SUSTAINING HUMAN AND NON-HUMAN ANIMAL POPULATIONS: FROM COMPETITION TO COEXISTENCE – A MODEL

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DANIEL B. NUTTALL

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ABSTRACT

SUSTAINING HUMAN AND NON-HUMAN ANIMAL POPULATIONS:
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Daniel B. Nuttall | Advisor:
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Anthropogenic factors are responsible for global decreases in biodiversity. Mitigating such decreases is central to the concept of sustainability. The concept of sustainability represents a "return to nature" approach. This ideological approach recognizes that an awareness of and adherence to ecological principles is required to achieve sustainability. Taken as a group these ecological principles are referred to as "natural theory". A particular subset of natural theory, called competition theory, describes how animal species which are competing for limited resources may coexist. Is it possible that the "solutions" derived by nature are in fact models for resolving competition between human animal (HA) and non-human animal (NHA) species?

The thesis uses conceptualization methods and insight theory to develop a Sustainable Resource Partitioning (SRP) Model which describes how HA and NHA species can move from competition to co-existence. The utility of the model lies in its ability to situate humans as a part of nature and as a consequence shift the goal of sustainable development. This new goal takes exception to the anthropocentric, mono-specific and "dominion

perspective' definition of sustainable development introduced by the WCED (1987). The model makes significant contributions in the area common to both competition theory and sustainability and notes the overlap in approach and terminology between these areas. The outcomes of the model include a new emphasis on asymmetrically exploitative competitive relationships and contested essential-renewable and essential-continuing resources. Consideration of the degree of substitutability of resources is recognized as critical and bound by taxonomy Given the role of intraspecific HA competition in extinction of NHA species additional emphasis is placed on understanding dominant community dynamics. Finally the roles of dominant and subordinate competitors, and, respectively, their effects and responses in interspecific competition, is provided.

The model was applied in rural Mozambique where basic exploratory field research was undertaken to develop an understanding of HA and NHA resource use in a competition setting. The competing species were *Ploceus olivaceiceps*, the Olive-headed Weaver, and *Homo sapiens*, a local human population. The model examines each contested resource and demonstrates, through analysis of the resource utlization function (RUF), a means of sustainable partitioning. The model is generalizable to the extent that it may be used in any HA-NHA setting. Finally, the model results in new knowledge in the form of a clear, explanatory, practical and predictive set of propositions which provides for the coexistence of human and non-human animal species and thus makes a direct and valuable contribution to sustainability. Such a contribution has enormous potential and directly addresses the pressing need identified by Chapin (1996) that "the concept of sustainability [be] applied to natural ecosystems".

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1.0 INTRODUCTION

The global land surface area is approximately 148,300,000 square kilometres and the majority of the 1.4 million known species inhabiting our biosphere live on this finite surface (Earth Facts 2000, Government of Australia 1995, Wilson 1988). All of these species interact in space and time through shared use of resources. Such sharing, under conditions of limited resource supply, results in competition (Curtis 1983). On a global scale the primate, *Homo sapiens*, is currently the undisputed winner of such competition; the species inhabits almost every terrestrial niche, consumes vast amounts of resources and is approaching a population estimated at over six billion individuals (Museum of Man 1997; Keddy 1989).

Such success in competition comes at a cost. Within the human animal (HA) species not all individuals have equal access to global resources. Approximately 1.3 billion people world-wide live in poverty and these people are situated primarily in tropical areas of the world (Africa News 1996; Wilson 1988). Moreover, both advantaged and disadvantaged portions of the global human population exert a combined effect upon non-human animal (NHA) populations. These anthropogenic effects include habitat loss, loss of biodiversity and increased rates of extinction. Again, these effects are most dramatic in tropical areas of the world. For example the rate of conversion of natural habitat to agriculture over a twenty year period between 1960 and 1980 was between 36.5 and 37.8% in tropical developing countries and –0.1% in North America (Swanson 1999). Alarm regarding species loss seems warranted as tropical forests are estimated to contain 50% of the world's species while making up only 7% of land mass (Wilson 1988, Swanson 1999). As a result of competition, tropical areas of the world are in dire need of a means to sustain both human and non-human animal species.

The relatively new concept of 'sustainability' has provided opportunities for re-examining the future of planet Earth. The emphasis within sustainability has remained largely anthropocentric, focussing on political (O'Riordan 1993; Choucri 1999), economic (Pearce 1993), social and cultural dimensions (Sachs1999; Eichler 1999). A focus on nature (Harcourt 1994) and the "ecological realities" of our existence (*e.g.*, the Second Law of Thermodynamics, see Rees 1988, 21) appears to be missing. In contrast, some authors have argued that the success of sustainability at conceptual and applied levels is dependent upon our connection with nature (Bryden 1994b; Wilson 1998), our ability to learn from nature (Suzuki 1998); an understanding that ecology sets the rules and regulations for running the domain (George 1997) and the conclusion that human culture must adhere to basic principles of ecological sustainability (Chapin *et al.* 1996; Rees 1988). The use of ecological theory in approaching sustainability has, however, been largely ignored. Chapin (1996, 1017), for example, states that "the concept of sustainability has not been applied to natural ecosystems". As such, the rift between sustainability and applied ecological theory remains.

Post-modern thought suggests that the nature versus human culture dichotomy is a false one which creates "dual prisons" (Descola and Palsson 1996, 3). The post-modern response to this dichotomy is to "exchange concepts and perspectives across this divide" (Descola and Palsson 1996, 11). These informing exchanges between nature and human culture, which illustrate the rules of ecology that human culture must adhere to in order to achieve sustainability, may be collectively referred to as a 'return to nature' approach. Within the general context of a return to nature approach the ideas of connection, convergence and interdependence of human animal (HA) and non-human animal (NHA) cultures suggests a body of 'natural theory' which applies to both. Examples of natural theory include natural selection, sexual selection, optimal foraging and competition theory. Competition theory is relevant and important in the context of sustainability because it explains how animal species are sustained or coexist when linked by competition for common resources (*e.g.*, honeycreepers, Pimm *et al.*, 1985; bats, Hickey *et al.*, 1996). The theory has not been applied to settings where HA and NHA species are competing for resources.

If ecology is a cornerstone of sustainability, and does not distinguish between HA and NHA species, and competition theory demonstrates how animal species may coexist, then sustainability can be achieved by applying competition theory to both human and non-human species. Accordingly, this thesis shifts the anthropocentric focus of sustainability to a more ecocentric emphasis and asks: "Can we take competition theory, which explains how competing non-human animals are sustained, and apply it to a setting where the stakeholders are an HA and an NHA species?".

This thesis undertakes the novel approach of applying competition theory in an effort to sustain both HA and NHA species, which, in turn, requires the development of a model. The model, as a systematic representation of logical analysis, explains and predicts how

HA and NHA populations may move from competition to coexistence. The model is then applied in the research setting of rural Mozambique where a local human animal population and a non-human animal population, the Olive-headed Weaver, are competing for resources.

The research goal and objectives are articulated as follows:

Goal

To use competition theory to develop and apply a model which allows HA and NHA populations to move from competition to coexistence and, in doing so, enhance the sustainability of both.

Objectives

1. To demonstrate that:

- sustainability marks a 'return to nature' in the form of natural theory;
- a particular form of natural theory, called competition theory, provides a means by which HA and NHA species may partition resources in a sustainable manner and thus coexist.

2. To develop a model based upon competition theory that describes how HA and NHA species may coexist through the partitioning of contested resources and thus contribute to the sustainability of both.

3. To test the model by performing basic research in Mozambique, in a setting where an HA and an NHA population are competing for resources.

4. To discuss the utility of the model in the research setting.

5. To discuss the broader applicability of the model.

2.0 REVIEW OF LITERATURE

A literature review is a systematic, explicit and reproducible method for identifying, evaluating and interpreting the existing body of recorded work produced by researchers, scholars and practitioners (Fink 1998). This literature review, guided by the research objectives, explores three discrete themes or "areas of relevance":

- Sustainability as a Return To Nature
- Sustainability and Natural Theory
- Sustainability and Competition Theory

2.1 Sustainability as Return to Nature

There is no single universal definition for the word sustainability (Pearce *et al.* 1989; Pearce and Turner 1990). Indeed, there is disagreement about whether the word itself is intended to express a 'concept' (Bryden 1994b, Rees 1988), a 'notion' (Turner 1993; Bryden 1994a; Munslow *et al.* 1995), a 'state' (Bryden 1994a) or a 'goal' (Turner 1993). These difficulties have not precluded attempts to organize more general approaches (Caldwell 1998), perspectives (Turner 1993), and principles (Turner 1993; Chapin *et al.*, 1996). Such generalizations avoid disagreement at the level of definition and provide a platform from which productive ideas may be emerge. This thesis will use the word 'concept', as a synonym for 'general idea', and as an antecedent descriptor to the term sustainability.

A variety of approaches to the concept of sustainability are recognized. Becker (1999, 4) suggests that, currently, ecological economic approaches are dominant (while approaches in social ecology, environmental history and environmental sociology are also present) and suggests that such approaches ignore sustainability as "a topic of research that is basically social". Nordhaus (1992) recognizes a technocentric approach, Rolston (1988) an ecocentric approach and Turner (1993) an economic approach. While a discussion of all of these approaches is beyond the scope of this thesis, the suitability of an ecocentric approach is supported for two reasons. First, if we are to address sustainability it must be addressed at its most fundamental or basic level – ultimately social and economic sustainability depend upon and are "subordinated" by ecological constraints (Becker *et al.* 1999, 5). The dependence of sustainability on ecological processes has been addressed by other authors (Rees 1988, Wilson 1988, World Bank, 1992, van der Bergh and van der Straaten 1994;). Second, while sustainability is most often associated with "ecological crisis phenomena such as climate change, deforestation, soil degradation, or loss of biodiversity" (Becker 1999, 4) the most recognized definition of sustainable development (WCED 1987) excludes nature. Such a contradiction suggests that the necessary focus of sustainability on 'nature' is missing (Harcourt 1994). Overall the ecocentric approach can be used to include nature in discussions regarding sustainability and, simultaneously, acknowledge dependence upon ecology.

Within an ecocentric approach, a focus on including 'nature' in the concept of sustainability, can occur in a variety of ways. Nature, variably defined, can be taken to include those features and processes outside the human species which are also outside human action (Simmons 1997). Among these features non-human animals are often recognized by human animals as critical components of nature and central to questions regarding sustainability (Raven 1997; May 1997). While a focus on an organismic definition of nature may be broadly interpreted (up to five Kingdoms of organisms as per Curtis 1983; see also work on microbial diversity by Pace (1997); diversity of mites by Halliday *et al.*, 1997) a subset of nature in the form of "human and non-human animals" may prove to be a useful focus. This purposeful narrowing of focus occurs for several reasons:

1) The evolution of the research topic resulted in a focus on a non-human avian species the Olive-headed Weaver. The additional emphasis on a model-based approach, which in turn seeks generalizability, suggested the inclusion of other members of the Kingdom Animalia. As such the model could be applied to a variety of HA-NHA settings. These settings, often ones of conflict, feature prominently in issues of conservation and sustainability, *e.g.*, human animals versus: elephants (Adkins, 1997; Badola 1998; de Boer 1998); native vertebrates (Goodrich and Buskirk 1995); birds (Burger and Gochfeld 1998) and snakes (Koonz 1991).

2) The emphasis on both human and non-human animals is a taxonomic distinction that emphasizes that both groups are members of the Kingdom Animalia. Such a distinction creates a single foundation for both human and non-human animal species and, at the level of language, begins to address one of Bryden's (1994) four

conditions of unsustainability, the rift between humans and nature. By this we mean that both humans and non-humans are animals and thus affected by many of the same natural processes (*e.g.*, climate, primary productivity, biogeochemical cycling).

3) Notwithstanding our desire to express commonality between HA and NHA species the separation of the Kingdom Animalia into human and non-human species creates a division which addresses the ultimate primacy of HA effect upon sustainability *and* the interdependence of human and non-human animals.

In summary, an ecocentric approach supplies the missing focus on nature in discussions regarding the concept of sustainability. This approach identifies animals, both human and non-human as a focus and subset of nature. The distinction between human and non-human animals is made given the primacy of human effect on NHA species. At the same time the use of the term animal implies commonality and a possible foundation for the development of generalizable models. Based upon this approach the thesis will now discuss the relationship between sustainability and natural theory.

A single global perspective of the human animal and non-human animal relationship is likely impossible. In western countries the dominant Judeo-Christian perspective reminds human animals to: "Be fruitful, and multiply, and fill the earth, and <u>subdue it; and have dominion</u> over the fish of the sea, and over the birds of the air, and over every living thing that moves upon the earth" (Genesis 1.28, in The Oxford Annotated Bible, 1962, 2, underlined areas author's emphasis). Additional literature reveals a diversity of HA-NHA relationships where the dominion of human animals has varied from: canine consumption (China, Korea, Philippines) to bovine reverence (India); from scientific research and sexual enslavement (chimpanzees, orangutans in south-east Asia) to the use of non-human animals for pets, hunting, companionship and forms of currency; from use as political gifts, as opponents in bullfighting or 'actors' in circuses to serving as settings for contemplation in the menageries of Aristotle and Alexander the Great (Cherfas 1984; Nuttall 1993). The common thread inherent in this diversity of relationships is best expressed in the latter part of the above statement from Genesis however which refers to "dominion over...". These words express a perspective that is evident throughout recorded history and thus approaches a single global perspective (Fox 1989). This perspective is referred to in this thesis as the 'Dominion Perspective'. While reverence and companionship may not seem at first glance to fall under the rubric of dominion it is important to remember that such cultural relationships can be altered almost overnight. Also, human animals may choose to dominate or revere, but both fates are the result of human animal dominion. As such, this thesis recognizes the 'Dominion Perspective' as both a primal and persistent ideological framework. The recognition of such a perspective within the context of this research is argued to be appropriate given:

a) that the roots of the World Commission on Environment and Development (WCED) and thus the roots of sustainability are in more developed countries and a "Dominion Perspective" is likely inherent in any definitions of sustainable development;

b) the First World's role in reducing global biodiversity, both directly and indirectly. Such decimation is related to the dominion perspective. Understanding the link between the dominion perspective and reduced biodiversity may provide the greatest opportunity to enhance biodiversity and contribute to sustainability.

The Dominion Perspective is implied in the WCED (1987, 43) definition of sustainable development: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". This definition implies both a mono- and intra-specific focus dealing with only one species, *Homo sapiens*, and interaction between members of this species. Such an anthropocentric perspective has been noted by other authors (Thompson 1998). The critical issue of contextualizing non-human animals arises: are non-human animals one of the resources or needs that are to be sustained for human use? Or does the definition of sustainable development need to arise explicitly out of a multi-specific (multi-species) perspective? Are we to expand our world view beyond that of a single stakeholder, *Homo sapiens*? If we are, does this satisfy the urging in Genesis that in addition to dominion we replenish the earth? Or does replenish refer only to HA procreation? This thesis suggests that in contrast to the WCED definition of SD there exists, in addition to generations of *Homo sapiens*, generations of *other* non-human animals. That a more comprehensive view of 'nature' should be a focus in sustainability and that the fate of both HA and NHA cultures is singular, has been echoed repeatedly in both journals and popular literature. Thompson (1998) for example, speaks of the need for an ethical realignment that allows both anthropocentric and ecocentric views to be balanced. In his review of this subject he cites: McHarg (1969) who speaks of viewing the biosphere as a single super-organism; Brennan (1988) who speaks of 'ecological humanism' and the need to recognize interdependence of humans and nature; Sterba (1994) and Norton (1997) who address the concept of 'convergence' and McNeely (1990) who discusses 'interdependence'. More recently the need to situate humans as part of global biodiversity (National Forum on Biodiversity 1988; Simmons 1997) is consistent with Leopold's (1949, 202) description of an "ethical sequence" that moves from concern for "self" through "family, social group, species, [non-human animals], ecosystems, land and earth". Such concerns about interconnectedness and interdependence and the desire to incorporate complex biophysical, socio-economic, historical and political factors in a single framework (Simmons 1997) recognize the "intuition that an ecologically centred approach is needed" (Thompson 1998, 188). Such approaches are not merely about a return to the subject of nature but a return to the 'nature of nature'; how it functions, regulates and sustains and how humans can integrate within this framework. Such integration may be seen in areas as diverse as economics and religion. In economics we see the recent introduction of conservation into the marketplace through full cost accounting, green taxes, economic incentives for conservation and the internalization of environmental externalities (Sevageldin 1997). Simultaneously in religion we see a movement that recognizes the Latin roots of the word religion (*religare*, to connect) as the first step to recognizing the ability of religion to be inclusive and address the whole of creation, in short, one spiritual and ecological life (Fox 1989). Finally, the focus of sustainability on renewable, non-renewable and continuing resources and their larger ecological implications (*e.g.*, ecological limits to sustainability) finds an extreme return to nature in deep ecology. Deep ecology posits that humans and all other life forms are fundamentally equal and that only through design with nature can humans live in accordance with ecology (Simmons 1997; Naess 1989). The popular literature also addresses these ideas of convergence, connection, interdependence and living with nature (McLuhan 1994; Quinn 1992; Maser 1999):

> "Being nature herself, I do not dare to fight against her".
> Cheikh Hamidou Kane, Senagalese writer (in McLuhan 1994, 307)

> "I believe that the Universe is basically good and that that throughout it great forces are at work striving to bring about a greater unity of all living things. It is through co-operation with these forces that Man will achieve all of which he is capable". Kenneth Kaunda, former President of the Republic of Zambia (in McLuhan 1994, 309).

Such inferences suggest a multi-specific perspective and thus we require a new approach to sustainable development, one that recognizes nature in the form of a multi-specific perspective. This thesis proposes a new multi-specific definition of SD: sustainable development is development that meets the needs of the present without compromising the ability of future human and non-human animal generations to meet their own needs. This alteration of the definition of SD provides the following benefits

1) The greater the number of stakeholders the more comprehensive the approach to sustainability.

2) Approaching sustaining multiple stakeholders from each stakeholder's perspective allows for a more holistic and inclusive process. By linking each stakeholder to the biosphere and to each other we can begin to understand stakeholder needs and relationships to natural resources.

3) The development of a conceptually level playing field through the recognition of *all* stakeholders as *animals*, suggests an organismic, 'living being' or 'Kingdom Animalia' approach. By creating such a level playing field we may ask the same questions of both of these stakeholder groups and approach identifying needs for each species as a starting point. At the same time the conceptual link between animals, their connections to each other and their common connection to natural resources and the biosphere is made – suggesting a combined or interconnected fate. Coincidentally, these considerations help anneal the rift between humans and nature – one of the four conditions of "unsustainability" posed by Bryden (1994b, 212).

The inclusion of NHA's in the definition of SD is a first step. However, mentioning two different stakeholder groups does not imply interdependence or commonality. Such implications are found in the idea of 'community'. Thus, our second area of focus within SD is how HA and NHA species contribute to the concept of community. Bryden (1994c) suggests that HA stakeholders contribute to the idea of community in different ways, including: communities of interest; physical communities/social communities (villages, watersheds, islands); a local social system (spatial context; Bradley & Lowe 1984). This thesis considers how such contributions to community may be extended to consider

NHA species. Bryden's tripartite interpretation appears to suggest a mono-specific, intra-specific, *Homo sapiens*-centred perspective. Anthropocentrism aside, a broader interpretation of the above perspective suggests that "communities of interest" could easily include non-human animals. Such reasoning is appropriate due to the fact that: both NHA and local HA populations can share the definition of community in that, together, they constitute "a collection of animals...sharing the same environment" (Webster's Dictionary 1990 , 198), and; both the human animal and non-human animal have an "interest" in natural resources and their utilization; the term "community of interest" is anthropocentric and externally imposed suggesting that the focus on both HA and NHA communities in the context of this research creates a community of interest.

Both the local HA and NHA communities are a "physical community" in that they share or overlap in requirement of specific resources and both may be simultaneously located in the same space and time in association with natural resources.

A "local social system" is often in effect as there are discrete biophysical units (biomes, ecosystems) inhabited by human and non-human animal species and this supplies a spatial context. The use of the term 'social' is judged to be appropriate as at its broadest definition in means "to relate" (Websters 1990, 941). The term is usually applied to human animals but we also understand that non-human animals have social relations, *e.g.*, social and communal habits of some weavers, social ants (Wilson 1971) primates (Strum 1987), hyenas (Kruuk 1972), wolves (Mech 1970) and lions (Schaller 1964) for example. Thus the phenomenon of relating is logically extended to inter-specific interaction as well. For example, humans and non-human animals experience social relations in the form of companion animals such as canids, felids and avifauna. Both human and avian communities relate through shared used of natural resources. The cutting down of a tree by a human organism is an inter-specific social act in that it relates to the avian community by affecting dynamics within that community.

Thus we arrive at a point where both our human and non-human animal stakeholders meet, separately (and sometimes together), the definition of community. Such separation however may have little utility in understanding interspecific interaction and integration in a natural resource setting where sustainability is a stated goal. As a means of furthering the utility of this exploration we turn to the ideas of Michael Gertler (1994, 75) who recommends that we: "reinvent relationships between individuals, communities and the resources they ultimately depend upon. More attention should be given to organizational arrangements for sharing and sharing responsibility for resources". How do we approach this idea of sharing? Coincidentally, the identification of a minimum of two populations and sharing of resources is a definition of community:

> "Ecologically speaking, a community comprises all the populations of organisms inhabiting a common environment and interacting with each other" (Curtis 1983, 962).

Additional definitions of community support the emphasis of this thesis which suggests that 'community' includes both human and avian species, for example "a body of individuals organized into a unit or manifesting, usually with awareness, some unifying trait" (source unknown) or "an assemblage of species at a particular time and place" (Forman and Godron 1986, 590). At the same time other definitions cling to the anthropocentric view: "A body of people living near one another and in social relationship" (Webster's Dictionary 1990, 198).

Neither the "body of individuals" reference, nor the "assemblage of species" reference excludes a multi-specific perspective. At the same time the context of a unifying trait may be interpreted to mean a "sharing of a common resource". The question of awareness presents an interesting problem. Do all members of a community share an awareness of all of the traits that unify them? Can "uniformity" only be imposed externally? If animals do not possess a higher consciousness can they ever be included in any community according to the above definition?

The issue of internal awareness versus external imposition of concept of community (as arbitrarily used as it is) suggests an examination of NHA awareness. Certainly animal species both avoid and are attracted to human communities as adaptive strategies suggesting awareness as well as complex social behaviour (Burger and Gochfeld 1998; *.e.g.*, behaviour in baboons, Strum 1987). Also, we acknowledge that humans possess awareness – a defining characteristic of our species (Diamond 1992). Humans are aware of trees that they cut down, saw and use as firewood or building material. Last, as humans we can impose the definition of community by suggesting that both species are unified through their awareness of use of certain resources. In summary, based upon our exploration of SD this thesis defines a community as "Organisms which are connected to each other through the shared use of resources in space and time".

Ultimately, the fact that human and non-human animals might be considered equal and part of a single community when viewed through the human-cultural lens of SD largely retains an anthropocentric perspective – we still see the world through human-made constructs and ideas. Could sustainability be viewed from the other side of the lens? Is there a perspective or a set of laws of nature that could be applied to all organisms – including humans – which could contribute to SD? As stated previously, both the scientific and lay literature suggests an awareness that nature governs "all" – including human animals:

> "It is the way", he said softly. "Take only what ye need. When ye take the deer, do not take the best. Take the smaller and the slower and then the deer will grow stronger and always give you meat. Pa-koh, the panther, knows and so must ye". And he laughed, "Only Ti-bi, the bee, stores more than he can use...and so he is robbed by the bear, and the 'coon...and the Cherokee. It is so with people who store and fat themselves with more than their share. They will have it taken from them. And there will be wars over it...and they will make long talks, trying to hold more than their share. They will say a flag stands for their right to do this...and men will die because of the words and the flag...but they will

not change the rules of the way" (Forrest Carter, Cherokee author of *The Education of Little Tree*, as quoted in McLuhan 1994, 388)

"You have alienated life and land by the exploitation of the natural resources. As a result of your greed there is a real possibility that our environment will be destroyed. If it is, we will also be destroyed because we are a part of nature..." (speech deliver by the Nishnawbe-Aski treaty Chiefs to the Premier of Ontario, William Davis, as quoted in McLuhan 1994, 396).

Given this literature search, particularly the work of Bryden (1994c) and Bradley and Lowe (1994), this thesis suggests that there is a *single* multi-specific community composed of human animal and non-human animal stakeholders who are connected to each other and interacting through the shared use of resources. This physical community is also a community of interest and possesses a local social system. This also effects our recently revised definition of SD which has moved from anthropocentric to multi-specific and now combines these stakeholders as a single community in a multi-specific community.

In summary, the identification of literature addressing human and non-human animal relations suggests that a dominion perspective may be used to characterize HA and NHA relationships throughout recorded history. This perspective is evident today in one of our most important, global and social guiding concepts - the commonly used definition of sustainable development. In light of the dominion perspective an evaluation of this definition suggests a move towards a multi-specific, single animal community which offers a means of integrating HA and NHA species – a critical step in removing one of the four conditions of un-sustainability. Such integration, recognition of interconnectedness and interdependence may be characterized as a return to nature. As a platform for this return the dual "awarenesses" of HA and NHA species allow for recognition of a single physically and socially connected community of interest. Such interdependence suggests that sustainability depends upon our understanding of the "nature of nature" and that human animals function as an interconnected, integral and vital part.

2.2 Sustainability and Natural Theory

E.O. Wilson believes that ecological and evolutionary principles apply to human as well as non-human animals (1975, 1978a). To a great extent these ecological and evolutionary principles are fundamental; there is little or no variation in time and space and the principles exist as a universal set of ecological and evolutionary laws. Similarly another set of universal laws, referred to as 'natural law', has been realized in ethical philosophy, theology, social theory and law. Natural law is seen as a set of principles based on the permanent characteristics of human nature. Cicero addresses the idea of natural law and its relationship with a form of 'nature':

> "True law is right reason in agreement with Nature; it is of universal application, unchanging and everlasting; it summons to duty by its

commands, and averts from wrongdoing by its prohibitions....There will not be different laws at Rome and at Athens, or different laws now and in the future, but one eternal and unchangeable law will be valid for all nations and for all times". Cicero, 1st Century BC, in De Republica (Encarta 1997-2000)

These principles were felt to serve as a standard for evaluating conduct and civil law and were fundamentally unchanging and universally applicable. The search for universal guiding principles in sustainability suggests a similar approach. Caldwell (1998, 6), for example, has suggested that there has been a failure to respect natural systems and an inclination to "work against rather than with nature and to dominate rather than co-opt". Such co-opting might be taken to suggest the identification and utilization of fundamental and universal principles. In addition, Frankel (1976) spoke of the temporary nature of human purposes in light of nature's messages, rights and maxims which, again, could be understood as fundamental natural laws and theory. Finally, Darwin spoke of natural selection (Curtis 1983), May (1978) referred to natural law and O'Riordan (1993, 45) spoke directly of "adherence to natural laws [that represent] fundamental environmental processes". This thesis recognizes the utility of identifying such laws and suggests that such laws exist in nature but are difficult to determine. Indeed our later exploration of competition theory will reveal that there is no consistent, unified body of knowledge or laws. Notwithstanding such explorations the concept of natural theory is taken from the fundamental, unchanging and universally applicable aspects of the concept of natural law while 'natural' is taken to mean of 'nature'. In its final abstracted form natural theory is interpreted to mean those fundamental, unchanging and universally acceptable laws of nature. While the actual existence of such laws may be debated at length this thesis will avoid such a debate and instead present the concept of natural theory instead. As such the term natural theory is defined as known standards, principles or theories that describe the characteristics of natural settings

It was stated earlier that HA-NHA interaction is governed by the dominion perspective which, in turn, affects how we interpret the world through the lens of SD. If natural theory is adopted and applied to both HA and NHA species it allows such a lens to be bi-directional and provides an opportunity for a reversal of the dominion perspective. The adoption of natural theory or lessons from nature repeats a common theme: the more we act like nature the more we are likely to approach true sustainability. Perhaps Robert Frost (1981, no page number) said it best when he said: "Nature is always hinting at us. It hints over and over again. And suddenly we take the hint".

The lyrical prose of Frost is echoed by the World Conservation Strategy (1980) which speaks indirectly about the relevance of and adherence to natural theory when referring to maintaining ecological processes at the molecular level (requiring an understanding of natural theory in terms of elemental cycling), preserving genetic diversity (laws of genetics and population biology), controlling discharge of pollutants (rates of nutrient and matter cycling, laws of organic and inorganic chemistry), understanding carrying capacity (laws of population dynamics) and sustainable yield (laws regarding limiting rates of biomass production) while conserving habitat. These concerns suggest that, like nature, we are interested in becoming more equitable, more forward (future) thinking, more efficient, less wasteful, less damaging and more sensitive. Such approaches suggest that not only should we attempt to preserve nature but that the way to accomplish such preservation is by acting more like nature.

Examples of natural theory include theories and models related to natural selection, optimal foraging or competition theory. Given that sustainability is overtly concerned with finite resources, their availability, and competition for them, competition theory is taken to be the form of natural theory central to this research. The literature suggests that as a result of competition for resources organisms have evolved ways of partitioning resources, which in turn allows for coexistence (Schoener 1974; Lawton and Hassell 1981; Pimm and Pimm 1982; Curtis 1983; Pimm *et al.*, 1985; Mitchell *et al.*, 1990; Hickey *et al.*, 1996). Such outcomes, overall, provide a 'lesson from nature' or example of a natural theory which, if followed or applied, may allow for a return to nature.

In summary, natural theory suggests a set of known standards or principles that describe the characteristics and functioning of natural settings and suggest the that the adoption of such standards or principles provides an opportunity to achieve sustainability.

2.3 Sustainability and Competition Theory

The role of natural theory in sustainability has rarely been addressed. When it has been addressed separately (Hansson 1992) we find it situated within the more traditional fields of natural science, for example biology, ecology and zoology. Within these fields areas such as evolution, population genetics, population dynamics and community ecology have served as the focus (Hansson 1992). Community ecology examines a myriad of biological interactions such as predator-prey relationships, mutualism, parasitism and competition. In any setting that considers competition theory and HA and NHA species, four possible competition scenarios may be dealt with: 1) intraspecific competition in HA's (interspecific competition does not exist as separate species, in our current day setting, are not recognized); 2) intraspecific competition within NHA's; 3) interspecific competition within NHA species and, finally; 4) interspecific competition between HA's and NHA's.

Competition theory does not tend to deal with HA intraspecific competition. This does not suggest that such research does not exist but only that it is rare. Examples of competition theory and HA competition are either superficial and occur in the common literature (*e.g.*, competition for non-renewable resources such as oil) or more scholarly publications which deal with sociobiology (Wilson 1975). Sociobiology includes the study of the biological basis of social behaviour (Clutton-Brock and Harvey 1977). Within sociobiological theory the exploration of intraspecific competition has been emphasized, largely because contemporary biologists and anthropologists see current day hominids as a single species. One phenomenon emphasized in particular is that of war (Alcock 1984; Durham 1976) particularly in regard to the extent that war is a form of cooperative aggression linked to the defense of or need for resources (see Vayda 1976). Notwithstanding their intraspecific emphasis these sociobiological theories generated much controversy, as some individuals felt that the identification of adaptive behaviour was synonymous with social or moral acceptance (Alcock 1984). For example the use of recreational drugs has been hypothesized as a means of demonstrating superior fitness under conditions of impediment. In evolutionary terms, a drugged state is synonymous with the long costly plumage of a male bird of paradise (Diamond 1992). These controversies are based upon the concept that socially and morally unacceptable behaviour in humans could be argued to be genetically determined and biologically adaptive and therefore should not and could not be changed (Alcock 1984). Sociobiology, however, attempts to explain how certain traits may rise or become adaptive. Again, we find that even within sociobiology, emphasis has been intraspecific and interspecific competition has been ignored.

Exploration of intraspecific NHA competition is common. In an overview of 81 studies dealing with resource partitioning Schoener (1974) noted the overwhelming emphasis on terrestrial non-human animal vertebrates. More recently searches of competition interaction theory reveal a continued emphasis on vertebrate species among them: honeycreepers (Pimm and Pimm 1982); hummingbirds (Pimm *et al.*, 1985); insects (Lawton and Hassell 1981); ants (Wilson 1978b); bats (Hickey *et al.*, 1996) and desert rodents (Mitchell *et al.*, 1990). Overall, competition theory in the natural sciences deals with non-human animal species and intraspecific competition is emphasized. In significantly fewer cases interspecific competition is studied (*e.g.* lizard species, Ballinger *et al.*, 1990; mountain lions, bobcats and coyotes, Kochler and Hornocker, 1991).

When human and non-human animal interaction is discussed such descriptions are superficial. Hansson (1992), for example, suggests that man is undoubtedly the most important predator and subsequently provides a brief and general overview of the extinction of large mammals in Hawaii, New Zealand and Madagascar. However, there is no apparent theoretical or applied knowledge that examines HA-NHA interaction within the framework of competition theory.

There are a wide variety of interactions between animal species and these interactions are difficult to classify (Grier and Burk 1992). Inconsistencies, even at the most general levels of classification are easily found. Keddy (1989), for example, suggests that there are three main types of interaction: competition, predation and mutualism. Curtis (1983) agrees that there are three general forms of interaction but concurs with Keddy on only two of them, stating that interaction is generally classified as competition, predation and symbiosis (meaning "living together"). Curtis further classifies symbiosis into mutualism (+,+), commensalism (+,0), and parasitism (+,-) based upon the net effect of the organisms upon each other (see "+" and "-" symbols after each definition). Grier and Burk (1992) attempt to simplify all of this in the form of Figure 1.

We will begin in the upper left of Figure 1 and move down the column, repeating the exercise for subsequent columns to the right. We will provide a brief overview of each form of interaction and explain the relevance of terms to the current study. Subsequently we will provide more depth to our investigation of competition. As a preface to exploring Grier and Burk's (1992) figure we begin by noting that the goals of sustainability and

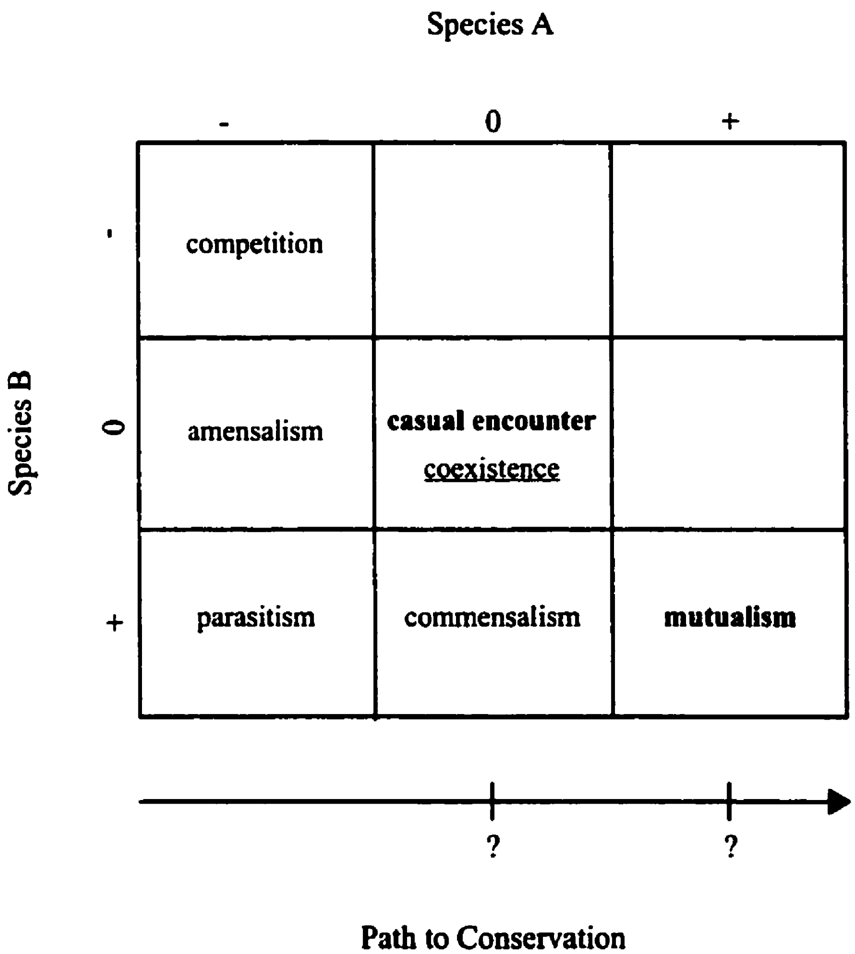


Figure 1: Defining Interaction Between Organisms (after Grier & Burk 1992). Categories of interaction in bold are forms of competition in which neither organism experiences any negative effects (as defined by Grier & Burk 1992). Coexistence (underlined) is designated to replace "casual encounter" and is defined as a form of interspecific interaction which is neutral - neither species experiences positive nor negative effects. The path to conservation is indicated by an arrow to the right and two question marks which suggest that the goal of conservation could be conceived of as either coexistence or mutualism. The goal of mutualism may be suspect however as it reinforces the ideology that nature can continually provide for the HA need for greater and greater benefit.

conservation focus on avoiding any forms of interaction that have negative effects. In other words, the entire left column of Figure 1 include forms of interaction which would, ideally, be avoided. Notwithstanding this general observation we will discuss all six forms of interaction outlined.

The first form of interaction is competition (-,-), a situation in which negative effects occur for both species. Given our earlier descriptions of global negative impacts on NHA populations it is understandable that the starting point for consideration of HA-NHA interaction is the setting of competition. While our understanding that negative impacts of HA species on NHA species are widespread (Goudie 1994), the negative impacts of NHA species on HA species are less often cited. Short term negative effects on human beings include parasites, attacks, crop pests, malaria and bacterial infections among others. Long term negative effects are likely to occur from human-induced decreases in biodiversity which will affect the ability of the environment to serve its three primary roles of life support, waste assimilation, and resource provision (Hunter 1995).

In addition to Curtis's (1983) description of forms of interaction, Grier and Burk (1992) introduce the idea of amensalism (-,0). The concept of amensalism indicates that one species experiences a negative effect while the other experiences neither a benefit nor a disadvantage. As with other pair-wise interactions each of our HA and NHA species can, alternately, be interpreted as experiencing the negative and neutral effects of interaction. In the first case, where we consider negative effects upon the NHA species and a neutral effect upon HA species it is difficult to imagine a long term interaction where non-human animals endure negative effects and associated effects on HA species remain neutral – largely due to the interconnected and interdependent existence of these two groups. While both species may experience positive and negative effects over short and long term periods it is unlikely that a neutral effect is ever achieved. Alternately we must consider settings where a negative effect is exerted against the HA species and there is a neutral effect upon the NHA species. Again, given the interconnected nature of HA and NHA species it is difficult to imagine a setting where negative effects occur for a human animal population and neutral effect occurs for an NHA population. For example, large-scale negative effects on human animals may provide some reprieve for non-human animal species. In settings of war where there has been massive depopulation of HA species there has also been positive effects on some of the NHA species such as small vertebrates which were able to re-populate areas abandoned by humans (Nuttall 1998). However, such an example could be interpreted not just as having a neutral effect on NHA species but a positive one, moving every scenario from amensalism to commensalism. Finally, it is possible to suggest that in the future all NHA species will ultimately be completely dependent upon HA species for survival (the exception being the complete removal of every member of the human species) and thus any negative impact on HA populations could also negatively affect NHA populations. However, we may also envision a setting where global scale biological warfare which targets HA species (negative effect) leaves NHA species and populations intact, and therefore constitutes a neutral to highly positive effect over the long term. Notwithstanding these rather extreme possibilities amensalism (and commensalism) as forms of interaction which leave one species experiencing a neutral effect, are unlikely candidates for conditions of sustainability.

We now turn our attention to parasitism. Of the many forms of HA-NHA interaction this form has likely received the most attention – largely due to the effects of parasitism on the health of both HA and NHA species (Corliss 1997; Petarcy *et al.*, 2000). This interest has stimulated an expanded and diverse literature which outlines the special nature of many parasitic relationships (Merten *et al.* 2000, Pointier 1999, Raoult and Roux 1999, Blaxter et al 2000, Roca *et al.*, 1999). For the sake of simplicity and utility within the process of research and model building this thesis will consider parasitism as defined by Grier and Burk (1992) as a form of interaction where effects on HA species are negative and effects on NHA species are positive. In the context of sustainability we once again want to remove the negative effect due to interaction and here an interesting constraint to sustainability arises: if we are to preserve nature should we preserve even those organisms which have negative effects on the HA population? Would or should HA culture eradicate all forms of disease causing organisms? Possibly the answer lies somewhere in the middle and in a context created through technology. Can HA culture develop the means to allow HA populations to be resistant to parasites while allowing the parasites populations to be sustained in other hosts or environments? Likely this is the case now as parasites exit in reservoirs outside human populations and are introduced through other vectors. Interestingly it may be possible to suggest that over some limited temporal extent that HA populations, which experience positive effects, are parasites of NHA populations, which experience negative effects. However, over the long term negative effects on NHA populations provide feedback that affects HA populations negatively.

The positive-negative relationship of parasitism is also similar to the form of interaction we refer to as predation. Here again one animal experiences a positive effect by ingesting another species which experiences a negative effect. As with other pair-wise interactions the context of sustainability supplies a direction: it is most likely that HA species prey upon NHA species and not the reverse. Of course interference competition in the form of hunting and killing has played a dramatic role in the evolution of the HA species and continues to this very day. Human animal extinctions of non-human animal species due to harvesting and land use decision-making are well known such as the passenger pigeons, the great auk, the dodo and many others (Swanson 1999).

A more circuitous form of competition may also occur and this is referred to in this thesis as conferred competition - the result of a (-,+) interaction where the HA species experiences a negative effect and the NHA species a positive effect. This form of interaction revolves around the creation of protected areas for NHA species. In such circumstances NHA populations do not exert negative effects on HA populations *per se,* however because setting aside resources for an NHA population is an act which *de facto* may limit access to the same resources for HA populations we arrive at a situation not captured by the terminology posed by Grier and Burk (1992). Under these circumstances a protected area which does not allow resource extraction of any kind by HA populations represents a pool of potential resources which are being denied. In short, conservation in the form of protected areas is a form of intraspecific HA competition - the status of competition is conferred upon HA-NHA interactions when HA consciousness addresses the idea of conservation and acts upon it by setting aside resources. Coincidentally, this allows us to define conservation in the context of competition theory and sustainability as the sustainable guarantee of resources for the exclusive use of a species. If the goal of sustaining HA and NHA populations through coexistence is to be achieved it is likely to occur by moving from the left-hand column toward the centre column and possibly beyond. This "path to conservation" is shown in Figure 1 (note the question mark indicating some degree of uncertainty). What happens as we continue our exploration of columns to the right?

Grier and Burk (1992, 291) make another alteration to Curtis's (1983) categories of interaction by describing a "0,0" relationship as a "casual encounter". In the middle column this description of "casual encounter" seems a drastic oversimplification. Obviously animal species can exert nil or neutral effects upon each other without ever encountering each other. Thus, casual encounter seems inappropriate. Conversely both negative and positive effects can also occur without HA and NHA species ever encountering each other (the long distance effects of HA pollution for example, might present a form of interaction without direct encounter). Thus our net "0,0" interaction at first glance seems of little utility. However, we may view this net neutral effect between species as the actual conceptual goal of conservation. This thesis refers to this net neutral effect as coexistence. Thus coexistence, for the purposes of this thesis, is defined as: a form of interspecific interaction in which neither species experiences positive nor negative effects. It follows that the move from competition to coexistence is about the guarantee of a certain level of resource supply or specialization of a species with regard to the use of certain resources, such that competition does not exist.

The concept of commensalism suggests that we consider a setting in where we assign values to HA and NHA species. The most likely assignment is 0-NHA and +HA. In other words, we envision a setting where there are no effects upon a non-human animal species and human animals benefit. The opposite suggests that human animal species would experience a neutral effect while an NHA species experiences a benefit, a situation which is counterintuitive based upon human animal history, particularly its widespread anthropocentric ethic which places the human species at the centre of the moral universe (Thompson 1998). Commensalism may be the path that has brought us to our current situation; HA's have believed they could prosper while having a neutral effect upon the environment, including its non-human animals. The interdependence of all living forms would suggest otherwise.

If the "path to conservation" arrow extends to the far right column only one option remains, a (+,+) relationship (mutualism) and possibly the ideal ideological endpoint of the "path to conservation". Is mutualism, "for long an "orphan interaction""(May 1986, 1120) our real goal? Here we must exercise caution. The loosely stated goal of conservation is to 'allow' other NHA species to exist. Should allowing a species to survive be interpreted as a positive effect? Or is the right to survival a "given right" as suggested by non-anthropocentric/biocentric or non-anthropocentric/ecocentric ethical theory? (Thompson 1998). If the sole goal of conservation is to equate the existence of a species with success, then even species with a few individuals are conservation successes. It is possible that mutualism, like commensalism fosters some of the same 'conservation bound' anthropocentric ethics which have taken us to our present predicament?.

It is also possible to suggest that HA species should never seek any form of interaction, which is designated with a "+" effect. This is because, loosely interpreted, positive effects within human animal culture are often interpreted in economic terms as increasing returns, increasing GNP's, incomes, or returns on investments. As Rees reminds us, such a focus on economic indicators or success and "growthmania" (Mishan 1967 in Rees, 1988, 22) pit an expanding economic system against fixed stocks and rates of materials and energy resources. By suggesting that the HA species take a step back (move from "+" to "0") within Grier and Burk's scheme we suggest that the HA desire to consistently receive "+" effects from "nature" be removed. This suggests that the ever increasing benefits desired by an increasing HA population can not, over the long term, produce positive or neutral effects on NHA (or ultimately HA) species. Lastly, a "+,+" form of interaction seems to suggest some kind of "happy balance" or "win-win" scenario. However, when one species experiences a greater "+" effect when compared to another species (also experiencing a "+" effect) a relative advantage occurs, and as such these symbols may be rather simplistic at more applied and functional levels. In summary, we have identified a number of forms of interaction shown in Figure 1, evaluate them in the context of the goals of sustainability and interpreted their usefulness. Based upon the preceding analysis this thesis derives three simple principles:

1) Avoid any negative interactions (remove of all options in far left column).
2) Avoid any interactions that are not balanced (removal of commensalism).
3) Avoid the false economy of continually expanding positive effects through interaction with nature (removal of symbiosis/mutualism).

Given that competition most closely resembles the current state of HA-NHA interaction we return to competition and a more in-depth discussion. Given our exploration of Figure 1 our approach is to ask "How can we move from competition to coexistence?". Of the variety of forms of interaction it is competition which has likely spawned the most interest and controversy. Some of this controversy has been generated because there is no coherent body or recent synthesis of 'competition theory'. Keddy (1989, 38) defines competition as the "negative effects that one organism has upon another by consuming or controlling access to a resource that is limited in availability".

Further, Keddy states that when one is considering competition one must consider:

1) kinds of resources
2) mechanisms of competition
3) kinds of individuals

An investigation of these dimensions of competition is a likely starting point or foundation for any research regarding competition. Keddy explores the classification of resources by identifying four means of describing resource types - trophic, temporo-spatial, mode of consumption, and finally, by resource ratios. Such a classification offers an initial framework for exploring resources. We will discuss all four methods briefly and then extract those methods that may prove useful in our discussions about natural theory and sustainability.

Keddy's first exploration considers trophic consumption at the atomic-elemental (C, H, N, O, P, S) level and while such a reductivist approach to competition may be suitable in some research it is likely that such an approach would not be capable of informing regarding the behaviour or characteristics of the sum of its parts, namely competition between species, particularly social and behavioral aspects. Ultimately it is too fine-grained an approach for a field study. Keddy's second exploration of temporal and spatial classification puts forward ideas related to resource availability and further, resource characteristics or classification in the form of being 'renewed continuously' or constant. These terms have relevance to the field of sustainability, as we are interested in such 'continuous renewal' as it approximates sustainability. These terms suggest that competition and sustainability are inextricably linked. As such, the rates and qualities of resource production are affected by the forms of competition for them. Keddy's third resource typologies, "mode of consumption", considers whether an organism harvests a fraction of a resource over a large space or harvests all of a resource from a much smaller space over time and is really another form of temporo-spatial competition. Keddy's final and fourth approach, considering resource ratios, addresses the number and types of resources an organism consumes and proposes a distinction between substitutable and essential resources. Substitutable resources are further subdivided into perfectly substitutable, complementary and antagonistic. Again, these terms have a utility in the arena of sustainability as the degree of resource substitutability of a resource will affect the intensity of competition for such a resource.

Keddy's second and fourth means of classifying resources bear closer scrutiny. The second form of classification addresses the resource characteristic of availability. Resources are identified as being constant or renewed continuously. Hunter (1995) while discussing sustainability expands upon this idea by suggesting that the environment provides three types of resources:

1) non-renewable (fossil fuels, oil and minerals)
2) renewable (animals, plants, air, water)
3) continuing (sunlight, wind, wave, geothermal and tidal energy)

The process of characterization of resources begins with our understanding that non-renewable resources play a limited role in discussions regarding sustainability. Any rate of use will ultimately deplete the resource so there is no question about 'sustaining' this finite resource for use by future generations (Hunter 1995). For example, supplies of finite resources and their expiry dates are anticipated by some to be as follows: uranium, 2010; oil, 2050; coal, 2400 (Guthrie and Perry 1980). In addition to the finite characteristics of resources such as oil we must also acknowledge that use by HA culture has far-reaching secondary effects on sustainability in terms of competition, the global economy, the development of alternate energy sources and, particularly, pollution. The predicted shortage of oil in the next few hundred years (Hunter 1995) emphasizes the observation that sustainability is primarily concerned with renewable and continuing resources (Hunter 1995; Chapin *et al.*, 1996; Becker 1999). Accordingly, this thesis will likely maintain such an emphasis. An interesting question arises: if there are no means of sustaining use of such resources is it necessary to conserve them at all? Part of the answer to this question may lie in examining alternative means of assessing the value of such resources. As mentioned above, oil is a non-renewable resource. Does this mean that we should completely deplete such resources based upon this classification? Are there other reasons for conserving such resources? For example, is it possible that oil serves a structural role in the geology of areas? Or does oil serve as some sort of historical hydro-carbon record? Such questions are worthy of consideration but are beyond the scope of this thesis.

In contrast to non-renewable resources, renewable resources such as plants, animals, air, water, fish and timber timber stocks, play critical roles in life-support, waste assimilation and as goods which have economic roles. These resources may, theoretically, be sustained and thus become a focus in characterizing resources.

Continuing resources are essentially forms of energy and, as such, are not generally perceived in terms of depletion. However, the quality of continuing resources such as sunlight, are affected by levels of atmospheric pollutants. Further, an additional focus might examine the role that continuing resources such as sunlight will play in displacing non-renewable sources of energy which would also provide a means of reducing waste products. However, the questions are, again, beyond the scope of this thesis. In short, our preliminary analysis of resource characteristics suggests that the focus of competition in the context of sustainability is contested renewable and continuing resources.

Contested renewable resources in most interspecific competition settings include such general resources as habitat in the form of vegetation, the variety of resources that serve as food, and water. These resources are tangible, quantifiable and may be isolated to a large extent in space and time (conversely, continuing resources are, to a large extent, 'intangible' in that states of quality are sometimes difficult to assess particularly on global scales). Issues of resource tangibility likely play a role in conservation and sustainability as those resources which are easily seen and which clearly indicate both their availability and their quality or condition (polluted water, dying trees, diseased animals) have the greatest opportunity of having an impact upon the human psyche and possibly changing human behaviour as a result (see Nuttall 1997 for topic of psychic hurt). Conversely resources such as air and water seem less tangible and therefore of less concern in regard to conservation and sustainability. Both the oxygen and nitrogen gas levels in our atmosphere play critical roles in oxidation of organic molecules by heterotrophs and the supply of nitrogen to soils through nitrification, however these resources are unseen. Overall, air also has the ability of acting as a medium that may transport materials that could decrease the fitness of plant, HA and NHA communities (plants, Heck and Anderson 1980; animals, Barthalmus 1980; humans, Guthrie 1980). Thus from a HA community perspective the tangibility of a renewable resource likely affects efforts to sustain such a resource. In summary, renewable resources play a significant role in issues related to sustainability given their direct use by HA and NHA populations as well as their overt tangibility. These resources exist physically and intra-psychically at local to national scales and form recognizable components of nature. Such attributes tend to provide a focus for models of natural resource management. Renewable resources which are less tangible, such as water and air, play a smaller role. If such preliminary characterization of these resources is helpful in establishing a focus for management then further characterization of resources may also prove useful.

We must also consider the continuing resources of sunlight, wind, waves, geothermal and tidal energy. Among these sunlight is of primary importance. Energy in the form of sunlight, the product of thermonuclear reactions taking place at the heart of the sun, drives all of the processes of life and thus has a dramatic effect upon the health of all living organisms including animals and the plants upon which they depend. Diminishment of the amount or quality of sunlight could drastically affect plant populations, primary production and thus the survivorship and fitness of many species. The relationship between air pollutants and plants has been described (Heck and Anderson 1980). Finally, wind resources provide moisture and a means of dissemination of seeds for many plants and lichens. These continuing resources are essential, there is no substitution. The identification and management of continuing essential resources will be discussed later with particular attention to relationship to scales of management and policy.

Keddy's fourth means of classifying resources examines the degree of resource substitutability. This means of resource classification initially suggests that there are a host of terms that describe the decreasing substitutability of resources. Based upon earlier discussion any such terms would be applied to renewable resources only, as continuing resources cannot be substituted. While considering resource substitutability Keddy uses the term "complementary" to describe resources. Often this is interpreted as being a condition where one resource cannot substitute for another but is a close approximation and is therefore complementary. Such an interpretation is incorrect. According to Keddy the term "complementary", actually means resources which act synergistically with others to create a heightened effect, *e.g.*, "a mixture of the two enhances growth more than equivalent amounts of either resource by itself" (Keddy 1989, 38). Keddy's presentation is confusing, largely because he integrates terminology that addresses resource *substitutability* with resource *effect.* Resource effect, particularly when one begins considering the almost limitless combinations of resources which could be combined to various degrees, is likely difficult to assess and thus, for the sake of simplicity and utility in terms of exploratory model construction it is more appropriate to consider single resources and their decreasing substitutability in a continuum as a starting point. This means that the word "complementary" is removed from consideration and an additional term "partially substitutable" is added. Thus our identification and evaluation of categories of renewable resources allow for the following four categories placed according to decreasing levels of substitutability:

1) essential
2) perfectly substitutable
3) partially substitutable
4) antagonistic

Within the subset of renewable resources priority would be given to ensuring the provision of essential resources. It is these resources which, if depleted, will have the greatest impact upon the stakeholder. The first priority of any effort to sustain the coexistence of competing populations is to guarantee contested renewable essential resources. A second priority would be those contested substitutable renewable resources (and the degree to which each resource is substitutable). Those resources, which best serve as resource substitutes, receive second priority. In decreasing priority we place resources which are less and less substitutable.

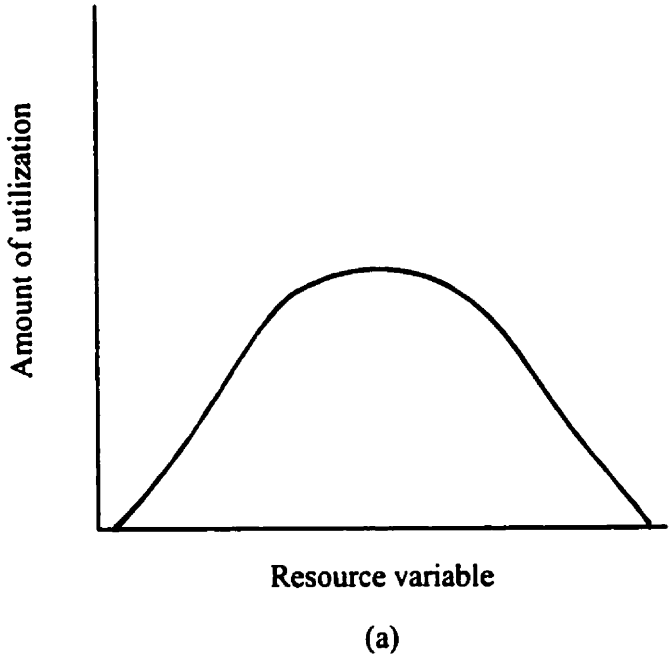
Mechanisms of competition include interference competition and exploitation competition (Keddy 1989). Interference competition suggests killing or disturbance while exploitation competition refers to the limiting of resource availability. Coincidentally, these two forms of competition overlap Cole's (1993) description of the ways that recreational activity affects wild animals, namely through harvesting (interference), habitat modification (exploitation), pollution (exploitation; to be discussed later) and direct disturbance (interference). Such dovetailing again suggests that competition theory may be a highly appropriate means of approaching human and non-human animal interactions in a context of sustainability.

The effects of human animals upon non-human animals are also affected by the kinds of individuals involved in competition. These competitive settings are characterized by individuals of different species, a form of interaction we refer to as inter-specific (between species). Interactions between members of the same species are referred to as intraspecific. Thus competition theory which focuses on interspecific competition is the likely framework for assessing interaction within a pair of human and non-human animal species.

This thesis considers an HA–NHA interspecific setting which suggests that the role of human animal culture (education, behaviour, policy) will have an enormous effect upon any competitive setting.

A trademark of *Homo sapiens* is likely to be imbalance in competitive settings, a condition that is omnipotent and ever present in the global competition setting. Characterization of competitive settings can be made on the basis of such imbalance or more specifically, according to the net effect, if any, on the particular form of competitive interaction. In competitive interactions where the effects of each species upon each other are equivalent the relationship is referred to as 'symmetrical' while if one population dominates the other in terms of resource use then the relationship is referred to as asymmetrical (Keddy 1989, 21).

Our last area of theory within competition theory focuses on the concept of the niche, largely because considerations of competition are almost always linked to the concept of the niche (Alley 1982; Pianka 1983). The concept of the niche has variable interpretations. This thesis will use MacArthur's concept of the niche as a resource utilization function (RUF). The RUF suggests that a resource which is variable according to some attribute (amount of energy, handling time) may be plotted along an x-axis while the amount of utilization may be plotted along the y-axis (MacArthur 1968, 1970, 1972). A typical plot assumes a bell shaped curve. The utilization of a resource for a single species as well as for a pair of species is shown in Figure 2. A series of such curves describing utilization and different resource types begins to describe an organism's 'profession' or what an organism



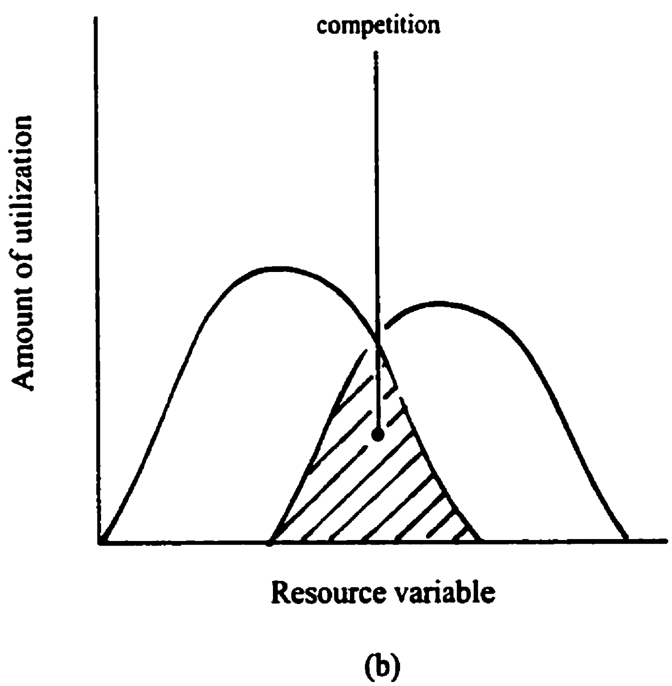
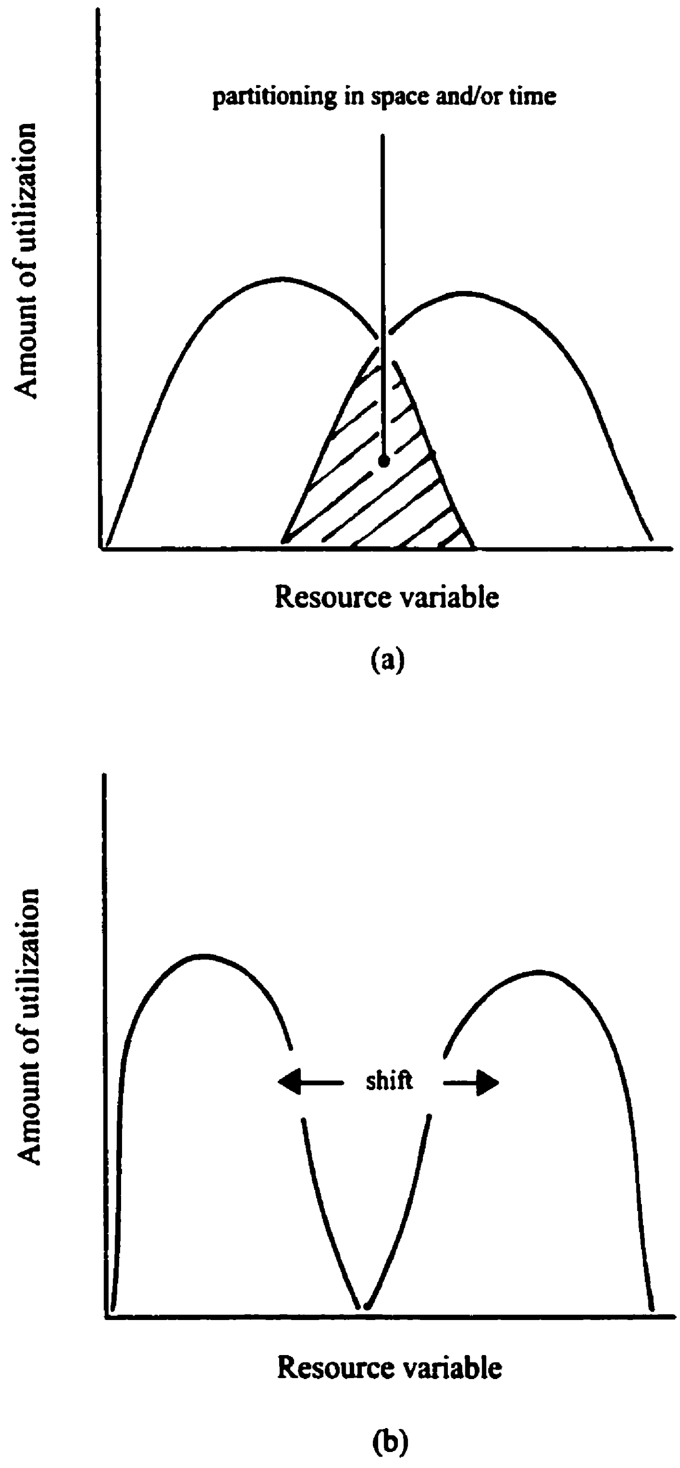


Figure 2: The niche: "a)" represents the niche as defined by MacArthur's resource utilization function or RUF for a single species (MacArthur 1972); "b)" represents the niches of two species sharing a single limiting resource. Competition is assumed to be most intense in areas of overlap.

'does' in a particular environment. When complete overlap in the RUF's of two populations occurs both populations are competing for exactly the same resource. As the curves of the two populations move apart and overlap decreases, so does competition. The greater the degree of overlap in RUF's the greater the competition. Competition for resources may be reduced in three ways. First, the RUF's and their overlapping portions can be reduced. In other words organisms may behaviourally or as a result of evolution adapt to using different portions of the resource variable in order to avoid competition. Graphically, the result is a pair of overlapping curves that move farther apart and reduced overlap. Such movement is referred to as a niche shift; the resources utilized by the animal are altered. Second, in the area of RUF overlap resource use may be partitioned in space. Third, in areas of RUF overlap the resource may be partitioned in time. This provides three means of reducing competition for resources and allowing for coexistence of species (Figure 3).

In summary, within the body of natural theory referred to as competition theory, a determination of kinds of resources is a first step to understanding how species may ultimately coexist. In these same settings we must also understand mechanisms of competition and kinds of individuals. Our knowledge of all three areas help define the niche or RUF of a species and further, to determine how overlap or competition can be reduced to allow for coexistence.

Taken as a whole the above sections on "Sustainability as a Return to Nature", "Sustainability and Natural Theory" and "Sustainability and Competition Theory"



<u>Figure 3:</u> From competition to coexistence in the RUF. In "a)" a pair of species have overlapping RUF's. Where competition is most intense resources may be partitioned in space and/or time. In "b)" the resource is partitioned through shifts in the RUFs.

suggest that the current WCED definition of sustainable development (SD) ultimately impoverishes the species *Homo sapiens* by presenting the species as separate from nature and that the key to sustainable development may lie in:

- recognizing the anthropocentric dominion perspective implicit in the current WCED definition of the concept of sustainability;

- moving this definition-concept in the direction of a multi -specific community perspective;

- acknowledging that, ultimately, the sustainability of the above community rests upon our ability to understand and apply the ways of nature ("natural theory");

- applying natural theory to HA-NHA competitive setting.

- using competition theory as a subset of natural theory, particularly MacArthur's (1968, 1970, 1972) concept of the niche as it relate to the partitioning of resources.

In summary, the literature suggests that the path to sustainability is a single trail taken by a variety of creatures. The insect, the bird, the lichen and the human obey the path of natural law and move toward an idealized goal – that of sustainable coexistence. The security of the path is directly proportional to the number of stakeholders that arrive at this destination.

Homo sapiens cannot arrive alone and must realize its role as integrated caretaker. In order to reach this destination we must recognize the anthropocentric dominion perspective implicit in the current WCED definition of sustainable development. Further, we must alter this concept of sustainable development to recognize a multi-specific, single community perspective. This perspective insists that the coexistence of a species within a community is dependent upon a natural theory perspective that peers into the future through the lens of sustainable development.

2.4 Synthesis of Literature Review

Within the literature the concept of sustainability remains elusive and presents a primary and persistent challenge to basic and applied research. Notwithstanding this elusiveness the recognition that an ecocentric approach is required is well supported given that ecology or nature ultimately subordinates other dimensions of sustainability. Both the literature on sustainability and criticism of this literature reveals that although an ecocentric approach is advocated and supported, such a focus is largely missing. This absence was noted: in the definition of sustainable development supplied by the WCED; in the lack of literature and knowledge linking the ecological dimension of sustainability to other dimensions of sustainability (political, economic, social and cultural); in the lack of application of principles of sustainability to natural ecosystems. The missing focus on nature may be supplied by observing that animals are primary components of nature and that the recognition and use of terminology such as "human animal" and "non-human animal" is an opportunity to indicate a combined and ecologically controlled ultimate fate.

It follows that the principles of ecology may be applied to all animals whether human or non-human. This creates an ecologically level playing field and is referred to, in this thesis, as a "Kingdom Animalia" approach. At the same time the evaluation of the literature suggests that the distinction between "human" and "non-human" animals must be made given the primacy of human effect.

The literature also suggests that the HA-NHA relationship may be characterized as expressing a "Dominion Perspective" and that this perspective is particularly evident in the Western hemisphere and is implied in the WCED (1987) definition of sustainable development. The utility of an ecocentric approach may be manifested through the development of an expanding ethic; a multi-specific perspective of sustainability which recognizes sustainability as comprehensive, connected, equitable and interdependent. Such integration and recognition of interconnectedness and interdependence is characterized as a return to nature and a means of removing one of the four conditions of "un-sustainability" (Bryden 1994b, 212). The literature attempts to integrate humans within a global ecology and posits that this species develop an understanding of, and a return to, the 'nature of nature' meaning an understanding of how nature actually functions and how to live within these limits. The approach will be problematic as ultimately it suggests that the over-arching freedom which we consider integral to expressing human animal culture will have limits placed upon it. Our seemingly endless stream of both fulfilled and unfulfilled wants, needs and desires will be truncated. Curtailing such freedom in a global climate characterized by inequity in power distribution and the complexities of multi-national and global controls will pose enormous problems.

The battle to retain particular freedoms in particular cultures will be hard fought. The question of a single combined fate contrasted against the inequitable paths that contribute to this fate poses additional challenges. For example, why should human animals share a common fate but not a common path? Deep ecologists would extend the same argument for all forms of life. The concept of present day and intergenerational equity are also components of sustainability and the question of a level playing field arises (placing all human and possibly non-human animals on the same path). Moving beyond the observation that a conceptually level playing field may be of some utility, further interpretation of the literature, particularly the work of Bryden (1994c) and Bradley and Lowe (1994), suggests an approach which identifies *single* multi-specific communities composed of HA and NHA stakeholders who are connected to each other and interacting through the shared use of resources. This physical community is also considered a community of interest and possessing a local social system. Such an interpretation affects definitions of sustainable development, moving it from anthropocentric to multi-specific and, ultimately, to a single multi-specific community.

Ecological and evolutionary principles are identified within the literature which may be applied to human as well as non-human animals. Although many of these principles are difficult to define there are some 'natural laws', interpreted collectively as natural theory, which are considered to be fundamental and universally acceptable. The suggestion that there are laws applicable to both HA and NHA species provides a means of reversing the dominion perspective. Overall, natural theory suggests a set of known standards or principles that describe the characteristics and functioning of natural settings and suggest the that the adoption of such standards or principles provides an opportunity to achieve sustainable coexistence. A particular subset of natural theory, referred to as competition theory presents an opportunity to deal with many of the same parameters which concern sustainability including kinds of resources, mechanisms of competition and kinds of individuals. Knowledge of all three areas helps define the niche or resource utilization function of a species and further, to determine how overlap or competition can be reduced to allow for coexistence. Such a reduction is the focus of this thesis and key to issues of sustainability as both HA and NHA species ultimately share a combined fate. With particular regard to the goal of this thesis the identification, analysis and interpretation of the literature suggests that avoiding such a fate will require:

1. acknowledging the utility and necessity of an ecocentric approach;
2. encouraging multidimensional and interdisciplinary research on sustainability in a manner consistent with ecocentric goals;
3. developing a common and synthetic ecocentric language and body of theory;
4. applying and evaluating new knowledge.

3.0 METHODOLOGY

Overview

The purpose of the methodology section is to describe the materials and subjects that were used as sources of raw data as well as the procedures used to formulate models and acquire and analyze data. The methods section also describes how the goals and objectives presented in the Introduction were met and provide enough depth to allow other researchers to replicate the work. The goal of this research was achieved through the realization of the objectives which occurred in three discrete methodological stages, corresponding to the following three sections: 3.1 Review of Literature; 3.2 Developing the SRP Model and 3.3 Research Methodologies.

3.1 Review of Literature

A review of literature was developed by identifying key issues, words and phrases that pertained to the research goal and objectives. These terms were then used as the focus for a computer-based literature search of books, periodicals and news articles. Electronic databases accessed at the University of Guelph and University of Manitoba included AGRICOLA, Biological Abstracts, Current Contents, Interdisciplinary Records, PAI (Current Articles and Papers), Philosopher's Index, Sociological Abstracts and Zoological Records. A variety of functions and operators were used to access the pertinent information including "and/or" functions to concatenate search terms as well as the use of operators to truncate (*e.g.*, *) search terms, insert wild card (*e.g* ."?") operators and quotation marks to define phrases. A sample of search terms included: competition; resource*competition; competition and theory; competition and interspecific; "resource partitioning coexistence; sustainable*coexistence; sustainable*partitioning, human* and animal*; modelling, models. Overall, results were often limited as the terms (particularly concatenated terms) describing the field of sustainability, in an interdisciplinary context, are recently evolved.

3.2 Developing the Sustainable Resource Partitioning Model

3.2.1 Introduction

Models, as structures of concepts (Britt 1997) or, as systematic theories of logical analysis, are concerned with prediction and explanation, two fundamental scientific goals (Phillips 1971). Other scientific goals may also be applied to models:

> "The goal of scientific theories is to (a) find out, (b) describe, (c) predict and (d) make use of functional relationships and regularities which are found in or constructed from the environment" (Peschl 1999, 188).

As such, models serve as human animal devices for making sense of the world, for helping human animals "cope effectively with their environment" (Philips 1971, 63) or aspects of social life (Babbie 1998):

> "It seems that both cognitive systems and science have a rather similar goal: the representation of the world. Both are interested in an adequate representation, description, explanation, prediction, and manipulation of environmental dynamics" (Peschl 1999, 187).

The above suggests that it is necessary to represent the environment in some way in order to survive within it (Peschl 1999). As such the goal of human evolutionary processes may be, in part, to generate representational structures which are capable of generating adequate behaviour or, in other words, to produce strategies for survival by depicting the environment (Peschl 1999). These models or representational systems aim at manipulating the organism's internal and external environmental dynamics in order to achieve desired states (Peschl 1999). To this extent we can suggest that in the context of sustainability models would play a significant role in establishing homeostasis, which is normally defined as "the maintenance of a relatively stable internal physiological environment or internal equilibrium in an organism" (Curtis 1983, 1097).

The more general utility of a model may also lie in its ability to (Keddy 1989):

1) communicate or describe a problem or challenge;
2) representation graphically a facet of nature while pondering a specific question;
3) introduce an organized train of logic and assumptions which can then be critiqued;
4) answer questions or shape the way in which questions are asked;
5) contribute to further study through data collection and experiments.

It follows that the SRP Model must be understood, not as an absolute or objective description but as a strategy for sustainability (coping with the 'environment') which meets the above criteria.

A model contains sets of propositions (statements about the nature of reality) which are systematically interrelated (Phillips 1971). By systematic we are referring to "the powerful tools of mathematical and logical analysis which can interrelate vast varieties of phenomena" (Philips 1971, 60). The movement towards interdisciplinary problem solving in the context of sustainability with its associated array of phenomena is thus fertile ground for the development of models.

The contribution of the literature to the development of the model is described in Section 2.5. Two additional methodological themes dominated the construction of the Sustainable Resource Partitioning (SRP) Model:

1) the theme of conceptualization from the work of Trochim and Linton (1986);
2) the theme of insight, in particular the "three-process theory of selection in insight" from work by Davidson (1995, 127).

The SRP Model may be interpreted as a result of a combination of the information gleaned from the literature review with the above two processes. The above two processes have not merely been combined but, rather, the work of Davidson has been subsumed within the larger process of conceptualization as outlined by Trochim and

Linton. The larger framework of Trochim and Linton will be discussed first followed by the work of Davidson.

3.2.2 Relationship Between Literature Review and Derivation of Model

The literature suggests that sustainability may be achieved by undertaking a return to nature approach which recognizes the utility of natural theory. Further, the literature suggests that natural theory encompasses a diversity of knowledge which identifies fundamental, unchanging and universally acceptable laws of nature. More concretely, the examination of natural theory reveals that the study of interaction between living organisms constitutes a cornerstone of natural theory, as exemplified by the work of Grier and Burk (1992). When the context of sustainability acts as a rubric for examining interaction between organisms the two conditions of competition and coexistence may be viewed as idealized endpoints. The goal of sustainability is, in part, to move away from the endpoint of competition towards the endpoint of coexistence. Thus, the logical starting point for a model would be to understand where sustainability is moving from or, in other words, to understand the nature of competition.

The model sees an examination of competition theory as the starting point and borrows from the work of Keddy (1989), a community ecologist, to undertake this exploration. The work of Keddy emphasizes an understanding of: kinds of resources; mechanisms of competition and kinds of individuals. Keddy states that this tri-partite emphasis is the foundation for understanding competitive interaction between two animal species. This emphasis is detailed in Steps 4, 5 and 6 of the model (see Figure 37). Necessarily, before we can undertake any such examination, we must first identify a setting where competition is occurring between two animal species, identify the resources which each species requires, and understand which resources are being competed for (Steps 1, 2 and 3 of the Model). In each of Steps 4, 5 and 6 the ecological theory is further contextualized by sustainability theory. In Step 4, for example, we further contextualize Keddy's work by using the work of Hunter (1995) to characterize the kinds of contested resources as renewable, non-renewable or continuing. Such a step combines ecological theory with sustainability theory. Ultimately, by being able to characterize kinds of resources, mechanisms of competition and kinds of individuals in this way we may develop a refined understanding of the components of interspecific interaction. Such interrelationship of two species to each other as well as their environment (resources) is a hallmark of the definition of ecology.

The literature reveals both the ultimate subordination of both HA and NHA cultures by ecological constraints and, simultaneously, the dominating influence of human culture. While ultimate ecological subordination is beyond the realm of the model, the dominance of human animal culture must be addressed. In the overall ecological framework of the model this is expressed in Step 7, where explicit attention is paid to the dominant HA species needs and effects upon interspecific competition. As suggested by Keddy's (1989) work in competition theory we must understand the needs and effects of species that dominate in competition. Such an understanding helps us determine how we might reduce asymmetry in competition and move from competition to coexistence.

Solely at the level of theory, and in the absence of any application in the field, the model allows us to develop a series of postulates regarding how our understanding of competition theory may be used to move from competition towards coexistence (see Section 4.2.3.8). These postulates are included in Step 8 of the model. The literature also illustrates three distinct mechanisms which illustrate how competing species may be sustained. These include the use of the same resource either in a different space or at a different time or by undergoing a niche shift that causes one or both species to use a different portion of the niche. This final step is shown in Step 9 of the model. Overall the literature suggests that we may achieve sustainability by understanding the goals of sustainability and applying ecological theory, in specific settings, in order to reach these goals.

3.2.3 Conceptualization – Trochim and Linton (1986)

Trochim and Linton (1986) define conceptualization methods as specifiable, definable processes which can be used to organize thinking and to represent it for others to see. They describe three stages in the development of a conceptual model:

1. Generation (G) of the conceptual domain. Distinguishable ideas, referred to as entities (resource use, human animals, non-human animals, coexistence) form the basic building blocks and together define the larger conceptual domain.

2. Structuring (S) of the conceptual domain. The relationships between and among the entities is defined. Here the work of Davidson (1995) was utilized – selective encoding, selective combination and selective comparison processes were implemented (see below).

3. Representation (R) of the conceptual domain. The structured set of entities is represented both verbally and pictorially.

3.2.4 The Nature of Insight – Davidson (1995)

There is no single methodology for the construction of a model. At the same time, a diversity of models exist and specific types of models tend to be discipline-bound such as models for decision-making (Perry and Moffat 1997); for developmental disorders (Teicher, 1996) or for pedagogy (Carnwell 2000). In their most diluted form the basic elements of models are generally thought to include concepts and relationships (Britt 1997). The formulation of models, the articulation of their concepts and their relationships, is suggested by some authors to be an act of discovery which may be viewed as irrational:

> "The process of discovery is said to be a more or less irrational process and, thus, cannot be included in a theory about scientific knowledge. In other words, the "context of discovery" is said to be shrouded in mystery for most traditional philosophers of science" (Peschl 1999, 185).

The themes of irrationality versus rationality in the context of insight may provide a means of suggesting how the SRP Model was derived.

Davidson's (1995, 125, 126) work on insight suggests that insight can occur through two means: one which includes the more traditional meaning of insight as an "a-ha" or "Special Process View" and; the other , a "Nothing Special View" which suggests that insight is merely an extension of the ordinary processes of perceiving, recognizing, learning and conceiving (see also Perkins 1981, Weisberg 1986). While debate about the validity of either of these views continues, Davidson develops a body of insight theory which suggests that that insight is the result of three essential and inter-related processes. Davidson's theory will be used to explore the development of the SRP Model. Davidson's (1995) three-process theory of insight involves:

1. selective encoding
2. selective combination
3. selective comparison.

Selective encoding occurs when an individual perceives within a set of stimuli one or more features which have previously not been obvious. Selective combination occurs when an individual assembles elements of a problem in a way that was previously unknown to the individual. In a related fashion the act of assembling a problem in a new way may be associated with selective comparison. Selective comparison occurs when an individual discovers a non-obvious relationship between new information and information acquired in the past. How each of the components of the three-process theory affected the construction of the SRP Model will now be discussed:

Selective Encoding

Throughout the academic and professional career of the author, and in preparation for field studies in Mozambique, an enormous diversity of stimuli were encountered. Many of the stimuli were 'recognizable' constructs of the 'natural' world (human and non-human animals, competition theory, resources, competition, coexistence). These stimuli were encountered or reinforced through the literature review. Over time certain stimuli became more obvious. These stimuli included:

1. the personal and subjective perception that the axiom of 'survival of the fittest was evident in both HA and NHA populations;
2. the understanding that the environment played a dominant role in setting the rules and regulations for survival;
3. the high visibility of competition for limited resources by both HA and NHA species;
4. the observation that decreases in biodiversity as a result of habitat destruction and fragmentation obscured the real, immediate and daily connection between HA and NHA species and their competition for discrete, quantifiable and sustainable resources
5. the observation that competition theory demonstrated how species could move from competition to coexistence in regard to resource use.

Selective Combination

The author's recent experiences in graduate coursework as well as the stimuli encountered in the literature review allowed for a unique combining of ecological theory and theory regarding sustainability. These stimuli were combined in new and novel ways that had previously been unknown to the author. The characterizing of resources according to ecological theory (substitutable, essential; after Keddy, 1989) but within a framework of sustainability (renewable, non-renewable, continuing; after Hunter, 1995) is one such example. An additional example is the modification or combining of ecological terms in an effort to ensure that such terms, while remaining useful within applied ecological theory, are coincidentally understood within strategies of sustainability. A final example of selective combining is the reinterpretation of the reversal of asymmetrical competition (from competition theory) via socio-economic effects (dimensions of sustainability) exerted by the subordinate species. The model, in its entirety, represents a high level of selective combining which, to some extent, may be expected when combining disciplines or seeking inter-disciplinary solutions.

These 'new' combination or novel observations were consistent with Peschl's (1999, 189) observation that "before any knowledge or a theory is constructed a cognitive system discovers that certain phenomena in the environment happen according to some repeatable patterns or rules". The patterns were largely gleaned from the literature. Based upon the above insights the researcher put together the elements of the 'problem' in a way that had not been obvious previously. In this case the awareness that competition theory as a discrete body of knowledge could be used to describe evolutionary solutions to competition for resources between HA and NHA species.

Selective Comparison

The knowledge encoded in selective combination came from the researcher's "past". The researcher "suddenly [realized] that new infomation [was] similar to old infomation in certain ways"(Davidson 1995, 129). Here again, the role of the literature review and past experience dominates. In other words the competition theory that had been used in the past to describe how resource partitioning in NHA species occurred and allowed for coexistence was thought to be suitable for application in the research setting. To some extent this is consistent with the notions of constructing correlations and constructing theories about a "hidden reality" as described by Peschl (1999, 191):

> "...the cognitive system has to construct a theory about the mechanisms that govem [the] hidden domain and that lead to the observed phenomena and regularities. The researcher strives to determine theoretical or abstract mechanisms that are capable of explaining, predicting or generating the environmental phenomenon."

Consistent with the goal of producing an exploratory model that describes an approach to achieving sustainable coexistence the above acts of selective encoding, combination and comparison and the adoption of competition theory suggested that the process of building a model would begin by re-examining resource use by HA and NHA populations in the research setting. The preceding step and first step in the model is a logical extension, that of recognizing the need to identify settings where HA-NHA competition for resources are occurring. Subsequent steps in the model follow the logic inherent in competition theory. The detailed results of this insightful model building process are detailed in Section 4.0 – Results and Discussion.

3.2.5 Summary of Approach to Developing SRP Model

Ultimately the Sustainable Resource Partitioning (SRP) Model serves to represent the environment in a more sustainable form than currently exists by expressing a means of approaching sustainability through the partitioning of contested resources shared by HA and NHA species. The model acts as a graphic representation of a train of logic which describes a particular problem, describes a solution, and in doing so is both explanatory and predictive. The model depends upon information obtained from the literature search as well as the researcher's past and is selectively encoded and combined in novel ways that demonstrate the hidden potential of interdisciplinary work.

3.3 Research Methodologies

The proposed research emphasis on resource use by both human and non-human animal species, combined with the inherent differences between HA and NHA research subjects, suggested the exploration of methodologies appropriate to each of these groups. Humans are believed to possess a unique consciousness, which is distinct from other non-human animal life forms, a distinct culture, and unique minds capable of thinking and reasoning and thus the study of humans is inherently different from the study of non-human animals and objects (Sheets-Johnstone 1996, Patton 1990). The distinct culture of humans is characterized by Morrow (1994) while contrasting the study of natural sciences and humans:

1) human social life is judge to be qualitatively different from other things studied by the natural sciences and consequently a humanistic approach is required;
2) interpreting meaning in human social life is the decisive feature that separates the practice of the human and natural sciences;
3) social facts are argued to be different from natural facts because they are created and re-created by the actions of human beings.

Such creation/re-creation of social fact is codified and manifested in a variety of ways including language, a phenomenon which allows for direct communication rather than inference during research and thus humans can ask humans about their behaviour, social interactions, feelings, plans, cultural values and purposes. In contrast, a traditional view of NHA species would suggest that animals possess neither a unique consciousness, a distinct culture, nor unique minds capable of thinking and reasoning and as such are simply "neutral objects waiting to be ordered" (Ellen 1996). The ordering of these neutral objects occurs largely through the mechanism of reductivist science – NHA species are observed, described, and characterized as having particular qualities or outputs (often behavioural) which are further analyzed and referenced with numerical measurement. Subsequently, NHA species are "understood" based upon these qualitative or quantitative descriptions. While these initial and traditional perspectives suggest separate approaches to understanding NHA and HA research populations recent debate about the validity of the assumed distinctiveness, and thus separation, of human culture from nature, must be addressed. Notwithstanding the above traditional approach to understanding NHA species recent "monist" theory suggests that the traditional "dualist" approach of man/human/society versus nature has been eroded by post-modern theory and evidence that suggests an expanding area of common ground. The monist approach which emphasizes the common ground of HA-NHA species is supported by:

1) the lack of distinction between human and non-human animals by many cultures (*e.g.*, the Achuar Jivaro of the Upper Amazon) (Descola 1994) suggesting that the Western dualist approach may be a cultural artifact;

2) that rational choice, long held to be the domain of *Homo sapiens*, is actually characterized by the natural domain and not human culture (Ingold 1996). This suggests that while nature is characterized by rational choice that society is controlled by an external narrative (primarily an economic structure, a "false" economy) that causes human behaviour to be exhibited in ways that are not optimal (and therefore not natural). Simply put, the monist approach advocates one nature – that which embeds humans in rational, natural, sustainable choice.

3) the suggestion that monist theories oppose the traditional, dualist model of evolution which sees environment (force) as a mechanism of ordering nature (response) and instead removes this binary opposition and suggests that the relationship between an organism and its environment is reciprocal. In other words the evolving organism is one of the selective pressures acting upon itself, a concept highly relevant to issues of sustainability (see Ho and Fox 1988).

4) the lack of distinction between *Homo sapiens* (human culture) and earlier hominids (as animals) suggesting again that instead of a binary opposition or divide between humans and nature there is a single joined continuum. If we are unable to determine when culture arose it cannot be dated, compared to a different and distinct period in time and thus expressed in a dualistic framework

Such HA-NHA commonality may have implications for methodological assumptions regarding the simultaneous study of HA and NHA cultures. For example, does a monist perspective, which recognizes a singular nature in which humans are embedded, extend to methodological approaches which in turn suggests that a singular methodology or the same methodologies be applied to both HA and NHA species in understanding resource use? If this is true then only quantitative/observational methods could be applied to both to determine resource use while qualitative/interview methods could only be applied to HA species. In seeking the consistency of a monist methodology and applying only quantitative/observational methods the absence of qualitative interview data for HA research subjects would ensure that an understanding of behaviour and perception would not be achieved, an aspect of research viewed as critical in determining sustainability at a global level. In summary, the use of quantitative/observational methodologies for NHA culture and qualitative/interview methodologies for HA culture is both expedient and relevant in the given research setting. While such an approach may be interpreted as a methodological rift which situates HA culture within a logical positivism framework and NHA culture within a phenomenological framework, we are reminded by Patton (1990) that it is methodological appropriateness that is required. Further, outcomes of the research may find ways to anneal such a methodological rift.

3.3.1 Understanding Natural Resource Use in NHA Populations

Resource use among NHA species has traditionally been explored in the fields of biology, ecology, zoology and animal behaviour (ethology). An overview of journals dealing with NHA resource use reflects these broad areas in journal titles such as Oecologia, Ecology, Animal Behaviour or Ethology. Alternately, journal subject matter and titles may reflect content according to taxonomically based groupings such as mammals (Journal of Mammalogy), birds (Condor, Emu) or primates (Journal of Primatology). In addition, published literature may focus on particular environments or ecosystems (*e.g.*, Freshwater Biology, Prairie Naturalists) or reflect more anthropocentric perspectives (*e.g.*, Journal of Wildlife Management). Overwhelmingly, quantitative, experimental and non-experimental approaches in the scientific model are adopted to determine resource use in NHA species. A small sample of such approaches include spatial analysis of habitat use through radio-collaring of mountain lions, bobcats and coyotes (Koehler and Hornocker 1991); body weight and zooplankton sampling to determine size class competition affecting resource use and growth in perch (Persson and Greenberg, 1990); competition for nectar resources in rufous hummingbirds (Heinemann 1992); statistical procedures for determining resource preferences among marine birds (Haney and Solow 1992); and foraging behaviour during observation periods to determine the effect of social groupings on resource use in the common bush-tanager (Valburg 1992). All of these approaches share a common "logical positivism" heritage - the use of quantitative and experimental methods to test hypothetical-deductive generalizations. The legacy of such logical positivism quantitative methods includes the generation of objective, standardized measures. For example Thomas and Taylor in a 1990 survey of study designs for comparing resource use and availability (review of 54 papers from the Journal of Wildlife Management, 1985-1988) noted that the majority involved the collecting, tagging, releasing and monitoring of animals with Chi-square goodness of fit statistical analyses. These measures allow numerous research subjects and their experiences to be understood through statistical aggregation and succinct generalizeable findings. The findings are then extrapolated to the community at large. Such methods are relevant to understanding animal populations as the gathering of data from individual organisms can help to determine habitat use, preference or natural resource use for the larger population.

It is also important to note that while quantitative approaches to understanding resource use were felt to be most appropriate for understanding the NHA community some qualitative approaches would also be used. Here, qualitative methods are understood to include data collection in the form of written documents, likely journal articles, specimens, tags and anecdotal written information which would detail where the species is usually found, the type of habitat it is usually associated with and other information. Such qualitative 'and largely historical descriptions often form a foundation for quantitative research. Particularly for species which are relatively unknown such evidence constitutes and important starting point for understanding resource use. The association between the search terms "qualitative" and "research" within the biological literature data bases is weak. In a search of Biological Abstracts between January 1989 and June 2000 (using NETDOC at the University of Manitoba) revealed a single record out of 88 records which used qualitative research (1.1%) related to non-human animals. This single paper uses qualitative assessment to divide birds into feeding groups (*e.g.*, herbivorous, insectivorous etc.; Cieslak 1995). Overall the literature indicates a recent and overwhelming use of quantitative approaches, built upon a foundation of qualitative-historical information, in determining resource use by NHA species.

3.3.2 Understanding Natural Resource Use in HA Populations

Sustainability may be characterized according to forms of interaction between HA species and the environment (Chapin *et al.*, 1996). Such interaction, in turn, is mediated by perception and behaviour, both social aspects of human culture. This social-cultural context of interaction (*e.g.*, influence of behaviour in relation to ethnic group, religion, education), particularly in regard to conservation, has been emphasized by authors such as Infield (1988), Heinen (1993) and Studsrod and Wegge (1995). Caldwell (1998, 1) further reminds us that sustainability depends upon "the ability and willingness of humans to *order their behaviour*...toward maintaining ecological integrity in human relationships with the earth" (italics author's emphasis). These authors emphasize the social context of humans in relation to sustainability and such an emphasis has a methodological bias towards qualitative approaches. Indeed one of the recognized problems of quantitative research with HA species is that it removes individuals from their social context and as such cannot contribute to understanding the social dimensions of sustainability.

Our understanding of the HA social context (within a phenomenological paradigm of inquiry) may arise from a research strategy expressing several strategic themes or approaches. Patton (1990) describes ten separate themes or approaches including: qualitative data, naturalistic inquiry, inductive analysis, holistic perspective, dynamic systems, unique case orientation, context sensitivity, empathic neutrality, and design flexibility.

Qualitative research tends to use the researcher (as instrument for measuring) to study specific issues with considerable depth or detail and without predetermined categories of analysis. Such an approach supplies detailed information regarding small groups and this in turn limits generalizability. Qualitative research most often records words as a method of interpreting issues. Qualitative approaches often use interviews as a means of understanding human community use of natural resources. Research addressing natural resource use by de Boer (1998) for example includes both qualitative and qualitative-quantitative methods through interviews and surveys in which numerical response rates to questions are assessed.

A specific form of interviewing, referred to as open-ended interviewing is used to gather detailed information. This form of interviewing (Patton 1990):

a) allows the researcher to understand the world as seen by the respondents;

b) permits the evaluator to study selected issues in depth and detail;

c) provides opportunities to approach the research without being constrained by pre-determined categories of analysis which contributes to depth, openness and detail;

d) produces a wealth of information about a small number of research subjects which allows for detailed understanding of a variety of experiences but reduces generalizability.

Naturalistic inquiry strategies allow the researcher to approach a setting without predetermined hypotheses. Instead, theory emerges from fieldwork experiences and is grounded in the data (Glaser and Straus 1967). Naturalistic inquiry (Patton 1990) is further characterized as inquiry in which:

a) the researcher does not attempt to manipulate the research setting;

b) the researcher attempts to understand phenomena in their naturally occurring states;

c) the focus is on capturing process, documenting variations and exploring important individual differences in experiences and outcomes;

d) there is no predetermined course established by or for the researcher.

Characteristics "a" through "c" above would likely apply to any research setting in which open-ended interviews are used to explore individual experiences within human communities in their naturally occurring states. However, there is often some predetermined course established by the researcher (often in conjunction with mandates from funding agencies) that include themes of research and thus, on a general or very broad level determine a course for the research. For example, the themes of sustainability and resource use direct the current research. It is the opinion of this researcher that such courses help determine topics of conversation *for* the research without predetermining outcomes *by* the researcher. Such modification of the strategy of naturalistic enquiry still fits with Guba's (1978) definition of naturalistic enquiry in that:

a) the researcher did not manipulate any phenomena in advance in order to conduct the research and,

b) there were no predetermined categories or variables used to describe the phenomenon under study.

Guba, in summary, describes naturalistic enquiry as a "discovery-oriented " approach that minimizes investigator manipulation of the study setting and places no prior constraints on what the outcomes of the research will be. Guba further suggests that naturalistic enquiry may be contrasted with experimental research where the investigator controls the conditions of study, external influences and therefore limits assessment to the outcomes of limited variables.

The above suggests that the naturalistic enquiry approach recognizes real world conditions where programs are subject to change and are therefore dynamic and process oriented. The shifting day-to-day reality and its complexity is accepted and recorded. Most importantly: "the data of the evaluation include whatever emerges as important to understanding the setting" (Patton 1990, 42).

Both qualitative and naturalistic approaches are inductive and holistic. An inductive approach will allow for specific observations to be recorded and then be used to build general patterns and theory. The approaches are holistic in that the entire research setting is understood as "a complex system that is more than the sum of its parts" (Patton 1990). In addition the holistic nature of such approaches focus on interdependencies and broad relationships as opposed to discrete variables and cause-effect relationships.

Inductive analysis involves immersion in the details and specifics of the data to discover important categories, dimensions and interrelationships; inductive analysis also begins by exploring genuinely open questions rather than testing theoretically derived (deductive) hypotheses. In complementary fashion the use of a holistic perspective allows the whole phenomenon under study to be understood as a complex system that is more than the sum of its parts; as such, the focus on complex interdependencies is not reduced to a few discrete variables and linear cause-effect relationships. This also constitutes a criticism of more quantitative methods in that quantitative approaches:

1. oversimplify the complexities of real world experiences,
2. miss major factors of importance that are not easily quantified and
3. fail to provide a sense of the study topic as a whole (Patton 1990).

In summary, qualitative and naturalistic approaches are ideal for understanding (through observation and interviewing) local human perceptions, experiences, thoughts on surroundings and events in these surroundings. Inductive and holistic approaches allow information to evolve from the research setting and investigation while attempting to understand an entire phenomenon understood to be a complex system. The products of such an approach would be pure description as well as quotations from interviewee responses. The use of quotes from interviewees suggest the exploration of methodological approaches with people oriented mandates. Exploration of methodological approaches often includes a distinction between four people-oriented mandates or methods, which may be used in gathering interview information (Lofland 1971):

1) the researcher will attempt to get close to the people and situation in order to understand what was going on;

2) the researcher will capture what actually takes place and what people actually say;
3) the researcher will include pure description of people, activities, interactions and settings;
4) the researcher would include direct quotations from people.

These approaches ensure that a comprehensive, meaningful record which characterizes research settings by maximizing the amount, breadth and utility of information.

Finally, Patton (1990) describes some strategies for research including: personal contact and insight; dynamic systems; unique case orientation; context sensitivity; empathic neutrality and design flexibility. These strategies are applied in ideal or 'pure' research methodology. As such, in practice, it is likely that only some of the strategies will be expressed and these will be expressed in varying degrees. Of these six approaches two are likely to be germane in the proposed HA:NHA setting. These strategies include:

1) personal contact and insight
2) design flexibility

Research which embodies the strategy of personal contact and insight suggests that not only does the researcher develop direct contact and familiarity with people, their situation and the phenomenon under study but that the researcher also incorporates their personal experiences and insights into the processes of inquiry and understanding of the phenomenon. Out of such an approach evolves (ideally) a sense of closeness and shared experience which allows the researcher to describe internal states which may be compared to external states (observed behaviours).

The final strategy in the examination of the qualitative aspects of this research includes "design flexibility" (Patton, 1990, 41). This suggests that the research will be "open to adapting inquiry as understanding deepens and/or situations change" and thus will avoid "getting locked into rigid designs that eliminate responsiveness; pursues new paths of discovery as they emerge" (Patton, 1990, 41).. The adaptability of the research is critical as there are no true standards for "paradigm purity and methodological orthodoxy" (Patton 1990, 150). Given the apparent complexity of the research, the contrast between HA and NHA populations and logistical considerations for the proposed research, design flexibility was felt to be of paramount importance.

Lastly, our exploration of themes, approaches and strategies in HA-oriented research should be contrasted with writing by Patton (1990) who suggests that researchers need not be concerned about theory, that they need only ask open ended questions of people and observe matters of interest.

Within the above discussion of strategic themes or approaches within a phenomenological paradigm the approach of a qualitative strategy includes a number of theoretical orientations. These theoretical orientations may include: ethnography; phenomenology; heuristics; ethnomethodology; symbolic interactionism; ecological psychology; systems theory; chaos theory; hermeneutics; orientational. A complete discussion of these orientations may be found in Patton (1990). The following themes of inquiry were explored as they were felt to be of possible value in relation to the proposed research topic:

1) phenomenology

2) ethnography

3) ecological psychology

Phenomenological inquiry focuses on the structure and essence of experience of a particular phenomenon for people in the research setting. The 'essence' is understood to be an understanding of what people experience and how they interpret the world. An additional emphasis in phenqmenological research is methodological, whereby the observer can only truly understand what another person experiences by experiencing it for themselves. Both or either or these preceding methodologies, focussing on what other people experience or experiencing it for ourselves, can occur and still be interpreted as phenomenological research. For the former, achieving and understanding of others' experiences often involves interviews which the researcher will use to define the basic elements of the experiences that are common to individuals in the research setting. For the latter, immersion in the research setting as well as setting experiences may provide additional information about the study group. The degree of immersion or involvement and the utility of the knowledge gained is debated.

According to Patton (1990, 67) ethnographers focus on the question: "What is the culture of this group of people?" An understanding of culture is often achieved through "participant observation" a term that refers to circumstances where researchers engage personally in particular activities in the research setting. Culture is understood to mean "that collection of behaviour patterns and beliefs" (Patton 1990, 68) that constitute "standards for deciding what can be, standards for deciding how one feels about it, standards for deciding what to do about it, and standard for deciding how to go about doing it" (Goodenough 1971, 21-22). An understanding of culture helps the researcher understand who is the research for and who will use the findings?. The goal is to interpret findings and apply outcomes within a cultural perspective.

In a related fashion this cultural perspective includes beliefs and perceptions about nature. Ecological psychology thus becomes a form of qualitative inquiry relevant to research regarding ecology, culture and sustainability. Ecological psychology asks the question: "what is the relationship between human behaviour and the environment?" (Patton 1990). Researchers involved in this form of inquiry see individuals and the environment as interdependent. Typically, ecological psychologists move from qualitative data collection in the form of descriptions to quantitative analysis of goal-directed behaviour and characteristics of behaviour settings.

While phenomenological, ethnographic and ecological psychology orientations may be major themes of the proposed research, a variety of approaches to gathering data are available. Within these themes both qualitative and naturalistic approaches could be used to inductively and holistically understand human experience in context-specific settings (Patton 1990). These approaches to research must also be understood.

In summary, with limited knowledge of the research setting it is likely that research methodologies will be encompassed by both logical positivism and phenomenological inquiry paradigms and these will be applied, respectively to NHA and HA species. Within the HA-phenomenological inquiry paradigm six discrete approaches to research are likely including qualitative, naturalistic, inductive and holistic approaches which employ the strategies of personal contact and insight as well as design flexibility. Finally, within a qualitative approach three theoretical orientations of phenomenology, ethnography, and ecological psychology were used. The research engaged human subjects, gathered specific observations and attempted to build general patterns. The research focussed on a complex system, its interdependencies (human, birds, resource use) and unifying principles (including those that unify beyond the level of human interview subjects). All of the above occurred through personal contact, observation and insight while allowing for changes in the design as was necessary. Research regarding the NHA population thus emphasized logical positivism using quantitative experimental approaches that provided objective, standardized measures. Some minor qualitative research was deemed appropriate in describing NHA history and distribution.

3.4 Field Research

As a preface to field work it is important to note that prior to arriving in Mozambique there was a large degree of uncertainty regarding the feasibility of methods of data collection. Concerns included:

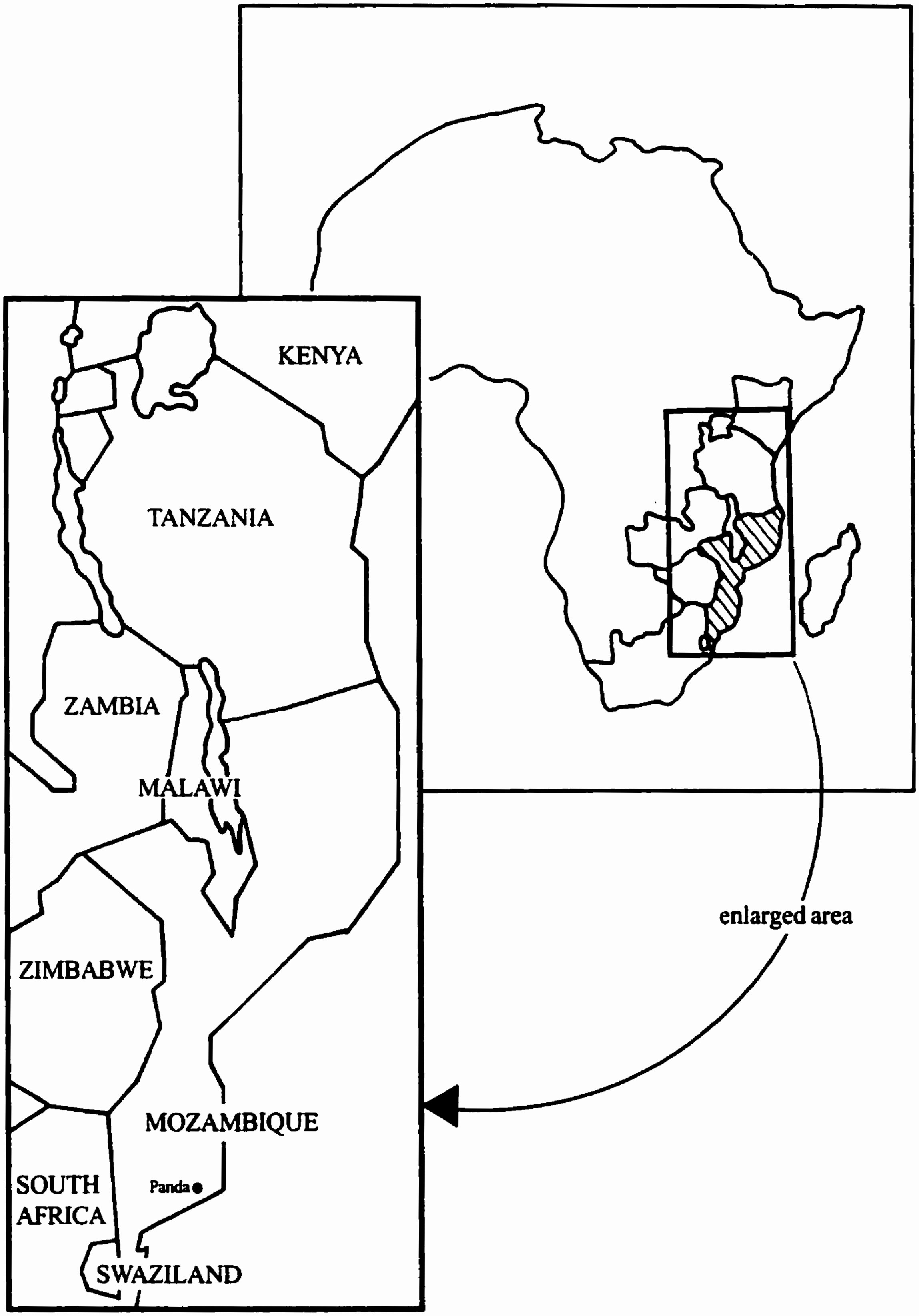
- safety of the researcher (*e.g.*, land mines, malaria, venomous snakes);
- feasibility of obtaining permits and permission;
- logistics of field work (support, materials, length of time in woodland);
- probability of locating bird species;
- probability of identifying bird species and locating nests;
- probability of bird being in breeding season;
- physical distance between researcher and birds /nests;
- types of information which could be gathered.

The basic nature of the research was inductive and saw understanding resource use as a starting point. This, in concert with limited knowledge of the research context, research subjects and general feasibility of methods, required an adaptable and broad methodological net in order to gather as much data as possible. As a result, the relevance of all data would be unknown, to some extent, until the completion of the research. These constraints, in concert with the fact that nothing was known of the NHA species, suggested that the researcher gather as much information as possible. To this end some of the data gathered, such as the history, morphology and distribution of the Olive-headed Weaver, does not related directly to the research goals and objectives. This broad approach to understanding the Olive-headed Weaver and its resource needs thus entailed a more 'classical' biological approach and the organization of the methods and results sections reflects this. Ultimately all of the information plays a role in contributing to understanding the kinds of resources the bird requires, how it may compete for these resources and the characteristics of the Olive-headed Weaver as a species.

As with the bird species the focus on resource use acted as the foundation for the development of open-ended questions for HA population interviews. However, in order to provide a flow to the interview, questions were presented in a stream such that there was a natural progression from one topic to another. For example the interviews began with questions about the individual and his or her family which allowed the researcher to then ask about: how the family arrived in the research setting; how they procured land; how they cleared the forest from the land; whether or not the forest was important; what kinds of resources it offered, etc. The streaming of the questions organized the responses into discrete socio-cultural, economic, ecological and political dimensions. As such the results are presented in this manner.

In Section 4.4.6 contested resource use for the HA and NHA populations is synthesized into a single overview.

Research was conducted in the People's Republic of Mozambique which is located in south-eastern Africa (Figure 4). The study area was located approximately 350 km north



<u>Figure 4:</u> Research setting of south-eastern Africa and Panda in Mozambique.

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of Maputo and 100 km inland from the coast (roughly the same latitude as the town of Inhambane). The study area was a discrete 10,000 ha forest. The nearest town, Panda, was located 23 km to the Northeast (see Figure 5 for location of study area). Throughout the bulk of this thesis, specifically the sections on Methodology and Results the two stakeholders are presented in order as the NHA and HA populations.

3.4.1 The NHA Population

NHA populations were approached using quantitative methods in an effort to establish objective, standardized measures. The desire to produce generalizable results from standardized measures necessitated the use of these methods. Statistical aggregation within a sample population would be used to generate succinct findings that could be extrapolated to the community at large. It is also important to note that while quantitative approaches were felt to be most appropriate for understanding NHA community some qualitative approaches would also be used. Here, qualitative methods are understood to include data collection in the form of written documents – likely journal articles, specimens tags and anecdotal written information accessed through field work..

Given the presumed threatened status and small population size of the Olive-headed Weaver (*Ploceus olivaceiceps*), field research methods were chosen to be as humane and non-invasive as possible. Field research methodology was consistent with "Category B " experiments which cause "little or no discomfort or stress" as outlined by the Canadian Council on Animal Care (CCAC 1991). Research activities such as behavioural

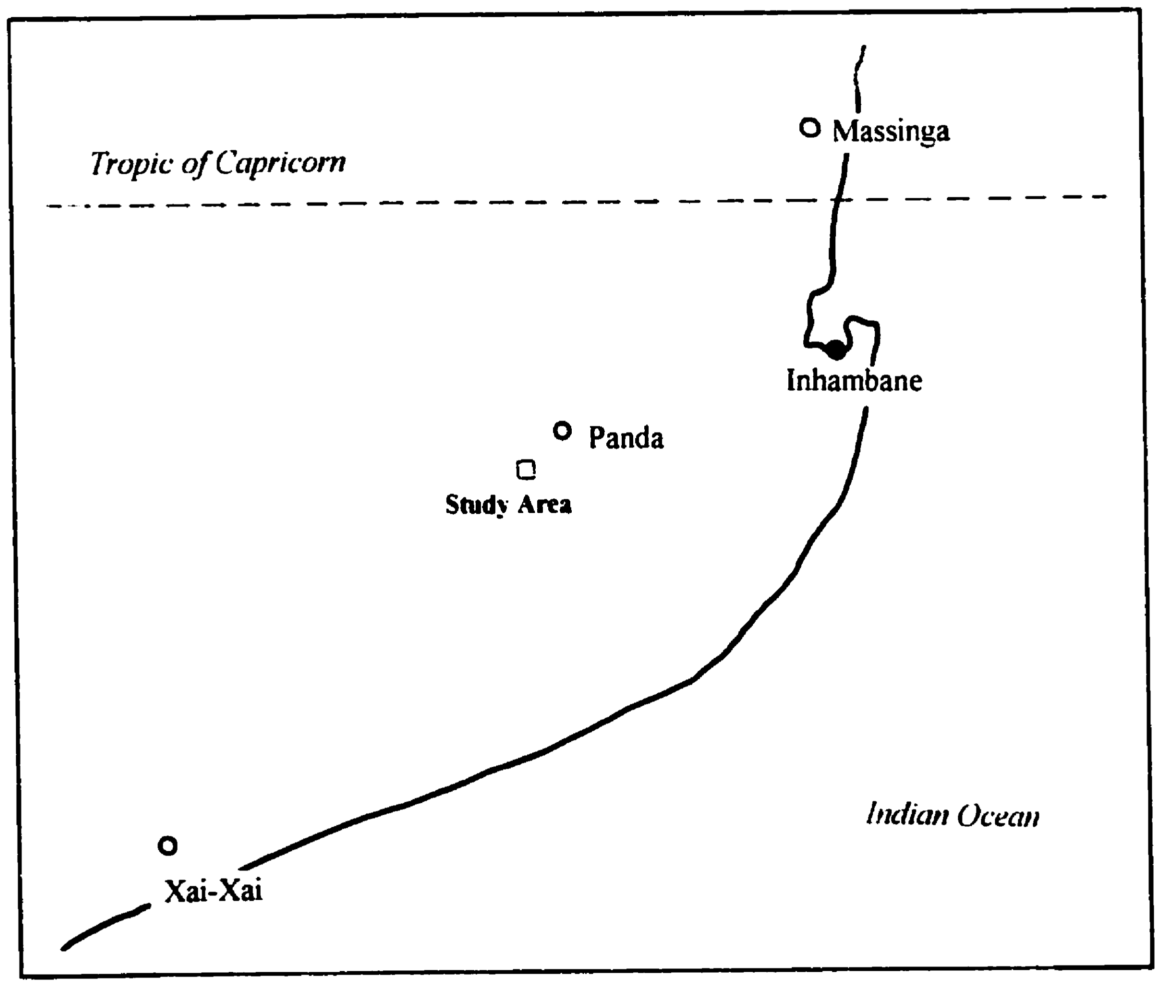

Figure 5: Research study area of discrete *Brachystegia* forest , 23 km south-west of Panda, Mozambique.

observations, collection of fecal samples and retrieval of abandoned nests were all completed with little or no disturbance to the bird population. Given the sensitive research context, lack of information, 'secretive' nature of the bird species and paucity of nesting sites an observational and descriptive approach was developed to provide an understanding of the bird's biology and resource use. In addition to an historical overview of the species the following aspects of the Weaver's biology were considered: distribution, current understanding of species distribution and population size, morphology, geographic location of nests, nest attributes, nest tree attributes, vegetative characteristics of nest tree areas and random areas, activity at the nest, foraging behaviour patterns and diet. The methods used in each of these areas is described below.

3.4.1.1 Distribution

An understanding of the potential distribution of the Weaver was gained through a largely historical analysis of preserved avian collections, academic and non-academic publications and personal communications. While a more comprehensive, *in situ* methodology is required, the current study had neither the funds nor the logistical support to undertake such a study. Given that the primary goal was to develop an understanding of the bird's biology, the researcher chose to focus an a location which offered the greatest possible chance of locating the bird, which was revealed to be a forest near the town of Panda in the Inhambane Province of Mozambique. The density of the species was initially approached by employing a variable circular plot method (Reynolds *et al.* 1980). Given the low abundance of the species a second method, Emlen's (1971) variable strip transect method was employed. Neither method proved successful due to the limited number of birds. Conservative estimates were provided by examining the total number of active and inactive nests discovered in a thoroughly searched plot of known area.

3.4.1.2. Morphology

The morphology of the bird was examined by using the same approach taken for distribution. Mean size of the bird was estimated through the use of historical literature. The colour and markings of the bird were compared through examination of preserved specimens at the Rothschild Zoological Museum in Tring England and Natural History Museum of Maputo as well as renderings created for bird field guides, photographs taken in the field and field observations.

3.4.1.3 Geographic Location of Nests

Nests were located by visual examination of tree canopies when trees were not in leaf. The geographic location of each nest (latitude and longitude using Global Positioning System, GPS) was recorded. Re-locating trees for subsequent research proved challenging as the GPS provided only the approximate position of the nest tree. Subsequently, each nest tree was then painted with a number to facilitate identification. Each nest tree was photographed with an object of known dimensions against it and then height was scaled from photographs. Tree diameter at breast height (dbh) was recorded at 1500 mm above surrounding grade. The diameter was calculated by wrapping a measuring tape around the trunk of the tree and dividing this measurement by "π".

3.4.1.4 Nest Attributes

At the conclusion of the breeding season five nests were collected and measured. Nest dimensions were recorded in millimetres, using a tape measure and calipers, as follows: nest chamber length, nest chamber width, spout outside and inside diameter, nest total length, and spout trailing edge. For a diagram of typical dimensioned components of an Olive-headed Weaver nest please refer to Figure 6. From these measurements two other measurements were calculated: spout thickness (spout outside diameter minus spout inside diameter); and spout length (nest total length minus spout trailing edge). In addition the distance of nest from edge of tree canopy (0-2, 2-4, 4-6 m), type of nest material and nest location on branch (branch tip or mid-branch) were recorded.

3.4.1.5 Nest Tree Attributes and Vegetation Characteristics of Nest Tree Area

A profile of nest tree area vegetation (nesting habitat) was approached following a modified method developed by James and Shugart (1970) and Kannan (1994). Using each nest tree (active or inactive) as a centre point, a distance of twenty metres was measured from the base and served as the radius for a circular plot of 1256.6 m^2 (0.126 ha). Within this plot the following infomation was recorded: tree species and dbh (including nest tree), whether a burl was present in area of dbh measurement, number of saplings in size categories 0-50mm, 50-100mm, 100-150mm, 150-200 mm (measured at 30 cm above ground level), type

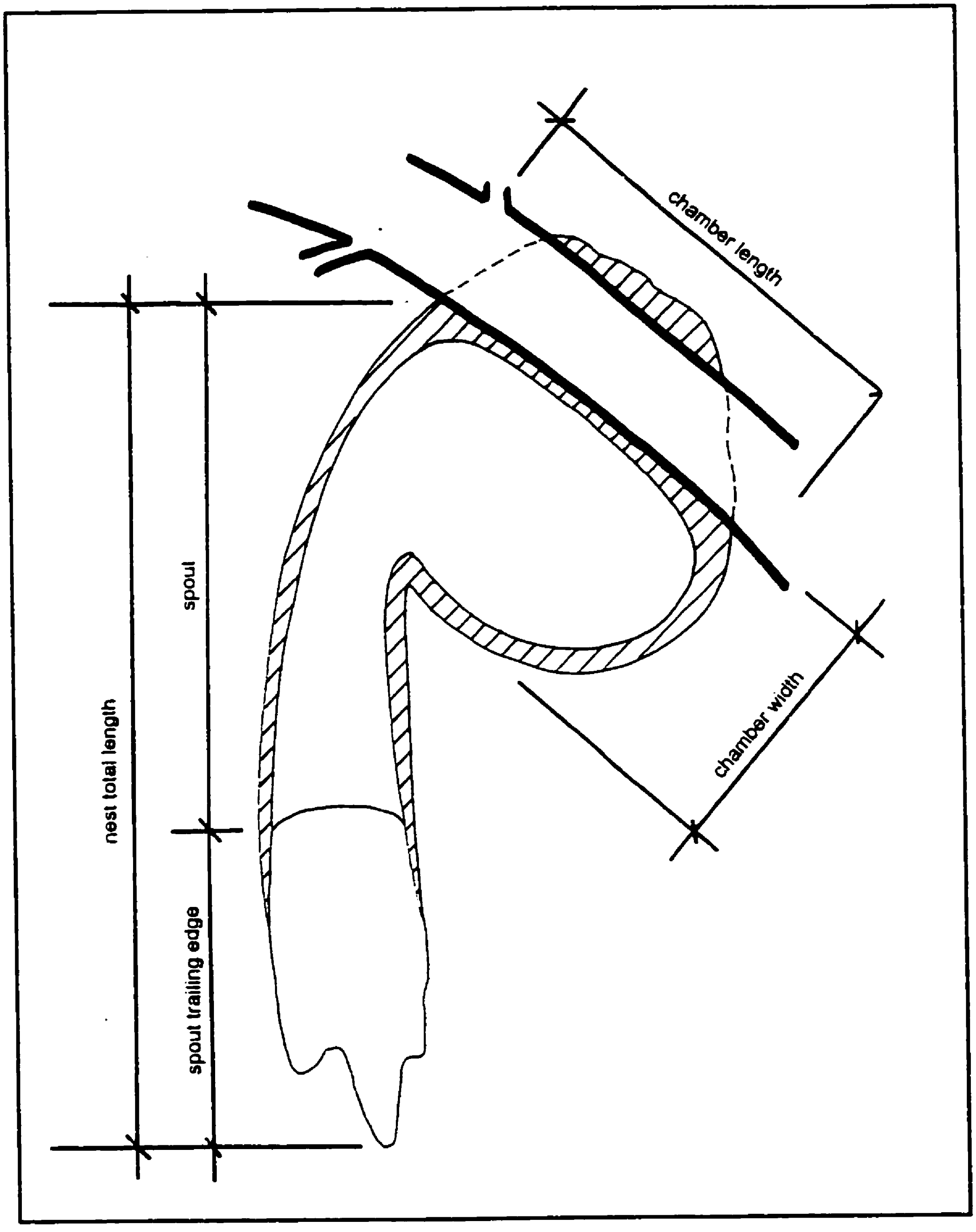

Figure 6: Diagram of typical dimensioned components of Olive-headed Weaver nest.

of substrate (grass, sand, forbs or combination) and presence of unique plant species (*Opuntia spp.*, *Aloe spp.*, Cycads). From this infomation the mean height and dbh of nest trees was calculated and the relationship between tree height and dbh was derived. The mean height and dbh of nest trees was compared with other trees within the nest tree areas. The characteristics of vegetation in nest areas were subsequently compared to random areas (see below). The term "tree" was applied to any plant that was greater than 200 mm dbh at 30 cm above surrounding substrate.

3.4.1.6 Vegetation Characteristics of Random Areas

Following a modified method used by Kannan (1994) 20 random vegetation plots were recorded in order to compare nesting habitat with random habitat. Random plots were located by using the nesting tree as a starting point and pacing 60 metres in a random direction allocated by the twist of a compass dial. The closest tree with a dbh greater than 200 mm was used as the new centre tree and the same vegetation attributes were recorded as for nesting tree habitat. It is important to remember that some areas surveyed in the random survey were inhabited by humans (there was often a paucity of trees) which may have affected the structure of the forest and so these areas, for both nesting tree areas and random samples, were discarded from analysis of vegetative characteristics.

3.4.1.7 Activity at the Nest

Each nest was observed for a minimum of two hours between 0500 and 1000 hrs to determine whether or not the nest was active (presence of breeding pair). Nesting activity observations were made from the ground with the aid of binoculars. Sex (male/female), frequency of visits (bird in/bird out of nest), duration of visits (difference in time between bird in and bird out) and presence of food or nesting material in the beak was recorded in real time using a tape recorder. The tapes were subsequently replayed and data transcribed.

3.4.1.8 Breeding Period

The breeding period was calculated by noting when nest building began and fledging of nestlings took place throughout the study period. This information was supplemented by the HA interview information where respondents noted that the Olive-headed Weaver breeds in August.

3.4.1.9 Foraging Behaviour Patterns

Foraging behaviour patterns were recorded when adult birds were located at random in the forest and followed while being observed through binoculars. A glossary of terms was developed to describe typical foraging behaviour patterns. Definitions of some terms were taken from other authors (Sodhi and Paszkowski 1995) while others were defined by this author for the purpose of this study. Real time, continuous recordings describing foraging episodes were analyzed for frequency of behaviours within and between sexes. If the frequency of any behaviour, for either sex, occurred at greater than once per 100 seconds it was included in analysis for both sexes. Frequencies of behaviours were ranked for both sexes and compared.

3.4.1.10 Diet

To determine diet a combination of field observations and dissection of faecal samples was used. Fledging faecal samples were obtained by retrieving faecal samples from the ground beneath nests. Samples were kept in air tight containers for up to two months, then softened with alcohol and examined under a dissecting scope for evidence of plant and animal material. The presence/absence of plant or insect material was recorded and if possible, the Order of insects. Classification of insects was performed with the assistance of Dr. Steven Marshall, an entomologist at the University of Guelph.

3.4.2 The HA Population

The method for understanding the local HA population involved Rapid Rural Appraisal (RRA). As a method, RRA was chosen because it was felt to be cost effective, information rich and more valid and reliable than a simple questionnaire. Further, RRA was judged to be appropriate given the emphasis on verbal interaction, particularly through semi-structured interviewing and observation (Chambers 1994). Semi-structured interviews are often regarded as the core of RRA (Grandsatff and Grandstaff 1987). Semi-structured interviews are valued as they are flexible, allow open-ended questions and provide opportunities for immediate follow up if novel information is presented. For a detailed analysis of underlying theory see Beebe (1987) and Jamieson (1987). Finally, it was felt that RRA would be an ideal way for the researcher, as an outsider, to "gain information and insight from local people and about local conditions" (Chambers 1994, 957). Had the research not been exploratory and/or the researcher more familiar with the local setting it is possible that RRA methods would not have been used. RRA methods usually suggest that the investigator adopts the role of the outsider who owns, analyses and uses the information using a mode best described as "extractive" (Chambers 1994, 959). Conversely, methods such as participatory rural appraisal (PRA) tend to be more empowering; the researcher acts as a facilitator and the information is owned, analyzed and used by local people (Chambers 1994).

Within the RRA approach human animal populations were examined using three discrete methodological themes including phenomenology, ethnography and ecological psychology. These themes were expressed in the form of three discrete questions, after Patton (1990):

1) Phenomenological theme: "What is the structure and essence of experience of natural resource utilization for the local Mozambican population?".

2) Ethnographic theme: "What is the culture of resource use in this local Mozambican population?".

3) Ecological Psychology theme: "How does this local Mozambican population accomplish cultural goals in relation to the environment and resource use?"

Within the larger theme-framework qualitative, naturalistic, inductive and holistic approaches were applied in interview settings in an effort to understand local resource use and included the strategies of using personal contact and insight as well as design flexibility. Qualitative approaches in the form of open-ended interviews were designed to allow the researcher to characterize the relationship between the local human animal population and the environment, particularly resource use. For example interviewees were asked: "What does the forest provide?" and "Are there animals in the forest?". This characterization would be through the respondent's eyes and provide a wealth of information in considerable depth. This approach was combined with a naturalistic approach, one which examined the real-life situation of a Mozambican community in as natural a manner as possible, meaning the avoidance of manipulation, control and intrusiveness. The interviews, as such, would be open to emerging topics and not place constraints on outcomes. In addition to this approach interviews would also be inductive, allowing relationships, categories and generalizations to emerge, rather than testing specific hypotheses. This inductive approach would allow the researcher to build information rather than pre-determine categories and topics. Finally, a holistic approach to the research was used to understand the whole phenomenon of HA, NHA communities and resource use as a complex system with interdependencies.

Once permission had been received from various levels of Government to proceed with the research and a base camp had been organized the local chief was approached to explain our presence in the bush, to mention our prior meetings with government officials and to ask for permission to speak with local community members regarding their lives and relationship with the forest. Permission to camp in the area was also requested. Interview participants were selected purposefully by the research assistant, Mr. Nelson Manave, who approached community members and asked them if they would speak to the research team. Mr. Manave was selected to participate in the research team because of his diverse knowledge of language (local dialects, Matswa, Tswa and Changana; Portuguese; a number of English words) and the ability to translate. Maximum variation in participants was sought – women, men, young and mature adults, subsistence farmers, hunters, teachers and labourers were among those interviewed. Local individuals and households (after Keating 1994) were engaged in purposeful conversation regarding their relationship with the landscape, in particular the forest and its resources. Such purposeful conversation is defined as an interview (Kahn and Cannell 1958). All participants were regarded as information-rich (Patton 1990), meaning that they had an understanding of resource need, use and availability as well as characteristics of the community. To some extent Patton's (1990, 176) description of "snowball sampling" is appropriate, once information-rich individuals had been contacted they often recommended other individuals to speak with. To avoid sampling only friends of friends of friends, which would stratify sampling somewhat, the research deviated at times from this approach, for example, by setting up interviews by chance (opportunistic sampling) and by setting up interviews in the local Maxixe market one day with permission but without notice. The goal of the interviews was to understand the essence of resource utilization (phenomenology and ecological psychology) as well as an understanding of the human animal culture (ethnographic) which used these resources.

3.4.2.1 Interview Settings

Interviews usually took place at respondent's homesteads which were located within the discrete 10,000 ha forest mentioned in Section 3.4. The homestead was defined as a discrete aggregation of huts, belonging to a family and their relatives who worked cooperatively in subsistence farming practices on a discrete piece of land. These settings usually included an object for the observer and assistants to sit upon (a chair or log) while the participants sat on other objects or on the bare ground or on reed mats. The setting was always outdoors, usually under the shade of a tree. Immediate surroundings included dwellings, structures for food storage, or structures that demarcated the boundary of the latrine, domestic farm animals and implements for daily use including mortars and pestle, hoes, basins and water containers, beehives. The substrate in the area of the dwellings was hard packed earth, often swept free from debris. Beyond this and almost always within view were cultivated areas and crops in varying degrees of maturity. All members of the family (average size between seven and eight individuals) present at the time participated and remained throughout the duration of the interview. The family, rather than the household was the fundamental unit of analysis given that extra, non-family members were not present and, in addition, that issues of generational differences and property transfer were familial (after Keating 1994; Gasson 1992).

A second interview setting was the local market. Here, the researchers provided chairs for themselves and respondents to sit in the shade of a tree at one end of the market. Within a loosely formed circle with a 100 m radius approximately a dozen stalls, made of wood frames and reeds were arranged. These shops displayed their wares hanging from their walls, and overhead structures in front which were intended to provide shade. Cookies, condensed milk, oil, tinned fish and cigarettes were common sale items. In addition to standing structures a few vendors sat on mats or blankets and displayed their wares: fresh meat from hunting or, rarely, seasonal vegetables like tomatoes.

The interview setting provided opportunities for recording of personal field observations. The "observation system" (McCall 1984, 269) included a set of rules for extracting information from the interview setting including non-verbal behaviours (laughing, pointing, drawing in dirt); appearance (clothing, shoes, material items) and the physical state of the environment (objects, implements, number of dwellings, evidence of domesticated animals). For a description of recording such observations see Schensul, Schensul and Le Compte (1999). It was felt that the observation settings and recording of personal observations might affect interview question probes and would thus affect the "detail and the generality of the resulting information as well as the questions to which the information is relevant (Hartmann and Wood 1982, 110). Notwithstanding this approach the information recorded was regarded as ancillary and not the focus of the research domains or factors (see subsequent Section).

3.4.2.2 Interview Structure

Interviews with key informants were arranged by the research assistant Mr. Nelson Manave. The use of key informants has been defined as "a technique of collecting information about a social situation by talking to a selected number of... participants" (Young and Young 1961). The key informants were chosen because they lived within the study area (the discrete *Brachystegia* woodland occupied by the Olive-headed Weaver), used local resources and were willing to speak with the interviewers. No key informants refuse to speak with the research team. All informants had roles which exposed them to the kinds of information being sought, a meaningful relationship with the knowledge, were willing to communicate this knowledge, were able to communicate the knowledge in an intelligible manner and were regarded as unbiased (Tremblay 1957). Mr. Manave generally set up the interview the day prior to the actual interview. Regarding the question of bias, informants are often criticized as being "unable to report accurately" (Freeman, Romney and Freeman 1987, 310) at least 50 percent of the time (Freeman, Romney and Freeman 1987), as a result of forgetting and generating false recalls. However, it is important to remember that any such bias tends to be in the direction of "consistency with...long-term patterns" (Freeman, Romney and Freeman 1987, 311) and is thus consistent with the types of information sought by the researcher. A variety of settings were used for interviewing including the homes of respondents, the local market and our base camp. Most of the interviews took place at the homes of respondents. Upon arriving at the respondent's home, chairs were generally offered, greetings exchanged and the interview begun. The interview structure was as follows:

1) exchange of greetings
2) introductions
3) explanation of research

4) questions, conversation and note taking

5) respondent's questions to interviewers

6) thank you to participant in form of sugar

As the core of RRA includes semi-structured interviews some discussion of this method is warranted. Semi-structured interviews may be distinguished from structured interviews as follows. The structured interview has "almost no flexibility" (True 1989, 123), follows an organized and rigorous procedure, and questions are asked exactly as formulated in the interview schedule, and exact answers are noted. The semi-structured interview, in contrast, also includes a list of questions to be asked in a particular order and instructions about the manner of asking, however, the interviewer is left with some discretion regarding how the interview is executed, for example the use of particular words (True 1989).

A defined set of questions served as the core for the interview while digressions were neither encouraged nor discouraged. Questions focussed on the four "domains" (after Schensul, Schensul and Le Compte 1999, 25, 150) of local HA population, local NHA population, resources and competition. Questions were designed to determine factors and subfactors within the domains (see Schensul, Schensul and Le Compte 1999). The factors were coincidental with kinds of resources, mechanisms of competition and kinds of individuals Keddy's (1989) tri-partite emphasis on characteristics of competitive interaction in competition theory. Sub-factors included modes of resource use, exploitation competition, interference competition, degree of symmetry in competition and intraspecific needs among others.

Given the exploratory nature of the research, interviews were composed of mostly open-ended questions, meaning that respondents answered in their own words and these words were then translated. The goal was to gather information that would provide an overview of the relationship between people, forest and resources. It was felt that this information might serve as a foundation for future more formal and more quantitative interview strategies. The interviews were of no fixed time frame. Males (both alone and with household units), females, individuals and families from a variety of age groups were interviewed. However, it was generally male heads of households within a homestead who responded. Researchers were told that interviewing females alone could be problematic however during interviews one day at a local market (a very public setting) several females were interviewed. A total of 16 interviews with a total of 64 participants (27 males, 37 females) were involved. In addition to recording the answers of respondents, observational data was included such as the presence of structures or domestic animals.

Translations were made from Matswa, Tswa and Changana to Portuguese by Mr. Nelson Manave and then Portuguese to English by Mr. Mike Rees. Mr. Mike Rees had been asked to be a member of the research team because of his logistical knowledge regarding set up of the base camp, an excellent knowledge of Portuguese and an understanding of possible threats to research (dealing with government officials, road blocks, threat of arrest). The issue of translation, and the problems associated with it, has received little attention in the published literature (see criticism by Crick 1982, Colby 1966 and Gumperz and Levinson 1996). At the same time this same literature sees social interaction as the primary means through which cultures are transmitted (Goodwin and

Heritage 1990) with linguistic and cultural relativity (Kay 1996) as central themes. With an awareness of such relativity "it [was] relatively easy to render in the target language everything that was said in the original [interview], the problem [was] to render all and only what was said in the original [interview]" (Kay 1996). For example, when asked how many wives he had a respondent replied that he had none. Given that he had several wives sitting adjacent to him it became clear that a kind of cultural relativity was in action; the researcher's definition of wife did not correspond to the respondent's definition. After further probing it became clear that there was a difference between government sanctioned marriage (which resulted in the creation of "wives"), and marriage according to local custom (which resulted in wives which were not recognized by the government). Such challenges have been noted elsewhere (work by Albert 1986 while studying the Kirundi in Burundi). In the long run, however, interviews were treated much like the bias suspected in knowledge produced by informants. By this it is meant that bias, over a significant number of interviews, would likely be in the direction of stable cultural patterns, which is consistent with the goal of the research. Further, when it appeared that clarification was required, further probes were used. At the end of the interview respondents were asked if any questions posed to them were offensive. Roles were then reversed and respondents were asked if they would like to ask the interviewer any questions. Finally, at the end of the interview a 2-kg bag of sugar was presented to the family or individual as a means of saying thank you.

3.4.2.3 Interview Questions

Translation occurred in two steps, from local dialects (Matswa, Tswa and Changana) to Portuguese and then Portuguese to English. Some respondents spoke Portuguese, enabling a more direct translation. Translators were given specific instructions regarding translation, in particular that there was to be no modification or substitution of words/phrases and that there was time for clarification of any points of conversation which 'fleshed out' back at camp. While the strictness of methods of translation were imposed throughout the research the interviewer was still free to modify particular words or, sometimes, the order of questions. Such approaches are still consistent with the semi-structured interview approach which forms the backbone of RRA. Typical question content and order is listed in Appendix 1. "Probing" statements were used to a great extent (a word or phrase uttered to stimulate the respondent to clarify or expand). Of the two forms of probes, extensions or echoes (True 1989), extensions dominated. For example, when asked "Is it important to leave any of the forest?" (see Appendix 1) respondents most often said yes. The probe extension, designed to elicit further detail, included "Why is this important?". Conversely, probe echoes (repeating what the respondent had said as an attempt to elicit more information) were avoided as their utility in the field setting both in terms of inter-cultural differences and time constraints of translation, was deemed to be of little value (respondents might not understand why a comment was repeated). The interviewer was aware of avoiding leading the respondents in any way and attempted to provide adequate time in which a respondent could answer. In general, time lags after the respondent answered a question did not result in additional information being volunteered. Respondents appeared to have felt they answered the question and simply waited for the next question. As such, no overt effort was made to introduce time lags. The respondent's affective (emotional) response to the question was also noted at times (*e.g.*, when one respondent laughingly referred to the "curandeiros" or shaman as the "mafia", this was recorded). All interviews took place within the boundaries of the study area.

3.4.2.4 Handling of Data

During the interviews answers by respondents were transcribed directly by hand, with quotation marks identifying direct quotes. Notes were reviewed at the end of each day and additional observations or further questions were recorded for subsequent interviews. In addition to recording responses from interviewees, overt observations were made and recorded such the presence of domesticated animals or number or qualities of structures in the research setting. Primary analysis of data involved the creation of a spreadsheet that identified questions and answers from all respondents. Based upon this spreadsheet, generalizations and inconsistencies could be noted in responses and an understanding of resources, forms of competition and characteristics of the local human animal population were developed.

3.4.2.5 Reliability and Validity of Information

Reliability generally refers to replicability, consistency, or the extent to which " a measurement procedure yields the same answer however and whenever it is carried out".

(Kirk & Miller 1986, 19). As such, reliability is often felt to be inapplicable to social research performed in natural settings. This inapplicability arises out of the assertion that replicability is dependent upon manipulation or control of the research setting and in contrast most social researchers do not attempt this manipulation (Wolcott 1995). Such concerns apply directly to the current research which seeks to undertake a naturalistic approach. To be succinct, social researchers cannot create the same research conditions twice. Given that objectivity is often seen to be dependent upon reliability, social research often poses concerns for those performing more controlled experiments. According to Wolcott, this should be of little concern to social researchers who should focus, instead, upon "carefully document[ing] ethnographic decision making" (1995, 168).

Validity refers to the degree to which observations actually measure or record what they purport to measure (Pelto and Pelto 1978). Much like the concept of reliability there is some question as to the relevance of applying this term, borrowed from quantitative research methods, to more qualitative social or ethnographic research. The degree to which field observations actually measure what they set out to measure may have degrees of validity, but there is, arguably no specific value or singular truth that may be revealed. The degree of validity may be affected by such things as methods, rigour of application and duration of time in the field. The more rigorous the research, the more sound the methodology, the more time in spent in the field, the more valid the research. As Sanjek (1991, 614) suggests "What the ethnographic method aims to achieve are accounts that support he claims they make. In terms of validity, there are better and worse ethnographic accounts". Two additional means of enhancing the validity of fieldwork may, arguably, be undertaken (see Bloor 2001). The first is achieved by triangulation, in which findings are judged to be more valid when a different method of collecting data yields identical findings. The second technique asserts that findings are valid when the researcher is able to demonstrate correspondence between the findings and the understanding of the members of the social unit being analyzed. In the first case validity is assumed because the different method used to gather data serves to minimize the possibility that measurement bias has accounted, in part, for the findings. The most obvious problem with the above assumptions occurs when the second data set, achieved through triangulation, does not yield similar results: which findings should prevail? As Bloor suggests (2001, 385) "the exercise cannot be a test of validity only when the findings are corroborated and not when the findings are confounded". In the second case, termed "member validation" (Bloor 2001, 387; also see Emerson 1981), most commonly refers to a process in which the researcher judges the validity of his or her work by taking the results back into the field and asking if the respondents recognize, understand and accept the findings of the research.

Overall, the approach to the field research taken was one which attempted to maximize the amount of time in the field, use personal observation to identify inconsistencies in the field and to be as consistent as possible during the semi-structured interviews. The investigation of reliability and validity suggested that, in the realm of social fieldwork, that "neither triangulation nor member validation [could] be regarded as tests of research findings (Bloor 2001, 394). It was subsequently determined that the research would best be served by carefully documenting the decisions made and leaving such decisions open to critical commentary. While every attempt was made to be rigorous "contemporary fieldwork, as a research methodology...doesn't claim to be totally objective social science, as either process or product, fieldwork or fieldwriting" (Chiseri-Slater and Stone Sunstein 1997, 39). Finally, it should be mentioned that the desire to enhance validity of work may be found in opportunities for reflexive elaboration. Some of this elaboration may occur through the examination of similar research performed in Mozambique, such as the work of de Boer (1998) which examined resource use through the administration of a questionnaire.

4.0 RESULTS AND DISCUSSION

The results reflect the outcomes of the focus of Section 3.0 – Methodology, and provides a similar organization to allow for easy cross-referencing. Accordingly, this section is divided into: 4.1 – Review of Literature; 4.2 – The SRP Model; 4.3 – Field Research and 4.4 – The SRP Model – Applied. In some sections ecotourism has been used as an illustrative example or scenario for discussing the results. It is important to note that this thesis does not focus on ecotourism nor consider ecotourism central to solutions concerning sub-Saharan African sustainability. Instead the thesis uses these examples because they are likely illustrative, relevant and likely familiar to readers interested in the sustainability of human and non-human animal cultures in the context of tropical developing countries.

4.1 Review of Literature

Human animal and non-human animal interaction is characterized by competition for limited resources. The outcome of each competition setting has the potential to, and does indeed often, reduce NHA population sizes, sometimes to the point of extinction. Such extinctions impoverish global biodiversity and ultimately have negative impacts on HA populations. Sustainability places an overt emphasis on resources and is thus linked, concretely, with competition. The path to sustainability is about reconciling such competition and such reconciliation may be found in the lessons of nature. These lessons of nature, referred to as natural theory, suggest the means by which coexistence, rather than competition, can occur. Achieving sustainable coexistence requires that HA communities recognize the anthropocentric dominion perspective implicit in the current definitions and approaches to sustainability. HA culture must alter this concept of sustainability to recognize a multi-specific, single community perspective. Similarly HA culture must find a way to understand resource use and partition the use of these resources in a sustainable manner in space and time. Our initial focus on competition theory as a form of natural theory suggests a research focus on contested resources. Subsequent model building expanded and refined this focus to include characteristics of resources, mechanisms of competition and kinds of individuals. The concept of the niche serves as a useful tool for sustainable resource partitioning.

4.2 The SRP Model

4.2.1 General Overview of the SRP Model

The model begins by identifying an HA-NHA interspecifically competitive setting (Step 1). Competition is linked to resource use (Step 2), particularly use which is contested (Step 3). These first three steps served as the focus for field research. The subsequent characterization of resources, forms of competition and kinds of individuals was considered to be central to the model and as such comprises three steps within the model (Steps 4, 5 and 6). The forms of characterization in each of these three steps integrates the fields of sustainability and competition theory thus integrating a return to nature as a means of solving ecological problems. Notwithstanding this integration it was clearly understood that HA culture played a significant role in controlling both the problems and solutions in matters related to competition, sustainability and ecotourism. The dominance of this role is articulated in Step 7. By characterizing (Steps 4, 5, 6) and subsequently analyzing these resources in the context of dominant community needs and effects ("symmetry" of the competitive relationship, Step 7) the concept of the resource partitioning may be applied with the explicit goal of moving from competition to coexistence. Subsequently, the model is able to provide general recommendations for limiting competition and sustaining resource use.

4.2.2 Detailed Method of Building the SRP Model

> Ought we, for instance, to begin by discussing each separate species - man, lion, ox, and the like - taking each in hand independently of the rest, or ought we rather to deal first with the attributes which they have in common in virtue of some common element of their nature, and proceed from this as a basis for the consideration of them separately?
>
> Aristotle, "De Partibus Animalium" (taken from Keddy 1989).

Current debates regarding conservation and development suggest that, in answer to Aristotle (above) we are interested *both* in animals as separate entities and as connected entities with a common nature. For example, as separate entities two species may have differential access to, need for and behaviour in response to procuring a particular resource. That two species have a shared requirement for a limited resource suggests that a single process, competition, unites them.

Thus our SRP Model begins with both the identification of separate animals and their resource requirements and then immediately moves to unite these species through competition by considering which resources are contested. The Resource Competition Interface (RCI) is a conceptual means of describing those resources that are competed for between human and non-human animal species. These resources become the focus of our goal of moving towards coexistence. The preparation of the RCI has three steps and they are coincidentally the first three steps of the SRP Model:

4.2.2.1 Step 1: The Identification of an HA-NHA Interspecific Competition Context

A context is identified where HA and NHA stakeholders are believed to be competing for resources. The identification of a setting where HA-NHA populations exist and interact is the first step in understanding the potential for coexistence of species under conditions of competition. These settings are numerous at a global level. The identification of a competitive setting is shown, conceptually, in Figure 7.

4.2.2.2 Step 2: The Identification of Species-Specific Resource Needs

Price (1984), supports Keddy's identification of resources as being a primary concern in competition, suggesting that "any study of a population or community should begin by explicitly considering resources". Resources are described by Tilman (1982) as

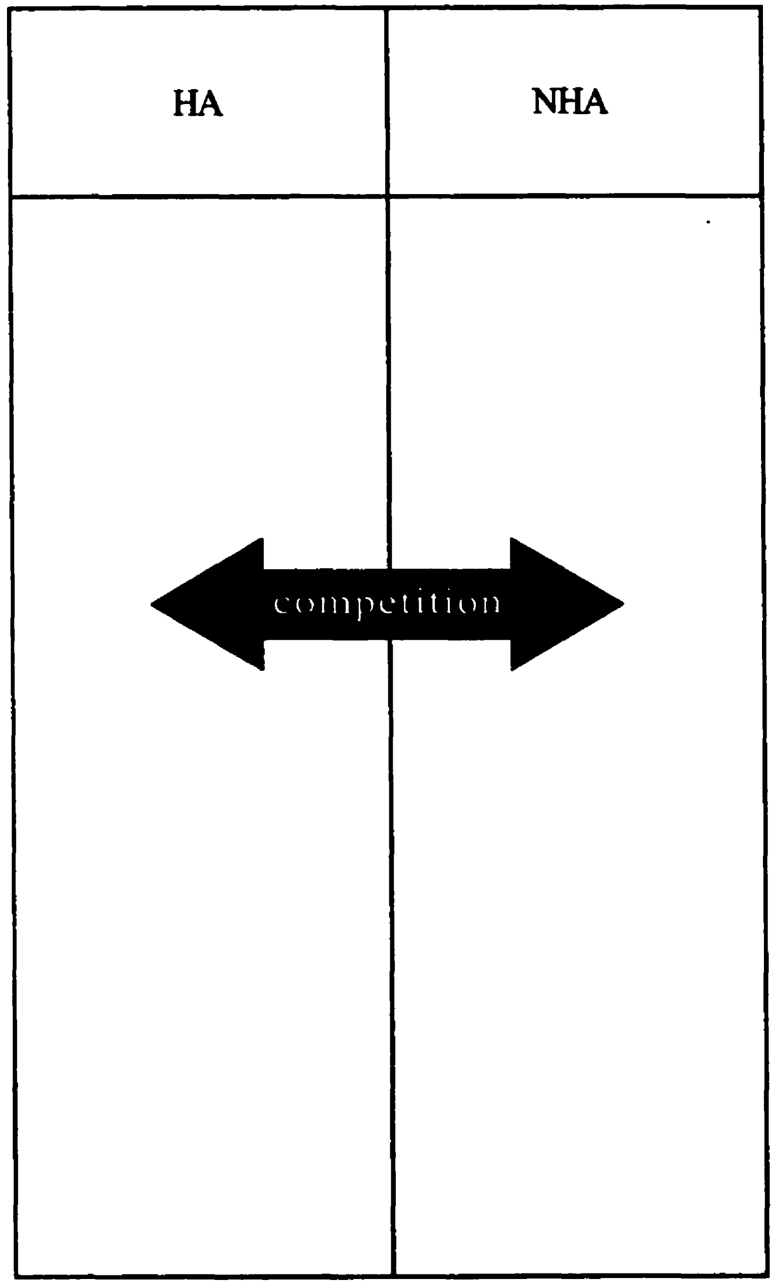

Figure 7: Step 1 of the SRP Model: The Identification of a Competitive Setting Between HA and NHA Species. Each column provides a species specific space within which resources may be identified.

substances or factors consumed by an organism which can lead to increased growth rates as their availability in the environment is increased.

In such a definition, the words "consumed" and "factor" play pivotal roles. This thesis suggests that the idea of consumption indicates use that prohibits other use. It follows then that some substances or factors are not consumed in the literal sense but are utilized such that they become unavailable to other organisms for their particular use. Human animals, for example, do not (generally) ingest trees. Instead, the tree is felled, cut, dried and used for a variety of uses. Such "utilization" renders the resource unavailable to other users. At the same time multi-dimensional (social, political, ecological, economic and cultural) human animal constructs may serve as important resources in the form of factors affecting growth rates. A factor such as policy is an example. Policy protecting an avian species such as the Peregrine Falcon is a factor that has the potential to increase population growth rates. Thus our common consideration of 'natural' resources must be extended to consider 'un-natural' resources as well, particularly in the form of policy (for the moment disregarding the issue that policy as an outgrowth of human culture may be viewed as natural). As the policy becomes more far-reaching, comprehensive, effective or stringent in its application its 'availability' (usefulness, effectiveness) also increases, and due to this availability is 'utilized', the result being a corresponding increase in the growth rate of a population. In 'short, as the factor policy is increased in availability we see corresponding increases in an organism's population. But is a factor such as policy strictly tied to the idea of 'increase'? It is unlikely that policy or any other factor is tied strictly to the idea of increase. In fact if policy is *altered* or a factor is *decreased* we may have corresponding increases in the growth rates of a population. Thus, the more general idea of alteration is useful to changing concepts of the definition of resource. It stands to reason that policy, lack of policy or particular forms of policy may introduce or remove competition by altering access to a resource which alters the negative effects that one organism may have on another. Thus a new definition of "resource" in the context of sustainability is required - one that broadens the ideas of "consumption" to "utilization", and contains the further caveat that a "factors" may include a very wide range of entities – including policy. As such a preliminary new definition of "resource", appropriate for the context of sustainability, and this thesis, begins as follows: any substance or factor utilized by an organism which can lead to increased growth rates as its availability in the environment is altered. Modification and specific reference to sustainability suggests that a resource is: any substance or factor utilized by an organism which can contribute to sustaining that organism or its community as its availability in the environment is altered.

Finally, we arrive at a definition of competition in the context of sustainability:

> The negative effects which one organism has upon another by utilizing, or controlling access to a substance or factor that is limited in availability and which could contribute to sustaining that organism or its community as its availability in the environment is altered.

It seems then that the resources required to sustain an NHA population in the context of competition with an HA community may include such natural resources as habitat, food and water as well as such "un-natural" factors such as policy. A conceptual representation of species specific resources is shown in Figure 8.

4.2.2.3 Step 3: The Identification of Contested Resources

The co-occurrence of two species and the identification of each species' resource needs does not demonstrate competition. Rather, as some authors suggest (Keddy 1989; Milne 1961; Price 1984) competition occurs only when resource limitation is demonstrated. Certainly in the case of human animal dominance over non-human animal populations, resource limitation in the form of habitat destruction has been clearly demonstrated. It follows that if sustainability is primarily concerned with competition it is also, by extension, concerned chiefly with those resources that are contested.

Resource use which is contested between HA and NHA populations becomes the focus of the RCI – these are the resources most likely to affect the sustainability of competing animal species. A conceptual representation of the identification of contested resources is shown in Figure 9. When resources have been identified as being contested they may be conceived of as being pulled in two directions by the two competitors. The RCI will typically include renewable resources as well as the generally recognized continuing resources of sunlight and other forms of energy. Other unique resources such as policy which fit into neither of these categories may also evolve. The RCI is illustrated in Figure 10.

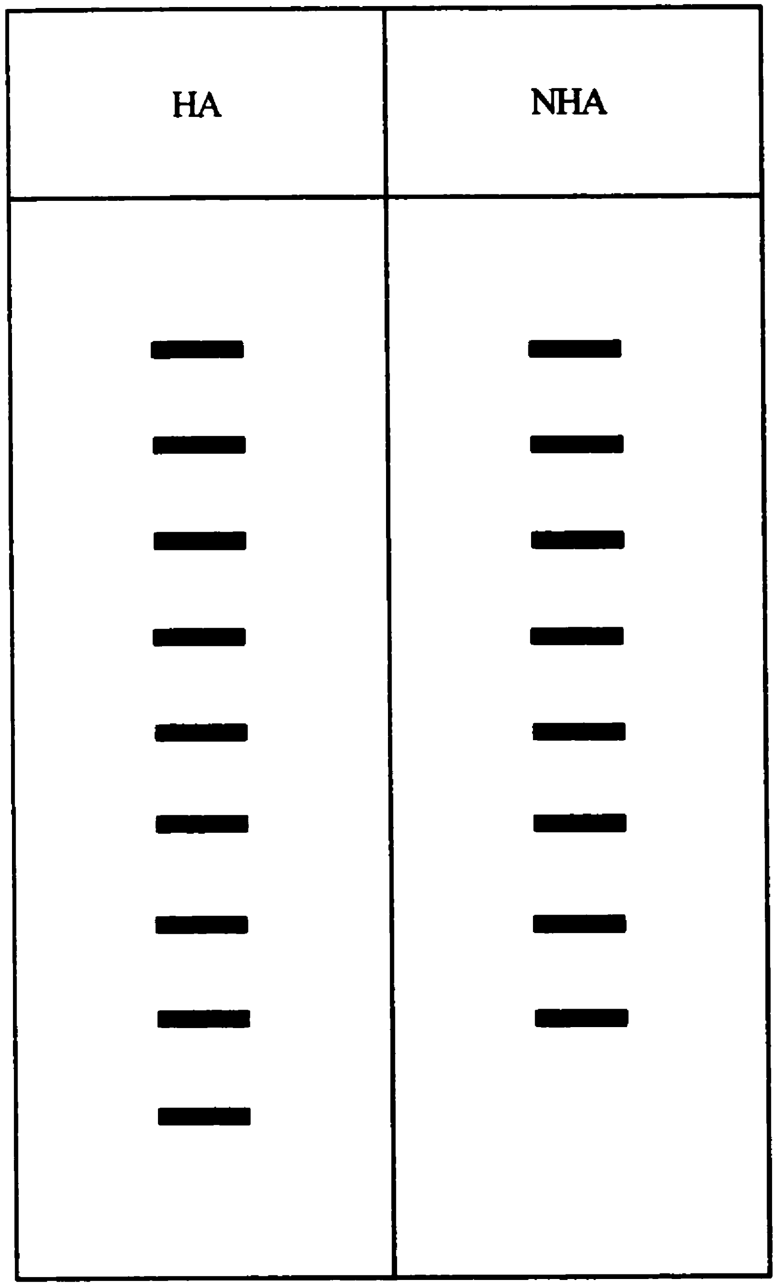

Figure 8: Step 2 of the SRP Model: the Identification of Resource Needs for HA-NHA Species in an Interspecifically Competitive Setting. Resources are indicated with horizontal black bars.

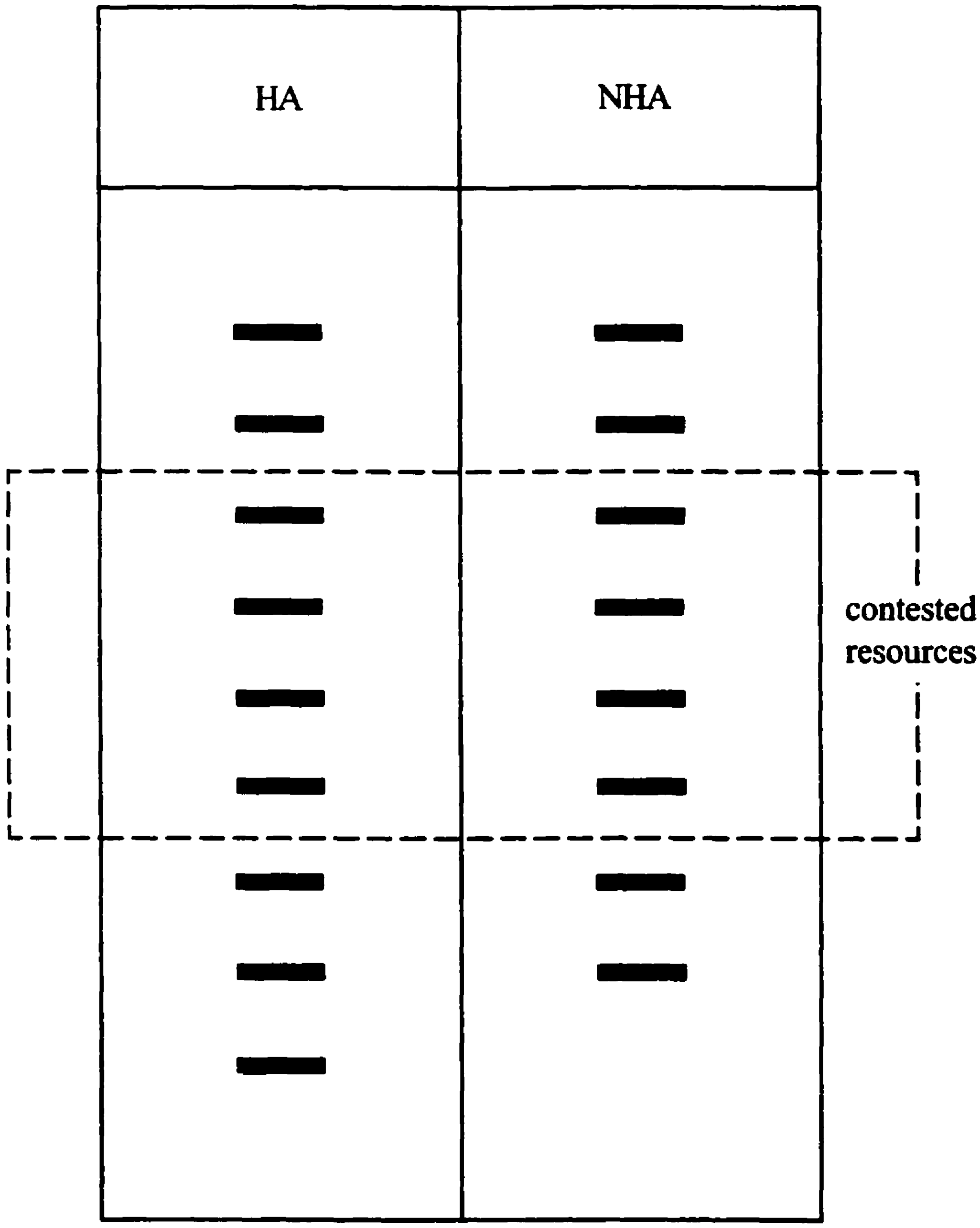

Figure 9: Step 3 of the SRP Model: the Identification of Contested Resources. The diagram suggests that HA and NHA communities depend upon specific resources, some of which are contested interspecifically.

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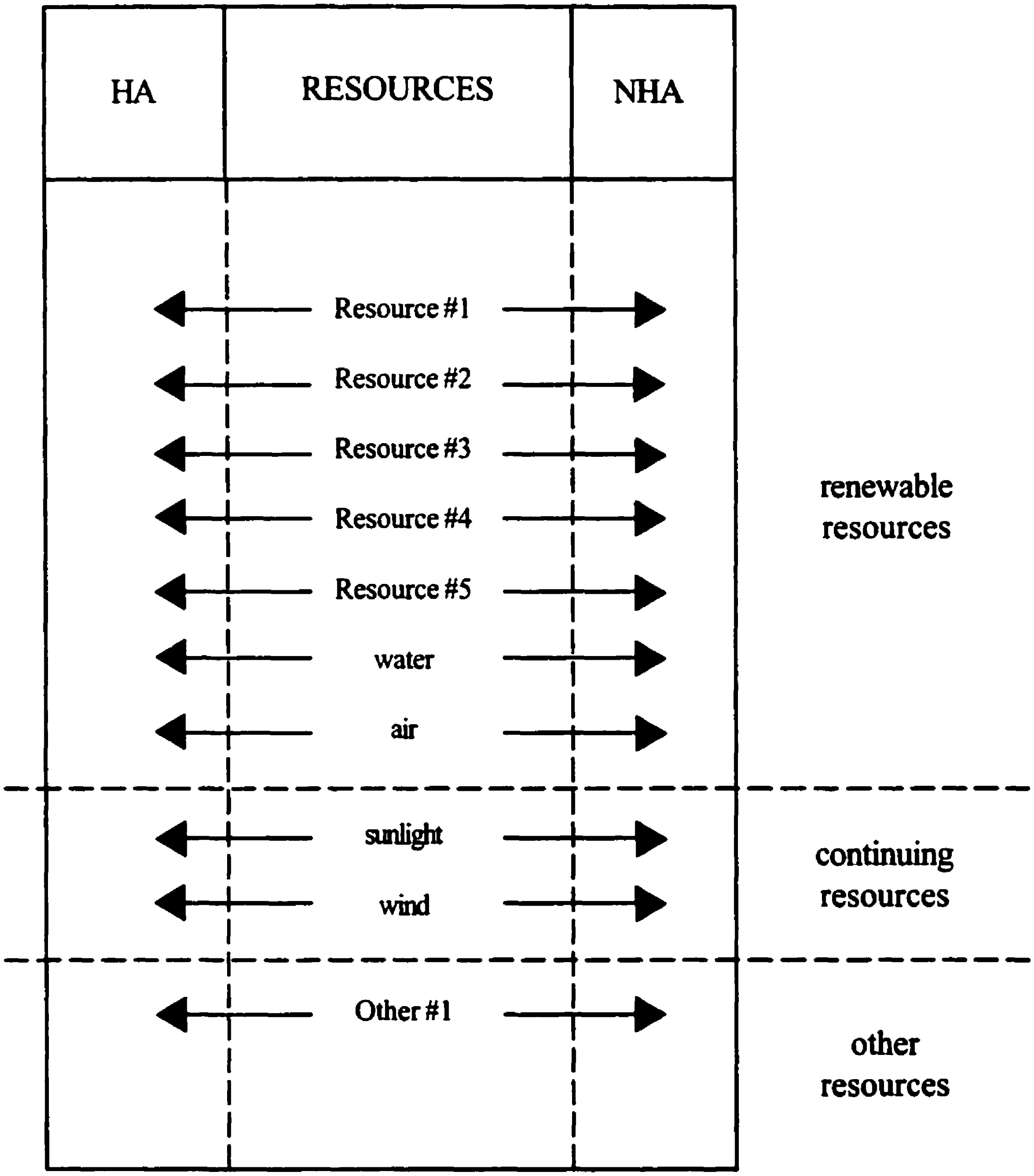

Figure 10: The Identification of Contested Resources in the Research Setting. The RCI identifies contested resources in multispecific stakeholders settings. Generally these resources are renewable and continuing resources although other factors, such as policy, may be identified as resources (see "Other #1") as a result of field research or developments in theory.

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The characterization of kinds of resources is the next step and the fourth step in moving towards sustainable resource partitioning (SRP). SRP is a form of natural theory resource management that has, as its primary goal, the sustainable partitioning of characterized resources in space and time for both HA and NHA stakeholder communities. Those steps proposed in the development of the Sustainable Resource Partitioning (SRP) Model that build upon the RCI and its identification of contested resources are:

Step 4: Characterization of kinds of resources

Step 5: Characterization of mechanisms of competition

Step 6: Characterization of kinds of individuals

Step 7: Characterization of dominant community stakeholder needs

Step 8: General recommendations for limiting competition

Step 9: Sustainable partitioning of resources.

It is important to note that while the SRP Model begins with *contested* resources as a starting point it could be suggested that given the far-reaching effects of HA culture that, ultimately, *all* natural resources are contested because all environments have been affected by the human presence (Gomez-Pompa and Kaus 1992; Fairhead and Leach 1995).

4.2.2.4 Step 4: The Characterization of Kinds of Contested Resources.

Our preliminary analysis of resource characteristics suggested that the focus of sustainability in HA-NHA competition settings are those contested resources that are renewable and continuing. This emphasis is shown in Figure 11. An emphasis on renewable resources occurs in the sustainability literature (see O'Riordan 1993).. Our consideration of the substitutability of contested tangible renewable resources in Section 2.3 suggested that categories of decreasing substitutability included:

1) renewable essential
2) renewable substitutable – perfectly substitutable
3) renewable substitutable – partially substitutable
4) renewable substitutable - antagonistic

Renewable-essential resources are the focus of sustainability and coexistence of species. The degree of specialization of a species in positively correlated with risk of extinction and thus essential resources, which by definition express such specialization, are the most critical for sustaining a particular population.

To carry the above analysis further one may suggest that the goal of sustaining resources for animal communities should focus not just on essential resources but also on those resources which are less than ideal, as "back-up" resources. Such an approach suggests that each animal has a "resource net" or pyramid of decreasing substitutability and that sustainability is concerned with casting a comprehensive resource net to guarantee resource supply. Such an approach is presented conceptually in Figure 12.

When we speak of resource nets and acknowledge that some of the resources used by an

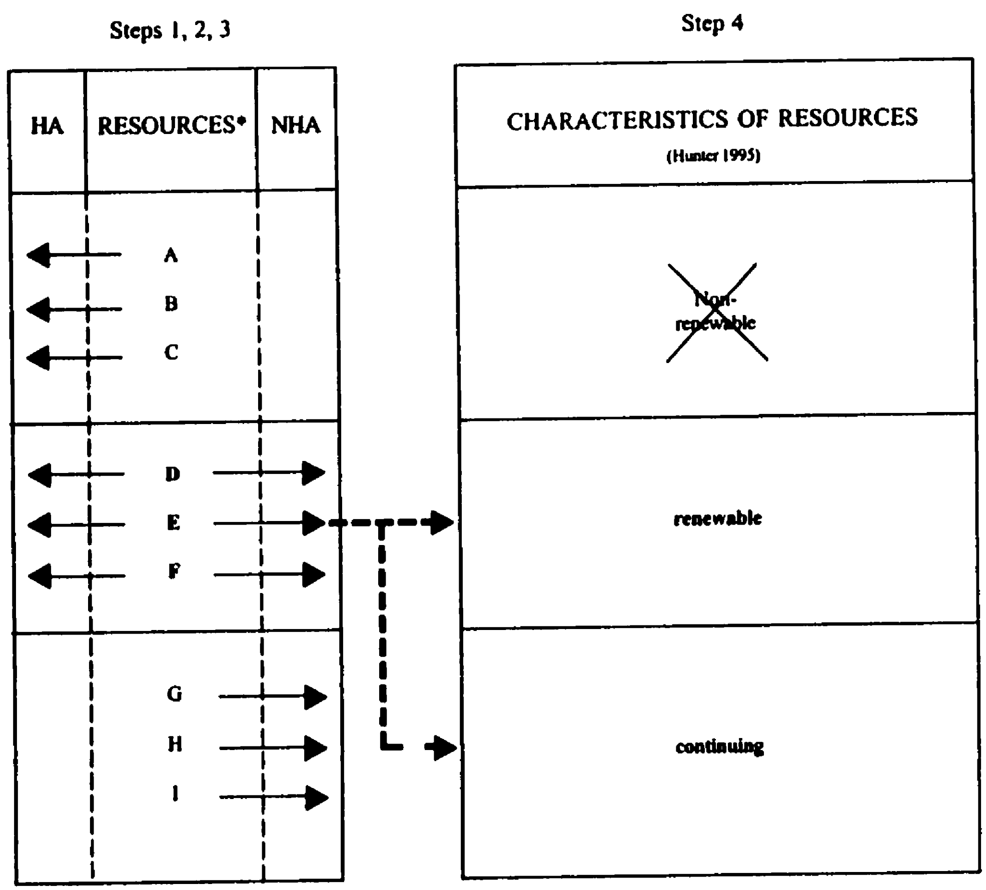

Figure 11: Step 4 of the Sustainable Resource Partitioning (SRP) Model: Resource Characteristics. The early stages of the model identify contested resources (Stages 1, 2 and 3) and then begin to characterize these resources (Step 4). Early stages of the model indicate an emphasis on renewable and continuing resources.

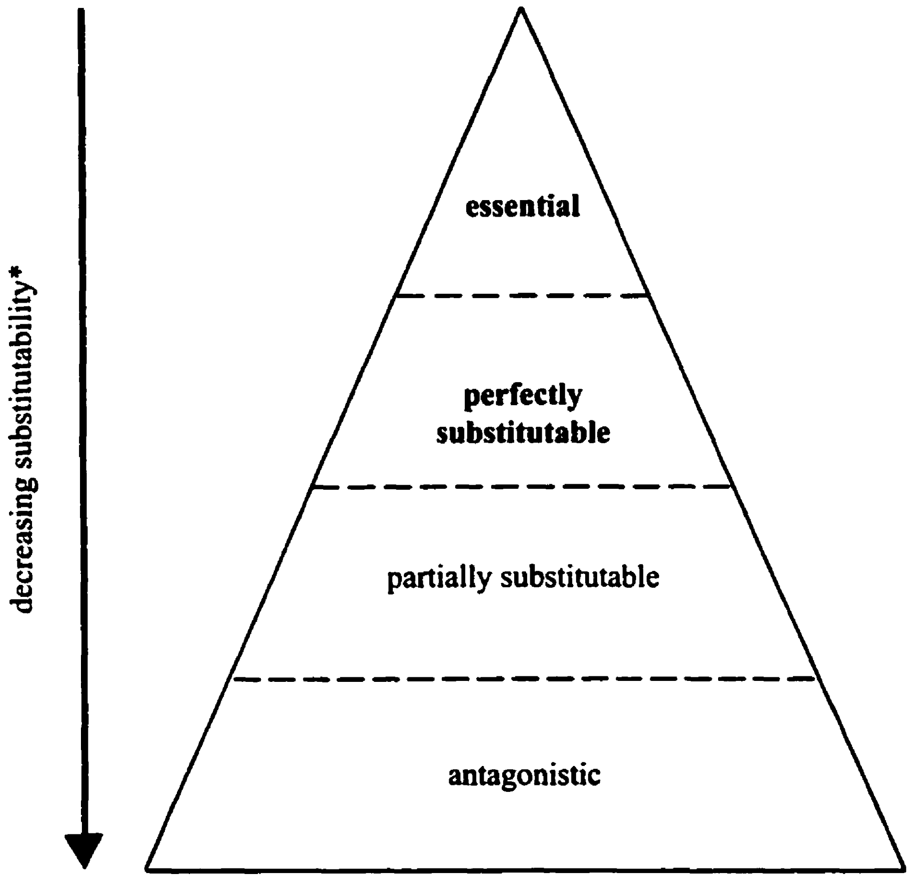

Figure 12: The Resource Net. Each species has a set of resources of decreasing substitutability. Sustainability focusses on sustaining those resources which are least substitutable (essential and perfectly substitutable). Guarantee of futurity of resources for a species must emphasize all levels of resources within the resource net. *Degree of resource substitutability is taxonomically bound.

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animal may be substituted we realize that much of the interpretation in this regard depends upon taxonomy. Two things are important here. First the resource must be correctly identified. Such necessity has been addressed by Helgason *et al.* (1996) and Daugherty (1990) who see correct identification as the foundation for conservation. Secondly, we must consider the taxonomic level at which a correctly identified resource is to be considered (from Kingdom to Family to Genus and Species). The importance of defining the taxonomic level in studies of competitive interactions has been noted by other authors. Alley (1982) for example emphasizes the functionally specified taxonomic unit (FSTU) while Schoener (1974) speaks of the necessity of delimiting the unit being studied, usually according to some taxonomic category. We may consider the resource of a preferred type of nesting tree required by a bird as an example. At the level of species of the tree it is reasonable to assume that there are other perfectly substitutable resources, for example, *Acer saccharum* (a maple tree) may be substituted with other species of *Acer*. However, when examined at the level of genus it is unlikely that the resource can be replaced, for example, by the Genus *Thuja*. An examination of *Acer* substitutability is shown in Figure 13. Because *Acer*, as a resource, can be substituted at the level of species, but not genus, it is *taxonomically bound* at the level of species.

As an additional example insects may be essential to a particular bird species at the level of Order (they cannot be replaced by grain or fruit, for example) but may be substitutable at the level of genus or species depending upon diet breadth (number of different insect species that diet is composed of). Thus the degree of resource substitutability is dependent in part upon the taxonomic level of the resource considered. In other words

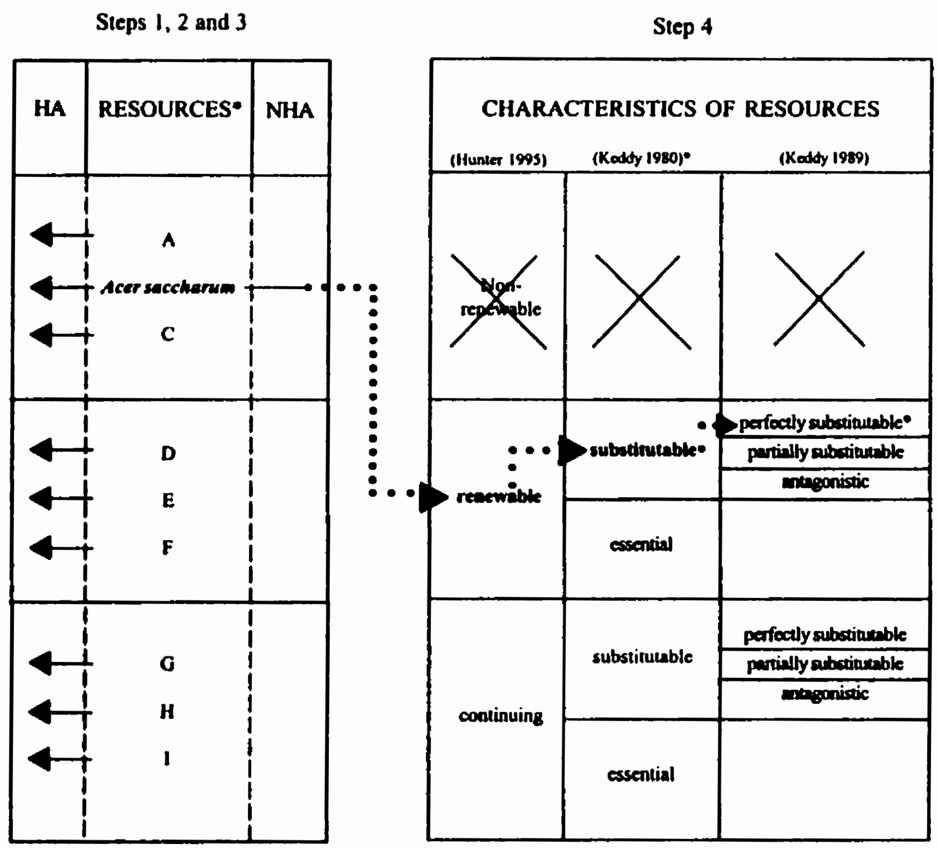


Figure 13: The Sustainable Resource Partitioning (SRP) Model. A hypothetically contested resource, *Acer*, is characterized as renewable and perfectly substitutable at the taxonomic level of species. The resource is not perfectly substitutable at the level of genus and in fact may be antagonistic, particularly over short evolutionary time spans. Note that some resources will be essential and therefore cannot be substituted. Often when resources are essential an organism has evolved to become specialized. Such species are more prone to extinction.

resource substitutability is "taxonomically bound".

The outcome of such a characterization of resources drastically changes the manner in which resources are managed. For example, a management plan that focuses on sustaining a resource at the level of species (*e.g.*, *Acer saccharum*, Sugar Maple) is vastly different from one that focuses on sustaining a variety of species within a genus, order or a more general descriptor of biome (*e.g.* Great Lakes-St. Lawrence Forest Region). This also suggests that management of a threatened species must include a comprehensive analysis of resource requirements and forms of competition. Management must understand all of these facets in order to be effective. Sustainability thus requires the massive undertaking of developing comprehensive biological awareness. While further investigation is required it appears that sustainability should focus on those taxonomic levels of resource that present a realistic likelihood of being manageable (likely a trade-off between funding, person-power, geographic extent, status of policy etc.). An example of such taxonomic levels attributed to a resource includes:

a) all trees >Carolinean Forest > *Acer saccharum*
b) Phylum Arthropoda > Order Coleoptera > *Oryctes nasicornis* (Rhinoceros beetle)

Some renewable resources like water are also essential at the described level. A resource like water for example is required by both HA and NHA species. The degree to which the resource is polluted is negatively correlated with the degree to which the resource is available and contributes to fitness. The more 'toxic' the water the less 'available' it is (see Figure 14). This decreased availability is really a form of controlling access to the resource and is thus a form of competition. The global scale of continuing resources suggests that scale appropriate management is critical. The identification and management of continuing essential resources will be discussed later with particular attention to scale, policy and management.

Our exploration of continuing resources (*e.g.*, sunlight) indicated that all continuing resources are also essential at the described level (Figure 15). In short, sunlight, wind, waves, geothermal and tidal energy cannot be replaced by anything else. There is no substitution at the defined 'taxonomic level'. Further, large scale environmental changes related to changes in he amount of energy reaching the planet's surface, due to contamination of air, poses risks to human health (McMichael and Martens 1995) and, by extension, to non-human animal health. However, such a large-grained approach denies the more subtle ways in which quality of the continuing resources (and therefore availability which defines competition) may be affected.

In summary, our ability to sustainably integrate both HA and NHA communities will depend, in large part, upon two major abilities. First, our ability to recognize contested resources, to characterize these resources according to their degree of substitutability and to manage these resources in response to this characterization. Critical to our understanding of the degree of substitutability is characterization of a resource according to taxonomic levels. Renewable, essential resources at specified taxonomic levels become the focus for sustainable partitioning of resources. When given a choice between sustaining resources at

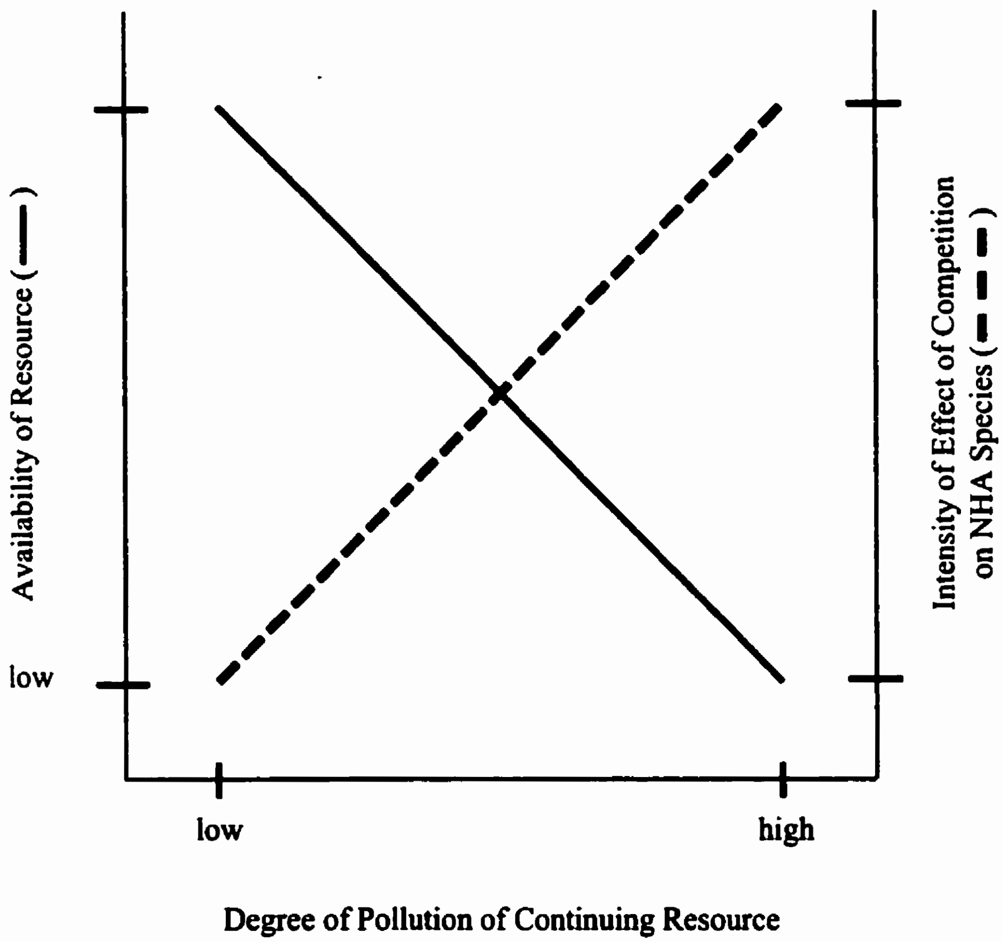


Figure 14: A Hypothetical Relationship Between the Degree of Pollution of a Continuing Resource by HA Species, Availability of Resource to NHA Species and Intentsity of Effect of Competition on NHA Species. As a resource becomes more polluted its availability to the subordinant species decreases which increases the level of interspecific competition.

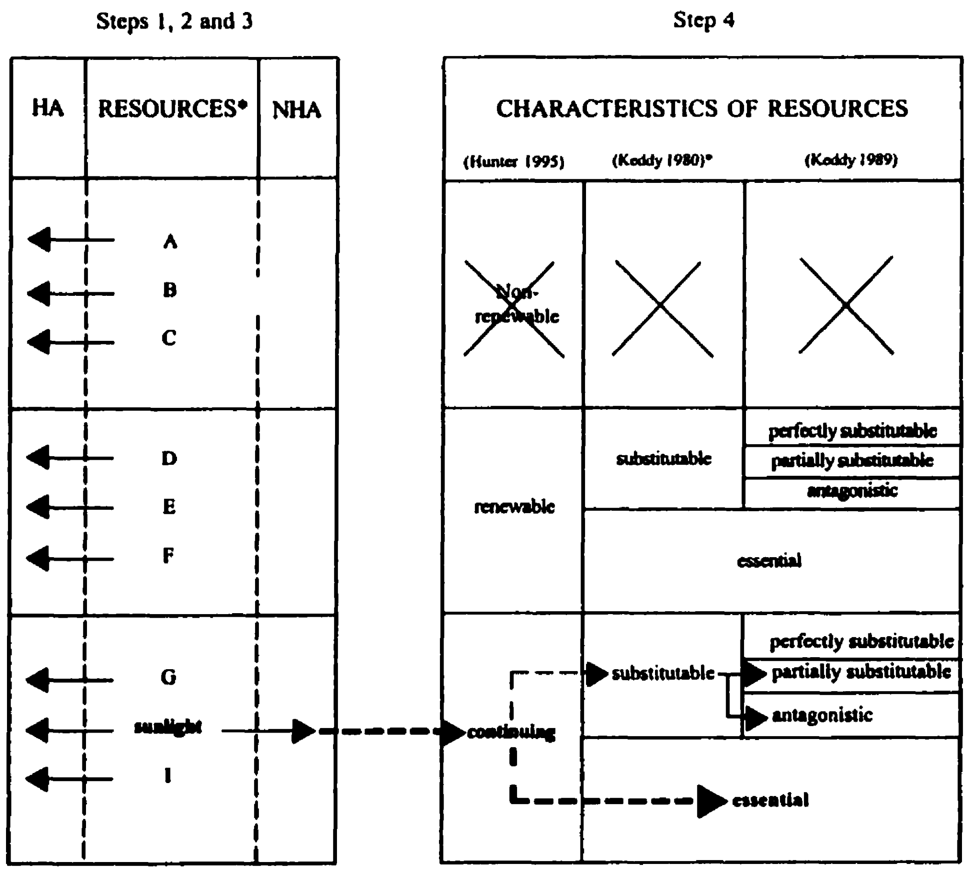


Figure 15: The Sustainable Resource Partitioning (SRP) Model. The contested continuing resource of water, like all other continuing reosurces may be defined as essential. By this we mean that the resource cannot be substituted by another. Notwithstanding this general definition we can also interpret continuing resources to be partially substituted when polluted. Such partial substitution meets the definition of competition by reducing access to a resource in its pure state. As pollution of a continuing resource increases, antagonistic substitution increases and competition for the resource increases.

higher or lower taxonomic levels the higher taxonomic level should be selected (*e.g.*, conserving at the level of *Acer* versus *Acer saccharum*) in an effort to enhance sustainability by maximizing potential substitutability. The logistics of such management must also be considered. Second, we must rely upon our global ability to manage continuing resources – all of which are essential and when decreased in quality constitute a form of competition.

4.2.2.5 Step 5: Characterization of Mechanisms of Competition

There are two broadly recognized forms of competitive interaction - interference competition and exploitation competition. Interference competition refers to competition where one individual directly affects another (antagonistic encounters or killing, for example). In more developed countries the majority of the population is not involved directly in interference competition. However, in tropical areas of the world, humans eat a variety of non-human animals. The numbers, in some cases are considerable. In a single state in Brazil, for example, it is estimated that 0.5 million birds are killed for food annually (Redford and Robinson 1991). At a larger scale it appears that hunters in tropical forests concentrate on three primary groups (in decreasing order): mammals, birds and reptiles (Robinson and Bennett 1999; Mena *et al.*, 1999; Bennet *et al.*, 1999). According to Robinson and Bodmer (1999) a broad generalization is that species larger than one kilogram in weight are primarily the focus of such hunting, although smaller prey may be taken. Thus most passerines are likely not the targets of such hunting.

Exploitation competition occurs when effects are indirect, and usually occurs through reduction in the amount of available resources. For example, when human animals deforest a portion of the landscape which serves as habitat for arboreal vertebrates they are involved in exploitation competition - they are reducing the pool of available resources for a species. Most HA-NHA research settings where biodiversity losses are occurring would be characterized as exploitation competition. A movement towards coexistence would require a reduction in exploitation competition.

Our identification of competition as either exploitative or interference suggests that coexistence of two species arises out of decreased direct interference (killing) or reducing the competition for characterized contested resources (based upon whether they are essential or substitutable to some degree). Figure 16 continues our characterization of *Acer* from Figure 13 and indicates the role of exploitation competition.

4.2.2.6 Step 6: Characterization of Kinds of Individuals

As described in the literature, competitive interactions are also classified according to whether the interactions are occurring between individuals of the same or different species. Interactions occurring between members of the same species are referred to as intraspecific (within species) while those occurring between members of different species are referred to as interspecific (between species). Interspecific interactions are explicit in referring to only a single pair of species (Keddy 1989). In interspecific settings kinds of individuals contribute to a net competitive effect, described previously by two terms – symmetrical and asymmetrical. The literature would suggest that asymmetry seems to

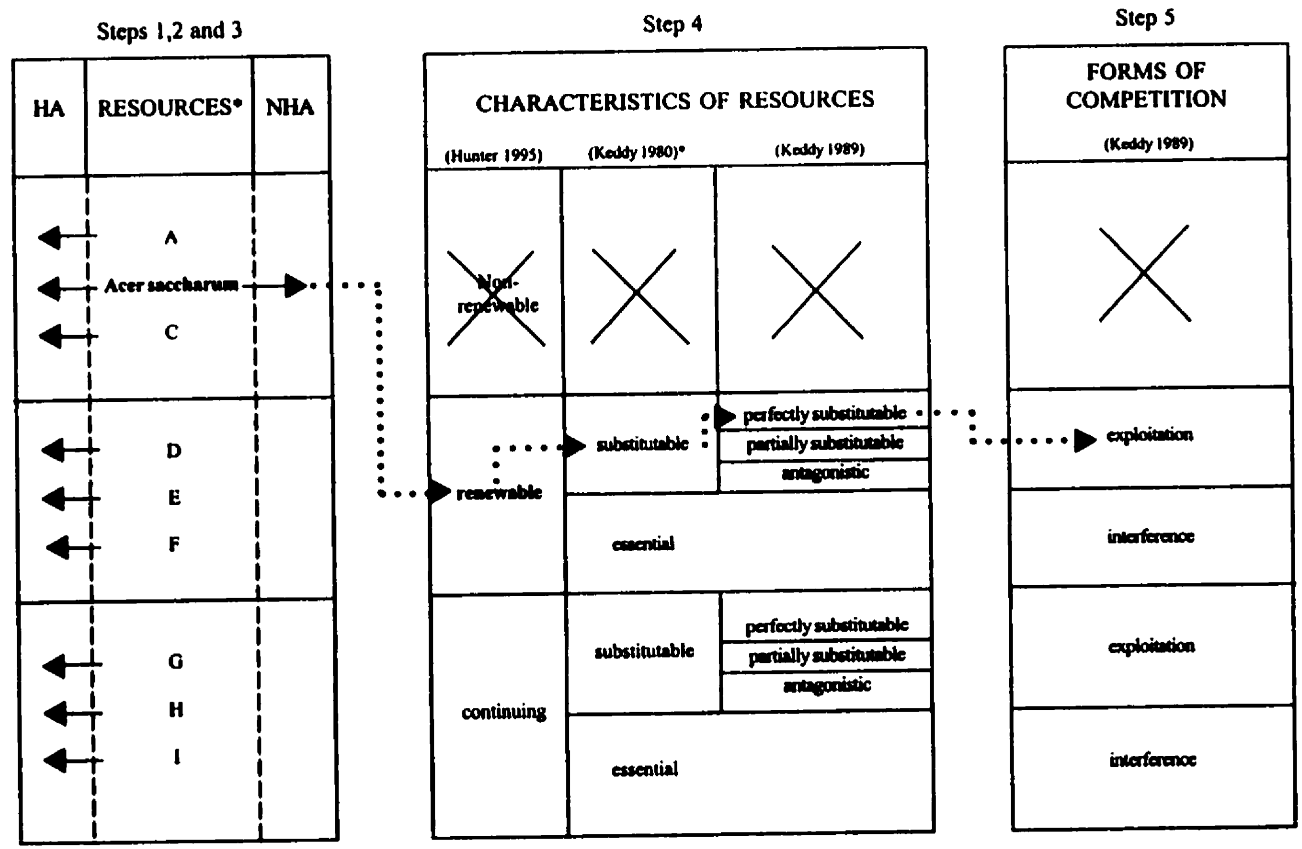


Figure 16: The Sustainable Resource Partitioning (SRP) Model. In Step 5 the Model characterizes contested resources according to their mechanism of competition. Here, *Acer* will be the subject of exploitation competition.

characterize most HA-NHA settings, with the HA species being dominant. The exploration of symmetry within an HA-NHA interspecifically competitive setting is shown in Figure 17. Here, regardless of how a resource is characterized exploitation competition likely dominates and in HA-NHA settings this relationship would be asymmetrical.

As soon as an asymmetrically competitive interaction arises it becomes essential to specify whether the competition is being viewed from the perspective of the dominant or subordinate (Keddy 1989). Most competitive relationships between NHA's and HA's are asymmetrical and human-dominated. Asymmetrical relationships suggest that the effects of the subordinate upon the dominant cannot be detected. Keddy (1989) also reminds us that once you have qualified a particular relationship that the analysis of such an interaction must consider not only the effects of the dominant but the responses of the subordinate (Goldberg and Fleetwood 1987; Goldberg, 1987). As such this thesis will view the competitive interaction primarily from the perspective of the dominant human animal community suggesting that the NHA community is subordinate. Effects and responses are defined as follows:

> "Effects are the negative pressures of each species on the other through exploitation and interference competition; in asymmetric competition the dominant will have most of the effects" (Keddy 1989,).

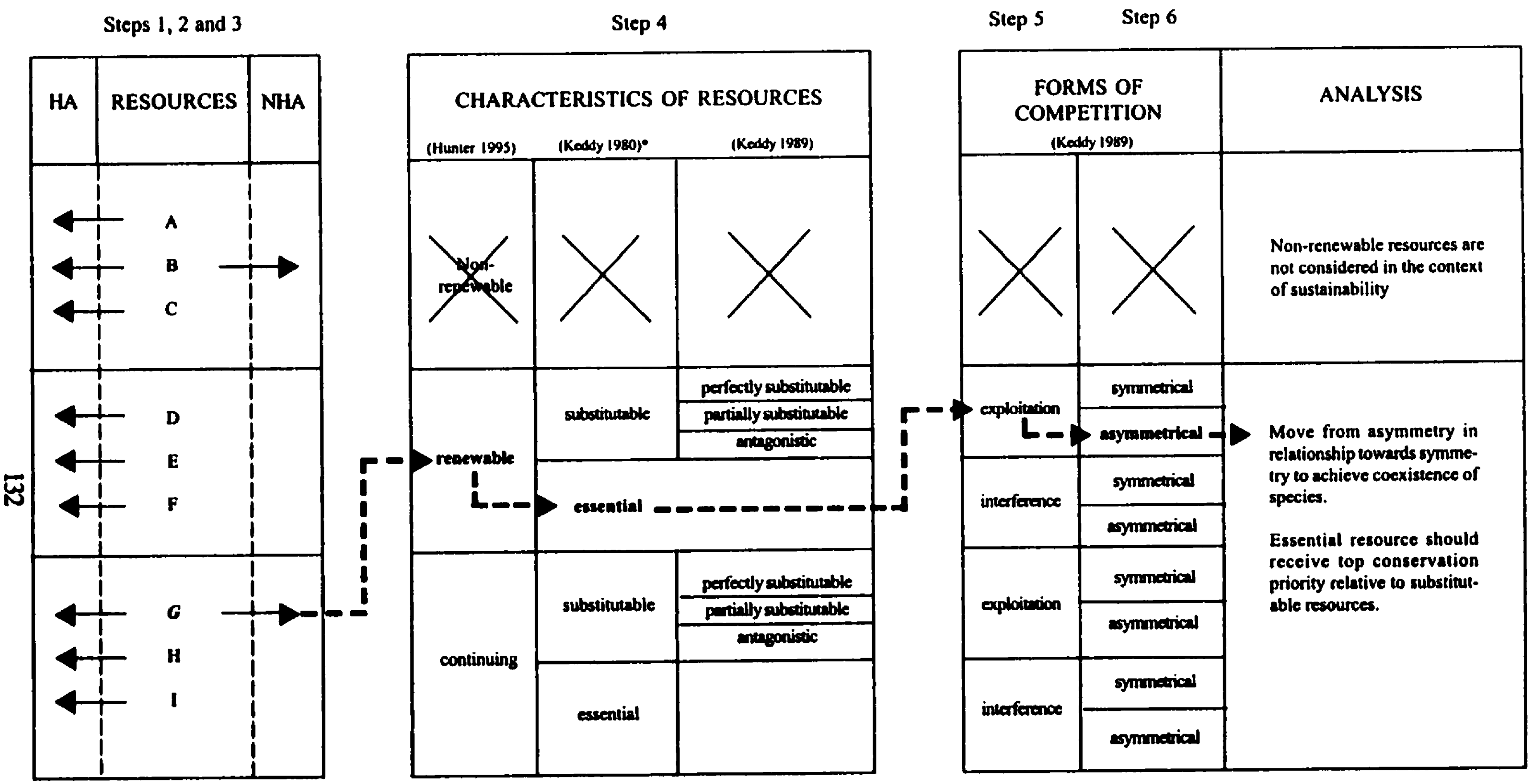


Figure 17: The Sustainable Resource Partitioning (SRP) Model. In Step 6 the symmetry/asymmetry of a competitive relationship is considered as a means of characterizing individuals. Resource *G*, as an example, is characterized initially as a renewable essential resource in s etting of exploitation competition. This hypothetical relationship is suggested to be strongly asymmetrical and as a result resource *G* should receive immediate consideration for conservation. Contested essential resources required by a subordinate species should receive priority before substitutable resources. In addition asymmetry in the relationship should be reduced.

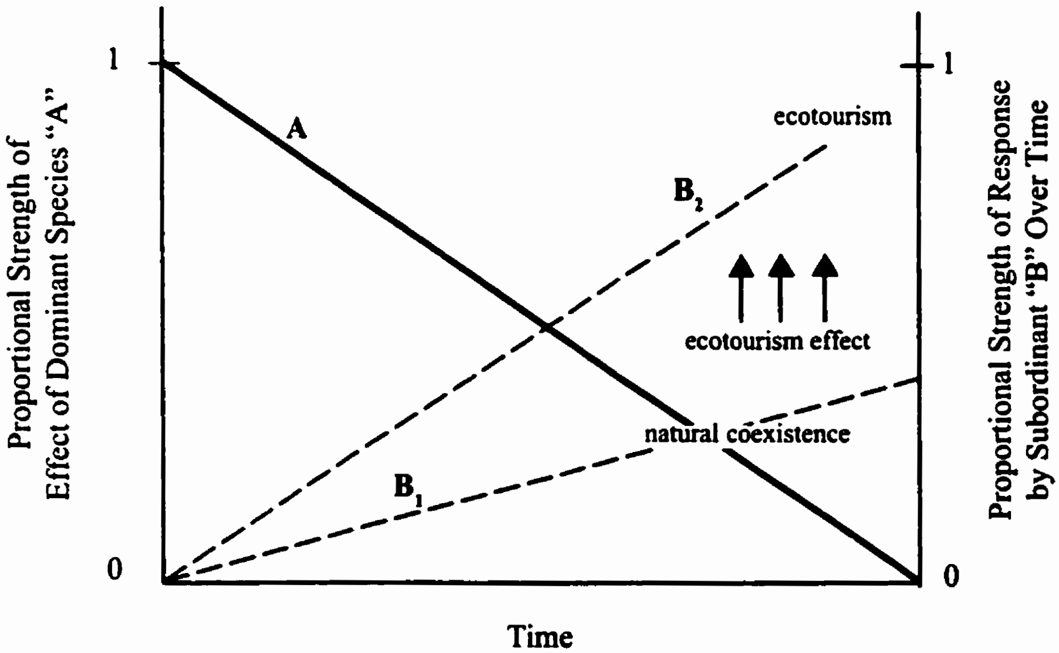
"Responses describe the impacts which these effects have on competitors. The response of a subordinate may be to tolerate the impact of the dominant" (Keddy 1989,).

There is also the view that, in strongly asymmetrically competitive settings that it would be rare that both organisms experience a negative effect (Keddy 1989). However, it is important to note that in the case of human dominance over non-human animals that successful competition against species after species leads to large scale loss of biological diversity and the long-term effects, although largely unknown, are predicted to be highly negative. Thus the interpretation of the general lack of negative effects upon a dominant within a strongly asymmetric competitive relationship is temporally bound. Ultimately, the dominant community will be affected. This suggests that it is in the best interests of the dominant community to maintain biodiversity and coexist with as many other species as possible.

These conditions suggest that the dominant HA community should be aware of long term dominance. In non-human animal settings where one species suppresses another through exploitation and/or interference competition, the term "competitive dominance" is applied (Keddy 1989). Competitive dominance begins as asymmetrical competition and subsequently the effects of the dominant upon the subordinate are steadily enhanced through a feed back loop. The feedback loop begins with increasing exploitation of a common resource, which in turn supports the dominant competitor to the point where it increases its population, which in turn results in greater consumption of resources and greater asymmetry in competition. The same loop can occur, in the same manner, for interference competition. The concept of competitive dominance is directly transferable to HA-NHA settings. As human animals consume more and more resources their population increases and even more resources are required. It is interesting to note that Keddy (1989) states that "communities structured by niche differentiation have received far more attention than those structured by dominance". Does this phenomenon occur because there are more examples of niche differentiation than domination in nature? Do human animals possess the only culture that consistently expresses such dominance?

It is also important to note in laboratory experiments involving *Paramecium* and *Drosophila* in closed systems, that competitive exclusion occurred in part because the systems were so simple (Arthur 1987). It appears that environmental complexity, heterogeneity and stochastic events inherent in nature act as stabilizing mechanisms. From this we draw a simple conclusion: the simpler an environment the greater the likelihood that competition will lead to competitive exclusion. Such an observation sounds a dire warning for those who think that we may have both biodiversity and reduced habitat.

As suggested by the experiments with *Drosophila* and *Paramecium* competitive exclusion often occurs when environmental heterogeneity is absent as a stabilizing mechanism. This observation suggests an overwhelming requirement for policy or changes in human behaviour as a means of maintaining heterogeneity *and* reversing or limiting asymmetry. By "reversal" we mean that we must allow the subordinate species to have an *effect* upon the dominant HA community. The relationship of asymmetry is explored in Figure 18.



<u>Figure 18:</u> Reversing Asymmetrical Competition. Line B1 indicates a species which is slowly and naturally increasing in its ability to compete against species A. Ecotourism allows a species to rapidly reverse asymmetry in competition by creating an effect of the subordinant on the dominant (decreasing the dominant's relative effect).

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How may such a reversing (partial, not complete) of asymmetry occur? A reversal of an asymmetrical relationship can occur when the subordinate has an effect on the dominant. As an example we may consider ecotourism. In an ecotourism setting the presence of the focal NHA species may aid in HA development, providing a means of ensuring resource supply (health care, education, water) for the dominant community, largely through the generation of revenue. In this manner the subordinate begins to affect the dominant (which automatically dissolves the definition of asymmetry). If we refer back to Figure 1 we can see that reversing asymmetry begins to move the form of interaction from the far left column to the middle column, where any form of negative (-) interaction is absent. In short the path to conservation may be represented by an arrow parallel to the x-axis of Figure 1, and pointing to the right (see figure). As suggested earlier (Section 2.3) it may be optimal to stop the path at coexistence in the centre column. Sadly, in more developed areas of the world the lack of apparent effects of subordinate NHA populations through ecotourism and subsequent responses by dominant HA populations suggests that the risk of competitive exclusion is even greater in such settings. In other words, when the effect of non-human animal population on human animal populations is not felt in any way then complete asymmetry and danger of extinction exists. We must make our dependence on NHA species more tangible. Co-dominance may be the root of coexistence. As an example we must consider "borrowed sustainability" where the conflict we would likely have with NHA species is transferred to developing countries where products are produced for developed country consumption. This leads to an apparent lack of competition between HA and NHA species in more developed countries. The identification of NHA populations as having a market value and positive effect on local communities may be one of the few ways to offset asymmetrical relationships. According to some authors, if biodiversity is to be conserved it will be the result of market-oriented approaches where the sustainable yield of useful organisms over the long term yields more profit than more destructive activities (Vandergeest 1996; Crook and Clapp 1998). Swanson (1999, 29) is equally as blunt, suggesting that "the continued existence of most species will depend upon their capacity to find a role in the societal asset portfolio" and "Whenever a given species is not expressly selected for inclusion within this portfolio, it is subjected to the general forces for disinvestment that lead to its decline".

Based upon the preceding steps a summary of contested resources, resource characteristics, mechanisms of competition and kinds of individuals can be derived for a specific competition setting (Figure 19).

4.2.2.7 Step 7: Characterization of Dominant Community Intra-specific Needs.

Within any HA-NHA competitive setting, particularly an asymmetrical setting, a separate discussion of intraspecific HA competition is required: "As the individuals of the same species come in all respects into the closest competition with each other, the struggle will generally be most severe between them" (Darwin 1859).

Given the asymmetrically competitive interaction and human domination within this setting, the seventh stage in the development of the SRP model is the consideration of human community intraspecific needs and its effects on interspecific competition.

INTERSPECIFICALLY CONTESTED RESOURCES	RESOURCE CHARACTERISTICS	FORMS OF COMPETITION	KINDS OF INDIVIDUALS
Resource #1	R, S (PS to C)	e	IN, s
Resource #2	R, E to S(PS)	e	IN, A
Resource #3	R, E to S	i	IN, s

Figure 19: Sample summary of characterization of resources, forms of competition and kinds of individuals for an SRP Model. "R" = renewable; "S" = substitutable; "E" = essential; "PS" = perfectly substitutable"; "C" = complementary; "A" = antagonistic; ** "IN" = interspecific; "INt" = intraspecific; "e" = exploitation; "i" = interference; "A" = asymmetrical, "s" = symmetrical". Characterization of whether a resource is "E" or "S" (and to what degree) will depend upon the resource's taxonomic classification.

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In other words, given the dominance of one community over the other what aspects of resource need *within* the human animal species affects competition *between* species? Further, are the needs of the subordinate community likely to be considered if dominant HA community needs are not met? Stated more succinctly the key to sustaining NHA communities rests in part, in meeting human animal community needs. Given the striking similarity on a global basis between the expression of need within HA communities (globalization plays a role here) Darwin (above) alludes to the severity of struggle that we can expect. Overall, it is the dominant stakeholder's drive for resources that undermines identical drives in the subordinate community. The relationship between intra-specific HA community needs and NHA community resource needs is shown in Figure 20. Intraspecific HA community needs will vary from location to location and depend upon the degree of development that has already occurred. In ecotourism settings for example the stress placed on sharing of resources between local and visiting HA populations has been noted (termed "competition" in Reid et. al., 1999). This thesis suggests that if basic human animal community needs can be met – and people are more educated, healthful, nutritionally sound – they are more likely to be able to understand environmental needs and to have empathy for sustaining non-human animal communities. Possibly, the key to both is a form of economy that provides the resources required for improved living conditions while sustaining the "environment" and its NHA resources. The link between HA culture and NHA culture through ecotourism and its positive effects on economic, social, cultural and environmental dimensions within a multi-dimensional lens have been described (Nuttall 1999). Moreover it is not just the fulfilment of HA resource need that is of interest but the manner in which the need is met, which is of importance. For example, food security may be improved by

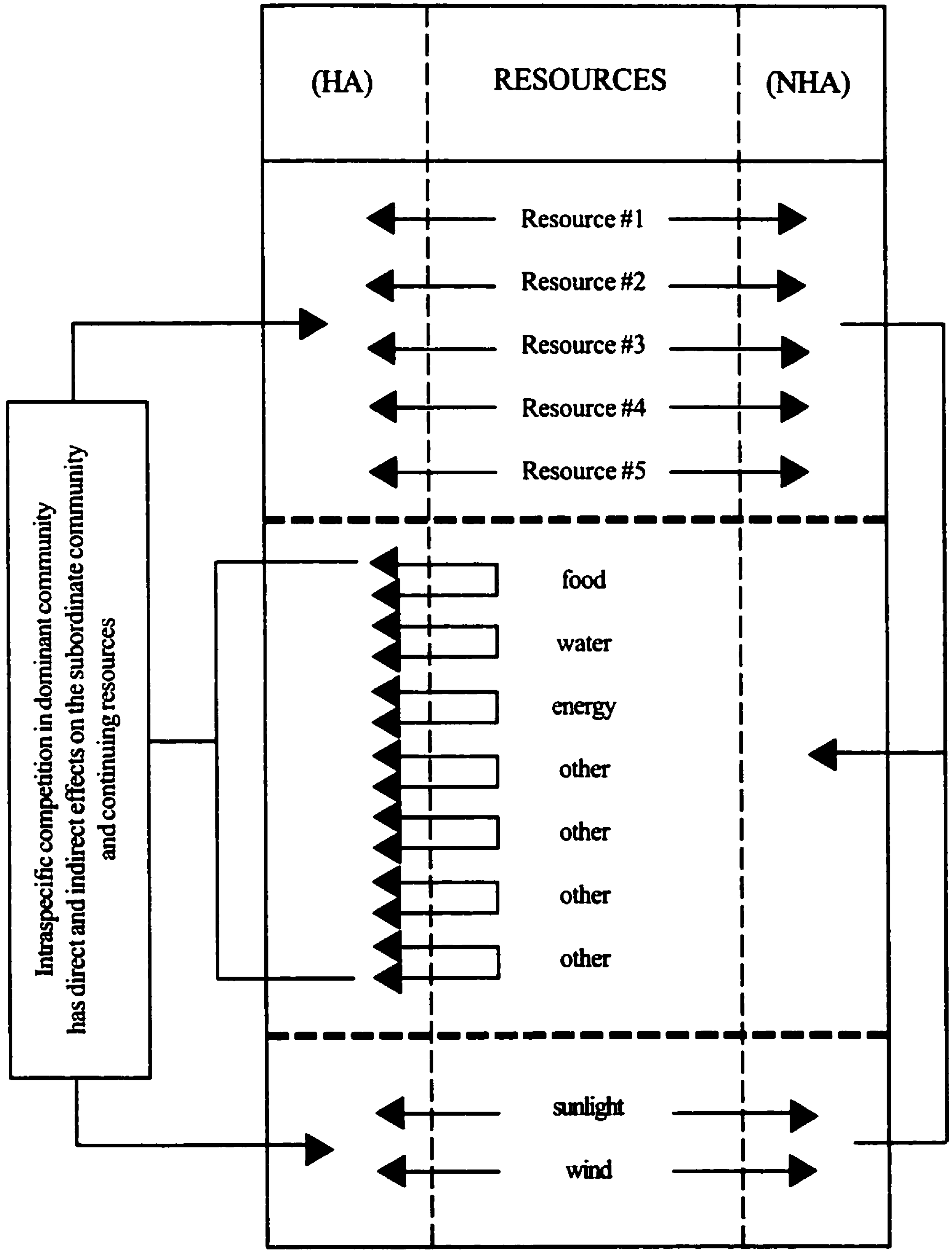

Figure 20: A Relationship Between Dominant Population Intraspecific Needs, Subordinate Population Intraspecific Needs and Continuing Resources. Consideration of dominant species needs is critical to managing resource needs for subordinate species.

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farming more land rather than improving yield on existing land or by improving methods of storing food resources.

4.2.2.8 Step 8: Preliminary postulates derived from model

Based upon the theory derived so far, what observations arise out of the analysis of resource characteristics and forms of competition within this interspecific, asymmetrically competitive setting? Further, what is the relevance of these observations regarding our goal of moving from competition to coexistence? At this step the synthesis of the SRP model allows an opportunity for analysis of the implications of theory. Borrowing from the terminology used in theory construction, as proposed by Babbie (1998), we are able derive a number of postulates. Postulates are "fundamental assertions, taken to be true, on which a theory is grounded" (Babbie 1998, 52). The following postulates describe means of limiting competition:

1) Focus on essential renewable and continuing resources particularly taxonomically bound resource nets of varying substitutability.

Identify contested resources and characterize these resources according to non-renewable, renewable or continuing. Management implications for these different categories of resources are variable in scale. Those resources which are substitutable must be further characterized according to the degree of substitutability. Degree of substitutability, in turn, depends upon the taxonomic level at which the resource is considered. The taxonomic level assigned to a resource in concert with the associated degree of substitutability casts a resource net. The wider (and thus deeper) the resource net the greater the flexibility in substitutability and the greater the likelihood of conservation. Be aware that when the taxonomic level of a resource changes the goals of sustainability change.

If a resource is characterized as essential for a particular NHA community then efforts must focus on sustaining that resource. The greater the number of essential resources required by an organism the greater the likelihood that specialization has occurred and risk of extinction is great. Conversely, the greater the number of resource substitutes and the degree of their substitutability, the greater the number of resources to be managed but the greater the likelihood that the resources and the communities depending upon them can be sustained.

In some cases one resource may be substituted by another. For example, in temperate North America the nesting materials of many passerines (*e.g.*, *Turdus migratorius*) are highly diverse and are likely highly substitutable. Essential and continuing resources however are not substitutable and must receive priority in settings where sustainable coexistence is a priority.

2) Substitutable resources must be managed as a group to ensure availability of resource and long term survivability of organisms

If a resource is substitutable it may be wholly or partially substitutable by any number of resources. The greater the number of these resources, which are, protected the smaller the likelihood that resource availability will play a role in decreased survivorship of a species. This entire pool of resources should be managed as a group.

3) Focus on exploitation competition.

In most conservation settings exploitation competition will be the focus. However, the role of interference competition in developing tropical countries should not be ignored. The emphasis on exploitation competition suggests a focus on contested resources and management plans that will alleviate such competition.

4) Reduce asymmetry of exploitation competition.

We must understand dominant species intraspecific needs and how fulfillment of need can affect subordinate species. The intraspecific needs of HA populations play a critical role in sustaining NHA populations. As the degree of impoverishment of an HA community increases the likelihood of any particular community guaranteeing resources for an NHA species is negligible. Reducing asymmetry of exploitation competition suggests that we find a means of allowing the subordinate NHA population to exert some effect upon the HA species. The effect must be a positive one. Recognition of the positive effects of NHA populations through a mechanism such as ecotourism reduces asymmetry.

5) All aspects of an interspecific, exploitative-competitive relationship must be understood and a holistic management plan undertaken.

Management that considers all aspects of an interspecific exploitation competition setting is holistic and offers the greatest likelihood of success. Guaranteeing access to a single resource or a particular set of resources will be of little utility if a limiting essential resource is not included in the suite. The classical work of biologists and field ecologists is invaluable in ascertaining baseline life history information for species and should be vigorously pursued. Conservation and coexistence cannot occur without an understanding of species and their resource requirements.

6) *Provide HA Community Education*

Within the context of sustainability provide scale-relevant (local and international), multi-dimensional conceptual links between renewable and continuing resources which can affect HA communities at a psychological level. Creating this awareness in concert with relevant policy, monitoring programs and a community generated mandate for desired outcomes is appropriate. Emphasize how renewable and continuing resources may be interpreted as tangible versus intangible and effect short-term versus long-term sustainability. Short term sustainability focuses on renewable resources.

Given our understanding of:

1. determination of contested interspecific resources;
2. characterization of resources (tri-partite focus);
3. dominant community resource needs and how these affect subordinate community resource needs;
4. general recommendations for limiting competition and sustaining resource use;

we are prepared to discuss how to partition the contested resources.

4.2.2.9 Step 9: Sustainable Partitioning of Resources

Stable systems are characterized by some form of ecological niche differentiation and give rise to stable coexistence (Arthur 1987). This stable coexistence is the result of use of different niches or differentiation within a niche. An ecological niche is defined as:

> "a description of the roles and associations of a particular species in the community of which it is a part; the way in which an organism interacts with the biotic and abiotic parts of its environment" (Curtis 1983, 1093).

Examples of such niche differentiation and stable coexistence abound in nature (sphagnum mosses, warblers, east African ungulates, Curtis 1983). Such niche differentiation may be based upon similar species utilizing different resources or by occupying different microhabitats. The above examples of natural partitioning suggest that coexistence occurs through partitioning of resources in space and time. Thus partitioning occurs when two species:

a) use slightly to vastly different resources (niche shift along RUF)
b) use the same resources but are separated in their use of resources by :
    i) space
    ii) time

Such partitioning in space and time has been noted among many groups of animals including insects (aphids; Jackson *et al.*, 1996), fishes (Piet and Guruge, 1997), birds (Koen 1988), mammals (mink and river otters; Ben-David *et al.*, 1996) and trees and grasses (Weltzin and McPherson 1997). Some trends with regard to partitioning of resources have been noted. Schoener (1974) for example, suggests that in an analysis of multi-dimensional partitioning that a relative ranking of the importance of particular resource dimensions may be achieved. Specifically, Schoener states that "habitat dimensions are more important more often than food-type dimensions which are more important more often than temporal dimensions". We may conceive of the importance of such ranking of partitioning as: habitat >> food >> time, and accordingly expect that in competitive settings that species will first partition habitats, then food then along temporal lines. In NHA-NHA settings we rarely see temporal partitioning as few animals can withstand omitting resources for certain time periods, in other words, experiencing no yield (Schoener 1974). Such relative ranking of habitat dimensions may have important implications for conservation as we predict that coexistence may be achieved primarily by separating habitat then food and possibly time (time may be easier to partition in HA: NHA settings as human animals can go without some resources for certain periods of time).

Sustainable Resource Partitioning (SRP) implies partitioning of resources in a manner that is sustainable to all stakeholders and thus implies management of natural resources. By partitioning it is suggested that some amounts of contested resources are released from conditions of competition and are provided, in a sustainable fashion, to each stakeholder. It is in effect a process that realizes (brings into being) that resource or portion of an RUF required by a particular species. The concepts of both the fundamental and realized niches are useful here. The fundamental niche is characterized by a resource use pattern that occurs in a competition free setting. The realized niche is that pattern of resource use that occurs during competition. Realized niches are by definition "smaller" than fundamental niches – some portion of the continuum of potential resources available is lost. The sustainable resource partitioning model seeks to narrow the fundamental niche of HA species to a realized niche that reduces competition with NHA species. Such a reduction in the HA species fundamental niche, in concert with sustaining the realized niches of other NHA species allows for coexistence. The guarantee of future availability of the resource for all stakeholders is implied and the end result is predicted to be a stable system. Where narrowing of the HA fundamental niche cannot occur contested resources must be partitioned in spaced and time (in areas of niche overlap).

The decision to partition resources in most scenarios will suggest a desire to sustain NHA stakeholders from which arise two broad questions:

a) What is the desired population size, area and type of management required to sustain the NHA stakeholder?

b) If finite amounts, quality and rates of production of contested resources are limiting to both HA and NHA stakeholders how much of a resource should be partitioned to HA versus NHA stakeholders?

The ecologically deterministic perspective of this thesis again situates *Homo sapiens* within larger animal culture and suggests that SRP is akin to realizing or *creating* (through management of natural and un-natural resources) the *Homo sapiens* niche in a sustainable fashion within the constraints of finite resource production. What the warbler species have done "naturally" (stable coexistence through niche differentiation) must be manifested for HA stakeholders. Such niche re-alignment, correction or realization suggests a HA cultural means of ensuring provision of resources for both HA and NHA stakeholders. Given the asymmetrically competitive relationship between HA stakeholders and other NHA stakeholders, self-regulation within HA culture is the key to SRP.

4.3 Field Research

Given the unique and interspecific nature of the research the fieldwork focused on basic research which examined HA and NHA populations using distinct and appropriate methodologies. Fieldwork focussing on the HA population embraced four discrete themes of research including phenomenology, ethnography and ecological psychology. Research approaches were qualitative, naturalistic, inductive and holistic while employing the strategy of design flexibility. Research regarding the NHA population emphasized a quantitative observational approach that provided objective, standardized measures which could be generalized to describe the population. Some minor qualitative research was used to describe the Olive-headed Weaver history and distribution.

The direct outcomes of exploratory and adaptive field research are organized according to the two species considered and are identified in the Appendices as "7.1 The NHA Population" and "7.2 The HA Population". The majority of the field work results have been placed in the appendices given that the exploratory research generated a voluminous amount of data and a portion of the results are not relevant to the stated goal and objectives. The presentation of all the results in the appendices demonstrates both the exploratory and inductive nature of the work, the need to be transparent, the breadth of the study as well as introducing data which may be valuable for future biological research or models. Finally the presence of all the field work results in the appendices allows the reader to determine for themselves the utility of information generated. Readers should consult the appendices to find detailed results regarding the Olive-headed Weaver and information regarding: historical overview; current understanding of distribution, density and population size; morphology; geographic locations of nests; nest attributes; nest tree attributes; vegetative characteristics of nest tree area and random areas; activity at the nest; foraging behaviour patterns and diet. Similarly, for a more detailed understanding of the human animal population readers should consult the following section in the appendices: socio-cultural; economic; ecological and political. Notwithstanding the inclusion of the majority of the results in the appendices, the results are summarized below in Figure 21 and emphasize the identification of contested resources in the research field setting..

4.4 The Sustainable Resource Partitioning Model - Applied

A significant result of the research methodology was the development of a model, which allowed for the sustainable coexistence of HA and NHA. The model offers a variety of benefits including important generalizations about the nature of interspecific competition between human and non-human animals within the context of sustainability. Further, the model describes a solution to a specific challenge based upon an organized train of logic and declared assumptions.

The model, as a graphical representation of applied natural theory, can be critiqued, shape the way in which questions are asked, act as a platform from which predictive and testable theory (data collection and experiments) may evolve, and ultimately, may answer the question of how we sustain the coexistence of HA and NHA populations. As mentioned in Section 3.0 the evolution of the model was largely intuitive but guided by

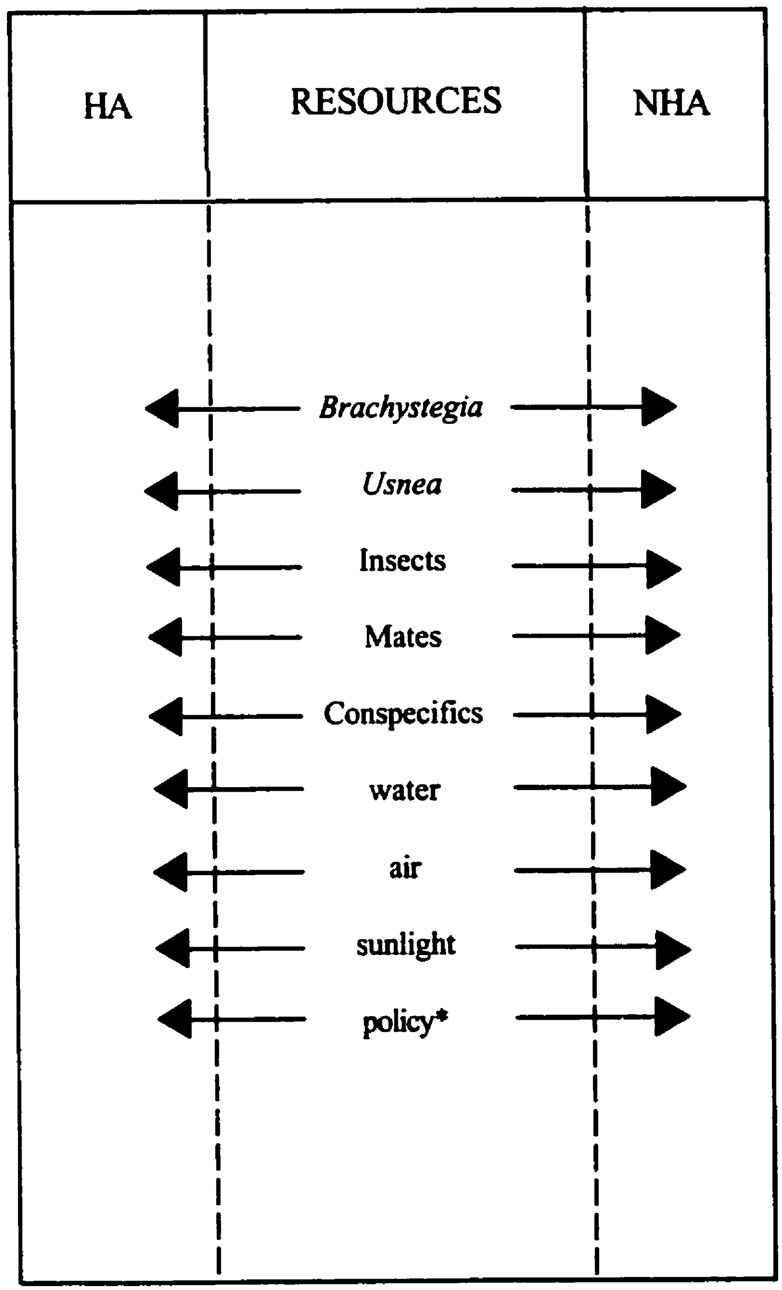

Figure 21: Results of Fieldwork and Summary of Contested Resources in the Research Setting. The RCI identifies *contested* resources in interspecific competition settings.

conceptualization theory and three-process insight theory. The model is shown in Figure 22. The thesis will now discuss the results of applying the model in the Mozambican research setting.

The genesis of this thesis is concern about global biodiversity loss and HA efforts to offset these losses, particularly in tropical areas of the world. As a barrier to sustainability the WCED (1987) definition of sustainable development is overtly anthropocentric. This definition requires modification from its current form to one which is connected and emphasizes a single multi-specific community that includes human and non-human animals. Notwithstanding the narrowness of the WCED definition the broader concept of sustainability appears to be consistent with a general philosophy which reflects a "return to nature" approach, demonstrated in our global concerns regarding air quality, greenhouse gases, disappearing habitat, conservation and biodiversity losses. For such an approach to be practical it requires that human animals not simply return to the 'idea' of nature but to the functioning of nature - how humans affect, are affected by and integrate with natural systems. The term 'natural theory' describes those known standards, principles or theories that describe the characteristics of natural systems. Both human and non-human animals can be sustained if natural theory is used as a template. Competition theory is described as particular subset of natural theory and is argued to be relevant given that sustainability is largely concerned with competition. Furthermore, the breadth of competition theory includes theory that describes the sustainable coexistence of species which is an implied goal of sustainability (using either the traditional WCED definition which sees NHA species as resources, or

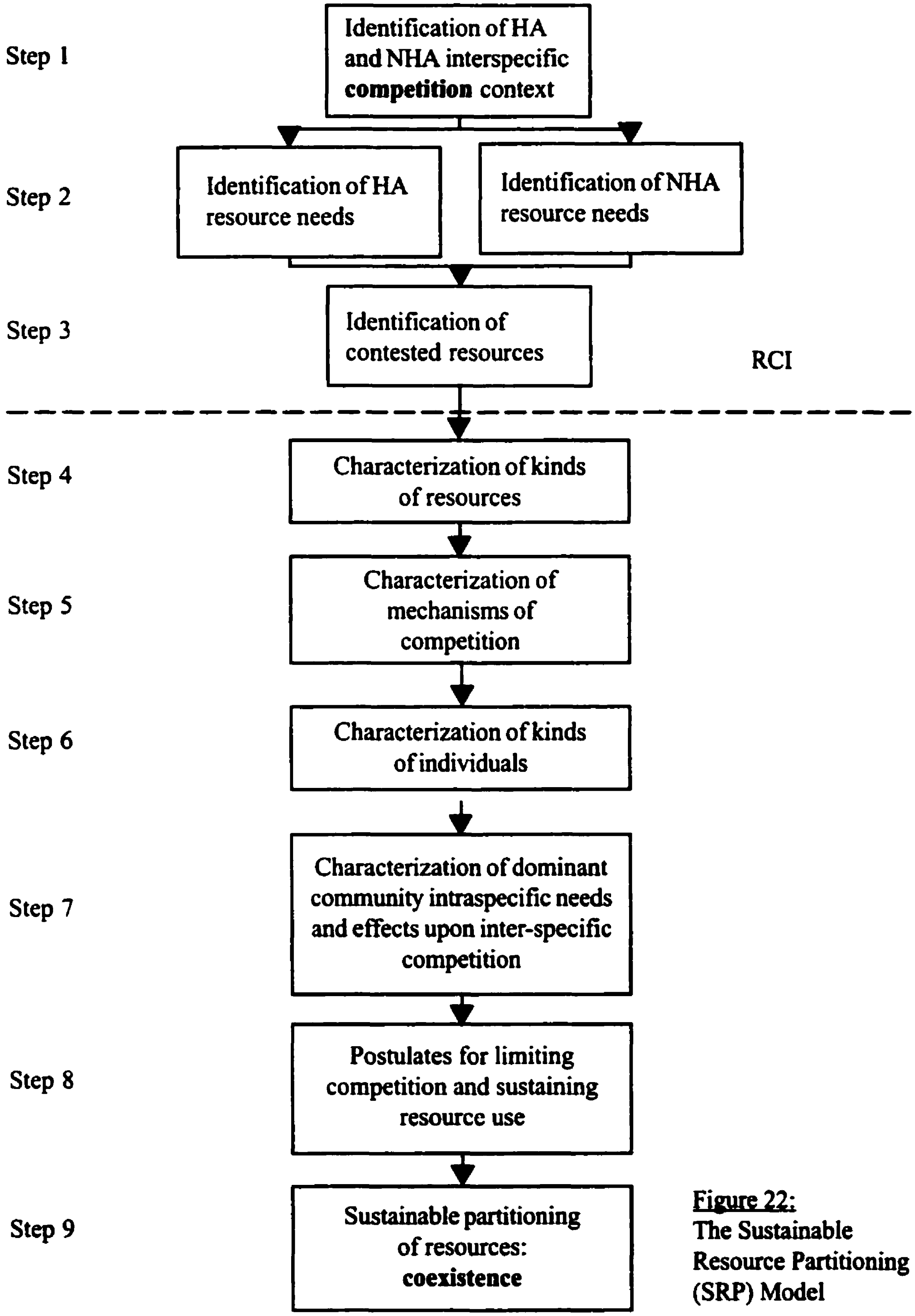

Figure 22:
The Sustainable Resource Partitioning (SRP) Model

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the modified version in this thesis which sees NHA species as part of a broader animal community of which humans are a part). This theory is referred to as resource partitioning. If the concept of sustainability predicts correctly that resources may be used sustainably and competition theory provides evidence that resources may be partitioned to allow coexistence then sustainable resource partitioning is feasible. In interspecific settings these principles can be used to guide interaction from competition to coexistence. The path from competition to coexistence is illustrated in the Sustainable Resource Partitioning Model.

A focus of the above model is the characterization of particular kinds of resources, mechanisms of competition and kinds of individuals in an interspecifically competitive setting. In the research setting of Mozambique competing human and non-human animal populations were characterized according to the tri-partite resource emphasis of competition theory and subsequently analyzed according to the sustainable resource partitioning model. This discussion will now address the relevance of the SRP Model to the research setting and suggest ways in which resource partitioning can contribute to sustaining human and non-human animal populations.

4.4.1 Step 1: Identification of an HA and NHA Interspecific Competition Context

The SRP Model begins with the identification of an interspecifically competitive setting (see Figure 22). The research setting near Panda, Mozambique was identified with the help of collaborators. In this research setting an avian non-human animal species, the

Olive-headed Weaver was suggested to be a threatened species due to competition with a local human animal population. Such a tropical setting, in a less developed, poverty stricken country, characterizes a common theme of human and non-human animals locked in competition over scarce resources. The SRP model and its emphasis on inter-specific interaction is highly suitable for such settings. The model's predicted outcome of coexistence is also of primary interest as we have demonstrated that one of the negative impacts of much needed development is increased competition between HA and NHA populations.

4.4.2 Step 2: Identification of HA and NHA Resource Needs.

The contested resource focus of both the concept of sustainability and competition theory suggested that an understanding of resource use for both HA and NHA populations was required. Field research developed an understanding of the resources required by both HA and NHA species (see Results, Section 4.2.3). There are also likely resources which are not contested between HA and NHA species however those resources which are contested and indeed those that are contested most vigorously serve as the focus for solving ecotourism's problems of decreasing wildlife due to increased resource competition. In any setting the emphasis within the SRP Model is therefore contested resources.

4.4.3 Step 3: Identification of Contested Resources

When the RCI is developed based upon the research setting contested resources include

Brachystegia trees, *Usnea*, insects, mates, conspecifics, water, air, sunlight (and other continuing resources) and policy (refer again to Figure 21). While the HA population has a suite of resource needs and some of these are subject to intra-specific competition it is inter-specific competition which has been largely ignored and serves as the focus here.

Further, we have a stated emphasis on those resources that are contested. Two broad categories of interspecifically contested resources arise: renewable and continuing. To some extent each group bears separate consideration. Renewable resources tend to be more local in scale while continuing resources tend to be more international and global. As such the local HA and NHA populations compete, directly, for tangible renewable resources while competition for continuing resources is more indirect. Contested renewable resources in the research setting include *Brachystegia* trees, *Usnea*, insects, mates, conspecifics and water. Contested continuing resources included sunlight and policy.

4.4.4 Step4: Characterization of Kinds of Contested Resources

The above contested renewable resources, due to their tangibility, offer our best hope of conserving intangible renewable and continuing resources such as water, air and sunlight. This is due to the fact that renewable resources are dependent upon these intangible resources – water, air, sunlight and policy. In an ecotourism setting the education of the visiting and local HA population must make this link. The existence of a diverse ecosystem with enough resources to support immense biodiversity is a sign that intangible renewable and continuing resources are readily available. Drought stricken Ethiopia may be an example of shifting global weather patterns related to depleted ozone, deforestation and the greenhouse effect. Again, the educational aspects of ecotourism for both visiting and local HA populations are critical.

We will now consider the degree of substitutability of these contested resources. Such substitutability should be examined from the perspective of the subordinate species given the asymmetry of the relationship. Without knowledge to the contrary it is possible to suggest that some of the resources used by the Olive-headed Weaver may be substituted. However, much of the interpretation in this regard, as suggested previously, depends upon the taxonomic level at which a resource is considered. We may consider the nesting material resource required by the Olive-headed Weaver as an example. At the level of species it is reasonable to assume that there are other perfectly substitutable resources. For example, *Usnea mexicana* may be substituted with other species of *Usnea*. However, when examined at the level of genus it is unlikely that the resource can be replaced, for example, by the Genus *Parmelia*, a crustose lichen species (Krog and Swinscow 1981). This would suggest that the resource *Usnea* is essential and taxonomically bound at the level of genus. Given the sensitivity of lichens, in general, to adverse environmental effects this thesis suggests that *Usnea*, at the level of genus, is an 'essential' resource for the Olive-headed Weaver and cannot be replaced. Finally, we must consider the timeframe for such substitutions. The disappearance of *Usnea* over a one hundred year period would likely not allow for changes in the nesting behaviour of the Olive-headed Weaver. An examination of *Usnea* and *Brachystegia* within Step 4 of the SRP model occurs in Figure 23.

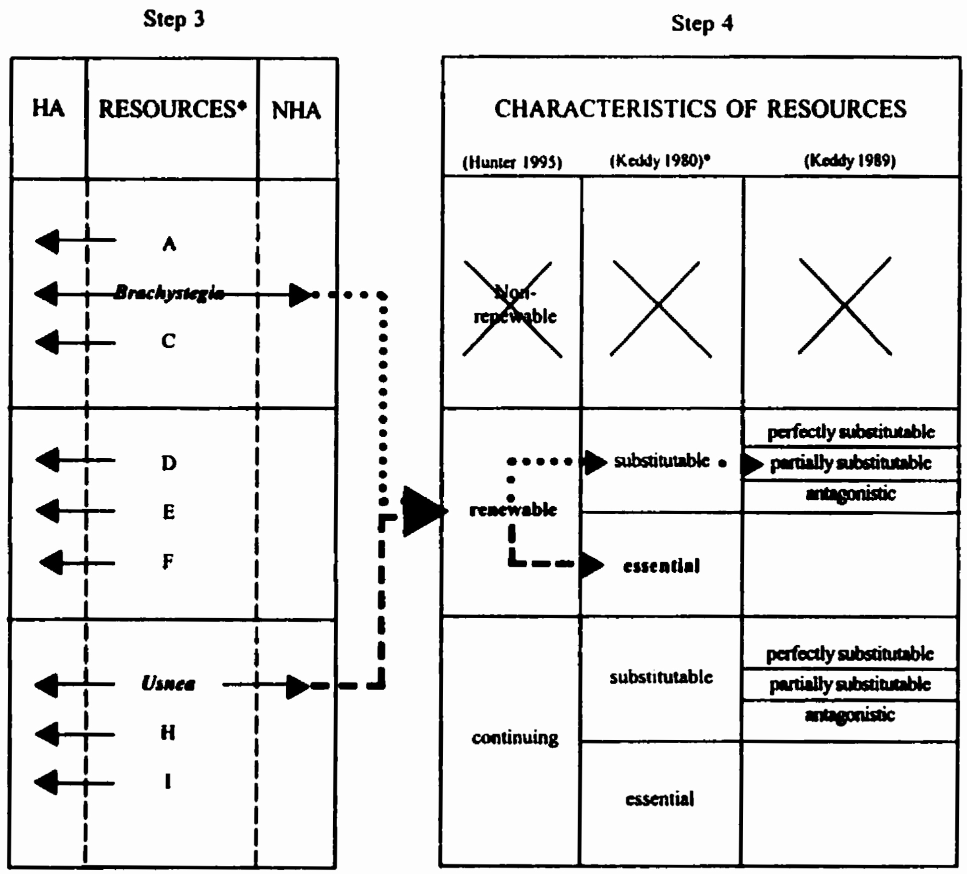

Figure 23: The Sustainable Resource Partitioning (SRP) Model. Contested resources *Usnea* and *Brachsytegia* are characterized as renewable, however *Brachystegia* is considered partially substitutable at the level of Genus, while *Usnea* is essential at the level of Genus. Such analysis suggests that the degree of substitutability of a resource is taxonomically bound.

Conversely, if we examine the issue of trees as a resource for nesting the structural attributes of *Brachystegia* may be met by other species or genera, indicating that *Brachystegia spiciformis* is a perfectly substitutable renewable resource (Figure 23). However, from a nest building perspective the species *B. spiciformis* may be essential if it is only this species which is colonized to a sufficient extent by *Usnea* to allow for penduline nest building. It is the position of this thesis that *Brachystegia* is a renewable and perfectly to partially substitutable resource for the Olive-headed Weaver. This substitution can be expanded to include the Genera *Brachystegia, Isoberlinia* and *Julbernardia*. Overall this suggests that *Brachystegia* as a species may be substituted by "miombo" at the level of biome, as a resource. Finally, it is possible that when nesting in trees other than *Brachystegia* that the fitness of Olive-headed Weavers may be decreased and this would demonstrate a partially and not perfectly substitutable resource. In short, the goal of sustaining miombo allows for a broadly tangible, easily recognized, substitutable and diverse resource which may be easily managed.

Insects are essential at the level of Order (they cannot be replaced by grain or fruit for example) but may be substitutable at the level of genus or species depending upon diet breadth (number of different insect species that diet is composed of). Mates are essential at the level of species (the definition of species relating to breeding) and cannot be substituted in any regard (unless hybridizing occurs with other sub-species). Finally, conspecifics are essential at the level of species but are partially substitutable to antagonistic depending upon classification at Genus, Family and Order taxonomic levels. As suggested previously the consideration of the substitutability of a resource is taxonomically bound.

The outcome of such a characterization of resources drastically changes the manner in which resources are managed. For example, a management plan that focuses on sustaining *Usnea mexicana* as a resource is vastly different from one that focuses on sustaining a variety of *Usnea* species. Similarly, sustainable resource partitioning involving *Brachystegia spiciformis* is markedly different from one involving miombo and thus a total of three genera. Currently the management of insects at the level of Order is required, as there has been little research regarding diet. New information about diet and preferred insect species could change management approaches or, alternately, consideration of possible impact of broad-spectrum insecticides would again suggest management at level of Order. The question of mates suggests that further research is required. Here we must understand whether we are managing one or several species, sub-species or races. As stated previously all continuing resources and the renewable resources of water and air are essential at the described levels. Thus our preliminary analysis suggests that we will focus on the sustainable resource partitioning of the following renewable resources and continuing resources at specified taxonomic levels: miombo woodland – Genera *Brachystegia, Julbernardia and Isoberlinia*; Genus *Usnea* - includes all species within genus *Usnea*; Order *Insecta* – management and conservation of insects in general; Species - *Ploceus olivaceiceps;* Class *Aves* – Mozambican conspecifics for winter-foraging bird parties; Water; Air; Sunlight and Policy.

The characterization of contested renewable and continuing resources according to their degree of substitutability, the determination of a resource net and the realization that such decisions are taxonomically bound has implications for ecotourism, particularly in regard to management of ecotourism areas. Basic biological knowledge, for example, is required for focal species, including the identification of resources required. Based upon this knowledge taxonomically bound resource nets based upon varying degrees of substitutability may be determined. Such a strategy can drastically alter the way in which species are managed. In the research setting, for example, a management strategy which sees miombo as the primary focus of conservation in the context of ecotourism falls drastically short of comprehensive. In this case subtle changes to the renewable intangible resource of air could decimate local *Usnea* populations. The result would be an ecotourism setting with a mature forest and no Olive-headed Weavers. At the same time, a more advanced strategy which focussed only on conserving *Usnea mexicana* would miss an opportunity to conserve all the perfectly substitutable members of the genus *Usnea*. It could be argued of course that as the depth and breadth of the resource net increases we ultimately reach the lowest level of antagonistic resources. While such a term is largely conceptual we may still ask – is there any point in conserving antagonistic resources? With limited time and money is likely that such resources would not be considered. However, it is also important to consider long-term evolutionary changes to utilization of RUF's in the form of niche shifts which allows us to predict that previously antagonistic resources may ultimately "move up" through the layers of the resource net to become closer to essential and thus worthy of conservation. Resource characterization allows ecotourist operations to understand more clearly how resources are to be managed and this in turn can enhance profitability which can be use to assist local HA populations.

4.4.5 Step 5: Characterization of Mechanisms of Competition

Our earlier discussion of mechanisms of competition identified two basic forms – interference and exploitation. The role of interference competition in tropical areas of the world was demonstrated to be substantial. In ecotourism settings, for example, interference competition is sometimes substantial, as in the case of larger vertebrates (poaching of elephants and hoofstock). The ability of any interspecifically competitive setting to reverse asymmetrical competition will be critical in reducing interference competition. From a purely economic perspective, if a particular form of development can demonstrate that a living animal is worth more per annum alive than dead then reversal of asymmetry is possible. In Amboseli National Park in Kenya for example the gross monetary values associated with non-consumptive viewing activities were determined for several species. Among these species individual lions were estimated to have an annual value of $27,000 US while the elephant herd was estimated at $610,000 US (Boo 1990). In Rwanda, approximately four million dollars per year are spent on gorilla-related tourism. Such strong reversals of asymmetry bode well for continued development of the ecotourism sector – if such reversals occur in tandem with sustainable resource partitioning. In the current research setting the Olive-headed Weaver rarely feels the effect of interference competition. Notwithstanding this minimal effect, the potential to reduce interference competition still exists for the Olive-headed Weaver.

Global habitat loss is the single largest source of exploitation competition. In turn, global habitat loss is the single largest cause of reductions in global biodiversity. In

Mozambique exploitation competition through habitat loss plays the single largest role in threatening the future of the Olive-headed Weaver. Taken as a group, renewable resources which are substitutable (*e.g.*, *Brachystegia*) face exploitation competition as do renewable-essential resources such as water and air. To a large extent substitutable resources which are taxonomically bound at levels of maximum substitutability, are affected by serial exploitation competition. This thesis defines serial exploitation competition as a state in which the removal of a single resource results in the simultaneous removal of other resources. For example, the removal of miombo will, in turn, removes *Usnea*, insects, mates and conspecifics. Notwithstanding such serial exploitation competition, contested renewable resources may be affected individually through exploitation competition. *Usnea*, for example, may be harvested directly or insects may be killed through the use of insecticides. Figure 24 continues our characterization of *Usnea* from Figure 23.

As was discussed previously, renewable continuing resources are affected primarily through exploitation competition, which affects their quality (Section 3.2.24). Here, particular forms of development play explicit roles in reducing environmental impact upon air and water quality and may also play a role in educating local HA population members about the relationship between development and environmental impact. It is important that these connections be made if large-scale exploitation competition for renewable essential resources such as air wand water is to be reduced.

Finally, the contested continuing essential resources of sunlight and policy may largely be

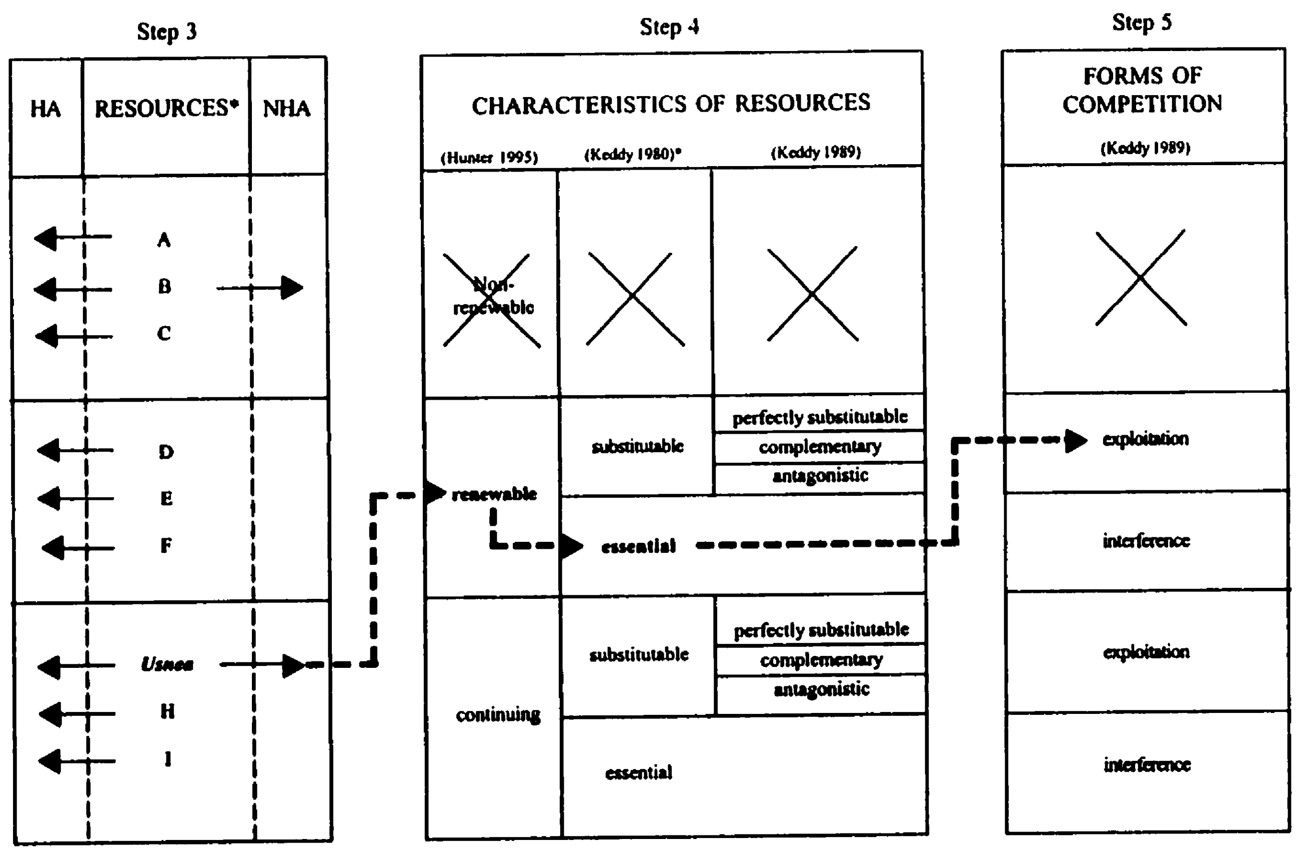

Figure 24: The Sustainable Resource Partitioning (SRP) Model. In Step 5 the Model characterizes contested resources according to their mechanism of competition. Here *Usnea* will be the subject of exploitation competition, through both direct and indirect removal from the ecosystem. *Usnea* is defined as essential at the taxonomic level of genus.

characterized as experiencing exploitation competition. Here, the quality of sunlight affects access to the resource while quality of policy has a widespread and serial effect upon utilization of all resources. Forms of development, as a result of enabling policy can therefore, in turn, affect utilization of other resources. More general large-scale policy can reduce exploitation competition for air of a particular (optimal) quality.

How does the characterization of mechanisms of competition affect development? As an example, certain forms of ecotourism (birding on foot versus motorized transport) can be correlated with forms of competition and resulting population dynamics. For example, motorized transport through dense bush on specific roads may result in less interference competition than walking tourists who may disturb shrub-nesting birds directly and decrease reproductive success. Alternately, the insensitive locating of a road for transport through an area of habitat required by the same bird may decrease reproductive success through exploitation competition. The relative sensitivity of any species to both forms of competition should be assessed. Development may, to a large extent, be about choosing the least damaging form of competition.

4.4.6 Step6: Characterization of Kinds of Individuals

The competitive interaction in the research setting is inter-specific and there is clearly an imbalance in this competition. This asymmetrical state is typical of most HA-NHA interaction which is competitive; a dominant HA population affects a subordinate NHA population.

Our earlier exploration of asymmetrical competition revealed that characterization of asymmetrical relationships usually considers the effects of the dominant species and responses by the subordinate. An examination of the competitive relationship between the Olive-headed Weaver and local human communities is illustrated in Table 1 and examines forms of competition, effects of the dominant human community and responses by the subordinate Olive-headed Weaver community (identification of strategies for reducing competition will be discussed later). The effects described in Table 1 are realized largely through the exploitation of essential renewable and continuing resources. In both renewable and continuing resources the degree of tangibility effects both HA perception of resource quality and availability. Intangible resources tend to have their effects realized at national and global scales while tangible resources tend to realize their effects at local to national scales. Policy must consider these varying degrees of resource tangibility and the scales at which they must be addressed. Asymmetry and human-domination serve as both the problem and potential solution. The local effects of the dominant human community can be generalized to be habitat loss due to direct and indirect causes. Currently, direct habitat loss occurs through the removal of trees and future habitat loss will occur through the same mechanism. The predicted response of the Olive-headed Weaver community is extinction at the local level. At a larger scale, changes to continuing essential and intangible resources such as sunlight and renewable essential intangible resources such as air and water pose the greatest threats to the Olive-headed Weaver population.

Table 1

Effects of Dominant HA Community and Responses by Subordinate NHA Community

Resource	Classification of Resource*	Form of Competition	Effects of Dominant Human Animal Community**	Responses by Subordinate OhW Community**
Miombo	R/S or E OhW may substitute with *Julbernardia* or *Isoberlinia* or.may be only species utilized	Exploitation	Removal of trees and replacement by crops; disturbance of *Brachystegia* forests leading to invasion by *Julbernardia*	Overall decreased range, decreased nesting success due to disturbance during breeding period due to felling, or *Julbernardia* being an antagonistic or complementary resource.
Genus *Usnea*	R/E or S *Usnea mexicana* may be substituted by other species of *Usnea* although this is currently undetermined. If substitution occurs it is likely complementar y or perfectly	Exploitation	Reduction in amount of resource due to tree removal, alteration of atmospheric conditions (ozone, amount of sunlight, particulates and acid rain due to industry), use for personal hygiene and traditional medicine.	Shift in distribution to coexist with *Usnea* resources in other areas, possible local extirpation or larger extinction due to widespread development of polluting industry. Lack of *Usnea* results in reduced nesting,

	substitutable. It is important to note however that regardless of degree of substitutability atmospheric pollution may remove all lichen resource options.		Note: use of *Usnea* by local communities does not compete with OhW as removal occurs from lower or fallen branches	increased intraspecific competition for remaining resources and decreased reproductive success/increased predation due to imperfect substitution through use of alternative nesting materials.
Order Insecta	R/E At the level of Class (thus including all species of insects) there is likely no form of substitution.	Exploitation	Possible reduced insect populations in future through use of insecticides and herbicides, current shift in insect availability and diversity due to replacement of forest with agriculture (shift in species composition).	Local extirpation or shift in distribution, decreased reproductive success, increased competition for specific insect species, extinction at larger scale through implementation of pesticides, herbicides at national scale.
Mates (assumption of single species)	R/E Olive-headed Weaver at research location may interbreed with other races or sub-species. However, connectivity to other popns required.	Exploitation	Decreasing overall population of OhW's and fragmenting populations through habitat destruction resulting in decreased opportunity for mating.	Decreased breeding and reproductive success, extirpation at local level

			Consumption of OhW's during periods of food shortage may occur and may skew sex ratios as males likely perform more sentinel behaviour and are exposed to predation while female sits on nest.	
Class Aves	R/E-S A determination of species composition of bird parties is required.	Exploitation and interference (bird species killed with slingshot and eaten, or eggs removed from nests).	Changes to species richness, shift in availability of bird party members.	Increased predation due to decreased availability of bird parties for foraging, overall reduction in avian diversity increases predation of OhW's by bird-eating vertebrates.
Water	R/E	Exploitation	Pollution leading to increased competition based upon quality. Intangible, renewable essential resource likely affected at local to national scales.	Decreased reproductive success and shifts in distribution as water of optimal quality becomes less and less available.
Air	R/E	Exploitation	Pollution leading to increased competition based upon quality. Intangible,	Largely unknown, however, decreased reproductive success and shifts

			renewable essential resource likely affected at local, national to international scales.	in distribution are expected as air of optimal quality becomes less and less available.
Sunlight	C/E	Exploitation	Pollution leading to increased competition based upon quality. Intangible, continuing essential resource likely affected at national to international scales.	Decreased nesting success as *Usnea* populations dwindle, shifts in distribution to less affected areas as sunlight of optimal quality becomes less and less available.
Policy	R/E	Exploitation	Anthropocentric view that insists that policy is a tool which benefits HA species only. Effects include wide-scale impoverishment of NHA communities through effects upon renewable and continuing resources.	As a resource policy is essentially unavailable. Depending upon availability and effectiveness and scope of policy effects may range from extinction to conservation.

*as renewable, non-renewable or continuous (R, NR, C) resources and status of resource need: substitutable (S) or essential (E)
** current and potential

The utility of the above analysis lies, in part, in demonstrating the inter-connectedness of resources: the miombo woodland supports *Usnea*, insects, the Olive-headed Weaver and other avian species. In turn, continuing intangible and renewable intangible resources support and connect these more tangible renewable resources. Thus any effects of the HA community upon continuing resources or miombo woodlands have drastic effects on a myriad of resources upon which the Olive-headed Weaver depends. Ultimately the response to a loss of miombo woodland (as habitat, source of food, source of cover and component of environmental heterogeneity) by the subordinate Olive-headed Weaver is extinction.

Our goal of reducing asymmetry in the competitive interaction between the Olive-headed Weaver population and the local HA population must now be addressed. Our earlier discussion while generating the model pointed to the necessity of establishing a means by which the subordinate species could affect the dominant. The existence of any effect was suggested to violate the definition of asymmetry. Further, this effect would have to offset conditions of impoverishment in the HA community as a means of reducing intraspecific competition and meeting intraspecific HA population needs. The realization of a positive effect on the HA population by the NHA population was suggested to occur generally through economic means of development. Ecotourism, for example, allows NHA populations to have an effect upon NHA populations which helps meet HA needs which, in turn, provides a positive feedback loop that sustains the NHA population.

Further analysis of Table 1 suggests that the promising role of particular forms of development is dependent upon co-ordination with government and policy. Ecotourism, for example, may emphasize tangible, local resources which are renewable and further consider whether these resources are substitutable or essential. However, given the interconnectedness of sustaining resources government policy must coordinate with development in providing policy which focuses on large-scale intangible renewable and continuing resources, many of which are regarded as essential in their pristine states. Development and government must work together and focus on policy.

Summary of Resources, Competition and Individuals

Kinds of Resources

As a result of fieldwork regarding the NHA population of Olive-headed Weaver five resources were identified including *Brachystegia*, *Usnea*, insects, mates and conspecifics (other birds species). As a result of earlier exploration of what constitutes a "resource" policy was also defined as a resource for NHA species and thus is added to the above list. The resources utilized by local HA community members include wood-fuel in the form of *Brachystegia*, medicines, foods and game gathered from the forest and cleared land for growing crops. In addition to these resources additional needs were identified including hospitals, transportation, schools, clean water, shops and veterinary help, these latter resources being the products of a more robust and often more urban economy. Both HA and NHA populations in the research setting also require the continuing resource of sunlight. Overall the resources appear to be renewable-essential supported by continuing resources. The summary of kinds of resources is included in Figure 25.

Mechanisms of Competition

Interspecific exploitation competition dominates the HA-NHA research setting. In particular, HA communities, through the removal of *Brachystegia* simultaneously remove *Usnea*, insects, mates and conspecifics. As such access to these resources is limited by HA populations. The Olive-headed Weaver appears to have no effect on the dominant HA population and thus the competitive relationship is overtly asymmetrical. At the current time, policy, as an "un-natural" resource also acts as a form of exploitation competition, by reducing access to all of the above resources.

According to interview results when land is need for agriculture it is cleared completely as trees left standing are felt to affect yield. A significant finding based upon the phenomenological approach of the research indicated that most respondents felt that the amount of forest available for future use was without limit. HA community understanding of space and amount of forest cover was limited but understandable given the lack of education and technology (would aerial photographs be meaningful?). Although conditions of poverty prevented most interview respondents from owning livestock, the activity of livestock would likely pose minimal threat to the continued existence of the Olive-headed Weaver, as livestock activity is focussed on the ground plane. Other animals may be more adversely affected. In terms of labour, the area has a

INTERSPECIFICALLY CONTESTED RESOURCES	RESOURCE CHARACTERISTICS	FORMS OF COMPETITION	KINDS OF INDIVIDUALS
Brachystegia	R, S (PS to C)[1]	E	INt,, A
Usnea	R, E[2] to S(PS)[3]	E	INt, A
Insects	R, E[4] to S(PS-C and A)[5]	E	INt, A
Mates	R, E[6] to S (PS to A)[7]	E, I	INt, A
Conspecifics	R, E[8], S[9]	E	INt, A
water	R, E	E	INt,
air	C, E	E	INt
sunlight	C, E	E	INt
policy	R, E	E, I	INt

Figure 25: Summary of characterization of resources and forms of competition for SRP Model. *"R" = renewable; "S" = substitutable; "E" = essential; "PS" = perfectly substitutable"; "C" = complementary; "A" = antagonistic; ** "IN" = interspecific; "INt" = intraspecific; "E" = exploitation; "I" = interference; "A" = asymmetrical.

Regarding "Summary of Characteristics": [1]PS at level of genus when extended to include genera typical of "miombo" but C when extended to other genera; [2]essential at level of Genus; [3]perfectly substitutable at level of species; [4]essential at level of Order; [5]perfectly substitutable to complemtary and antagonistic at level of Family, Genus and Species; [6]essential at level of species; [7]PS to antagonitic at levels below species; [8]essential at level of Class; [9]PS to A at levels of Order, Family, Genus and Species.

tradition of forestry and is a form of extraction which, at the national level, does not focus on *Brachystegia*, again suggesting that some forms of exploitation competition in the form of forestry (precious species or first class species) may not directly affect the Olive-headed Weaver (Cuco 1994). At the same time forests (as classrooms) must maintain their representativeness in terms of diversity and function as habitat; thus some precious or first class species must remain. The lack of roads and transportation currently limits competition. An asphalt road and more widespread use of vehicles would quickly result in increased resource extraction as markets would be more accessible, travel time decreased and transportation made easier. Improved access and transportation may have an additional effect, that of increasing spatial knowledge among HA community members. A larger understanding of space, forest cover, and density of population might help individuals understand these larger scales of competition and the need for sustainable resource use. Although it is likely that development in Mozambique will have an urban emphasis and this may help limit movement to rural areas we must be aware that the population, overall will continue to grow. Traditional methods of land transfer between generations and in accordance with marriage custom are likely to play a role in the requirement for more land. Post-war recovery means increased pressure on land and its resources. Competition between the local population and NHA species (scorpions, snakes, bush pigs and francolins, for example) suggests that some negative views towards wildlife are held and these views are related to both exploitation and interference competition. Interference competition includes bites from scorpions and snakes while exploitation competition includes the destruction of crops by a variety of animals. Ecotourism would offer a means of offsetting the costs and health impacts associated with such damages. Competition in the form of clearing by ring barking (exploitation) and burning (interference through smothering of nestlings) could be offset by setting aside tracts of forest which remain untouched and scheduling burning during periods when nestlings are not in nests and in areas where nests do not occur or prevailing winds will clear moke away from protected or managed areas. A form of exploitation competition may also be found in the rapidly depleted fertility of recently cleared land. Here, natural processes precipitate the gradual removal and use of nutrients until the land is "tired". The rotation of crops, interplanting with leguminous crops, or rotation with leguminous crops (groundnuts) would supply nitrogen. Animal based fecal fertilizer would also be available if the community moved more towards livestock production (although livestock production in general is difficult in Mozambique given a variety of disease causing vectors).

A summary of forms of competition is included in Figure 25.

Kinds of Individuals

According to our SRP Model, competition theory only allows us to characterize individuals as being the same or different species and whether the relationship is symmetrical or asymmetrical. In the Mozambican research setting the competitive relationship is consistently interspecific and asymmetrical (again refer to Figure 25).

The simplistic nature of the model poses some problems at this stage, largely because such classifications do not capture the subtle ways in which HA and NHA individuals may affect competition. The quantitative approach to studying NHA animals also places constraints; we are limited by those variables, forms of analysis and results which we have at our disposal and which are appropriate and feasible in the research setting. The complexities of the HA population and the ways in which they might affect competition bear closer scrutiny as do some of the methods used to collect data.

The majority of the respondents were male which may affect the generalizability of responses. Overall the local population is in a post-war phase; trying to recover from losses of family members, possessions, homesteads and land. Interestingly it is the period immediately following war when communities are most likely to be able to embrace further change. Ironically this is also the period of greatest uncertainty, lawlessness, confusion and re-location to areas which may have previously been conservation areas. Is it possible that post-war recovery plans could be developed which address this problem? People who had left the area and subsequently returned had returned in part because they had invested so much in the land and they had been born there. Poverty, food shortages, lack of employment and post-war re-location all contribute to an HA culture which seeks mainly to survive from day to day. As such, the pressing needs of obtaining food, clearing land and retrieving water take precedence over partitioning of resources for a little-known avian species. Of course, it is exactly this scenario that makes ecotourism an attractive option with its potential for rural development, employment, minimal start-up costs and opportunities for self-determination and conservation of natural resources

At the same time, the fact that the local population is highly dependent upon the land for resources bodes well for emphasizing the importance of NHA and plant resources. Some other aspects of the local human animal culture may also play a role in supporting the environment and ecotourism. Although formal religion, usually a form of Christianity, plays a minor role in day to day existence and only some traditional ceremonies remain, it is possible that these aspects of the local culture could be sustained and related to coexistence. However, a diversity of opinions within the local community was expressed in regard to traditional ways, from recognition to dismissal. Clearly the community is in transition and diverse in regard to belief systems. Both religion and traditional ways could easily be incorporated into the goal of coexistence and ecotourism. Christian religion could focus on Genesis and its edict of "replenishing the land" while animism and traditional ceremonies could both contribute to celebrating the land and its resources.

Education is limited and much needed. Obviously in the area of education both biology, ecology and traditional ways of interpreting the land and its resources would be ideal. The conservation ethic needs to be formally incorporated into all levels of education. The act of naming and identifying surroundings (plants, animals, birds, signs of ecosystem health) is also felt to be critical as this was not well developed. Women appeared to be most adept at answering questions about their children's education, used the forest for recreation (walking), retrieved water, sought medical help, had the most contact with the land, and thought "forest" was an important form of "classroom". Based upon these observations it is possible that a gendered approach to sustainability, coexistence and ecotourism would be optimal. Unfortunately, as women get married younger than men and are displaced when they marry (to live with the groom's family) the opportunity for educated women to remain attached to the land is also reduced.

Health is also an important factor and may be related to the perception that nature is some ways is "bad". Mosquitoes cause malaria and organisms in the water make people sick, while agricultural pests and biting insects are also a problem. Health, whether achieved through modem medicine or a *curandeiros,* is a prerequisite to all aspects of resource extraction and conservation. Interestingly, the work of the traditional doctor or curandeiros is also a link to landscape and thus the conservation of tradition in this scenario is coincidental with the conservation of landscape (requiring the educational link between forest resources, the curandeiros, and health).

Overall the local population is predicted to continue its current interactions with the landscape, harvesting renewable resources at rates which exceed replenishment and without an awareness of the 'big picture'. At the same time, this population competes very minimally for continuing resources. Here, more developed countries play direct and indirect roles in the net increase of damage to continuing resources which coincidentally increases competition for them. Less developed countries and rural populations within developing countries may be victimized by such dynamics (changing global weather patterns, ozone depletion, etc.). To some extent the essential resources required by the HA population might be met through ecotourism.

In summary, our examination of kinds of resources, mechanisms of competition and characteristics of kinds of individuals suggests that ecotourism can play a significant role in sustaining resources, providing HA community needs (food, water, health care, education, employment etc.) and that meeting these needs

4.4.7 Step 7: Characterization of Dominant Community Intraspecific Needs

The enormous impact of HA populations through interference and exploitation competition of continuous and renewable resources suggests that the path to the sustainable coexistence of the HA-NHA community lies in understanding HA community needs. At global, international and national scales we can see the dramatic effects of intraspecific competition for resources in the form of war. War over oil in the Arabian Gulf and water in the Middle East are suggested to be the result of conflicts over resource availability (O'Riordan 1993). Conversely, the lack of competition and the absence of a concept of war among some hunter-gatherer societies (*e.g.*, !Kung Bushmen groups) has also been described and suggested to be the result of "little overlap in resource demands" (Durham 1976, 391).

In the research setting an examination of HA community resource needs, the means of securing each resource and the effects of securing that resource on the dominant HA community as well as secondary effects on the subordinate Olive-headed Weaver population is understood to be critical and is shown in Table 2.

Table 2

HA Intraspecific Competition and Effects upon NHA Community

Resource	Classification of Resource*	Means of Securing Resource and Effects of Securing Resource on Dominant Human Animal Community**	Secondary Effects on Subordinate OhW Community**
Food	R/E-S While food is essential the types of food required are substitutable and in fact shifts in types of agricultural crops may increase yield and nutrition.	Food security may be enhanced through such activities as increasing yield, improving food storage, planting nitrogen fixing crops, rotating crops, using organic means of increasing soil fertility, increasing nutrition of crops, and planting drought-tolerant crops. Food security contributes to overall mental and physical health which ensures that humans are, in turn, able to participate more fully in other activities. By increasing yield and nutrition less land is required for cultivation.	Decrease in deforestation and resulting increase in available habitat.
Water	R/E	Implementation and management of wells and water table. The issue of proximity or access to clean potable water is an issue. Wells adjacent to	Time saved and subsequently invested in education, particularly in regard to the to the role of the environment, can contribute to increased knowledge and interest in

		homesteads or filtering of water at regularly placed community pumps is required. Time saved through such interventions can be utilized in other ways (education, health care) and is particularly important for women.	ecology, conservation and sustainability. Effects may include decreased direct predation, habitat preservation, innovative forms of management and, ultimately, sustaining of OhW population.
Health Care	R/E	Both a higher standard of health care centralized in Panda and a means of bringing basic health care to rural communities on a regular basis is required. Improved health, greater work efficiency, greater food security, more effective education, better outlook, decreased infant and adult morbidity and mortality, increased productivity.	Increased attendance and performance at school and link to landscape through education. Greater contribution to agricultural labour and subsequent contribution to food production may result in decreased deforestation. Both the above may contribute to sustaining the OhW population.
Education	R/E	Increased availability of education for both children and adults. Increased awareness and understanding, a more holistic perspective, understanding of benefits of certain forms of development may contribute to a greater understanding of sustainability.	Increased population, decreased competition for resources, futurity
Employment (Industry)	R/NR/C and E/S	Development of local industry or employment is critical to ensure that there	Could lead to reduced fecundity, decreased population, reduced

		is access to all members of community and that transportation is not an issue. Non-polluting, sustainable industries that connect people to landscape are recommended.	distribution or, To sustaining both human and non-human animal communities.
Transport	E-S A variety of forms of transportation may be used from cars, to donkeys.	Increased personal wealth is one means of securing resource. The effects of securing transportation include increased access to health care, education and alternative markets for trade.	Automobile emissions may effect *Usnea*. Increased opportunities for education may effect sustenance of OhW.
Policy	E	Petitioning and education of government officials, local participatory action and involvement of government. The effect of policy should be the sustainable integration of both human animal and non-human animal communities. This will likely occur through self-regulation of HA communities, meeting HA needs and education.	Protection and guarantee of access to resources
Energy (wood fuel)	E/S	Sustainable management of forest resources or use of alternate energy sources.	Conservation of habitat.

*as renewable, non-renewable or continuous (R, NR, C) resources and status of resource need: substitutable (S) or essential (E)
** current and potential

The analysis of resource security and secondary effects seems to suggest that meeting human animal community needs in a thoughtful, sustainable manner is also a means of securing the future of the Olive-headed Weaver. This simultaneous striving to meet the needs of both populations begins to speak of coexistence. Our meeting of local HA population needs in the research setting of Mozambique identified food, water, health care, education, employment, transportation and energy as needs. While food, energy and water requirements can be met to a limited extent through the use of dwindling forest resources the remaining four needs require a political, economic, social and cultural framework which in turn is generated by government and funding. The expectation that top-down processes from national or international governments or agencies will meet HA and NHA resource needs is short-sighted and unrealistic. A local, community-based initiative that focuses on the economic integration of NHA populations in an ecotourism scenario can be used to meet the dominant HA population needs and, as stated previously, reduce asymmetry in competition. This future may only be secured if development scenarios place a premium value on the long-term sustainability of the environment and coexisting species rather than investing in other areas.

4.4.8 Step 8: Recommendations for Limiting Competition and Sustaining Resources

Our earlier exploration of the SRP Model allowed us to make some general recommendations regarding the move from competition to coexistence. We will not reiterate these general recommendations here as they will be discussed to a large extent when contextualizing more specific recommendations. We now turn to the specific task of partitioning resources in the research setting as the final stage of the model.

4.4.9 Context Specific Recommendations for Resource Partitioning

Identifying all of the resources involved in interspecific exploitation competition is critical. The management of a miombo forest for sustainable yield of tree species and the elimination of industry to sustain *Usnea* populations will be impractical if local farmers are applying pesticides which kill insect populations which are part of the Olive-headed Weaver's diet. A holistic approach is required, one that characterizes resources and the forms of competition and subsequently involves scale-appropriate government and local action towards a common goal of coexistence. Ecotourism can achieve such coexistence if natural theory is used to guide development and because both inputs and outputs in such a context are 'natural'.

When we consider resources to be partitioned it is clear that the suite of contested resources required by the Olive-headed Weaver and HA populations include resources such as miombo, *Usnea*, insects, mates, conspecifics, policy, food, water, energy (wood fuel), air, sunlight and policy. Our consideration of contested resources excludes health care, education, employment and transportation. We note, however, that our earlier arguments indicate that these last four resource needs maybe met by sustainable partitioning of the preceding resources in the context of development (such as ecotourism). Of those resources secured through ecotourism special attention must be paid to education. In expanding our prior discussion on reducing asymmetry in the research setting education will play a critical role. Education offers the best opportunity to demonstrate the inter-relatedness of animal communities that may in turn help to heal the rift between human and non-human animals and sustainability (Bryden 1994b). This allows the economic effects that reduce asymmetry to be expanded to include philosophical effects. As such, resources may be sustained simply for ecocentric reasons (Thomas 1998). This philosophical approach may be integrated in an educational format that emphasizes the link between HA population intraspecific resource needs to the positive effects of the environment:

1. The Olive-headed Weaver plays a role in dispersal of *Usnea* that, in turn, is a resource required by local communities.
2. The Olive-headed Weaver may serve as a food resource during times of drought and starvation.
3. The Olive-headed Weaver may act in controlling insect populations that may in turn decrease insect population impact on crops.
4. The supply of some forms of native plant material for insect populations it may decrease impact upon agricultural crops.

We will now turn our attention to the sustainable partitioning of the following resources. As a final preface it is important to remember that resource partitioning can occur in three ways when we consider RUF curves and overlap in interspecific competition:

1) competitors use portions of the RUF such that no overlap occurs and competition ceases;
2) competitors continue to use overlapping resources but partition the resource in space;
3) competitors continue to use overlapping resources but partition the resource in time.

While the evolution of non-competition by utilizing different portions of overlapping RUF's occurs on an evolutionary time scale this thesis recognizes the broad adaptability of the HA species and suggest that if short-term changes can result in increased competition and greater overlap, that short-term changes can also result in decreased competition (relying upon human morality, ethics, education and changes in behaviour).

Renewable Resources

Miombo

According to Schoener (1974), the partitioning of habitat is a first priority. As miombo is widespread and essentially a monoculture (dominated by mature *Brachystegia*) there are few resource alternatives. Both the HA and NHA populations required the same resource. We begin with the assumptions that mature *Brachystegia* (as a synonym for miombo) is the contested resource and land is cleared completely by HA populations in preparation for subsistence farming. If we then interpret competition for *Brachystegia* in the form of an RUF (MacArthur 1968, 1970, 1972) and plot "dbh" as a resource variable on the x-axis, against amount of utilization on the y-axis we see immediately that both the

Olive-headed Weaver and the local HA population use the same resource in nearly the same manner (Figure 26). Under conditions of deforestation HA populations utilize a broad spectrum of dbh sizes. Conversely the Olive-headed Weaver uses a narrower range, with a mean dbh at approximately 39 cm, as per field research. Under these circumstances competitive exclusion will occur unless one niche is shifted. The only plausible short term directional shift is one predicated on changes in human behaviour. Unfortunately any displacement of the HA RUF to the left simply means that HA population use the miombo at a younger stage which precludes any use by the Olive-headed Weaver. Simultaneously the Olive-headed Weaver RUF cannot be shifted to the left as mature trees are required for colonization by *Usnea*. It appears that a leftward niche shift by either population as a means of providing coexistence (removing overlap of RUF's) is untenable in this setting. Moving the HA RUF to the right is the only remaining option and requires a behavioural niche shift for HA communities. It is possible that after a period of use by the Weaver the very mature miombo forest trees could be utilized for human animal needs as required. Here, fieldwork informs the possible point at which trees may be harvested. The mean dbh of nesting trees selected by Olive-headed Weavers was 38.275 cm. Allowing for a portion of the standard deviation on the right side of this point might suggest that HA populations be allowed to harvest trees which are 45 cm and greater in dbh. This suggests that somehow the HA community has some use for mature trees and this in fact is true, mature trees serve as firewood, provide shade and lichens and habitat for the other forest animals that are hunted (Figure 27).

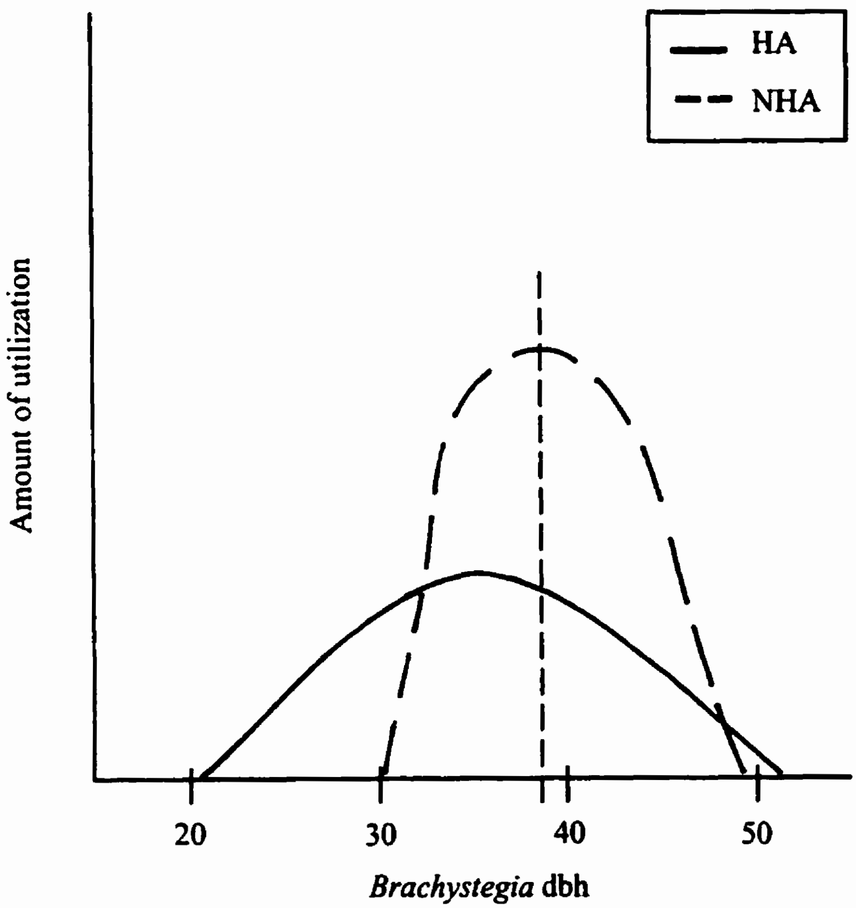

Figure 26: Competition for Miombo as a Result of Overlapping Niches or RUFs. The field data indicates an average *Brachystegia* dbh for nesting trees of approximately 39 cm. The HA population uses a broader portion of the resource variable (dbh) particularly when deforesting for agriculture as all plant material is removed.

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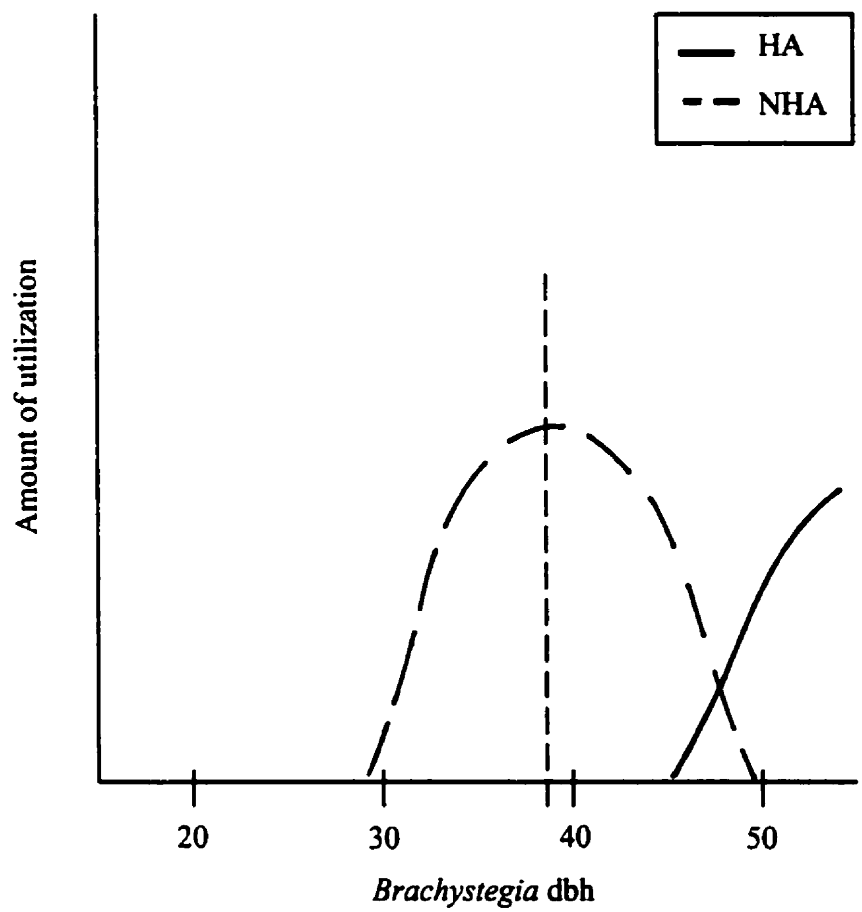

Figure 27: Partitioning of Miombo through Shifting of the HA RUF. By forcing the HA RUF to the right to the point where *Brachystegia* trees with dbh greater than 45 cm exist we can provide for coexistence. Two assumptions are included: 1) clearcutting of the forest is occuring and 2) only mature forest exists.

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Ensuring that HA communities only utilize mature *Brachystegia* trees also provides one way of partitioning the resource in time. In addition to delaying of harvest, trees could also be partitioned on a seasonal basis. The above scenario seems to suggest spot cutting or removal of individual trees or groups of trees that exceed the minimum diameter. Further partitioning could occur by limiting the season of removal to periods when Olive-headed Weavers are not nesting. This might work for agriculturally defined seasons of clearing land and planting) but would not work regarding the felling of trees for firewood.

Our analysis thus far examines partitioning along an RUF and partitioning in time. We must also consider partitioning in space.

The coincidental outcome of moving the RUF to the right for the HA community and thus implementing partitioning in time could be used a general strategy for moving from competition to coexistence however subsistence farming could not take place solely in those areas where trees with dbh's greater than 45 cm were removed. As a form of management using dbh is highly suitable for the current setting of Mozambique in that it is "low-tech", easily taught, affordable and could become a tangible indicator for desired outcome management (Lindberg and McCool 1998).

It is likely then that moving the HA RUF to the right and introducing temporal partitioning at the same time might be ideal for areas which are not expected to be deforested or are protected. Core protected areas for the Olive-headed Weaver are an example. Here, mature forests would function as a source of resources for both HA and

NHA populations. The creation of a protected area results in the partitioning of miombo in space. With little intervention HA communities could manage these areas to sustain a constant supply of mature miombo. At the same time other natural resources could be sustained: understorey plants could be harvested, wildlife could be sustained for hunting and firewood in the form of deadfalls or felled trees with a dbh greater than 45 cm, could be collected. Maintaining the overall structural integrity of such forests also contributes the cleaner water, absorbing carbon dioxide and radiation, assimilating wastes, cleaning the air and balancing atmospheric gases. Notwithstanding the benefits of reduced exploitation competition by resource partitioning along RUF, temporal and spatial dimensions there may still be concerns about interference competition. Interference competition in the form of hunting or burning of adjacent forested area (drifting smoke could asphyxiate nestlings) could still result in NHA population decreases. As discussed previously partitioning continuing resources such as air or reducing interference competition would likely be the result of local, national to international scale implementation of policy as an largely intangible "unnatural" resource.

Our earlier exploration of renewable resources demonstrated a dependence of renewable resources upon continuing resources. While continuing resources will be discussed later it is important to note here that conservation of miombo forests will depend upon essential continuing resources which are sustained in unpartitioned (unpolluted) states.

Finally, our forms of resource partitioning may not be enough to overcome the asymmetrically competitive setting where HA domination may ultimately result in the clear cutting of remaining miombo woodland. However, much like our earlier discussion in which the Olive-headed Weaver exerts an effect upon the HA community via economic means and ecotourism the same may be possible for miombo forests. For example, it may be possible to offset asymmetry of competition between miombo and HA populations by allowing the forest to have an economically competitive effect upon HA populations. For example given the relatively low biological diversity of *Brachystegia* or miombo forests (which is akin to a homogeneous crop which is a human culture strategy for increasing production and profit) local communities may be able to develop marketable products related to these species. The relatively natural state of miombo homogeneity may ensure that miombo products, if marketable, could be sustained at economic densities (Crook and Clapp 1998).

In summary, in regard to the contested resource of miombo (*Brachystegia*) the HA-NHA competition setting can be moved from competition to coexistence through simultaneous use of 3 forms of partitioning: RUF niche shift, temporal partitioning and spatial partitioning.

Usnea Genus

The Genus *Usnea* depends upon trees as a substrate for colonization in the study area and likely throughout the range of the species. Trees must be of a certain age before colonization is achieved. Colonization is likely to continue until the tree dies, falls over and degrades. Our exploration of partitioning of *Usnea* using niche shift, space and time will follows suit as with miombo.

We begin with a discussion on using niche shift to partition *Usnea*. We must first determine a resource variable to use and with *Usnea* thallus length appears to be a variable that limits use in both HA and NHA populations. In order for *Usnea* to be harvested by HA individuals it must be of a sufficient length. As well, the Olive-headed Weaver requires thallus lengths that will be sufficient enough to travel from the branch to the tips of the spout of the nest (see Figures 6). The length required by HA populations is less than that required by NHA populations but because these shorter lengths give rise to longer lengths (as with dbh in miombo) the greater length becomes the limiting variable within the RUF. Here again, fieldwork proves to be valuable as the mean nest total length (Section 4.1.5) of Olive-headed Weavers is 28.7 cm. Given that the nest possesses a curvature it is likely that strands must exceed this mean total length and thus a figure of 30 cm thallus length is used for the purposes of this discussion. Without strands of sufficient length the Olive-headed Weaver cannot build its nest. The RUF's for *Usnea* utilization are shown in Figure 28.

In Figure 28 the RUF of the HA population is wider and flatter – suggesting that HA animals will use the lichen when it is much shorter. In contrast, average nest total length creates a mean around 30 cm and allowing for some deviation is shown to range from 20 to 40 cm in length. As with miombo, discussed above, shifting the HA-NHA curves to the left is untenable. By suggesting that HA populations harvest only those *Usnea* strands which are greater than 35 cm in length we can shift the HA RUF to the right. As

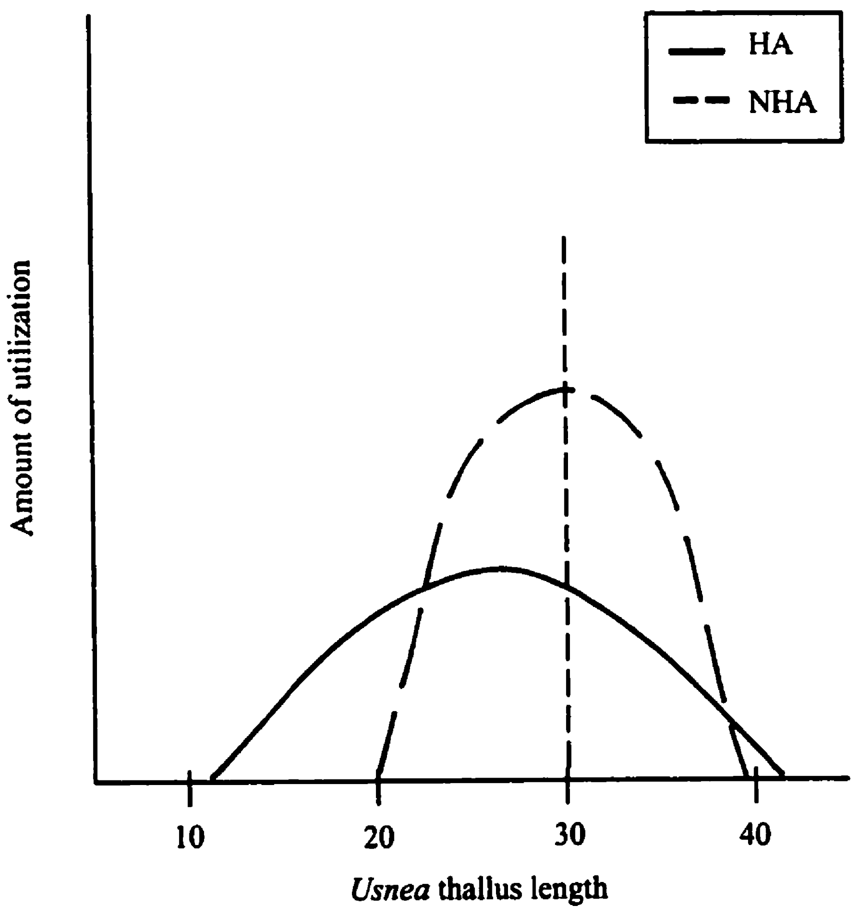

Figure 28: Overlap of *Usnea* RUF's for HA and Olive-headed Weaver Populations. The HA population uses *Usnea* throughout a greater range of thallus length than the NHA population (maximum strand length is limiting in this population).

with miombo such a shift allows for coexistence rather than competition (Figure 29). As with our previous example longer *Usnea* strands are necessarily older *Usnea* strands which provides a form of temporal partitioning. In addition we might consider a form of seasonal temporal partitioning which would mean that lichens might only be gathered at certain times of the year (January to July to avoid breeding season). This, however, is unrealistic from an HA population point of view because the resource is required year round. Spatial partitioning may solve this problem, however.

During field research it was noted that Olive-headed Weaver nests were always located in the upper third of the canopy of trees. Given that the mean height of nesting trees was calculated to be 17.75m the nests and the lichens they use are naturally separated in space from HA populations. However, HA individuals will (easily!) climb trees to retrieve wildlife, eggs, fruits and lichen when necessary and thus some exploitation competition occurs. Vertical stratification is a phenomenon that is common in birds and coincidentally allows for greater horizontal overlap (Koplin and Hoffman 1968; Schoener 1974). This means that HA and NHA populations may overlap over large areas as long as vertical stratification is maintained. Such natural stratification suggests a lesson from nature that can be applied in moving *Usnea* competition towards coexistence. If HA populations harvest only those lichens from the bottom third of any tree canopy this acts as form of spatial partitioning and is an ideal management strategy (Figure 30).

A critical question for management arises: How long does it take for a lichen to go from colonizing a tree's bark to strands (thalli) which can be used for securing (starting) or

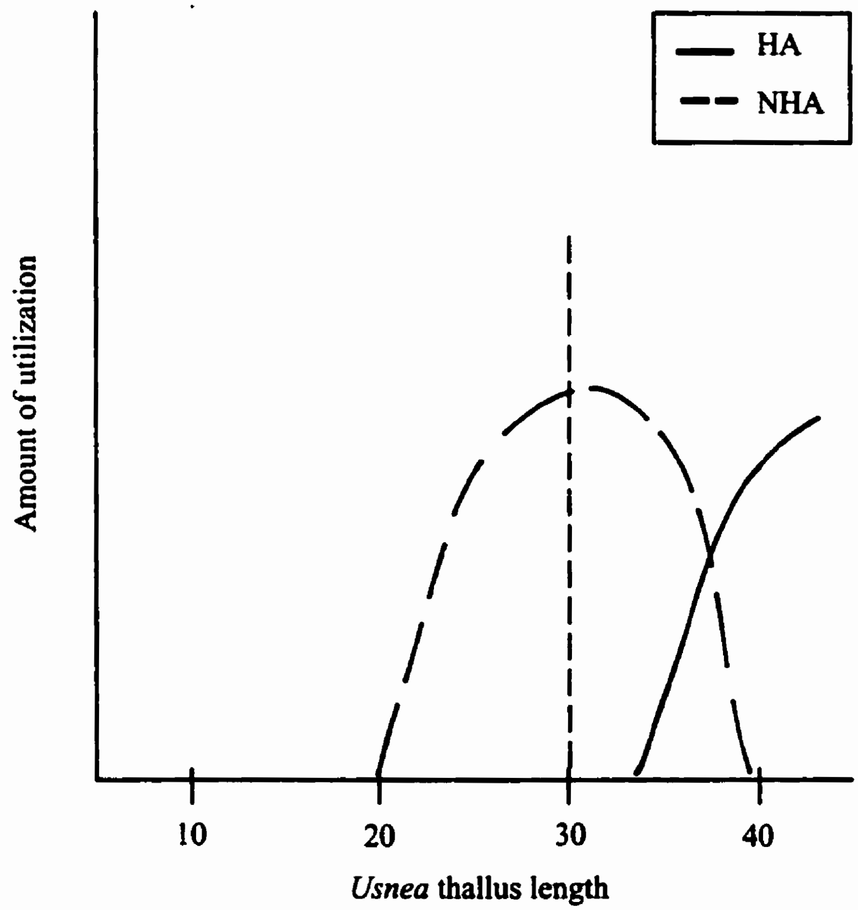

Figure 29: Partitioning of *Usnea* through shifting of the HA RUF. By forcing the HA RUF to the right to the point where *Usnea* strands (thalli) are greater than 35 cm in length we can partition *Usnea* to allow for coexistence.

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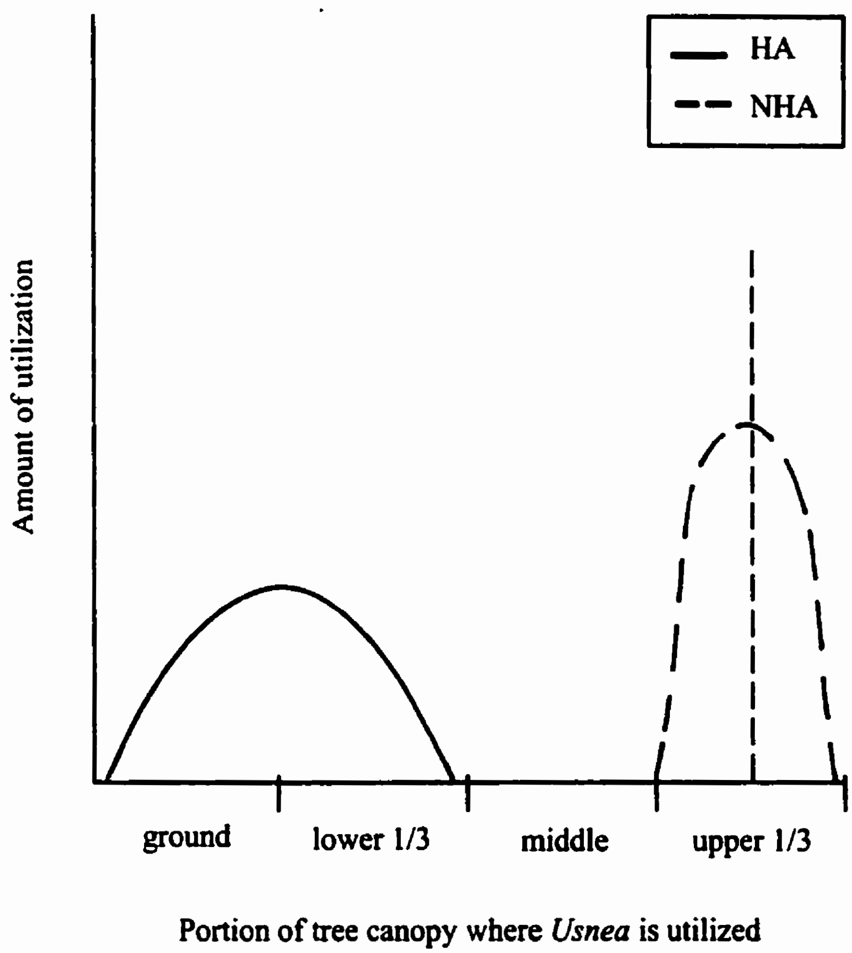

Figure 30: Partitioning of *Usnea* through vertical stratification of RUFs. The HA population would gather *Usnea* from the ground (fallen branches) as well as up to a maximum of the bottom 1/3 of the tree canopy. The Olive-headed Weaver population would use *Usnea* from the top 2/3 of the canopy.

building a nest? Thus once mature stands of miombo are established resource management must allow for sufficient colonization of the tree by lichen to permit secure attachment and building of nests. Lichen attached to fallen *Brachystegia* branches is abundant in mature forests and the resource could also be partitioned by allowing human animal communities to collect *Usnea* from fallen limbs or the lower branches of trees.

The assumption that conservation of *Brachystegia* forests is directly related to conservation of lichens such as *Usnea* and insect populations will now be addressed. The thesis proposes that deforestation of miombo forests for subsistence agriculture is an extreme form of clear cutting whereby no form of vegetation remains. Management which has as its goal the production of old growth forests is the necessary step for conserving *Brachystegia* trees and lichens. The disappearance of lichens as a result of clear cutting has been documented by Ahlner (1948), Jorgensen (1978) and Esseen *et al.* (1992). Esseen *et al.* (1992, 293) states: "By definition clear cutting eliminates all epiphytic lichens and bryophytes".

We must also understand that deforestation and fragmentation affect interaction with continuing resources including the overall wind speed, moisture and light penetration of forests. Thus management must consider resource interdependency and interaction with essential renewable resources such as water and air as well as continuing resources such a sunlight. That said, a large and theoretically sustainable *Brachystegia* woodland, ideal for lichen colonization may not be fully realized if global weather patterns are affecting winds, air or water quality or levels of sunlight. Thus management of lichen resource is, in part, dependent upon management of large scale resources such as sunlight, wind and air quality. The partitioning of such continuing resources poses some intriguing problems and these are discussed later.

Lichen populations can be supported through proper management, particularly if the amount of edge relative to interior is minimized. This is because arboreal lichens are severely affected by fragmentation due to increased air speed and decreased humidity (Angelstam 1992). In addition lichens are slow growing and are therefore confined to stands of trees that are long lived. *Usnea longissima*, known as a "fire-refugia lichen" in temperate forest models, requires several hundred years of continuity and thallus size increases with increasing tree size (Esseen 1981, Esseen *et al.*, 1981). It is because of their slow growth rates and long life spans that lichens often require stable and long-lasting habitats (Topham 1977). In some temperate areas lichen biomass slowly increases up to a more or less constant level when tree ages reach about 100-150 years (Edwards *et al.*, 1960; Scotter 1962, Stevenson 1986). *Usnea* is also dependent upon microclimate and habitat structure and thus ecotourism can conserve forested areas that reach these stages of maturity. *Usnea* has been used as an indicator of old growth forests in boreal Fennoscandia. (Esseen *et al.*, 1992). In Europe *Usnea longissima* is severely endangered mostly due to forest fragmentation from clear cutting and air pollution (Esseen 1992). In some areas of the world (Fennoscandia) *Usnea* is completely dependent upon wind dispersal of fragments from one tree to another thus the sometimes stormy conditions of coastal Mozambique within their relatively stable humidity may be crucial for survival. Such limited means of dispersal may also explain *Usnea*'s sensitivity to environmental disturbance and may also indicate that the relationship with the Olive-headed Weaver is critical as a means of dispersal.

Even minor changes to old growth forest structure can produce highly negative results:

> The present evidence suggests that very specific habitat demands and an inefficient method of long-range dispersal are responsible *for U. longissima's* sensitivity to environmental disturbance. For example, cutting a few host trees or clear-cutting nearby forest may totally destroy a site. The only way to maintain naturally functioning populations of this lichen, and of other species dependent on long forest continuity, is to preserve the habitat from all kinds of forest operations. However, it is also necessary to have buffer zones wide enough to maintain an unchanged microclimate (Esseen *et al.* 1992, 274).

The concept of patch buffering is thus required for two reasons: the conservation of forest interior lichen species, upon which the Olive-headed Weaver is dependent; and, the avoidance of generalist predators which affect the Olive-headed Weaver directly through interference competition.

Finally, we reiterate that for the Olive-headed Weaver certain resources like the *Usnea,* at the level of species, are essential; nothing can replace this required resource. If *Usnea* disappears, the Olive-headed Weaver will disappear. Management plans must maintain adequate populations of *Usnea* and understand the relationship between: (a) atmospheric pollution and lichen population survivability, and, (b) miombo woodland stand size, edge effects and microclimate changes and lichen colonization and survivability

The relationship between *Usnea* as an essential-renewable resource and its dependence upon essential-continuing, intangible, large-scale resources suggest that conservation of *Usnea* lies, in part, in large-scale policy in regard to air quality.

<u>Order Insecta</u>

Determining an insect related resource variable along which HA and Olive-headed Weaver populations could partition resources poses some difficulties. The year-round diet of the Olive-headed Weaver is unknown. However, insects, in general, are assumed to be a staple. Based upon the fieldwork, an analysis of foraging methods and fecal samples confirm the importance of insects to the diet. There is no way of knowing how much overlap there is between the breadth of insects in the Weaver diet and those most likely to be utilized by HA populations. Utilization of insects by HA populations may include targeting by pesticides applied in agricultural settings. Pesticides, herbicides and fertilizers are all currently unavailable in rural Mozambique and if available would not be afforded by many. Notwithstanding these limitations, if overall development of Mozambique occurs there is a possibility that in the future the insect diet of the Weaver may be threatened by agricultural pesticides. This provides a realistic scenario for exploring partitioning of insect resources.

If we consider defining insects according to the way they are partitioned by their own behaviour in space we may generalize that the majority of insects which are the focus of HA pesticide applications tend to dominate at the lower levels in a vertically stratified setting. Of primary concern to HA populations are those insects that occupy the soil or eat crops. HA crops reach a maximum height of about 3 m. The killing of insects is a form of exploitation competition (relative to the dietary needs of the Olive-headed Weaver) and in a sense this approximates the insect "diet" of the HA population. Based upon field research we are aware that the Olive-headed Weaver tends to occupy the canopies of trees both in terms of foraging and nesting. Based upon the relationship between dbh and tree height derived from field work we can calculate the average height of random trees (as opposed to nesting trees) to get some idea of the extent of the vertical structure of the forest. This figure is based upon an average random tree dbh of 29 cm suggests an average forest height of roughly 15 m. We may assume that Olive-headed Weavers tend to forage in the upper 2/3 of these trees while insects that compete for HA crops tend to exist at heights greater less than 3m from the ground. It may be possible to design pesticides which are "heavy" (tending to stay near the ground when utilized under appropriate conditions) and irrespective of the true overlap in insect "diet" breadth in HA and Weaver populations the insecticide would only affect those insects found closest to the ground at any one time. This would leave canopy insects for the Olive-headed Weaver. There is little to prevent insects from altering their point along the vertical gradient, particularly after being affected by a pesticide but we rely here upon these events being more or less probabilistic in a stochastic world. Certainly bark beetles and lichenophagous insects would be protected by this strategy. This strategy coincidentally provides a spatial means of partitioning insect resources. Again, given the mobility of most insects any other forms of partitioning would be difficult. The partitioning of insects based on pesticide use and position within a vertically stratified environment is shown in Figure 31.

The timing of insect blooms is a well-documented response to seasonal spurts in vegetative growth that in turn are related to seasonal moisture regimes. As mentioned previously HA communities do not compete directly for insects as a resource. However, indirectly, they utilize or make unavailable the resource through application of pesticides and herbicides. By eliminating or controlling timing of application it is possible to partition insect resources so that they remain available for the Olive-headed Weaver particularly during the months of August through December when breeding is taking place. It is likely that during the breeding period that richer insect supplies and decreased competition from guild members allow for narrower niche breadths (both in terms of habitat and diet) and thus competition from HA stakeholders may be minimized. However, during these same months food supply is also typically low for HA communities and thus it is possible that during the preceding months that application of pesticides could be greatest in an effort to offset potential food shortages. If pesticides are applied when the realized diet niche breadth is smallest then Olive-headed Weavers could be particularly prone to extirpation (discounting behavioural changes that expand the niche to approximate its fundamental width). Such changes to guild competition and niche breadth are supported by Koen (1988) who mentions that the number of bark gleaning, hovering and sallying species is lower in tropical African forests than in the

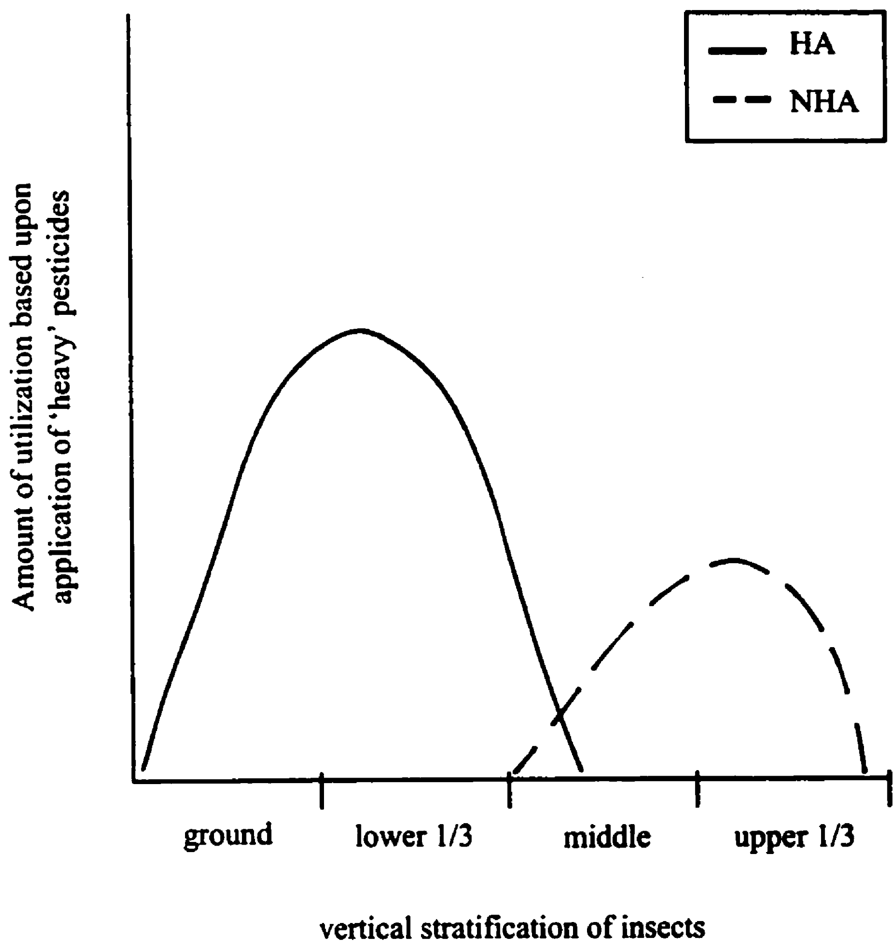

Figure 31: Partitioning of Insects through Vertical Stratification of Heavy Pesticides. Heavy pesticides would be used and affect only those insects which occupied the lower stratum. Canopy based insects, an important resource for the Olive-headed Weaver, would be partitioned and allow for coexistence.

neotropics and that this phenomenon likely leads to finer niche partitioning due to expanded diet resources, leading to selective foraging and narrow niche breadths. Birds with such narrow niche breadths are prone to extinction.

The conservation of old growth *Brachystegia* forests is crucial not only for sustaining *Usnea* populations but for sustaining insect populations as well. Many insects are known to be confined to old growth habitats; the same as those required by *Usnea* (Palm 1946). Decaying wood on standing trees, snags, stumps, logs and windfall material in old growth forests provides habitat for a large number of invertebrates (Esseen *et al.* 1992; Hamilton 1987). It is important that some dead fall and rotting trees be left to be available for the life cycles of insects, decomposers and other NHA species.

Mature *Brachystegia* trees, with their coarse bark microtopography, not only provide a substrate for colonization by *Usnea*, they also provide a large supply of invertebrates. In temperate boreal forests, for example, rough barked trees such as Scots Pine provide a greater supply of arthropods to birds than other less rough barked species (Morrison *et al*, 1985). The *Brachystegia-Usnea*-Insecta complex is further strengthened when we discover that in addition to consumption of tree material the fungal mycelia play a dominant role as a nutrient source for many species of beetles (Lawrence 1989). The results of examination of fecal samples in this study showed a large amount of beetle body parts and thus confirms the importance of beetles to the diet of the Olive-headed Weaver. This is further supported by behavioral observations during feeding that indicated that the "hop-glean-rotate" sequence was the most common behavioral sequence during feeding. The "glean" phase of this sequence indicates the removal of insects from the lichenized bark surface of mature *Brachystegia*. Thus not only does the Olive-headed Weaver require a patch of a minimum size, a buffer must be included in the overall calculation of this area and the forest must be managed to supply old growth and some decaying (snag) *Brachystegia* trees.

Such associations (bird-miombo-lichen-insect) suggest some degree of specialization. Species that are specialists are known to be the first to disappear from fragmented forest systems. The Olive-headed Weaver and *Usnea* populations as well as some insect prey populations may therefore be at risk (Harris and Gallagher 1989). Further, if keystone species or co-evolved complexes disappear, such as the Olive-headed Weaver/*Usnea* complex, parasites or competitors may be elevated (Karr 1982; Janzen 1986) or trophic ladder ripple effects may occur. Insect population explosions have, for example, been linked to decreases in predator population in tropical areas (spider-lizard complex) (Schoener and Spiller 1987), and the insectivorous habits of the Olive-headed Weaver, as well as other species, should not be underestimated, particularly in regard to agricultural pests and therefore benefit to HA communities.

Mates

For most passerine species mortality rates during the period from egg to adult are enormous. In Song Sparrows for example, of every 100 eggs laid, 26 are lost before hatching, a further 22 hatchlings die before fledging and of those that fledge 42 die during the first year, leaving 10 of the original 100 birds (Johnston 1956). This pattern is typical for most passerine species. Our goal of ensuring that adequate mates exist is linked to both a desired and minimum viable population size which are related to rates of immigration and emigration, numbers and proximity of patches and availability of corridors. Such explorations are beyond the scope of this research.

Notwithstanding the above comments, it appears that our primary goal of partitioning miombo forest and *Usnea* will contribute to sustaining Weaver populations which in turn will sustain HA populations through the vehicle of ecotourism. In addition our knowledge of the precipitous decline in passerine species during the early life cycle stages suggest that any attempts to provide mates likely begins with decreasing the rate at which young Weavers are 'utilized' by HA communities. The idealized goal of partitioning in such a case would be shown in Figure 32 where the combined rate of utilization by the environment and HA communities is decreased to the point where there is little utilization of eggs and nestlings and more birds survive to adulthood. This essentially redistributes the area under the RUF curve – flattening the curve near the y-axis and raising the curve at the right end of the x-axis. To achieve this form of partitioning HA communities would have to decrease interference competition in the forms of egg collection and asphyxiation of nestlings during burning of fields and forests. Such a redistribution bodes well for ecotourism as it maximizes the number of adults that may be viewed.

In addition, the partitioning of mates in space and time can occur through the implementation of several areas of refuge connected by corridors. As the number of

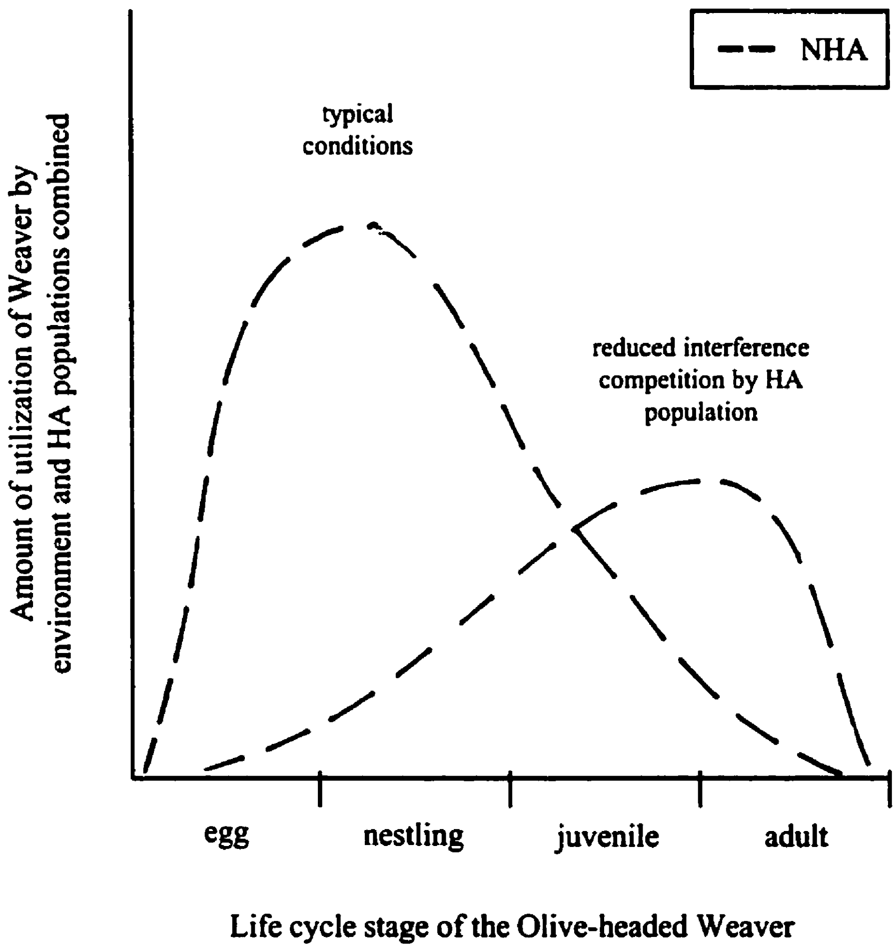

Figure 32: Partitioning of Mates by Decreasing Weaver Utilization During Early Life Cycle Stages. By ensuring that eggs are not taken, birds are not killed (interference competition) and burning of the forest does not occur during the breeding season the high mortality of the Weaver during early life cycle stages may be alleviated.

locations where the species appears increases the probability that any one stochastic event will decimate the population decreases. The provision of mates infers the long-term sustenance of the Olive-headed Weaver which begins to address dynamics related to population regulation.

Protection of the Olive-headed Weaver during breeding season represents a form of temporal partitioning; a specific period of time where no yield (*e.g.*, killed birds) is allowed. Coincidentally, the period when birds are breeding and are most easily located by ecotourists is also the period when local HA populations are most likely experiencing food shortages. As such temporal partitioning (a protected season) becomes coincidental with the most intense period of avian ecotourism and the profits from such ecotourism are used to offset food shortages. Overall our earlier observation that humans are the only species which can experience periods of no yield from resources suggests that human animal behaviorally and culturally are more adaptable and thus must play a larger role in guaranteeing resources for coexistence.

Conspecifics

The partitioning of resources for the Olive-headed Weaver provide a model for the partitioning of resources for other species. Much of what may be applied to the Olive-headed Weaver may be applied to other passerine species. The Olive-headed Weaver is dependent upon its associations with other bird species, particularly during the winter months when large bird parties form to forage for resources which may be scarce. The partitioning of miombo woodland and associated forms of vegetation, particularly in the form of connected patches should also contribute to sustaining other avian species.

Water

Renewable resource such as water may be partitioned along a RUF where the x-axis represents quality of resource. HA culture with its technology, filters, ozonation and chlorination will occupy that portion of the RUF where water quality is maximized. This suggests that global decreases in water quality will be left available to NHA populations and impoverished HA populations. While global dynamics affecting global water supply are beyond the scope of this paper, some comment at the national scale of Mozambique may be appropriate.

In Mozambique, for example, the majority of watersheds that traverse the country (from west to east where they are deposited in the Indian Ocean) originate in neighbouring countries. Any action plan to provide sustainable water resources for Mozambique's future must concentrate on conserving intra-national watersheds. These watersheds should be sustained at or returned to pristine states as the value and need for clean water will only increase. By managing conservation of water quantity and quality on a catchment or watershed basis it is theoretically possible to manage water resources that move across the surface of the earth. At the same time, understanding how these overland resources contribute to groundwater aquifers and their distribution is also critical (two separate watersheds may share a common aquifer, suggesting that management of both watersheds would be required). Ultimately, however, the atmospheric portion of the water cycle suggests, again, that global initiatives to prevent atmospheric contamination of water are the real target. Mozambique should monitor atmospheric, surface and ground water quality as well as monitor precipitation patterns and humidity levels. Research regarding the *Usnea* population (growth rates, abundance) and structure of the study area woodland (structure, edge characteristics) in relation to humidity levels and levels of atmospheric pollutants may be required.

More likely, however, we should consider the consequences of connectivity of each resource and interactions between continuing resources. For each resource, at both global and local scales a net effect occurs; the resource may increase or decrease in quality. In addition, the interaction between wind and air quality may result in the partitioning of air of a particularly poor quality and its association with a particular geographic area. Global changes in ozone levels and air pollution, amount of reflectivity and destruction of forests all play roles in altering global climate patterns which can starve certain areas of the world by changing global precipitation patterns.

Air

Like water quality air quality may be partitionable in that NHA populations may be able to utilize air of poor quality, particularly when there are interventions using technology. Again, developing countries will not have this luxury. Like global water quality, it seems unlikely that air, as a resource, can be partitioned. Rather, on a global level the atmosphere is one giant sink where some deleterious effects remain "up" (depleted ozone) while others come "down", *e.g.*, acid rain and particulates. The global ideal is to partition all air into the singular ideal state of zero emissions. Notwithstanding such idealism, the partitioning of air in space suggests that through an understanding of air mass movements locally, internationally and seasonally that patterns of distribution of air-borne pollutants can be estimated. On a national scale, industry likely to deposit airborne pollutants in general, and those likely to deposit pollutants in conservation areas, specifically, should be avoided in Možambique. Also consideration should be given to establishing on both a continental and global basis frameworks for limiting the deposition of pollutants into the atmosphere. Finally, industry which is non-polluting or limits environmental impact should be considered

Continuing Resources

The environment has three primary roles as regards the support of human and non-human animals and their communities: life support, resource use, and waste deposition. The life support role of the environment includes such attributes as climate regulation, maintenance of biodiversity and regulation of atmospheric composition. Waste deposition, directly related to resource use, occurs in three ways (Hunter 1995): dispersal into low concentrations; re-use (CO2 from emissions is used by plants for photosynthesis); storage (in an inert or pollutable form).

Waste deposition is directly linked with carrying capacity or renewable resources. When pollution impairs the ecosystem it can depress resource viability to the point where it can no longer be used as a resource. The environment's ability to deal with waste is generally regarded as a "free good" or falling outside of most economic considerations. Under some conditions large, single dose pollution events are assigned costs for cleanup as in the case of Exxon-Valdez. We must pay for production, consumption and products of consumption. In developing countries pollution controls and associated costs are even weaker.

In the near future continuing resources such as sunlight and wind are more likely to have quality altered rather than experience complete depletion. Partitioning of any of these resources may be viewed as the supply of the resource in a particular qualitative state. In other words, as resources are polluted the availability of the resource to a species decreases and competition increases. This relationship was shown on the far right of Figure 14. To the left side of Figure 14 we had ideal conditions; a continuing resource which was available due to its purity and relative lack of competition based upon this state. However, notwithstanding the relative lack of competition based upon purity the resource will still be competed for. Thus, the left side of Figure 14 can be reinterpreted in the form of Figure 33. In this figure low to nil pollution is tantamount to a pure or ideal state of a resource and thus quality is, theoretically, optimal. The HA curve suggests that HA populations will try to use high quality resources almost exclusively (quality is related to fitness). NHA populations will try to be as far to the right as possible, but will be forced leftward by HA populations.

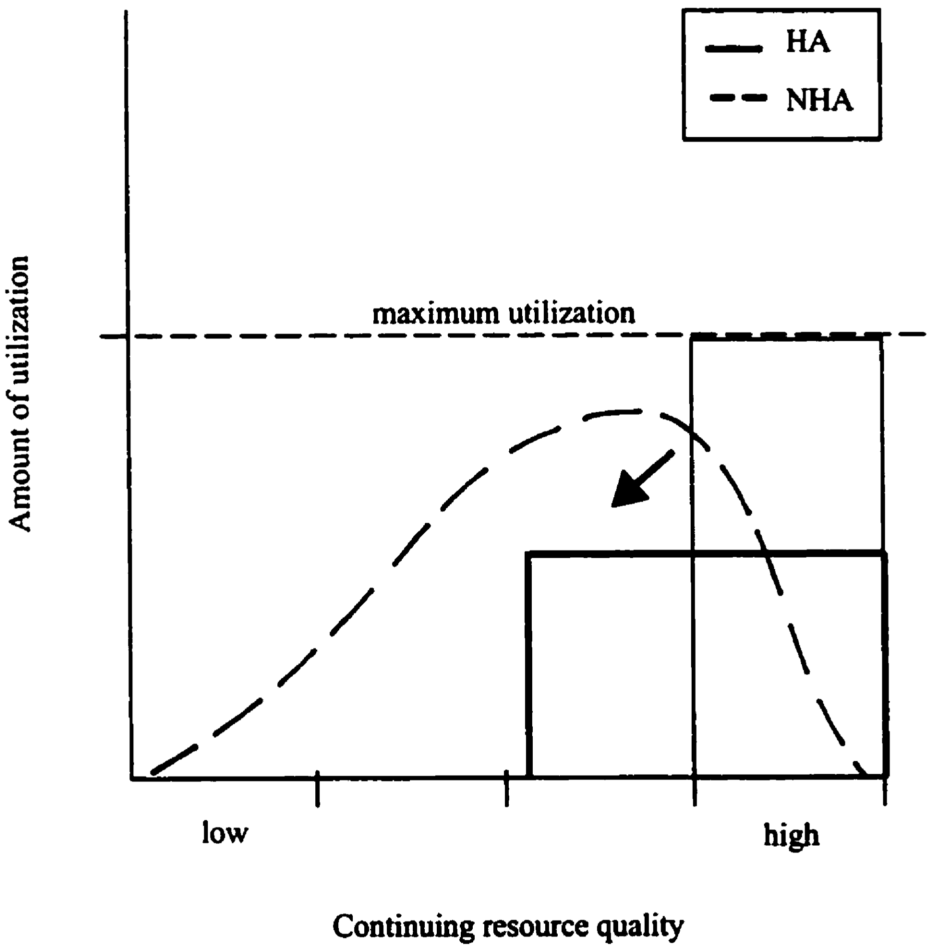

Figure 33: Partitioning of Continuous Resource Quality by HA and NHA populations. HA populations tend to create barriers to high quality resource use by utilizing them at some maximal rates throughout their distirbution. By decreasing this HA utilization we can make high quality resources available to NHA species and contribute to their continued existence.

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In terms of niche shifts, continuing resources cannot be shifted to the right as they cannot, on a global level, exceed their optimal states (*e.g.*, clean air free from pollution cannot be made of a higher quality). We expect the HA curve, in fact, to become a rectangle in which the amount of resource being utilized in its pure state is maximized at all times. Graphically, this blocks access to high quality resources for NHA populations. To allow NHA populations access to these resources our only option is to shift the HA niche to the left and allow overlap with NHA populations. Overlap in continuing resources suggests strongly our interconnected fate as there are ultimately, few ways to partition continuing resources in either space or time.

To some extent NHA populations may be able to withstand continuing resources of decreased quality. Ultimately, however, a cascade of decreasing quality of continuing resources foreshadows negative consequences that are global in scale. In the absence of prevention, rehabilitation, mitigation or the technology to clean air, NHA populations in some areas of the world face a fate similar to that of HA populations; adapting to survive with resources of less than optimal quality

In developed areas of the world the HA niche can actually shift to the left as technology may be used to take continuing resources in an impoverished state and return them to a state of high quality. We will now address the continuing resources of sunlight, policy and wind very briefly.

The association between geography, resource quality and human animal political culture suggests that different resources be considered at different scales based upon their transmissibility. In other words, resources which move easily between political units such as air and water and wind must be managed at such levels. Conversely, resources such as miombo, which have definite geographic extents, should be managed at a different scale. The scale of resource management must reflect the extent and transmissibility of the resource (Figure 34).

Sunlight

The sun is responsible for the energy flow that gives rise to living matter and weather. The amount of energy reaching the surface of the earth can be decreased by airborne pollution. Infrared energy can be trapped in the earth's atmosphere through increased carbon dioxide and contribute to the 'greenhouse effect'. Generally considered a problem which is global in scale, solutions must be as incremental as the causes. This suggests that at local scales HA populations must ensure that the reflectivity of the earth's surface, the amount of cloud cover, levels of atmospheric carbon dioxide (burning of fossil fuels) and ozone concentrations be maintained in particular states. In Mozambique emissions from burning wood fuel are a significant by-product of energy consumption largely because there are few alternatives. Some forms of industry such as ecotourism may be able to provide some of the economic impetus to achieve these alternate goals. It may be possible to partition the burning of forests in time (to avoid the breeding season); partition air quality locally and globally through reduced production of fluorocarbons,

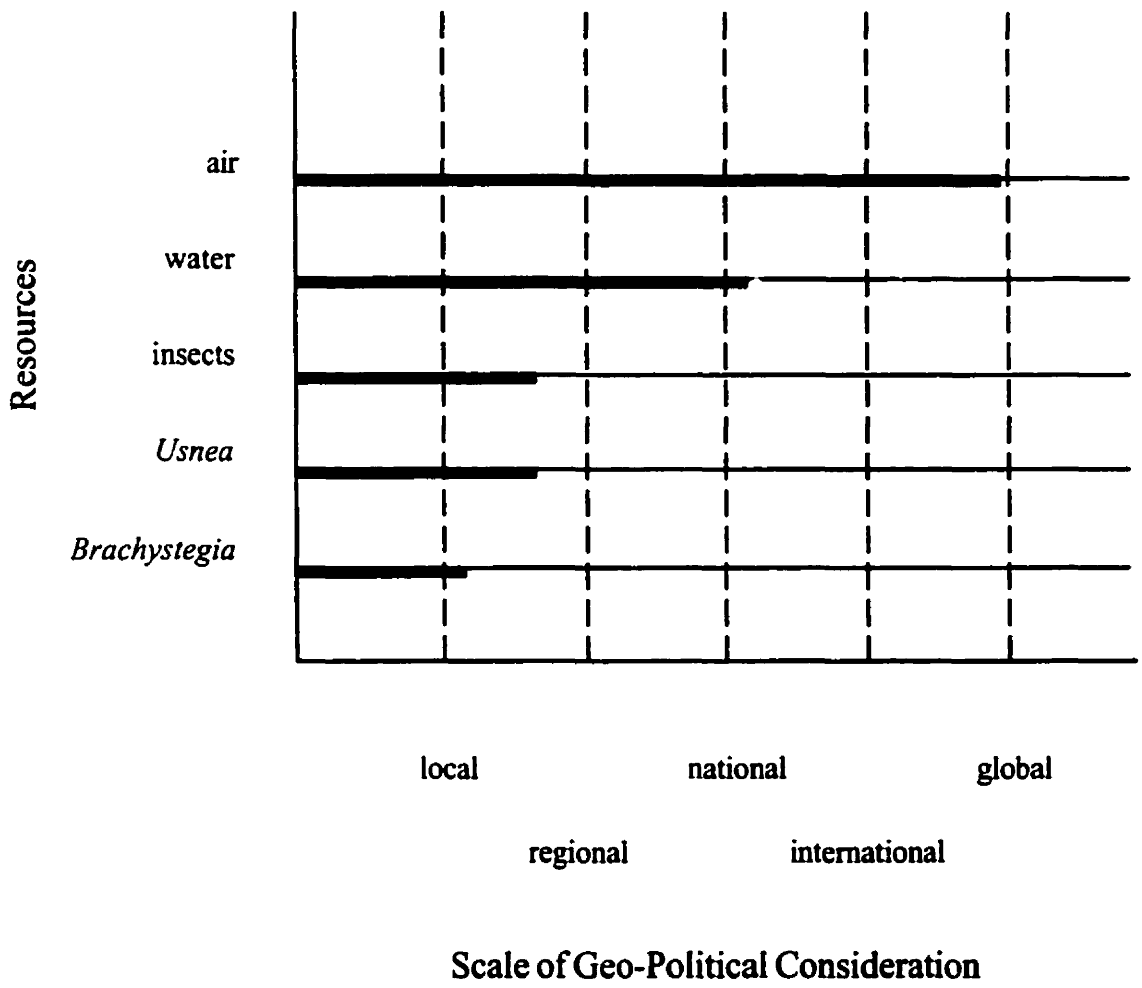

Figure 34: The characteristics of a resource determines, to a large extent, the geo-political scale of consideration of that resource. Politics, as an un-natural resource, range in scale from the global to the local and affect resource management and therefore sustainability. Resources such as *Brachystegia* or *Usnea* must be managed at local to national levels.

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locally and globally and, finally, partition air quality locally and globally through reduced emission of air-borne particulate matter.

Policy

Policy and its products are partitioned in space, usually bound by socio-political, geographic and ecological boundaries. Use of this resource by the Olive-headed Weaver is limited by the dominant HA community and thus policy is a resource which is partitioned along taxonomic lines. Finally, policy is also partitioned in time as new governments and revised policies have differential effects upon HA and NHA communities. A new government or policy can spell death or survival for both HA or NHA species. As the availability of fitness enhancing policy increases (covers a wider area, has more stringent application, partitions resources effectively so that coexistence occurs) the fitness (genetic contribution to succeeding generations) of the target species (that species to which policy is applied) also increases (Figure 35). Policy, then, as an un-natural resource is entirely necessary for NHA species in the short term and ultimately for HA species. As a resource policy is already partitioned. It is available in large amounts to HA populations which experience increased fitness as a result (largely in more developed countries). Policy is largely unavailable as a means of increasing the fitness of NHA species. The relationship between policy benefits and its utilization in HA and NHA species is shown in Figure 36. In this figure it is clear that the NHA RUF of policy utilization must be shifted to the right.

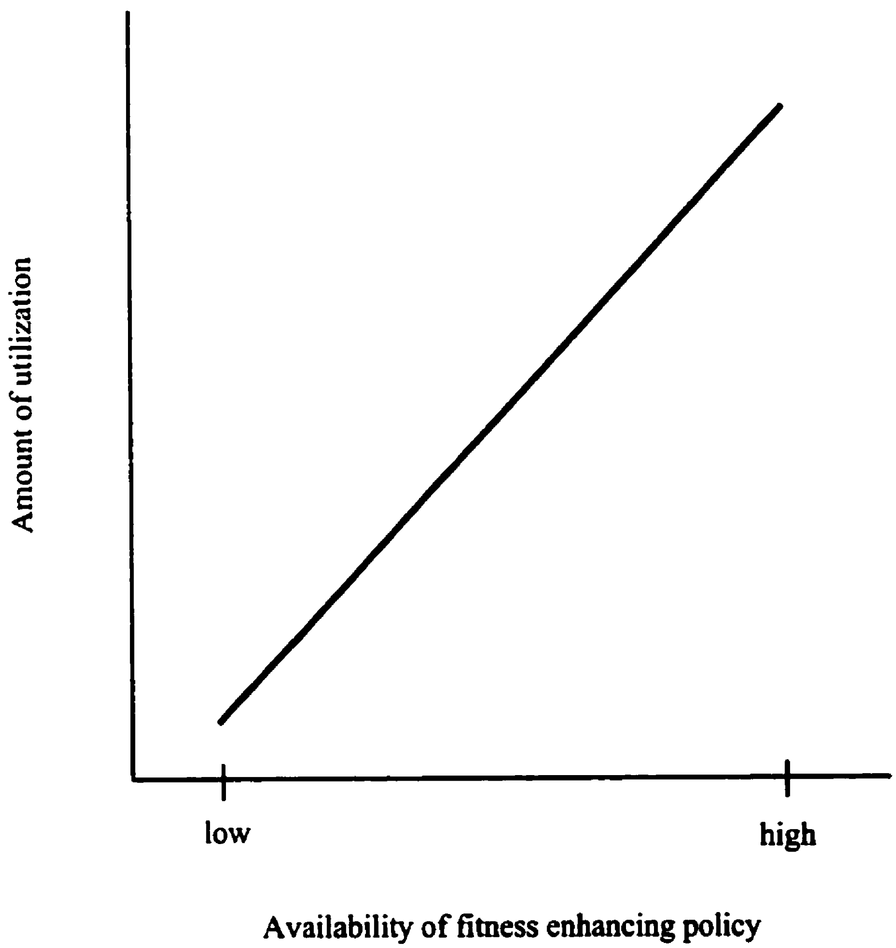

Figure 35: The Relationship Between Availability of Fitness Enhancing Policy as a Resource and Utilization rates. As the availability of fitness enhancing policy increases there are corresponding rates of utilization, demonstrated by increased fitness.

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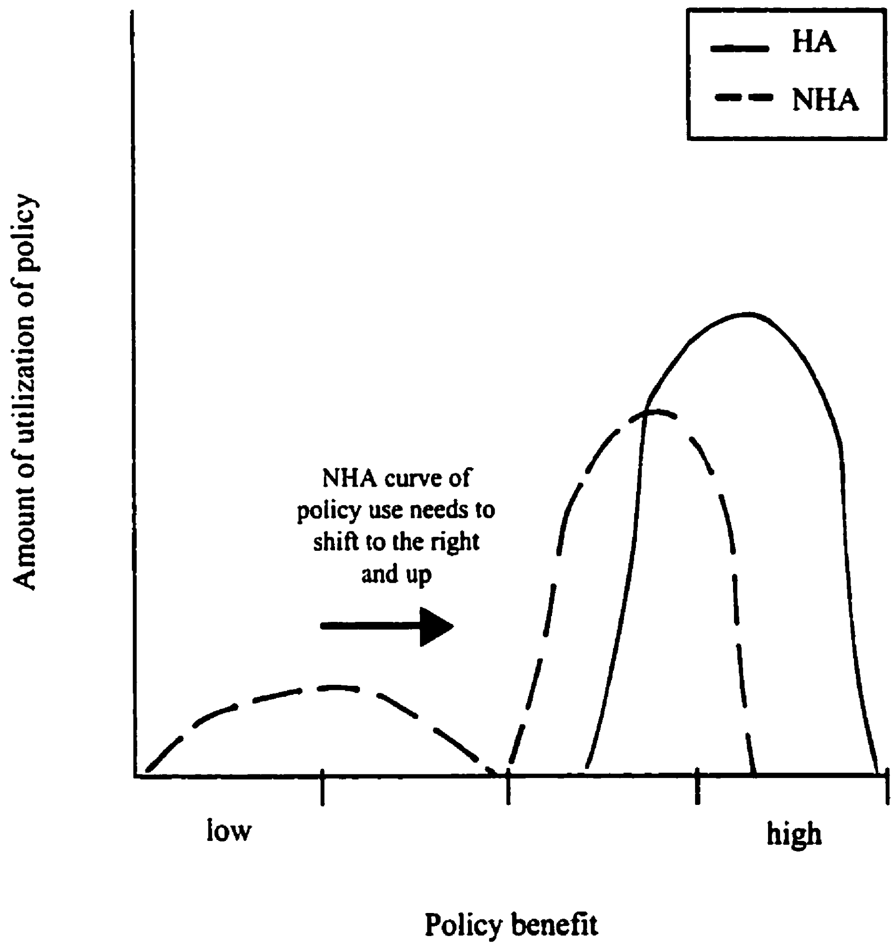

Figure 36: Partitioning of Policy by HA and NHA Populations. Policy as a resource is generally unavailable to NHA populations and resulting utlization is low. HA populations demonstrate high utilization of beneficial policy while NHA populations utilize policy rarely, presumably due to its low benefits.

Wind

Global weather patterns are affected by the tilt of the earth and its daily and seasonal rotations which affect the amounts of energy received from the sun. Worldwide patterns are further affected by the simple phenomenon of warm air rising and cool air falling, the patterns of air currents determining the major patterns of wind and thus rainfall. These patterns are further affected by topography and other earth surface characteristics such as large bodies of water. Wind, as a resource, provides three critical functions for the Olive-headed Weaver including dissemination of lichen, transportation of moisture (local and global scales) and transportation of aerial pollutants. Movement of wind is likely affected at two broad scales. Locally wind movement affects the dissemination of lichen strands, delivery of moisture (humidity) and transport of aerial pollutants to lichens within woodlands. Globally, changes to ozone levels may affect biosphere thermodynamics and thus movement of wind. Mozambique should participate in political efforts to control global changes to weather patterns that may be attributable to the greenhouse effect (global warming). The country should also map local *Usnea* populations and directions of prevailing winds relative to possible industrial sites

The resources identified above fall into two primary categories as per earlier discussion - renewable and continuing resources. Continuing resources common to both stakeholders (air, sunlight, wind and water) are partitioned in that a certain amount and quality of the resource must be maintained for use by both stakeholders. To guarantee renewable resources such as *Brachystegia*, *Usnea* and insects seems to suggest that, overall, areas of old growth or mature forests must be set aside or managed sustainably as per agreed upon goals. The overall goal here is to understand how a forest of a certain size, managed in a certain way can sustain, indefinitely, a given population of Olive-headed Weavers and a local HA community. The strategy of uneven aged stand management is a well-known approach to natural resource management that allows for continuous production of valuable forest tree species. Such production necessitates setting aside a set area of forest with constant replacement of mature *Brachystegia*. The needs of both HA and NHA populations could be met through such management of miombo woodlands.

5.0 CONCLUSIONS

> "imagination, planning and innovation...therein lies the future of any sustainable society" (Thomas 1994, 67)

This conclusion follows the logic developed in the evolution of the research. This logic began with the literature, its scope, definitions and terminology (see Section 2.0); proceeded through the complexities of model development (Section 3.2); explored appropriate methodologies for field work (Section 3.3); described the application of the model in the field (Section 3.4 and Appendix 7.1, 7.2) and, finally, described the results of applying the model (Section 4.4). Each of the above steps is described in succession and provides a concluding statement.

Throughout the thesis the role of terminology in describing and defining has been critical, particularly the power of language to be inclusive or exclusive, to broaden interpretation, to constrain or direct thought and behaviour. Significantly, the thesis achieves early direction through critical reflection on terminology. As such the realization of the thesis goal and objectives was characterized, in part, by a distinctive terminology in the form of "human animals" and "non-human animals". The use of these specific terms served two specific functions. The first function, through the use of the terms "human" and "non-human" addressed the historic precedent of using binary opposites as a means of ordering thought. The second function, supplied through concatenation of "human" and "non-human" with the word "animal", dictated a common biological heritage and, ultimately, implied subordination to ecological function. Such purposeful defining and ecocentric juxtapositioning begins to allow for the post-modern dialogue that releases these terms from their "dual prisons" (Descola and Palsson 1996) and, in addition, begins to heal the "rift" between human culture and nature (Bryden 1994). Our exploration of language as a means of connecting ideas and concepts is extended when we consider sustainability with its inherent assumptions and inferences. Clearly, sustainability with its focus on limited resources, issues of futurity and questions of equity has a direct relationship with the historical and contemporary dynamics of HA-NHA competition for limited resources at both local and global ecological scales. The linking of sustainability with ecology is viewed as critical, particularly given the missing emphasis on nature in the WCED definition of sustainable development. The result of such deliberation regarding language and its usage has been the alteration of, or the genesis of, definitions for such terms as sustainable resource partitioning, sustainable development, competition, community, resource, resource tangibility and resource net among others. These basic explorations are the result of the relative newness of the concept of sustainability, the revisiting of natural theory through the lens of sustainability, the need to reference ecology, the search for broad application and the need to establish inter-connectedness and interdependence. This may be viewed in a negative light by some, as a form of reinventing the wheel. However, the absence of stone wheels on contemporary automobiles illustrates a relevant point; constant reinvention is what allows vehicles of knowledge to move forward and, indeed, the entire whole rests upon such reinvention. Based upon the above, this thesis concludes that a more ecocentric approach to sustainability requires a critical, purposeful and often synthetic approach to defining terms. This approach is deemed critical in the creation of a new foundation for building and exploring natural theory as a means of achieving sustainability.

This thesis demonstrates that our ability to approximate the functioning of natural systems (to understand the lessons from nature in the form of natural theory and apply these in the context of sustainability) is the key to co-existent states and thus the thesis in general, and the model in particular, should be predicated on natural theory, particularly competition theory and its cornerstones of resource characteristics, mechanisms of competition and kinds of individuals. In addition, any such model must not only acknowledge these natural theory building blocks but also build something out of them. Competition theory was considered relevant to sustainability because it addressed, directly, the issues of resource quality and availability as well as issues of access, futurity and equity. Furthermore, this thesis uses competition theory to pull sustainability in a new direction; one that situates humans as a part of nature and recognizes multi-specific interconnectedness. The dramatic influence of competition theory on the concept of sustainable development is clear: it provides an answer to the question, "How can human and non-human animal populations move from competition to coexistence?". Based upon the above exploration this thesis concludes that competition theory provides a clear and unambiguous demonstration of how nature moves from competition to coexistence and suggests that such a body of theory is directly transferable to any setting where HA and NHA populations are competing for resources.

Competition theory explains how different species which are competing for the same limited resources may coexist. The SRP model recognizes that sustainability and competition theory intersect in their emphasis on limited resources, equity and futurity and, further, demonstrates that coexistence is possible through niche realignment/shift or the separation of resource use in space or time. The model begins with the basic building blocks of contested resources, characterizes these resources in the context of sustainability (as renewable, non-renewable and continuing), identifies mechanisms of competition (*e.g.*, interference and exploitation competition), characterizes the kinds of individuals (interspecific emphasis), makes general recommendations for limiting competition and sustaining resource use (making the model broadly generalizable at this point) and, ultimately, recommends specific ways of partitioning contested resources in the Mozambican research setting as a means of illustrating how the model may achieve its goal of sustained coexistence. The model provides a cogent argument for the use of situated and comprehensive HA and NHA knowledge.

The model revealed that characterized resources were primarily essential-renewable and essential-continuing resources. Such a characterization is likely in other HA-NHA settings and thus the generalizeable nature of the model is again noted. Further, the model indicates that the degree of substitutability of any resource affects the size of the resource net and has implications for management. In addition to the degree of substitutability the model reveals that the conservation of contested resources depends upon the taxonomic level used to describe the resource. In other words resource conservation is taxonomically bound. Finally, the degree of tangibility of any resource also affects anthropocentric conservation strategies and the interpretation of competitive settings. As resource tangibility was increased there was an increasing likelihood that the resource would be considered in a conservation strategy. The mechanism of competition was also stressed in the model and revealed as primarily one of exploitation, rather than interference competition. The kinds of individuals involved in such exploitation competition were primarily engaged in interspecific competition for contested resources in an asymmetrical, human-animal dominated setting. Critical to this exploration was the concept of reversing this asymmetry through application of natural theory in the form of competition theory which demonstrates that through the re-alignment of niches or the partitioning of resources in space and time that species may coexist.

The above findings contribute to achieving the research goal by establishing the existence and of a common theoretical framework in the form of competition theory. The relevance of this commonness is the opportunity to apply the ways of nature to human animal culture. Significantly, if we can incorporate human animal culture into an "organismic perspective" it becomes possible to view HA-NHA competition in the same vein as NHA-NHA competition. The observation that NHA-NHA competition can lead to coexistence further suggests the possibility of moving HA-NHA interaction in the same direction, ultimately achieving the greater sustainability of both. This thesis concludes that while the success of the Sustainable Resource Partitioning model is predicated on the use of competition theory, that this success depends equally upon the incorporation of sustainability theory (characterization of resources as renewable, non-renewable and continuing) in particular the ecological dimensions (taxonomy and resource nets) as well as the socio-cultural (HA needs, behaviour, intraspecific competition), political (scale of consideration for continuing resources), and economic (reversal of asymmetry through economic means by subordinate species) dimensions. The success of sustainability will depend upon our ability to be comprehensive, multi-dimensional (with an ecocentric emphasis), and synthetic in our approaches.

Much like Bryden's (1994) "rift" the methodological rift acknowledges how differently we traditionally approach HA and NHA cultures. The modernism of these quantitative/observational and qualitative/phenomenological approaches is contrasted sharply with the postmodern treatment of the situated knowledge which finds its "dialogue" its "exchange" (Descola and Palsson 1996) within the SRP model. It is this dialogue, this exchange, that provides the platform for sustainable partitioning of resources and the resultant state of coexistence. As such the basic research serves its purpose of identifying species specific resource use and, moving beyond this, the further characterization of contested resources. It is possible that the research did not reveal all of the resources which are contested by the two species, however, we must acknowledge that basic exploratory research is often incomplete. Ultimately the model was able to suggest ways in which all of the identified contested resources could be partitioned in space and/or time. This finding concretely supports the goal of the thesis as such partitioning enhances the sustainability of both the HA and NHA populations. As a reminder, this has enormous implications for less developed and developing nations in tropical areas of the world for it is in those areas that HA populations are expanding, biodiversity is great and the need for sustainable coexistence is urgent. This thesis concludes that a post modern approach to considering HA-NHA competition settings is valuable because such an approach moves from binary opposition to a monist approach that can help erode current conditions of unsustainability. Further, in moving to a monist approach a basic understanding of resource use by stakeholders is required which serves as the foundation for postmodern dialogue in the context of sustainability.

In the research setting of Mozambique the utility of the SRP model was demonstrated through the sustainable partitioning of interspecifically contested resources. Using MacArthur's definition of the niche as a resource utilization function (RUF) the development of a situated competition resource interface (CRI) revealed contested resources, among them miombo woodland (the Genera *Brachystegia, Julbernardia and Isoberlinia)*; the Genus *Usnea* (including all species within genus *Usnea)*; the Order *Insecta* (management and conservation of insects in general); the species - *Ploceus olivaceiceps;* the Class *Aves* (Mozambican conspecifics for winter-foraging bird parties); water, air, sunlight (in particular qualitative states) and, finally, policy. By using the SRP Model these resources were partitioned sustainably in space and time. Based upon the field work this thesis concludes that the SRP model may be applied in a field setting. At the same time it must be acknowledged that considerable time and effort is required to develop an understanding of stakeholder resource use, mechanisms of competition and kinds of individuals.

The drama of competition for resources, particularly in the research setting, is often captured in two simple words: conservation and development. The act of conservation, of setting something aside in perpetuity, is simultaneously about removing resources from the human animal domain. The SRP model advocates such removal in the form of partitioning. The model suggests that we place something out of our own reach, that we consciously deprive the human animal, that ultimately we are competing with ourselves by limiting access to certain resources. Such a wilful and deliberate act demonstrates that at some level we are aware of nature, its importance and, ultimately, its connection to our own fate. Our common salvation will depend upon our ability to comprehend how life on this planet is ordered, how it evolves, how it solves the long-term challenge of survival. Natural theory is the larger body of knowledge that considers this challenge and competition theory is a subset of this knowledge. This research concludes that it is the human animal species which has the capacity to recognize the validity of an ecocentric approach and the obligation to change its behaviour as a means of achieving sustainability.

The broader applicability of the model is yet to be determined (see limitations and future directions below). However, it is important to note that even without applying the entire model that the preliminary postulates derived (see Section 4.2.2.8) may be used to isolate or narrow the focus of any sustainability research concerned with moving HA-NHA competition towards coexistence. These postulates exist at the intersection of competition theorv and sustainability theory. The postulates suggest that consideration of any HA-NHA competition setting must proceed by categorizing resources, focussing on subsets of resources, considering their degree of substitutability, focussing on certain forms of competition and, ultimately, reversing asymmetry of competition in a holistic manner with appropriate HA community education. Based upon the above, this thesis concludes that exploration and synthesis at a purely theoretical level offers a myriad of opportunities for re-conceiving our approach to sustainability.

In summary, the goal of this thesis was to develop a means of sustaining human animal (HA) and non-human animal (NHA) populations. The ecocentric approach of the Sustainable Resource Partitioning (SRP) model is consistent with the ideological shift which is suggested in the concept of sustainability but largely missing in the definition of sustainable development provided by the WCED (1987). This ecocentric approach insists that not only must we understand but that we must adhere to the primacy of basic ecological principles and their role in setting the rules for sustainability and the fate of coexistent species (Rees, 1988; Wilson 1988; Becker *et al.*, 1999; George, 1997; Chapin *et al.*, 1996). The model lies at the intersection of sustainability and ecology and provides the much needed emphasize on ecology and sustainability. The model uses ecological theory to identify contested resources, resource characteristics, mechanisms of competition and kinds of individuals in interspecific settings. Further, it demonstrates both generally and specifically how the sustainable partitioning of contested resources allows for both human and non-human animal species to coexist. The move towards such coexistence is useful in any setting where human and non-human animal communities compete for resources. Given the rapid expansion of the human animal population and the significant and well documented threat posed by this expansion the need to develop ways of coexisting becomes more and more urgent. Ultimately our interdependent and co-evolved life forms exist as a single community with a shared but largely human directed fate. The research makes significant contributions to knowledge in the fields of sustainable rural communities by:

1.0 Demonstrating that while the necessity and relevance of an ecocentric approach to sustainability is understood that current definitions of sustainability are not applied to natural ecosystems and, that the current definition of sustainable development is not ecocentric.

2.0 Adopting an ecocentric approach which demonstrates that the current definition of sustainable development is insufficient given its anthropocentric and monospecific approach which perpetuates a "dominion perspective" and infers that non-human animal are merely "resources" to be sustained.

3.0 Defining community in the context of sustainability as organisms which are connected to each other through the shared use of resources.

4.0 Implementing an ecocentric approach to inform and propose a new definition of sustainable development as development that meets the needs of the present without compromising the ability of future generations of the human and non-human animal community to meet its own needs.

5.0 Defining natural theory as known standards, principles or theories that describe the characteristics of natural settings.

6.0 Observing that there is no theoretical or applied knowledge that examines HA-NHA interaction within competition theory.

7.0 Replacing traditional pair-wise analysis of interactions between species through modifications based upon the superimposition of the context of sustainability which removes all negative interaction, states of imbalance and ideologies that support unsustainability.

8.0 Introducing the concept of conferred competition which suggests that the HA act of setting aside land for preservation is a form of self-imposed or HA-HA competition which limits resources to HA species.

9.0 Introducing a new definition for conservation in the context of sustainability as the sustainable guarantee of resources for the exclusive use of a species.

10.0 Introducing 'laws of interaction' based upon placement and modification of Grier and Burk's (1992) work in the context of sustainability.

11.0 Identifying areas where sustainability and competition share a common history, scope and overlap in terminology, suggesting that the two constructs are dealing with similar issues and that theory from one area (competition theory) may be applicable in another (sustainability), and based upon this: undertaking field work which uses competition theory and its emphasis on kinds of resources, mechanisms of competition and kinds of individuals as a stating point; and, revising Keddy's list of degree of substitutability to four more comprehensive terms instead of three including: essential, perfectly substitutable, partially substitutable and antagonistic.

12.0 Integrating conceptualization theory and insight theories to develop a novel and synthetic approach to model building.

13.0 Developing a model that demonstrates a means of moving from competition to coexistence of HA and NHA populations. The model identifies how: resource characteristics are a critical concern in strategies of competition and coexistence; mechanisms of competition affect competition and coexistence; kinds of individuals affect competition and coexistence; identifying contested renewable essential resources is the first priority in sustaining the coexistence of competing populations

14.0 Developing new or modified definitions, phrases and terms which display a synthesizing approach to sustainability and competition theory which in affects the ability of terminology to embrace conceptually, be comprehensive and of utility, among them: "resource", in which the word "utilization" replaces "consumption" to provide a more comprehensive and accurate means of identifying how resources are made inaccessible; "policy as an un-natural resource", by redefining "resource" human animal constructs such as policy may be viewed as factors which can lead to increased growth rates as its availability (or effectiveness) in the environment is increased;

"competition", a new definition based upon modifications to the definition of "resource" and subsequent situating in context of sustainability; "resource tangibility", an expression that suggests that the degree of tangibility of a resource effects our its ability to create an impact upon the human psyche and subsequently our ability to change behaviour in response (e.g., to evaluate, to sustain); "resource net", the overall resources required by an organism as defined by levels of decreasing substitutability; "taxonomically bound", in reference to resource substitutability indicating that how we define a resource taxonomically affects how substitutable it is and how we manage the resource.

15.0 Completing unique and original field work on the Olive-headed Weaver including: the first recording of breeding of the species in southern Africa; the first recording of nestlings in southern Africa; the first ever photograph of a species in the wild; observations on species morphology (shape, colour) that correct popular images of the species; observations that contest the habitats portrayed in species images; identification of locations where specimens were collected historically and where specimens may be located currently; the first published accounts of the species in popular literature (Nuttall 1998a, b); the first published overview of the historical and current distribution of the species which extends, considerably, the known distribution of the species (Nuttall 2001); demonstration of species preference for mature *Brachystegia* forests; discovery of the unique nature of nest including presence of siphon, use of sole building material and unique position within canopy and on tree branch; demonstration that male and female weavers participate in nest building (new finding regarding males) and feeding during nestling stages but that overall, female investment is greater, particularly during the incubation stage; first discovery of evidence of breeding in southern Africa; first discovery of evidence of nestlings in southern Africa; first description of typical foraging behaviour patterns ("hop-glean-rotate" along mature branches, feeding in crustose lichens and bark) which refutes previous descriptions of feeding behaviour.

16.0 Completing unique and original field work regarding post-war HA communities in southern Mozambique which includes new knowledge that indicates a pronounced reliance upon sustainable exploitation of natural resources as a means of sustenance (plants and animals), habitation, fuelwood, medicine and commerce. The economy is primarily one of agricultural subsistence. The local population culture remains in a state of recovery from colonial influence, from war, from imposed values, all occurring in a context of extreme poverty. The need for food security, clean water, health care, education and transportation is dire.

17.0 Addressing interdisciplinarity as envisioned by Bryden (1994a) who stressed the importance of biological science and its relationship to social science for the Rural Studies Ph.D. program at the University of Guelph.

Overall, the research develops a clear goal and objectives and undertakes exploratory and basic interdisciplinary and multidimensional field research in the challenging setting of post-war, rural Mozambique. Adequate preparation through the identification, evaluation and interpretation of the relevant literature demonstrates a superior grasp of both the theoretical and applied subject matter and a matching ability to integrate and synthesize disparate ideas and theory. The research provides a much needed ecocentric approach and goes beyond the given material in a critical and constructive manner, demonstrating a synthesizing approach which recognizes the complexities of terminology, time and space, multiple dimensions and species. This synthesis is evident in areas of integrated terminology, ideas, and traditions and clearly moves into the post-modern "gap" created through use of by binary opposition as a means of ordering thought. The approach is logical, creative, organized and results in new knowledge in the form of a clear, explanatory and predictive model which provides for the coexistence of human and non-human animal species and thus makes a direct and valuable contribution to sustainability. Finally, one of the most notable attributes of the model is its practicality – a researcher can examine a competition setting, determine resource use by the players and then take concrete steps to achieve coexistence. Such a contribution has enormous potential and directly addresses the pressing need identified by Chapin (1996) that "the concept of sustainability has not been applied to natural ecosystems".

In its current form this thesis has several limitations. These limitation include:

1. The need to obtain large amounts of basic biological knowledge about both NHA and HA species, particularly with regard to resource use and the feasibility of reversing the asymmetry that appears to be inherent in HA-NHA competition settings.

2. The results of the model need to be operationalized. The model predicts that by understanding HA-NHA resource use in an interspecifically competitive setting and

by re-aligning HA niche (RUF) that species may co-exist. To the extent that this thesis predicts that such an outcome is feasible the SRP model needs to be tested by returning to Mozambique and undertaking further research which implements a realignment of the HA niche. More broadly, the model could be applied in several different HA-NHA competition settings.

3. The model's focus on a single non-human animal species may be regarded as narrow. While this point is valid it is important to point out that the use of indicator keystone species may be of some utility here, particularly those species which may be regarded as indicators of ecosystem threat, as in the case of bird species (Furness and Greenwood 1993). Further, the model, while acting as a starting point, may be expanded to include more than one NHA species for a given setting.

4. The research does not provide a means by which multiple groups of species may be simultaneously analyzed and complex interactions examined, which may be a drawback. That said, many conservation scenarios involve pair-wise HA-NHA interaction (*e.g.*, people versus elephants, Adkins 1997) scenarios and given this the research results may be highly applicable.

The research also points to some opportunities for future research including:

5. The opportunity to apply the model in any context where HA-NHA competition is occurring. As developed, the model places no limitation regarding context of

application.

6. The need to devise a means of incorporating several HA populations or several NHA populations. While the model does not limit the type of NHA species which may be considered the amount of data required to execute the model may prove to be insurmountable in many settings. A more substantial link with field ecologists and biologists and their data bases may be required. For example, many ecological studies exist which would provide basic knowledge of species-specific resource use (*e.g.*, Kannan's 1994 work on *Buceros bicornis*, the Great Pied Hornbill). Also, situations where asymmetry in competition may be reversed, such as ecotourism, also often have a narrow species specific focus (*e.g.*, the "big five" – leopard. lion, elephant, rhinoceros and buffalo - in Africa). In short, while pair-wise species research may prove to be useful and the preliminary information available a more robust analysis will be required in order to consider multiple species. Further testing of the model with different.species is required as well as the application of the outcome of the model in the Mozambican setting.

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7.0 APPENDICES

The direct outcomes of exploratory and adaptive field research are organized according to the two species considered and are identified here as "7.1 The NHA Population" and "7.2 The HA Population". As mentioned previously (Section 3.2) not all results are relevant to the stated goal and objectives. However, their presentation here demonstrates the inductive nature of the work, the need to be transparent, the breadth of the study as well as introducing data which may be valuable for future biological research or models.

7.1 Results of Field Work : The NHA Population

The results regarding the Olive-headed Weaver are divided into 11 sub-sections including:

- Historical Overview
- Current Understanding of Distribution, Density and Population Size
- Morphology
- Geographic Locations of Nests
- Nest Attributes
- Nest Tree Attributes
- Vegetative Characteristics of Nest Tree Area and Random Areas
- Activity at the Nest
- Breeding Period
- Foraging Behaviour Patterns
- Diet

7.1.1 Historical Overview

An historical overview of the species was generated through:

- review of scientific journals and museum notes from the 1800's to present,
- examination of preserved specimens at museums,
- correspondence with ornithologists and field collectors,
- review of popular field guides and literature.

The following represents a synthesis of information from all of these sources. Though currently the scientific name is debated this thesis will follow the nomenclature in Robert's Birds of Southern Africa (Maclean 1993) and use *Ploceus olivaceiceps* to describe the Olive-headed Weaver. As an additional preface to this chronology it is important to address the definition of "southern Africa" when the term is used in conjunction with ornithology. Specifically the subcontinent of southern Africa is usually defined as the region to the south of the Kunene, Karango and Zambezi rivers (Harrison *et al.* 1997).

The earliest descriptions of *Ploceus olivaceiceps* were provided by Anton Reichenow in 1899, in the publication "Ornithologische Monatsberichte, vii", which was published in Berlin (reference not available). More formally, the species was described in a later publication "Die Vogel Afrikas" (Reichenow 1903). Though the "discovery" of the species is attributed to Reichenow it is not known whether he or someone else collected the specimen(s) or how many were collected. It is known, however, that the specimens were collected in Songea, in the Southern Province of Tanganyika, now Tanzania (Clancey and Lawson 1966) and subsequently came to be regarded as the 'type'. The specimens were given the scientific name *Symplectes olivaceiceps* and were housed in the collection of the Zoological Museum in Berlin.

There is mention of both *Symplectes olivaceiceps* and *P. olivaceiceps* by Anton Reichenow in "Die Vogel Afrikas, Band IV, Atlas" which was published in 1905 (Reichenow 1905). Here begins the pattern of using several genera to describe the Olive-headed Weaver - a pattern that would later include the genera *Xanthophilus* and *Hyphanturgus*. The illustration of a male Olive-headed Weaver in Die Vogel Afrikas shows, to a great extent, the bird we know today as *Ploceus olivaceiceps*. The bird is illustrated with a clearly demarcated rust coloured breast with forehead, crown, nape, mantle, and back a solid olive green. The rump is shown as having a small amount of yellow. There is no yellow or rust shown on either the crown or forehead, the bill is black and eyes are brown.

The specific epithet of the species continued to change as well, with some authors suggesting that different races or subspecies existed. In the early 1930's bulletins describing the fieldwork of Moreau originally refer to *Symplectes olivaceiceps* (Rchw), (Low 1932; Sclater 1932), while Sclater suggested that the species be recorded as *P. o. nicolli*. Sclater and Moreau's fieldwork was focused near Amani in the East Usambara Mountains of then northeastern Tanganyika (current day Tanzania). The area is close to the border with Kenya (Clancey and Lawson 1966). Sclater also compiled a *Systema* that placed 59 weaver species under the Genus Ploceus. At the same time he further divided these into 12 sub-genera, among them *Symplectes* and *Xanthophilus* (Vincent, pers. comm. 1998). As recently as 1985 (Collar and Stuart 1985) the specimens collected by Moreau have been referred to as *P. nicolli* and there is some question as to whether or not the species discovered in the Usambara Mountains is distinct from *P. olivaceiceps* (Franzmann 1983; Stuart and Hutton 1977; Stuart and van der Willigen 1978).

While the early history of the Olive-headed Weaver begins in Tanzania, subsequent work moves south and westward into Malawi and northern Mozambique. During a collecting trip spanning 1931-32, Jack Vincent collected five *Ploceus olivaceiceps*. Of these specimens, four were collected near Furancungo in the Tete Province of current day northwestern Mozambique and became the first recorded specimens for Mozambique (Vincent 1934). A month later Vincent collected a fifth specimen near Zobue, Portuguese East Africa, on the Nyasaland (Malawi) side of the border thus collecting the first recorded specimen for Malawi. The bird from Malawi was sent to Berlin to Dr. E. Stresemann for comparison with the type specimen. In addition to collected specimens, the weaver was also visually recorded by Vincent just west of Mwanza in the Kirk Mountains (100 km west of Blantyre, Malawi) at an elevation of 884 metres above sea level (Vincent 1934). The issue of elevation is significant as any birds collected before 1960 are collected at high elevations (greater than 1000 m above sea level) and north of the Zambezi River. In 1935, just a few years after Vincent's expedition, C.W. Benson, working near Mzimba, in central Malawi, collected a single female specimen that he labeled *Ploceus olivaceiceps*. A year later, in 1936, Benson collected another specimen which he referred to as *Symplectes olivaceiceps*, collected at Nchimi Mountain in Nyasaland. However, changes in nomenclature begin again in 1941 when C.W. Benson published a four part series of notes on Nyasaland birds and included a visual record of *Xanthophilus olivaceiceps* on Nchisi Mountain (Benson 1941). The use of the genus *Xanthophilus* continued for almost ten years during which Benson and his famed collector Jali Makawa collected single specimens at Michiru Hill in the Blantyre District of Nyasaland in 1944 and Unangu, Mozambique in 1945 (Benson 1946). In 1951 C.W. Benson collected two juveniles from a nest at Kapiriuta, Dedza District of Nyasaland (Malawi) and labeled them *P. olivaceiceps*. Four years later, Rui Quadros collected two specimens of *P. olivaceiceps* in Alto Molocue, northern Mozambique (collection of the Natural History Museum of Maputo) and it is at this point that the genera *Symplectes*, *Xanthophilus* and *Hyphanturgus* are lost and the genus *Ploceus* is used consistently.

In 1960 the first discovery of Olive-headed Weaver in southern Africa occurred when a single specimen was collected by M.O.E. Baddeley, taxidermist of the Durban Museum. The bird was collected at Panda during a Durban Museum ornithological expedition that included P. A. Clancey and W. J. Lawson (Clancey and Lawson 1961). A year later the existence of the species came to widespread attention when first announced in a short note in Ostrich (Clancey and Lawson 1961). Six years later Clancey collected another 23 specimens of *Ploceus olivaceiceps* at Panda. Now, in conjunction with the Durban Museum's 1960 field work, there were 24 specimens, four of which were sent to the Museum of Natural History of Maputo (then the Museu Dr. Alvaro de Castro, Lourenco

Marques), while 20 were sent to the Durban Museum. Clancey proposed the name of *P. o. vicarius*, indicating sub-species based upon the observations that the Panda population appeared to be morphologically distinct (smaller, variation in markings and colour intensity). Clancey did not compare the specimens collected in Panda to the German "type" specimen but instead compared the birds to the single pair collected from Alto Molocue in 1955 which were believed to represent *P. o. olivaceiceps*, the central race. In summary, three races were now identified: *P. o. nicolli* representing the northern race, collected in Tanzania; *P. o. olivaceiceps*, representing the central race; and the Panda population, *P. o. vicarius*, representing the southern race.

If we suggest that at least two specimens were gathered by Reichenow to serve as the "type" and we consider later work by Sclater (assumed two specimens), Vincent and Benson (12 specimens), Rui Quadros (two specimens), Baddeley, Clancey and Lawson (24 specimens), then the total number of known *P. olivaceiceps* specimens in collections, world wide, might total 42 specimens. Thirty-eight of these specimens are confirmed in collections as follows: 20, Durban Museum; six, Natural History Museum of Maputo; 12 Rothschild Zoological Museum, Tring, England. Recent correspondence from ornithologists suggests that an additional five specimens are located in Pretoria, while two are located in Bulawayo (T.B. Oatley, pers. comm., 1999) possibly bringing the total number of confirmed specimens to 45.

In the ensuing years field guides, focusing mostly on southern Africa (Clancey 1971; Britton 1980, Newman 1983, 1999; Maclean 1993) based their descriptions of the distribution and habits of the species largely on the published accounts of the two collecting trips to Panda and a visual sighting at Muanza in the Sofala Province of Mozambique (Clancey and Lawson 1966; Clancey 1968). In 1979 and 1980 the late Dylan Aspinwall (see Ostrich, Volume 67 for a description of his outstanding work) extended the range of the species when he recorded the Olive-headed Weaver in eastern Zambia, the sightings occurring in close proximity to bordering Malawi and Mozambique (Aspinwall 1979, 1985). The song of the bird was described in 1992 based upon a recording made in the Dzalanyama Forest of Malawi (Medland 1992).

More recent field sightings have confirmed the presence of the species outside of Mozambique. There have been numerous sightings in the plateau areas of Malawi, particularly the S. Viphya plateau (Dowsett-Lemaire and Dowsett, in prep) and recent work on the Tanzanian Bird Atlas (Neil Baker pers. comm.) includes 15 records of the species, eight of these confirming the presence of the Olive-headed Weaver in the Songea Area where the species was first discovered (at or near Kalulu, Likuyu, Peramiho, Mbaragandu and Madaba). Additional sightings in Tanzania, at Ilehe and Tanda Mbuga lie north and largely westward from Songea towards the southern end of Lake Tanganyika. There is also a recent sighting just south of Lake Victoria, near Karumwa, which is further supported by a sighting at nearby Mwamazengu, by Terry Oatley (Oatley, pers. comm., 1999). Such sightings extend, considerably, the northern extent of the species distribution. Finally, a number of recent sightings in the Eastern Province of Zambia confirm the presence of the Olive-headed Weaver in this area (Dowsett *et al.*, 1999). This information will be made available in the forthcoming Bird Atlas of Zambia

(Dowsett *et al.* 2000, in prep). Based upon both historical and more recent data the distribution of the species is shown in Figure 37 (from Nuttall and Parker 2001). Notwithstanding the above information there is, overall, a lack of records. The lack of records may be attributed to the following:

1) birds have been poorly documented in certain areas such as northeastern Mozambique, the region south of Lake Victoria in Tanzania, the region north and east of the Songea area sightings, and other areas. In short, where there are no birders, there are no birds;

2) the species may exist as a highly fragmented meta-population and at higher elevations making contact with the species unlikely;

3) the species has likely been extirpated throughout much of an assumed formerly continuous and expansive range;

4) the species is relatively unknown and unobtrusive in behaviour and thus escapes detection.

In summary, a comprehensive overview of the historical distribution of the Olive-headed Weaver reveals a discontinuous historical distribution, ranging from northern Tanzania to central and southern Malawi, easternmost Zambia and southern, central and northern Mozambique. Throughout this historical range the species has generally existed at

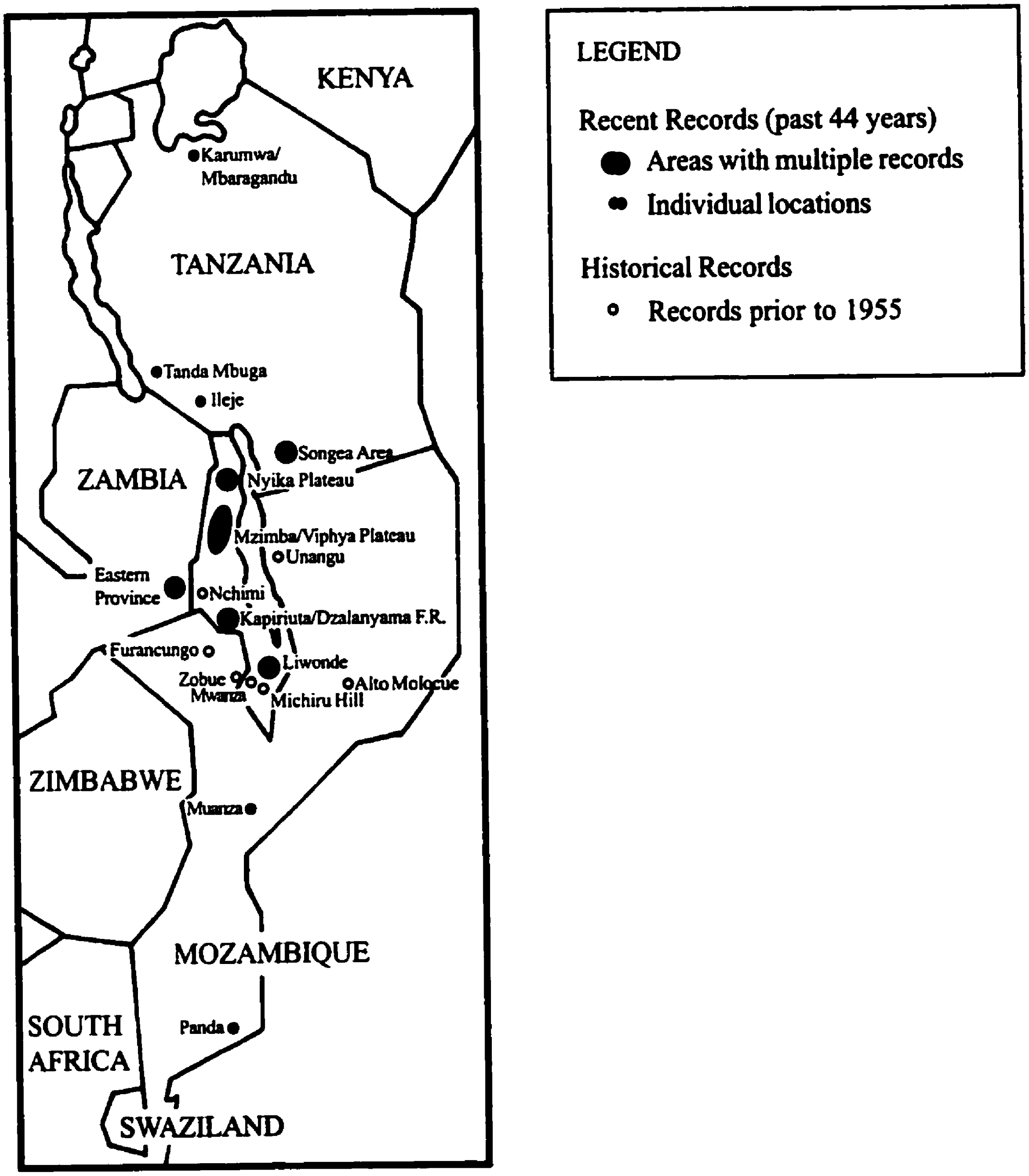

Figure 37: Overview of distribution of Olive-headed Weaver (*Ploceus olivaceiceps*).

elevations greater than 800m above sea level. Currently, in Mozambique, the species is thought to exist as a single, small, lowland population that appears to be declining in numbers. This remnant population occupies a very small range within a fragmenting forest in the Inhambane Province of Mozambique.

7.1.2 Current Understanding of Density and Population Size at Panda

Within the geopolitical boundaries of Mozambique there are currently no confirmed reports of *Ploceus olivaceiceps* outside of the Panda population - the species has not been located outside of this population for nearly 28 years. The size of the remnant forest near Panda is estimated to be 10,000 ha or 100 km^2 in area, and the amount of suitable habitat is estimated to be approximately ten percent of this, or 10 km^2 (Parker pers. comm. 1999). Recent fieldwork by the author, as well as Vincent Parker, confirms a population of *Ploceus olivaceiceps* resident in a remnant forest stand of miombo near Panda, Mozambique. This is the only population of *Ploceus olivaceiceps* known to either of these researchers (Parker pers. comm. 1998). Three different methodologies are used to estimate the frequency of occurrence and density of the Olive-headed Weaver at Panda:

1. Using *historical information* to estimate frequency of occurrence. In May of 1966 Clancey collected 23 *Ploceus olivaceiceps* over a period of 10 days (Clancey and Lawson, 1966) and suggested that it would have been possible to collect many more if an effort had been made. While he begins this article

describing the species as "rare" and advises us that initially he thought the species to be "uncommon", he later suggests that his May visit finds the bird "locally plentiful" (Clancey and Lawson, 1966, 35, 36). The terms used to describe population status may be found in field guides and generally indicate how readily one may see a species in a given area. The terms, in order of decreasing abundance, are: "very common", "common", "fairly common", "uncommon", "scarce", "rare' and "very rare" (Maclean 1993, xxxiii). During the current field research, which took place in two periods, including May-June and September-December, we found, respectively, the birds to be fairly common and scarce. The two periods would be considered, respectively, breeding and non-breeding seasons. Overall the status of the Panda population is best described as uncommon.

2. Using the *total number of active nests* that were recorded within the search area. A total of 4 active nests were located within a search area of 13.2 km^2. Given the four pairs of birds that were actively nesting within this area a conservative density estimate of one pair of birds per 3.25/km^2 is derived. Using nearest neighbour analysis the mean distance between the four active nests was, to the nearest metre, 975 m. Assuming a circular nesting territory, and using the nearest neighbour to re-calculate the breeding territory, the average area "surrounding" each active nest would be 2.99 km^2. Using the above figures of density of breeding birds a total population size of around 60 breeding birds is estimated. An estimate of the population including non-breeding birds brings this figure

to approximately 100 birds.

3. Using the *total number of nests* located within the same search area (26 nests: of 29 weaver nests one was an outlying data point while two others were lost data points due to GPS error) provides another estimate of population density. Using this approach a density of one pair of birds for every 1 km^2 was calculated. This upper limit must be tempered with the knowledge that not all of these nests were active and that 'inactive' nests may be 'abandoned nests'. During courtship many members of the Weaver family build nests which are eventually abandoned. Alternately, these nests may be the result of repeated nesting. Many of these nests were found in close proximity to each other (sometimes neighbouring trees). It is possible that the weaver establishes a territory within which it repeatedly nests, building new nests each season. Remnant nests survive in previously used trees.

In an effort to be conservative the second approach seems most appropriate. Thus for the purposes of this paper a breeding density of one pair birds per 3.25 km^2 will be used, equivalent to one pair breeding birds/300 ha or one breeding bird/1.625 km^2 .

7.1.3 Morphology

Morphology refers to the form and structure of a species. The transmission of information regarding the morphology of most organisms is communicated via images that exist primarily in two forms: illustrations and photographs. Historically, the information used for the creation of illustrations comes from two sources – dead specimens and observations of living specimens. Dead specimens are invaluable as they provide an overview of the appearance of the bird while information on attached tags provides measurements and a description of the appearance of the bird at the time of collection (foot, bill and eye colour for example). Images of birds, in the form of illustrations, can also arise from the observation of living specimens. Living specimens can provide information about posture and movement or habitat if the birds are observed *in situ*. Finally, images of birds can also be achieved in the form of photographs, which are usually of living specimens (in cages or *in situ*).

Variability in the "accuracy" of an image of a bird is likely related to 5 factors:

1) familiarity with preserved specimens
2) accuracy of preserved specimen tag information
3) familiarity with bird in the field
4) contextual knowledge
5) ability of artist

Thus, as familiarity with living and dead specimens, tag information, contextual knowledge and abilities of the artist changes, so does the image of the bird. All of this information is synthesized by the artist who then often has the further responsibility of instilling the dynamism and context of habitat that we associate with living creatures. The morphology of the Olive-headed Weaver will be discussed in four areas:

1) overview of illustrations
2) information from dead specimens
3) photographs of living birds
4) comparison of illustrations, dead specimens and photos of living birds

1) Overview of Illustrations:

A chronological overview of illustrations of the Olive-headed Weaver is as follows:

- *Ploceus olivaceiceps* – male – coloured etching - Reichenow (1905).
- *Ploceus olivaceiceps vicarius* – male – painting - Clancey (1971)
- *Ploceus olivaceiceps* – male and female – colour plates - Maclean (1993).
- *Ploceus olivaceiceps vicarius* – male and female – painting - Clancey (1996).
- *Ploceus olivaceiceps* – male and female – illustration - Newman (1999).
- Olive-headed Weaver – male and female – 1985 illustration – Clancey (in Parker 1999).

These images were based primarily on the examination of dead specimens and some field observations. An examination of these images reveals the greatest variation in three areas: body form; plumage colour (both presence/absence of colour and boundaries of colouration); and context (the environmental setting in which the bird is depicted).

1) *Body form*. It is important to note here that the overall form of the Olive-headed Weaver, particularly in images 2, 3 and 5, appears to be influenced by contextual knowledge – knowledge about "weavers" and their form, in general. An example of the "idea" of the "generalized" weaver form may be found in the ubiquitous Masked Weaver – a medium sized (male: 16 cm TL, mean tail length 5.12 cm, mean weight 27.8) weaver found over most of southern Africa. The overall form of the Olive-headed Weaver, as illustrated in images 2, 3 and 5, is identical to the Masked Weaver, with changes to markings the primary difference. In contrast, limited data and field observations for the Olive-headed Weaver reveal a smaller bird with a truncated tail. For example, total length of males verified during this research suggest a mean of slightly less than 15 cm, with a mean tail length of 4.29 cm and a weight ranging from 20-24 g (Clancey and Lawson 1966; Maclean 1993). The Olive-headed Weaver with a shorter tail lends a "stout" and "nuthatch-like" appearance to the bird. The overall form of the weaver is best captured in image number 4 (Clancey 1996) where the stout form of the bird is revealed without the bird appearing to be overly "plump".

2) *Plumage colour*. The earliest images of the Olive-headed Weaver (male only) show a stark, tri-coloured bird with a dark olive dorsal surface, a clearly demarcated rust breast and the remainder of the bird yellow. Almost 70 years later Clancey's earliest image, again showing only the male (1971) blurs the boundaries between these 3 coloured areas. Here, a diffuse orange/rust forehead, a yellowish crown, a rust coloured breast which bleeds into the belly and a strong yellow back and rump appears. The overall olive colour of the bird has been reduced and muddied and the bird has become more yellow. Later, in

Maclean's (1993) publication both sexes are shown – the male resembling Clancey's work while the female is di-chromatic – an olive coloured dorsal surface and yellow ventral surface with a very slight, almost unnoticeable, blush of rust in the breast. In Clancey's second published illustration of the species (1996) both male and female are pictured and both possess a distinct and now dark rust-brown breast patch which meets the olive of the throat. The overall yellow cast of the preceding illustration, particularly in the male's nape area has been reduced. The area of rust in the male seems larger than the females and, in addition, there is a clearly illustrated rust coloured forehead in the male. As well the female has very little yellow on the forehead. Later work by Newman 1999 shows a yellowish crown on the male. Of particular note is the fact that the female in Maclean (1993) and Newman (1999) is without any evident rust on her breast (the breast is all yellow) and the male has a mostly yellow forehead (rust colour is absent). These illustrations are incorrect based upon an examination of male and female preserved specimens throughout the range of the species and field observations by this author. Finally, Clancey's 1985 illustration (Parker 1999) again reverses some of his earlier work by making the crown and nape of the male more yellow (and orange) while the breast has become more orange rust, rather than dark rust-brown.

3) *Context.* In addition to the morphology of the species it is also important to consider the illustrative context of the bird, namely the habitat which is depicted with the species if any. This context, much like the morphology of the bird, evolves. In Reichenow's image (1905) there are several "exotic" palm fronds evident and the bird is perched upon one of these fronds. In the distant background

additional palms may be seen. All of this backdrop imagery suggests an exotic and tropical locale through the representation of almost iconoclastic representation of vegetation. The vegetation says nothing about the bird's actual habitat and instead suggests only "foreign-ness" (the book is published in temperate Europe). Subsequently, Clancey's works (1971, 1996, 1999) provide a different context for the Olive-headed Weaver. In the earlier illustration the bird is clearly 'perching' while in the later illustration the bird appears to be 'creeping' or 'clinging'– possibly suggesting something about the behaviour of the species. Further, the evolving backdrops suggests a woodland or forest bird which occupies steeply inclined slopes covered with miombo – a setting consistent with the bulk of later field observations (miombo being a generic term describing forests composed of tree species belonging to the Genera *Brachystegia*, *Julbernardia* and *Isoberlinia*). Branches are often shown as dead which may suggest maturity in the woodland or forest. The bird appears to be high in the canopy. Such depictions begin to tell a larger story and to contextualize the bird, appropriately in terms of habitat. Linking the bird with its habitat connects viewers of such images with landscape and nature. Such connection to nature contributes to sustainability. In the most recent work by Clancey an added feature is the introduction of a close up of *Brachystegia* leaf while the birds are shown both clinging and perching. The situating of the birds in these illustrated landscapes which speak of habitat tell significantly larger stories than mere diagrams. Unfortunately Clancey misses a significant opportunity to further the Olive-headed Weaver and habitat association when the depiction of the Weaver shows a strand of vegetation (grass or strand of palm leaf) in the bird's beak – suggesting 'typical'

Weaver nest building behaviour and 'typical' Weaver material. A more accurate representation would have shown the Weaver with *Usnea* in its beak.

2) *Information from Dead Specimens:*

The following dead specimens were examined:

- *Ploceus olivaceiceps* – four males, two females – Nat. Hist. Mus. Maputo (1997).
- *Ploceus olivaceiceps* – six males, five females, one immature – Rothschild Zool. Mus. (1998)

Photographs of 12 dead and stuffed specimens collected by Vincent and Benson, courtesy of the Rothschild Zoological Museum in Tring, England, and photographs of six specimens from the Natural History Museum of Maputo are shown, respectively, in Figures 38 and 39. Tags on dead specimens included such information as eye, bill and foot colour. Olive- headed Weaver specimen tag information indicated that eye colour identification is variable and may be accounted for, in part, by disparate ages of birds. Regardless, eye colour was identified as ranging from neutral orange to crimson to brown or red to reddish brown in adults. Bill colour was consistent across adult specimens and was listed as black. Foot colour was generally listed as medium brown in adults. Measurement information was gathered in the field when specimens are collected. Of those birds collected in the 1932-1951 field expeditions by Benson and Vincent the sex ratio of mature birds (n=10) was 1.25 to 1.0 (female to male), the mean TL (total length) to the

Figure 38a: Olive-headed Weaver specimens from Rothschild Zoological Museum, Tring, England. Ventral surface of 6 males, 6 females (L-R). Female to farthest left is immature.

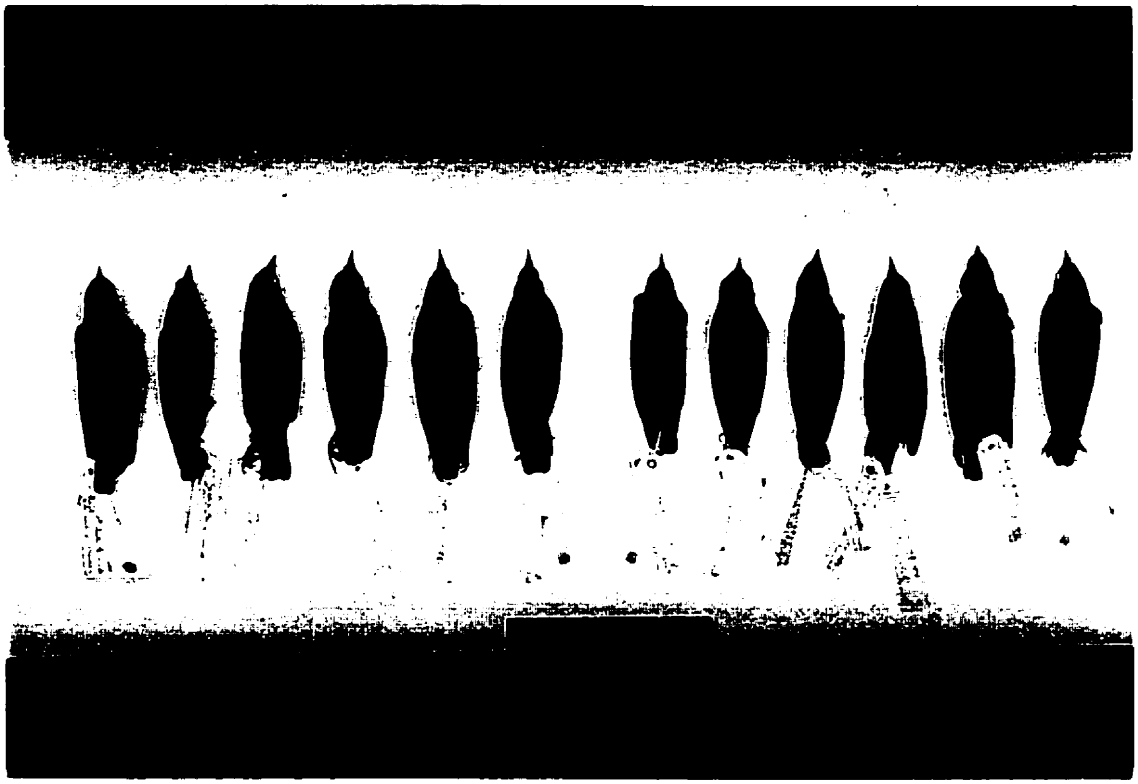

Figure 38b: Olive-headed Weaver specimens from Rothschild Zoological Museum, Tring, England. Dorsal surface of 6 males, 6 females (L-R). Female to farthest left is immature.

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Figure 38c: Olive-headed Weaver specimens from Rothschild Zoological Museum, Tring, England. Ventral surface of 1 male, 1 female (L-R).

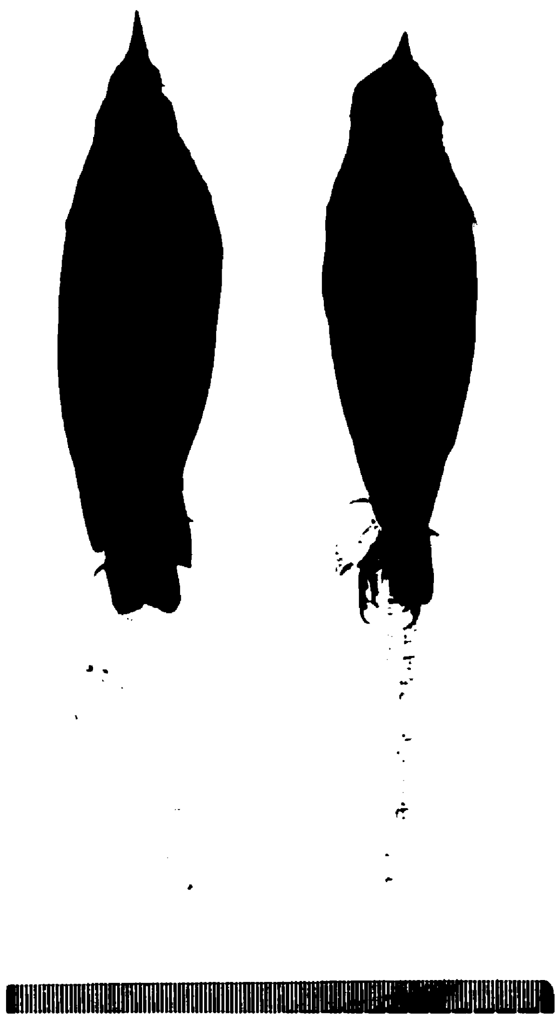

Figure 38d: Olive-headed Weaver specimens from Rothschild Zoological Museum, Tring, England. Dorsal surface of 1 male, 1 female (L-R).

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Figure 38e: Olive-headed Weaver specimens from Rothschild Zoological Museum, Tring, England. Ventral and dorsal surface of 2 males (L-R).

Figure 38f: Olive-headed Weaver specimens from Rothschild Zoological Museum, Tring, England. Ventral and dorsal surface of 2 females (L-R).

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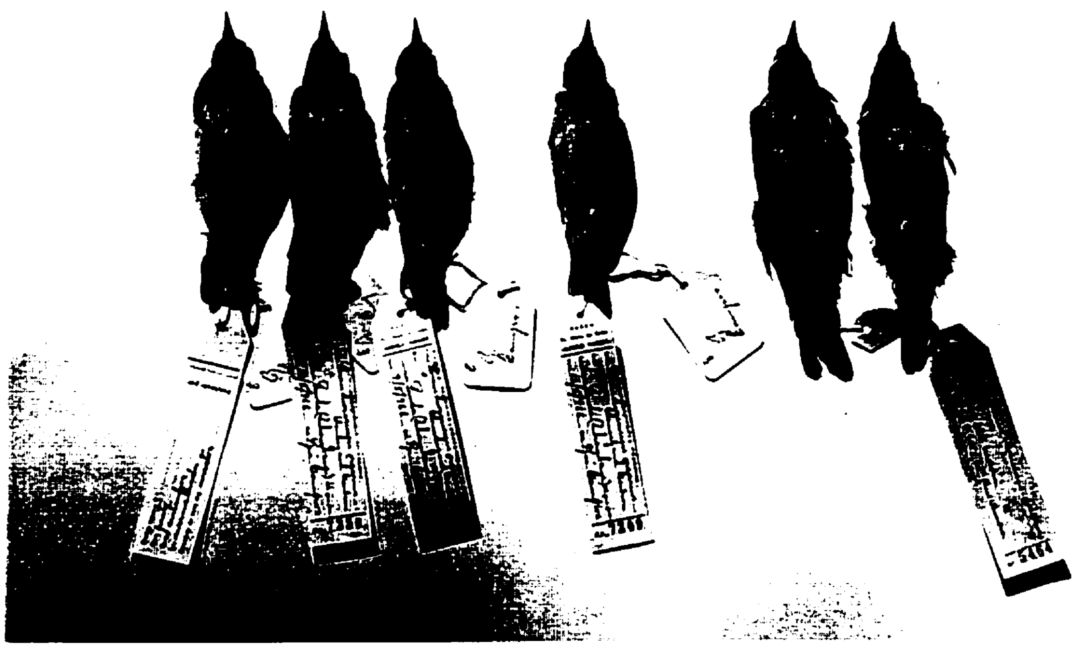

Figure 39a: Olive-headed Weaver specimens from Natural History Museum, Maputo, Mozambique. Ventral surface of 6 birds(L-R): 3 males (Panda); 1 female (Panda) and 1 male, female (Alto Molocue).

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Figure 39b: Olive-headed Weaver specimens from Natural History Museum, Maputo, Mozambique. Dorsal surface of 6 birds(L-R): 3 males (Panda); 1 female (Panda) and 1 male, female (Alto Molocue).

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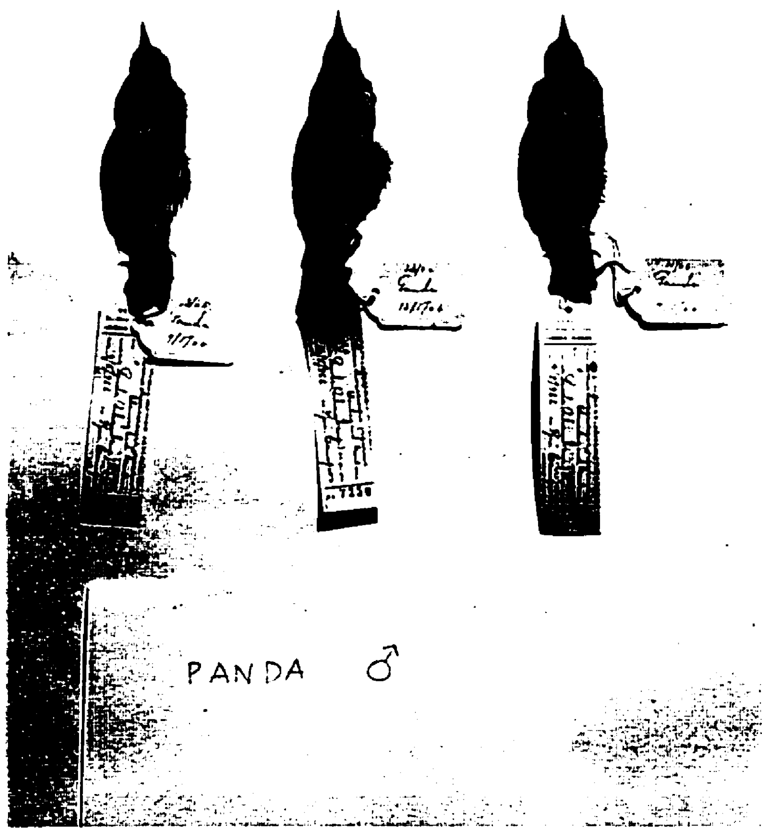


Figure 39c: Olive-headed Weaver specimens from Natural History Museum, Maputo, Mozambique. Ventral surface of 3 males from Panda.

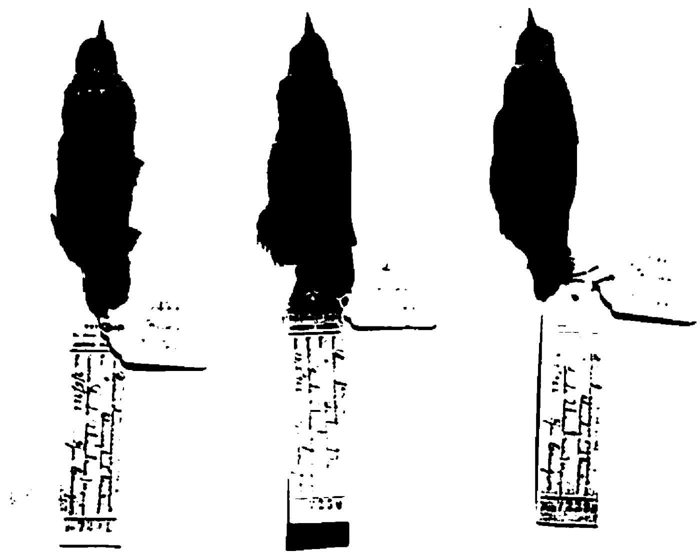


Figure 39d: Olive-headed Weaver specimens from Natural History Museum, Maputo, Mozambique. Dorsal surface of 3 males from Panda.

Figure 39e: Olive-headed Weaver specimens from Natural History Museum, Maputo, Mozambique. Ventral surface of female from Panda.

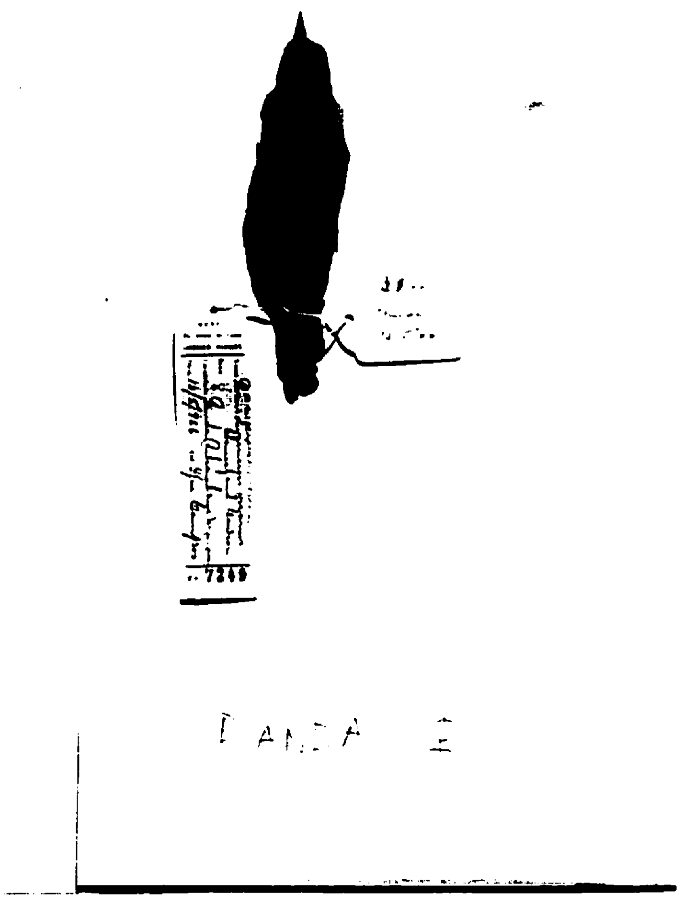


Figure 39f: Olive-headed Weaver specimens from Natural History Museum, Maputo, Mozambique. Dorsal surface of female from Panda.

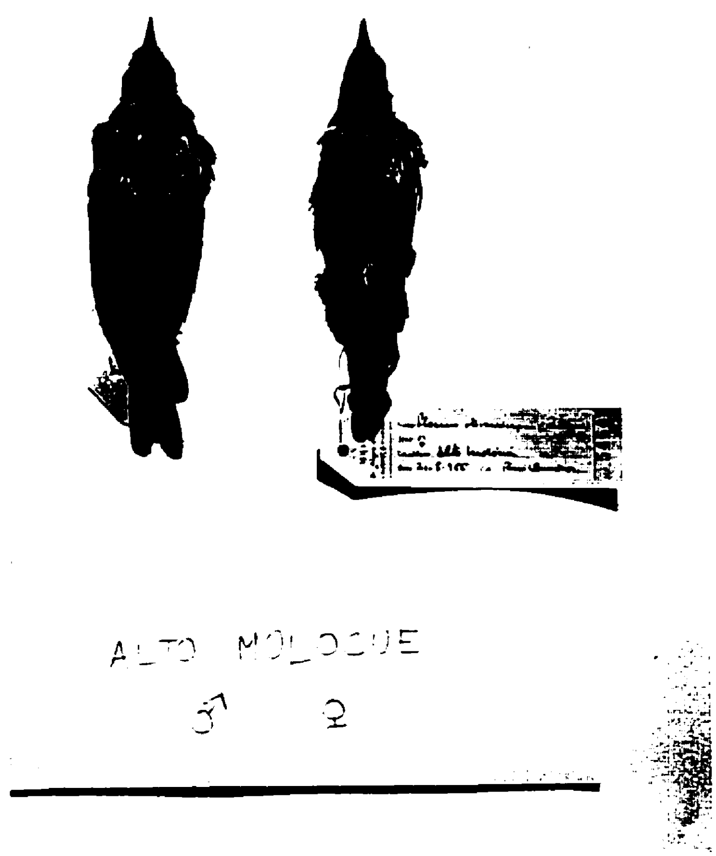


Figure 39g: Olive-headed Weaver specimens from Natural History Museum, Maputo, Mozambique. Ventral surface of male and female (L-R) from Alto Molocue, Mozambique.

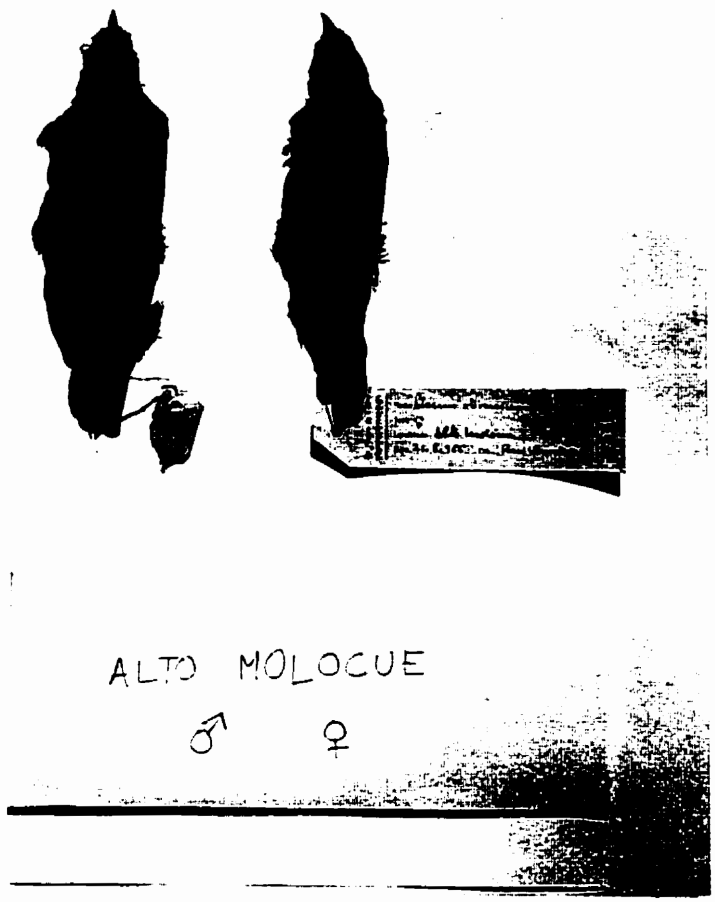


Figure 39h: Olive-headed Weaver specimens from Natural History Museum, Maputo, Mozambique. Dorsal surface of male and female (L-R) from Alto Molocue, Mozambique.

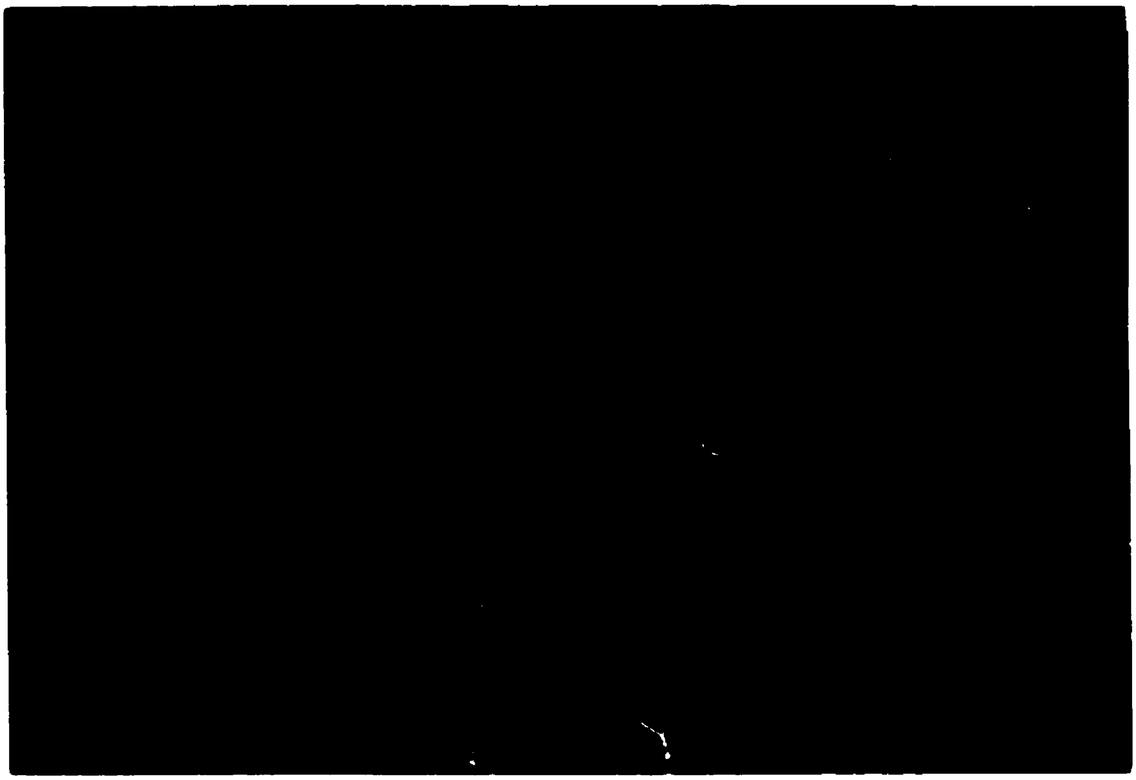
nearest millimetre was 153 (n=10). Weight of birds was not recorded. Clancey and Lawson's (1966) work (where a total of 24 specimens were collected) suggest a weight range of 20.6 -24 g for males (n=11) and 17.5 - 21.6 g for females (n=8). The total length of the bird is listed as 16 cm (in contrast to what was verified in this research, see above). Four birds from this expedition (3 males, 1 female) and one pair (1 male; 1 female) from Alto Molocue are housed at the Natural History Museum of Maputo. The plumage of the birds is discussed in detail in the section comparing illustrations, dead specimens and photographs of living birds.

3) *Photographs*

The first photographs (ever) of an Olive-headed Weaver in the wild are shown in Figure 40

4) Comparison of Illustrations, Specimens and Photos

The issues of overall body shape as well as sex in conjunction with colour are most in need of clarification in field guides (and whether or not this morphological variation supports Clancey's designation of sub-species). Based upon study of specimens at the Rothschild Zoological Museum (specimens are mostly from northern Mozambique and Malawi) and the Natural History Museum of Maputo as well as field observations at Panda the following comments are made in regard to morphology. These observations should have implications for future depictions of the generalized Olive-headed Weaver:

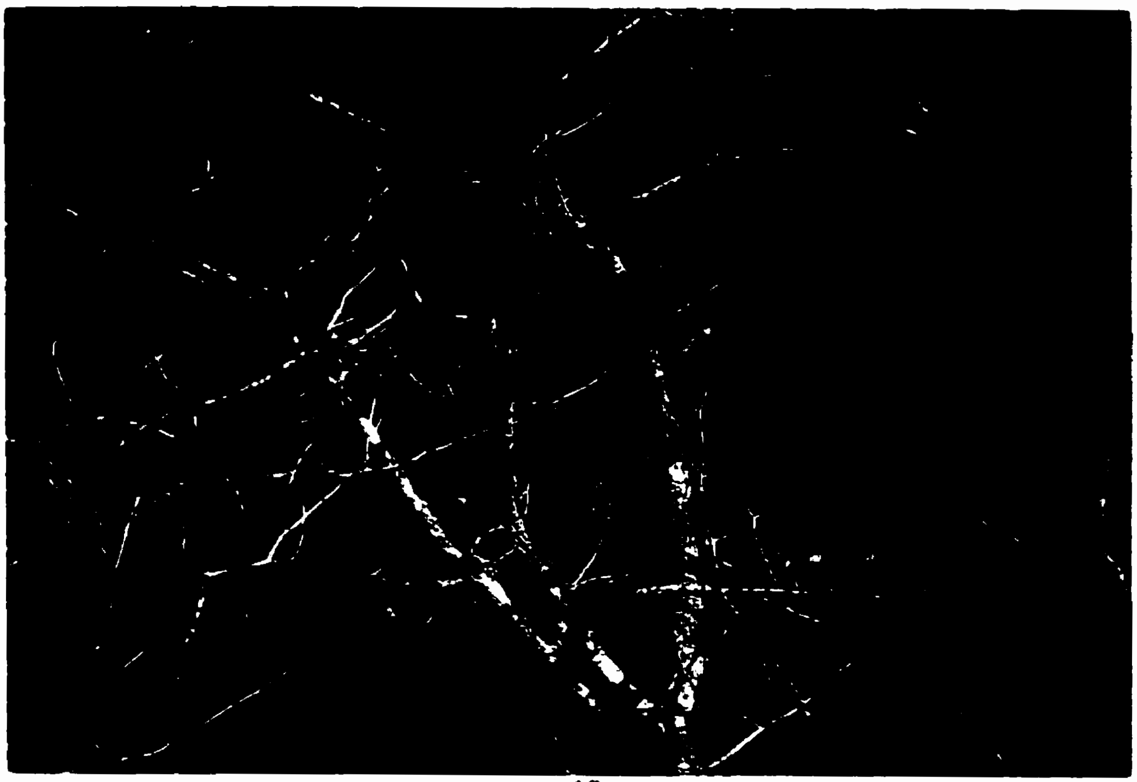


(a)

(b)

Figure 40: First ever photographs of a living Olive-headed Weaver.

(c)



(d)

<u>Figure 40:</u> First ever photographs of a living Olive-headed Weaver.

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1) in males the olive colour of the chin may be darker than the female's and blends almost indistinguishably into the dark rust of the breast while in females the boundary between the olive chin and the rust breast is a fairly clearly demarcated line;

2) in males the rust breast is darker than in females and may occupy a slightly larger area by moving more posteriorly;

3) in males the forehead is a rust/orange which becomes infused with olive through the crown and blends into a predominantly olive colour on the back and rump (minor presence of yellow); the upper tail coverts are yellowish;

4) in females the entire dorsal surface is predominantly olive with an undertone of yellow, the yellow becomes quite evident in the upper tail coverts, as in the male;

5) in both sexes, while moving towards the tail from the breast, the ventral surface is a golden yellow, including the undertail coverts;

6) in both sexes the colour under the chin extends around and up to include the auricular areas;

7) in both sexes the wings are a dark olive-grey as is the tail.

7.1.4 Geographic Locations of Nests

A GPS was used to record the geographic locations of nests. The total area occupied by these nests was 13.2 km^2. Average distance between active nests was 975 m, while average distance between inactive nests was 162.66 m. It is important to remember that among non-active nests several nests may occur in one breeding territory for reasons mentioned in Section 3.1.12.

7.1.5 Nest Attributes

Of 36 bird nests initially presumed to be Olive-headed Weaver, only 29 were eventually confirmed. Depending upon the variable being measured some data points were discarded. This allowed for analysis of 26 or 27 nests, depending upon the variable being measured. For example, when analyzing the distribution of the nesting trees, two GPS data points which were saved in the field later indicated that the trees were located in the Indian Ocean, off the coast of Mozambique. Such points were discarded.

In all cases the nests were composed completely of *Usnea*. A sample of *Usnea* taken from a nest and sent to Geneva, Switzerland to Usnea taxonomist and specialist Philippe Clerc was revealed to be *Usnea mexicana* Vain., also known as *U. gigas*, *U. africana* or *U. himantoides* in Africa. Mr. Clerc mentioned that *U. mexicana* is very common in southern Africa and has been collected in his own studies in the Inyanga Mountains of Zimbabwe (Clerc, pers. comm 1998). In some cases small bits of debris were caught in the nests and in one case an epiphytic plant, a small living orchid, was integrated with the nest exterior. Nests were never integrated with the ends of branches (typical for many weavers), rather, nests were almost always located deeper within the canopy, usually within 2 m of the canopy edge, attached to the midpoint (between successive branches) of larger branches, which appeared to be greater than 2 cm diameter. Nests were usually located in the upper third of the tree canopy, and usually located near the apex and centreline of the tree. An illustration of the typical nest form is shown in Figure 41. This research strongly refutes the suggestion by some authors (Maclean 1993) that the nest has a "vertical entrance (no spout)". Using the 5 nests gathered after the breeding season it was determined that chamber size remains relatively constant while spout length was more variable. A diagram of nest parts and dimensions was shown in Figure 6. Nest total length (which includes spout and spout trailing edge) varied from 22 to 35 cm while nest chamber length varied between 15 to 18 cm and nest chamber width varied between 11 and 12 cm. Means for specific nest dimensions were as follows:

Variable	Average Dimension (cm)
Spout length	17.9
Spout trailing edge	10.6
Nest total length	28.7
Spout inside diameter	4.8
Spout outside diameter	7.9
Spout thickness	3.1

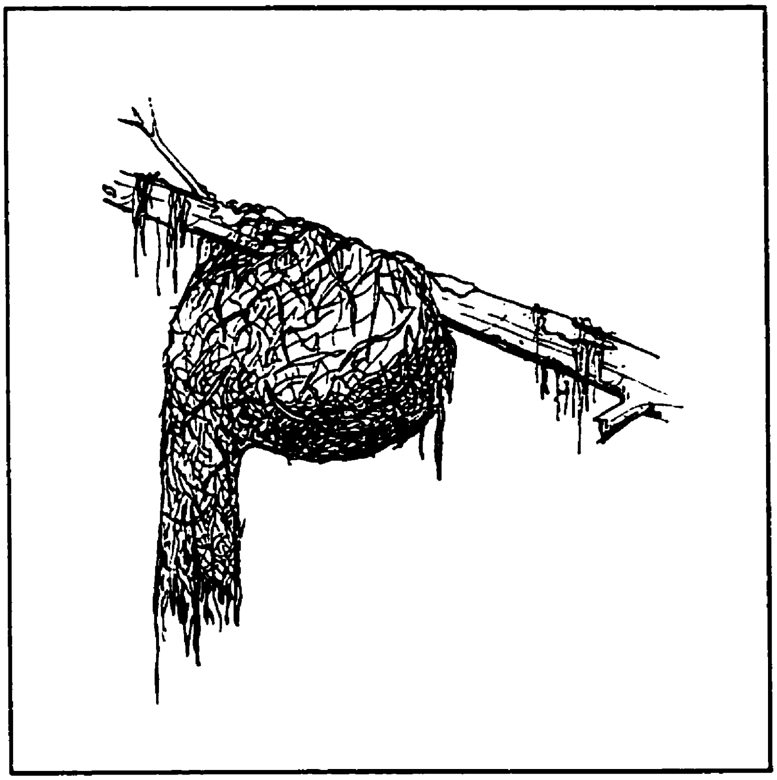

Figure 41: Illustration of typical branch position and nest form of Olive-headed Weaver.

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Chamber length	16.7
Chamber width	12.0

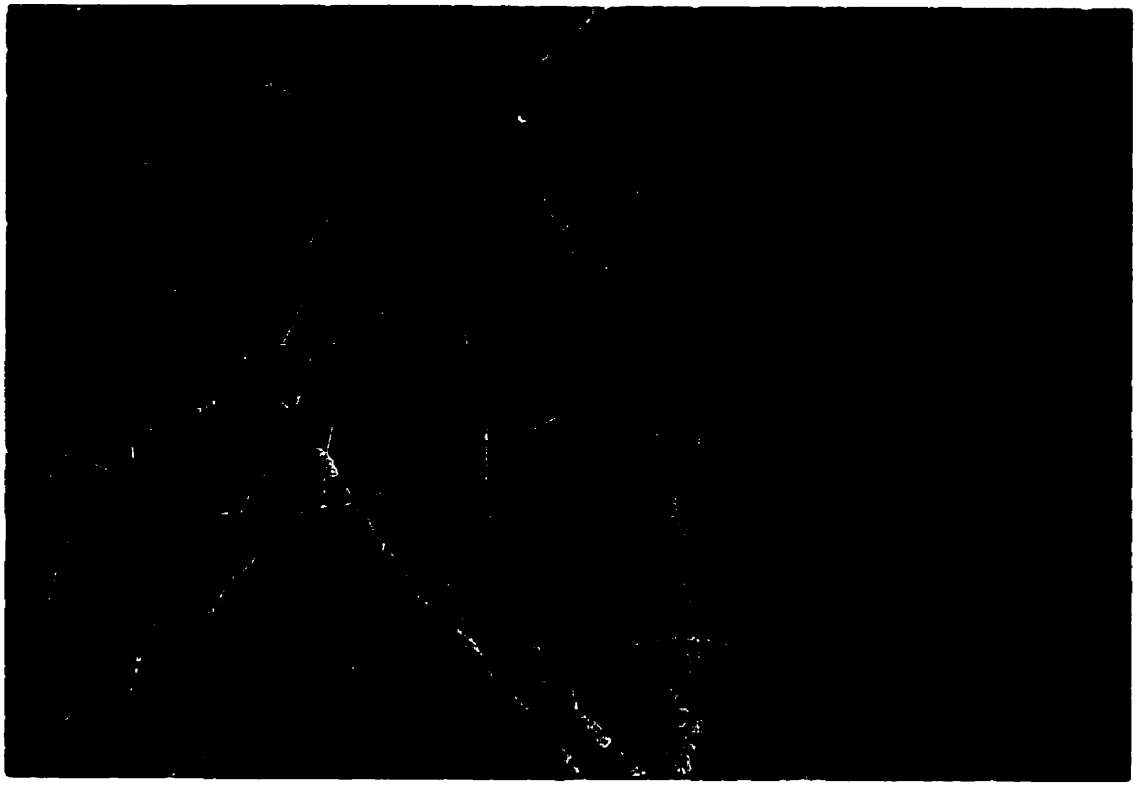
Spout trailing edge (the strands of hanging *Usnea* at the terminus of the spout that are transparent) varied between 6 and 17 cm. Some of this variability may be seen in photographs of nests shown in Figure 42.

Approximately 74% of nests (20 out of 26 nests) were located within 2 m of the crown of the tree while 22% were within 2.1 to 4 m (6 of 26 nests; see Figure 43). The remaining nest, accounting for 4%, was located within 4.1 to 6 m. One nest of the total of 27 nests was discounted because it was located in a bifurcation of a branch that had broken and become inverted within the canopy, and thus distance to crown was not assessed.

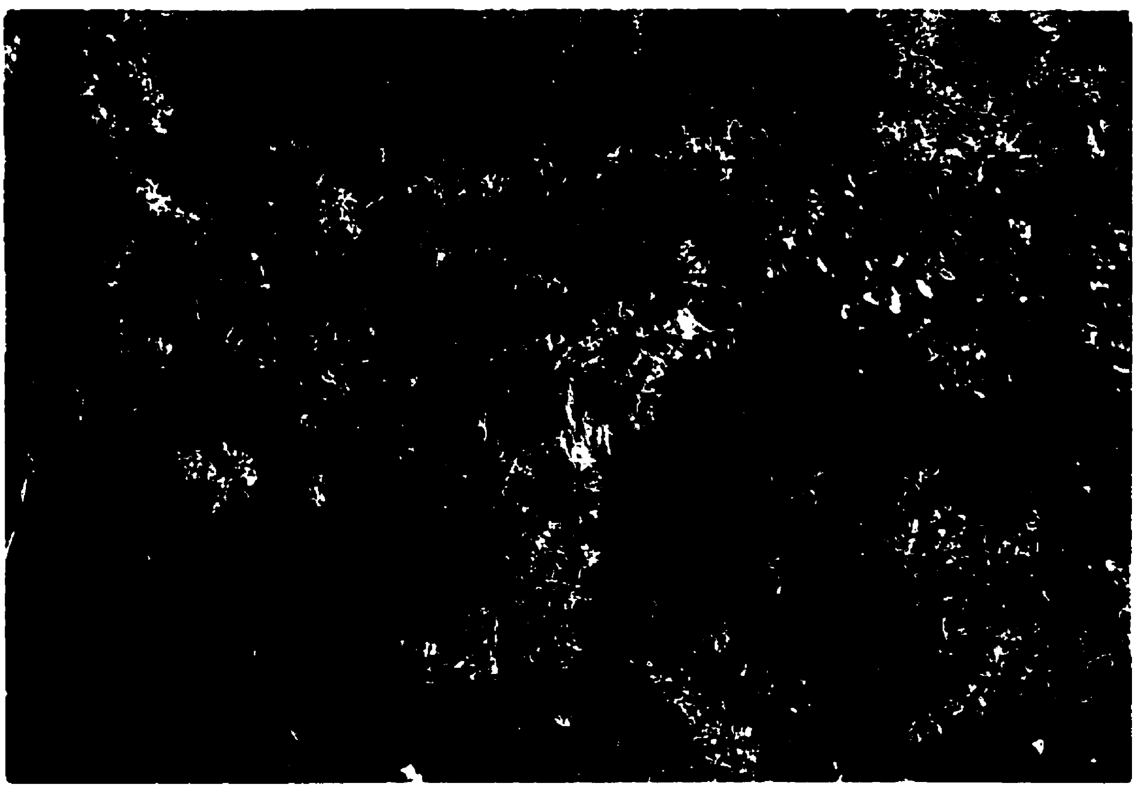
7.1.6 Nest Tree Attributes

All 29 Olive-headed Weaver nests were located in *Brachystegia*. Again, depending upon the variable being measured some trees were discarded from analysis. For example, when analyzing tree diameter at breast height (dbh) 3 trees were discarded because the measurement of the trunk occurred where a burl or outgrowth in the tree was located.

The mean height of nesting trees was 17.75 m. The mean diameter of trees at breast height ("dbh", measured at 1500 mm above ground level) was 382.75 mm. A significant positive relationship between tree height and tree dbh was demonstrated (ANOVA, $F_{1,24} = 20.441$,



a)



b)

Figure 42: Photographs of Olive-headed Weaver nest: "a" - winter; "b" - summer.

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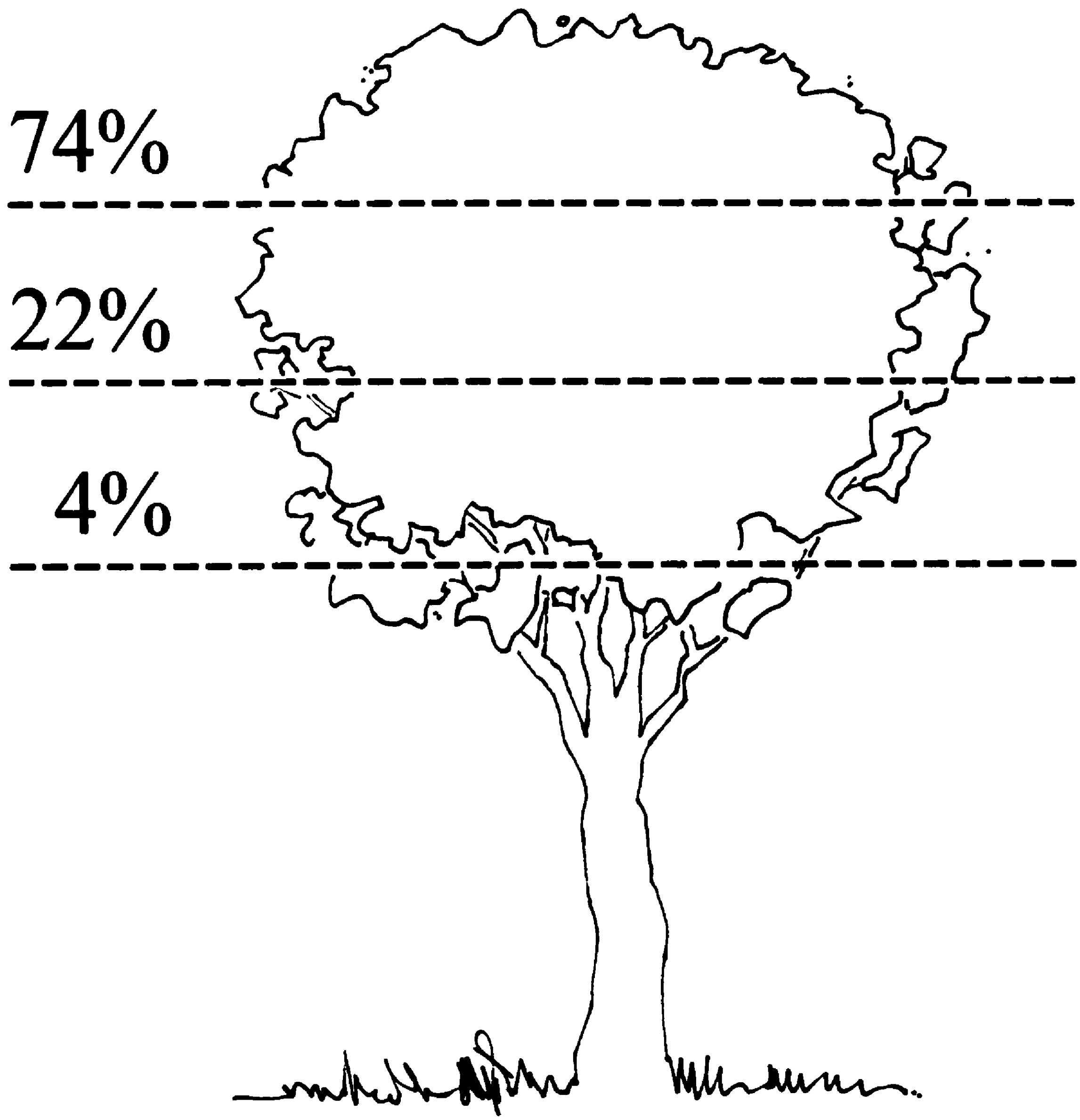


Figure 43: Nest Position Within Tree Canopy of Olive-headed Weaver. Typically, the bird nests in the uppermost branches of *Brachystegia* trees.

p = 0.0001) and was described by the relationship: tree height = 6.537 + 0.0298 x tree dbh. The amount of variability in tree height explained by tree dbh is moderate (r^2 = 0.46, significance of r^2 = 0.0001), suggesting that other variables in addition to tree dbh influence tree height. None of the nesting trees, either active or inactive were in leaf when birds were breeding. The amount of *Usnea* (lichen) in any nesting tree, either active or inactive, was variable. Mean tree height for active and inactive nests were not significantly different (two-sample t-test, two-tailed, t = .693, p > 0.05). Mean diameter at breast height (dbh) for active and inactive nests were not significantly different (two sample t-test, two tailed, t = .797, p > 0.05). The mean diameter at breast height (dbh) of *Brachystegia* nest trees (x = 390.5, n = 20) was significantly greater than the mean dbh of other *Brachystegia* trees (x = 308.4, n = 189) found within the nest tree sample area (two-sample t-test, two-tailed, t = 3.30, p = 0.0011; Figure 44). Given our earlier analysis of the relationship between tree dbh and tree height we can suggest that within nest tree areas birds are actively selecting the largest trees – those with the greatest dbh and height.

7.1.7 Vegetative Characteristics of Nest Tree Areas and Random Areas

Of those nests which were active during the breeding season 75% (3 out of 4 active nests) were located in areas that had not recently been burned. The possibility exists that the remaining nest of these 4 active nests could have been built and breeding commenced before the area was burned. Burning was occurring throughout the study period. Regardless of whether nests were active or inactive the majority of nests (80%) were located in areas which had not been burned over recently. This may suggest that the

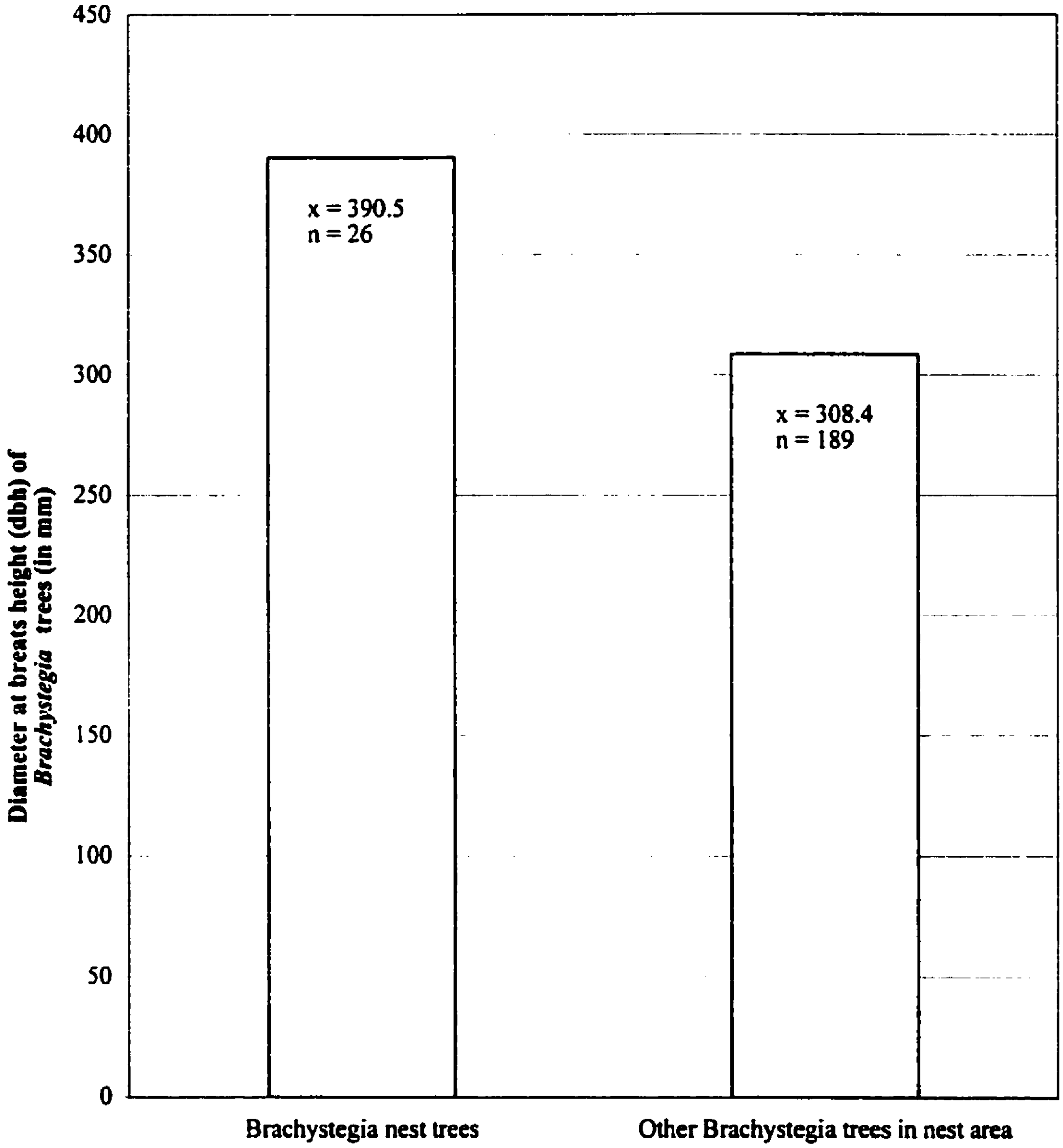


Figure 44: Mean dbh of *Brachystegia* nest trees and other *Brachystegia* trees in the nesting area. Means differ significantly.

species has a preference for undisturbed forest.

The substrate in nest tree areas was grass and sand in all of the sampled areas, as it was in random areas (small forbs and vines were also present). During a more widespread search for nests in what appeared to be 'suitable' habitat (large trees in undisturbed areas with abundant *Usnea*) no nests could be located. However, these areas often had significant undergrowth. It is possible that the Olive-headed Weaver selects areas with large trees and little or no undergrowth other than grass, and then selects the largest trees within these areas. The presence of other types of vegetation (*Aloe, Balanites, Acacia, Garconia, Opuntia*) was not correlated with habitat selection for nesting.

The mean dbh of *Brachystegia* trees within the nest tree area ($x = 316.29$, $n = 209$) was also significantly greater than the mean dbh of *Brachystegia* trees ($x = 289.57$, $n = 210$) sampled in the random vegetation survey areas (two-sample t-test, two-tailed, $t = 2.597$, $p = 0.0097$, Figure 45). Using dbh from trees sampled in the nest tree area, and those from randomly sampled areas, the height of trees was calculated based upon the relationship shown earlier in 4.1.6. Results for tree height are identical to those for dbh in the above paragraph, due to auto-correlation, however, we can say with some certainty that the Olive-headed Weaver, within a largely monospecific woodland patch, is nesting in areas with larger trees (as measured by dbh and height).

Within the study area the number of *Brachystegia* trees and saplings for nest tree areas and random areas were compared. Among saplings 4 size classes were used (0-50mm,

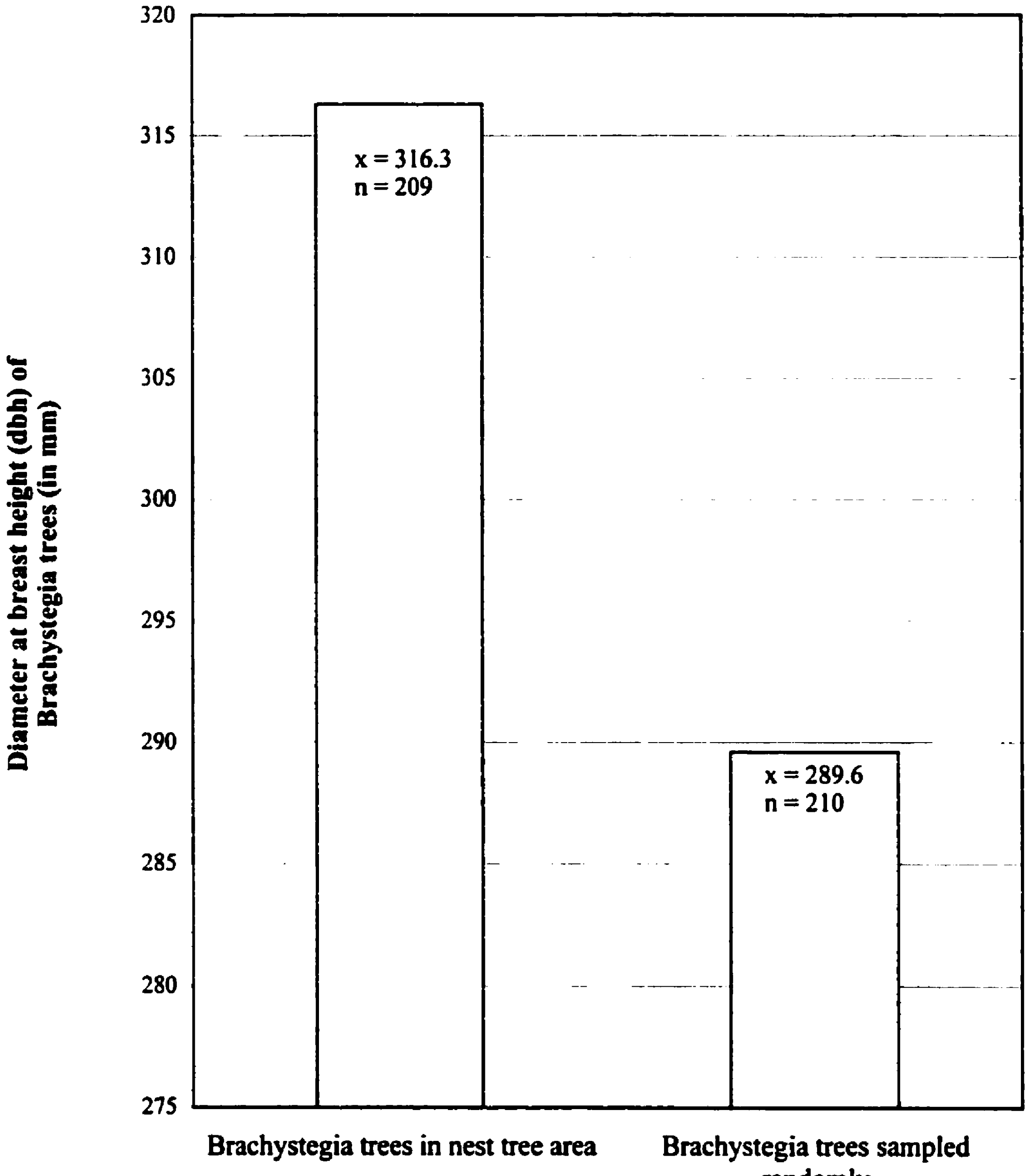


Figure 45: Comparison of mean dbh of Brachystegia trees in nest tree and random areas. Means differ significantly.

50-100mm, 100-150mm, 150-200 mm). This analysis was done to determine if birds were actively selecting for certain forest attributes such as age structure (as indicated by presence and number of saplings) or density of *Brachystegia* trees. There was no difference between nest tree areas and random vegetation areas for *Brachystegia* or sapling class numbers (all two-sample t-tests, two-tailed, with the following "t" and "p" values: for comparison of *Brachystegia* trees, $t = -.5598$, $p = .5791$; 0-50 mm saplings, $t = 1.4071$, $p = .1680$; 50-100 mm saplings, $t = .1971$, $p = .8449$; 100-150 mm saplings, $t = 1.4157$, $p = 0.1655$; 150-200 mm saplings, $t = -.9001$, $p = .3740$). Thus while we might expect that selection for the largest trees might also be correlated with a particular seral stage or forest structure, the current data set does not support this.

7.1.8 Activity at the Nest

This section compares duration of visits and visitation rates during nest building (NB), incubation (I) and nestling (N) stages for males (m) and females (f).

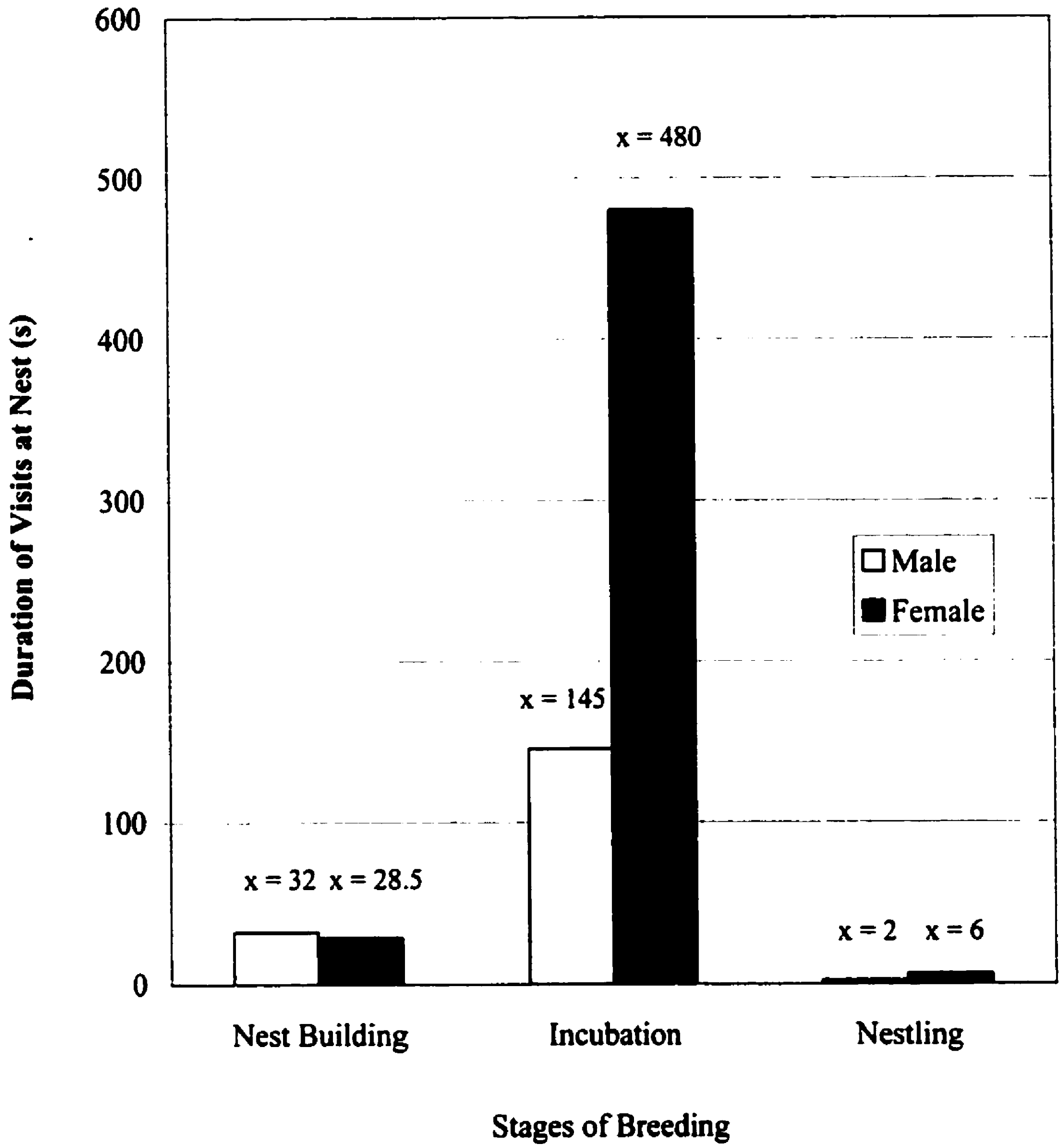
1) *Duration of Visits at Nest*

Analysis of variance for duration of visit at nest indicated a significant difference between the sexes across phases (ANOVA, $F_{5,103} = 22.69$, $p = 0.0001$). However, closer examination by phase and sex also indicated an interaction (F test, $F_{2,103} = 6.14$, $p = 0.003$), prompting an expansion of analysis. Pair-wise comparison by stage and sex indicated that the mean duration of visits by females during the incubation phase was significantly greater than mean duration of visits for males during the same phase, and for either sex during any other phase (two sample t-tests, two-tailed, p between 0.0001 and 0.0003 for all comparisons, Figure 46). When sexes were combined it was found that mean duration of visits at the nest was significantly greater during the incubation stage than other stages (two sample t-tests, two-tailed: I vs. N, $t = 5.745$, $p = 0.0001$; I vs. NB, $t = 5.6999$, $p = 0.0001$;).

There was no significant difference in mean duration of visits at nest between nest building and nestling stages (two sample t-test, two-tailed, N vs. NB, $t = 6.94$, $p = 0.4893$). When mean duration of visits for each sex was combined across all phases of breeding, female duration of visit at the nest was significantly greater than male (two sample t-test, two-tailed, $t = 2.897$, $p = 0.0046$). The above information indicates clearly that male Olive-headed Weavers are involved in nest making – a finding which had previously been unrecorded (see Maclean 1993).

2) Visitation Rates

Initial analysis of variance for number of visits to the nest during a one hour period indicated a significant difference in mean visitation rate between males and females (ANOVA, $F_{5,26} = 7.48$, $p = 0.0002$), however, subsequent analysis revealed there was no interaction between phase of breeding and sex (F test, $F_{2,26} = 1.17$, $p = 0.327$).



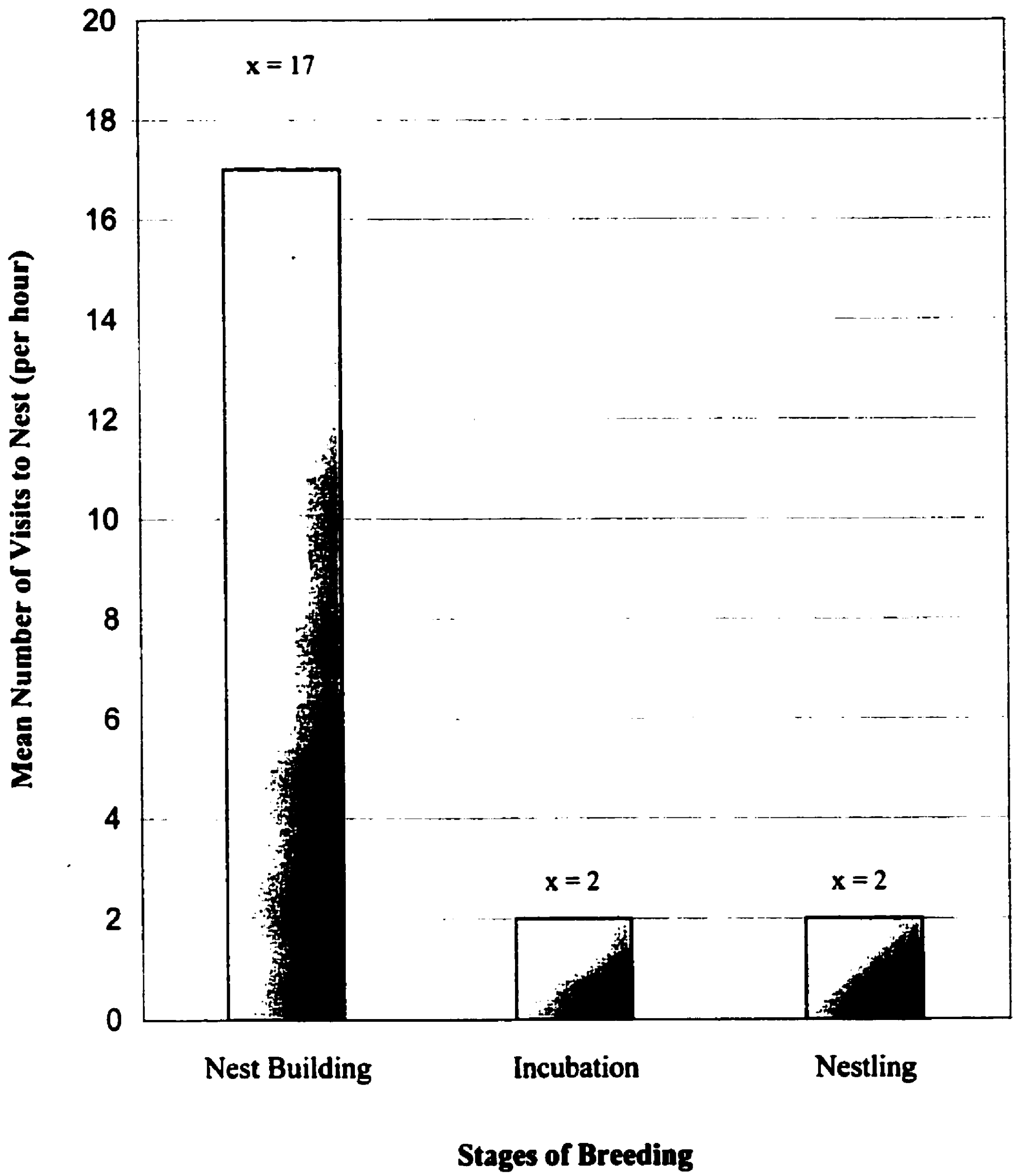
<u>Figure 46:</u> A comparison of mean duration of visits at nest for male and female Olive-headed Weavers during 3 stages of breeding.

Removal of the interaction term and re-analysis revealed a significant difference within phase and sex (ANOVA, $F_{3,28} = 11.55$, $p = 0.0001$). Subsequent analysis of phase and sex separately revealed that the effect of phase alone was significant - the mean visitation rate of males and females combined is significantly greater at the nest building (NB) phase than either incubation (I) or nestling (N), (two sample t-test, two-tailed: NB vs. I, $t = 4.79$, $p = 0.0001$; NB vs. N, $t = 4.941$, $p = 0.0001$, I vs. N, $t = 0.063$, $p = 0.9502$, Figure 47). The variable of sex, when measured across all phases of breeding was very close to significant with females visiting the nest at an average of 9.7 times per hour while the male visited the nest an average of 4.6 times per hour (two sample t-test, two-tailed, $t = 2.051$, $p = 0.0590$).

7.1.9 Breeding Period

For the purposes of this thesis the breeding period was defined as the series of events between onset of nest building and fledging of young. Five stages were considered:

1) Nest Building (NB)
2) Egg Laying (EL)
3) Incubation (I)
4) Nestling (N)
5) Fledging (F)



<u>Figure 47:</u> A Comparison of the Mean Number of Visits per hour for Male and Female Olive-headed Weavers Combined Between Phases of Breeding

Data were gathered for stages 1, 3 and 4. Of the 29 nests located during the breeding season only 4 (20%) were found to be active meaning that the presence of nesting birds was recorded. In the Panda area the nesting period may begin as early as August and extend through November (based upon Interview #7 and other personal interviews). This period is typically known as the rainy season.

During field work, stages of the breeding cycle were confirmed through direct observation (heard nestlings, saw parents carrying food to nest, saw parents enter the nest without food or with nesting material) and the following assumptions:

- When adults were seen carrying food to the nest and it was confirmed that adults were not feeding each other (both sexes were determined to be away from nest when one parent arrived at nest with food), the nest status is designated as "N" indicating presence of nestlings.

- When adults were seen entering the nest and it was clear that they were not carrying food either the status of "I" for incubation or the status of "L" for laying was given depending upon events preceding or following the date in question.

- If a nest had been allocated "N" for nestling status on one day and on a subsequent day there was no activity and no signs of nest destruction the nest was assumed to have fledged.

When stages of the breeding cycle could not be directly observed or reasonably deduced they were inferred based upon data gathered through an examination of life history traits within the genus *Ploceus* (the True Weavers) from Maclean 1993 (**Table** 3). For example, within the True Weavers a clutch size of two to three eggs is normally laid and mean incubation period is around 13 days. Based upon the above means of collecting information the following conclusions, in regard to breeding period of the Olive-headed Weaver, were made:

- The nest building phase is variable in duration.
- The incubation period is 13 - 16 days (Table 3).
- The nestling period is approximately 15 days based upon limited data provided by this study (Nest 22), and information regarding the True Weavers (Table 3).
- Average clutch size was assumed to be 3 eggs, laid over 3 days, based upon information regarding the True Weavers (Table 3).
- Incubation was assumed to be synchronous, beginning with laying of third egg, based upon information regarding the True Weavers (Table 3).

This research demonstrates breeding of this species in southern Africa in contrast to Maclean who states that breeding was "not recorded in southern Africa" (Maclean 1993, 718). Similarly, this research demonstrates evidence of nestlings that were heard when observing nests, also listed as "unrecorded" by Maclean (1993, 718).

Table 3 : Summary of Nesting Characteristics of True Weavers*

Species No.	Common Name	Scientific Name	Gregar. or Col. Breeders?	Nest Built by?	Use of Usnea?	Clutch Size	Incubation Period(d)	Sexes Incubating	Nestling Period(d)	Nestlings fed by?	Independent
1	Forest Weaver	*Ploceus bicolor*	N	M	to line nest	3	unrecorded	unrecorded	22 (captivity)	unrecorded	18
2	Olive-headed Weaver	*Ploceus olivaceiceps*	N	unrecorded	entire nest	2 to 3	unrecorded	unrecorded	unrecorded	unrecorded	unrecorded
3	Spectacled Weaver	*Ploceus ocularis*	N	M,F (mostly M)	no	3	13.5	M,F	18 to 19	both	unrecorded
4	Spottedbacked Weaver	*Ploceus cucullatus*	Y	M	no	2 to 3	12	F only	17 to 21	both, mostly F	unrecorded
5	Chestnut Weaver	*Ploceus rubiginosu s*	Y	M, lined by F	no	3	11 to 14	F only	13 to 16	F only	unrecorded
6	Cape Weaver	*Ploceus capensis*	Y	M, lined by F	no	2 to 3	13.5	F only	17	both, mostly F	unrecorded
7	Masked Weaver	*Ploceus velatus*	Y	M, lined by F	no	2 to 3	unrecorded	F only	unrecorded	F only	unrecorded
8	Lesser Masked Weaver	*Ploceus intermedius*	Y	M	no	2 to 3	unrecorded	unrecorded	unrecorded	both	unrecorded
9	Golden Weaver	*Ploceus xanthops*	Y	?	no	2 to 3	unrecorded	unrecorded	19 to 21	both, mostly F	unrecorded
10	Yellow Weaver	*Ploceus subaureus*	Y	M, lined by F	no	2 to 3	unrecorded	unrecorded	unrecorded	unrecorded	unrecorded
11	Brownheaded Weaver	*Ploceus xanthopterus*	Y	M	no	2 to 3	14 to 16	F only	14 to 17	F only	unrecorded
Means			NA	NA	NA	**2 to 3**	**13**	NA	**18**	NA	NA

*All information taken from Maclean (1993).

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7.1.10 Foraging Behaviour Patterns

Foraging birds were followed for a total of 48 minutes during the breeding season. Males were observed for 19 minutes and females were observed for 29 minutes (to the nearest minute). A total of 16 different terms were defined to describe the movements of the birds while foraging. A glossary of these terms may be found in Table 4. When frequency of any behaviour for either sex exceeded 0.01 (behaviours which occur more than once every 100 seconds) the behaviour was assessed for both sexes individually and then as a combined (male plus female) frequency.

When sexes are compared separately or combined the same 8 behaviours ranked in the same order of frequency. From most frequently occurring to least the ranking of behaviours is as follows: hopping, gleaning, rotating, changing branches, flight, moving away from trunk, moving out of sight of observer, and moving up tree through branches. These behaviours occurred primarily on the trunk and larger branches of *Brachystegia* tree and involved gleaning from bark where crustose lichens were present. The bird was not observed in the finer branches of any tree or in foliage and did not demonstrate any preference for foraging in *Usnea*. Figure 48 illustrates graphically the frequency of all recorded behaviour patterns.

The above information on foraging refutes Maclean's (1993, 718) suggestion that the bird "forages...off branches and foliage and in clumps of *Usnea*". Birds were rarely recorded in foliage or clumps of *Usnea* and instead concentrated foraging activities on branches (at least during the breeding season).

Table 4 : Glossary of Terms for Observations of Foraging Behaviours Observations

Category	Code	Recorded Word	Explanation
logistics			
	St	trial begins (t=0)	recording session begins
	X	bird out of view	bird cannot be seen by observer
	...	still not seen	bird has moved out of view of observer (elapsed time)
	!	bird back in view	bird can now be seen again by observer
	"rusty..."	rusty...	"rusty breast" - additional recorded comments
	flip	flip	tape was flipped
environment			
	B	branch	branch
	B6	branch/inches	branch with mention of diameter (in.)
	C	crevice	crevice or fissure in branch or trunk (*Balanites* spp.)
	T	trunk	trunk of tree
	t	twig	twigs of branches
	Y	bifurcation	bifurcation in branch
bird			
	ag	away from ground	bird is moving away from ground
	dB	down branch	bird is moving downwards in canopy of tree, using branches
	uB	up branch	bird is moving upwards in canopy of tree, using branches
	DB	change branch	bird has changed branches within the same tree
	c	call	bird calls
	F	flight	bird moves more than 12 inches using wings
	F5'	flight 5 feet	as above, indicating distance flown
	G	glean	bird removes prey item from a surface
	H	hop	bird moves less than 12 inches in a single movement
	NT	new tree	bird is in new tree
	R	rotate	bird clings to side or underside of branch
	r	reverse	bird reverses direction
	s	stand	bird is not moving, erect posture
	aT	away from trunk	bird is moving away from trunk
	tT	towards trunk	bird is moving towards trunk
	dT	down trunk	bird is moving down trunk
	uT	up trunk	bird is moving up trunk

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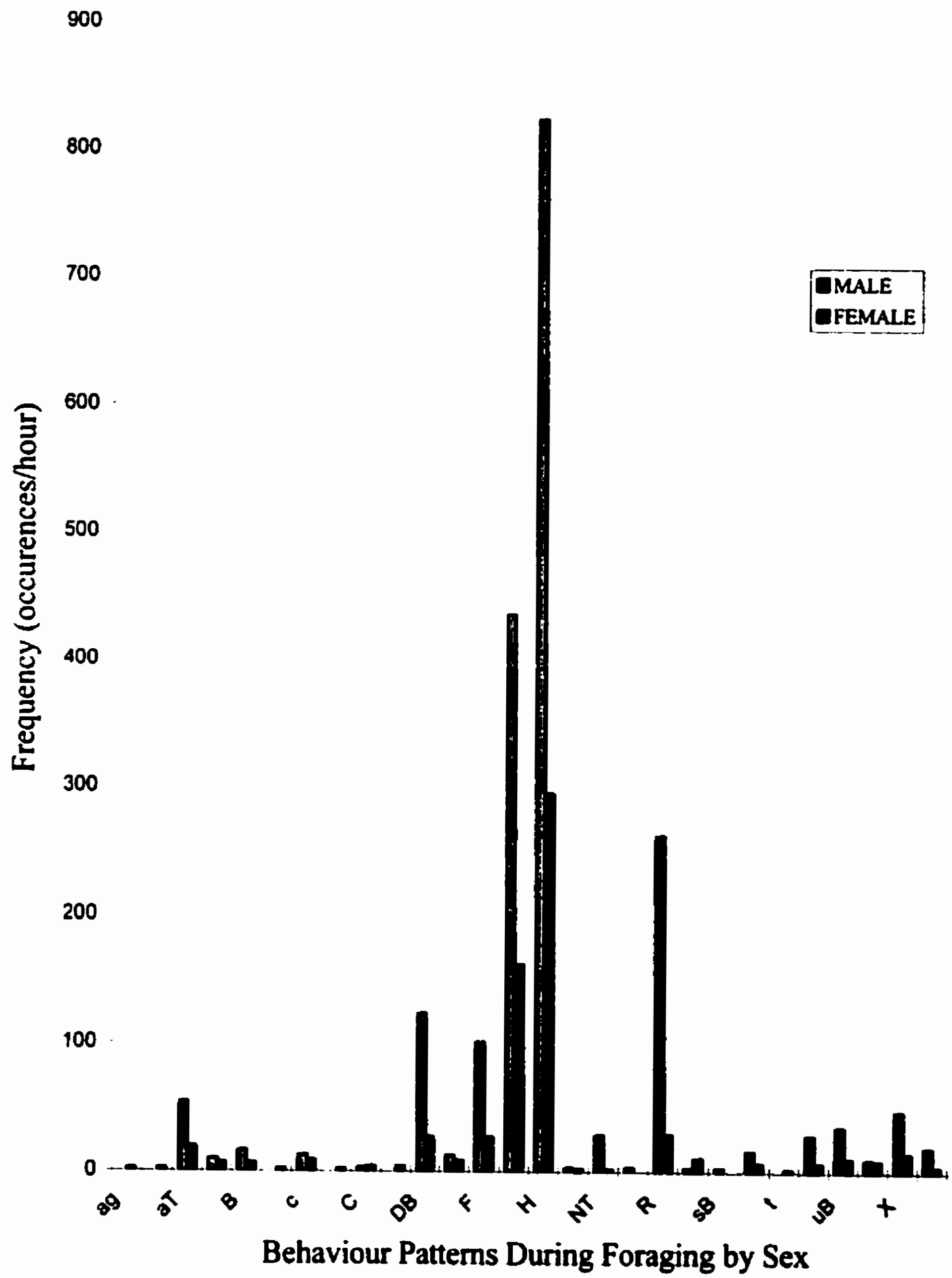

Figure 48: Frequency of Male and Female Foraging Behaviour Patterns

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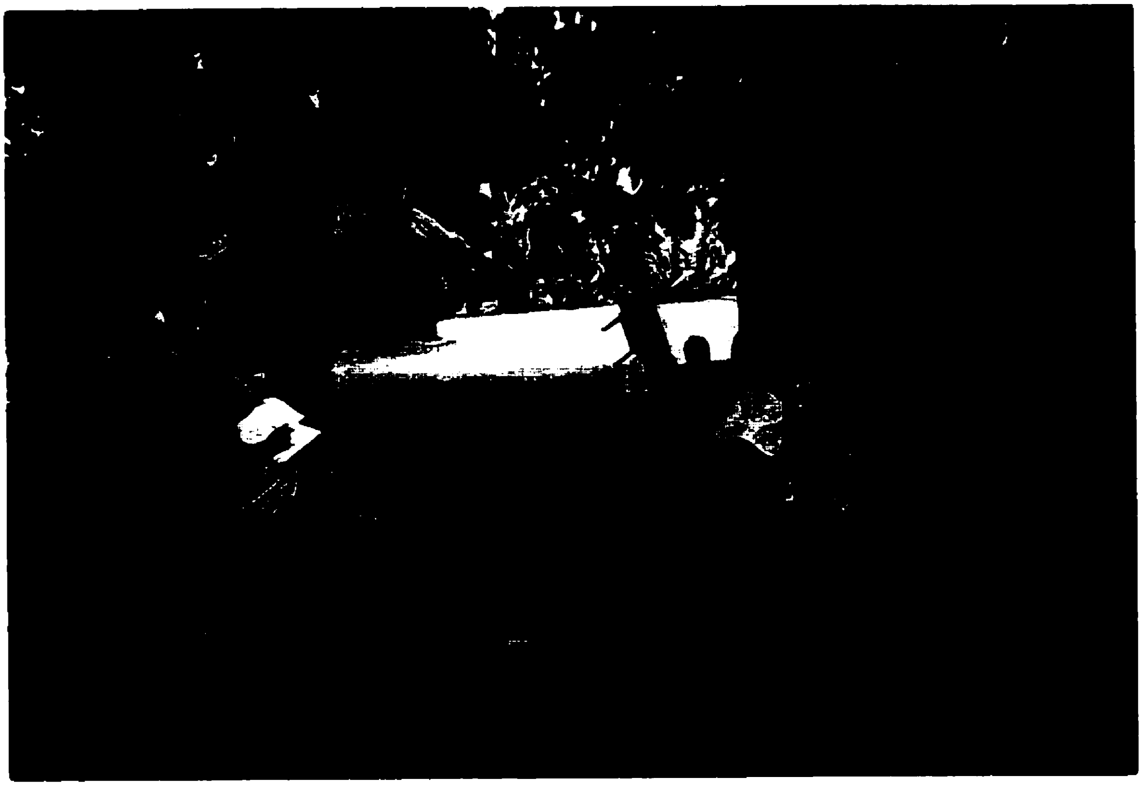
7.1.11 Diet

Stereoscopic investigation of fledgling faecal samples indicated both plant and insect materials. Plant materials that survived digestion appeared to be crustose lichens. The majority of the faecal sample was composed of insect body parts (legs, femurs, eyes, mandibles) and fragments of body parts (elytra fragments, scales). Insect diet appears to be diverse at the ordinal level and included evidence of the following: Lepidoptera (butterflies and moths); Coleoptera (beetles), including possible Platypodids (leaf and bark beetles, *e.g.* weevil); Hymenoptera (parasitic wasps) and Homoptera (plant hoppers, spittlebugs).

7.2 Results of Field Work: The HA Population

To assist readers in finding more in depth information or to allow cross-referencing, references to sample interviews are provided throughout the body of the text of this summary.

These findings offer both an overview of different dimensions of lives of individuals and families who live within the study area as well as detailed illustrative information. Both men and women, married and single, young and old, and from a variety of professions (farming, teaching, hunting, storeowners) were interviewed. Typical interview settings are shown in Figure 49. Interview data are organized in four parts emphasizing socio-cultural, economic, ecological and political dimensions. The four parts are:



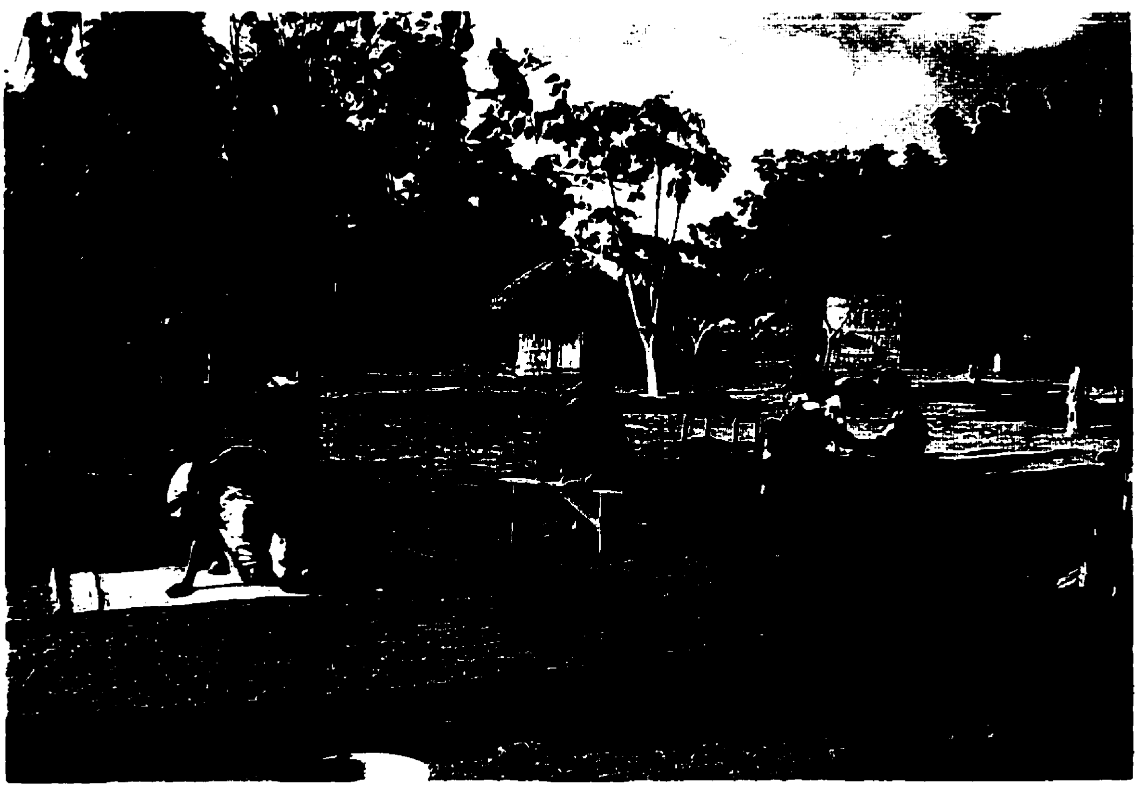


Figure 49: Typical interview settings.

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1) Part I : Socio-cultural

2) Part II : Economic

3) Part III : Ecological

4) Part IV: Political

Part I: Socio-cultural Factors

7.2.1 Households

Individuals and families have lived in the study area for varying periods of time - from a minimum of 1 year (Interview 10 - a single male teacher) to a maximum of 56 years (Interview 15). The mean duration was 19 years. Family sizes ranged from single individuals to 18 people with a mean family unit size of 7 to 8 people. When interviews were held it was primarily the eldest males that represented families. As all interviews inquired about 'family', the individual being interviewed, regardless of gender was identified as the 'family representative'. Approximately 81 percent of family representatives interviewed were male. The average age of male family representatives or respondents was 48 years. Average age of female family representatives or respondents was 24 years.

7.2.2 Movement of Families

The context of war plays a significant role in dictating when, where and how people moved, either to the area or from it. The war between FRELIMO and RENAMO began in 1975, when colonial Portuguese occupation ceased, and ended in 1992. During these 17 years of war, emigration and immigration at local and international scales were massive, involving millions of people. The dynamics of the war exerted differential effects depending upon the context. Some families fled to neighbouring countries or fled to cities within Mozambique. Other families moved within rural Mozambique or never moved at all. People in the study area had the following responses to the war (1975-1992):

a) stayed at their homesteads (Interviews 9, 15);
b) stayed at their homesteads and, when trouble began, slept in the forest at night (Interview 8), or slept in the river valley at night (Interview 15);
c) moved to neighbouring towns when attacks and abductions began occurring.

Displacement was not the only effect of the war. Murder, abductions, theft of livestock and possessions, burning of buildings and night raids were common. The war affected the net wealth and mobility of families. For example, many people lost cattle and donkeys during the war. These forms of livestock serve as a repository of capital, a means of working the land and a means of transportation. The loss of cattle and donkeys is a significant setback to these families (Interview 1).

Roughly one-third of families were born in the study area while the remainder immigrated to the area. The reasons for immigrating to and from the area are as follows:

1) Immigration to Study Area

Families originally came to this area because:

a) there were fewer people (Interview 3) which made procuring land relatively easy.

b) work was available in the form of a local sawmill, which was in operation between 1974 and 1988 (Interviews 4, 5, 8, 9, 15). Other forms of employment were also available. One individual came to the area to teach (teacher of secondary school, paid by Ministry of Education, which in turn is funded by the World Bank; Interview 10).

c) it was felt to be safer. During the war families had lost family members, land or possessions in another area and thought that by moving to the study area that they would be safer (Interview 1, 2). The reason for the safety and relative peacefulness of the area was quite straightforward - the FRELIMO garrison was based in Panda, just 23 kilometres away. The proximity of FRELIMO was felt to keep RENAMO guerrillas 'at bay' and decrease their ability to destabilize the country through rural marauding. In addition to the presence of FRELIMO in Panda, the local sawmill was also protected by FRELIMO troops (Interview 5). Whether people actually worked for the sawmill or farmed nearby, with FRELIMO patrolling the area people felt safer.

2) *Emigration from Area and Subsequent Return*

Whether they had always lived in the area or had recently immigrated some families had to leave as it became more and more unsafe. Most fled to Panda (Interviews 1, 4, 5, 8) while one family went to Maxixe (Interview2). People left the area at varying times, ranging from 1988 to 1992. All of the dates for emigration from the area occurred *after* the sawmill, which was protected by FRELIMO troops, closed down. It appears, then, that the protection and the financial stability offered by the sawmill were a major force in maintaining rural stability. On average, regardless of leaving date, people stayed away for three years. Subsequently, people returned to the area, stating that they returned because they were born here (Interview 14, 16) or because they had invested so much in the land (fruit and other trees; Interview 4). Since the signing of the Peace Accord in 1992 some male family members have left the area in search of employment in neighbouring countries, usually South Africa.

7.2.3 Language

Five language groups were represented during the interviewing process. These languages were: Shangaan, Matswa, Xitswa, Portuguese and English. Shangaan, Matswa and Portuguese were most commonly used during the interview process.

7.2.4 Traditional Beliefs and Religion

Most of the individuals and families interviewed did not practice any traditional religions (*e.g.*, animism), did not perform any traditional ceremonies, and did not attend traditional churches. Fewer than half of those interviewed identified a particular religion. Those religions identified included: International Apostolics, Light of the Apostle, Methodist and Church of the 12 Apostles. The churches were generally located nearby or in Panda.

When asked if any traditional ceremonies were still practiced a small portion of respondents (Interview 3, 4) mentioned the rain ceremony, performed for the rain god, which was performed before the respondents came to this area - they no longer perform it. The rain ceremony (Interview 3) is normally done in times of drought, usually during the mid-summer months of November and December. The ceremony involves building a structure and making sacrifices in the form of goats or chickens that are killed while people are speaking and praying. The animals are then eaten. One family said that sacrifices are not done with live animals while the other said that live animals were used. The spirit to whom the sacrifices are offered is referred to as "makwakwa", "makwaloo" or "mahalanine makwakwa"

Sometimes a celebration is held when someone dies. After the individual dies, a period of one week passes, and then a celebratory mass involving food and drink is held. Other people said that when someone dies a period of 24 hours passes and then the body is buried. There is a graveyard in the area. If the graveyard is too far away then people are buried near the house.

7.2.5 Education

1) Formal

Both boys and girls attend school (Interview3). School begins at Standard 1 and goes as high as Standard 10. School levels and locations are as follows:

1) Standards 1, 2 (Primary) - at market in study area
2) Standards 3, 4, 5 (Secondary) - nearby in Chivallo
3) Standards 6, 7 - 23 km away in Panda
4) Standards 8, 9 and 10 are available in Maxixe.

Primary school was generally between 0.1 and 2 km or less than 3 hours walk (Interviews 1, 2, 3, 4, 5). Primary school was understood to mean standards 1 and 2 with secondary education beyond this. Subjects taught from Standards 3 to 5 included Portuguese, Mathematics, Biology, Geography and History. At this level students were also taught "life skills" which included practical exercises such as how to carve a spoon, pottery and physical education. Secondary school also takes place in Maxixe and Panda.

According to one of the teachers at the school in Chivallo (Secondary school), students are taught agriculture and basic ecology as subjects, although it does not appear that they are discrete courses unto themselves (Interview 10). The same teacher stated that students are taught about local birds and animals. However, this statement was refuted by another respondent who stated that "the children do not learn about local animals in school" (Interview 5). When asked for examples about what is taught in ecology, the respondent said that he teaches:

a) that people must not set fires in the forest;
b) that people must look after the trees because they give fruit;
c) that some animal species must be protected;
d) that tortoises must be domesticated (and fed cooked mandioca);
e) that mushroom and fungi of the forest must be preserved.

According to one respondent (Interview 14), it was important that the children learn about the forest. When asked about whether it is sufficient that the animals and forests exist in books, she responds negatively stating that it would be confusing to a child to learn about these things in books and then and not see them reflected in the 'real world' around them.

Some respondents said that their children do not go to school because there was no money (Interview 13) and that money is required in order to have the correct government registration forms.

2) *Non-formal*

Non-formal education takes place when individuals are exposed to information transmitted outside of the classroom setting. Many individuals had knowledge of:

a) local plants, their names, their uses;
b) how to use plant resources to make a rope;
c) how to erect structures;
d) agricultural practices (when to pant, how to plant, how to prepare land);
e) how to prepare different food (cassava, corn);
f) local animals, their names and where to find them;
g) how to hunt, shoot, snare local game;
h) several languages.

Very few people knew how to identify the Olive-headed Weaver or its nest (including the secondary school ecology teacher who was able to recognize other weaver species). One respondent in particular, a young man who used a walker to move through the forest, correctly identified 46 out of 57 birds that were shown to him. Some of these birds were local to the area while others were not. The success rate in identification for this young man was 81percent. This same man had several things to say about the Olive-headed Weaver:

a) they only see the bird when they go into the forest;
b) they see the bird once for every 2 visits in the forest;
c) they see the bird all year round;
d) they usually see 2 birds at a time;

e) they never see birds traveling in a group;

f) usually they see the birds at the top of the trees;

g) the "eagle" eats these birds while on the wing;

h) no other animal eats these birds;

i) they will use a slingshot to kill and eat the bird.

7.2.6 Marriage

This section will consider three forms of marriage and the relationship between marriage and land. The three forms of marriage are: traditional; church; and government (official).

1) *Traditional Marriage*

The form of traditional marriage is referred to the "labola" marriage (Interview 1). A labola marriage is one in which a bride price is instituted. In the labola system a man may meet a woman either through arrangement and mediation by the families or simply based upon mutual attraction. If there is agreement between the man and woman to get married then the father of the bride sets a price or labola for his daughter. The price of the daughter may be based upon such factors as education; the more educated the woman is the greater the price, and the greater the probability of a government (official) wedding.

The labola is negotiated in cars, cash and other gifts, such as suits (formal clothing) which are given to the parents and grandparents of the bride. The labola is paid for by the groom although the groom's family may help out. Once the families have negotiated a bride price a date is set for a wedding ceremony and party. The ceremony takes place at the bride's house while the party takes place at the groom's house. As the occasion is deemed special there will be meat and alcohol served. The alcohol (five litres of wine, Interview 4), once made by the families, is now purchased from stores. The responsibility for funding the party is assumed by the groom's family. On the day of the marriage the labola is delivered by the family of the groom.

Most males who use the labola system to marry additional wives have from one to three wives. According to respondents most couples usually have about four children. The traditional labola system of marriage is the most common.

2) *Church Marriages*

While not obligatory (Interview 2) some marriages occur in a church. These are not recognized by the law (meaning government, Interview 1). According to an interpreter, at one time the Government banned all forms of church marriage which is why people got married on their own.

3) *Official Marriage*

Most respondents were not "officially married". Official marriages are those that are recognized by the government, through registration in Panda (Interview 1). For example, when asked if he has any wives, Augusta (Interview 3) replies "three". When I inquire about his "marriages" the family laughs, telling me "he is not married!". They mean his marriage has not been sanctioned by the government.

Most men get married in their early 20's while women tend to be married in their late teens, aged 17-20 (Interview 1). Marriages may or may not be arranged and this depends upon the household (Interviews 1, 4). Mutual attraction is the most important factor and this tends to sort itself out between individuals. However, if, for example, a son is working in South Africa he may write home and request that his family arrange introductions for him ("I want a wife", Interview 4). Again, though an introduction may be arranged mutual attraction is still important and there is no obligation for the meeting parties to move the relationship forward.

4) Marriage and Land.

The giving or acquisition of land is not an official part of marriage, but is something that is considered a practical, post-marriage process (Interview 2). When a man and woman get married they will share land with the groom's family (Interview 4). If there is no land they will move and acquire some. The acquisition of new land is the responsibility of the groom (Interview 2) and/or the father of the groom primarily (Interviews 3, 4). Thus, in summary, the giving or acquisition of land is arranged, often trans-generationally, by the groom's side of the family. Therefore kinship is patrilineal and land acquisition is associated with sons and maleness in this context.

7.2.7 Transportation

Most individuals in the study area relied upon a tractor ("bus") which went by on the road once a day into Panda and made the same return trip once a day. Thus an entire day could be spent doing a very simple task such as buying soap and salt in Panda. Some respondents said that the tractor was expensive and would therefore rather walk the 23-km distance (Interview 4). Some families had donkeys (Interview 4) but most people walked.

7.2.8 Health

Even though a majority of people used medicines from the forest, they also would visit the local healer and/or go to the hospital in Panda. Most individuals did not have any transportation and would have to wait for the tractor in order to get to the hospital in Panda. The most often described illnesses and diseases were stomach problems, headaches, malaria and conjunctivitis. Children are born in Panda if there is time and if there is transportation. If these are not available the baby is born at home (Interview 3).

7.2.9 Quality of Life

Respondents felt that their quality of life would be improved if they had access to:

a) hospitals (Intetviews 8, 9, 13, 14, 15)

b) transportation (Interviews 9, 13, 15)

c) schools (Interviews 9, 13, 14)

d) wells/water (Interview 2, 8, 9, 14)

e) shops (Interview 14)

f) veterinary help (Interview 15)

7.2.10 Agriculture

This section will provide a general overview of agriculture and then discuss 3 specific areas: obtaining and clearing land, perceptions about land, and livestock.

Staple crops include beans, cassava, corn and peanuts while a small portion grow papaya and pineapple. There are several types of beans: butter beans, gigeraleena (Interview 3) and nyemba beans. Mature cashews trees are common and found throughout the area. A few families culture new trees.

Most respondents felt that it didn't matter where you planted crops as all land was the same. During drought, these crops would be the first to fail. To compensate for drought, some families would plant small gardens on the flood plain, in "wet areas" (Interview 15) or the "reed bed" (Interview 12) where the soil was moist and fertile. This was most often done when staple food supplies and/or money were in short supply. These flood plain crops included lettuce, onion, potatoes and sugarcane (Interviews 12, 16). During droughts the last line of defense was cassava and its leaves (when considering cultivated crops only).

The crops take variable amounts of time to mature and the time between planting and harvest is variable – mostly due to the amount of precipitation. Average figures for maturation are: beans, 5-6 months; cashew trees, 60 months; cassava, Type A, 6-8 months/Type B, 12 months; corn, 3-5 months; peanuts, 3-6 months; pineapple, 12-24 months. Seed for crops is not usually purchased but saved from previous year's crops. If there is a poor year then it means that there is no food *and* no seed for crops (Interview 2).

In general, no fertilizers are added to the soil and no water is added to the soil. One respondent said they would use manure if they had it and chemical fertilizers if they could afford it, and if it existed (Interview1). There is no irrigation and the people depend solely on rainfall. Fertilizers also require water and this poses another challenge to improving soil fertility. Also "beasties" occur if you use fertilizers (Interview 1). Other animal "pests" which destroyed crops were listed as: "beasties" or insects; Francolins (game birds which are scared away or caught with traps); bush pigs; and, at one time monkeys (now locally extirpated).

According to respondents the land may be cultivated: indefinitely (Interview 1); until cashew and mahogany trees provide too much canopy (about 10-15 years, Interview 4); for about 3 years after which the land is "tired" and one must wait another year before planting again (Interview 8); for about 15-20 years (Interview 2).

1) *Obtaining and Clearing Land*

Respondents stated that there was not set way of obtaining land, that it could occur in several different ways including: simply arriving in the area and taking land; arriving in area and asking resident people for permission (Interview 1,2); asking the local chief or secretary where to get land; speak with Department of Agriculture (Interview 8); obtaining a sponsor from the community.

While the above may seem like separate approaches, they may actually be related. Upon arriving in the area people will find a sponsor who will help them find land. Part of this assistance may include presenting newcomers to the local chief and/or secretary who is a government official. The chief or secretary may assist in speaking with local residents about obtaining land. One respondent said that the government has no control over the land (Interview 1).

For approximately one half of all respondents the land they are now farming was originally forested. Respondents felt that where they plant crops is irrelevant - "all land is the same" (Interview 1).

The amount of land being utilized by any one respondent or family was difficult to assess. Most did not know the size of their land. Those that did estimate the size of their parcel or parcels of land estimated them to be between 2 and 6 ha. When multiple parcels or large parcels of land are owned not all of the area or all of the parcels is always utilized. Often some parcels or areas are left as forest until needed ("only half the land is cultivated"; Interview 1).

It is expected that sons will continue to farm (Interview 2) and indeed when some children and young men were asked where they would like to live they responded that they preferred the farm (to a city) because "it can give us everything we need" (Interview 7).

When it is determined that land is to be used for agriculture it is cleared completely, including any plants or trees that provide fruit or medicines (Interview 2). The majority of respondents indicated that it is men who clear the land (see Section 3.2.11). Cashew trees are either planted or left on the land, as are Natal Mahogany trees (Interviews 13, 14, 15, 16). One respondent stated that leaving any trees behind would affect "yield" (Interview 8). Clearing is largely manual with the aid of simple tools such as a machete. Clearing the land will occur through one of two methods or a combination of both. The two processes are 'ring barking' and burning. Ring barking refers to the removal of the bark and cambium layer in a ring around the trunk of the tree usually within a metre of the ground. The cutting of these layers interrupts the flow of nourishment from the leaves to the roots of the tree. The roots eventually starve, and the tree dies - a process that takes about a year. The machete is used for ring-barking. Alternately, trees may be burned, which is said to be a faster method (Interviews 1,5). Brush and deadfall material is piled against the trunk of the tree and burned. When the tree falls the branches are cut up (using the machete) and used to burn down other trees, or is used for firewood or other uses. Sometimes the tree does not fall on its own and it is left. Crops are planted around it. Eventually the tree will fall, often as a result of high winds. The tree is then burned where it fell or chopped up and used for firewood. Figure 50 shows burned trees and interplanted crops of maize and cassava. A combination of both ring barking and burning can be used as initial ring barking causing the death of the tree will make the tree weaker and easier to burn or be felled. The roots of the tree are not removed as the use of fire will allow almost complete combustion and this is viewed as fertilizer (Interview 1).

2) *Perceptions About Land*

Most respondents felt that there would always be enough forest for them and their future offspring (Interviews 13, 15). Most respondents did not feel it was important to save any forest, that "there would always be forest" (Interviews 1, 8). Children and adolescents supported this view, stating that "when we are older there will still be plenty of forest left" (Interview 7).

Opinions regarding the amount of forest and its relationship to animals was varied. Some respondents felt that when the forest was cut down that animals simply move to new forest (Interview 12).

Regarding conservation a few respondents felt it was important to save some of the forest (Interview 11, 12, 13), stating that it provides a context for education (in order to teach children about animals and forests, they must use books. However, if the animals and forest in the books do not exist in 'real' life it will be confusing for children (Interview

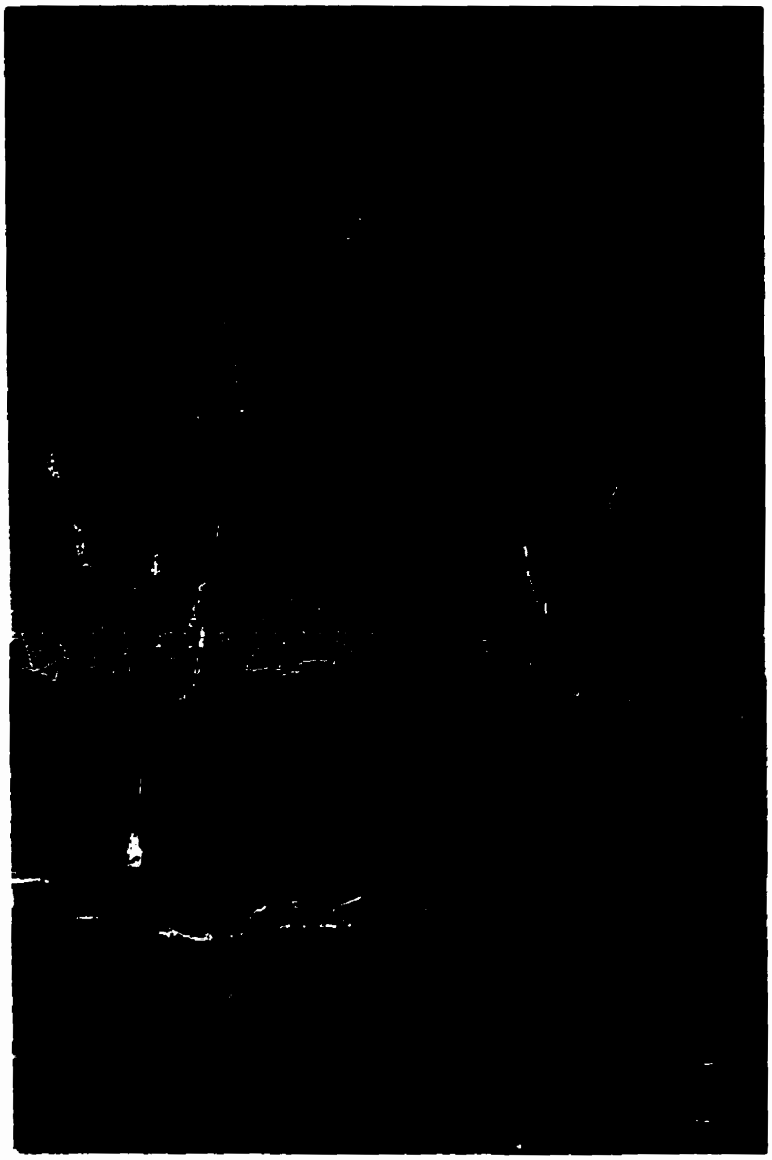

Figure 50: Tree removal via burning, clearing and planting of maize and cassava.

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14). Further, some respondents felt that if a protected forest was implemented that it would have to be implemented far away because some forest animals are bad for man like scorpion, cobras, hippos, bush pigs, monkeys and Francolins and these animals could be kept there (Interview 4, 5, 11). 'Bad animals' were interpreted to be those which could cause harm humans either directly (physical damage) or indirectly (through removing or damaging crops).

Land is usually transferred to the eldest son upon the death of the head of the family. The son then becomes the new head of the family (Interviews 1, 3)

The idea of regulation of land use is touched on by one respondent when he comments that when the sawmill was in operation there were areas where the people were not allowed to cut but now everyone could cut where they wanted to. When asked where the biggest or most amount of forest was, most respondents said that it was on the west side of the road (Interviews 9, 15). This, coincidentally was where most of the animals were said to be found and where hunting took place.

3) *Livestock*

Most families had one or more pigs, goats or chickens. Ducks were less common. Some families had cats or dogs. Few farmers had cows or donkeys which could be used to plow the field or for transportation. About half of the farmers had once owned cattle but they had been killed or stolen during the war.

<u>Part II</u> : Economic

7.2.11 Labour

Work in the fields begins early in the morning when it is cool enough to walk to the fields and work in them. Men will usually perform tasks such as tree felling and plowing while females will hoe, take care of the children and prepare meals. Both sexes will gather wood, or find thatching. People rest during the hottest part of the day (Interviews 2, 3,5,6).

While there is some division of labour as stated above, there is also a tendency for everyone to work as required or when an opportunity arises to make money. For example, although it is usually women who clear land after the trees are felled men will perform this task if being paid by someone to clear their land (Interview 11).

About half of the respondents had, at one time or another, been involved with sawmills. Many respondents came to the study area to work for the local sawmill (Interviews 4, 8, 9). For example, "Mademo" (meaning "woods of Mozambique") was the local sawmill. Eventually the sawmill closed down and then was burned down by "bandits" (Interview 11). Some individuals were involved with other sawmills before they came to the study area (sawmill in Mawaelea; Interview 2) or are presently involved with sawmills at other location, such as the sawmill in Massinga (Interview 11). The sawmill which used to be here has apparently moved to Maxixe. The sawmill used to pay 7,000 Mt per month

(10,000 Mt = approximately $1.00 US in 1997).

The preferred species sought and harvested by Mademo included (Interviews 7 and 9):

a) "chanfuta" – *Afzelia cuanzensis*, Pod Mahogany

b) "umbila" - *Pterocarpus angolensis*

c) "mitsondo" - *Brachystegia*

Not all family members stay and work on family land. Some family members (usually sons) go to work in Maputo, the capital of Mozambique, or in South Africa (Interview 3). Jobs in these other areas include taxi driver (in Maputo, Interview 1; Maxixe, Interview 2). According to one respondent (Interview 5), when males are finished schooling they will try to find a job elsewhere. This was supported in interviews with young men who stated that they would leave their home when older to look for work (Interview 7). If they do not find work they return to work on the farm. Women stay until they are of marrying age and then they go to live on the groom's land with the groom's family (Interview 5).

7.2.12 Trade

If there is extra food it may be sold or traded (Interview 4). Trade and purchase most often occur in exchange for capalanas, condensed milk, corn, rice, salt, soap, sugar, seed, oil, peanuts, coconuts, cloth or clothes (Interviews 1, 2, 3, 4, 5) and these exchanges take place at the local market or in Panda. Trading in Maxixe will fetch a higher price (Interview 1). However, transportation and funds for transportation are required. Cassava, dried and ground, is one of the most common commodities to be traded (Interview 3).

Respondents indicated that there was very little in the way of crafts or goods that were produced and sold (Interview 2). Apparently some people in the area make hats, baskets or mats but these were not seen at the local market (Interviews 2, 3). Some families cut and sell reeds (Interviews 2, 4, 5). Other items available in the local market in the study area included: paraffin, bags, biscuits, and wash powder (Interview 11).

7.2.13 Commerce

If there is extra money people will purchase things for the house or place it in the bank. When FRELIMO first came here people would hide money (Interview 1). One respondent stated that only people who work outside of the area (South Africa for example) require banks (Interview 4) and similarly another respondent stated that "only those who work outside the home have a bank account" (Interview 4). In contrast to these statements some families (both husband and wife) had bank accounts in Panda (Interview 3).

Costs of certain products were: bundle of reeds, 5,000 Mt; sugar, 10,000 Mt per kg; salt, 5000 Mt per kg; tinned fish (Pilchards), 7000 Mt per tin; small cigarettes, 5000 Mt per pack. Game is usually sold in pieces and is sometimes cooked before it is sold. Most people cannot afford to buy the whole animal. The following prices for game and domesticated animals are mentioned (all prices are in US dollars at 1997 exchange rates): duiker (whole), 200,000 Mt = approx. $20.00 US; duiker (pieces), 100,000 Mt (once all pieces sold total for animal is approximately $10.00 US); chicken (cock), 70,000 Mt (approximately $7.00 US); chicken (hen), 25-35,000 Mt (approximately $2.50 to 3.50 US); wild pig (pieces, cooked), 10,000 Mt ($1.00 US per piece). Most respondents said they would take other work if they could find it.

Part III: Ecological

7.2.14 Food and Water Security

In addition to the nutritional effects that water provides, the act of obtaining water has a variety of cultural effects mostly due to the long distance to walk, which consumes vast amounts of time and affects the daily rhythm of activities. Water also effects social attributes such as socializing, networking and the physical location of families and power. Ultimately, however, the need for water is physiological and is placed under the heading of generalized ecological needs.

Most often it is the months between August and December that provide the least food security (Interviews 9, 13, 14, 15, 16) due to insufficient rainfall. If there is no rain there is no food. While ground cassava (Figure 51) is a staple the last line of defense, during times of drought cassava leaves may be eaten (Interview 1, 3) unless people have enough

Figure 51: Pounding of Cassava root, a staple of the local diet.

money to buy food. One respondent specifically identified the fruit of *Balanites* ("inulo" tree), referred to as "inzulo", as something to eat during the drought (salt is required to boil the inner seed in order to remove the seed coat; this after the shell of the fruit has been removed.). A photograph of a young man opening this fruit is shown in Figure 52.

Water is usually available from both the stream and wells. The distance to obtain water is highly variable from "close by" and "just across the road" (Interviews 2, 13) to a few kilometres (Interviews 4, 5) or an hours walk (Interview 3, 14). Some respondents complained that the water was brackish and does not taste good (Interview 2).

7.2.15 Use of Natural Resources

1) *Utilitarian*

In general, *Brachystegia*, also known as "mitsondo", is not used for construction because it rots too quickly (Interview 4, 9), nor is it used for tools as it is not strong enough (Interview 7). The sawmill that existed between 1974 and 1988 used mitsondo for making doors and window frames (Interview 2).

The inner bark of *Brachystegia* can be used to make rope while smaller and younger trees can be used as poles. The inner red bark is also used to treat ulcers of the mouth. The wood itself is used for building houses and furniture according to some respondents (Interview 7). Other respondents said that other than the sawmill's use for the wood

Figure 52: A young man opens fruit from the *Balanites* spp. tree.

they knew of no other use (Interview 3). During one interview, when a respondent was asked if a grain silo was made of *Brachystegia,* the respondent said "no". The wood is used primarily for firewood (Interview 4).

Respondents consumed a variety of foodstuffs from the forest including plants such as: amarullo vine, which bears fruit; 'kakana", a type of climber used as a tea; "mafuru", *Trichelia emetica* (Natal Mahogany) for both fruit and oil; "masala" or *Strychnos* (Green Monkey Orange); "makwakwa" , another plant from the Genus *Strychnos*; "majajaua"; "mateetee", a grape-like fruit from a bush; "mabobo", a reddish fruit; "mavilu" or "vilu", *Vinguira fausta* (Wild Meddler); waterberries and lichen, *Usnea,* used for toilet paper, menstruation and medicine.

Wild animals are utilized frequently as a source of protein (Interviews 13, 14, 15). Most respondents ate wild game which they either killed themselves or purchased from hunters or the local market. The following is a list of animals that respondents said they ate: antelope (small); elephant; gazelle (2 types); gerbils (brown back/white front, I am shown "rat" traps; Interview 1); tortoise eggs (offered to me in camp); wild pig; francolins (killed using a slingshot); guinea fowl (slingshot); doves (slingshot); green pigeon (slingshot); black-eyed bulbul; parrot; spur-winged goose; mongoose (slingshot); rabbit (Spring Hare; slingshot); reed buck; hippo; nyala; baboon; vervet; small birds including Olive-headed Weaver (slingshot); bird eggs; zebra; and kudu.

When asked if there were more or less animals than five years ago, respondents stated that there were fewer animals. The respondents used to see kudu, many hippo, monkeys, bush pigs, gazelles, budh buck (duiker), and macaque, but now they only see monkeys which are far away and that they kill with dogs (Interviews 4, 5). There are still two hippos down in the river near Chivallo. When one respondent was asked why no one had killed the hippo he replied "because no one has the means" (Interview 4). In addition he stated that if the hippo threatens the crops they will send a message to Panda and someone will come out and kill it. According to one respondent there are still reed buck, bushbuck, nyala and sable on the far side of the river (Interview 11). In this same area (west side of road) another respondent said there were still reed buck, bush buck, nyala and sable in the forests (Interview 12). He also said that they are not allowed to kill the sable because the DNFFB would get mad.

Other (Interview 14) natural resources utilized included honey and cactus. The honey is gathered by finding bees in the forest and opening a small hole in the tree through which a cassava leave paste is placed. The paste causes the bees to leave and the honey is collected. The cacti are not indigenous to the area but grow sporadically in the forest (Genus *Opuntia*). The cacti were used by one respondent to make a fence around his household and adjacent dwellings (Interview 2).

According to some respondents the government recognizes a hunting season from September to December and outside of this period they are not allowed to take game (Interview 2). Game is hunted with dogs, bow and arrow, slingshot, snares and rifles. Some respondents stated that people with hunting licenses from Panda hunt in the area.

One respondent who identified himself as a 'professional' hunter said that he uses a bow and arrow by day and at night he uses the same with a head lamp. He says that he is not allowed to kill the hippo, according to the government. There are also crocodiles that they are prohibited from killing but the young ones are sometimes caught in snares. These young crocodiles are let go. He also collects bird eggs to sell and eat. This respondent tends to move from area to area, spending up to 3 days in an area, in order to hunt. He walks 20 to 21 km to hunt animals and concentrates his hunting on the far side (west side) of the river. He uses logging trucks to get to distant hunting areas.

A majority of the respondents use forest resources for medicine in some form (Interview 1). There were several levels of understanding and use of forest medicines:

a) a small proportion of respondents would only use a hospital and did not use forest medicines (6 percent).

b) some respondents would use medicines from the forest to cure themselves and if this did not work they would then see the *curandeiros* (56 percent).

c) some people would consult the curandeiros or shaman or herbalist when sick and receive medicine from the forest through the curandeiros (28 percent).

d) The remaining respondents (10 percent) had variable responses to questions regarding the use of forest medicines including: a respondent who thought the curandeiros to be a bad person (laughingly referred to as "mafia"; Interview 11); a respondent did not know the medicinal plants but his mother did and she would gather the medicine (Interview 11); several respondents did not use plants, did not know the names of the plants but could identify them and state their uses; some people would take medicine from the forest and if this did not work they would go to the hospital in Panda.

Of those respondents who obtained medicines form the forest examples of plants included: "kakana", used for malaria; "man root", for sores on the legs (Interview 4); "micodudo", for conjunctivitis; and papaya root, for toothaches.

2) Non-utilitarian Use

Some respondents said they liked to walk in the forest to pass the time (Interview 14) while others stated that they do not spend any time in the forest (Interview 13). The forest also posses a complex network of paths which offer shade if one is travelling through the forest. The forest also offers shade to people as they wait at the side of the road for buses.

Part IV: Political

7.2.16 Forms of Government

There is a traditional chief in the area and meeting the chief is often a formality simply to announce your presence and reasons for being in the area. At the same location there is a politically appointed secretary who acts as liaison to the government.

There was confusion about whether or not people paid taxes to the government. Most respondents said they do not pay taxes. One respondent said that they pay a "head tax" once a year for males over the age of 18 (Interview 6).

7.2.17 Government Assistance

There was confusion about the role of the government in agriculture and indeed some people did not know that the DNFFB and Ministerio Da Agricultura Y Pesca even existed (Interview 1). When asked if the Government offered any assistance to farmers some respondents said "no" (Interview 2), while others (approximately 64 percent) said, "yes, during the war". The assistance given during the war was in the form of beans, corn, peas, oil and hoes. These commodities were distributed in Panda given its relative safeness. The Government also has seeds available for purchase. One respondent purchased rice, nyemba beans and maize from the government last year (Interview 5). When assistance is offered it is offered closest to where the chief lives. For example, when wells are put in they were put on the far side of the river, closest to the chief (Interview 2).

7.2.18 Other Forms of Assistance

Some respondents said that the Red Cross used to give aid during and immediately after the civil war (1975-1992) but that this aid had been discontinued. The Red Cross gave dried beans, dried corn, fish (salted cod), cooking oil and at times offered some technical assistance. Other respondents said that they thought they received some form of aid but did not know what this aid was.

7.3 Interview Questions

1) May we ask about your family?
2) How large is your family?
3) How many people live here?
4) Who is the "head" of this family?
5) What languages does your family speak?
6) Have you always lived here?
7) Why did you choose to live here?
8) How were you affected by the war?
9) Where are your parents?
10) How many of your children are married?

11) How does one decide who they will marry?

12) How does courtship and the ceremony take place?

13) Where do marriages take place? In a church?

14) At what age do people get married?

15) Where is the church?

16) Do you go to a church?

17) Where will the newly married couple live? How will they get land?

18) Where do they get the land?

19) Who will work the land?

20) How much land do you have here?

21) What do you do if you want more land?

22) Is there enough land for your children? Your grandchildren?

23) How far does the forest go?

24) Is there other work that can be done in this area?

25) What is grown on this land here?

26) When are the various crops planted and harvested?

27) Do you use fertilizer?

28) Do you use water?

29) Where do you get water?

30) Does it matter where you plant your crops?

31) How do you clear the forest?

32) The trees that are felled (Brachystegia) can they be used for anything?

33) Do you have any equipment for farming or clearing the forest?

34) Are you ever without food?

35) What do you do when you are without food?

36) What time of year does the shortage of food usually occur?

37) Does the government offer you any help? Other organizations?

38) Do you ever have an excess of food? What do you do with it?

39) Do you have livestock?

40) Is it important to leave any of the forest? Why or why not?

41) What does the forest provide?

42) Are there any animals in the forest?

43) Do forest animals cause problems for your crops?

44) Can you eat any of the animals from the forest?

45) Which animals can you eat?

46) What birds are good to eat? Do you eat the small ones?

47) Do you eat wild bird's eggs?

48) Are they easy to find? Do you have to walk far?

49) What else does the forest provide (food, medicine, firewood)?

50) Are there foods that can be gathered from the forest?

51) Are there medicines that can be gathered from the forest?

52) What do you do when you are sick?

53) What kind of illnesses do people get?

54) Do you go to a hospital or shaman (herbalist/"koo-ran-day-oh")?

55) Do you go to Panda or other towns or cities for any reason? Why?

56) What do you purchase there?

57) Do you have transportation?

58) What do you do on a typical day?

59) Do you make anything that you sell?