INTRODUCTION

All life on earth is part of one great, interdependent system. It interacts with, and depends on, the non-living components of the planet: atmosphere, oceans, freshwaters, rocks and soils. Humanity depends totally on this community of life—this biosphere—of which we are an integral part (Global Biodiversity Strategy, 1992).

In the remote past, human actions were trivial when set against the dominant process of nature. No longer. The human species now influences the fundamental processes of the planet. Ozone depletion, world wide pollution and climate change are testimonies to our power.

Economic development is essential if the millions of people who live in poverty and endure hunger and hopelessness are to achieve a quality of life commensurate with the most basic of human rights. Economic progress is urgent if we are not only to meet the needs of the people alike today but also to give hope to the billions born into the world over the next century. Better health care, education, employment and other opportunities for a creative life are also essential components of a strategy for keeping human numbers within the planet's "carrying capacity".

Development has to be both people-centered and conservation-based. Unless we protect the structure, functions and diversity of the world's natural systems—on which our

species and all others depend—development will undermine itself and fail. Unless we use Earth's resources sustainably and prudently, we deny people their future. Development must not come at the expense of other groups or later generations, nor threaten other species' survival.

THE VALUE OF BIODIVERSITY

Earth's plants, animals and microorganisms—interacting with one another and with the physical environment in ecosystems—form the foundation of sustainable development. Biotic resources from this wealth of life, support human livelihood and aspirations and make it possible to adapt to changing needs and environments. The steady erosion of the diversity of genes, species and ecosystems, (together form biodiversity), taking place today will subvert progress towards a sustainable society. Indeed, the continuing loss of biodiversity is a telling measure of the imbalance between human needs and wants and nature's capacity (Botkin and Keller, 1995).

From both wild and domesticated components of biodiversity humanity derives all of its food and many medicines and industrial products. The sheer 'variety' of life has enormous value. The variety of distinctive species, ecosystems and habitats influence the productivity and services provided by ecosystems (Raven, 1992). The value of variety is particularly apparent in agriculture. For generations, people have raised a wide range of crops and livestock to stabilize and enhance productivity. The wisdom of these techniques—including their contributions to watershed protection, soil fertility maintenance and receptivity to integrated pest management strategies—is being reaffirmed today as farmers around the world turn to alternative low-input production systems.

The many values of biodiversity and its importance for development suggest why biodiversity conservation differs from traditional nature conservation. Biodiversity conservation entails a shift from defensive posture—protecting nature from the impacts of development—to an offensive effort seeking to meet peoples' needs from biological resources while ensuring the long-term sustainability of Earth's biotic wealth. It thus involves not only the protection of wild species but also the safeguarding of the genetic diversity of cultivated and domesticated species and their wild relatives (McNeely *et al.*, 1991).

LOSSES OF BIODIVERSITY AND THEIR CAUSES

Biological diversity is being eroded as fast today as at any time since the dinosaurs died out some sixty five million years ago. The crucible of extinction is believed to be tropical forests. Around 10 million species live on earth according to the best estimates and tropical forests house between 50 to 90% of this total (Reid, 1992). About 17 million ha of tropical forests are now being cleared annually (FAO, 1991), and scientists estimate that at these rates roughly 5 to 10% of tropical species may face extinction within the next 30 years (Ehrlich and Wilson, 1991; Reid, 1992). This estimate may prove conservative, however. Rates of tropical forest loss are accelerating and some particularly species rich forests are likely to be largely destroyed in our lifetime. Some scientists believe that about 60,000 of the world's 240,000 plant species and perhaps even higher proportions of vertebrates and insect species, could lose their lease on life over the next three decades unless deforestation is slowed immediately (Raven, 1988).

The current losses of biodiversity have both direct and indirect causes. The direct mechanisms include habitat loss and fragmentation, invasion by introduced species, the over exploitation of living resources, pollution, global climate change and industrial agriculture and forestry but these are not the root of the problem. Biotic impoverishment is an almost inevitable consequence of the ways in which the human species has used and misused the environment in the course of its rise to dominance.

WOODLAND: THE LAST PRESERVE OF BIODIVERSITY

A woodland or forest is the culmination of several cycles of replacement communities, both plants and animals and hence represents a stable phase of a biosphere. The fauna and flora of the forest is a product of several physical factors woven into a fabric—what Yapp (1962) calls as 'web of life'—over a period of time.

Of all the biomes, the forest is the best preserved biosphere with maximum species diversity. Scientists were startled in 1980 by the discovery of a tremendous diversity of insects in tropical forests. In one study of just 19 trees in Panama, fully 80% of the 1,200 beetle species discovered were previously unknown to science. At least six million to nine million species of arthropods—and possibly more than thirty million—are now thought to dwell in the tropics with only a small fraction currently described. A single square meter of temperate forest can hold 200,000 mites and tens of thousands of other

invertebrates. How many species these communities contain is still anyone's guess (Thomas, 1990).

DEFORESTATION: A GLOBAL DILEMMA

In spite of the importance of forests, it is difficult to determine the net rate of change in forest resources worldwide. Some experts believe that there is a worldwide net increase in forests because large areas in the temperate zone which were cleared in the nineteenth and early twentieth centuries are now regenerating. Other experts believe that there is a worldwide—and perhaps rapid—net decrease in total forest area. The surprising and important point is that information is lacking on which to base an accurate evaluation. Because forest cover large, often remote areas that are little visited or studied, it is difficult to assess the total amount of forest area. Only recently have programmes begun to obtain accurate estimates of the distribution and abundance of forests and these suggest that past methods over estimated forest biomass by 100% to 400% (Council on Environmental Quality and the US department of State, 1981).

Recognising the limits of existing information it is useful to review the standard information about forests. It is generally estimated that forest covered one-quarter of the Earth's entire land area in 1950, but only one-fifth in 1980 (Botkin and Simpson, 1990).

Today deforestation continues in areas where forests remain. Many of these forests are in tropics, in mountain regions or in high latitudes—places that were difficult to exploit before the advent of modern transportation and heavy earth-moving machines (Perlin, 1989). The problem is especially severe in tropics because many tropical nations have high human population growth (Buschbacher, 1986).

The destruction of tropical forests in the world today is so extensive, devastating and irrevocable that humanity may soon lose one of its richest, most diverse and valuable biotic resource. Exploding population and ignorance of ecological systems are the main causes of such heavy depredation. However, another major cause of forest loss is the expansion of marginal agriculture, though in specific regions commercial timber harvest may pose an even greater problem (Janzen, 1988).

STATUS OF FORESTS IN INDIA

In the Indian subcontinent the term forest does not merely mean an area covered with trees but it carries the impression of and entity that is a sum total of ecological, edaphic

and biological parameters. According to the cultural traits of the country, forests hold a very important place in the life and philosophy of the people apart from the material gains that it brings about continuously ever since the birth of civilization.

India has an area of 752.3 lakh ha notified as forest of these, 406.1 lakh ha area is classified as reserved and 215.1 lakh ha as protected. Unclassified forest area is spread over 131.1 lakh ha. About 22.74% of the country's total geographical area is under actual forest cover. However, independent forestry experts put the figure much lower (Trivedi and Raj, 1992). Increased urbanization, industrialization and mining has entailed indiscriminate felling of trees and denudation of forests. According to an estimate (Trivedi and Raj, 1992) India is losing more than 1.5 million ha of forest cover each year and has already lost 22 million ha of forest during the last three decades due to over exploitation, misuse and conversion to agricultural fields.

FORESTS OF GUJARAT: THE STATUS QUO

The area under forest in Gujarat is 18,707.80 sq. km. which accounts for 9.532% of the total area of the state (Forest Department, Govt. of Gujarat). The eastern border of the state is endowed with a discontinuous chain of hilly forest patches. These hilly regions form the part of Aravallis, Vindhyas and Westernmost spurs of Satpura ranges and northern spurs of Sahyadri ranges. The vegetation becomes denser when one moves from North to South Gujarat, as the rainfall increases towards the South and is maximum at Dharampur and in the Dangs forests. The soils are also richer in South Gujarat than in North Gujarat and Saurashtra. Patches of moist deciduous forests start south of the river Narmada and slowly merge with the completely moist deciduous forests with some elements of evergreen species on the southern side of the Tapti river. On the other hand, the forests are dry deciduous in the hilly areas in the North and Central Gujarat slowly merging with thorny scrub jungles, especially where grazing pressures and other biotic interferences are high. The tropical dry deciduous forest also exists in Junagadh district. Northern parts of Saurashtra are more arid and the vegetation is more like that of the Rann of Kutch—the scrub jungles (Gujarat Ecology Commission, 1996).

Gujarat has vast areas of land that are draught prone, severity of which varies from year to year. The decline in vegetation will increase the pressure on the existing forest patches, fragmenting them even further. Once contiguous forest belts of the eastern border of Gujarat is now represented by patches. The movement of species will be further hampered by the fragmented condition of the forests. Between these forest

patches human settlements move in further, preventing recolonization or even regeneration. The first casualty of fragmentation of forests will be trees and the dependent animals of the woodland.

According to Sauer (1994) a native forest community cannot maintain itself without successful regeneration of its species which requires successful reproduction and survival at the early life stages of the species that make up the community. This process called 'recruitment' is not taking place in most of the forests in Gujarat, which contributes to the rapid decline of the forest cover. The failures of recruitment are due to exotic species, exotic pathogens, altered water tables, pollution, altered fire patterns, changes in populations of grazing animals, landscape fragmentation and direct disturbances by humans. Illegal grazing of animals in forest areas usually results in removal of the saplings, eventually leading to inadequate regeneration and recruitment (Gujarat Ecology Commission, 1996).

STUDY AREA AND ITS IMPORTANCE

The area (Shoolpaneshwar Wildlife Sanctuary—SWS) surveyed during the present investigation is situated in the hilly ranges of the Bharuch district in South Gujarat. The SWS has received great attention as it is a part of the catchment of Karjan reservoir as well as the proposed Sardar Sarovar. It is also one of the best forests in Gujarat.

The Shoolpaneshwar Wildlife Sanctuary is an extension of the old Dumkhal Slothbear Sanctuary. Previously this was a hunting reserve of the erstwhile state of Rajpipla. The Gujarat gazetteer Bharuch district mentions about the presence of thick moist deciduous to semi evergreen forests in the area with a large number of wildlife, including Bison (Palande, 1961).

Initially, for the protection of endangered wild animals an area of 150 sq. km. was declared protected under section 18 of the Wildlife (Protection) Act 1972. This area has been known as Dumkhal Slothbear Sanctuary. Later, on recommendation of Rishad Naoroji, who first noticed the rich avifaunal diversity in this area, 297 sq. km. of adjoining land was added to the Dumkhal Slothbear Sanctuary in the year 1987. By declaration of the said additional area the sanctuary area is increased to 448 sq. km. with a new name for the entire area as 'Shoolpaneshwar Wildlife Sanctuary' (Amin, 1992). Shoolpaneshwar is a historic temple located on the bank of river Narmada in village

Surpan, which along with other two villages on the northern periphery of the sanctuary will go under submergence once the construction of Navagam dam is completed.

After declaration of the additional area as wildlife sanctuary the authorities felt that still some important area is left out for protection under section 18 of Wildlife (Protection) Act 1972 and hence an area of 159 sq. km. has been further proposed as an additional area to the present SWS. After this latest addition and also some revenue areas (which were not included in the forest department documents), the SWS now comprises of an area of 675 sq. km (Amin, 1992).

OBJECTIVES OF THE PRESENT STUDY

The available literature indicates that the sanctuary area has been explored for its floristic component (Singh, 1969; Patel, 1971; Pradeepkumar, 1993). Nevertheless, the study of fauna has been largely limited to birds and that too confined to parts of the present study area (Ali, 1956; Monga and Naoroji, 1984; Naoroji, 1985). The first objective of the present study therefore, was to **identify the different life forms and enlist them** (Chapter I). A long list of names of plants and animals makes reading laborious. However, listing of these life forms is necessary for knowing what is present today and later, a similar list will make it possible to evaluate the nature and extent of changes that have taken place.

Like any of its type world over, the forest biotope of the SWS would also be facing the threat of degradation due to anthropogenic activities. The loss of forest habitat affects the survival, composition, abundance and distribution of organisms. One particular community which is very prone to any change in environmental conditions is that of birds (Morrison, 1986). Birds have been considered useful biological indicators because they are ecologically versatile and live in all kinds of habitats as herbivores, carnivores and omnivores (Järvinen and Väisänen, 1979; Järvinen, 1983). Having a strict habitat preference and relatively short genesis time birds are very sensitive to change in habitat and hence can be used as an excellent indicator community to assess the modification to existing habitat (Joshua and Johnsigh, 1986). Therefore, as a prime goal of the present study, an **extensive ornithological survey** in Shoolpaneshwar Wildlife Sanctuary was undertaken (Chapter II). One of the major benefits of such bird community studies in forested habitat and estimation of abundance of bird species is that the studies when repeated after several years, could help in assessing the status of bird species themselves and their habitat (Joshua and Johnsigh, 1986).

Species composition of a community is interlinked to the available resources of the area in question. Differences in food sources and patterns of food availability affect the species composition and exploitation patterns of the bird community. The structure of the bird community changes with changes in the diversity and abundance of food resources. Other factors such as physical structure of the habitat (stratification, foliage density, etc.) and biotic interactions also influence the number of individuals and species inhabiting the forest. Algar Rajan (1994) is of opinion that the prolonged habitat loss will lead to the decrease in number of the 'forest interior species' which in due course will be replaced by the 'edge species'. Because of their extreme vertical mobility birds are especially sensitive to vertical stratification of vegetation and because of their size and activity lend themselves well to observation (Pearson, 1971). In Point Calimere Wildlife Sanctuary it was observed that the loss of canopy cover indirectly affected the population of the bird species especially the breeding birds (Algar Rajan, 1994). Hence, in the current study an attempt was made to learn the **pattern of distribution of avian community in relation to its trophic and habitat preferences and also in relation to the vertical stratification** (Chapter III).

Moreover, the Rajpipla forests (now a part of SWS), have long been identified as a rich abode for raptors (Monga and Naoroji, 1984). Nevertheless, such a diverse population of raptors, occupying higher trophic level might greatly influence the co-existence of other organisms in the biotope. In the present study therefore, an attempt was also diverted at understanding **the mode of utilization of resources among various species of raptors and owls in the sanctuary** (Chapter IV).

Finally, using the baseline data derived from the present study, certain recommendations have been made with the hope that it could be applied to the management of this area and in a modified form be applied to the management of other similar biotope elsewhere in the country.