west Amazon is their employment most commonly as simples: only rarely are two or more species mixed for therapeutic use – quite in contrast to the usual situation in the preparation of curares.

Peoples on every continent have learned to tip their arrows or darts with poisonous preparations, derived mainly from plants. In number of species so employed, South America is the centre for the use of arrow poisons or curares. And in diversity of ingredients, it appears that the north-western part of the Amazon represents the epicentre.

Although curares have been carefully studied as sources of medicinally valuable compounds, there remains much to do from this point of view. It would hardly be an exaggeration to state that every tribe (and often every payé) dedicated to the preparation of curare has a different formula.

While most curare formulae call for a number of vegetal ingredients, the most widely prepared Amazon arrow poisons have as their basically active plants members of the Menispermaceae (species of *Abuta, Curarea, Chondrodendron* and other genera) or of the loganiaceous genus

Strychnos. Alkaloids from the menispermaceous genera have, of course, become extremely important in Western medicine during the past 50 years. Recent ethnopharmacological studies have, however, uncovered new sources of curares – even curares prepared of one species.

More than 150 years ago, the German botanist von Martius discovered that Indians on the Rio Japurá in Brazil were preparing a curare based on the annonaceous *Unonopsis veneficiorum*. Recently we have learned (Schultes 1969) that the distant Kofán Indians of Colombia and Ecuador prepare an arrow poison from the fruits of this plant. This species contains bisbenzylquinolic compounds, but it is not known that these constituents can be responsible for the curariform activity. The Kofáns use another annonaceous plant in making a curare: the bark of a small tree of the genus *Anaxagorea*. The Kofán Indians likewise use the fruits of the lauraceous *Ocotea venenosa*, which also contain bisbenzylquinolic constituents. Another interesting toxic plant utilized by the Kofáns is the thymiliaceous *Schoenobiblos peruvianus*, the fruits of which are the sole ingredients of an arrow poison; they are also a favourite fish poison of this tribe. The Thymeliaceae is rich in coumarin derivatives, but these are not believed to have curare activity.

In 1954, a new hallucinogenic snuff was identified in the north-west Amazon, prepared from the resin-like bark exudate of several species of the myristicaceous genus *Virola*. During the study of this interesting use we discovered that the Waika Indians of Brazil tip their darts with the exudate and with no other ingredient as a commonly employed curare (Schultes 1954). While the hallucinogenic principlest – ryptamines – have been identified, there is no suspicion of the constituent that can act as an arrow poison (Schultes and Holmstedt 1968).

Amongst the other species reportedly used as active components of arrow poisons are *Vochysia columbiensis*, utilized by the Makó Indians of the Rio Piraparaná who enjoy the reputation of making the best curare in the region; and the caryocaraceous *Anthodiscus obovatus* from which the Tukanos of the Vaupés prepare with a species of *Strychnos* a relatively strong arrow poison.

While many Indian tribes cultivate species of the euphorbiaceous *Phyllanthus* and the composite *Clibadium* and utilize the bark of wild species of the legume *Lonchocarpus* as fish poisons, many other species of lesser ichthyotoxic value have recently been identified (Schultes 1969) as members of the euphorbiaceous *Nealchornia*, the myrsinaceous *Conomorpha*, the acanthaceous *Mendoncia* and the connaraceous *Connarus*. A curious fish poison is prepared from the leaves of the araceous *Philodendron crasspedodronum* amongst the Indians of the Vaupés: the leaves, tied up and left to ferment for several days, are then crushed and thrown into still water. The Waoranis of Ecuador esteem the bark of the bignoniaceous *Minquartia guianensis* as an ichthyotoxic agent (Davis and Yost 1983). A very unusual discovery has been the use by the Tikunas of the Colombian Amazonas of the dried pulp of the fruit of the bombacaceous *Patinoa ichthyotoxica*; no chemical constituent known from this family is known to have toxic properties (Schultes and Cuatrecasas 1972).

There are many plants that the natives classify as poisonous and for which they have no use. Especially interesting are cucurbitaceous species in the genus *Gurania*, a family that deserves closer phytochemical study.

Several species of the marcgraviaceous genus *Souroubea* are valued in the Vaupés as the source of calmative teas administered to elderly natives suffering from "susto" (psychological fear) or to induce sleep. Two or three plants – especially the cultivated cucurbitaceous *Cayaponia* *ophthalmica* – are employed, apparently with some success, in treating conjunctivitis, a very frequent condition in the region (Schultes 1964).

One of the medicinal uses most worthy of scientific evaluation is the application of the reddish resin-like bark exudate of several species of *Virola* and of the guttiferous *Vismia* to fungal infections of the skin, an extremely common affliction in the wet tropics. The condition often seems to clear up with this treatment for 10 or 15 days, but whether it represents a cure or merely suppression cannot be known given the present state of our technical understanding. Recent preliminary chemical studies have yielded several chemical constituents from *Virola* – lignans and neolignans – that may possibly account for antifungal activity. Other plants are employed in treating infections of the skin or of the mucous membrane of the mouth: the gum extracted from the pseudobulbs of the orchid *Eriopsis spectrum*, a decoction of the bark of several species of *Vochysia*, an infusion of the leaves of *Souroubea crassipetala* and the powdered bark of the rubiaceous *Calycophyllum acreanum* and *C. Spruceanum*. A warm decoction of the leaves of *Anthurium crassinervium* var. *caatingae* is used by the Kubeos as an ear-wash to relieve a painful condition due probably to fungal infection.

One of the commonest medicinal plants of the Makunas is the malpighiaceous *Mezia includens*: the root is considered to be strongly laxative when crushed and soaked in water in which faria flour (from *Manihot esculenta*) has been sitting for several hours. The boiled leaves make an emetic tea and, when they are applied warm as a cataplasm on the abdomen, are said to help a condition that seems to be hepatitis (Schultes 1975).

Despite its toxicity, *Aristolochia medicinalis* is administered in the Vaupés to calm what appear to be epileptic seizures. The treatment is reported sometimes to be worse than the disease, since use of this tea, it is alleged, can cause insanity if not used with caution.

Only several species were encountered in use as presumed oral contraceptives: *Philodendron dyscarpium, Urospatha antisyleptica* and *Anthurium Tessmannii* – all members of the aroid family. The Bara-Makó of the Rio Piraparaná, who call the moraceous *Pourouma cecropiaefolia* "we-wít-kat-tu" ("no children medicine") scrape the bark from the root, rub the scrapings in water and give the drink to women; according to the natives, the drink can cause permanent sterility. These same Indians report that the leaves of *Vochysia lomatophylla* in warm chicha (a slightly fermented drink made from *Manihot esculenta*) has aborifacient properties. It is perhaps significant that the distant Campa Indians of Peru value this *Vochysia* as a possible contraceptive.

Several plants are widely employed as styptics to staunch the flow of blood from wounds: *Helosis guianensis* of the Balanophoraceae; *Costus erythrocoryne* and *Quiina leptoclada* of the Zingiberaceae and Quiinaceae, respectively.

A recently published ethnobotanical study of the bignoniaceous genus *Martinella* may be extremely significant. An extract of the root of *M. obovata* is widely employed throughout northern South America as an "eye medicine". References to this use over such an extensive area is "compelling evidence that *Martinella* contains medically useful properties" (Gentry and Cook 1984). In the Vaupés, another bignoniaceous liana – *Arrabidea xanthophylla* – is valued in treating conjunctivitis.

The number of species for which vermifugal and febrifugal properties are claimed is naturally very high in view of the prevalence of intestinal parasites and various fevers, especially malaria. Very few of the plants so employed have been chemically or pharmacologically examined, although numerous species belong to genera recognized as having astringent properties. It will be sufficient to mention several members of the solanaceous genus *Brunfelsia* in connection with febrifugal activity: *B. chiricaspi, B. grandiflora* and *B. grandiflora* subsp. *Schultesii*. The ingestion of a decoction of the leaves rapidly induces a sensation of chills: in fact, the vernacular name *chiricaspi* means "chill plant". In addition to this febrifugal use, these plants have additional applications in local medicine: in treating rheumatic pains and arthritis as well as snakebites. They may occasionally be added to the hallucinogenic drink ayahuasca (prepared from the malpighiaceous *Banisteriopsis Caapi*) in order to lengthen and intensifiy the psychoactivity of the narcotic. And *Brunfelsia*, taken alone, can itself have hallucinogenic effects (Plowman 1977). Yet little is known of the chemistry of such a well-known and highly esteemed native medicine. Recent chemical studies of *B. grandiflora* subsp. *Schultesii* disclosed a novel convulsant – pyrrole-3-carboxyamidine – which has been named brunfelsamidine, but it is not clear that this represents the physiologically active constituent (Lloyd *et al.* 1985).

It is true that a major part of the world's population depends upon traditional medicines, deriving mostly from vegetal sources. This large segment of humanity will undoubtedly need to continue using their native remedies in the future. It is therefore imperative that modern science collect and preserve as much as possible of the available knowledge that primitive societies have amassed over the centuries on the physiological effects and the presumed medicinal properties of bioactive plants.

There is another equally important reason for documenting ethnopharmacological knowledge. It is the search for potentially new therapeutic agents to be used for advanced medicine which will ultimately rebound to benefit the local indigenous societies who still fully depend on native floras for cures and remedies.

Ethnopharmacology has recently been defined as the "observation, identification, description and experimental investigation of the ingredients and the effects of indigenous drugs". It is clearly a highly interdisciplinary field, ... not just a science of the past, utilizing an outmoded approach. It still constitutes a scientific backbone in the development of active therapeutics based upon traditional medicine of various ethnic groups. Although not highly esteemed at the moment, it is a challenge to modern pharmacologists"(Bruhn and Holmstedt, 1982; Holmstedt and Bruhn 1983).

The United States pharmaceutical industry attains from the prescription market alone annual sales in excess of $3,000,000,000. These prescriptions rely primarily on medicinal agents found only in plants, many of them first discovered in use among aboriginal societies throughout the world. Providing a more equitable compensation to traditional societies in return for the transfer of pharmaceutical knowledge is our next challenge. Further, reinvesting part of the profits into the conservation of plant diversity so as to preserve future sources of natural and renewable curative elements would certainly be wise.

Ethnobotanical conservation, like all other aspects of conservation, will be more widely respected and appreciated if it can be couched firmly on an economically advantageous base for both aboriginal and technologically advanced societies. Once this is established, the future of both the pharmaceutical industries and the wild plant species on which they depend will look healthier.

FISHING AND TRADITIONAL KNOWLEDGE

Robert E. Johannes

It was the first day of the new moon in November, the first day of the year according to the traditional Palauan calender. Daelbai, a Palauan fisherman, had offered to take me to see a spawning aggregation of mojarra, a local marine food fish. We arrived at Ngerong Island about noon and walked to a spot near a deep channel leading through the barrier to the ocean. We climbed small coconut palms. He pointed to an area offshore. "What colour do you see?", he said. "White", I replied, referring to the white sand beneath the shallow water. "By four o'clock it will be black," he said.

At four o'clock it was black – with fish; thousands upon thousands of mojarras. They had appeared as if on cue, as Palauans say they have always done on the afternoon of the new moon on the first day of the Palauan new year. They would return, as they did each year, for several days around each new moon period for the next few months.

We netted a few fish from the aggregation. The gentlest pressure on their abdomens caused them to extrude eggs or milt; they were "running ripe" – a sign that they would spawn within, at most, a few hours. They would move about a hundred metres to sandy patches at the edge of the channel, said Daelbai; and would release their eggs and milt into the water early in the evening when the tide had begun to ebb.

The mojarra, *Gerres oblongus*, is well known to tropical marine biologists. But I could find nothing in the scientific literature about where, when or how it spawned. This is just one of many examples of knowledge of the timing, location and behaviour of spawning aggregations of various fishes possessed by formally unschooled Pacific Island traditional fishermen, yet unknown to science.

On other occasions, always at specific locations, phases of the moon and months specified by Palauan fishermen, I swam among, or observed from above, spawning aggregations of other fishes such as groupers, jacks (trevallies), herring, rabbitfish and snappers which were massing to spawn. In fact, while interviewing and working with Palauan fishermen in the mid-1970s I was told of the precise locations, months and lunar periods at which some 55 species of food fish in the tiny archipelago of Palau would spawn (Johannes 1981). This was more than twice as many species of fish as had been described as exhibiting lunar spawning periodicity in the scientific literature for the entire world.

A pattern emerged as I examined this information. Many species of reef fish, especially the larger ones, migrate year after year to specific locations near the outer reef edge. Here they form large, often very docile and approachable aggregations. Most species aggregate around new or full moon, the semi-monthly periods of maximum tides. The spawning act takes place typically around dusk or dawn starting as the tide begins to ebb, at locations favouring the transport of the tiny, drifting eggs out into deep water and beyond the myriad predators that would consume them in the shallow reef communities (Johannes 1978a).

It was not for lack of interest that marine biologists had not previously recognized this general phenomenon. Indeed, such knowledge is invaluable to biologists responsible for managing tropical fisheries (Johannes 1980). But native fishermen are far more numerous than marine biologists. They have been plying their trade and passing on their accumulated knowledge for many more generations than we have. And they spend far more of their time on or in the water than do typical researchers with classes to teach, assignments to mark, committee meetings to attend, data to analyse and proposals and papers to write.

It should not be surprising, therefore, that a native fisherman will often know much about his nearby waters and their inhabitants than we do not. What *is* surprising is how long it has taken marine biologists to realize the value of this knowledge, and to begin to make serious efforts to record and verify it.

Among those fishermen who know much about their prey are the inhabitants of the islands of Polynesia and Micronesia, where fish are traditionally the most important form of animal protein and where clear lagoon waters facilitate their observation. More species of fish are found around some of these islands, including those of Palau, than in the waters of the entire Pacific, Arctic and Atlantic coasts of Canada. These highly diverse fish stocks present some of the most complex fisheries management problems in the world. Since biologists today possess only a small fraction of the information necessary for their sound management, the knowledge provided by native fishermen can be of substantial benefit to the fisheries manager.

Populations of most species of coral reef fishes are normally spread out over large areas. Under these conditions, it is almost impossible to get any notion of population sizes. But the difficulties are greatly reduced if the fisheries biologist knows where and when these fish aggregate to spawn. Just as salmon returning to their rivers to spawn are easier to count than at any other time during their lives, so are many reef fish easiest to census when they are on their spawning grounds (Johannes 1980).

The reason that Pacific island fishermen know so much about these spawning aggregations is that such aggregations constitute the conditions under which these species are most easily caught. Typically, fish in spawning aggregations are not only present in much larger concentrations than at any other time, but they are also unusually docile and easy to approach, as Palauan fishermen often pointed out. This makes them especially easy to net or spear.

Paluans, like many other tropical Pacific islanders, did not consider spawning time to be a time of uncontrolled slaughter, however. It was simply looked upon as a time when fish were caught more easily than usual. Like many Pacific island peoples they had a well-developed traditional marine conservation ethic.

It is unlikely that wise conservation practices evolved in the absence of a perceived need for them. In this connection it is instructive to compare the evolution of marine conservation practices in the islands of Oceania and in Europe. Lacking the wide, productive continental shelves that characterized continental coastlines, the islanders' marine resources were limited largely to the narrow fringes of reef and lagoon around their islands. But they were vital because terrestrial sources of animal protein in most of these islands were extremely scarce.

So the limits of the islanders' marine resources became obvious to them centuries ago. As a consequence they devised and adopted almost all the basic fishery practices that we in the West have only recently introduced (Johannes 1978b). These measures include closed seasons, closed areas, size limits, and limited entry. Not all taboos associated with fishing were intended as conservation measures; however, it is now well established that conservation was the specific purpose of many of them.

It was only about 90 years ago that Europeans, blessed with the huge fisheries associated with their continental shelf and abundant sources of terrestrial animal protein, first became aware of the need for conservation of marine stocks. Indeed one of the most famous biologists of his day, T.H. Huxley, proclaimed in 1883, "I believe, then, that the cod fishery, the herring fishery, the pilchard fishery, the mackerel fishery, and probably all the great sea fisheries are inexhaustible; that is to say, nothing we do seriously affects the number of fish. And any attempt to regulate these fisheries seems consequently, from the nature of the case, to be useless." (Huxley 1884). Not surprisingly, it was only after the turn of the century that marine conservation measures were implemented in Western countries.

Given this belated recognition by westerners of the value of marine fisheries conservation, the purposes of some traditional Pacific Island conservation measures were not appreciated by colonial powers and Pacific islanders were sometimes forced to abandon them (Johannes 1978b). Traditional fishing rights, a form of limited entry practised in the islands, is an example of a custom with important resource management implications recognized by Westerners only in the past few years. If a group of fishermen own the exclusive traditional rights to fish in an area, it is in their best interests to harvest in moderation. When such customs are destroyed, everyone has access to the fishing grounds. This predisposes the fishermen, now embedded in Westernized market economies, to catch as much as they can; what they do not catch is liable to be caught by someone else rather than form the basis for continuing good yields in future years. Failure of colonial governments to recognize and uphold traditional fishing rights is one of the reasons overfishing is the norm in much of Oceania today.

More and more examples of fishermen and marine hunters being centuries ahead of marine scientists in discovering important biological information are coming to light. For example, throughout much of the tropics, native fishermen have known for countless generations that green turtles, now on the IUCN Endangered Species List, migrate to the same nesting locations repeatedly over a number of years to lay their eggs. This information, central to the management of turtle stocks, was doubted by scientists until Archie Carr decided in the 1950s to investigate the claims of these fishermen, and found them to be accurate.

Recent research among the Inuit (Eskimos) reveals a knowledge of their prey and its environment that is in some ways superior to that of biologists. For example, the Inuit of Point Barrow were convinced in 1978 that estimates of the population of bowhead whales made by the International Whaling Commission were too low. The Commission's biologists counted whales as they swam through channels between shore ice and offshore pack ice on their spring and autumn migrations. The Inuit claimed, however, that biologists were overlooking other whales that swam under the ice. Subsequent research using hydrophones to record the calls of passing whales substantiated their claims.

Freeman (1984) and Nelson (1969) have described the phenomenal knowledge of Inuit hunters concerning the characteristics of arctic sea and sea ice environments. Such knowledge is useful not only to hunters of seals and polar bears. Roots (1981) states:

> "Judicious use of mathematical modelling of environmental processes is essential to good arctic marine engineering ... (However) we should keep in mind that although we may dress up the estimates with numbers to make them look like data or conclusions, our general understanding of the overall relationships between arctic weather and arctic ocean behaviour is not demonstrably better than that of the Inuit who have a "feel" for it, based on long and intimate observation ... One of the most under-utilized sources of information in many vital areas of arctic development is the accumulated practical knowledge that the Inuit possess."

Westernization and conversion to a cash economy have resulted in the breakdown of many customs and traditions associated with fishing. One result is a rapid loss of traditional knowledge about the sea throughout the non-Western world. In Palau it is mainly the older fishermen who possess the expert knowledge; most of the young are not interested in acquiring it. But the Palauan system of traditional fishing rights continues to function and helps prevent depletion of the fishing grounds. And the fishermen continue to recognize the need for conservation.

Some years ago the fishermen became alarmed over the dwindling number of groupers that aggregated on their main spawning ground – an apparent consequence of increased fishing pressure associated with a recently developed export market. So they declared fishing on the spawning aggregations to be forbidden. On the day I went to see this spawning aggregation I could have filled my boat with fish in short order. But, although no one was present to enforce the closure, no fishermen were there either. They knew the value of letting the stock build up again.

NATURE-INTENSIVE AGRICULTURE: THE FOOD PRODUCTION SYSTEM OF YAP ISLANDS

Marjorie V.C. Falanruw

Introduction

Environmental costs of modern Western agriculture, the quality of urban life and the inter-relationship between urban and rural environments, and between those environments and the natural landscape are all matters of growing concern to scientists and laymen alike. The application of ecological principles to land-use planning has become the most important contribution of environmental science (Odum 1971). Of equal concern is the transfer of Western agricultural methods to other parts of the world. Whether these have ever been successful particularly in tropical areas is debatable (Vermeer 1973, Richards 1985). Indeed, concerned scientists are realizing that "agroecosystems" need to be designed to reflect the stability of natural systems (Cox and Atkins 1979).

Models already exist to examine some of the features of an agroecosystem which developed long before Western scientists were present to direct its development. The author has resided for some 17 years on Yap islands, participating in the traditional agricultural system, and pursuing research.

The Setting

The Yap Islands cover approximately 100 sq km of the Western Caroline Islands in the Pacific Ocean. The inhabitants of these islands are best known for their "stone money", huge stone discs quarried in Palau and Guam and transported to Yap on canoes and rafts. A pre-contact population of about 40,000, or about 400 sq km is postulated (Underwood 1969), which compares to a current population density of only 100 sq km (1987 UN Data). That a population anywhere near this dense could have been maintained, and have had enough surplus energy to voyage afar for cultural tokens such as stone money, is a tribute to the traditional Yapese food production system.

Yap is a tropical island with a mean temperature of 27°C with average monthly temperatures varying but less than 0.5°C. This means that decomposition rates are high, and populations of pests and weeds can grow unabated in the absence of a cold season.

Lying near the intertropical convergence zone, the island's rainfall pattern is irregular. In some years, there is a pattern of spring drought followed by torrential rainfall in the summer and autumn months. In other years, rain is dispersed more evenly throughout the year. The mean annual rainfall for the period 1949-1980 was 3028 mm. These climatic conditions present classical problems of how to utilize tropical soils without exposing them to erosion and nutrient depletion.

The topography of Yap permits the collection of rainfall and the flow of water from uplands to lowlands and then into the sea. Variations in elevation have resulted in a series of natural habitat zones where sediments and nutrients carried with this fresh water are filtered out and utilized in a series of biotic communities successively less tolerant of siltation (Falanruw 1980). The force of frequent torrential rainfall is buffered in uplands by forests. Water then flows into coastal depressions which function as silt traps, and subsequently into mangroves where sediments are further filtered out. These sediments undergo decay and chemical buffering amid the specialized aerial roots of these marine forests. Silt which gets through the mangroves flows into deep areas parallel to the mangroves which function as a second silt trap. Much of the remaining silt then settles out in seagrass meadows. The filtering zone serves to maintain the clarity of lagoon waters for marine life requiring sunlight for photosynthetic activity.

The System

The early inhabitants of Yap modified the islands into an anthropocentric food production system incorporating taro patches, tree gardens, and mixed multi-layered gardens alternated with secondary tree cover. Although the traditional agricultural system has resulted in a change in species composition in the various habitats, the ecological function of these habitats has been maintained. Agroforests buffer rainfall and stabilize and develop soil as do forests; taro patches function as silt traps as do swamps; and mangroves are left to perform their buffering, filtering, and fish nursery functions while at the same time providing a source of wood and a nearshore area for fishing and shellfish gathering. Thus, the people's agricultural system is compatible with maintaining the quality of the marine environment which is the inhabitants main source of protein.

The Yapese agricultural system is described in detail in the following sections. Also noted are instances of native land biota maintained in conjunction with the agricultural system.

The Taro Patch

Taro, a tropical plant (*Colcasia esculenta*) of the arum family having a tuberous root, is an important source of food on Yap. Sites chosen for taro patches, usually by ancestors of the present generation, are mostly marshy lowland areas such as exist in swamp forests just inland from mangroves. Sites are deepened, and water is generally directed to flow through a series of depressions. This results in drainage of the land, management of water, and trapping of nutrient-rich silt in the taro patch.

Once established, most taro patches produce continuously. Replanting of the main staple *Cyrtosperma chamissonis* (Araceae), is done at the same time as harvesting, generally utilizing the smaller sucker corms. Numerous varieties of *C. chamissonis* are maintained. Some are valued for their particular texture, others because they are resistant to attack by organisms which bore into the corms, while some grow better in drier habitats. On Yap, women are responsible for growing taro. Varieties are therefore matched to the preferences of the grower and her extended family, and to local conditions which vary with the taro patch, and over time. Thus each woman, or group of women, has a "genetic bank" of planting material to draw upon. The corms of this giant swamp taro reach harvesting size in 1-3 years. However, they can continue to grow and generally some are left to become large. These corms are reserved for special occasions.

Once harvested the corms do not store well and are generally consumed within 1-4 days. The culture of *Cyrtosperma* provides a reliable source of food throughout the year. Most people, at least today, maintain more taro patches than immediately needed, to serve as a supplementary supply for special occasions and times when other seasonal staples fail.

The culture of a second major taro, *Colocasia esculenta*, is more seasonal, requiring initial preparation of the taro patch during the drier part of the year. Culture of this taro is more intensive, and includes the working in of green manures and the mounding of soil about the developing corm which matures much faster than the *Cyrtosperma* corm but cannot be left in the ground indefinitely. A considerable body of knowledge and taboos are involved in the culture of this taro as well, including the choice of green manures, development of a proper growing medium, choice of variety for the site and intended use, management of water flow, and planting and tending of the plant to obtain the desired shape, size and consistency of corm.

The culture of *Cyrtosperma* and *Colocasia* makes use of variations in silt trap habitat and provides a means of obtaining either fast production in years when the dry season permits, or reliable production throughout the year. While a *Phytophtora* fungus has been devastating to *Colocasia* crops in parts of the Pacific such as Bougainville and Manus, its presence in Yap has not been as serious, probably because of reliance on two major genera, disease buffering resulting from the carefully nurtured genetic variability in each species, and a number of cultural practices resulting in reduced incidence of disease.

Each taro patch is a special endowment from one generation to the next, bringing with it a biotic culture resulting from the efforts and expertise of the woman who tended it, generally throughout her adult lifetime.

Living with Yap's taro patch environment is the rail *Poliolimnas cinereus*. While this bird has become extinct in the nearby Marianas Islands (Baker 1951, Jenkins 1983), it continues to thrive in Yap – perhaps as a result of taro culture. Unlike most rails, it builds its nest off the ground between the stems of tall grass or giant taro leaves. Because *Cyrtosperma* requires a long maturation period, the rail's nest is rarely disturbed. The bird is quite common and may be an important biological pest control, as it feeds on insect pests of taro and other crops.

Tree Gardens

Over many generations, tree gardens developed around homes and in the drained areas created by the excavation of taro patches and construction of drained paths between homes and villages. Backyard and pathside tree gardens became confluent and today make up about 26 per cent of Yap's total vegetation.

Trees commonly found in Yap's tree gardens include coconuts, breadfruit, betel nut, "chestnut" (*Inocarpus fagifer*, a legume with a large nut), four species of bananas with hybrids and varieties including those eaten ripe, those most often cooked green or half-ripe, and others utilized not for their fruit but for fibres from the stalk. There are many varieties of citrus including sweet and sour oranges, lemons, limes, lemon-limes, calomondin and pomelo. Also common are mangoes, soursop, *Crataeva speciosa*, (a small tree in the family Capparidaceae with a vegetable-like fruit), starfruit and "pickles" (*Averrhoa* spp.), *Pangium edule, Artocarpus heterophyllus*, cacao, papayas, *Eugenia* "apples", guava, *Spondias* spp, and other fruit trees mixed with timber and wild species of trees and with an understorey of shrubs and herbs useful for food, fibres, medicine, condiments, and ornamentation.

Over 50 species of fruit trees are to be found in these tree gardens. Of species that have long been cultivated by the Yapese, there are numerous locally recognized varieties including for example, 21 named coconut varieties, 28 named breadfruit and 37 named bananas. Each local variety has its special uses. Some varieties of coconut, for example, are prized for their ample meat, others are valued for their fibre, sweet water, medicinal uses, or edible husks. Such tree gardens represent considerable genetic wealth.

Tree gardens recycle nutrients via deep roots and fallen leaves as in a wild forest. They are maintained largely by the pruning activities of their owners who select desired trees by cutting or girdling unwanted trees. Desired species may be planted, but many of the trees propagate themselves. Once established, such tree gardens represent a very energy-efficient system.

Like the taro patch, the agroforest of the Yapese system accommodates wild species. One such species is the fruit bat, *Pteropus mariannus yapensis* (Falanruw, in press). This native mammal is important in pollination and seed distribution. It roosts in colonies generally situated in forests or mangroves and flies at dusk to feeding areas often on the perimeter of agroforests. Fruit bats feed on some of the same fruits that people eat, such as breadfruit, and also on many wild fruits and plant parts. They disperse the seed of these species and there is often a fruit bat tree garden surrounding the agroforests. Fruit bats are in turn the main source of animal protein for the Yapese of more inland villages who, for cultural reasons, have more limited access to marine resources. The bats thus provide a secondary source of nutrition derived from the wild fruits on which they feed.

Intermittent Gardens

Areas usually inland of villages, are used for yam gardens and other crops generally grown in mixed, multi-layered culture. A fallow period is periodically introduced during which secondary growth develops.

Sites chosen for such gardens are relatively well-drained areas of secondary vegetation, and generally the sites of previous gardens within the land available to a family. The choice of site is determined by a number of factors, foremost of which is the intensity of the dry season. An extended dry season is required for vegetation to dry to the point where it can be burned thus allowing sunlight to penetrate a garden area. Other factors include the amount of land, energy, help and need a woman or family has. The soils in areas of secondary forest are fertile, and there is a nearby supply of poles for trellises. Such areas are preferred when it is possible to accomplish the task of preparing them. During years with shorter dry periods, and when land or a woman's time and energy are limited, areas of nearby weedy secondary vegetation are used.

The first step in making a garden is to open a "skylight" in the canopy. This is done by clearing herbaceous vegetation, piling it about trees and burning the vegetation, scorching the bases of trees, girdling the trees, or both as needed. As the trees drop their leaves, the canopy opens gradually so that young plantings receive an increasing amount of light.

The major crop grown in such gardens is yams of the genus *Dioscorea* (family Dioscoreaceae). There are at least six species of *Dioscorea* recorded from Yap. Defngin (1964) lists some 34

Yapese names for locally recognized varieties. Planting material consists of the tops of tubers which have been previously harvested as well as small whole yams. Expertise and experience are involved in the initial clearing of the land, timing of burning to obtain ash fertilizer, preparation of yam holes and planting of yams, including choice of varieties for the site and microhabitat, and the production of desired sizes and shapes of tubers. Some yams require better drainage; some have tubers that grow up rather than down; some vines twine to the right, and some twine to the left. It is preferable to grow yams with long tubers on a hill so that they may be dug out diagonally, or a tuber may be directed to grow down a hollow tree trunk so that it acquires an attractive form. Some varieties are preferred for their potential to grow very large while others are prized for their special texture.

Dried yam cuttings are placed in prepared holes and mounds well mulched with dried vegetation, and provided with trellises. The latter are generally poles, often bamboo, leading to trees which will allow the vines to grow up into the sunlight and produce large tubers. In areas rich in bamboo, trellises consist of tall "tepees" of poles tied together at the top. A border of fallen logs is often formed about the yam plantings and mulch piled within this area. The mulch buffers rainfall, keeps weeds from growing, and contributes to soil structure. The logs catch and hold any soil runoff.

Yam vines generally grow for eight to eleven months and then begin to wither. They are then harvested, usually between October and March. Planting and harvest times vary with the onset and end of the rainy season, which also fluctuates considerably. The mix of species produces an extended harvest. Varieties of *D. esculenta* are generally harvested first. Next come the many varieties of *D. alata*. There is no definite planting and harvesting time for *D. nummularia*. The tubers of some varieties may be left to grow another year so that they become bigger, and others may be left to provide a reserve food or "seed" supply. Yam tubers can be stored for up to two years if well cared for and if the sprout is continually removed. Most yams are valued in particular for presentation on special occasions such as traditional exchanges.

At the time yams are planted – in the most favourable microhabitat – the rest of the garden area is filled in with a mix of other crops, generally in a predictable succession. The first and most common of these are members of the Cucurbitaceae family including pumpkins (*Cucurbita* spp.) and wax gourds, (*Benicasa hispida*), which grow rapidly in the ash fertilizer forming a protective layer of vegetation over the soil as rainfall increases. The cucurbits produce a fast crop and often die back, thus decreasing shading, by the time of the major vegetative growth of the yams and other crops. Sweet potatoes (*Ipomoea batatas*, family Convolvulaceae), pineapples and sugar cane may be planted in suitable areas. Other crops include *Xanthosoma* and perhaps *Colocasia* taro. Banana trees are usually planted, and weeds that are cleared from the garden are piled around the banana trees as mulch. However, papaya trees grow naturally. Today the bush spinach *Abelmoschus manihot*, winged beans, and occasionally *Cnidoscolus chayamana* may be planted. Passion fruit and luffa vines grow spontaneously from rootstalks or seeds in the area. Fruit trees such as lemon-limes, soursop, and *Averrhoa* spp. are often present.

These crops grow rapidly so that a multi-storeyed canopy of leaves is formed by the time the heaviest rains come. The intermediate crops such as pumpkins, wax gourds, bush spinach, and taros are harvested as they mature, while the yams are harvested at the end of the growing season. The garden may be replanted if the soil is still fertile. Otherwise, it is only sporadically tended for harvesting longer-term crops, and gradually abandoned over a period of about three years.

As gardens are abandoned, they are invaded by herbaceous weeds; woody species regrow from partially burnt stumps and underground parts or from plants that were left growing in the garden, causing a canopy to reform. Many of the secondary species that grow in abandoned gardens are utilized. For example, bamboo provides building materials; *Morinda citrifolia* is used for medicine, dye, and as food during famine; and the bark of *Hibiscus tiliaceus* trees provides fibres used for tying, fishing, and making dancing skirts. The ferns growing in the understorey of secondary vegetation existing at a stage where the area can be gardened again, are incorporated into more everyday "grass" skirts. (Materials used in much-publicized attire of Yap women vary with the kind of skirt, but never include grass!) By-products of the food production system such as coconut and *Inocarpus* shells and husks provide cooking fuel. Wastes are fed to pigs or piled about banana trees which thrive on the mulch.

Eventually, if old garden areas are not disturbed, the species characteristic of forests will return. Birds and fruit bats are the agents of seed dispersal. About 33 per cent of Yap's vegetation is made up of a mosaic of forests, intermittent gardens and secondary vegetation at some stage between gardens and forests. This allows for the maintenance of a pool of wild species.

Lessons for Modern Tropical Agriculture

The traditional Yapese agricultural system provides an example of ecological adaptation. Rather than rearranging the environment and applying large inputs of energy, water, fertilizers, and pesticides, it makes use of microhabitat and natural processes. It could be characterized as nature intensive to contrast it with other major agricultural systems which are labour intensive or energy, chemical, and capital intensive.

The natural flow of water, and nutrients carried with this water, are utilized. The tree canopy is manipulated first to provide sunlight for crops and biomass which is converted to ash fertilizer, and later to buffer rainfall and shade weeds. The system is highly efficient in terms of human energy and requires no further external use of energy. Like a natural tropical forest, it is diverse and structurally complex, factors that result in resilience to disruptions, and thus stability in the long run. Despite irregularities in the weather, the system provides major staples throughout the year; the seasonal production of yams counterpointing the breadfruit season, with giant swamp taro providing a supplement throughout the year. Variety is provided by the mixture of tree crops and the mix of species grown in the intermittent gardens. The tree gardens provide long-term stability, and the mixed intermittent gardens utilize seasonal conditions of drought and rainfall.

The Yapese system of agriculture has not always been ideal. There are large areas of the island with degraded soils, thought to be due to overintensive use and too frequent burning so that a tree canopy could not re-form. Such areas bare witness to the dangers of irreversible removal of a tree canopy, and the unsuitability of open-canopy cultivation under tropical conditions. Modern techniques such as the use of matches, the burning of rubber tyres around tree bases, and especially clearing with bulldozers are tipping the land use balance in the direction of unsustainability.

The Current Situation

For a nature-intensive system to work, people must be very aware of natural phenomena. There are today a growing number of distractions such as television and the schedule of Government jobs and aid programmes, to divert people's attention from natural phenomena and traditional food producing systems. In addition, the import of goods, energy and technology have made it possible to forestall the consequences of ignoring the basic rules of caloric self-sufficiency and sustainability of lifestyle. Anthropocentric indicators of the islands' limitations, such as difficulty in feeding a growing population, are no longer present. It is ironic that the traditional Yapese system is eroding at a time when the value of agroecosystems is beginning to be appreciated, and ecologists and planners are trying to alleviate the problems brought on by the hasty application of the Western development formula. The changes which are possible as a result are rapid, spectacular, and so attractive that they lead people to disparage their own resources, technologies and traditions of production.

Scientists' recognition of the value of many traditional practices is coming at a time when there is a rush for development based on the Western development formula of applying money, energy, strong chemicals, and powerful technology to a given situation. In as much as the agricultural revolution was brought about by farmers, not scientists (Richards 1985), it follows that the "agroecological revolution" required to alleviate many of today's environmental problems must draw upon existing examples of agroecosystems. It is thus imperative that scientists and development agencies recognize, learn from, and build upon nature intensive systems such as that described here before the knowledge, motivation and intuition which are fundamental to the effective working of such systems disappear.

DOING WHAT COMES NATURALLY: ECOLOGICAL INVENTIVENESS IN AFRICAN RICE FARMING

Paul Richards

Broadly speaking, European, Asian and African agricultural practices are the outcome of three distinct trajectories of technological development. European (and North American) agriculture has long pursued the option of substituting machines for labour (Boserup 1965). The pattern in Asian agriculture (most especially in East and South-east Asia) has been to emphasise labour-intensive managerial innovations. Wet rice cultivation, in particular, requires field skills for which there are few readily-available mechanical substitutes. The practical primacy of skilled labour over machines has tended to favour high rural population densities and small-scale intensive production units (Bray 1986).

Sub-Saharan Africa (especially the humid zone) exemplifies a third and quite separate pattern of agricultural development (Richards 1985). Here, adoption of management-intensive agricultural techniques has been inhibited in many areas by historically low population densities (a set of circumstances exacerbated by the slave trade and by massively dislocative epidemics – e.g. rinderpest, venereal diseases and influenza – associated with the spread of international "market forces" in the 19th century). But at the same time, African tropical environments, although rich and fertile in some respects, are often ill-suited to agricultural mechanization along European and North American lines. For example, traction difficulties and the danger of accelerated soil erosion both place sharp limits on the extent to which tropical forests can be efficiently and safely cleared, stumped and ploughed. European and Asian models for agricultural change appear to be equally inappropriate in African circumstances, therefore, and Africa has to find its own way forward.

The chief characteristic of an indigenous approach to agricultural change is the stress given to ecological issues. Although of necessity any agricultural production system combines mechanical, managerial and ecological elements, there is nevertheless something distinctive about the ecological emphasis in the African case. Time and again, the evidence suggests that in Africa farming is thought of not so much as a battle against nature, but as a series of variations upon themes and processes observed within nature. Part of the conceptual legacy of shifting cultivation is the notion that a "farm" comes from the wilderness, is a variation upon it, and returns to wilderness once again. There are no permanent winners and losers. The ecological pulse of the wilderness is the ground bass around which many small-scale farmers in Africa improvise ingenious agricultural variations. Virtue and profit (to change the metaphor), reside in attempts to hitch a ride upon, rather than to over-ride and forcibly control, processes observed "in nature".

Prior to the rise of modern ecological theory (Worster 1978), outside observers were often impervious to the complex and subtle principles upon which African agricultural systems were based. Innovations such as shifting cultivation (rotational fallowing), intercropping and floodretreat irrigation were frequently misconstrued as evidence of the "backwardness" and "primitive mentality" of African farmers, and not (as they ought more properly to have been regarded) as practical applications of fundamental ecological insights. Although a number of pioneer ecologists began to take African farming systems seriously in the 1930s, the prevailing view in government departments and development agency circles in the last 50 years has been that if European methods of production could not be adapted to African circumstances (as suggested by the Groundnut Scheme in Tanzania) then the Asian option was the obvious alternative to which to turn, (hence recent efforts by the World Bank and other agencies to conjure up an African version of the Green Revolution). Only now, in the aftermath of an appalling series of droughts and famines, and the evident failure of many Green Revolution initiatives, has the climate of opinion begun to shift away from technology transfer and towards a greater interest in the possibility of agricultural research and development based on local understanding of agro-ecological dynamics.

This chapter attempts to characterize one such local ecological dynamic in African agriculture. The focus is upon traditional rice farming strategies in central Sierra Leone. The case study suggests that local ideas about rice farming are grounded in a solid and effective understanding of landscape, soil and vegetation processes, and that this understanding is open to the possibility of future elaborations so far unexplored by development agencies, who have preferred to concentrate on a technology transfer strategy under the assumption that African agriculture has little potential for change from within.

Case Study: Catenary Rice Farming Systems in Sierra Leone

After the hunger and food riots of 1919, Governor Wilkinson of Sierra Leone decided that the country's difficulties were due to the survival of an especially outmoded form of agricultural production – shifting cultivation of dry rice – and that the answer would be to promote irrigation agriculture along Asian lines, (he had previously seen colonial service in Malaya). Accordingly, a rice expert from Madras, A.C. Pillai, was sent for to advise on the problem. After a year's careful study, Pillai respectfully reported that Sierra Leone farmers were not unfamiliar with methods for cultivating wet rice and that their yields were often better than those achieved on similar land in Madras. The Colonial Secretary, Winston Churchill, minuted that there seemed little the administration could teach the denizens of the swamps of Sierra Leone, other than to exhort them to continue with what they were doing already. Nevertheless, this did not deter the administration, nor has it deterred development agencies in Sierra Leone since, from imagining that enlightment would come from the East – that Asian rice technologies should substitute for African.

The most recent phase in this saga of technology transfer from Asia to Africa began in the 1960s. Taiwanese experts were brought in to develop labour intensive water control methods for double cropping of high-yielding varieties in inland valley swamps (in effect, to introduce the classic Green Revolution rice package). These developments were subsequently promoted country-wide by the Peace Corps, the Food and Agriculture Organization, and later by Integrated Agricultural Development Projects funded by the World Bank.

Many farmers in Sierra Leone reject Asian swamp rice cultivation techniques promoted by these agencies not because they are hostile to the cultivation of swamp rice, but because labour requirements and timing of field operations are incompatible with local farming methods based on carefully integrated exploitation of the soil catena. Development agencies think of wet and dry rice as binary oppositions. According to this scheme, dry rice is "primitive" and wet rice "modern", and therefore the aim of policy should be to replace the former with the latter. Local farming methods approach wet rice cultivation through a different route. Wet and dry, valley and upland, like shifting and permanent cultivation are points marking the extremes on a continuum. The important issue is not the labelling of the extremes but what happens in between. There is no more sense in treating wet and dry rice as substitutes than in imagining that our lives are more fully developed when our end replaces our beginning. (Incidentally, this coincides with the botanical position: botanists reject any clear-cut categorical separation of "wet" and "dry" rices.)

Wet and dry rice are categories of minds schooled in the property relations found in long-settled, high-population density districts. The historical experience of long-fallow agriculture in Africa has produced a rather different set of sensitivities and perceptions. African shifting cultivators bring to their task a much greater awareness of the importance of process continuities in landscape and vegetation communities, and a sense of how these continuities might be manipulated in the farming process. The essence of local agricultural strategies in many parts of Sierra Leone (as elsewhere in the West African rice zone) is the notion of adjusting to seasonal irregularities by integrated management of the soil catena. In effect, the essential aim is to find ways of cultivating different rices in different soil and moisture environments in ways which are complementary rather than competitive.

Let me illustrate from fieldwork in a village, Mogbuama, in central Sierra Leone (full details of this study are to be found in Richards 1986). Here, there are three broad categories of rice cultivation. The first rices each year are quick-maturing types planted on low-lying land with moisture retentive soils. Three soil/land types are involved. "Tumu" soils are derived from old river terrace materials at the foot of the escarpment. "Nganya" soils are located on the lower arc of the catenary profile on valley sides in the zone of granitic rocks to the east of the settlement. "Bati" farms are located in deep-flooding grasslands along the banks of the two major rivers flowing through Mogbuama territory. Early rices can be grown in all three contexts. Farmers with "bati" and "tumu" land specialize in early rice, and often have surpluses for sale when prices are at a maximum. However, cultivation in these two settings tends to be risky. Unseasonal early rain may make it difficult to burn the cleared farm, for example. Most of the early rice grown on "Nganya" soils is for subsistence purposes only. Here, farmers have the chance to plant up the valley slope, and to vary their planting strategies according to the particular rainfall characteristics in any given season. Rice yields on "tumu" and "bati" farms are ca. 1200-1500 kg/ha. Yields on valley-slope farms in the granite zone are ca. 20-30% lower, but more reliable.

A typical early rice matures within 100-120 days. Therefore, rices planted on tumu and bati farms in April are ready for harvest, at the height of the hungry season in July and August when rice prices double. In consequence, every farmer tries to plant some quick-growing rice, even if only for subsistence purposes. The quickest varieties (e.g. the "glaberrima" rice, "pende") ripen within 90 days. In Mogbuama in 1983, 63 out of 98 households had some quick maturing varieties planted on low-lying land.

Medium duration rices are planted on upland segments of the catenary profile when the rains are well-established. Taking on average 120-140 days from planting to harvest they are higher yielding (though often not by much) and more reliable than many of the quick rices. Seventy per cent of all farm land in Mogbuama in 1983 was planted to medium duration varieties of this kind. The upland farm is still the main focus of attention for the majority of Mogbuama farmers.

The third category of rice cultivation in Mogbuama is that which embraces the long-duration flood-tolerant rices – "yaka" in Mende – broadcast on dried-up water courses during the earlier part of the farming year and then left to grow on the rising flood while other more urgent matters are attended to. "Yaka" rices take 150-200 days to ripen, and are generally ready for harvest between November and January. "Yaka" rices yield well – up to 2000 kg/ha or more on occasions. Because the rising flood suppresses weed growth, and due to their ability to adjust to varying depths of flood, "yaka" rices need little attention after the initial effort of clearing the water course into which they are planted.

Through experience of "yaka" rices, farmers in Mogbuama are not unaware of the high yields associated with swamp cultivation. However, they are thought not to taste as good as any of the other types of rice. A farmer planting "yaka" rice does so with the intention of selling it. This is why this type of swamp cultivation is not a matter for household initiative. The first concern of the household labour group is to secure the family's subsistence each year. If there is time left over, then individual members of the household may grow "yaka" rice as a private business venture. Therefore, much of this type of rice is grown by women and young male dependants. High yields – sometimes double those obtainable on upland farms – are tempered by the fact that all "yaka" rices are long duration varieties, and are only ready for harvest after the main rice harvest when prices are at their lowest. This is why the cultivation of "yaka" rice is only ever seen as a useful supplement to upland rice cultivation, and not as a substitute for it.

Rightly or wrongly, farmers perceive the swamp cultivation techniques promoted by development agencies in Sierra Leone as belonging to this third category of rice farming. Many of the high-yielding "improved" varieties promoted by these agencies are classed by farmers, on grounds of their ancestry, duration and taste, as "yaka" rices. In Mogbuama in 1983 about 15% of all land in cultivation was planted to "yaka" rices, which in turn produced about 20% of the total rice crop by weight, but, because of the seasonal price swing, only about 12% by value. Of 59 distinct rice varieties planted by 98 Mogbuama farm households, 10 could be classed as "yaka" rices (15 were quick-growing rices, and the balance, medium-duration "upland" varieties).

The major constraint on agricultural output in Mogbuama is labour supply. Labour bottlenecks occur during May and June at the peak of the rice planting season, (labour hire rates increase by 50% between April and June), and then again in October at the peak of the harvest season. There is often a shortage of women's labour for weeding during July and August, made worse by hungry season shortages of cash and food. Given these constraints it is now possible to see the logic behind the balance Mogbuama households aim for in combining some early rice cultivation (typically 15%), with upland farming (typically 70%) and some cultivation of long-duration swamp varieties (typically 15%).

Such combinations ameliorate the labour bottlenecks by spreading out planting, weeding and harvesting operations over as long a period as possible. In addition, quick rice helps reduce the problem of the hungry season, upland intercrops provide variety of diet and useful cash crops, and the "yaka" rices provide individuals within the household with a sideline to meet their need for cash income while interfering as little as possible with household fanning activities.

Officially recommended swamp cultivation practices threaten this delicate balance. Bunded swamps are in general much more labour intensive than local swamp cultivation techniques. A bunded swamp competes for labour with other farming activities in the critical period from May to August. Unlike "yaka" rices left to fend for themselves on the rising flood, management of a bunded swamp cannot be fitted into spare moments during the peak season. Thus, it is difficult for farmers to build the skill and experience necessary to make a success of water controlled swamps while still hanging on to their tried and tested upland methods. Water controlled swamps require an all-or-nothing commitment from the outset. Few farmers can risk taking such a step in the dark. Even the best Green Revolution rices cannot yet out-perform the speediest of local quick-ripening varieties. In consequence, farmers cannot yet see any advantage over their own methods for ensuring an early harvest. Bunded swamps produce only rice, and yet intercrops are vital for household subsistence, and as a source of additional earnings.

Many small-scale farmers have concluded, therefore, that their mix of quick rices on moisture retentive soils, upland intercropping and low-intensity swamp cultivation represents a better, safer, more productive package than anything on offer from development agencies. Until these agencies can devise swamp cultivation techniques that integrate rather than compete with the other vital concerns of the average farmer they will continue to see their investment capital sink without trace into the swamps of Sierra Leone. The irony is that farmers are already experimenting on their own account. These experiments (described in detail in Richards 1986) are shaped by the logic of the catenary system as a whole, and the values and historical perceptions that it embodies. They include an interest in intra-specific intercropping (of long-duration and short-duration rice varieties) on bati land; attempts to select for bird resistance properties (e.g. awns) in early-ripening rices; new intercrop mixes on uplands; selection of varieties producing effective rattoon growth; and application of stick bunds to reduce the high risk of soil erosion on the lower sections of the catenary profile.

Conclusion

If formal sector research and development programmes are to benefit rice cultivators (and other food-crop producers in Sub-Saharan Africa) it is increasingly apparent that they will have to work with, rather than against, the grain of such localised perceptions, practices, and trajectories of change and innovation. Policy must attune itself to the ecological lessons of African historical experience. Above all, this means it must appreciate and capitalise upon the legacy of what African cultivators have learned about ecological dynamics from their prolonged and profound experience of shifting cultivation.

TRADITIONAL ENVIRONMENTAL KNOWLEDGE AND RESOURCE MANAGEMENT IN NEW CALEDONIA

Arthur Lyon Dahl

Based on work, prepared for the South Pacific Regional Environment Programme (SPREP), and revised from A.L. Dahl, "Traditional environmental management in New Caledonia: a review of existing knowledge", SPREP Topic Review 18, South Pacific Commission, Noumea, New Caledonia, 1985. Permission to reuse this material is gratefully acknowledged.

While much has been written in general terms about indigenous peoples knowledge of and care for their environmental resources, only a few detailed case studies in widely scattered areas of the Pacific can be found in the literature. Outstanding among these are the work of Johannes (1978, 1981) on fishing in Palau, of Barrau (1956a) on agriculture in New Caledonia, and of Spriggs (1981) on taro irrigation in Vanuatu. References to environmental knowledge elsewhere in the literature are dispersed and often anecdotal. At times, their environmental context and importance have not even been understood.

This review examines the scope of traditional Kanak knowledge of the environment and of their approaches to environmental conservation and management in New Caledonia, insofar as these can be determined from published sources. Discussions with both Kanaks (the Melanesians of New Caledonia) and ethnologists provided additional indications and examples of the extent of traditional knowledge. The perspective used is that of an ecologist rather than an ethnologist, and thus without any pretension to ethnological rigour. All the published sources cited are by Europeans (with the inevitable disadvantage of viewing a culture through foreign eyes), and some are known to be unreliable or biased in their interpretations, but such weaknesses may be less apt to affect environmental information than other dimensions of traditional culture. However, in one instance in this study where it was possible to check with knowledgeable local informants, erroneous information published by a well-known ethnologist was apparently given to him as a joke. While the detailed information in many published sources still requires confirmation by the Kanaks themselves, the general conclusions seem to be valid.

Present state of knowledge

It is clear that only a tiny fraction of the environmental knowledge in Kanak culture has ever been recorded. Much has already been lost, and the old men and women who still possess such knowledge reasonably intact have not passed it on to the next generation; it is dying with them. There is clearly some hesitancy to pass on this precious heritage either outside the family line, or to those who do not appreciate it. Persons of middle age often recall the existence of such knowledge from their childhood, but for them it has fallen into disuse, and their personal experience in its application is generally limited. The young in general have seen no pertinence in such traditions to a modern way of life, and have thus remained disinterested, although this may change with the current revival of interest and pride in Kanak culture.

There are many reasons why so much of this traditional heritage has been lost. For generations, the "superstitions of primitive peoples" have been discredited by missionaries, administrators, educators and European colonists. Father Lambert (1900), for instance, declined to record all the "superstitious ceremonies related to fishing. It is sufficient to say: pity our poor natives, may we appreciate and encourage the apostolic work, which alone is capable of dispelling such darkness". Children are no longer educated in the family or the tribe, but in schools where Western-style education has given little time to traditional cultures. Traditional patterns of social organization for collective action have been disrupted, making it impossible to continue group occupations such as collective fishing or the irrigated cultivation of taro. New occupations in towns, mines or commercial a griculture have attracted the most able, and reduced the extent of traditional subsistence activities. Traditional knowledge no longer passes automatically from father to son or mother to daughter. Even where subsistence activities have continued, new technologies have replaced old, and the old knowledge has seemed superfluous even where it would still be useful. The technological solution is an easy temptation for all societies.

Clearly there is no point in going back to a traditional technology such as hand-woven sennit nets when new nylon nets are readily available and more efficient. However, much of the knowledge of the fisheries resources is even more necessary today if catches are to be maintained and overfishing, made easier by new technologies, is to be avoided. The same is true in many other areas of resource use. Many imported development approaches have proven destructive of the resource base, and local traditional techniques which have been adapted to local conditions and refined over centuries may provide a better guide to sustainable development (Barrau 1978). The originally productive land and native irrigation systems in New Caledonia were degraded by European cattle raising in the first 50 years of colonization, leading to erosion and the replacement of useful species by introduced weeds (Barrau 1953a, 1954).

As will be apparent from this review, some areas of traditional knowledge have been reasonably well recorded, while others have entirely escaped the interest of Western scholars. The number of studies in depth based on extensive field work is very limited; many papers simply repeat the observations of earlier workers with slight additions or reinterpretations. Often the existence of some type of knowledge or practice has been noted, but the actual content of necessary detail has not; a reference to the flowering of a tree is of little use without knowing which tree is being referred to. Even more unfortunately, the literature consists entirely of reports by outside observers. No Kanak has yet come forward to record his own culture free of the biases inherent in any outside perspective. Perhaps this review will stimulate others to fill the lacunae identified here.

Studies of traditional life in New Caledonia fall naturally into three groupings. The first in the nineteenth and early twentieth century records of exploration, early scientific research, and missionary observation. These tend to range over many subjects, but often include scattered items of environmental interest, particularly since the decline in Kanak culture was still in its early stages. Publications are very sparse in the second period to about 1950, with the outstanding exception of the work by Maurice Leenhardt. The postwar period has seen at least two generations of outstanding work in ethnology, geography, sociology and botany, among other fields, but much of this has come too late to capture more than fragments of traditional knowledge. For convenience, this review will group traditional practices by the type of resource or activity concerned, as this best follows the usage of most past authors.

Agriculture

Since agriculture was the basis of Kanak society in New Caledonia, it is only natural that it is the most widely documented aspect of traditional resource use. Early travellers such as Garnier (1875) and Lemire (1884) were particularly impressed by the irrigated taro terraces. Lemire also noted the scarcity and hunger created by the problem of bridging the gap between harvests. Glaumont (1897) singled out the important features of yam mounds as structures to trap rainfall in the dry season while protecting against erosion and flooding in the wet season. He also described the extent and ingenuity of the systems of taro irrigation. Lambert (1900) devoted two chapters to agriculture, with much useful information in spite of his bias as a missionary trying to destroy the superstitions of the natives. Among other things, he noted the pleasure many villagers found in brushfires set while clearing gardens, a problem of poor resource management that continues today. Jeanneney's (1891) advice on agriculture includes much useful information, but he does not indicate its origin, although some must certainly be traditional.

The essential features of Kanak agriculture are now reasonably well understood. The two principal crops in pre-European times were yams (*Dioscorea* spp.) and taro (*Colocasia* and related genera), both the subject of intensive and highly specialized cultivation techniques which have been described many times. For New Caledonia, the study by Barrau (1956a) is perhaps the most complete.

Yams are a dry land crop with great cultural significance. They are grown in mounds specially prepared to provide ideal conditions for tuber development. On slopes, these mounds are crescent shaped with the points down hill. Stone or clod retaining walls were often used to retain mound form, and the channels near the points were generally lined with stones to prevent erosion (Leenhardt 1930, Barrau 1956a). On valley bottoms and along streams, the mounds were circular or more often linear, three to four metres wide, more than one metre high, and sometimes extending for several hundred metres (Doumenge 1974a). Lands subject to heavy flooding were avoided (Saussol 1979). The channels dug out to make the mounds provided drainage and helped to protect against flood damage during the wet season (Barrau 1956a). The slopes of the mounds were often planted with sugar cane and other crops to retain the soil; windbreaks and mulching were also used (Barrau 1956a). The vines were trained up straight poles, which could be removed in the event of a cyclone; basket-like trellises were used in the Loyalty Islands. Special techniques such as planting the yams over hollow cavities allowed the production of tubers up to two metres long (Leenhardt 1930, Guiart 1963). The different soil conditions in the Loyalty Islands dictated different agricultural techniques (Guiart 1963).

Taro requires saturated or continually humid conditions for growth, which with the seasonal and irregular rainfall patterns of New Caledonia makes irrigation essential (Curry 1960). Legend records that the technique of irrigated taro cultivation was brought long ago by foreigners who made many mistakes at first (Leenhardt 1930, Barrau 1956a), but the numerous traces of terraces show the extent to which the art was developed and perfected locally. Water was captured high up on permanent streams and conveyed through canals, often over several kilometres, to slopes where terraces could be constructed. Aquaducts were used to cross depressions, hollowed trees were used to bridge gullies, and special overflows protected against damage in heavy rains

(Leenhardt, 1930, Doumenge 1974a, Spriggs 1981). Terraces generally two to six metres wide were carved out of slopes up to 80 per cent (Barrau 1956a), with an outer wall sometimes reinforced with stones or logs. Stone-lined spillways and sluice-gates directed the water from one terrace to another, and permitted precise control of water flow (Leenhardt 1930), but the systems required constant surveillance and maintenance. The hydraulic works were protected by a code of prohibitions and taboos (Leenhardt 1930, Barrau 1956a, 1965). Earthworms were a significant cause of leaks. Plantings along the banks had both magical and practical significance in stabilization and erosion control (Leenhardt 1930). Some heads of valleys became great amphitheatres of taro terraces. These terraces were also developed along streams, and in low swampy areas where the taro was planted in raised beds (Barrau 1956a). Similar types of irrigated taro cultivation are still practised in some parts of Vanuatu (Barrau 1956c), where they have recently been thoroughly documented (Spriggs 1981).

Both yams and taros are maintained as vegetatively reproduced clones (Doumenge 1975). Many varieties were imported at different times (Dubois 1951, Barrau 1956a, 1967b), and others were probably generated spontaneously in gardens long left in fallow (Haudricourt 1964). The result was a large number of varieties adapted to different culture conditions and harvest times, which were grown in different gardens and even different parts of a terrace or mound (Barrau 1956a). One village was reported to maintain 25 varieties of taro (Barrau 1962). There was an obvious awareness of the importance of these varieties, and new forms were sought out and tried (Haudricourt 1964). While various lists or descriptions of these varieties have been made (Straatmans 1950, Barrau 1956a, Haudricourt 1964, Bourret 1973), the precise conditions for which they were adapted have seldom been noted, nor has there been a comparable effort to preserve the varieties themselves, and with the decline in subsistence agriculture and the collapse of irrigated taro cultivation, a large part of this valuable genetic resource base has probably been lost (Barrau 1956a).

Many secondary crops, such as sugar cane, bananas, and other fruits, greens and nuts, were grown in and around these staples, or gathered in abandoned gardens or in the wild. For instance, the root of magnagna (*Pueraria thunbergiana*) provided both food and fibre (Garnier 1875, Barrau 1956b, Haudricourt 1964). In one tribe, its use as food was restricted to times of drought (Guiart 1963). Other edible plants were used only in times of scarcity; these may have been more important in early pre-cultivation times (Dubois 1951, Barrau 1956a, 1960). Other plants were important sources of fibres and other materials. These useful plants have been reasonably well documented elsewhere, so no attempt will be made to discuss them all here (Vieillard 1862, Vieillard and Deplanche 1863, Lanessan 1886, Virot 1951, Barrau 1953b, 1956a, 1958, 1962, Dubois 1971, Doumenge 1975). Unfortunately, some listings of useful plants do not indicate whether the use is traditional or a European introduction (Jeanneney 1891, Barrau 1950, Bourret 1981).

There were two principal constraints on traditional agriculture in New Caledonia. The first was the difficulty of maintaining an adequate food supply all year round. References to periods of scarcity and the use of less palatable foods for the forest are common. The yam is a seasonal crop, and while it can be stored for about six to ten months under cool dry conditions (Guiart 1963), there is often a gap before the next harvest, especially if much of the supply is consumed at an important event. Taro keeps only a few days after harvesting, but with irrigation it can be planted all year round and held in the ground for a long period after maturity. This was a principal justification for the effort of maintaining irrigated taro. The potential for growing both of these staples also varied from one area to another, and in some places it was necessary to rely on lesser crops (Guiart 1963). The accumulation of agricultural surpluses was therefore impossible (Guiart 1963, Doumenge 1982), and a system of exchanges for immediate consumption remained the basis of the economic system (Guiart 1963). The food supply was also vulnerable to disasters such as cyclones, and plantings were fragmented for better security (Doumenge 1982). The success or failure of a crop depended on factors beyond human control, and much traditional magic was an attempt to influence these factors. With the introduction of new crops and imported foodstuffs, uncertainity about a reliable food supply is now less of a problem.

The second constraint was the lack of methods for maintaining or improving soil fertility (Doumenge 1982). In spite of the great investment in constructing terraces or mounds, only a single harvest was generally possible before yields declined. A fallow period of three to ten years was often necessary before the land could be used again (Barrau 1956a; Doumenge 1975). This meant that extensive areas of land had to be developed, with a large percentage in fallow at any one time (Doumenge, 1982). Europeans unaccustomed to such a system often interpreted fallow land as abandoned land, leading to assumptions that the population did not need so much land, and even to projections of a much larger Kanak population in the past (Roux 1983). The creation of the reserves and the consequent reduction in agricultural land available to the Kanak population made such long fallows impossible, resulting in declines in soil fertility and productivity (Barrau 1956a). Destruction of forests and frequent burning have only accelerated the problem (Barrau 1958). The adoption of intensified cultivation with new crops, and European techniques of cultivation with their consequent accelerated erosion can only make matters worse (Barrau 1956a). Inexpensive soil supplements or means of maintaining soil fertility are needed to resolve this problem in modern subsistence agriculture (Barrau 1958).

The agricultural calendar is one of the most critical aspects of any agricultural system, yet little information on this has been preserved. Leenhardt (1930) gives a general description of the yam calendar from clearing the land in July through planting in September and October, to the start of the new yam harvest in March. Lambert (1900) noted that the time for yam planting was marked by the rise of a particular constellation. However, the details in terms of adaptation to particular local areas, weather patterns, crop varieties, and other factors are lacking. Even Leenhardt's (1947, see 1979) valuable study of Melanesian concepts of time provides little further information. The potential for variation is shown in a comparable yam calendar for Pentecost Island, Vanuatu, where yams are planted in November-December and the new yam harvest begins in May (Muller 1975). Even Spriggs' (1981) valuable study of taro cultivation is silent on questions of timing. Such timing was one of the most important aspects of Melanesian life, to the point that plants such as yams that permitted man to situate himself in time were given magic or ritual qualities (Barrau 1967a). Counting or measuring time does not seem to have been part of Melanesian culture, so there was more reliance on celestial events and on a calendar by association with events in nature such as the flowering or fruiting of trees (Lambert 1900, Leenhardt 1947 see 1979, Barrau 1958). However, other than two examples given by Leenhardt, there seem to be no published records of what these associations actually are, although this type of information is readily volunteered even today.

Another area where the published record is silent is on the traditional control of plant pests and diseases. Even though the number of such problems has obviously increased with European introductions, there must have been traditional control methods that have apparently escaped observers' attention.

Traditional agriculture in New Caledonia has declined steadily since the arrival of the Europeans, and today only the simpler types of subsistence cultivation remain. Garnier (1875) describes taro terraces on Mont-Dore already abandoned in 1864. The European introduction of cattle that trampled hillside structures and raided gardens was disastrous for the irrigation systems on which taro depended (Leenhardt 1930, Barrau 1956a). It is possible that introduced deer (Barrau and Devambez 1957) may have had a similar but less noticeable effect. With the displacement of many clans from their ancestral lands, and the colonization of the best agricultural land by Europeans who did not understand or appreciate traditional agriculture, the continuity of agricultural development was broken. The population decline, the breakdown of traditional social structures, the competition for land and labour from cash crops such as coffee and other employment, the introduction of crops easier to cultivate such as manioc, and the availability of imported foods have all contributed to the collapse of traditional agricultural systems (Barrau 1956a, 1958, Curry 1960, Doumenge 1974b). In the Canala area, the number of populated centres has declined from 150 to 30 and the formerly cultivated land had been reduced by half by about 1970 (Doumenge 1974a). The nickel "boom" at that time brought traditional agriculture to its lowest point ever, but there has been some return to the land since the end of the boom (Bourret 1978). Even where yam cultivation continues, the less demanding varieties are now preferred. Little remains today of the elaborate and sophisticated agricultural systems of the past.

Fishing

Compared with agriculture, the documentation of traditional fishing has been greatly neglected in New Caledonia. Only one significant paper is devoted in part to fishing methods in the territory, including a few references to traditional methods (Legand 1950), and there is nothing comparable to the excellent studies done elsewhere in the region (for example Nordhoff 1930, Johannes 1978, 1981, Gillett 1984) although research on the subject is now in progress (I. Leblic and M.-H.Tuilieres, personal communication). From the scattered references, the following picture of traditional fishing knowledge can be constructed.

Fishing was a significant activity for coastal people who claimed property rights over fishing areas (Lemire 1884, Guiart 1963), and who often traded fish for other staples grown in the interior (Barrau 1956a, Guiart 1963). Early observers often commented on the abundance of marine resources such as *Tridacna* clams (Lemire 1884, Legand 1950) and turtles (Legand 1950).

The basic fishing techniques seem similar to many Pacific Island areas. Women gleaned crabs, sea urchins, octopus and various shellfish (Locard 1896) from reef and mangrove areas accessible at low tide (Lambert 1900). Fishing with nets, lines and spears was a men's occupation (Lambert 1900). Nets were made with fibres from a forest vine (Garnier 1875) or with coconut fibre (Legand 1950) and could reach 50 metres in length (Lambert 1900). The fish encircled with such a net were grabbed, clubbed or speared (Lambert 1900, Legand 1950). Special large nets were made for catching turtles (Lambert 1900, Legand 1950, Guiart 1963). Smaller nets served to catch sardines or mullet (Lambert 1900). Coconut leaves were also used to encircle fish (Legand 1950). Fish traps were constructed, particularly in the Loyalty Islands, and were sometimes baited with papaya leaves (Legand 1950, Guiart 1963). Dugong were hunted when possible (Lemire 1884, Legand 1950). Turtle eggs collected on the beach were reserved for the chief, at least in the south (Garnier 1875).

Poisons from various plants were also used for fishing (Legand 1950) in both rivers and the sea, and the plants used have been documented (Virot 1950) – in the case of *Euphorbia kanalensis* they were even cultivated (Barrau 1956a). Traditionally such techniques were used judiciously and in moderation (Barrau 1956a). Lambert (1900) reports that a bundle composed of three (unidentified) plants was placed in the sea to attract sardines. A lure made of a rock or shell, with coconut leaf tail imitating the form of a rat and suspended from a fishing pole, was used to catch octopus (Legand 1950). Metais (1976) describes a unique technique for collecting shells for shell money on the fibre skirts of old women, but when this technique was described to some of the few old people who still make shell money it brought only laughter; the ethnologist's informant apparently told it as a joke.

There appears to have been an extensive lore linking the flowering or fruiting of various trees with the best times for catching different species of fish. Lambert (1900) refers to a women's song listing the trees that flower on the arrival of the fish. Leenhardt (1947 see 1979) notes that erythrine flowers are the signal for the shark hunt. My informants have confirmed the widespread occurrence of this type of information. Unfortunately, the details as to which flower is associated with which fish in which area have never been recorded.

Most island peoples observed a complex set of rules governing fisheries which ensured sound management of the resource. This would seem to have been the case in New Caledonia, as Guiart (1963) describes a ban on fishing on Ouvea for the fist six months of the year. However, no further details are given and no other references to such practices have been found in the literature. Similarly, Pacific Islanders had detailed knowledge of the behaviour, migration and reproduction of different species of fish, and of the best locations and times to catch them (Johannes 1978), but none of this has been recorded for New Caledonia.

Subsistence fishing has suffered the same decline as agriculture, and those techniques requiring collective effort are rarely if ever practised (Metais 1976). The changes brought by European fishing technology and improved boats have probably been even greater than in agriculture. Even with the great areas of reef and lagoon available in New Caledonia, overfishing has become an increasing problem. A return to more traditional fisheries' management techniques might be a solution, but so little has been recorded and so much time has passed that it may now be too late to try to salvage or reconstruct them.

Hunting

The lack of adequate sources of animal protein on the land was a major problem, especially for tribes without access to or an orientation towards the sea. The forest only provided flying foxes (fruit bats) and pigeons (notous) as game worth hunting (Guiart 1963). The land snail (Barrau 1956a) and certain grubs were also eaten. None of the lore associated with traditional hunting seems to have been recorded.

As in other societies where animal protein was limited, the desire for flesh was frequently expressed (Lambert 1900) and cannibalism was practised (Lemire 1884). Kanak legends often describe wars motivated by a desire for meat, and in certain areas it was a role of certain families to supply one of their members for the chief's meat. The European introduction of large mammals has made other sources of protein widely available. Deer in particular have helped to fill the meat requirement of tribes in the mountainous interior (Barrau and Devambez 1957).

Medicine

The one aspect of traditional medicine that has attracted scholarly attention is the use of medicinal plants. Apart from the general lists of useful plants described above, which often include medicinal uses, there have been a number of studies specifically on medicinal plants (Lenormand 1948, Guillaumin 1951, Barrau 1957, Rageau 1973, Bourret 1981) although some of these do not distinguish between pre-European and more modern uses of these plants.

Traditional medicine is known to include both rational and psycho-therapeutic techniques, together with a folk classification and nomenclature of ills and diseases, and involves both simple family remedies and specialist healers for different types of treatments (Barrau 1966). Traditional surgeons, for instance, were able to replace parts of the skull with coconut shell (Metais 1976). It is the specialist knowledge that is particularly difficult to obtain and that is rapidly being lost (Barrau 1966, Metais 1967). By the mid-1960s the surgeons had disappeared in New Caledonia, and only one traditional midwife remained (Metais 1967). The documentation on this aspect of traditional knowledge is almost non-existent.

Technology

Traditional technology involved the knowledge and skills necessary to use the materials available in the environment to meet various human needs. A few of these techniques, such as the fabrication of bark cloth and various types of string and rope, have been noted (Lambert 1900) as have the techniques for pottery (Leenhardt 1930), working jade (Garnier 1875) and the fabrication of different implements (Lambert 1900, Leenhardt 1930). However, the skills that can only come from practical experience with these techniques have largely been lost.

While Kanak huts sometimes achieved the spectacular proportions of up to nine metres diameter by twelve metres high (Leenhardt 1930), they were originally condemned by the administration as unsanitary (Guiart 1956) and every effort was made to replace them by European-style constructions. However, the closed hut was much better adapted to the hot days, cold nights and mosquitoes of most rural areas, than the corrugated iron shacks that were built to replace them, and today many families keep both. With time, other qualities of the Kanak hut came to be appreciated, such as its flexible construction that made it very resistant to cyclones (Guiart 1956, 1963, Doumenge 1982). Only now, however, have the techniques of hut construction been documented in detail (Boulay 1984a, 1984b).

Less has been noted on traditional knowledge of trees and their woods. The Kanaks were able to cut large trees in the forest, move them to a building site and erect them as centre posts, or hollow them out for canoes or aqueducts (Leenhardt 1930). There was obviously a very complete knowledge of the qualities and resistances of each wood and their appropriateness for different tasks. Yet the Europeans on their arrival had to learn these things all over again (Sebert 1874).

Better documented is the place of Melanesian communities in the landscape, the space occupied by different clans and the layout of the village, for which a number of examples have been described (Leenhardt 1930, Avias 1953, Doumenge 1982, Bensa and Riviere 1982) but this is only marginally pertinent to the management of environmental resources and will not be treated further here.

General

The scope of traditional Kanak knowledge of nature and the environment was very large. There were names for and a classification of every significant species of plant and animal (Lambert 1900). Periodic events like the movements of celestial bodies, the flowering and fruiting of trees, and the migrations of birds and fish were observed and incorporated into their system of knowledge. Celestial navigation was practised, and the weather could be predicted, with only rare errors (Lambert 1900). Apart from some names, none of the details have been recorded.

While the process of the observation of natural phenomena in Kanak society was similar to that of modern science, the intellectual context within which the observations were interpreted was very different. The Kanak did not identify himself as separate from the world around him; on the contrary, he was part of the world and perceived himself by analogy with objects in nature such as the yam, whose cycle symbolized the cycle of life (Leenhardt 1944, 1947 see 1979). The ancestors were born from trees, and the body was identified with the vegetable kingdom (Leenhardt 1947 see 1979). The different plants had symbolic meanings that were used as a kind of language (Leenhardt 1930, Barrau 1970). The land was the spiritual as well as material source of life (Saussol 1979). It is no wonder that the habitat was worshipped (Leenhardt 1947 see 1979) and that there was no distinction between magic or myth and the natural world.

Knowledge was not held equally by everyone; there was a tendency towards specialisation in the community (Leenhardt 1947 see 1979). Each family had its own knowledge and magic passed from generation to generation, and its assigned hereditary role in the community. The family of chiefs symbolized the clan and provided political leadership, announcing decisions taken in consultation with appropriate specialists. Others provided priests, war chiefs, orators and other figures in the community.

Many of these specialists had a role in managing environmental resources. The family of the first occupants provided the master of the land who distributed the land and maintained the cadastral system. There was often a master of yams or dry (male) crops, and a master of wet or female crops (taro, bananas, sugar cane) who were the agricultural technicians and decided the timing of gardening operations (Glaumont 1897, Leenhardt 1930, Barrau 1956a, 1965, Guiart 1963). Secondary crops such as banana and magnagna could also have their master (Guiart 1963). The doctors and healers had their special knowledge of sicknesses, medicines and other treatments (Leenhardt 1947, Metais 1976). Fishing knowledge and magic was held by the families responsible for supplying fish to the chief (Leenhardt 1947 see 1979, Guiart 1963). A clan might be foresters or carpenters, with a knowledge of the forest trees, the qualities of each wood, the techniques for cutting and hauling a tree to the building site, and the construction of huts or the making of canoes (Leenhardt 1947 see 1979, Metais 1976). Families might own magic to control the sun, the rain, cyclones, or the land breeze to chase away bad weather (Leenhardt 1930, Tavernier 1955, Guiart 1963). These different specializations were not mutually exclusive, and the number varied with the area and the size of the community. The roles could also be combined; a sculptor might also be a surgeon, since both required similar cutting skills (Leenhardt 1947 see 1979). The names of families often refer to an agricultural function or to family magic (Doumenge 1974a).

There was also some separation of specializations between men and women (Metais 1976). Taro was a female crop, and women were better informants than men on the different varieties of taro

(Barrau 1956a). Pottery, tattooing, midwifery and some types of healing were also women's roles (Metais 1976). These specialists have largely disappeared and much of their knowledge has been lost. From the fragmentary information that remains, it is possible to give some indications of how they must have worked. The head of a family on Lifou had a magic allowing him to climb up on a promontory and to ask the relations of his god in another locality to send fish to his brothers-in-law; although the rite is no longer followed, when the wind blows from the other locality it still washes fish up on the sand, just as it did the day after the rite (Guiart 1963). The magic was thus related to a natural phenomenon, and the skill of the magician may have lain in knowing when to perform the rite.

The master of a crop frequently had a small sacred garden in which he first practised the different acts in the cultivation of the crops (Leenhardt 1930). Barrau (1965) suggests that these ritual gardens served as microexperimental gardens and meteorological stations permitting the master to adapt his decisions to the variable climate. A knowledge or skill was intimately related to the myth or magic with which it was inherited. Leenhardt (1947 see 1979) describes a skilled sculptor and surgeon whose confidence rested in the gift from his deified ancestors; when he became a Christian, this confidence was destroyed and his skill was lost. A resource might be managed through a taboo or prohibition. A taboo might be placed on a garden to protect the crop before the harvest, or an area of tall grass might be protected presumably because it was needed to repair the thatch on the huts in the village (Lemire 1884).

Conclusions

The above fragmentary description of traditional environmental knowledge and management in New Caledonia shows what a rich heritage there must have been and how little has been preserved or recorded. On some subjects there is a good written description, although what is described is not derived from practical experience. For other topics, there are only generalities without the detail necessary to be useful. In some areas there is only a hint of the former existence of practice or knowledge that might have been very useful as a guide to solving modern resource management problems.

What we do not know is how much of this information may still exist, perhaps unconsciously, in the daily practices of rural workers or the memories of old people. While no one living today can remember back to pre-colonial times (Doumenge, 1974a), there may still be some who were young when such skills were valued in the family. This knowledge can only be saved if young people, preferably within the family, appreciate it and are willing to make the effort to learn it. Problems of confidence and language make it much more difficult for outsiders to collect and record such information. If this review encourages the renewed transmission of traditional knowledge or inspires useful research, it will have served its purpose.

While this study has necessarily concentrated on the Kanak people of New Caledonia, the example given has much wider importance to the whole of the Pacific Islands. Details may differ, but the general principles of environmental knowledge and resource management are similar throughout much of the region, and their pertinence to modern problems of development is just as great. Other areas may be fortunate in having seen less of their traditional experience eroded by introduced practices and changing education. The example of New Caledonia can serve as a warning for them to record this knowledge and reinforce its transmission before it is too late.

CONCLUSION: ISSUES IN THE APPLICATION OF TRADITIONAL KNOWLEDGE TO ENVIRONMENTAL SCIENCE

Graham B. K. Baines

From the !Kung of southern Africa (N. Blurton Jones, M.J. Konner) to the tropical island fishermen of Palau (R.E. Johannes); from the traditional rice cultivation experts of Sierra Leone (P. Richards) to the skilled Indian "fire technologists" of northern Alberta's boreal forest (H.T. Lewis) – the samples of traditional environmental wisdom presented in this book persuasively demonstrate how much the environmental scientist can learn from traditional knowledge systems.

Johannes stresses how effective traditional knowledge can be in showing the scientist "what questions to ask and where and when to look for answers". In deliberately simple terms, *Falanruw* describes what is, in fact, an extremely complex and sophisticated system of Yapese island agriculture. Such indigenous agricultural systems have been described by many writers. "Shifting" or "swidden" agriculture has received particular attention. Yet how few have looked beyond the last planted crop and recognized, as has Falanruw, that elements of the secondary growth itself are part of the crop, that the production system extends well beyond the more obvious "crop garden". The right questions were not asked.

Lewis evocatively describes the Indian trapper methodically "firing" vegetation so as to maintain that particular habitat complex essential for the wildlife which sustain his own life and livelihood. It is a long established technology, he tells us, and yet scientists have only very recently become aware of it. Anthropologists had observed it, but they were "scientifically naive about the ecological role of fire and the significance that fires could have for hunting-gathering technologies". Neither the scientist nor the anthropologist had been sufficiently free of cultural bias, sufficiently "objective", even to be able to decide that questions were worth asking, let alone where and when to look for answers.

Dahl eloquently presents the intricately woven matrix of traditional knowledge and environmental management in Kanak society of New Caledonia. As he makes clear, this matrix is increasingly threatened by an encroaching technology which ignores too often the value and fragility of natural systems. In its failure to recognise the integrity, sophistication and worth of traditional knowledge systems, modern environmental science has missed much. There is indeed a tremendous cost in **not** investigating traditional knowledge, for it could yield so much of interest and benefit to modern societies.

That it has taken so long for anthropologists, wildlife managers and foresters to recognize the wealth of ecological understanding implicit in "fire technology", thus delaying advances in scientific understanding of fire and environment, represents a net loss for environmental science. And if that example fails to persuade, *Richard's* description of the consequences of the attempts of agricultural "experts" to displace an effective indigenous African rice farming system and substitute Asian swamp rice cultivation techniques may present a clearer message. The economic, social and political costs are readily apparent.

Traditional knowledge rarely can be found in written form. Nor is it organized and structured in ways accessible to science. Folk taxonomies, for instance, are based on criteria which may differ markedly from those of the Linnean system. Different aspects of traditional knowledge are retained by women and by men. For some, their specialized knowledge defines their status in their communities. The revelation of certain critical parts of this knowledge may undermine their standing, even deprive them of a livelihood – as it might for a traditional medical practitioner who has disclosed all his medicines and their dosages.

An investigator of traditional knowledge faces a daunting challenge, and many difficulties. Irrespective of "scientific objectivity", differences of perception, values and language between those who hold traditional knowledge and those who wish to document it and apply it are significant. Unless investigators of traditional knowledge make more effort to understand these differences and to develop effective investigative methods then, at best, incomplete revelations of traditional knowledge will result. At worst, the information obtained will prove misleading.

Much has been done, through the social sciences, to address these difficulties, with a certain measure of success. Yet, in relation to the total knowledge about environment and ecology retained within any one traditional society, that which has been documented is relatively small.

While anthropologists are in the forefront of those with an interest in the investigation and application of traditional ecological knowledge, an increasing number of ecologists are becoming involved. The Working Group on Traditional Ecological Knowledge of the IUCN Commission on Ecology, includes members of both disciplines and also a few who have qualifications both in anthropology and in the biological sciences.

Widespread enthusiasm for the investigation and application of traditional ecological knowledge is apparent. There is growing appreciation that much of that knowledge is useful in identifying new resources and in achieving resource conservation goals. Yet an examination of the various initiatives being undertaken reveals a very disconcerting fact – that most of these do little or nothing to view and interpret traditional ecological knowledge in its all-important social context.

Schultes' authoritative account of the immense and largely untapped potential of medicinal plants in Amazonia alludes to this distressing pattern in his concluding remarks.

For example, it is well known that the Amazonian Amerindians who revealed their knowledge of the *Hevea brasiliensis* tree exudate which became the basis of the rubber industry were brutally enslaved for it. Many less dramatic, though still troubling, accounts could be rendered of benefits which have accrued for the "First World" through application of "Third World" knowledge without adequate reward for informants and their societies, or even to their detriment.

The pharmaceutical and other industries drawing on "chemical ideas" from plants and animals continue a long established theme of exploitation of traditional knowledge. Fijians still wonder why they will not derive benefit from medically useful alkaloids discovered in the *Piper methysticum* shrub, a consignment of which they provided for a West German laboratory some years ago. They had been encouraged by visions of a local industry based on cropping of that plant. This was not to be. All that the pharmaceutical industry needs is to know which plants are used in traditional medicine, import a few tons of leaf or bark, concentrate the "active principle" and then ascertain its molecular structure. From that point the industry demonstrates no further interest in those who contributed the knowledge which provided the opportunity – and the profits. The molecule is synthesized; the pharmaceutical product manufactured.

It need not be this way. A new approach to the commercial development of resources identified by traditional societies could be developed, provided the will is there. Arrangements to facilitate this would necessarily include an appropriate international legal convention.

Those who seek to document traditional knowledge cannot afford to be naive about the possibility of their work being used to the detriment of those who entrust them with information. To gather and to apply traditional knowledge in the name of all mankind is a worthy objective. But this must not be at the expense of tribal societies. There is a moral imperative to ensure that this objective is achieved through mutually supportive relationships with traditional knowledge informants.

Practical models for such partnerships are needed. These must inevitably involve actions to protect the rights and dues of those societies who shaped and supplied traditional knowledge. This is not an easy task, but the costs in time and effort are insignificant when compared to the returns to the advancement of environmental science.

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Prepared and published with financial support from the Commission of the European Communities, and by the Government of France

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