IMPACT OF AGRICULTURAL DEVELOPMENT ON WILD LIFE ECOLOGY AROUND DUDHWA NATIONAL PARK.

DISSERTATION

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CERTIFICATE

This is to certify that Miss Shahina Taiyeb has completed her dissertation 'Impact of Agricultural Development on Wild Life Ecology Around Dudhwa National Park' for the degree of Master of Philosophy under my supervision. To the best of my knowledge this is an original work and has not been previously submitted for any degree of this or any other university.

I recommend that this dissertation be placed before the examiner for evaluation.

(Mehdi Raza)
Supervisor

DEDICATED
TO
My Parents

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(Shahina Taiyeb)

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INTRODUCTION

The present study 'Agricultural Development and its impact on wild life ecology around Dudhwa National Park' is related to the general problem of wild life preservation. Since wild life cannot survive in ecologically imbalanced environment, the study of ecosystem and its component is essential.

In an ecosystem every component is in a perfect state of equilibrium. Any process of economic development by human societies with varying levels of their technology in harvesting natural resources, is an intervention in nature and its life support system.

Wild life and its conservation is very important from economic point of view. To a layman conservationist are anti social element and they take it into negative sense. In fact, the concern for wild life is in a sense the concern for man himself. All forms of life human, animal and plant are so closely interlinked that disturbance in one gives rise to imbalance in the others. The existence of man and his civilization would ultimately be threatened with the extinction of species of plant and animals.

To understand this it is necessary to describe some basic principle of ecology. Ecologist consider all organic life on earth to be organised as a series of energy transfers called trophic levels in a closed system of living and non-living parts which they call the ecosystem. Plants comprises the first trophic level because they convert the solar energy into organic matter or plant tissues. Plants are also called the autotrophs or primary producers. Animals who feed on plants are called herbivores, or primary consumers. Animals who feed on herbivores are called carnivores or secondary consumers. Omnivores, like man feed on both plant and animals. There are also organisms which feed on products of decay called 'decomposers'. They release the energy back into the ecosystem and complete the cycle. Producers, consumers and decomposers constitute the food chains. Various food chains are again joined at different trophic levels forming complected food webs. In this intricate web of relationships, the existence of one organism is dependent upon the other.

Such food chains also keep a check on their numbers. Even a single link in this strand creates an imbalance which ultimately threatened the existence of man on this planet. Pollutants, like insecticides, or

industrial effluents, are now known to travel through different organisms in the food chain, passing from one organism to other, affecting man himself as the ultimate consumer. Nature maintains this vast diversity of animals and plants in a complex organisation in which the various life processes of production consumption and disposal of waste are maintained in a well balanced cycle. Man has disturbed this cycle by his interference and in discriminate destruction of forest and wild life. In this way he is cutting his own neck.

Wild life is the best indicator of this imbalance. Wild life at any level where the imbalance exist, wild life start getting extinct. Man can check that level and maintain this intricate cycle of relationship wild life are also renewable resources as long as the ecosystem is not disturbed but they will also become nonrenewable, if natural conditions are not favourable to them. If one species of plant and animal get extinct it has gone forever and its economic importance to man also came to an end. That is why conservation of wild life has become the very important for human existence as well as for economic point of view.

Keeping in view the above mentioned point the first chapter is related to the ecosystem, the concept in

geography. Since wild life cannot survive without its habitat, which in turn depends upon the ecosystem. Geographers, also study ecosystem ecology but they give more important to environment while ecologist to organism.

The delicate ecological balance has been constantly disturbed by man's developmental activities. The second chapter of this study is related to economic development and ecological imbalance.

The third chapter is related to the ecological animal geography. This chapter deals with the distribution of animals on the earth surface and the mutual influence of environment and animals upon each other.

The rapid extinction of certain species, and threat to others have created a sense of awareness among naturalist and ecologist. The main cause of their depletion is man himself. The habitat destruction, poaching and other activities of man have accelerated the extinction of wild life on this planet. The fourth chapter,'man and vanishing animals' highlited such problem.

The last chapter of this study devoted to a brief geographical account of the study area - Dudhwa National Park, Lakhimpur Kheri. The general features of the park are discussed in it.

CHAPTER I

ECOSYSTEM, THE CONCEPT IN GEOGRAPHY

In recent years there has been a marked growth of geography's interest in ecological problems relating to an ever increasing involvement of geographers in all aspect of environmental management: this has been primarily necessitated by growth of production potential with the last few decades; accelerated pace of scientific and technological discoveries; an expotential increase in population; a progress in those sciences which offer a macro- view of phenomena and a basic and recurrent questioning of the goals of 'consumer society'[1] (Poelmans-Kirschen, 1974).

Geography shares this concern with the biospheric preservation as a viable ecosystem with ecology and a number of other sciences. Both geography and ecology share a common interest in the 'distribution, organisation and morphology of phenomena on the surface of the earth and it is therefore not surprising that a broad similarity exists between the two in terms of concept, methods and techniques.

The wholistic 'conseptualisation' of man environment relationship, which in modern parlance would be termed the

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1 Poelmans Kirschen, J. (1974), 'Consumption and the Environment', Naturopa 21, pp.23-5.

ecological perspective, is not new in geography. The classic position was stated by Hettner[1] (1905, p.554): "both nature and man are intrinsic to the particular character of areas and indeed in such an intricate union that they cannot be seperated from each other. "Hettner's formulation of the man environment interaction has crystallized into a distinctly ecological view point in geography with a deep committment to problems of resource evaluation and management. The ecological point of view in geography seeks to evaluate the complex interrelationships in the man environment society formet. The ecological perspective in geography was further strengthened by the relevance movement in Geography in 1970.

Of late the internal structure of geography has been under going significant changes which are being manifested in diverse emerging trends and yet at the same time there is an increasing unity of approach to the subject. Haggett (1972)[2] observes that the realms of geographical

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1 Hettner, A. (1905), Das Wesen and die Methoden der Geographie; Geographische Zeitschrift, 11, pp.545-564.

2 Haggett, P. (1972), Geography - A Modern Synthesis (Harper and Row, New York).

activity can be rationally divided into three analytical approaches:

1) Spatial analysis which focusses attention on spatial relationships and interactions in properties or series of properties of the environments.

2) Ecological analysis which has its focuss on symbiosis in man-environment variables and,

3) The regional approach which seeks to combine the spatial and ecological approaches in geography. "The region has been regarded as a unique functional complex which is in an apparent equilibrium and constitute a 'whole' which is more than the sum ofits part. This concept of region which is so similar to the ecological approach has been fully reflected in the French school of regional geography and also in the works of British geographers in the first half of the century.

Among the different sub-disciplines of geography the ecological perspective has always been the focal theme of biogeography which conceptually and methodologically acts as a bridging discipline between human geography and physical geography. Indeed, in view of its dominant ecological approach, the status of biogeography as a

sub-discipline of geography has often been questioned. Scholars like Friedrichs[1] (1958) would regard biogeography as simply a part of ecology. Powe (1961)[2] and Fosberg (1976)[3] however, suggests a criterion for differentiating the two disciplins which based upon the scale of the study. 'Ecology' according to Fosberg is essentially a study of small scale local ecosystems while ecological studies on a regional, continental or global scale would fall within the realm of biogeography but irrespective of the scale of study due to methodological nuances ecosystem studies can be regarded as essentially biogeographical. In the ecosystem is not merely the study of relationship between the individual species of plants and animals but puts emphasis on the functional linkages between the organic and inorganic components and spatial organization of and within the ecosystem, this is primarily an area of concern for biogeography. Moreover in most ecosystems, man is

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1 Friederichs, K. 1958, 'A Definition of Ecology and Some Thought about Basic Concepts', Ecology, 39, pp.154-9.

2 Powe, J.S. 1961, 'The Level of Integration Concept and Ecology', Ecology, 42, pp.420-7.

3 Fosberg, F.R. 1976, 'Geography, Ecology and Biogeography', Annals of the Association of American Geographers, 66, pp.117-28.

an ecologically dominant component he has to be assigned a pivotal role in ecosystem studies.

Man indeed, because of his dominant role is creating and recreating new ecosystems, Geography conceptually and methodologically better equipped than ecology to study ecosystems dominated not by man the organism but man the culture bearer. Simmons (1974)[1] accordingly suggests that attention in biogeography should centre on a synthesis of ecology, cultural anthropology and economics.

In spite of the clear cut disciplinary goals, as outlined above, modern biogeography has not impirically and methodologically lived upto expectations. It suffers from obvious weaknesses as pointed out by Saur (1972). There appears to be a preoccupation with field exploration and its con-comitant involvement with the details of biotic distribution at the expense of the development of a coherent body of theoretical generalizations.

Within the limits imposed by a lack of theoretical generalization, the range of interests persued by biogeography

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1 Simmons, I.G. 1974, The Ecology of Natural Resources (Arnold, London).

has been truly impressive. According to Cole (1971)[1] biogeographical studies can be put into six main areas of interest:

1. Physiology, composition and distribution of species of plants and animals at different scales.
2. Studies of plants and animals ecologies at different scales in temporal perspective, seeking to explain the changing pattern of species distribution.
3. Pedological studies, specially the role of cultural practices on soil developments.
4. Geo-botanical and bio-geo-chemical studies focussing on analysing the role of physiographic factors on plant distribution and plant mineral contents.
5. Studies of applied nature with a integrated approach to the understanding of vegetation, soil, geomorphology and land use practices with a view to provide a scientific basis of evaluation and resource management.
6. Conservation and resource studies heavily draw upon both geography and ecology.

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1 Cole, M. 1971, 'Plants, Animals and Environment', Geographical Magazine, 44, pp.230-1.

The increasing significance of biogeography as a major sub-descipline of geography is noted in last two of the themes listed above. As aptly stated by Taylor (1974)[1] biogeography can and should play an important role in the resource management movement because conceptually and methodologically can integrate the physical and cultural aspects of resource assessment both in terms of present utilisation and the potential. The discipline therefore is well placed to provide scientific basis of perspective resource planning. The main contribution of biogeography, or for that matter geography itself is that firstly it can ideally suggest strategis for resource development that could reconcile ecological, cultural or environmental parameters. Secondly the ability to reconcile the global, macro, meso and micro view points of space relations and thirdly, being essentially interdisciplinary in nature, the ability to borrow and incorporate ideas and methods from a wide range of sister disciplines between the animate model and the physical environment, provides an ideal conseptual framework for analytical studies of

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1 Taylor, 1974, 'The Ecological Basis of Resource Management', Area, 6, pp.101-6.

all aspects of man environment interaction biogeography as already explained broadly corresponds to ecology, the main difference being that the geographers puts the environment first and the biologist the organism.

The organism plants and animals and the habitat functionally constitute an ecosystem, short for ecological system. The ecosystem exists and functions in that part of the earth which is called the biosphere which comprises four principal components: plants, animals, man and micro-organism apart from the components of the physical environment. There a total and complete structural and functional interdependence between the components of a biospheric ecosystem. For example an organism cannot survive outside its group (population) and the community (all the population occupying a given area) cannot exist without the water nutrients and energy cycles of an ecosystem.

Before we proceed further it would be worthwhile to elaborate the eomsept of an ecosystem. The term was coimed and used first by ecologist Tansley[1] in 1935 as a

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1 Tansley, A.G. 1935, 'The Use and Abuse of Vegetational Comsepts and Tsrms', Ecology, 16, pp.284-307.

general terms denoting the whole complex of organism together with the habitat they occupy. All linked by an intricate web of relationships. Fosberg 1963[1] defines an ecosystem as follows: "a functioning interacting system composed of one or more living organism and their effective environment both physical and biological...." The ecosystem clearly involves very complex relationships. In terms of Forsbergs definition in the ecosystem concept the functional relationship between organisms and their physical environment is of overriding importance. The biotic component of the ecosystem depends upon the abiotic components for carbondioxide, water and nutrients. The decomposition of the biota after death is also facilitated by the abiotic elements. The food chain which facilitate the distribution of energy in the biota as well as the pathways through which the chemicals essential to life move through the ecosystem generally operates in a circular cyclic manner. An understanding of the flow of energy and nutrients in the ecosystem is essential for perceiving that may be the most subtle and dangerous interests to the existence of organism man, included.

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1 Fosberg, F.R. (1963), The Island Ecosystem in Fosberg, F.R. (Ed.), Man's Place in the Island Ecosystem, Honolulu, pp.1-6.

The ecosystem represents the application of formal system analysis to organism - environment existence. A system has been defined (Chorley and Kennedy 1971)[1] as "a structured set of objects and or attributes, consisting of variables that exhibit discernable relationships with one another". The world, therefore, can be visualized in system terms, as an interlocking and interdependent system of biotic and abiotic elements at different hierarchic levels. According to Parke 1980,[2] a system can be isolated, closed or open depending upon the degree of interchange of mass and energy with the surrounding system.

The isolated system is more or less related with no exchange of matter and energy with its environment. A closal system lacks ability to exchange matter with its environment but can do so far energy is concerned. An open system, exchanges both matter and energy with its environment. All the three types of system belong to one of the following subsystems: natural, modified and controlled. In the natural system there is no interference by man. In the modified system human interference takes

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1 Chorley, R.J. and Kennedy, B.A. (1971), Physical Geography - A System Approach, (Prentice Hall).

2 Parke, C.C. (1980), 'Ecology and Environmental Management, p.41.

place but on a limited scale on the other hand in the controlled system human action is the major regulator in the present day model. Most ecosystems are either modified or controlled depending upon the degree of human interference.

We are now in a position to summarize the main attributes of an ecosystem (Smith, 1974).

1. An ecosystem is a major ecological unit consisting of both functionally interdependent of biotic and abiotic components.

2. The components of the ecosystem are bound together by a cyclic flow of energy and matter through a number of structured relationship between soil, water, nutrients, consumers and decomposers.

3. The function of an ecosystem is entirely related to the maintenance of these cyclic flows through its structural components.

4. In a natural ecosystem the total amount of energy is fixed and depends upon the amount of plants fiscal which in turn limits the number of organisms at each feeding levels.

5. Ecosystem are maintained in a dynamic state of equilibrium and pass on from a less complex level to a more

complex state, a directional change which has been termed succession the early stages are characterized by an excess of energy per unit of biomass. As the ecosystem becomes more and more mature, the energy flows through more complex channels, there is little waste of it.

6. As the total amount of energy in a natural ecosystem is fixed, the size of the population that an ecosystem can support is also necessarily limited. The population cannot cross the limits without seriously jeopardizing the whole system. Then for a healthy, functioning ecosystem the population has got to be stabilized.

7. The major functional unit of the ecosystem is the population.[1] It occupies a certain functional niche that is related to the population's role in energy flow and cycling of nutrients.

8. Both the environment and the amount of energy fixation in any given ecosystem are limited. When a population reaches the limits imposed by the ecosystem, its numbers must stabilize or failing, this, decline (often sharply) from desease, strife, starvation, low reproduction and so on.

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1 Robinson, N., Biogeography, 1972, p.28.

9. The ecosystem has historical aspects, the present is related to the past, and the future is related to the present.

10. The distribution of ecosystem on the earth is remarkably small in geographic extent when compared with the total volume of earth. What we term the biosphere including only the surface layer of solid ground or sediments beneath bodies of, water, the oceans, lakes and streams and that portion of atmosphere inhabited by flying or floating organisms such as birds, bats and bacteria.

COMPONENTS OF THE ECOSYSTEM

Humanity shares the physical vehicle of earth with an enormous diversity of other living things, plants, animals and microorganisms. There may be as many as 10 million different ~~kinds~~ species of organisms alive today. In turn each species consist of one or more population, being a group of individuals more or less isolated from other populations of the same species. This diverse array is not static. The populations of plants, animals, and microorganisms of earth or of any area of earth make up a biological community, a community bound together by an intricate web of relationships, of course

this living web is embedded in the physical environment, interact with it and modifies it.[1]

Thus from structural point of ecosystem has two components. The first is biotic and other is abiotic.

1. Abiotic Substances

1. These include basic inorganic and organic compounds of the environment. The inorganic components of the ecosystems are carbon dioxide, water, nitrogen, calcium, phosphate, all of which are involved in material cycles (geochemical cycle);[2] It also includes such physical factors and gradients as moisture, wind currents and solar radiation. The amount of non living components such as phosphorus, nitrogen, etc. that are present at any given time is known as standing state or standing quantity. The amino acids, decomposition products of animal are also abiotic substances.

2. Organic compounds of ecosystem are protein, carbohydrates, lipid, humic substances and amino acids, all of which are synthesized in the biotic phase.

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1 Ehrlich Paul, Ehrlich, H. Anne, and/John, P., Holdren Eco-Science, Population, Resources, Environments, pp.97-98.

2 Verma, P.S., "Cell Biology, Genetics, Evolution and Ecology", 1980, p.142.

2. Biotic Components

Biotic components consist of producers, consumers and decomposers.

1. Producer are autotrophic organism (self nourishing) largely green plants, which are able to manufacture food from simple inorganic substances. Synthetic bacteria also comes into this classification. On land the producers are usually large rooted green plants while in deep water systems they are microscopic plants known as phytoplankton. (phyto = plant, plankton = floating life)[1] Chemosynthetic bacteria and carotinoids bearing purple bacteria that also assimilate Co_2 with the energy of sunlight but only in the presence of organic compounds, also come in this category.

The term producer is misleading one because in an energy context, producers produce carbohydrates and not energy. Since they convert or trans duce the radient energy into chemical form E.J. Kormondy suggests better alternative terms 'converters' or 'transducers'. Because of wide use the term producer is still retained.

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1 Odum, P. Engine, Fundamentals of Ecology, 1971, pp.8-9.

2. Consumers - Those living members of ecosystem which consume the food synthesized by producers are called consumers. Under this category are included all different kinds of animals that are found in an ecosystem. There are different classes or categories of consumers such as:

a) consumers of the first order or primary consumer, macroconsumer or phagotrophs,

b) consumer of the second order or secondary consumer,

c) consumers of the third order or tertiary consumers, and

d) parasites, scavengers and saprobes.

Primary Macro Consumers or Phagotrophs (phago = to eat)

In this category comes purely herbivorous animals that are dependent for their food on producers or green plants.[1] Insects rodents, rabbit, deer, cow, buffalow, goat are some of the common herbivores in the terrestrial ecosystem, and small crustaceaus molluscs etc. in the aquatic habitat Elton (1939)[2] named herbivores of ecosystem as "Key industry animals". The herbivores serve as the chief food source for carnivores.

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1 Osum, P. Eugene (1971), Fundamentals of Ecology, p.8.

2 Kaushik, M.P. (1974), Introductory Ecology, p.210.

Secondary Macro Consumers include both carnivores and omnivores. Carnivores are flesh eating animals and the omnivores are the animals that are adapted to consume herbivores as well as plants as their food. Example of secondary consumers are sparrow, cros, fox, wolves, dogs, cat, snakes etc.[1]

Tertiary Consumers or Micro-consumers /are top carnivores which prey upon other carnivores, omnivores and herbivores, lions, tigers, hawk, valture etc. are considered as tertiary or top consumers.[2]

Parasites, Scavengers and Saprobes (Sapro to decompose) or Osmotrophs (Osmo = to pass through a membrane). The tissues of various living organisms (plant and animals) in the community are eaten by parasites. Dead parts of the body of plants and animals are eaten by scavengers and saprophytes.

Saprotrophs are the heterophic organisms mostly bacteria and fungi which break down the complex compounds

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1 Odum, P. Eugene (1972), Fundamentals of Ecology, p.8.

2 Verma, P.S., (1980), Cell Biology, Genetics, Evolution and Ecology, pp.142-143.

of dead organisms, absorb some of the decomposition products and release inorganic nutrients that are made available to the producers to complete the various cycles of elements. The producers, phagotrophs and saprotrophs, thus, make up the biomass of the ecosystem the living weight.

Example of Ecosystem

A classic example of an ecosystem is a small lake or pond include the water, dissolved oxygen carbon dioxide, inorganic salt such as phosphates, nitrates and chlorides of sodium, potassium and calcium, and a multitude of organic compounds such as amino acids, humic acids, etc.[1] The living part of the fresh water pond can be subdivided according to the functions of the organisms.[2] In a fresh water pond there are two types of producers, the larger plants growing along the shore or floating in shallow water, and the microscopic floating plants, most of which are algae, that are distributed throughout the water as deep as light will penetrate. These tiny plants, collectively

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1 Verma, P.S. and Agarwal, V.K., Cell Biology, Gentics, Evolution and Ecology, 1980, p.144.

2 Odum, P.Eugene, (1972), Fundamentals of Ecology, pp.12-13.

referred to as phytoplankton, are usually not visible unless they are present in great abundance and give the water a greenish tinge.[1]

The macroconsumers or phagotrophs of pond ecosystem include insect and insect larvae, crustacea, fish and perhaps some fresh water clams which consume green plants and algae as their food. These herbivorous aquatic animals are the food of secondary consumers. Frogs, big fishes, water snakes, crabs are secondary consumers. In the pond, besides the secondary consumers, there are consumers of highest order as water birds turtile etc.

The ecosystem is completed by saprotrophs or decomposer organisms such as bacteria, flagellate protozoans and fungi, which break down the organic compounds of cells from dead producer and consumer organisms either into small organic modecules, which they utilize themselves or into inorganic substances that can be used as raw material by green plants.

Principals and Concepts Pertaining to Energy in Ecosystem

Energy is defined as the ability to do work. The behaviour of energy is described by the following law.

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1 Kaushik, M.P., Introductory Ecology, 1979, pp.211-212.

1. The first law of thermodynamic states that energy may be transformed from one type into another but is never created or destroyed. This law is applied in ecosystem in following way[1]

The solar energy is transferred in plants by photosynthesis process. The light absorbed by chlorophyll molecules and by other pigments in plants is transferred to electrons in such a way as to create strong axidants, that is molecules that readily remove electrons from other molecules (oxidise them), or reductants, that is molecules that readily supply electron to other molecules (reduce them).

It is these oxidants and reductants that assist plants in producing carbohydrates and oxygen from molecules of carbon dioxide and water. Plants respire oxygen but retain carbohydrates which are converted to energy and stored in the form of chemical bonds, notably those of adenosine triphosphate (ATP) which is the basic energy currency of all living cells. High energy phosphate bonds of ATP contain 12,000 calories and release 7,500 calories when broken[2]

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1 Manorama Year Book (1986), Biospher, pp.114-115.

2 Manorma Year Book (1985), pp.133-136.

This energy is carried up the food chain by herbivores feeding on plants and carnivores feeding on herbivores. Omnivores like man draw their energy both from plant and animal sources. Much of the energy drawn by plants and animals (including man) is consumed and spent in maintaining the process of life.

The energy that is not expended in the course of life is stored in dead matter. Decomposing bacteria break up the dead matter and convert it into humus or organic sediments, releasing carbon dioxide water and heat into the ecosystem. Thus the basic ingredients of life are returned to the soil. The plants draw their nutrients from the soil and keep the cycle going.

The second law of thermodynamic deals with the transfer of energy toward an ever less available and more dispersed state.[1] As far as the solar system is concerned, the dispersed state in respect to energy is one in which all energy is in the form of evenly distributed heat energy. This tendency has been spoken of as "the running down of the solar system.

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1 Verma, P.S. and Agarwal, U.K. (1980), Cell Biology, Genetics, Evolution and Ecology, pp.160-161.

Thus no transfer is 100 per cent effective, and inefficient. In some instances of the total amount of sunlight energy only 1 per cent will be converted finally into chemical energy tied up in foods within the plants.

BIOGEOCHEMICAL CYCLES

Chemical elements including all the essential elements of protoplasm tend to circulate in the biosphere in characteristic paths from environment to organism and back to the environment.[1] These more or less circular paths are known as biogeochemical cycles; after Vernadskiy (1934). "Bio" refers to living organism and "geo" to the rock, soil, air and water of the earth.

Organic and Abiotic Phases of Geochemical Cycle

The flow of chemical elements through the food chain can be viewed as the organic phase of this cycle. Other is abiotic phase which are of critical importance to the ecosystem, as the major reservoirs for all nutrient elements are external to the food chains, and flow in the

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1 Odum, E. Eugene (1972), Fundamentals of Ecology, p.86.

abiotic phases tends to be much slower than in the organic phase. There are two classes of abiotic phase in biogeochemical cycle.

1. Sedimentary phase which is part of all cycles.
2. Atmospheric phase which is possessed by some.[1]

Types of Biogeochemical Cycles

There are two types of biogeochemical cycles, the gasious and the sedimentary. In gasious cycles the main reservoir of nutrients is the atmosphere and the Ocean. In sedimentary cycles the main reservoir is the soil and the sedimentary and other rocks of the earth's crust. Both involve biotic and abiotic agents, both are driven by the flow of energy and both are tied to the water cycle.

A Water Cycle

Living organisms, atmosphere and earth maintain between them a circulation of water and moisture, which is referred to as water cycle or hydrologic cycle. Water plays a versatile role in the functioning of the biosphere and life processes.

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1 ibid.

1. First it is the medium through which many nutrients are made available to plants: solids and gases have to be dissolved before they can be taken in by plants.[1]
2. Second not only do most chemicals reactions in animal life happen only when substances are in solution but sometimes the water itself enters into the chemical reaction.
3. The hydrogen, which is necessary for the formation of carbohydrates e.g. sugars, starch and cellulose, is derived from water.[2]

Further more water plays a highly significant role, especially as a limiting factor, in the physical environment in which organism live, for rainfall, humidity rate of evaporation and availability of surface water supplies determines the rate and extent of growth and the chances of survival.[3] Eventually, the hydrologic cycle can be defined as an alternation of evaporation and precipitation, with the energy used to evaporate the

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1 Robinson, H., Biogeography, 1972, p.26.
2 ibid.
3 Manorma Year Book, 1986, p.136.

water being dissipated as heat in the atmosphere as the water condenses.

Gaseous Cycles

The gaseous geochemical cycles are of following types:

1. The Oxygen Cycle

Oxygen is the by product of photosynthesis, is involved in the oxidation of carbohydrates with release of energy, carbondioxide and water.[1] Oxygen when combines with nitrogen compounds it form nitrates, with iron to ferric oxides, and with many other minerals to form various other oxides. In these states oxygen is temporarily withdrawn from circulation. In photosynthesis the oxygen freed is split from the water molecule. This oxygen is then reconstituted into water during plant and animal respiration.

2. The Carbon Cycle

The biosphere contains a complex mixture of carbon compounds.in a continuous state of creation

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1 Verma, P.S., and Agarwal, U.K.(1980), Cell Biology Genetics and Ecology, p.150.

transformation and decomposition. Practically all organic matters originates in the process of photosynthesis. The plants use the radient energy of the sun to convert carbondioxide and water into carbohydrates by splitting water to derive hydrogen and by drawing in carbondioxide from the air. In the process the plants release free oxygen (O_2) into the atmosphere, at the same time all living organism inhale oxygen and respire carbondioxide. But while respiration and decomposition (in case of dead matter) go on all the time, photosynthesis takes place only during day time. During day time carbondioxide in the atmosphere comes down from an average of 320 parts per million to around 305 parts but at night it increases, going upto as much as 400 parts per million, near the ground level.

Nitrogen Cycle

Nitrogen as it obtain in the atmosphere cannot be used by the higher organisms. It has to be "fixed" that is, incorporated into a chemical compound Nitrogen in other words has to be converted into ammonia or amino acids, so as to be of use to plants and animals.

Fixation of atmospheric nitrogen on land is carried out by organisms called diazotrophs who possess the

genetic code for the synthesis of enzymes nitrogenase which catalyses nitrogen fixation. These organisms fall into two broad classes - symbiotic and nonsymbiotic. Symbiotic diazotrophs operate in association with some species of plants like legumes. They contribute the lions share 83 per cent of nitrogen fixation on land. Non-symbiotic agents who contribute the rest 17 per cent include blue green algae and aerobic (those require oxygen) bacteria and anaerobic (those who do not require oxygen) bacteria.

The total annual nitrogen required by the biosphere is estimated to be 1050 million metric tonns (mmt) of these diazotrophs account for only 140 mmt. Non-biological agents like lightening or fire contribute 40 mmt. The balance of 870 mmt comes from nitrogen locked up in dead plants and animals.[1] These are recycled by nature as nitrates. The nitrates are converted into amino acids by decomposing bacteria. In aerobic conditions where oxygen is available, bacteria will again intervene to oxidise the amino acids into carbondioxide, water and amonia. The nitrogen in the form of amonia is returned to the atmosphere

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1 Manorma Year Book, 1986, pp.135-136.

where it get dissolved in rain water and ultimately replenishes the Earth.

Sedimentary Cycles

Mineral elements required by living organisms are obtained initially from inorganic sources. The mineral cycle varies from one element to another, but essentially it consist of two phases; the salt solution phase and the rock phase. There are different kinds of sedimentary or mineral cycles, depending on the kinds of elements, but following two cycles are very significant for a ecosystem.

Sulfur Cycle

Sulfur, like nitrogen, is an essential part of protein and amino acids and is characteristic of organic compounds. The sulfur cycle is both sedimentary and gaseous. The sedimentary phase of sulfur cycle is long termed and in it sulfur is tied up in organic and inorganic deposits. From these deposits it is released by weathering and decomposition, and is carried to terrestrial and aquatic ecosystem in a salt solution. Atmospheric (gaseous) phase of sulfur cycle is less pronounced and it permits circulation on a global scale. Sulfur enters the atmosphere from several sources the combustion of fossil fuels, volcanic eruption, the surface of the oceans and gases

released by decomposition. Atmospheric sulfur cioxide, soluble in water, is carried back to earth in rain water as weak sulfuric acid, H_2SO_4. Sulfur in a soluble form, mostly as sulfate is absorbed through plants roots, where it is incorporated into certain organic molecules, such as some amino acids and proteins. From the producers the sulfur in amino acids is transferred to the consumer animals, with excess being excreted in the faces.

Phosphorus Cycle

Phosphorus cycle has no atmospheric phase. It occurs naturally in environment as phosphate. The ultimate source of phosphate in the ecosystem is crystalline rocks. As these are eroded and weathered, phosphate is made available to living organisms, generally as ionic phosphate. This is introduced into autotrophic plants through their roots, where it is incorporated into living tissues. From autotrophs, it is passed along the grazing food chain in the same fashion as nitrogen and sulfur, with excess phosphate being excreted in the faces. Phosphates can also be released as particulate matter from forest and grassland fires.

In the detritus food chain, as large organic molecules containing phosphates are degraded, the phosphate

is liberated as inorganic ionic phosphate. In this form it can be immediately be taken up by autotrophs, or it can be incorporated into a sediment particle, either in the soil of a terrestrial ecosystem or in a sediment of an aquatic ecosystem. The sedimentary phase of phosphorous cycle remains comparatively slow than the organic phase.

Concept of Habitat and Niche

The habitat of an organism is the place where one would go to find it. The ecological niche on the other hand is a more inclusive term that includes not only the physical space occupied by an organism, but also its functional role in the community (as for example, its trophic position and its position inenvironmental gradients of temperature, moisture, pH, soil and other conditions of existences. These three aspects of the ecological niche can be conveniently designated as the spatial or habitat niche, the trophic niche, and multidimensional or hypervolume niche consequently, the ecological niche of an organism depends not only on where it lives but also on what it does (how it transforms energy, behaves, responds to and modifies its physical and biotic environment), and how it is constrained by other species. By analogy, it may be said that the habitat is the organisms "address"

and the niche is its "profession", biologically speaking. Since a description of the complete ecological niche for a species would include an infinite set of biological characteristics and physical parameters, the concept is most useful, and quantitatively most applicable, in terms of differences between species (or the same species at two or more locations) in one or a few major (i.e. operationally significant) feature.

The term habitat is widely used, not only in ecology but eleswhere. It is generally understood to mean simply the place where an organism lives.

Habitat may also refer to the place occupied by an entire community. For example, the habitat of the "Sandsage grassland community" is the series of ridges of sandy soil occuring along the north sides of rivers in the southern Great Plains region of the United States. Habitat in this case consists mostly of physical or abiotic complexes.

Food Chain

In an ecosystem, green plants alone are able to trap in solar energy and convert it into chemical energy. The chemical energy is locked up in the various organic compounds, such as carbohydrates, fats and proteins present in the green plants for their energy.

The transfer of food energy from the source in plants through a series of organisms with repeated eating and being eaten is referred to as the food chain. At each transfer a large proportion 80 to 90 per cent[1] of the potential energy is lost as heat. Therefore, the number of steps or 'links' is a sequence is limited usually to four or five. The shorter the food chain or nearer the organism to the beginning of the chain, the greater the available energy. Food chains are of two basic types.

1. The grazing food chain.
2. The detritus food chain.

1. Grazing Food Chain

Which starting from a green plant base, goes to grazing herbivores and to carnivores.

2. The Detritus Food Chain

Which goes from dead organic matter into micro-organisms and then to detritus feeding organisms and their predators.

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1 Odum, P.Eugene, (1972), Fundamentals of Ecology, p.63.

Food Web

Food chains are not isolated sequences but are interconnected with one another. The interlocking pattern is often spoken of as the food web.

Ecological Pyramids

In the successive steps of grazing food chain considerable portion of the potential energy is lost as heat and the number and mass of the organisms in each step is limited by the amount of energy available. Since some energy is lost as heat in each transformation the steps becomes progressively smaller near the top. This relationship is sometimes called "ecological pyramids". Longer the food chain the less energy is available for final members. The higher the steps in the ecological pyramid lower the number of individuals and larger their size.

The use of ecological pyramids was advanced by C.E.Elton (1927).[1] There are different types of ecological pyramids. In each ecological pyramid producer level forms the base and successive levels make up the apex. Three

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1 Verma, P.S., Cell Biology, Genetics, Evolution, and Ecology, p.168.

types of pyramidal relations may be found among the organisms at different levels in the ecosystem. These are:

1. Pyramid of number
2. Pyramid of biomass (biomass is the weight of living organism)
3. Pyramid of energy.

Pyramid of Numbers

It depicts the number of individual organisms at different trophic levels of food chain. This pyramid was advanced by Charles Elton (1927), who pointed out the great difference in the numbers of the organisms involved in each step of the food chain. The producers at the lower end (base of pyramid) of the chain are most abundant. Successive links of carnivores decrease rapidly in number Until there are very few carnivores at the top. The pyramid of number ignores the biomass of organisms and it also does not indicate the energy transferred or the use of energy by the groups involved.

Pyramid of Biomass

The biomass of the members of the food chain present at any one time forms the pyramid. of the biomass.

Pyramid of biomass indicates decrease of biomass in each trophical levels from base to apex. For example, the total biomass of the producers ingested by herbivores is more than the total biomass of the herbivores in an ecosystem. Likewise, the total biomass of the primary carnivores or secondary consumer will be less than the herbivores and so on. Since some energy and material is lost in each successive link, the total mass supported at each level is limited by the rate at which the energy is being stored below. This usually gives sloping pyramid for most of communities in terrestrial and shallow energy flow.

In case of parasites, the pyramid of biomass may be inverted.

Pyramid of Energy

This depicts not only the amount of water situation at each trophic level of the food chain but more important, the actual role various organisms assume in transfer of energy at the successive higher trophic level. Some producer organisms may have small biomass but the total energy they assimilate and pass on to comsumers may be greater than that of organisms with much larger biomass. Higher

trophic levels are more efficient in energy utilization but much heat is lost in energy transfer. Energy lost by respiration also progressively increases from lower to higher trophic state.

Ecology and Ecosystem - As Tools of Geographical Analysis

Geographers, following the views of the ecologists are not increasingly adopting the concept of ecosystem as a unifying conceptual framework for analysing the man-environment interaction specially its resource use and management aspects. By employing the system approach as a method for conceiving a given environment as an integrated whole, identifying the component and processes involved in environmental imbalances, this can help policy formulation for putting man environment relationship in a scientific framework.

As a conceptual and methodological tool of analysis in geography the ecosystem has distinct advantages. Firstly it is an alternative approach to the understanding of the central theme of geographical enquiry i.e. that of the relationship of man and environment in an area. Secondly the ecosystem concept, by combining organism, habitat and biome in a single conceptual model, satisfactorily

overcomes one of the most tickish methodological problems of geography: that of dualism between man and environment and physical and human geography (Hartshorne, 1959).[1] The subject matter of geography can thus be coherently organized in an ideal framework.

By adopting the ecosystem approach geography can act as a bridging discipline between physical, biological and social sciences. It is not surprising, therefore that today there are deeper fusion of ideas and results from the life science (Hewitt and Hare 1973).[2] It has also been suggested that a more biological approach enhances the prestige of geography within the academic world (Eyre 1964).[3] In this connection Simmons 1966[4] has argued that only the ecosystem and ecological approaches in geography can satisfactorily integrate the cultural factors with the biological and physicalness. The concept can also be used to show how man manipulates the natural environment for his own benefit conceptually. As

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1 Hartshorne, R. 1959, Perspective on the Nature of Geography, London, pp.65-80.

2 Hewitt and Hare, 1973, Man and Environment: Conceptual Frameworks (Commission on College Geog. Resources, Paper 20).

3 Eyre, S.R. 1964, 'The Integration of Geography through Soil and Vegetation Studies, Geography, 49, p.111.

4 Simmons, I.G., 1966, 'Ecology and Land Use: Transactions of the Institute of British Geographers, 38, pp.59-72.

understand after flow of energy and the cycling of material in ecosystem can help us perceive what may be the most subtle and dangerous threat to human existence. This threat is the potential destruction by man's own activities of those ecological systems upon which the very existence of human species depend.

As rigidly pointed out by Eyre,(1964)[1] geographers by adopting the ecological approach can also easily get rid of the baneful effects of the deep rooted dogma of environmental determinism in geography.

Stoddort (1967)[2] lists four major attributes of the ecosystem concept which make it an ideal tool of geographical analysis:

a) It's monistic i.e. it brings together environment, man and the plants and the animal world within a single framework, within which the interaction between the components can be analysed. The ecosystem approach thus dipresses geographic dualism because it has not emphasize any particular component (organism, plant and animals

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1 Eyre, S.R. 1964, 'The Integration of Geography through Soil and Vegetation Studies, Geography 49, p.111.

2 Stoddort, D.R. 1967, 'Growth and Structure of Geography', Transactions of the Institute of British Geographers, 41, pp.1-19.

climate etc.) of the ecosystem but make the functional interaction between them its focal theme.

b) Ecosystem are structured in a more or less orderly rational and comprehensible ways. Stoddart points out that once the structures are recognized they can be easily investigated and studied. It is a better methodological tool than to take up the transcendental properties of the earth and its regions as organic wholes. For instance the geometry of land forms settlement patterns and communication networks can very satisfactorily be studied at structural level. It is not, therefore, surprising that many geographers have been concerned with structural studies. This sort of approach is particularly suited for area studies.

c) The ecosystem is a functioning entity and is an state of dynamic equilibrium with a cyclic flow of energy and matter. In the geographical context, the framework of communication and the goods and people flowing through it may be cited as an example. This concept also tends itself to quantification of component once the geographer has defined the system framework. Indeed a simple ecosystem can entirely be defined in quantified terms. The possibilities of quantification of gross structural

characteristics of ecosystems have been demonstrated in a number of studies (Odum and Odum, 1955[1]; Odum and Smalley, 1959)[2].

d) The ecosystem is a type of general open system tending towards a steady state under the laws of open system thermodynamics. The concept of the climax vegetation of maturity in soil and of grade in geomorphology are all reflections of the application of the principle thermo-dynamic ideas.

The ecosystem is the further advantage of capable of being studied at various sizes,levels and complexities - a square metre of grass land, a pool, a large lake, a large tract of forest, rivers ocean etc. All the ecosystems of the world are inter-connected. It is the task of a geographer to search out aspects of reality which are significant at the levels at which the system is conceived. According to Stoddart the system can be constructed at the framework level or as a simple cybernative system or at the more complex level of social system and living organism.

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1 Odum, H.T. and Odum, E.P. (1955), Trophic Structure and Productivity of a Windward Coral reef Community on Eniwetok Atoll; Ecological Monographs, 25, pp.291-320.

2 Odum, E.P. and Smalley, A.E. (1959), Comparison of Population Energy Flow of a Herbivorous and a Deposit Feeding Invertebrate in a Salt Marsh Ecosystem; Proceedings of the National Academy of Science, 45, pp.617-622.

In view of the importance of the ecosystem concept as a tool of geographical analysis, there has been a considerable spurt of interest in system analysis during the last five years. This is partly due an increased availability of system text-books in geography. Much credit for this goes to scholars like Bannet and Chorley, 1978[1], Huggett[2], 1980, Dury 1981[3] etc. In addition biogeographers have easy access to a very large value of ecological text-books which use the system approach as a means of strategy of research whereby complex problems can be solved while at the general level geographers are showing considerable interest in system thinking, at the practical applicability level the out has been far from impressive, this is borne out by the fact that since 1970's practically all biogeography text-books have been conceived and organized in terms of ecological system approach. There is no dearth in geographical literature an ecosystem studies involving man conducted on traditional quantitative laws

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1 Bennett, R.J. and Chorley, R.J. (1978), Environmental Systems Philosophy and Controle.

2 Huggett, R. (1980), System Analysis in Geography, (Oxford).

3 Dury, G.H. (1981), An Introduction to Environmental Systems (London).

application of formal system concept and ecological model building are recent development and not very frequent. Following, Tansley's classic model Eyre (1963)[1] used an extremely simply ecosystem model which simple present pictorial linkages of ecosystem components. It is a sort of corrective model designed at summarising a sort of relationship. Simple correlative model like the one used by Eyre which comprise of interlinked lines of probable relationships can be improved upon by incorporating an expreciation of the causal mechanisms which underlies a relationship. A correlative model can thus be transformed into an explanatory model. To be really effective explanatory models may be further refined by rendering the explanatory relationships into mathematical or pictorial relations. The model then becomes truly functional and working model for the construction of both the correlative and explanatory ecosystem models involves the collection of dates and, of increasing use now a days computers simulation outputs, construction of actual model, testing of the model and finally acceptance or rejection of the

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1 Eyre, S.R. (1963), Vegetation and Soils, London.

model as a definitive working model (Jones, 1983)[1] of new bioecological model in Geography deals with very simplified situations and hence are not very close to the complex probalistic ecosystems of the real world. This lack of correspondence between the simple, often deterministic models which are in common use and the complex real world ecosystem is the main reason for the failure of system analysis methodology in geography. Day (1974) has aptly remarked "equiped as we are currently with only limited theoretical knowledge of the ways in which ecosystems function. It is the simple deterministic systems which will level themselves most readily to study by system analysis methods. Hopefully the future generations of geographers using the stockastic modelling processes as using micro-computers may be able to satisfactorily construct matrix and multivariable model.

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1 Jones, G.E. (1983), "The Usefulness of System Theory in Ecosystem Studies Area, Vol.15, No.2.

CHAPTER II

ECONOMIC DEVELOPMENT AND ECOLOGICAL IMBALANCE

It is a very difficult task to maintain a balance between socioeconomic development and ecological purity. The potential conflict between economic development and environmental issues is likely to be resolved in favour of the former. And with the growth of industries water air and land are also subjected to the worst kind of foulling.

Let us take a bird's eye view of the origin of ecological imbalance due to economic development.

a) An important cause of the environmental problems that face us today around the world is the ability that man has acquired to control nature and exploit natural resources. Human history went through three phases.

In the first phase, man was a slave to the environment like any other species that had evolved on our planet.

In the second phase, he learnt to control it, but whatever he did to the environment was taken care of by the regenerative capacity of nature.

In the third phase, the meddling became far too much, man began to exploit nature beyond its regenerative capacity. The forests were cut at a rate that they could not regenerate in the natural course. And pollution began to occur at a rate that nature's cleaning capacity could not cope with.

All this occurred because of increasing knowledge that man acquired, for example of chemistry, of mining and of physics. The knowledge of chemistry led to establishment of chemical industry at the beginning of the industrial revolution. This meant factories and all the pollution that goes with them. Man's ability to produce new material through what the crust of our planet provides in the form of mineral, led to extensive mining. And advances in physics led to the problem of radioactive pollution.

b) Another important reason for the continued existence of environmental problem is man's greed as against need. Much of the greed if not all arises because humanity is divided today into religions, castes, language groups, and so on. Greed compels members of each parochial group to acquire as much of material and resource as they can irrespective of the consequences.

c) The third significant reason for the appearance of environmental problems around us is the population pressure. This leads to deforestation, for more people mean an increased requirement of space for them to live and to produce food. It also leads to depletion of the natural resources of land, such as essential minerals, at rates which are greater than ratio at which nature would allow this replenishment in normal courses to an enhanced industrialization, and to accumulation of larger quantities of wastes of all kinds, which if not adequately and properly disposed of, can act as major pollutants.

d) An other cause might be political ambition (i) to acquire dominance over other people which calls for massive resource exploitation and its concomitant environmental hazards, and (ii) to exploit others who are vulnerable, so that we have multinationals market products in developing countries that act as pollutants and which they will not market in the developed countries, where there are adequate laws for the protection of environment and for preventing contamination of food. The use of chemical agents in warfare in recent times has been well documented; this has led to chemical pollution of vast areas, besides mass destruction of plant life. Any nuclear conflict would have wide ranging global environmental effects which could

be so dramatic and drastic that they may, in fact, wipe out all life on our planet. A nuclear war could lead to a nuclear winter which would cut off solar radiation to an extent that plant life which is the beginning of all food chains in our planet would no longer be possible. Seveso in Italy and Bhopal in our country should act as reminders of what pollution due to industry can be like and what it can lead to. What we forget is that many Bhopals and many Sevesos are around us all the time.

All the above mention ecological hazards are the result of unprecedented economic development. In this chapter an attempt has been made to evaluate the environmental consequences of broad types of economic activities: primary, secondary and tertiary.

(1) Primary economic activities which include agriculture, forestry, fishing mining are essentially extractive and take out items of value from the natures store house.

(2) In the secondary type of economic activity man increases the value of already existing item by changing its form. All type of industries in which manufacturing of minerals and other primary products are included comes under this category.

(3) The third type of economic activities, also called Tertiary, included transportation and different types of services.

AGRICULTURAL DEVELOPMENT AND ECOLOGICAL IMBALANCES

Agriculture was man's first great challenge to natural systems because it is based on man's delebrate interference in the ecosystem. Man build huge irrigation system and cleares forests to grow food. Plato stated that over cropping and overgrasing will lead to soil erosion which may replace the fertile land into deserts. Ancient Sumeria, was the granary of the Great Babylonian Empire. The Sumerian harvested two crops and grazed sheep between the crops. Only 20 per cent land of Iraq is cultivated today the rest is dotted with mounds representing forgotten town, the ancient irrigation works are filled with silt the end product of erosion.

Agricultural development has created so many problems, like waterlogging, salinity and alkalinity, soil erosion, land degradation, ravine formation, floods and famines. Pest and disease control in crops results in pest resistance to pesticides, pesticide contamination of water, plant and animal, uptake of toxic chemicals, disappearence of genetic resources and health hazards.

The mismanagement of the ecosystem has promoted the spread of arid conditions. Drought has become the regular features. The major impact of agricultural development on ecology is given as follows.

Famines

The population of the world is increasing and food production has to increase. Famine is a global problem. According to the world Social Prospects Association of the United Nations, famine victims are believed to exceed 500 million in number, every minute it kills 24 people, 18 of them are children.

In countries like India, the problem has became really acute - India, for instance has lost the ecological and environmental balance. One of the main reasons being the extensive and continuous loss of our valuable forests and well grown trees. The forest area of the size of Haryana is cleared every year. According to the data made available by the central forestry commission, nearly 75 million hectares i.e., 22 per cent of the total land is under forest cover. But the recent report of the Dept. of Space reveals that total area under good forest cover (with a density of more than 30 per cent) was around 10 to 11 per cent in the year 1984. India is losing

1.3[1] million hectare of forest a year. This has adversely affected the ecosystem balance. Regular rains, for which most of our country was well known, have become irregular and the yearly droughts have become a permanent menace.

Agricultural development must take care of the ecological balance. In the pursuit of agricultural development whenever ecological balance has been overlooked, disaster has overtaken human kind. One of the glaring example is that of Sahelian zone south of the Sahara desert. The Sahel is a transitional zone stretching for about 5000 km from Senegal in the west to northern Ethopia in the east. At a station (Zinder) in Niger in southern Sahel wet and dry years alternated. The wetter phase made it easier for the population to settle and cultivate land which had been devoted to pasture farming. The ecosystem could not endure these pressures for many years and signs of desertification appeared in the lengthy periods of drought known as the Sahel drought.

Soil Erosion and Ravines

Nature requires about 500 to 1000 years to create a layer of one inch of the top soil, which is the most important and fertile portion of soil. This contains lacs

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1 The State of India's Environment (1984-85), A Citizen Report, p.48.

of germs which help in maintaining the natural ecosystem. It is said that one teaspoonful of top soil contain billions of microflora and microfauna. It has been assessed by the concerned ministeries that near 120 million tonnes of top soil of worth of 24,000[1] crore rupees is carried down every year.

Projections for the period 1975-2000 Regarding soil loss and reclamation[2]

Population 1975	4000 million
Cultivated land	1240 million hectare
Cultivated land per person	.31 hectare
1975-2000 loss to urbanization and soil erosion	300 million hectare
Potential land added to arable base	300 million hectare
2000 - population	6253 million
Cultivated land per person	.15 hectare

The above table show that final quarter of this century will set a net loss of cultivated land. If this

1 The State of Environment, Selected Topic, 1977.
2 United Nations, Environment Programme, p.9.

proves to be the case, this process will halve the area of farm land per person which cannot be compensated by the growth of productivity per unit area through more intensive management during the same period.

In India as many as 175 million hectare constituting 53 per cent of India's total land area are subject to serious environmental degradation of the cultivated area of about 140 million hectare nearly 60 per cent[1] require soil conservation measure.

In the Deccan black soil area the top soil loss in a single year is often as high as 40-100 tonnes per hectare.

The National Commission on Indian Agriculture (1976)[2] reports that reckless destruction of forests in the Siwalik in Punjab, Haryana and Himachal Pradesh has converted extensive areas into gully lands. Ravine and gully erosion are possibly the most spectacular types of

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1 Basu Biman, (1986), Yojana, Vol.30, No.10, p.5.
2 The State of India's Environment, 1984-85, p.15.

erosion and have already degraded about 40 lakh hectare in the country. The problem mainly affects the states of Uttar Pradesh, Madhya Pradesh, Bihar, Rajasthan and Gujrat, which account for over 33 lakh hectares of ravines found along the Chambal, Yamuna, Mahi, Sabarmati and their tributaries. These ravines are threatening to encroach upon another 50 lakh hectare to 60 lakh hectare of adjoining productive table lands.[1] These ravines spread fast into cultivated land. According to National Commission on Indian Agriculture, 700[2] hectares of good land degenerates into ravines every year and this deterioration has affected not only the agricultural land but also habitations, roads, railways and other public properties. On a rough estimate out of a total of about 4 million hectares, Uttar Pradesh, Madhya Pradesh, Rajasthan and Gujarat contain about 80 per cent of the ravine land and there is urgent need to carry out standard soil survey in these areas to distinguish the various types of soils and the types of ravines, and they may be mapped on a suitable scale. Some of these ravines could be reclaimed for purposes of

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1 The State of India's Environment 1984-85, The Second Citizen Report, p.15.

2 Shafi, M., National Conference (1987), on 'Ecosystem and Management of Agriculture at Department of Geography, Aligarh.

agriculture, some for afforestation or horticulture. In order to prevent the recurrence of the ravines, the whole of the watershed be treated, beginning from the water divide line to the confluence of the ravine with main river.

In the race to provide food for the expanding world population, improper farming practices leads to serious environmental disruption including the expansion of agriculture to steep hill sides, overly intensive cultivation, too heavy reliance on marginally productive semi arid lands, and inadequate conservation measures are increasing the erosion and depleting the nutrients of top soils. The result is reduced fertility of the land, lowering its capacity to food production.

In many parts of the world hill sides are being deforested to make way for more farms and to produce fuel for cooking food. The rains so longer soaks into the ground but runoff in the form of uncontrollable torrents which tear away the soil under cultivation, flood the lowering crop land and clog reservoir and irrigation canals with silt.

Shifting cultivation also leads to ecological imbalance. According to one estimate 25 per cent of the world land surface primarily in tropical or subtropical regions

is occupied by 300 million people who practice shifting cultivation. In some areas it is damaging the productivity of the area and to reduce its carrying capacity. A United Nations report noted that shifting agriculture "achieves high productivity per man a day with small capital investment.....if cultivation is not prolonged, rapid regeneration of secondary forest vegelation occur when the land is abandoned.[1]

As a result of reduced forested areas and the spread of settled agriculture fallow periods will unavoidably shorten leading to nutrient losses, adverse shifts in the species composition in the naturally occuring flora and fauna (a reduction of overall species diversity and an increasing preponderance of weed species) increased nutrient leaching from soils accelerating competition from weeds and declining yields.

Slash and burn agriculture or jhum cultivation practised in Assam, Manipur, Tripura, Meghalaya, Mizoram, Nagaland, Arunachal Pradesh, Orissa, Madhya Pradesh, Andhra Pradesh. As a result of this the bed rock in many

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1 The Global 2000 Report to the President 1982, pp.235-236.

parts of Orissa and Andhra Pradesh has been exposed. In North-east India the danger of landslide has increased, so much so that about 2.7 million hectare of forest land are affected by Jhuming cycle which at present varies between 1 and 17 years in Arunachal Pradesh, 4-5 years in Meghalaya, Mizoram and Tripura, 5 and 10 years in Assam hills, 6 and 8 years in Manipur, and 6 and 16 years in Nagaland. It is not an easy task to stop Jhuming where a total of about 3 million[1] hectares are involved, and at any one time about half a million hectares of area, and an equal number of families.

The practice of Jhuming can be made more productive by introducing better agricultural practices. Terracing would be a suitable measure in keeping with the ecosystem.

In Manipur cash crops like potatoes and maize have increased the intensity of the problem of Jhum and the solution lies in resorting to terracing on a more extensive scale.

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1 Shafi, M., (1987), Key Note Address at the National Conference on "Ecosystem and Management of Agriculture" at the Department of Geography, A.M.U., Aligarh, p.8.

Fertilizer Use and its Effect on Environment

With the introduction of Green Revolution, the use of chemical fertilizers has considerably increased and fertilizers are also indispensable for increasing food production, but their excessive use has caused a threat to the environment. In some countries of the world, fertilizer (NPK) consumption per hectare of arable land is quite high.

In Neitherlands	743 kg	
Belgium	529 kg	
Japan	449 kg	
West Germany	428 kg	
Korea	391 kg	
Egypt	204 kg	
India	27 kg	(1978-79)

So at the moment there is no environmental threat from fertilizers to India, as the consumption is quite low. In fact the average consumption for Asia is 52. In order to derive the maximum benefit, one should know

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1 Shafi, M., ibid., p.9.

the right amount, the right type of fertilizer, the right place and the right time. If these are not taken care of there may be excessive concentration of nitrogen compound in water and may lead to ammonia toxicity to fish and create health hazards to man and animals. Excessive concentration of nitrites in water may impair the health of infants. The lurking threat to the environment lies in the leaching of fertilizers from the agricultural fields to water courses.

Scientific understanding of atmospheric influence of fertilizer is not yet developed, but it is reported by the National Academy of Science that nitrous oxide from fertilizer usage, when it makes its way into the stratosphere, reacts in a fashion that deplete the ozone layer.

From the perspective of ecology the known terrestrial effects of increased fertilizer usage are quite harmful. The addition of large amounts of three critical nutrients (phosphorus, potassium and fixed nitrogen) might be expected to produce many changes in soils. As nitrogen is often the limiting nutrient for decomposition of soil organic matter in soils, increase nitrogen usage contribute to reduction of soil organic matter, thus degrading soil and contributing carbondioxide to the atmosphere. The most apparent effect is simply the intended increase in plant

growth. One potentially adverse effect concerns the accelerated decomposition of organic matter in soil.

Some projections suggest that the nitrous oxide produced as a result of agriculture could at least double within the next 50 years, which could deplete the ozone layer by as much as 15 per cent.[1] Also the burning of fuels adds substantial amount of nitrogen compounds to the atmosphere. Ultra Violet beams (UVB) can kill micro-organism outright, and in plant and animals it can destroy individual cells. The molecular structure of protein and nucleic acids which are the building blocks of plant and animal tissue and together make up the greater part of its dry weight, are damaged by Ultra Violet radiation so that they can no longer properly perform their biological functions.[2]

One of the greatest hazards to the environment has been brought by modern agricultural operations through pesticides and insecticides which are sprayed to protect the crop from diseases. The chemical used in crop

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1 The State of Environment 1977, United Nation's Environment Programme, p.3.

2 The Global 2000 Report to the President 1982, p.285.

management have been classified according to their specific use into several categories namely, insecticides, fungicides, weedicides, nematicides, acricides, rodenticides.

The F.A.O. gathered some data for the less developed countries (LDCs) in 1975 and found that pesticide use in the LDCs have increased by about 50 per cent over the two year period 1971-73 and that consumption for 1974-77 was expected to increase more slowly, at about (9 per cent per year).[1] These figures are significantly influenced by the heavy use of pesticides in India, Mexico and Argentina, if this slowed rate of increase (9 per cent per year) continues LDCs pesticides use by 2000 would still be more than 10 times the 1971-73[2] rate.

The environmental problems anticipated from increases in pesticides use are suggested by problems that have already occur and can be expected to continue. They include:

1) Biological amplification and concentration of persistent pesticides in the tissues of higher order predators including humans.

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1 The Global 2000 Report to the President 1982, p.285.

2 ibid., p.286.

2) Development of increased resistance to pesticides by numerous insect pests, and hence possible decline in yields through increased vulnerability to pests.

3) Destruction of natural pest controls such as insect eating birds and predatory insects, and hence further increases in the cost of and decreases in the effectiveness of preventing crops losses caused by pests.

4) Emergence of new pests previously not troublesome, and

5) Increased poisoning of farm workers and families from nonpersistent pesticides.

The health hazards of pesticides have particularly increased in the recent years owing to 1) the increase in quantities of pesticides used, 2) increase in the number of pests 3) their residual toxicity. The residual toxicity of DDT, BHC, aldrindieldrin, endrin chlordane, toxaphene is dangerous to human health. The consumption of minute quantities of residues of pesticides along with foodstuff unconsciously constitute national health hazards. The continued use of DDT causes it to accumulate slowly and circulate widely in the biosphere. It is found in the tissues of penguins in Australia, in the bodies of children in the Thailand, and in mothers milk in Indiana (USA). Residues of BHC (Benzene Hexa Chloride) were found in the

mothers' and Cows' milk in Tamil Nadu where samples were taken from all over the state by the Agriculture University, Coimbatore. Another study of Ludhiana showed that residues of BHC and DDT (Dichloro dephenyl-trichloro-ethane) were found in butter and wheat flour samples collected for this purpose. A field study done by the AIMS indicated the presence of 4.7 PPM of DDT in the fat tissues of the residents of Delhi.[1] As BHC and DDT have residue toxicity, they have a chance of causing cancer, since they linger on in grains, plants and vegetables.

The Herbicides sprayed on sugarcane plantations may easily be carried away by the wind. They reach neighbouring crop such as beans tomatoes and destroy them. Intensive aerial application of pesticides has been known to pollute the air and effect the people in nearby towns, causing headaches, dissiness and nausea. The level of DDT and its metabolites were found to be the highest in India, although their per hectare use is low as compared to the developed countries. The vegetable growers are the worst offenders as they spray DDT freely even at the time of picking the vegetables.

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1 Shafi, M., op. cit.

Excessive Grazing, Threat to Environment

The world's herding population, depending upon grassland or savannas to sustain their livestock, maintain a delicate, often tenuous relationship with their local environments. When herds are not managed to sustain the productivity of the ecosystem it leads to the deterioration of range land. Once begun range land deterioration is difficult to control. Most grasslands are located in semi arid areas, where heavy grazing destroys the ability of plant to resist drought and leads to eventual loss of palatable species in favour of weed species.

Overgrazing can also create serious problems of soil loss and degradation. For example, in the Sudanese province of Kordofan on the Saharan fringe, the domestic livestock population quadrupled between 1975 and 1966.[1] Such over-grazing breaks down the dynamic equilibrium, eventually, the destruction of plant cover creates patches of bare soil, causing serious wind erosion. Intense grazing hampers regeneration as it causes injury to plants either because of frequency or degree of removal of its photosynthetic organs or destroying the woody portion by trampling.

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1 The Global 2000 Report to the President, p.234.

Less direct but even more important consequences of intense grazing is it impairs the capacity of plants to grow and reproduce.

The problem of grazing is acute in India, the FAO report points out. In 1975, India had about 15 per cent of the world's cattle, 46 per cent of its buffaloes, 17 per cent of its goats and 4 per cent of its sheep. "Grazing intensity is high in most of the forest areas of India![1] Incessant lopping of graziers has reduced vast forested areas to an unstable low scrub in the Himalayan zone. The report also points out that the extension of irregulated and cultivated land areas is leading to a decrease in land available for grazing and in the absence of attractive employment opportunities, the graziers are being forced into a heavy reliance on grazing in forest areas and consequent degradation of the forests. The effects of haphazard grazing are alarming. Land degradation due to overgrazing leads to desert like conditions which in turn reduce animal productivity and increase the economic pressure on human beings who depend on animals for

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1 The State of India's Environment 1984-85: A Citizen Report, p.3.

their livelihood. Thus do pastoral nomads turn into landless labourer's.

One of the main reasons for overgrazing is too many animals and too little grass. Only about 13 million hectare in the country are classified as permanent grazing lands which is obviously not enough. While in US 60 per cent of the cultivated land is devoted to fodder production.[1] In India the figure is only 5 per cent.

Economic Development and Genetic Erosion

Plant and animal life, as it has evolved on this earth, has produced a bewildering diversity. There are millions of species of plants and animals, but even within a species, there exist enormous diversity. For instance, there are an estimated 120,000[2] types of rice plants alone in the world.

This massive diversity, or "gene pool" as scientist like to call it, is a common heritage of all human beings. It is not just the wild living resources that are today

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1 ibid.

2 ibid., p.30.

threatened because of the destruction of their habitat, domestic species of plant and animal are also facing genetic attrition, partly because of those very activities that are undertaken by human beings in the name of economic development, such as the Green Revolution in food crops, blue revolution in fish production, white revolution in milk, and massive afforestation with high yielding mono-cultures. In this process, farmers can replace thousands of wild varieties and primitive cultivated varieties overnight with one high yielding variety. If the displaced varieties are not collected and properly stored, they could be lost forever.

India possess an extremely rich diversity of plants and animal life. The Indian region is considered one of the 12 centres of genetic diversity in the world. At mid century, Indian farmers cultivated 50,000 varieties of rice. By 2000 they will probably grow not more than 50. Every single variety could be invaluable one day. A single sample of wild rice collected from eastern Uttar Pradesh in 1963 gave Asian farmers a gene that saved 30[1] million hectares of paddy from the dreaded grassy stunt virus.

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1 ibid., p.299.

Surveys in a small part of the Silent Valley in Kerala, saved from damnation by a people's campaign, have revealed nine species and an entire genus of plants new to science. A little over 10 per cent[1] of India's flora faces extinction, many species may be lost even before their possible value is known to society.

Irrigation and its Adverse Effect on Ecology

A decline in soil fertility or even a total loss of land to agriculture, due to increase in salinity or alkalinity, is a common problem in many parts of the world without adequate drainage, excessive or unwise irrigation can lift salts to the soil surface, and even in the absence of subsurface salts, waterlogging may reduce fertility. That is why many irrigation projects also take their toll. The causes vary, but world wide an estimated 125,000 hectares of irrigated land are lost from production each year due to waterlogging, salinization and alkalinization. This loss rate amount to only about .06 per cent per year of the world's total irrigated land.[2]

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1 The State of India's Environment 1982, A Citizine Report, p.164.

2 The Global 2000 Report to the President 1982, p.279.

Problem of waterlogging salinization and alkalinization occur in arid region where irrigation system supply water to the soil faster than drainage can remove it. The excess water raises the watertable to a level near the ground surface. Evaporation brings dissolved soil salts to the surface, where they inhibit plant growth and form a mineral crust. The water that returns to local streams and rivers is often so laden with salt that irrigation down stream is impaired. Canal seepage may cause the water-table to rise. A study of major modern irrigation schemes in the Punjab shows that seepage from unlined canals has in the first 10 years of operation, raised the water-table 7-9 in above previous level.[1]

Such problem reach extreme proportion in Pakistan even as early as the 1960s, and 22 per cent of all irrigated land was seriously damaged by waterlogging or salinity. At that time in the Sind 49 per cent of all agricultural land was moderately or severely water-logged 50 per cent was highly saline and 27 per cent was moderately saline according to UN data.[2]

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1 The State of Environment 1977, Selected Topics: A U.N.O. Environment Programme, p.10.

2 The State of Environment: A UNEP Programme, 1977, p.10.

Some experts claim that the fertility of between 30 per cent and 80 per cent of the world's irrigated land is currently being affected to a greater or lesser extent by salinization. Among other major areas affected by salinization are the Helmut Valley in Afghanistan, the Imperial Valley and Colorado basin in the United States, the Mexicali Valley in northern Mexico, and the Euphrates and Tigris basins in Syria and Iraq. On a global scale 200,000-300,000 hectare of irrigated land, an area of the size of Luxembourg, are being lost by salinization and waterlogging every year.

According to projections made by the (FAO) of the United Nations, the irrigated area in developing countries is expected to expand from 105 to 148 million hectares between 1980 and 2000, with "three quarters of this expansion taking place in the Far East and three quarters of that in India alone.[1]

The country has constructed several big dams and irrigation projects since Independence. Nearly 181 out of 246 irrigation projects undertaken since 1951, are yet incomplete. The costs have considerably gone up and Rs.30,000 are now required for irrigating one hectare of land through the irrigation system. Alongwith the long

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1 The State of India's Environment 1982, A Citizens' report Published from Centre for Science and Environment, p.3.

gestation period, several years are required thereafter to consume the created potential. The financial losses from these big irrigation projects are of the order of Rs.800/- crores per year and the water-logging and salinization have converted thousand of hectares of the fertile lands into wastelands. The rehabilitation of the people ousted from the catchment areas and the lossess caused to our environment due to felling of trees have no limitations. The seventh five year plan document reveals that the country could irrigate only 25.3 million hectares at the end of the VI Plan through the big projects as against 26.1 million hectares irrigated through the development of ground water since independence. It has also been established that the ground water irrigation is more productive than the big canal systems. The ground water irrigation considerably saves the valuable water as well. According to B.D. Dhavan of the Institute of Economic Growth, productivity through ground water irrigation is 100 per cent more than that of canal irrigation.

However "irrigation has not been an unmixed blessing" points out senior agricultural scientist M.S. Swaminathan in a paper entitled "Indian Agriculture at the Cross Roads. In a number of irrigation projects,

salinity and waterlogging have appeared within a few years of the introduction of irrigation. This has harmed many farmers more than it has benefitted them.

Land in canal areas are often flat and poorly drained, which results in waterlogging and salinity over a period of time due to several curcumstances. First, the application of canal water to crops has often been far in excess of their needs. There are few installations and field channels to regulate the flow of water to individual fields. Secondly, canals and distributaries are usually not lined and they contribute to waterlogging through seepage. In some surface irrigation systems as much as 90 per cent of the water released from the reservoir can be lost because of seepage.

Nearly seven million hectares of land have already gone out of production because of severe salinity and an additional six million hectare of land lying seriously affected by waterlogging.

One important cause of waterlogging is neglect of drainage while building engineering works flood control embankments and road, rail and canal embankments. "If as is often the case, such embankments do not contain adequate

cross-drainage works, water gets held against them and cause damage to the area submerged.

Adverse Environmental Effects of Mining

Mining ruins the land water, forests and air. The loss or pollution of natural resources degrade the quality of human life in these areas. Increasingly mineral based production units like coal-fired power plants, steel plants and cement factories are located near the mines. A cluster of eight thermal power stations are planned near the Singrauli coal mines, because it is cheaper and easier to transport electricity than to transport coal. The mining activity has multiplier effect. It attracts other industries like iron and steel industries, aluminium extraction plants, copper complexes, cement factories, engineering units, rail and road networks, sidings and stockyards. The environmental onslaught of this mining-manufacturing complexes multiplies murderously.

If mineral deposits are relatively near the surface, they are mined by the open pit method. In this case, a pit is dug i.e. the soil is removed to a great depth, then dumped to the side creating man made plateau which may remove large areas of land from use. Not only is the exploited land destroyed, so are areas much larger than those directly

effected by industry. The hydrological conditions of the locality are disrupted, water, soil and air pollution occurs leading to lower agricultural harvests, lower timber increament, the drying out and destruction of vegetation, deterioration of sanitary conditions for human beings and domestic animals. The measures to eliminate the negative effects of open pit mining are first, the use of refuse ores in production and secondly, the recultivation of land. According to the organization for economic cooperation and development, annual accumulations of coal mining waste are.

Coal Mines Waste[1]

90 million metric tonnes	---	U.S.A.
60 million metric tonnes	---	West Germany
56 million metric tonnes	---	U.K.

Uranium is also responsible for large amount of mining waste. Nonfuel mineral commodities whose extraction is accompanied by considerable waste include: copper, iron ore, phosphate rock, stone and clay.

1 The Geobal 2000 Report to the President, 1982, p.385.

Loss of Agricultural Land due to Mining Activity

A precise estimate of the amount of agricultural land lost to mining is not readily available. The total amount of land directly given to mining can be computed from the Directory of Mine Leases published by the Indian Bureau of Mines (IBM)[1] Nagpur and adds up to a few million hectares.

The disposal of mining debris require additional area and renders the surrounding land infertile. "On an average 2 tonnes of reject material is required to be removed for every tonne of soliable (iron) ore"[2] says a report on an ecodevelopment plan for Goa prepared for the Planning Commission. Rainwater washes out material from the waste dumps to the adjoining agricultural fields and streams. The residues often harden on drying, making the fields uncultivable.

Macro statistics do not show that mining makes the land much more profitable than agriculture. In 1981-82, some 143 million hectares of land produced some Rs.468,000 crore worth of agricultural goods, about Rs.3,270 per hectare.

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1 The State of India's Environment 1984-85, A Citizens' Report, p.20.

2 ibid.

The mines spread over 5 million hectares to 15 million hectares earned only about Rs.3,400 crore that is between Rs.6,800 and Rs.2,266[1] per hectare from theseearning must be substracted the environmental cost of natural resource destruction and of rehabilitation.

Deforestation

Much of the mining activity in India is being carried out in forested regions. The obvious result is deforestation and erosion. Underground mining also significantly denudes forests because timber is used for supporting the roofs of mine galleries. In Goa, mining leases are spread over 43 per cent[2] of the forest area.

Some of the most intensely mined areas in the central eastern India mining heart land lie in an ecologically sensitive region. In this region the Chota Nagpur plateau and the Maikal Range feed five major rivers: the Narmada, Sone, Rihand, Mahanadi and Damodar. At Amarkantak, the highest point in the Maikal Range, and the source of the

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1 ibid., p.26.

2 ibid., p.21

Narmada river, the Bharat Aluminium Company (BALCO) and the Hindustan Aluminium Company (HINDALCO)[1] operate bauxite mines. Here one can see bald brown hills standing in stark contrast against the lush green covers of sal forest on the unmined hills.

The exquisite Doon Valley is in danger because of uncontrolled quarrying for limestone and the verdant beauty of the Mussoorie hills has also been destroyed. In the valley, the area under the tree cover is now reported to be only 12 per cent as against the officially recommended 60 per cent.[2]

The main negative impact of quarrying is on the water resource and the scenic attraction of the Mussoorie hills concludes the report of a study team led by J.Bandopadhyay of the Indian Institute of Management, Bangalore. According to the report Commissioned by the Department of Environment, mine debris is allowed to fall freely into river and canal beds, disrupting drinking water and irrigation supplies. In the Baldi river catchment area foodgrain production fell by 28 per cent in the last two decades and the water sources of 18 villages in the same area decreased.

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1 ibid., p.21.

2 ibid., p.22.

Effect of Mining on Water Quality

Surface and underground water is frequently polluted by effluents of mining and milling operations and by rainfall and its stream action on solid mine and mill waste, 38 per cent of waste water discharged by all major United States groups, in 1973. 8 per cent water was polluted from petroleum and coal products and 1 per cent by stone glass and clay products.[1]

One example of water pollution from mining, is acid mine drainage, which is caused by reaction of water and air with sulfur bearing minerals in coal or metal mines and dumps. The sulfur acid produced in this reaction enters streams, lakes and rivers where it lowers the pH, killing many form of life.

By locating mineral treatment facilities near the mines water pollution problem get worse. These units use enormous quantities of water for washing the ore. The untreated effluents, slimes or tailings are often released into neighbouring streams or lakes.

The NMDC (National Mineral Development Corporation operates iron ore mines at Bailadilla in Bastar. The daily

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1 The Global 2000 Report to the President 1982, p.287.

production is about 15,000 tonnes.[1] Most of it is exported to Japan. The mining operation consume a tonne of water for each tonne of ore produced. The water is obtained by damming the Kirindul nullah. Effluents containing 18 per cent to 20 per cent of the mined ore from the ore screening plant at Deposit 14,[2] are dumped into the nullah turning it into thick red slime. This turbid stream joins the Sankhini river just downstream from the plant, turning its water red, Pollution of Sankhini river affects 51 neighbouring villages with a population of almost 40,000[3] persons. The villagers, mostly tribals, have no clean water to drink, wash clothes or bathe. Their cattle also suffer. "All we have got from this project is lal pani", one villager told a visiting journalist.

Industrial Development and Ecological Imbalance

Industries discharges liquid wastes in the water and emit noxious gases in the atmosphere. The cumulative effect of both results in ecological degradation on a considerable extent. The gaseous emissions consist largely of sulfur oxide nitrogen oxides, carbon monoxide and hydrocarbons. The consequent of such, polluted air is

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1 The State of India's Environment 1984-85, p.22.

2 The State of India's Environment 1984-85, A Citizens' Report, p.22.

3 ibid.

adverse on the health of people, animals and plants, climate in cities, on architectural structure, marble statues and other works of art.

Smog is formed when the mist is combined with factory smoke and automobile exhaust, Quantity of condensation nuclei is increased by the industrial waste emission in the atmosphere, which results in the steady increase in the number of cloudy and misty days.

The smog which occur in autumn and winter (from October to February) known as London Smog,[1] which causes catarrh of the respiratory tracts, bronchitis and dyspeptic disorders.

There is second type of smog which was first occur in Los Angles. Thus called Los Angles Smog.[2] It is now more often called photo chemical smog, due to the fact that it is formed in polluted air as a result of photochemical reaction occuring under the impact of solar radiation.

Various chronic illnesses like irritation of the mucous membrane of eye, nose and throat, as physcia aggravation of pulmonary are provoked due to photochemical

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1 Astanin, H.P. and Blagosklonou, K.N., Conservation of Nature, 1983, p.40.

2 ibid.

smog. It is not uncommon for death to result. Vegetation suffers as well including crop Vineyards and Shrubbery.

The most threatened monument of India is the best known beautiful Taj Mahal. Regular emission of sulphur dioxide (25-30 tonnes) carbon monoxide (100-150 tonnes) hydrocarbons (60-100 tonnes) nitrogenoxide (100 tonnes) and trace metal like vanadium, nickel, cadmuim and chromium from the gigantic oil refinery will slowly destroy the Taj Mahal. When sulphur dioxide get combined with atmospheric moisture it convert into sulphurous or sulphuric acid, both highly corrosive substance. According to J.M. Daves Dean of the School of Environmental Sciences at Jawaharlal Nehru University, "increased acidity will definitely damage the marble of the Taj Mahal irreparably over a period of 50 to 100 years.[1] Acid Rain is another resultant of industrial development acid rain contains the pH value less than 5.6, while pH value of distilled water is 7.0 and above or below this value signifies alkalinity and acidity.[2]

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1 The State of India's Environment 1984-85, A Citizens Report, published from Centre for Science and Environment, New Delhi, p.127.

2 The State of India's Environment 1984-85, A Citizens' Report, p.136.

Pollutants like nitrogen oxide and sulphurdioxide from industries, power plants, automobiles, oil and fossil fuels are added into the air. They are transformed into nitric and sulphuric acids which ultimately get washed down with rain. It was in the fifties that acid rain was first noticed when the dead fish floating on the surface of the blue lakes in southern Norway. It has also destroyed large clumps of forests and lakes in Europe and north America. Lakes become dead because there is no life as fish, bacteria and algae, ultimately ecosystem of lakes gets collapse.

Acid rain is an international problem. The winds can transport it from one country to another. For example London has diffused its pollutants through engineers built tall chimneys and descended in the Sweden in the form of acid rain, polluting 150,000 lakes.[1]

Human, bird and animals can't escape themselves by this disaster. It has been studies that the content of lime and calcium is lowering down in the shells of the fly

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1 ibid.

catcher. The eggs are therefore, weak and brittle and sometimes they dont hatch![1]

According to C.K. Vashney, environment expert at Jawaharlal Nehru University, New Delhi. "The current pace of development is bound to promote acidification of the Indian Environment". There is 115 million tonnes increase in coal production in last 30 years and will probably reach 240 million tonnes by 2000. It was 35 million tonnes in 1950 and 150 million tonnes in 1980. The emission of sulphuric dioxide has gone upto 3.20 million tonnes in 1979 while it was only 1.38[2] million tonnes in 1966, an increase of 21 per cent while United States had 8.4 per cent increase during the same period.[3] Such data shows that there is continuous increase in sulphur dioxide emission in India with the rapid expansion in the thermal power generation programme.

Fertilizer Factories

Large quantities of air pollutants like fluorine gas, particulates sulphur dioxide and trioxide from sulphuric

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1 Times of India, February 7, 1986, p.24.

2 The State of India's Environment 1984-85, p.136.

3 The State of India's Environment 1984-85, A Citizens Report Published from Centre for Science and Environment, p.136.

or phosphatic acid units and nitrogen oxide, ammonia, hydrocarbons and particulates from nitrogen based plants are being emitted into the atmosphere.

There are 67 large fertilizer factories in India producing 3 million tonnes fertilizer in the year 1979-80.[1]

The fertilizer factory in Avadi, Tamil Nadu, facing a serious risk situation, writes "The Hindu"[2] Pollution became acute when the stack of the factory collapsed, people were suffering from irritation of eyes and breathing difficulties when fumes were let off at levels far below the original 10.5 metres height.

Textile Mills

Large amount of organic chemicals are operated in humid environments in textile mills. Cotton dust smoke and other combustion wastes, kerosene or peptha vapours, sulphuric acid, nitrogen oxide, chlorine, formaldehyde and chlorine oxide are their major effluents which pollute the atmosphere.

According to G.R. Pillai and S.M. Doshi of (BTRA) Bombay Textile Research Association "the ill effects of all

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1 The State of India's Environment 1982, p.76.

2 ibid.

such pollutants have not been fully realized in India with the result that control measures are seldom as rigorous or persuasive as in foreign countries".[1]

Thin deposits of cotton fluff and dust are deposited around textile mills, which effect the health of the workers inside the mills. Such people are suffering from byssinosis, weakens respiratory functions and resistence to lung diseases, especially T.B. and chronic bronchitis. It has been estimated in a survey by Bombay's KEM Hospital that 10 to 16 per cent incidence of byssinosis are found among textile mill labourers.[2]

The fortnightly 'India Today' reports that a 25 crore[3] Birla Company named Harihar Polyfibres near Nalavagul village of Chitradurga district in Karnataka playing havoc with the life of the peoples of this area. The tall chimneys of Harihar polyfibres always emit soot mingled with chemicals and other toxic byproducts. As a consequence of this the pillars supporting huts, beams holding the roofs of houses almost crumble into powder at the barest touch.

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1 ibid.
2 ibid.
3 ibid., p.82.

Men, women and children are suffering from skin eruptions, boils pockmarks as in smallpox, dryskin and skin irritation, cracked soles, burning sensation accompained by cough, yellowing of the eyes as in jaundice and an unknown malady of the intestines livestock and other animals were also noticeably suffering from unusual ailments.

Plants and Air Pollution

In his presidential address at the annual convention of the Indian Science Congress held at Banaras Hindu University in January 1981[1] A.K. Sharma said that plants have been found to be seriously affected by air pollution. S.B. Chaphekar and his colleagues at the Institute of Science, Bombay conducted a three year study, titled "Effects of Industrial pollution on plants"[2] found that mango trees in Bombay have been damaged due to pollution.

Some trees were completely damaged in the surrounding area of Hindustan Petroleum Refinery upto 30 per cent of the mango tree leaves became dead along roadsides, revealed the study.

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1 ibid., p.83.
2 ibid.

Due to vicious circle of increased pollution the photosynthesis rate has been reduced and the air purifying action of plant absorbing carbon dioxide and releasing oxygen is reduced. The National Geographic magazine reports that decline in forest growth is linked with acid deposition due to acid rain (a recent West German study).

Increase in atmospheric levels of sulphur dioxide has reducee the rice production according to researchers in Japan.

Water Pollution by Industries

Before going deeply into industrial development and water pollution we should first understand the nature of water pollution. The only mean of clearing water is nature itself. The hydrological cycle which include evaporation of water of the ocean, condensation and return it to earth as rain. Through photosynthesis the green aquatic plants yield oxygen to river water. The rivers also "inhale oxygen with every swirl of the water. As long as this natural process of recuperation can match the process of despoilation,(the river sustain life.

What happen when a load of rubbish is thrown into a river. There are two kind of organism in water, the aerobes, which cannot do without oxygen and the anaerobes

which shy away from oxygen. The first one inhabit the upper level of water while second live in the depths.

The solids and waste material from industries and households, which dumped into the water, they are attaked by these two kind of organism. The a@robes get multiplied and consume the dissolved and suspended waste by using the oxygen. These a@robes in turn produces inorganic and mineral matter. Which are absorbed by algae. In process they release oxygen into the water through photosynthesis.

The solid matter in the rubish also contain a host of disease germs which are destroyed by rivers protozoa. These protozoa get oxygen from the intake of the river or from the algae.

But modern industrial society and increase in population are rapidly increasing the quantum of waste into the river which in turn increases the need of oxygen of aerobes and the protozoa in the river. But the river can only supply a limited amount of oxygen. As a result of shortage of oxygen the aerobes and protozoa starts dying off. As the oxygen level reduces in upper layer, the anaerobes rise and attack the waste material. They use hydrogen in doing so. Such process produce the foul smelling hydrogen sulphide gas when hydrogen combine with sulphur from the

waste. The water becomes useless and muddy. The sunlight is unable to penetrate the surface. Algae and fish begins to die in the absence of sunlight. What remains is a "foul" river, smelly, and sluggish, devoid of life and a menace to all other life.

This can be seen happening by the few examples given below.

Times of India of December 7, 1986 reports that Effluents Choking Periyar River. This river has become a dumping ground for all kinds of toxic effluents of biological, chemical and industrial varieties, posing threat to the life of 3 million people.[1] Of Greater Cochin area who entirely depend on this river for their drinking water requirements. Several chemical plants dotting the bank of the river discharging the tonnes of treated and untreated effluents into the river endangering the fauna and flora.

According to an organization for environmental protection headed by poetess Miss Sugatta Kumari hundred of tonnes of mezothorium and uranium wastes are being dumped into the sea and Periyar river which are certain

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1 Times of India, December 7, 1986, p.12.

to reach human being through fish, posing grave dangers of radiation induced cancer.

The same has happened with the Chaliyar river in Kerala where discharge of the high level murcury by a Rayon factory has turned the water brown and the fish is no longer safe for eating.

This is not the sad story of Chaliyar only but almost all the rivers in India. According to NEERI National Environmental Engineering Research Institute, 70 per cent of India's inland water is unfit for human consumption.[1]

Even the existence of world famous Dal Lake is threatened by the pollution. The Dal has shrunk to 11 sq. km from 22.5 sq. km in 1974. Mud and city wastes are dumped along its banks to convert the area for unauthorised construction and farming. About 200 houses have come up over a 500 hectares area of the lake.[2] Moreover, the waste from house boats, hotels and residential houses further

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1 Rao, P.U., Hindustan Times, 26th September, 1986, p.12.

2 Hindustan Times, February 17, 1987, p.4.

pollutes the lake. Adding to this are about 8,000 tonnes of silt that collect each year in the lake, most of it through Telbal Mullah (Hindustan Times, February 17, 1987).

In Oriss, the rivers Mahanadi at Cuttack, Nagavalli at Rayagada, and Rushikulya in Ganjan district, all of which are sources of drinking water are polluted by discharge from paper mills, a caustic soda plant and untreated human waste.

The rivers in the south except for the Loel and the Karo, are heavily polluted by the discharge from steel plants, coal washeries, thermal power plants, fertilizer units and chemical industries. In Tamil Nadu, for instance, the 430[1] tanneries are a major source of pollution not only of surface but underground water as well.

Urbanization and Ecological Imbalance

The process of urbanization has brought ecological crisis by polluting air with its numerous poorly maintained vehicles, smoke from houses and pollutants from industries. Ecologist carlos Bustamento of Peru's National University

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1 Gautam, S.G.Vohra, Times of India, 25th February 1984, p.8.

of Engg. noted that Lima's serious air pollution is due to city's numerous old and poorly maintained vehicles and estimated that such vehicles emit 5 times more pollution than new cars.

Aukara's Health Ministry recently reported that the air was laden with 2.5 times[1] more sulphur dioxide and four times more smoke than the maximum level set by WHO. In Bombay largely because of industrial growth, pollutants enter the area's air at the rate of 1000 tonnes every four hours including 38.4 per cent carbon mono oxide, 33.4 per cent sulphur dioxide, 9.8 per cent oxides of nitrogen.[2]

The process of urbanization has been accelerated because of increasing population which in turn effect the quality of environment.

Urban population in all cities of 100,000 or more (in millions)

	1950	1975	2000
World	392	903	2,167
Industrialized countries	262	503	756
Less developed countries	130	480	1,411

Source: Trends and prospects in the populations of urban agglomerations 1950-2000 as assessed in 1973-1975).

1 The Global 2000 Report to the President, 1982.

2 ibid., pp.241-243.

Urban slums and Shanty towns, where sanitation and other public services are non existent or at best, minimal. Recent estimates indicate that the population in such settlements are doubling in size every 5-7 years, while the urban population as a whole double every 10-15 years. In Bombay where uncontrolled settlements are among the largest in the world. Thus rapid growth create pressure on sanitation, waste disposal, water health care, shelter, etc. It also result in sewage burdens in stream, rivers and lakes and along coastlines and spreading in many countries.

Urbanization and Water Pollution

Cities causes local but severe changes in the hydrologic cycle. The pavement and roofs of urbanization greatly increase the percentage of the land's surface which is impervious to water rather than infiltrate into the ground. A high proportion of precipitation runs off into streams causing greater flooding than in the country. Urban land use promote erosion and produces large quantities of sediments.

Urbanization decreases the quality of water in the following ways:

1) Waste material including dissolved solids, pathogenic bacteria and heat are added into the water.

2) Discharge of waste material into lakes, ponds etc.

3) Flooding of sewage system owing to heavy rain and subsequent discharge of the untreated sewage into the water sources.

4) Finally, urban commonly causes streams to lose their attractiveness. Increased floods caused scoured or muddy stream channels. Reduced oxygen content and reduced water flow alter aquatic life and contribute to turbid slimy and smelly streams.

Community wastes from human settlements accounts for four times as much waste water as industrial effluents, Most of these waste are discharged untreated into the water courses out of India's 3,119 towns and cities only 217 have partial (209) or full (8) sewerage and sewage treatment facilities. These cover less than a third of the urban population.

The Indian standard for inland surface water recommends an average MPN not exceeding 5,000 per 100 ml. Before the Yamuna enters Delhi 100 ml of water contain about 7,500 coliform organism. But further downstream at Okhla, after it has received Delhi's waste water, the MPN skyrockets

to 24,000,000 per 100 ml according to tests conducted by central Board for Prevention and Control of Water Pollution (CBPCWP).[1]

In Kanpur MPN value for the Ganga, as high as 10^5- 10^5 per 100 ml were measured as far back as 1966.[2] Today the situation is likely to be worse.

It was estimated by NEERI that about 632 tonnes of pollutants foul the atmosphere over Calcutta everyday. Nearly 45 per cent of the pollutants were suspended particles, and the presence of carbon monnoxide was as high as 28 per cent.[3]

In view of all this it is not surprising that blackish dirt accumulates on fans and this high population city sometimes looks like a ball of smoke, particularly in the morning and evening hours in winter, where viewed through the windows of an aeroplane approaching the city.

Times of India reports that Kota, a town in Rajasthan is under environmental threat. Due to increased

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1 The State of India's Environment, 1982, p.16.

2 ibid., p.20.

3 Chakrabarti, H.C., Capital, October 15-28, p.30.

or incessant industrialization the sky of Kota has been polluted with sulphur dioxide, various introgenous gases and other toxic particulate matter. Air pollution sources are both anthropogenic and natural.

The anthropogenic sources are classified into mobile or dynamic sources and stationary sources. Mobile or dynamic sources consist of automobiles, transport means, of which Kota has almost 40,000![1] The stationary sources consist of chemical and allied industries, mining operations, thermal power plant steam engine, marshalling yard and domestic activities such as fuel burning.

The chief threats, however are the thermal power station and a local chemical industries complex. Both of these are situated within the city limits.

It is estimated that 70 per cent of the acidity is due to SO_2 and the remaining on account of nitrogen oxide. The acid rain phenomena has been directly attributed to the release of a significant amount of sulphur dioxide in the atmosphere.

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1 Sharma Rahul, Times of India, 26th September 1986, p.6.

Kota thermal power station has two boilers of 40 M.W. capacity each. These boilers are provided with electrostatic precipitators (ESPs). It is shocking therefore to find that it releases SO_2 in the order of 115.2 tonnes per day (TDP) which is almost 60 per cent[1] of the total SO_2 released in Rajasthan.

Apart from the acid rain SO_2 absorbed on solid particles get deposited over plant and soil in the form of dry deposition.

In conclusion we can say that the crisis of environmental degradation is inescapable and will lead inevitably to a catastrophe if man does not begin to think ecologically and then resolutely employ the power of his brain. He has to apply an ecological strategy.

If we irresponsibly allow the present mismanagement to continue the people of the 21st century will despite their technological brilliance go down in history as barbarians.

Not just buildings, art, electricity, cultivated fields, planted forests and other man made creations belong

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1 ibid.

to our civilization. Free living nature is also part of our heritage. If man destroys the last remnants of free nature he forfeits the right to talk about himself in terms of civilization.

An important part of modern nature conservation is just to insure the existence of all types of habitats, as well as of all plants and animal species. Man can benefit from the conservation of nature in many ways. In fact to conserve the world's natural resources is to enhance the possibility of man's survival.

CHAPTER III

ANIMAL ECOLOGICAL GEOGRAPHY

Animal ecological geography or zoogeography is the scientific study of animal life with reference to the distribution of animals on the earth surface and the mutual influence of environment and animals upon each other. As the name implies the term indicate that both zoology and geography are included in the subject matter of zoogeography.

Zoogeography as a sub-discipline of geography is very broad based since all groups of animals, from protozoans and coilenterates to vertebrates, have been included, though very unequally in zoogeographic studies. Among plants, the relations with the total environment are much more direct and obvious than among animals. The animals are to certain extent independent of their micro-environment because of their capacity of motion. They can get their food,water and warmth in new localities. They can migrate from one place to other and can make adjustment there.[1]

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1 Allee, W.C., Karl, P. Schmidt, Ecological Animal Geography, 1951, p.3.

How this field of zoology came into the subject matter of geography? The answer of this question can be sought from the subject matter of geography itself. Geography is the description and explanation of the features which comprise the earth's surface and of their causal phenomena. Living beings - members of the classic plant and animal kingdom - occupy nearly all the surface of the globe. They are widely distributed in the sea, they float and swim on the surface or in the water and they cover the bottom as mats of animal and plant life. There is scarcely a land area that cannot harbor some sort of life. Even such inhospitable areas as desert, icefields and windswept mountain tops may show at least enduring diaspores or primitive forms carried there by the elements. Besides the more or less continuous cover of land vegetation and network of animal life within it, the lower reaches of the air also carry aerial forms of living organisms. The geographer considers the sum total of these environments as forming the biosphere, the sphere of living things.

In broad term animal ecological geography is concerned with the phenomena of biosphere. Not only environment effects the animals but plants and animal also changes the landscape of the earth. For instance, plants

and animals contribute to the physical weathering of rocks; they are also activity contribute to rock formation for example, in the form of coral and algal rocks, coal and guano deposits, both play an important function in soil formation; while vegetation may affect local atmospheric conditions.[1]

The difference between the two descipline ecology and geography is that while biologist give emphasis to organism first the geographer gives primary importance to the environment. In the words of J.L. Davies: "Ecological distributions are conceived as being on a local scale and often resulting from habitat preferences, geographical distribution are on a regional or continental scale. The field of zoogeography is commonly limited, explicity implicity to the latter yet the study of the distribution of animals in a wood or on a mountain side is as much zoogeographic as the study of distributions on a continent or within a major bioms. There is a real danger in appearing to limit the descipline to a consideration of the broader and more spectacular patterns. The distribution

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1 Udvardy Mikos, D.F., Dynamic Zoogeography, 1969, p.1.

arises because, on the smaller scale, the question of the available fauna does not arise and distribution factors are purely ecological. As a result such distributions tend to be studied by ecologists, but they are nonetheless zoogeography. This question of scale should not be allowed to divorce studies, for the principles formulated at one scale may be important in study at another".[1]

HISTORY OF ZOOGEOGRAPHY

No full history of zoogeography - of man's idea about animal distribution has been written, but Gadow gives a useful summary of it.[2]

Even before Darwin, more formal ideas about animal distribution were held by Buffon and other writers of whom about a dozen are listed by Gadow. Some of them were trying to find centers of creation. Sclater has divided the world into six region according to the distribution of the birds two years before the publication of the Origin of Species.

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1 Davies, J.L. (1961), "Aim and Method in Zoogeography", Gegr. Review, Vol.51, pp.85-97.
As quoted in Robinson, H., Biogeography, 1972, pp.350-351.

2 Gadow, H. (1913), The Wanderings of Animals, as mentioned in Darlington 1957, Zoogeography, pp.20-21.

Darwin's book 'The Origin of Species'[1] has stipulated a more scientific approach to learning of distribution of animals in geography. Darwin in his famous voyage on the Beagle was much struck by the curious phenomena of distribution which that voyage brought before his eyes, and it was these phenomena which helped to direct his attention to that line of thought which resulted ultimately in the publication of his theory of natural selection. The two facts which especially struck him were:

(1) Similarity of physical conditions does not necessarily results in a similar fauna, and conversely. For example, there is considerable uniformity in the fauna of South America in spite of contrast in its climate from its length to breadth. The continent contains the cold deserts of the high Andes to the luxuriance of the Brazilian forest, the burning desert of Chile to the grassy plains of the Argentine.

On the other hand the grassland of South America and Africa possesses the same physical conditions but the animals of both the regions are not the same.

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1 Darwin, C. (1859), 'The Origin of Species
As Mentioned in Darlington 1957,
Zoogeography, pp.20-21.

(2) The second point which surprised him was that similarities and dissimilarities between the fauna of two regions are due to the nature of the barriers which seperates the two regions. For example mountains like Himalaya and Atlas seperate two different faunas. Identical or similar animals are found in the land which were seperated by shallow or narrow strait and dissimilar fauna has been registered in the areas seperated by broad and deep belt of ocean then he came into the conclusion that each species originated in a particular region, and spread out from that region till it was stopped by some barrier to its further distribution. This has led to scholars to the study of distribution and division of the globe into zoogeographical regions.[1]

To trace the process whereby zoogeography came to be incorporated into the biological sciences we must go back to the beginning of the 19th century when the biological sciences started to differentiating from the natural history of the past.

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1 Newbigin, I. Marion, Animal Geography, 1913, pp.11-12.

The first important theorizer of zoological knowledge was the German scholar Ernst Haeckel, who was deeply influenced by Darwin's theory of evolution. Haeckel has also given definition and concept of zoogeography in his book of General Zoology (1866) which had advanced since decandolle's time mainly in the descriptive field. According to him this aspect of animal distribution is the focal theme of the descipline 'Chorology' which include geography and topography, description of habitat and their limits of distribution. It also includes the vertical distribution i.e., the depth limits for aquatic animals and the altitudinal zonation of land forms. The father of zoogeography, Alfred Russel Wallace has established a clear distinction between the point of view of the geographer and the zoologist.[1] For the one he coined the term "zoological geography" for the other, "geographical zoology".[1] In the area of geographical zoology, he advocated a revision of the distribution of the animal world by systematic groups and at the same time, made due allowance for historical causal relations and for the interaction of different biota Wallace's system of zoogeographical regions was based

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1 Wallace, R.A., The Geographical Distribution of Animals, 1876.

principally on the distribution of a few groups of animals, but his results satisfied geographers because the regional limits of continents or of major topographic regions within them - that is, with geographic boundaries.[1]

The two most recent books on zoogeography in English are Plant and Animal Geography 1958[2] and Zoogeography of Land and Inland Waters[3] Newbigin's book was published shortly after her death. H.J. Fleure, in a tribute to Newbigin, wrote "She had a vision of the world of life as a sphere of cumulative interactions which she saw modifying not only the structure and functions of individual plant and animal, but also the assemblages or associations of living things in the various regions of a changing world".[4]

As compared to other branches of geography, zoogeography has been less fully studied and developed on lines different form phytogeography. This is not to say

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1 Udvardy, Miklos, D.F., Dynamic Zoogeography, 1969, p.23.

2 Newbigin, Animal Geography, 1936, p.238.

3 Beaufort, L.F. de., Zoogeography of Land and Inland Waters, 1951.

4 Quoted in Robinson, H., Biogeography, 1972, p.3.

there is lack of work or research upon animal life; on the contrary there is a very rich literature on zoogeography ranging from the pioneer studies of Darwin and Wallace to the late Richard Hess's Ecological Animal Geography and the more recent works[1] of P.J. Darlington, C.S. Elton, G.G.Simpson and J.Z.Young. The great complexity of the factors which influence animal life and the diverse reactions of the varied types of animals to the controlling factors, as well as the fact that the relations of animals with the environment are less direct and obvious than in case of plants, have made zoogeography a more difficult, if not less interesting, subject of study and a number of zoogeographic problems have been less easily resolved.

Zoogeography: Its Relations with Other Subjects

There is not a single scientific descipline which can advance independently and without the support of advances in other fields. When zoogeography is viewed by a magnifying glass it shows a Kaleidoscopic picture composed of geography,

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1 Darlington, P.J., Zoogeography, 1957.
Elton, C.S., Simpson, G.G. and Young, J.Z., 1940, 'Mammals and Land Bridges'.

animal ecology, plant geography, paleontology, evolution and systematics, the desciplines which immediately surround and intermesh with zoogeography. Further away we find demecology (a recent term for population ecology), synecology (the ecology of biotic community) plant ecology, plant evolution, geology, ethology, physiology and morphology. These desciplines are also related to zoogeography.

Geographic and topographic description of the habitats as Haeckel United under chorology are as important to animals as the number of their chromosomes. It also shows the place of zoogeography in the system of biological sciences. These factors metabolize the energy of the organism and relate them to another group. The spatial relations of these objects of study are treated here as biological attributes, and it can be easily seen that different aspects of zoogeography interwine on a biological rather than a spatial basis.

It has been said that the present and past distribution of animals is based on characteristics of their biological habitus, a term given by Russian entomologist Bertenev. The term includes several biological characteristics of animals, such as the facts of their structure, of their

internal functioning (physiological functions), and of their functioning in relation to the environment (ecology and ethology); but even among these phenomena, there are some that easily escape our attention as concrete objects of study. Such parameters as number of offspring, longevity, selection of particular habitat and food, and site of reproduction will serve as examples. In this interpretation, the biological habitus complements the morphological habitus (appearance, structure and shape) and modes of functioning. In this perspective, zoogeography is a branch of the study of the structural and functional reactions of the animal. This particular reaction pertain to the space that forms the immediate environment not only of the individual but also the total population of a species.[1]

The Field of Animal Ecological Geography

1. Faunal Zoogeography

Faunal zoogeography forms the basis for every further development of the subject. The functions of faunal zoogeography are the: accumulation of faunal lists, in which

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1 Udvardy D.F. Miklos, Dynamic Zoogeography, 1969, p.45.

the animal populations, whether single groups or into to are enumerated for specific areas of varying extent. The second function is the identification of animal species. The third most important function of this branch is to distinguish the various habitat according to soil, vegetation and climatic conditions, each inhabitated by a definite and well characterized animal community.

The criterion of faunal zoogeography is systematic which further suggests new problems for ecological animal geography. For example different geographical sub-species are recognized in the case of widely distributed animals. Their wide distribution give them different appearence in different parts of their range. An expert eye is always required to distinguish such sub-species because they may also be united by intermediates. These minor geographic differentiations are very important as they reveals the influence of external conditions upon animals. Many detailed studies of this type have been made, especially for birds and mammals, and the work of the systematists in this field although consequence, is especially valuable. It is, of course, to be desired that a uniform nomenclature and a definite characterization of these geographic sub-species be introduced.

The definition of sub-species as geographically representative forms, regardless of contiguity of range or of intergradation, preserves the useful trinomial grouping. In fact it brings the definition of species and formenkreis into essential congruence. Mayr Ernst has reshaped these definitions and given the terms allopatric for forms not found in the same territory and thus geographically representative, and sympatric, for forms, that remains distinct in spite of overlapping distribution.

After such a process the data can now be ordered and analysed which will lead to the establishment of hidden natural laws and their interrelations. Faunal zoogeography, therefore leads directly to classification of the facts of distribution, this classification may proceed in various directions.

2. Comparative Zoogeography

This branch tries to classify animal distribution according to their resemblances. There are different methods and views of the comparisons. Homologies, denotes inherited resemblance, and analogies, means acquired resemblances, are distinguished in comparative anatomy, and a similar distinction applies to animal distributions. The comparison of the varied faunal lists of natural relations

of their component reveals the difference of faunal whose distribution does not agree with the present geographic division of the earth. Such animals of North Africa as snails, insects, birds, reptiles and amphibians are much more closely related to the animals of the corresponding groups in South Europe than to those of Africa south of Sahara. The fauna of South Asia and trans-Saharan Africa is identical while it is not similar with the fauna of Asia's north of Himalaya. The homologies among such comparable faunal are based upon the blood relationship of their components and upon a common evolution in time and space. The larger faunal of this kind characterize the faunal regions and their subdivisions, within which the animal inhabitants are homologously comparable. For example, the representatives of natural groups in South America, such as the iguanid lizards, the oven bird family and the rodents, are interrelated and of common origin wehether they inhabit the forests, the prairies, or the mountains.

The distribution of species can be understood under two ways: one is the means of dispersal available to the animal, and the second is existing physical or biotic barriers to such dispersal. That is why closely related species like related human stocks in general have adjacent

and continuous distribution, since it is to be assumed that the area in which they developed from their common ancestors was the common origin of their distribution. As a consequence of the differences in means of dispersal in different natural groups of animals, the external barriers affect the different groups in diverse ways. Water animals are limited in their spread by land, and land animals by water. While mountain ranges put a barrier for land animal, birds are least affected by this kind. The dispersal of any group get effected by lack of food, adverse climate or the presence of more successful competitors.

The geologic changes in the earth's surface are more effective and take shorter period of time and present more important barrier than the dispersal through organic evolution. For example the high mountains like the Himalaya's, the Atlas and the Alips were once vast areas of sea, and rivers had other courses in formal times, the deserts of today were well watered areas and that ice sheets extended over previously inhabited regions, which were repopulated after the withdrawal of the ice. It is highly probable that land connections formerly existed between certain regions now seperated, such as North Africa and

Southern Europe and North America and Eurasia (via Alaska). This has led to the seperation of formerly continuous areas where ranges of related animals existed and regions may be united whose faunal were only distantly allied. The older a natural division of the animal kingdom, the more such changes of barriers will have occured during its history, and the more opportunities of dispersal will have been available to its members.

3. Historical Zoogeography

The idea of biological evolution, propounded by Darwin and Wallace together with the growth of the science of paleontology, which provided a fossil record illustrating the developments and relationships of animal life, resulted in the development of another aspect of zoogeography, which is known as historical zoogeography. Historical zoogeography in this way attempts to work out the development in geologic time of present day distribution by studying the homologies of animal distribution. For such studies the systematic groups of related animals may be taken into account. The problems would be then of such type: why the groups like the penguins, hummingbirds, monotremes, lemurs, or armadillos are restricted to specific areas; and the absence of otherwise widely distributed forms from certain

particular areas as bears in Africa south of Sahara or of placental mammals in Australia, and the presence of related forms in widely seperated regions, such as the tapirs in tropical America and in Malaysia, peripatus in New Zealand, south Africa and south America, and the hase shoe crabs on the east coast of North America and in the Moluccas on the other hand the geographic unit may be taken as the starting point, and the fauna of a given region may be analyzed by studying the distributions of the subordinate faunal of diverse origin represented in the area. In celebes, for example, Asiatic and Australian elements are intermingled. Four immigrations can be distinguished, which entered celebes at successive periods over four distinct routes. These highways of immigration were i) via Java, ii) via Flores, iii) via the philippines and iv) via the Moluccas.

The aims of historical zoogeography are unquestionably high and valid answers to its questions would be of great importance. It is remarkable that one is able to find clues to events of the remote past by the analysis of the homologies in animal distribution. Historical zoogeography has been valued highly in the eyes of numerous investigators because of its endeavor to unravel the

history of the colonization of continents, and to discover the highways of distribution and the causes of migration in the past epochs. This was particularly true in the half century following Darwin's Origin of Species, when the study of homologies overshadowed all other lines of research in zoology. During that period Historic Zoogeography was enthroned was actively investigated, and now exhibit in consequence a fine series of well-established and connected results.

4. Ecological Zoogeography

Ecological communities of animals may be recognized that resemble each other superficially in correspondence with resemblances between their environments. These are acquired rather than inherited tendencies. For example the inhabitents of the rain forests of the vardous tropical countries, South America, Africa and Malaysia, exhibit a whole series of evident resemblances, among which adaptations for climbing and for parachute jumping are especially notable. The animals in mountain streams in all part of the world have numerous and surprising resemblances in their possession of adhesive apparatus.

The ecological view point, as contrasted with the historical, regards the analogies or acquired tendencies

between animal communities in similar habitats. Ecology is the science of the relation of organisms to their surroundings, living as well as nonliving; it is the science of the "domestic economy" of plants and animals. Ecological zoogeography views animals in their dependence on the conditions of their native regions, in their adaptation to their surroundings, without reference to the geographic location of the region, whether in America or Africa, the northern or the southern hemisphere. This phase of zoogeography may also proceed either from a geographic viewpoint or from the animal itself. The geographic questions concern the requirements created by the environmental conditions of a given area for the structure and habits of its inhabitants; the modifications in appearance and habits undergone by the animal population in adaptation to the given conditions; and the selective operation of habitat requirements on the composition of the fauna.

In contrast with the speculative nature of much historical zoogeography, ecological zoogeography bears the germs of a more truly causal science. Although still in its infancy, it has established some general laws, such as the application of the law of minima to the phenomena

of distribution, Bergmann's Rule and the correlation between the weight of the heart and the isotherms of climate.

5. Causal Zoogeography

The causal zoogeography tries to find the answer of the problems like what comparable phenomena the species in an area contain and what are the causes of the appearance of groups with varying limits or of the causes that condition the characteristics in groups with similar habitats. Depending upon whether the associations to be studied are homologous or analogous, causal zoogeography studies the historical reasons for the evident differences in distribution of the natural groups of animals or the ecological relations between an environment and its animal population.

Specialised Environmental Adaptation

Plant and animals both are closely related to the environment. For their survival they adapt themselves accordingly. Certain species of animals show distinct preferences for particular habitats, for example some have predilection for life in a tree, some like soil while other choose waterside or marshy environments.

Terricolae is the term used for creatures that live in the soil. It includes creatures like earth worms various kinds of insects, rodents and moles Borrowing animals are generally nocturnal in their habits and resort to tubernation during the lean cold season. Life in the earth has led to many terricolous creatures developing specific adaptations, e.g. strong, clawed forepaws for digging, spatulate hind paws for throwing up earth, sharp, pointed heads strong, forward-projecting teeths or short or rudementary tails. Life underground dispenses with the need for sight, and thus the eyes of terricolous creatures degenerate and some are almost blind.

Aquicolae are other type of creatures which are attracted to moist environments, e.g. beaver and other have even adjusted themselves in a semi-aquatic mode of life. Availability of food also attract birds and mammals around waterside, larval, insects, worms, fish etc. are abundant in streams and lakeside localities. Birds develop peculiar bills, webbed feet and sometimes long legs to enable them to wade into deeper water. For instance, storks, flamingoes have such characteristics. Semi-aquatic mammals, such as the beaver and other develop lithe, streamlined bodies, webbed feet and thick fur. One of the most surprising

example is of an ungulate, hippopotamus which has adjusted himself to a semiaquatic life; it loves to walow in a warm water and mud. In this case the main adaptations occur in the head, where the ears, eyes and nostrils are found in upper portion of the skull. The water buffalo has a similar love of water.

Arboricolae are the animals which live largely in trees. Such animals have developed arboreal habits, that is activities which enable them to climb jump and move readily. Monkeys, for instance, show a variety of adaptations e.g. long forearms, opposable thumbs, long toes and prehensile tails, which fit them for life in the trees.

The development of membrances between the limbs and the body among flying squirrel and flying lemur made them capable to glide from branch to branch. Most of the Aroricolae live on a vegetarian diet of leaves, fruits and nuts.

Farm and Colour

A fascinating aspect of animal life relates to farm and colour in animals, form and colour embraces much things as disguise and camoaflage, mimicry and luminescence. Animals adapt such characteristics for security purposes

or to avoid attack from enemies. Any signal of danger makes them quite still, so that their shape and colouring prevent them from being seen; others try to scare away their enemies by adopting terrifying attitudes and simulating aggression.

Animals adopt 'protective' colouring according to climate and vegetation to their surrounding to escape detection. For example, many creatures living in snowy environments are white or change their summer colouring to winter white with the arrival of the snow. Counter-shading i.e., where the back of an animal is darker than the under part, is a simple form of concealment common to nearly all the vertebrates. Counter shading enables the animal to fade into its surroundings, and cancell out the effects of light and shade. Some animals have strongly patterned bodies, e.g., stripes and irregular patches of contrasting colours, at close quarters these markings stand out clearly but at a distance they blur and provide an effective camouflage. The stripes of the Zebra against the tall grasses of the Savanna or of the black-and-white Malayan tapir which haunts boulder strewn stream courses or of the leopard whose large dark spots enable it to lurk in the dappled light which filters through the jungle growth. Among the lower animals there are some which are

capable of making rapid colour changes e.g. lizards and frogs. Many lizards are very difficult to distinguish against the bark of a tree, and the gecko has a fringe along its sides and tail which helps it to merge with the tree bark. Some sea creatures adopt themselves according to the colour of seeweed in which they live. The unique example of such type is the sea-dragon, a kind of sea horse which has long out growth of skin and conceal himself in the fronds of sea weed. Many butterflies have leaf-shaped wings so that when they light on a ting they look like a leaf.

The other interesting feature about the farm and colour is the "warning colour" adapted by some animals to show that they are unpalatable, dangerous or to be avoided wasps, shakes, some toads and the brightly spotted ladybird beetle are some of the animals displaying warning colours. Another kind of warning colour serves as an alaram signal e.g., springhik, when alarmed, jumps into the air to display long white back hairs which are normally hidden. The same is with rabbits and antelopes. They raise their tail to show a white patch when disturbed and frightened.

Mimicry is another kind of adaptation among animals. Mimicry includes some fraudulent forms as warming

colours, frightening attitudes and imitation. Many small, defenceless creatures adopt mimicry to bluff their enemies e.g. some species of syrphid flies (hoverflies) imitate the colour patterns of wasps, certain edible buterflies mimic those having an obnoxious taste.

Finally the colour pattern in animals play an important role in mating e.g. among birds, especially males are usually more exotically coloured than the females, displaying their brilliant plumage during courtship.

The Effect of Vegetation

Animal and vegetation both are very closely linked. Animals cannot live without vegetation as it provides both food and shelter to them. Many animals prefer certain habitat like grassland or forest while some can live in every one, but majority are limited to a particular type of vegetation. Food habits also make them selective to particular habitat e.g. ungulates which are grass eating types are seldom found in thickly forested regions. On the other hand tree dwelling types are not normally to be found in grassland areas.

Plants, either directly or indirectly, provide the food supplies for animals and a sufficient amount of

organic food is an indispensable condition for the habitability of an area for animals.

Animals which are omnivorous are termed euryphagous and those which are vegetarian and carnivorous stenophagous; but both carnivory and herbivory may be narrowly specialised or have a wide range i.e. there may be euryphagous and stenophageous carnivores and both type of herbivores. Euryphagy tend to be general among carnivorous animals, a condition which helps to extend their distribution, Stenophagy, on the other hand, is apt to limit distribution.

The Effect of Climate on Animals

Climatic conditions are composed of moisture, temperature, pressure and light. Various animals prefer various climatic conditions. For example some animal prefer drier habitats while others wants to live only under very moist or humid conditions. Water living creatures of necessity need water but all terrestial animals require some water, albeit in greater or lesser amounts.

Different terms are being applied for the animals related to different climatic conditions, Stenohygric is the term used for the animals which are restricted to narrow limits of variation in atmospheric humidity. Amphibians, worms, most snails, hippopotami and water buffalo are

included in this category. Euryhygric animals accommodate or can live under wide variations in humidity. They are numerous among the insects, birds and mammals. The effect of rainfall on animals is not very obvious and it is in its indirect effects on plant life that rainfall has its greatest influence.

Temperature is also an important factor which effect animal life. Though there are variations among temperature tolerant limits but the upper and lower limits are restricted, the lower limit is just below freezing point and the upper limit around 50°C[1] (122°F). Some animals can tolerate high temperatures and others very low temperatures. Frogs and other animals liberate to avoid the effect low temperatures. Eurythermal is the term which denotes that the species can tolerate fairly wide range of temperature e.g. some of the predatory cats, on the sperm whole on the other hand stenothermal connotes about the species which can exist only within narrow ranges crocodiles and penguins are the best example of this type. Stenothermal animals may be either heat tolerant or cold tolerant.

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1 Robinson, H., Biogeography, 1972, p.361.

George has quoted in his book of animal geography:

> "Low temperature prevents animals adopted to tropical conditions spreading to the poles. Reptiles which are primarily tropical, being numerous and varied where temperatures are high, decrease both in number and variety towards the poles. Crocodiles are hardly known outside the tropics and the most northerly occurrence of a turtle, the European pond tortoise, is 57½° and this is exceptional for the order. Conversely high temperature prevents animals adapted to a cold climate spreading to the tropics, Dalliid black fishes are limited in this way to northern polar regions. Penguin too are limited to cold water but, because cold current flow north from the Antarctic, they have in one case reached the equator"[1].

The effect of light on animals is as effective as on green plants (which need essential light for the photosynthetic process). Nocternal animals and some as soil dwellers, cave dweller and those living in deep water

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1 Wilmea George, 'Animal Geography' is mentioned in Robinson, H., Biogeography, 1962, p.361.

live without light throughout their life. Although some of the simpler forms of life are tolerant of the dark and although some of the higher forms are able to dispense with light, at least for periods, most animals do in fact need light. But in desert and at very elevated lands where there is very intense insolation, too much light is injurious for the animals. In such cases animals seem to adopt a dark coloration as a measure of protection against the sun's rays. "Uiruses, bacteria, fungal spores and many microscopic animals, given sufficient exposure, are killed by the ultra violet radiation of sunlight.

At high altitudes variation in atmospheric pressure are a particularly significant environmental factor. Effects at great elevations seem to be related more to the deficiency in oxygen than to any decrease in pressure. Some fishes have vertical ranges which are limited through the effects of pressure while deep sea fishes, which live under very high pressure do so by means of physiological adjustment.

The Zoogeographical Realms

Zoogeographical regions can be defined as those regions or portion of the earth's surface, having an assemblage of fauna, more particularly mammalian fauna,

possessing some unique features which distinguish it from other areas.

According to Miss W.George, the zoogeographic regions are:

> "When the distributions of all animals are added together, the dissimilarities in individual ranges mark out the world into distinct region. These regions are differentiated from one another by the different mixtures of animals which they contain, as well as by the fact that they may also contain a family which is uniquely found there. For instance one region is characterized by the coexistence of tapirs and members of the camel family even though neither family is itself confined to the region. No other region has this particular combination. In addition the same region has within its confines several families of vertebrates that are found nowhere else in the world".[1]

Thus it may be said that, in broad terms, a zoogeographical region correspond very roughly with the continents or are confined to areas of more limited exten

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1 ibid., p.365.

than the continents dense forest generally show certain arboreal adaptations, such as the prehensile tail, the opposable thumb and great toe. But in New Guinea, for example certain kangaroos have taken to the trees and become arboreal. The only possible conditions is the hypotehsis that the specialized forms in each seperate region have been evolved from pre-existing unspecialized forms inhabiting the region. In the continent of Australia, and parts of the adjacent regions, kangaroo are abundant and are for the most part Savana animals. But where tropical forest occur in N.Queensland and New Guinea, there certain forms have taken to the arboreal life, and have thus protected themselves from the competition of ground living forms no less than from the attacks of some possible enemies. We may say, them that when any stock of terrestrial animals reaches a new region, and is there isolated from any cause, that stock will tend to give rise to specialized groups, more or less perfectly adapted to all the possible varieties of habitat which the region affords. Such type of changes have led zoologist and geographer to divide the globle into distinct zoogeographical realms.[1]

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1 Newbigin, I.M., Animal Geography, 1931, pp.208-209.

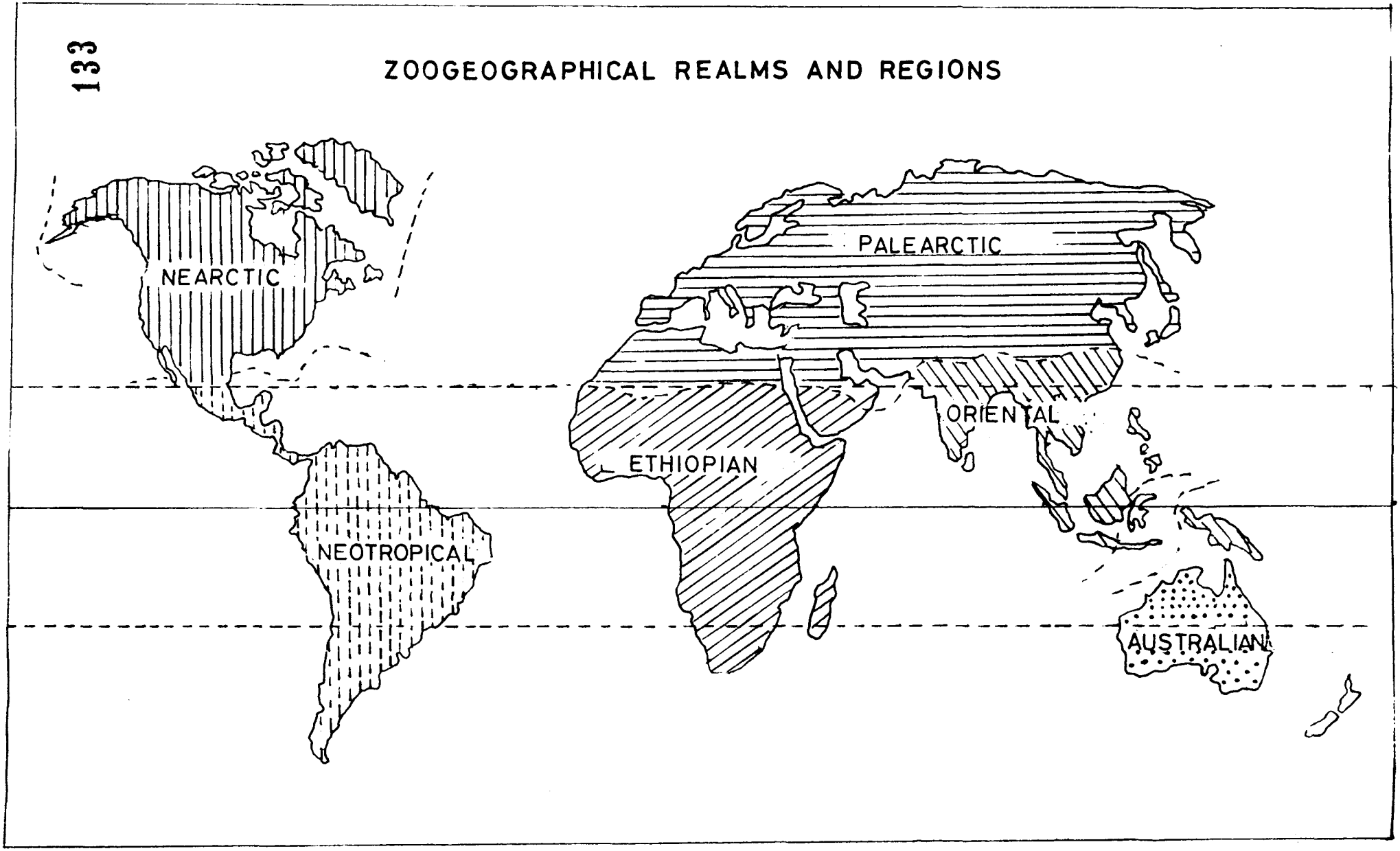
ZOOGEOGRAPHICAL REALMS AND REGIONS
NEARCTIC
PALEARCTIC
ORIENTAL
ETHIOPIAN
NEOTROPICAL
AUSTRALIAN

FIG. 1

The first attempt to divide the world into zoogeographical regions was that made in 1857[1] by P.L. Sclater, Secretary of the Zoological Society in London. He recognised six avifaunal regions or the basis of kind of birds found in different regions. A.R. Wallacs and Charles Darwin in 1876[2], divided the land animals according to their geographical distribution.

The geographical distributions of Sclater and Iwallace have stood the test of time and basically we still use their map. Their zoogeographical regions largely, though not entirely, corresponded with the continental land masses, and each region was seperated from its neighbour by a fairly clearcut physical barrier, a stretch of water a high mountain range or a belt of arid desert. The six recognized regions were as follows:

a) Palearctic region
b) Nearetic region
c) Neotropical region
d) Australian region
e) Ethiopian region
f) Oriental region

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1 Robinson, H., Biogeography, 1972, p.366.
2 ibid.

There is another system of classification under which the Palearctic and Nearctic regions are combined and this enlarged region is given the name of Holaretic. This system is based on the fact that though the fauna of the Palearctic region outwardly differs from that of the Nearctic region, these differences are not generally deeper than the genus level. It is therefore concluded that the fauna of these two regions has evolved from common ancestral stock early in geological history when the two land masses (Palearctic and Nearctic regions) were not seperated by the ocean and formed a much wider land mass.

Again this view it has been argued that the Neotropical and Australian regions are so different and so distinctive zoologically from the rest of the world and from each other that it would be more correct to rank them as of equivalent status to the Nearctic and the three old world regions combined. According to such a division, we can envisage three zoogeographical realms subdivided into regions as follows:

1. Arctogea
   a) Nearctic
   b) Palearctic
   c) Ethiopian
   d) Oriental

2. Neogea (Neotropical)
3. Notogea (Australian)

The Arctogean Realm

It is called Arctogea, or the Northern World region, because of its mainly northern position, though Africa extends far to the south. It is comprised of North America approximately as far south as the Tropic of Caucer and Green land together with the northern half of the old world land mass again roughly as far south as the northern tropic, known as the Palearctic region (Eastern Holarctic), plus the oriental and Ethiopian regions. Marsupial North American opossum and monotremes are absent in this realm on the other hand placental mammals are predominating here. There is similarity of fauna and flora in the lands of Arctogea. The homogeneous fauna reveals that the whole of America and Africa were connected by land bridges in the past. Eurasia and America were joined by Bering Strait and Africa and Eurasia were connected by the Sinai Peninsula and Strait of Gibralter.

The Holarctic Region

(i) East (Palearctic)
(ii) West (Nearactic)

The area of this region has been covered by Europe, Africa upto Tropic of Cancer. Asia north of Himalayan mountain system and North America. The western or Nearctic section has no primates, and eastern or Palaearctic has only species of Simnopithecus and Macacus. In the Palaearctic section the sheep and goats are well represented but to the west they are few. Both section have oscen. The antelopes are scantily represented in both, while deer are abundant. Camels and horses are found only in the east while in west they are absent. Carnivores are in abundance in both the regions but elephants are absent. Old world has one special and peculiar form that is badger, while the Nearctic section shares the stunk and racoon with the Neotropical region.[1]

The region is characterized by the most specialised forms of placental mammals, and the most important feature of the region is that animals have adjusted themselves very well under the geographical condition which developed subsequent to the retreat of the Pleistocene ice age. There is complete absence of marsupials, monotremes

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1 Newbigin, M.I., op. cit., p.216.

edentates (toothless mammals of early placental mammal form) and primate except man and Barbary apes.

The Palearctic region is also called the old world and is comprised of most part of Asia which is in the north of the Himalaya and Tsinling shan of China, whole Europe, the Mediterranean zone of North Africa, north part of Arabia and whole Southwest Asia Atlantic ocean has divided Palearctic region and Nearctic region by water. On the other hand Bering Strait where the sea is shallow provides a land bridge between the two. The best evidence, is the hairy mammoth which is present in these neighbouring areas.

On account of this land bridge animals were able to disperse from one area to otter. The existence of similar species like beaver, other, bear, wolf, reindeer (caribon), elk (moose) and red dur (wapiti) are found in both Palearctic and Nearctic regions. But the mammalian fauna failed to become completely merged and identical![1]

There are 28[2] families of land mammals in Palearctic region except various but families. The two

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1 Robinson, H., Biogeography, 1972, p.372.

2 George, W., Animal Geography, 1962, p.19.

families of mammals that are restricted to the Palearctic are both myomorph rodents. They are the Spalacidae or mole rats and the Selevinilidae.

Birds because of their ability to fly, are very widely spread in the world and most of the birds of the Palearctic subregion are members of families which have a very wide distribution. There are pheasants, wrens, black birds, finches, warblers, sea birds, geese and birds of prey amongst the very large total number of families. Nearetic birds are even less differentiated from the neighbouring regions.[1] Two distinguishing features of the Palearctic sub-region are the restriction of the hedge sparrow family to the area and the complete absence of parrots.

Ethiopian Region

The Ethiopian region comprised of the continent of Africa south of the Atlas and Sahara, and includes the south corner of Arabia. Madagaskar may be looked upon more correctly, as a sub-region of the Ethiopian region.

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1 George, W., ibid., pp.17-20.

Physically, the Ethiopian region has many points of resemblance with the Neotropical region: both have land continuity with their northern neighbours but otherwise are surrounded and isolated by water, and both have many great rivers and extensive stretches of tropical evergreen forest and tropical grassland with respect to its faunal characteristics, 'The Ethiopian mammal fauna is the most varied of all the regions, consisting of 38 families exoluding bats. In number of unique families it ranks second only to the Neotropical. The Ethiopian region belonged to the Arctogean realm, that is why it has received the modern elements in its fauna from northern sources, 12 families are not similar to others while 26 families are shared with either the Palearctic or oriental region. The evidences show that during Pleistocene ice age there were steppe grassland over the zone of Sahara desert, and animals were able to move freely southwards into this zone. Thus, there is striking similarity between the Ethiopian and Oriental regions. However with the disappearance of the Ice Age, a phase of desiccation set in North Africa and the Sahara was formed which effectually barred the return of those creatures which had migrated southwards. Certain new species were prevented from reaching Africa e.g. panda, the tiger, sheep, and goats.

Some forms have become extinct in Oriental region but are now surviving in Ethiopian region like Giraffe, the hippopotamus and the Chimpanzee. The most reasonable explanation of such things is the varied climate of Ethiopian region. There is diversity of bovids antelope in Africa which is found nowhere else. The lion cheetah and white rhinoceros along with jackal, hyena are found throughout Africa.

Two unique creatures aardvark, or cape anteater and the warthog are found only in Africa. The first one aardvark is living chiefly on ant, is an burrowing animal, having its large, pointed ears, long tongue, highly curved back, powerful tail and short legs with sharp hooves.

The other unique warthog is an pig family's ugly ungulate, having large head, a long muzzle and its jaws are equipped with tusks.

The avifauna of Ethiopian region is more or less similar to oriental region and rich in variety except six families are exclusive to it. This region contains cuckoos, woodpeckers and hornbill as well as sunbirds, orioles and many birds of prey, but only comparatively few pigeons, parrots and pheasants. Exclusive to the region are ostriches, secretary birds, hammerheads, crested

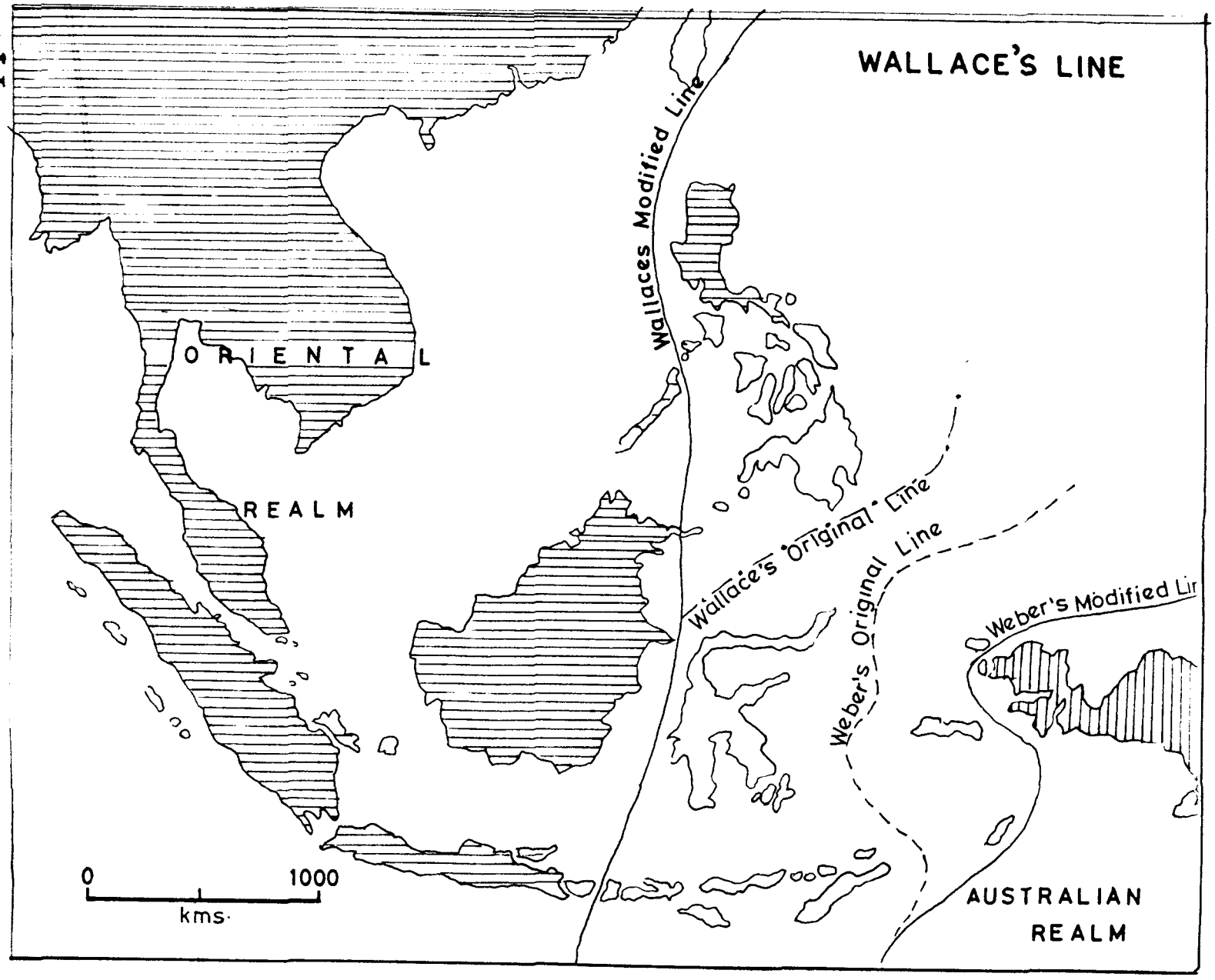
WALLACE'S LINE
Wallaces Modified Line
ORIENTAL
REALM
Wallace's Original Line
Weber's Original Line
Weber's Modified Lir
0
1000
kms.
AUSTRALIAN
REALM

FIG.2

touracos, mousebirds and helmet shrikes. The Ostrich is the only member of a unique order, doubtfully related to other large flightless birds in other parts of the southern hemisphere. There are many snakes, chameleons and some lizards. Frogs and toads are widespread. Fish life is diverse and there are several endemic families, among them the mormyrids which possess an electrical mechanism.

The Oriental Region

The oriental region is comprised of India and Southeast Asia, whereas Indian Peninsula has only one continental Island named Srilanka while Southeast Asian Peninsula has many, e.g. East Indies, the greater part of the Indonesian Archipelago and the Philippines. It is bounded by the Himalayas in the north and the Indian and Pacific oceans on its other sides, but there is no definte physical boundary in the southeast corner where the Islands of the Malay Archipelago string out until they reach Australia. There is much controversies among Wallace and Weber's line of eastern boundaries, usually Wallace's line is accepted. Wallace's line also mark the natural eastern limit of the larger Asian mammals including orang-utah elephant, tiger, rhinoceros. Their distribution is not equal and wide. While orang utah is restricted to Sumatra and Borneo the tiger occurs in all mainland countries

plus Sumatra Java and Bali Rhino is found in both Islands and mainland, but its number is very less.

The elephant is found all over the mainland countries and in Sumatra wild buffalo is also widely distributed in the mainland and archipelagoe, but in many Island it may be feral. Monkeys (leaf monkeys) are restricted only upto Timor, Celebes and Philippines. Several smaller animal forms and insects, butterlies, birds and reptiles extend much farther eastward. Webers line was drawn much farther in the east to show the eastward extent of the Asian fauna, approximately along the edge of Sahul Shelf. In fact Weber's line has delineated the Asian poisonous snakes and marsupial and monotremes of Australian region.[1]

Dissimilarities occur in Oriental region between the fauna of Indian sub-continent and regions of Southeast Asia, Burma, China, which lies beyond the Assam. Two types of migrations are found over here. One is from westside and other from eastern side. Both are around the mountainous barrier. The migrant of western side have crossed the mts. and deserts and was followed by animals

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1 Tiwari, S.K., Zoogeography of India and South-East Asia, 1985, pp.27-28.

that were tolerant of arid conditions or adapted to mountainous terrain, e.g. mountain lion which is still the inhabitant of the hill country of the northwest of the Indian subcontinent. The eastern avenue through the forested mountain country of China was followed by animals that were accustomed to wooded country.

Among all the zoogeographical regions the population of Primates is largest in the Oriental region. The dominant species are gibbons, orange utang and old world monkeys, lorises, tree shrews and tarsiers. Other important animals of the region are two type of Rhino Indian elephant, water buffalo, the tiger and deer. Antelopes are only confined to Indian subcontinent.[1]

Sub-regions Wallace (1876)[2] divided oriental Region into 4 sub-regions.

(1) Indian Sub-Region: It embraces the Central and Northern India from river Indus and the foot of Himalayas. Southwards to Goa upto Karnataka. It is the least humid part of Oriental Region. Many species (or even genera)

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1 Robinson, H., op, cit., pp.381-382.

2 Wallace, A.R., The Geographical Distribution of Animals, 1876.

do not cross the limit of this region. Maximum number of big cats are found over here only. The lions and the tiger meets only in India. Zoogeographically the noteworthy species of Orient like Susu and gharials are found only in India.

(2) Ceyloneese (Sri Lankan) Sub-Region: This sub-region includes the part of Indian Peninsula and the Island of Ceylon. The sub-region has many exclusive species and most of the general represented here show affinity with South-east Asian Fauna.

(3) Indo-Chinese Sub-Region: The sub-region is composed of South China, Burma, Thailand and Indo-China. This part of the Oriental Region is richest and more varied in its faunal content than any other part of the region.

(4) Indo-Malayan Sub-Region: It is comprised of Malayan Peninsula and Islands of East Indies.

Neotropical Region

The whole of South America, most of Mexico and the West Indies make up the Neotropical region. The climate of the region is tropical except southernmost part which merge into south temperate zone. The basin of the Amazon provides an evergreen forest. Further south the

rain forests give place to extensive grass plains and small semi desert areas, while the Andean Cordillera has high mts forest, and semi arid high level inter montane plateaus. The geological history of South America and Australia bears a close resemblance. The both regions were linked before Jurassic times. In Jurassic period and open to colonization by early types of animals.

The Neotropical Region is both highly peculiar and rich in species. Here are no anthropoid apes, no dog - faced monkeys and no lemurs, but on the other hand a peculiar family of broadnosed monkeys and furry forms called marmosets. Only vampire bats are found here. Of the carnivores bears are represented by only one species, while racoon are plentiful and skunks are common to this region and the Nearetic.

Peculiar ungulates e.g., dur, pig, tapirs, hamas, but no antelopes sheep, goats, oxen noreses are found here. Other type of marsupial called Selvas are found here.

The birds of South America are almost as peculiar as the mammals. Among the important families are humming bird, the macaws, the toucans, the jacamars, the motmots, the chatterers, etc. The so-called American Ostrich, is characteristic and is represented by several species.

Australian Region

The Australian region includes Australia, Tasmania, New Guinea and the easternmost Islands of the Indonesian archipelago. The region is unique in having no land connections with any other region and possesses a highly distinctive archaic type of fauna. Here the higher or placental mammals are absent with the exception of bats a few rodents of the mouse section, the dingo or native dog of Australia and the pig of New Guinea are found.

The marsupials are extraordinarily numerous and very diverse, and a peculiar feature is that the more specialized form e.g. the certainly modern tree Kangaroos, occur towards the north. In Queensland and New Guinea and whereas the more primitive forms e.g, the Tasmanian wolf and Tasmanian devil, occur to the south in the Island of Tasmania. This is another link in the chain of evidence which suggests that Australia received its original marsupials from the south, through a connection with South America, rather than from north, through the islands of the Austro-Malayan region. We need not consider further the marsupials of the region beyond noticing that there are forms adapted to almost every kind of habitat, and showing curious adaptive resemblances to the placentals.

Many peculiar and interesting birds are found overhere. New Guinea is especially remarkable for its beautiful birds of paradise, represented on the mainland chiefly by the bower birds. Trogons and kingfishers, hawks and cuckoos all occur in the region together with pigeon and parrots both of which reach their greatest diversity there.

CHAPTER IV

MAN AND VANISHING ANIMALS

Since, 1950, the world population has doubled, food production has nearly tripled, and fossil fuel use has more than quadrupled. The impact of this growth in population and consumption has been severe, particularly upon the atmosphere, tropical rain forests and the earth's top soils.

A United States environmental group of Washington based World Watch Institute reported in an International conference of biologists in 1986[1] that continued degradation of natural habitats could bring a wave of extinctions comparable to that which wiped out the dinosaurs and half of all other extant species. Some 65 million years ago.

About three hundred years ago the last dodo bird died on an island in the Indian Ocean. The last passenger pigeon died in 1914[2] in the Cincinnati zoo. The dodo and the passenger pigeon are gone now forever.

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1 Times of India, 14th February 1987, p.4.

2 Wild Life Society, Ways of Wild Life.

'The dodo' wrote the American humorist will cuppy, "seems to have been invented for the sole purpose of becoming extinct and that was all that he was good for". Cuppy's gibe at the poor dodo is not hyperbole. The dodo was first sighted in 1507. By 1681, barely 75 years[1] after it had become extinct.

Dodo belongs to the pigeon family but is flightless. What we know about these birds comes from the reports of the Portugese sailors. The Portuguese sailors shot them for food. The birds were reported to be so stupid that they simply started at the guns trained on them. This led to their quick extermination. In recent years it was noticed that a big tree, native to Mauritius, calveria major, was getting depleted in number. In 1973 there were only 13[2] calveria trees in Mauritius, all of them around 300 years old and dying.

Researches conducted by Stanley A. Temple and others of the Wisconsin University, USA, have shown that the calveria seeds depended on the dodo for germination.

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1 The Manorama Year Book 1986, p.138.

2 ibid.

Man has also created problems for the great auk like the dodo, the auk could fly, and it build its nest on the ground. Its meat was probably oily like that of other sea birds, but there was lots of it. Sailors from passing ships stopped to club the birds for food and in 1844[1] on the Island of Eldey, the last of the great auks were killed.

Even passenger pigeos have become extinct. In 1813 therewere so many pigeons that John James Audubon observed a flight of these birds on the Ohio river and noted it was so dense, "The light of the noonday sun was obscured as by an eclipse"[2]. The flight passed over him undiminished throughout his 80 km trip.

But settlers cut trees, destroyed roosting areas, and changed much of the pigeons' habitat. Pigeons were netted commercially for their meat, and their flightless young, called squab, were knocked from nests with poles. By the beginning of the twentieth century the big flocks were a thing of the past, and the few remaining individuals were in zoos.

At one time the American buffalo or bison was almost exterminated, but again concerned conservationists took

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1 Ways of Wild-life prepared by the Wildlife Society, Edited by Eleanor Horwitz, p.101.

2 ibid., p.102.

gradually there was less and less food available. Dinosaurs could not adapt to these changes. The unnatural and accelerated extinction of animals largely at the hands of man is an altogether different matter. The toll on wildlife has never been so great, nor so threatening, as it has during the past two or three centuries and, more especially, as it is at the present time, and this despite attempts to preserve many species. During the 19th century something like seventy species became extinct and during the first half of the present century at least a further forty have died out. Indeed, it is estimated that among the mammals alone the rate of extinction may be as high as one species a year.[1] The existence of something of the order of 1,000 creatures is in danger while 270[2] mammal species are officially listed as being in real danger of extinction.

HUMAN INFLUENCE

Human action and interference is the primary and most important cause of animal extinction. Because of their intelligence and tool using abilities humans have become exceptionally powerful animals. As they change the land

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1 Robinson, H., Biogeography, 1972, p.419.

2 ibid.

around them, they also change the living conditions for other animals. In some cases, the changes people bring about make it impossible for other animals to survive. Most species that are in trouble today are endangered directly or indirectly because of people. Hunted to excess, wilfully destroyed and driven from its natural habitat, wildlife has fallen victim to man's expansion, struggle for living space, economic greed and sporting diversions. There is no question of doubt that during the past hundred or so years the major cause of diminishing animal populations is the destruction of faunal habitat. As a result of forest clearence, the cultivation of grasslands and the draining of marshes, etc., animals have been squeezed out of existence; their range lands have become circumscribed and reduced and accordingly, their food supply has been lessened.

Throughout history man has captured or killed individual animals in vast numbers, and direct interference over, say, the last 10,000 years has caused extinction or brought more animals to the verge of extinction than anything else. Man has hunted for food, fur, hides and ivory. Whales are hunted for their oil and meat sea turtles are slain for their meat, eggs and shells. Otters are killed for their fur.

Changes in biological diversity also cause extinction. The extent to which diversity of the flora and fauna is maintained provide a basic index to the ecological health of the planet. Presently the world's biota contains an estimated 3-10 million[1] species. Until the present century the number of species extinguished as a result of human activities was small, and the species so effected were regarded as curiosities. Between now and 2000, however, the number of extinction caused by human activities will increase rapidly. The projected growth in human population and economic activity can be expected to create enormous economic and political pressure to convert the planet's remaining wild land to other uses. As a consequence, the extinction rate will accelerate considerably.

The death of an individual is very different from the death of a species. A species is a natural biotic unit - a population or a series of population of sufficient genetic similarity that successful reproduction between individuals can take place. The death of an individual of a particular species represents the loss of one of a series of similar individuals all capable of reproducing the basic form and its reproductive potential.

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1 The Global 2000 Report to the President, 1982, p.327.

Extinction, then, is an irreversible process through which the potential contributions of biological resources are lost forever. In fact, plant and animal species are the only truly non-renewable resources. Most resources traditionally termed "non-renewable" - minerals and fossil fuels - received that label because they lack the reproductive capacity let most non-biological compounds and elements are at least in theory, fully renewable. Given sufficient energy, non-biological resources can be seperated, transformed and restored to any desired form. By contrast, biotic resources - species (not individuals) and ecosystems - are completely non-renewable. Once extinguished, species cannot be recreated. When extinct biotic resources and their contribution are lost forever. An estimate was prepared for the Global 2000 study by Thomas E. L. of the World Wildlife Fund. According to him "if the present trend continue as they certainly will in many areas - hundreds of thousands of species can be expected to be lost by the year 2000.

Extinction, of course, is the normal fate of virtually all species. The gradual processes of natural extinction will continue in the years ahead, but the extinctions projected for the coming decades will be largely

Table 1

Extinction of species implied by global 2000 Studies Projection[1]

	Present species in 1000	Projected deforest-ation	Loss of species	Extinction in 1000s
Tropical Forest				
Latin America	300-1000	50	33	100-333
Africa	150- 900	20	13	20-65
South & South-east Asia	300-1000	60	43	129-430
Sub-total	759-2500	-	-	249-828
Ocean, fresh water non-tropical forests islands etc.	2250-7500	-	8	188-625
Total	3000-10000	-	-	437-1453
		High Deforestation Case		
Tropical Forest				
Latin America	300-1000	67	50	150-500
Africa	150-500	67	50	75-250
South & South-east Asia	300-1000	67	50	150-300
Sub-total	750-2500	-	-	375-1250
All other habitats ocean, fresh water non-tropical forest island etc.	2250-7500	8	-	188-625
Total	3000-10000	-	-	563-1875

1 The Global 2000 Report to the President, 1982, p.9.

human generated and on a scale that renders natural extinction trivial by comparison. Efforts to meet basic human needs and rising expectations are likely to lead to the extinction of between one-fifth and one-seventh of all species over the next two decades. A substantial fraction of the extinctions are expected to occur in the tropics. The lost potential of the earth's biological resources is often neglected in considering the consequences of deforestation in the tropics. Tropical forest contain both the richest variety and the least well known flora and fauna in the world. It would be difficult to overstate the potential value of this huge stock of biological capital, which if carefully managed, could be a rich, sustainable source of building materials and fuel, as well as medicinal plants, specially woods, nut, and fruits.

However, if present trends continue, sustained benefits from this capital will never be realized. Unique local plants and animals will be unknowingly and carelessly destroyed. Particularly well adapted or fast growing local trees will be cut before their fruits or seeds are collected. Predatory insects and plants with herbicidal or insecticidal properties will be lost for lack of observation and study. Diverse assemblies of gigantic trees, their understories, and their resident communities of mammals, birds, and insects.

In short, the projected loss of tropical forests represents a massive expenditure of biological capital, an expenditure so sudden and so large that it will surely limit the future benefits that even careful management and husbanding can sustain from the remaining biotic resources of the earth.

Extinct Species

It is not enough to save one, or even a few, animals "for the record" in a zoo or on a refuge. When animals are so scarce that it is hard for humans to find them, it is hard for them to find each other too. Animals may not be able to find mates and this can be disastrous. There is a critical minimum number of individuals that must survive so that the species can continue when the number of individuals fall below that minimum, the species is headed for extinction unless man artificially rescues the population and revives it.

In 1973, the International Union for the conservation of Nature published a list of extinct animals including 63 species and 55 sub-species[1] of mammals. The aurochs,

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1 Astanin, L.P. and Blagosklonou, K.N., Conservation of Nature, 1983, p.106.

a kind of wild ox, an ancestor of Europian domestic cattle, has died out, The tarpan, a European wild horse has become extinct. The sea cow, a large mammal of the Sirenia order reaching a length of 8 to 10 metres and 4 to 5 tonnes in weight, was completely annihilated in the later part of the 18th century.

Not only mammals have suffered, 69 birds species have also died out on the earth since 1600.[1]

The IUCN has published a special Red Book (red is the colour of danger) which provides all the necessary information about disappearing species of animals, their habitat, numbers (how many animals still survive in their natural environment), and the reason why they are being reduced. The Red Book contains conclusions by leading scientists and instructions on priority actions to save the species from extinction.

Five volumes of the International Red Book have been published. On January 1, 1972, the first volume included 236 species (292 sub-species) of mammals; the second volume included 287 species (341 sub-species) of

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1 ibid.

birds the third volume 36 species[1] and sub-species of amphibians and 119 of reptiles; the fourth volume is devoted to rare fish, and fifth to plants. The species in the Red Book are divided into four groups:[2]

1. Threatened (vanishing) species requiring total protection (these species are described on red colour pages).

2. Rare Species, not directly threatened by extinction but existing in small numbers or on a restricted territory; there is a real threat that they may disappear (white pages).

3. Endangered Species, their numbers are rapidly and steadily decreasing (yellow pages).

4. Indefinite Species; apparently threatened by extinction, but exact facts on the state of their populations are not available (on grey pages at the end of each volume.

A section for restored species has also been introduced: they are described on green pages.

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1 ibid.

2 ibid., p.107.

The Soviet Red Book came into existence in 1974.[1] It includes the following animals:

Mammals threatened by extinction and rare mammals include, among others: the desman Asian river beaver, Amur tiger, snow leopard, Atlantic Walrus, Greenland Whale, Bukharu deer,European Bison, red wolf striped hyena, Ussuri spotted deer, and others.

The birds threatened by extinction and rare birds include: the white albatross, mountain goose, white and black crane, bustard, black stork, pink pelican, flamingo, small swan, golden eagle, steppe eagle, caucasian black grouse, and others.

The Red Book is a call for help and a specific programme of practical things that can be done to protect the animal and plant kingdoms.

A species that live only in limited areas or that depends on one or a small number of foods, such as the Everglade Kite, which eat only one particular kind of snail, is especially vulnerable. Some species have a narrow range

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1 ibid.

of tolerance for variations in temperature or in the amount of moisture they can tolerate. Animals living on islands are especially vulnerable. Animals with low reproductive rates are also candidates for extinction. Some animals need wilderness and solitude and are not tolerant of man's habitat changes. Their number is certain to decline because of the decrease in wild areas.

India's Vanishing Wild Life

The Indian subcontinent is one of the most fascinating ecological and geographic regions in the world. Here lies the nearly rainless desert of Thar and the rainiest place on earth Cherrapunjee; the hot salty Rann of Kutch and the permanently snow bound peaks of the Himalayas, the wet coastal regions of Kerala and the Islands of Andamans and Nicobar; the great lake of Chilka and the river system of Ganga-Brahmputra.

This variety of ecological conditions sustain a tremendous amount of diverse life forms. About 15,000 species of plants (out of a known world total of 250,000) and 75,000 animal species (out of world total of 1.5 million) have been described from India. On 2 per cent[1] of the

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1 The State of India's Environment, A Citizen's Report, 1982, p.165.

world's landmass, we possess around 5 per cent of the known living organisms on earth.

But the sun is slowly setting on India's wildlife, "Like spectres in the shades of the forests, the wildlife Burton, (Brigadier General and author of the book 'Sport and Wildlife in the Deccan) say has vanished never to return. The vast Ganga plain, which offered a magnificient view of the wild, has now been converted into endless tracts of wheat and sugarcane fields. Houses have replaced trees. Huge herds of cattle graze sullenly on the bare glades. The distant howl of the jackal, the frightened yelp of the deer, the deep roar of the tiger, the chattering of the langurs - all these have faded like a distant dream, only to replace by the raucous cawing of the crows, the noisy barking of the dogs and the steady chug of a tractor.

In India, during ancient times hunting, poaching or felling of trees were not only illegal but considered anti-social and irreligious acts. The old ashrams were our National Parks and were the sanctum sanetorum of all forms of life. The highest form of our understanding of nature and natural environment is depicted in Kalidas's famous play Shakuntala. Every wild plant and animal bade

a touching farewell to Shakuntala, the departing daughter of the ashram. The most moving scene in the play is that where Shakuntala bid farewell to the jasmine creeper and the forest fawn. The entire play portrays our cultural understanding of wildlife, nature, environment and the whole ecosystem when man was one with nature.

Taking the geographical and spatial distribution of wildlife in India we can say that once extensive wildlife of India is now restricted and confined to a few geographical zones. Palaeontological (fossil) and historical evidences shows that the Indian lion, Indian wild ass, one horned rhinoceros, elephant, tiger, cheetah, four horned antelope, Indian gaur (bison); the crocodile, the python, king cobra and the great Indian bustard etc. were more extensively distributed in the past, than at present. Even during the last two centuries the country was the happy hunting ground of employees of the East India Company, British Soldiers and civil servants. According to one story, a single hunter shot as many as 4000 game birds while another killed 2000 ducks. Yet another, after shooting 400[1] tigers in 25 years.

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1 Saukhala, K.S., "Conservation not Exploitation", '<u>Span</u>', 1970.

Another blow to Indian wildlife came during World War II. The scattered armies carrying firearms wiped out wildlife from many parts of the country. The story does not end there. The next blow came when the spotted and striped skins caught the eye of buyers in foreign markets. The skins started slipping from leopards or to attractive fashion models. The extensive cultivation and excessive demand for timber, the felling of forests and destruction of their habitat were further nails in these animals' coffins.

India's wild animals are now making what could well be their last stand in the countries 59 national parks and 254[1] sanctuaries. Yet this large number of reserves really means that all the country's wildlife is now crammed into an ecologically insufficient 4 per cent of the country's geographical area, occupying hardly 15 per cent[2] of the rapidly dwindling reserved forests. "What is left for the animals today are small islands of protection in a vast ocean of human habitation". Says H.S. Panwar, Director of the Wildlife Institute of India, Dehra Dun.[3]

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1 Chengappa Raj, 1987, India Today, June 15, p.129.

2 ibid.

3 ibid.

In fact, so systematically has India's wildlife been decimated that while only 13 species were in the Central Government's endangered list in 1952, the number went upto 41 species of mammals, two species of reptiles and 18 species of birds by 1972. Since then, the Government had been forced to periodically revise the list, and by November last year, the number of endangered mammals had shot up from 41 to 70, reptiles from 2 to 16 and birds from 18 to 38.[1]

Schedule one of the Wildlife Protection Act 1972 lists 133 species[2] as either rare or highly endangered.

A little over 10 per cent of India's flora also face extinction. "Extinction is more tragic with plants than with other forms of life" says the IUCN. "Many species will be lost before their possible value to society is known".[3]

Today, the position of wild animals is in general alarming and many species are greatly endangered and are fighting a losing battle for survival. An account of the

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1 ibid.

2 The State of India's Environment 1982, p.165.

3 ibid.

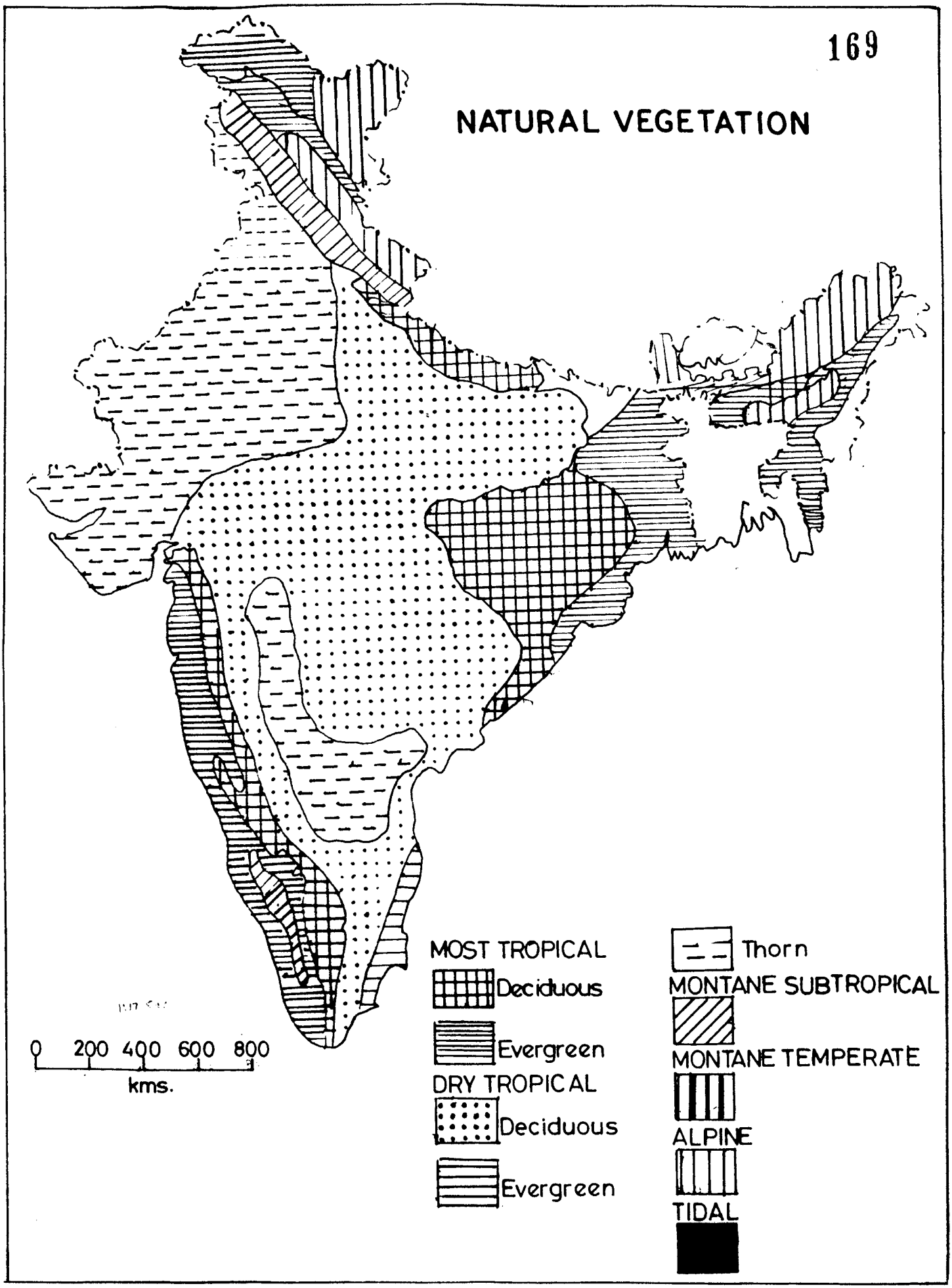
NATURAL VEGETATION
0 200 400 600 800
kms.
MOST TROPICAL
Deciduous
Evergreen
DRY TROPICAL
Deciduous
Evergreen
Thorn
MONTANE SUBTROPICAL
MONTANE TEMPERATE
ALPINE
TIDAL

FIG. 4

INDIA
DISTRIBUTION OF WILD LIFE AND NATIONAL PARKS

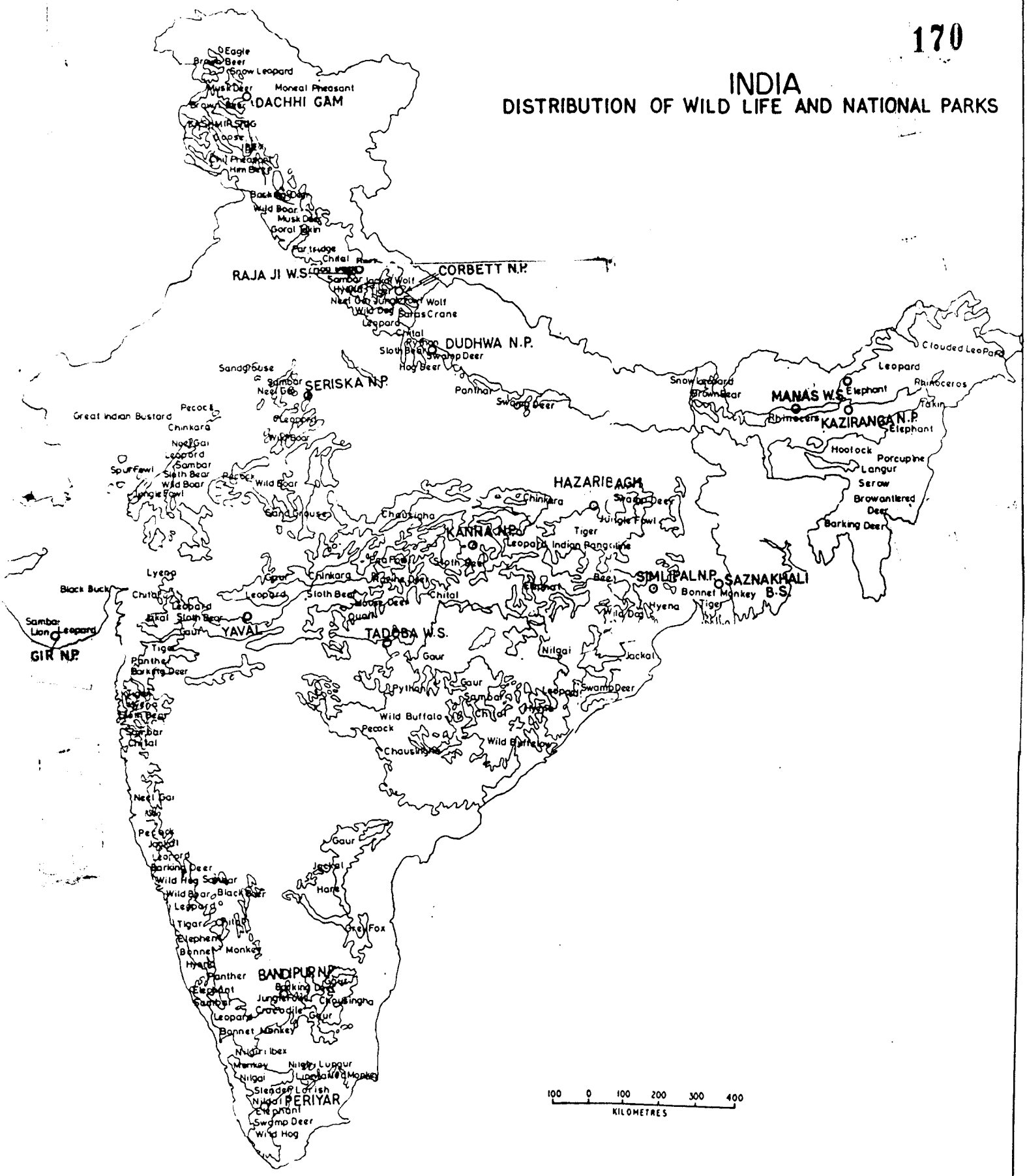

FIG. 3

various threatened species is given below according to ecological and zoogeographical regions of India. Each of these ecological regions has been subjected to distinctive demographic pressure, commercial exploitation, agricultural expansion and other modern development activities, which are so much a part of the present day industrial and agricultural economy.

ECOLOGICAL SUB-DIVISIONS

1. Himalayan Mountain Systems
   (a) The Himalayan Foothills
   (b) The High Altitude Region of Western Himalayas.
   (c) The Eastern Himalayan Sub-zone.
2. The Peninsular Indian Sub-region
   (a) Peninsular India and the Drainage Basin of the Ganges.
   (b) The Indian Desert.
3. The Tropical Evergreen Forests or Indo-Malayan Sub-region.

1. The Himalayan Foothills

The Himalayan foothills are characterised by bhabar and tarai formations and the siwalik ranges in the south. This is one of the richest area for the typical big mammals of northern India. The elephant, sambar, swamp deer, cheetal, hog deer, barking deer, wild boar, rhino, hyena, jackal all abound here. The number of tigers in India were estimated at 20,000 to 40,000 in the year 1900 and today we have hardly about 2000.[1] Project tiger was initiated in 1978,in response to the alarming decrease in the population of wild tigers. The project was launched by the Government of India with a grant of Rs.50 million in cooperation with WWF - India and IUCN. In 1973 nine tiger reserve in nine states with a total area of 13,017 sq. km were set aside, with a tiger population of 268.[2]

According to the latest census figures, Indian tigers have risen from 3,015 in 1979 to 4,005 in 1985. Of these, 1,121 belong to Project Tiger reserve. The number

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1 Krishnamurthy, A.V.R.G., Forest and Wildlife in India, 1980, p.258.

2 The State of India's Environment, 1982, p.171.

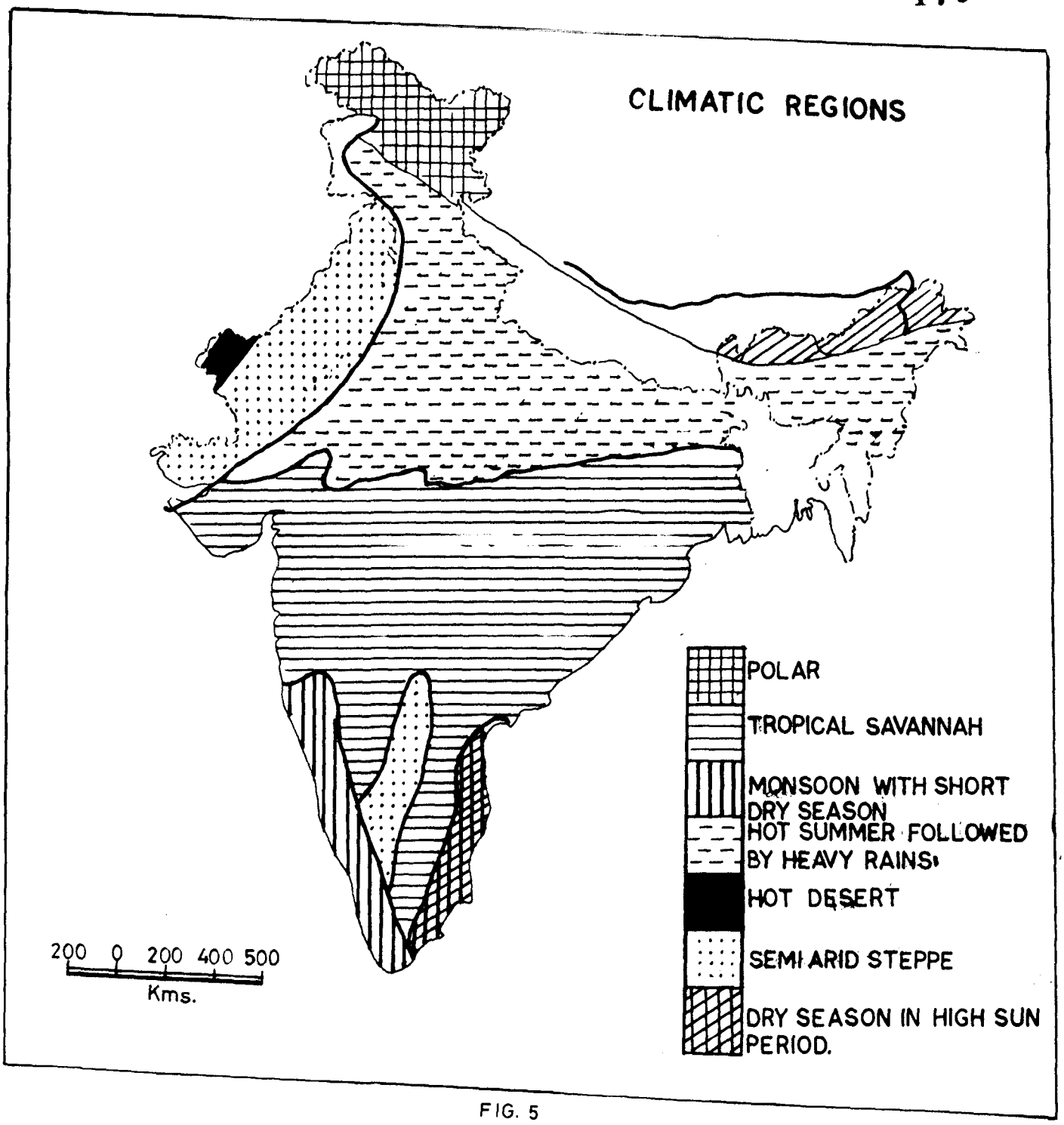
CLIMATIC REGIONS
POLAR
TROPICAL SAVANNAH
MONSOON WITH SHORT DRY SEASON
HOT SUMMER FOLLOWED BY HEAVY RAINS
HOT DESERT
SEMI ARID STEPPE
DRY SEASON IN HIGH SUN PERIOD.
200 0 200 400 500
Kms.

FIG. 5

of Tiger Reserves has also been risen from 9 to 16 with the Dudhwa National Park.[1]

The swamp deer is also making a quick exit. Hunted for its meat and deprived of an estimated 80 per cent[2] of its original habitat. The Hispid hare, that scampered around on the foothills of the Himalayas near Assam, is also heading towards oblivion. The wolf, the jackal, the Indian fox and the wild dog are among the threatened carnivora. One estimate places the population of the Indian wolf at a mere 500 to 800.[3] With their habitats and prey diminishing rapidly, wolves are preying increasingly on livestock, and are therefore being killed by shepherds and formers. The great Indian one norned rhinoceros, which once, ranged all along the Himalayan foothills is now confined to a few pockets in Assam and Nepal tarai and is considered a rare species. It was hunted for its horn, believed to have aphrodisiac properties, almost to the point of extinction by 1904.

Of the nearly 1000 rhinos left in the country no less than 91 were killed by the poachers in 1983,

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1 Hindustan Times, 27th August, 1986, p.6.
2 India Today, June 15, 1987, p.130.
3 The State of India's Environment, 1982, p.167.

with 36 slain in Kaziranga alone . As P.C. Das, Chief Conservator of Forests says: "Under the present circumstances, think the rhino would be lucky to live for another 15 years![1]"

The brow-antlered deer is another rare deer found in this region, confined to Keibul Lamjo Sanctuary in Manipur. This deer lives on a floating mass of vegetation deposits called 'Phumdi' and due to its floating habitat, has been named the 'dancing deer'[2] of Manipur by the late S.P.Gee. Extensively poached by the locals, the deer faced extinction in the 1970s, their number dropping to just 14. Although their numbers have since increased to 50, there are signs that the floating vegetation is naturally decreasing, thereby shrinking the Thamin's fragile habitat.

Most of this area, especially the tarai belt has however been colonised by agriculture and much of the wildlife has disappeared from here. The large elephant herds which used to migrate all along the foothills have been fragmented by agriculture, construction of reservoir for hydroelectric generation and other human artifacts. In the north-eastern states, which harbour the largest population of elephants

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1 India Today, March 31, 1984, p.150.

2 Sharma, V.B., Wildlife in India, 1982, p.25.

in the country, they are under attack for other reasons. Meghalay forests, for instance, can support just 750 elephants though the state has over 2000[1] elephants. Much of their habitat has been degraded because of the slash and burn cultivation followed by the tribals. Deprived of fodder, the elephants have even started raiding crops. Some 20 people[2] are killed annually by elephants in attacks, provoked and unprovoked, and an equal number of elephant are shot at and killed by people careful protection from poachers is also needed to ensure their survival. Ivory sells at Rs.1000 per kg and tusk of a large Indian male elephant weigh about 60 kg, which have taken a heavy toll of their population. The golden langurs also find themselves on the present endangered list. The gangetic gharial the sole representative of the family gavialidae, occur in Himalayan tributaries of the river Ganges, though being bred in captivity, is still threatened.

(ii) The High Altitude Region of Western Himalayas (Kashmir and Western Ladakh to Kumaon)

This region consists of the belt of coniferous - pine forests occupying altitudinal zone from 1500 m to

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1 Chengappa Raj, India Today, 1987, June 15, 1987, p.135.

2 The State of India's Environment, 1982, A Citizens Report, p.166.

nearly 2500 m . The Rhododendron, dwarf hill bamboo and birch forests mixed with alpine pastures extend above the pine belt upto the snow line; the cold desert plateau of Ladakh exist in the extreme northwest.

One of the typical animal of this region is wildass which is found in Ladakh and Tibet's palaearctic deserts. Though identified as a rare and endangered species, it is still fairly common in Rupshu, Changthang and Chang Chenmo areas of Ladakh.

The snow leopards was once the lord of the upper Himalayas. Its range spread from Kashmir to Bhutan, where it roamed the rocky heights at night, preying on wild sheep and goats. According to Indian Express of Ist November 1986[1] this grey ghost of Himalaya is highly endangered and the species could become extinct like the Indian Cheetah if we do not now take step to ensure its survival. In the wilds ecologists can confirm its existence only by the pug marks. Optimistic estimates put the present number of snow leopards at less than 300[2] and dropping rapidly. At the

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1 Indian Express Magazine, November 1, 1986, p.4

2 India Today, June 15, 1987, p.130.

recently held 5th International Snow Leopard Symposium[1] in Srinagar, experts from all over the world met to decide the best course of action for the world and all agreed that first step is to save its habitat from human intrusion and to protect the species from the avarice of poachers and from merchants in the fur trade. The skins of the big spotted cats fetch a pretty price - £124,270 for a cloneled leopard skin and £94,750 for Bengal tiger skin in Japanese market, according to a report in "Business India" in 1981.

Strict protection of the big cats has forced traders to go after smaller animals like lynx, fox, jackal and wolf.

The Kashmir stag or hangul and musk deer have also been reduced to the stage of almost no return. In the alpine scrubs of the lower Himalayas, the male musk deer is widely hunted for the little gland above its abdomen, whose secretions perfume the cosmetic industry in the west. Each musk pod, when dried, produces between 20 gm to 50 gm.[2] of powder and to extract one kg 25[3] male deers have to be

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1 Indian Express Magazine, November 1, 1986, p.4

2 India Today, June, 15, 1987, p.130.

3 ibid.

killed. Japan imported 150 kg of musk from India at Rs.40,000 a kg in 1980.[1]

A particularly tragic aspect of the poaching of the musk deer is that it is totally unnecessary. The musk can be extracted easily either in the liquid stage by a process similar to "milking" or later when it hardens. Into granules by scraping the dried substance out through the external openings.[2]

In the beautiful vale of Kashmir, barely 20 km from Srinagar, lies the Dachigam National Park, home of Kashmir stag or hangul. A common animal when Kashmir was a princely state, the hangul's population fell below 200[3] in the late sixties. Poaching, habitat destruction and competition for food from domestic livestock were the main causes for their decline. Thanks to a joint IUCN-WWF Project, setup in 1970, this deer are about 700 now.

The Eastern Himalayan Sub-Zone

Northeast India has the third largest resource of plants in the world for any area of similar size. About

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1 The State of India's Environment, 1982, A Citizens' Report, p.164.

2 Indian Express Magazine, November 30, 1986, p.4.

3 ibid., September 21, 1986, p.6.

50 per cent[1] of the total flora of India comes from this region. The tropical forests in the Garo Hills and parts of the Khasi and Jaintia hills (once abounded in wild elephants, deer, wild boar, gaur, wild buffalo capped langur and the Hoolock Gibbon among other animals. No data exist of the population of these animals except for tigers. In 1972[2], there were just 32 tigers in the state. In 1979 their number went up to 35. The barking deer is now a rare sight. This deer was one of the main dispersing agent of the seeds of certain plant species through its excreta. Wild elephants are most threatened in the Jaintia Hills where their habitat has succumbed almost totally to jhumning. They damage crops and are in constant conflict with the farmers.

The peafowl, hornbill, tragopan khaleej pheasant, and whistling teal once abundant in Meghalaya are now rare. Wild birds which consume pests like locusts and wood-destroying termites are not finding enough tree cover and are instead invading crops and kitchen,gardens. Consequently

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1 The State of India's Environment, 1982, p.169.

2 ibid.

crop pests have also increased leading to an increase in the use of pesticides. Besides increasing production costs, these are polluting the hill streams.

The Peninsular Indian Sub-Region

Peninsular India is the true home of the Indian fauna. It is characterised by the raised plateau land of the Deccan extending northwards into the flood plain of the Indo Gangetic basin and westward into the Great Thar desert including little Rann of Kutch. It is possible to identify two broad zones.

1. Peninsular India and the drainage basin of the Ganga.
2. The Indian desert.

1) Peninsular India and Parts of Drainage Basin of the Ganga

In its natural state, this region is the home of tropical moist deciduous to tropical dry deciduous and scrub vegetation depending upon the variation in rainfall and humidity. The fauna of this region is wild ungulates, elephant, muntjak, sambar, deer, wildboar, gaur, cheetal, hog deer, swamp deer, sambar, barking deer, nilgai and black buck, chinkara, gazelle, wild dog, tiger, leepard, cheetah, Asiatic lion, hyena and jackal, the Nilgiri Thar etc.

The sturdy mountain goat Nilgiri Thar, that perches itself acrobatically on the steep grassy downs, faces extinction as it is regularly killed for its meat. The chatter of the black faced Nilgiri Langur in the trees below is slowly falling salient. The oil from its fat is sold as an all purpose balm and its flesh relished by poachers.

The chinkara or four horned antelope is indigenous to south India. The elephant population is restricted to a few southern states, even though it has been once extensively distributed throughout the country. Tavernnier (1952)[1] a French Traveller and Jeweller recorded its (elephant) natural distribution from the Seshachalam Hills of Andhra Pradesh (near about the Temple town of Tirupathi) to Kodur in Cuddapah District indicating the once prevailing moist deciduous forests and rich Wildlife Today we do not have even a single elephant. The black panther is restricted to a few pockets in south India. The majestic Indian lion, which has adorned the pages of many a mythological and historicals books, once roamed the entire peninsular region of India. In Andhra Pradesh in 1972 the number of

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1 Krishnamurthy, A.U.R.G., India (1980), p.257.

tiger was 36 and according to 1976 census[1] this figure was put at 89, thanks to protection. Andhra Pradesh State, could also boast of existence of a cheetah last seen a few years ago in 1952 in chittor district. Today this species is completely extinct. The same is the fate of the Great Indian Bustard, which was commonly seen in several parts of the country but is now almost extinct. Around Saroornagar near Hyderabad, which was the same preserve and shooting block of Nizam, large herds of black-buck, were a feast to the sportman's eye, with myraids of tiny glowing-eyes, on a night's trip till 1950. But today we cannot find even their hoofs.

(ii) Endangered Wildlife in Rajasthan Desert and Rann of Kutch

In earlier times the western Rajasthan was quite rich in wildlife resources. A large number of animals have either vanished from this region or are on the verge of extinction. Therefore, the existing fauna should be protected from poachers to reclaim the old wildlife status of the region, which would attract tourists and ultimately enhance the socioeconomic conditions of desert masses.

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1 Krishnamurthy, A.U.R.G., Forest and Wildlife in India, 1980, p.258.

Among aquatic reptiles, two species viz., crocodile and the fresh-water turtle are restricted to the Jawai Dam at the foothills of the Aravalli ranges. It is evident from the record that these two species are near extinction due to poaching and habitat destruction. The only species of large terrestrial reptiles, the Rocky Python molurus, ~~found on the molurus~~, found on the foothills of Aravalli is also vanishing from the desert scene.

Prominent avian species are very scanty particularly in the sandy habitat of western Rajasthan. Grey-partridge is fairly well distributed throughout the desert, whereas, the painted partridge inhabits only the Aravalli ranges in bushy thickets of scrub grassland in Rajasthan desert. The two species of Quails, are found in thickets and dense rangelands.

The Great Indian Bustard has been exterminated over most of its range due to hunting and habitat destruction, and found in very low numbers in Rajasthan desert. Among other migratory fauna, which are of some significance are Houbara, Lesser Florican, Common Crave, Imperial sandgrouse and various species of ducks. The flamingo city near Pachem and khadir islands of the little Rann of Kutch is well known as breeding colony. And in the undulating hills

of the Gir forest, the Asiatic lion fights its last battle for survival. The once proud lions dominated the grasslands but they were so systematically exterminated that by 1920 their numbers had dwindled to around 50![1] But with the Gir forest declared a sanctuary, their numbers have now reached a stable 200, their number being 289 in 1959.[2]

The beautiful Indian Gazelle-Antelope which was once plentiful, is no more to be been and it is in the protected list. It inhabits sandy Gazelles are very well adapted ecophysiologically to survive even during droughts due to its minimum water requirement.

The black buck was once most abundant wild ungulate of India has become a sanctuary animal. Interestingly, the blackbuck is well protected and conserved by the "Bishnoi" community in Rajasthan desert. The Bishnois never allow its hunting and treat it as a sacred animal. There was a dense population of the antilopes during 1920. The number of blackbuck has dwindled considerably in Punjab and Haryana regions.

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1 India Today, June 15, 1987, p.135.

2 Krishnamurthy, A.U.R.G., op. cit.

The wild ass was found to inhabit arid tracts of northwest India and Pakistan, Previously, they were recorded in the north of Jaisalmer and Bikaner districts in W. Rajasthan (Gee 1963).[1] Now they are confined to small pockets in the little Runn of Kutch in the southern part of the Thar desert. Their number has dwindled from an estimated population of about 5000 in 1946 to 870 in 1962.[2]

(iii) The Tropical Rain Forest Region

This region consists of the heavy rainfall zones. These comprise the North-east India and western Ghats region in the south including the Malabar Coast.

The Nilgiris, an off shoot of the Western Ghats, rise precipitously to form extensive Grassy downs and tablelands interspersed with densely forested gorges of evergreen vegetation known as Sholas. This provide the main shelter to wild elephant, gaur and other large animals of these hills.

The lion-tailed Macaque which inhabits the evergreen rain forests and "sholas" of south India, is among the world's

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1 Gee, E.P., The Indian Wild Ass, A Survey J. Bombay Nat. Hist. Soc. 60, 1963, pp.516-529.

2 Rana, B.D. and Advani, R., Chetals, 1986, p.7.

most endargered primates. Referring to it, Paul Heltne, who specialises in primates reproduction research at the Johns Hopkins School of Medicine in Baltimore, says, "there may be no more than 195 of this beautiful animal left in the wild----- its forest home has diminished rapidly over the last 30 years to a small fraction of its former extent".[1]

The area is one of the richest region of flowering plants. From a very small area, Silent Valley in Kerala, covering less than 9000 hectares, the Botanical Survey of India recently discovered nine species new to science a new genus of plants.

The area of maximum diversity in India is northeastern India which is also the most threatened. The second major area of genetic diversity is the lower region of the western Ghats around the Nilgiris. Over 1500 of the rare flowering plants are subjected to a lesser or greater degree of threatened extinction.

It may indeed be said, that wanton destruction of wild animals, is due to a deterioration in the moral and

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1 The State of India's Environment: A Citizens' Report, 1982, p.167.

aesthetic values, that we as a nation, had in the past. Each living creature has its own charm and beauty, which gives a peculiar aesthetic joy to the beholder with the wanton destruction of wild life, in recent years, the list of endangered animals is on the increase, and the list is long and tortuous, and cannot but fill one with disgust, at this senseless slaughter. We often fail to remember, that unlike other forms of God's creation, life once taken cannot be put back, an animal once made extinct, cannot be brought back to life, inspite of all our technological advances. Species on the threshold of extinction whatever may be the reason is lost forever.

CHAPTER V

DUDHWA NATIONAL PARK
(A GEOGRAPHICAL ACCOUNT)

The conservation of forest and wild life species is important from ecological point of view because natural forest and wildreness areas are fast disappearing in this subcontinent, under pressure of human population explosion as well as due to rapid industrialization.

To conserve the natural diversity in plants and animals. UNESCO has launched the 'Man and Biosphere' programme during early seventies. About 250 Biosphere Reserves had been established in 65 countries by 1986. In 1978 an advisory group of the Indian National Man and Biosphere Programme identified 12 sites for establishing Biospheric Reserves ranging from Nanda Devi in the Himalayas to the Gulf of Mannar along the Bay of Bengal, representing the diverse biogeographic provinces in the country (Appendix 1). While the geographical area is divided into realms and provinces, the world's ecological communities of plants and animals are broken up into 14 major biomes. Each province consist of one biome. In India we find four major biomes.

LOCATION OF DUDHWA NATIONAL PARK

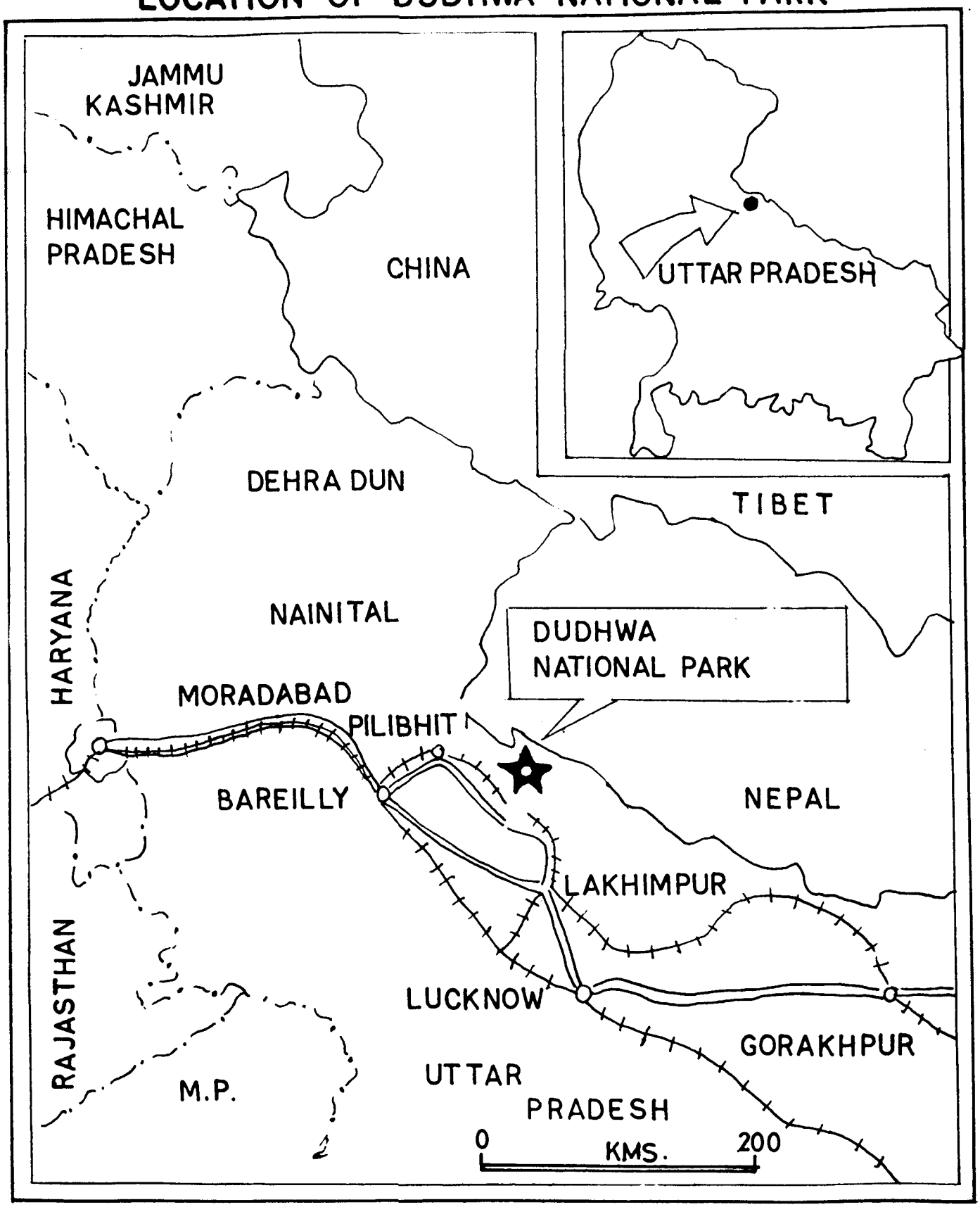

FIG.6

1. Mixed mountain system
2. Tropical humid forest
3. Tropical dry forest/woodland
4. Warm desert/semi desert

Dudhwa National Park is a part of these biome named tropical dry forest/woodland.

LOCATION OF THE PARK

The park is situated between 28°18' and 28°42'N latutude and 80°28'[1] and 80°57' east longitude. It's northern, northwestern and northeastern borders are marked by Nepal territory. The remaining parts are bounded by North Kheri forest division. The Mohan river in the north seperates the forest from Nepal and about 70 km is on the border with that country.[2] The Suheli river and Joraha Nullah runs along the southern longer sides and forms the natural boundary of the park for a considerable distance. The Dudwa forest consists of one large compact block which

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1 Singh, R.L., 'Management Plan of the Dudhwa National Park (1982-83 to 1991-92), p.4.

2 Singh, R.L., Frontline, January 10-23, 1987, p.54.

looks like a distorted rectangle in shape. The length of the side being approximately 50 km and 10 km[1] respectively. The altitude of the park ranges from 183 metres in the extreme north along Mohar River to 152 metres[2] in the forthest southeast corner along the Suheli River. The elevation at Dudhwa is 184 metres.[3] The foothills of the Himalayas are about 30 km[4] to the north of this park.

BRIEF HISTORY

The history of the dates from 1861 when this area was taken over from Khairigarh Paragana for the purpose of their preservation. All the forests of this park were reserved under the Indian Forest Act XVI of 1927 notification No.85/XIV-66.[5] In 1861, they came under the control of "Suprintendent of forest", who was later on designated as conservator.

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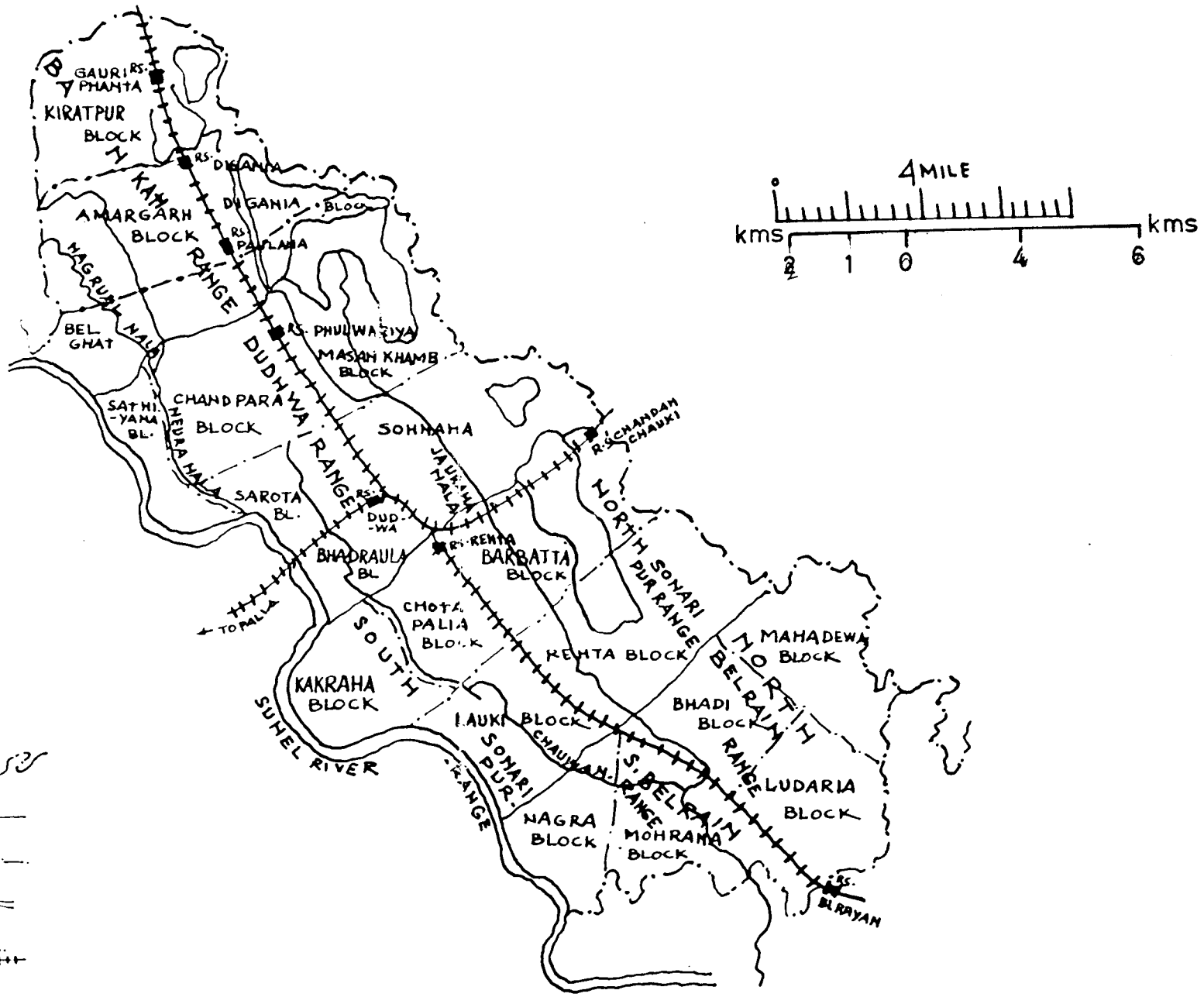
1 Singh, R.L., op. cit., p.4.

2 Information Booklet Prepared by the U.P. Government Forest Department, p.3.

3 ibid.

4 Singh, R.L., op. cit., p.4.

5 ibid.



INDEX.

1. PARK BOUNDRY
2. FOREST RANGE BOUNDRY
3. BLOCK BOUNDRY
4. RIVER – NALA
5. VILLAGE (THARU)
6. RAILWAY LINE RS.

FIG. NO. 7 DUDWA NATIONAL PARK

Poaching, hunting, grazing of domestic livestock and frequent fires are some of the major causes of degradation of habitat that leads to the depletion of wild life. All this goes on inspite of the enactment of laws to prevent the damage. Alarmed by this the Uttar Pradesh Forest Department (formed in 1956) initiated the formation of a sanctuary for swamp deer and Sonaripur Sanctuary covering a total area of about 15.766 acres[1] was constituted. 1968, an area of about 212 sq. km was declared as Sanctuary, which provided more suitable conditions for the rehabilitation of swamp deer and other wildlife species of the region. Ultimately, having considered the floral, faunal, ecological, geomorphological importance and the wildlife potential of the area, the Government of Uttar Pradesh later increased the area of the Park 490 sq. km and notified these areas as Dudhwa National Park on the Ist February 1977, to be protected and managed under the provisions of the Wildlife Protection Act 1972.[2]

PARK AREA

Dudhwa National Park located in the Tarai belt on the Indo Nepal border has been divided into six ranges:

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1 Singh, R.L., ibid., p.8.

2 ibid.

Bankati, Dudwa, North Sonaripur, South Sonaripur, North Bellrain and South Bellrain. The ranges are further divided into blocks and compartments which are given below.

S.No.	Range	Block	Compartment	Area in hectare
1.	Bankati	1. Kiratpur	1-12	3228.52
		2. Amargarh	1-13	3208.68
		3. Belghat	1- 8	2717.68
		4. Dingania	4- 5	510.71
2.	Dudwa	1. Sathiana	1- 5	2029.50
		2. Chandpara	1-12	3775.44
		3. Sarauta	1-10	2782.99
		4. Farseiryer	2	295.01
		5. Bhadraula	1- 6	1418.00
		6. Saunaha	3-6 & 10	2723.92
		7. Masankhamb	3-10 & 11	1039.22
3.	North Sonaripur	1. Barbata	----	1477.09
		2. Rehta	----	1822.29
4.	South Sonaripur	1. Chota Palia	1- 9	2432.13
		2. Gulra	1- 2	276.92
		3. Kakraha	1- 6	2642.91
		4. Lauki	1-10	3436.98

contd.....

A TYPICAL SOIL STRATA RECORDED OF TUBEWELL BORING DONE MORE OR LESS IN THE MID OF PARK NEAR SONARI PUR FOREST REST HOUSE (1987).

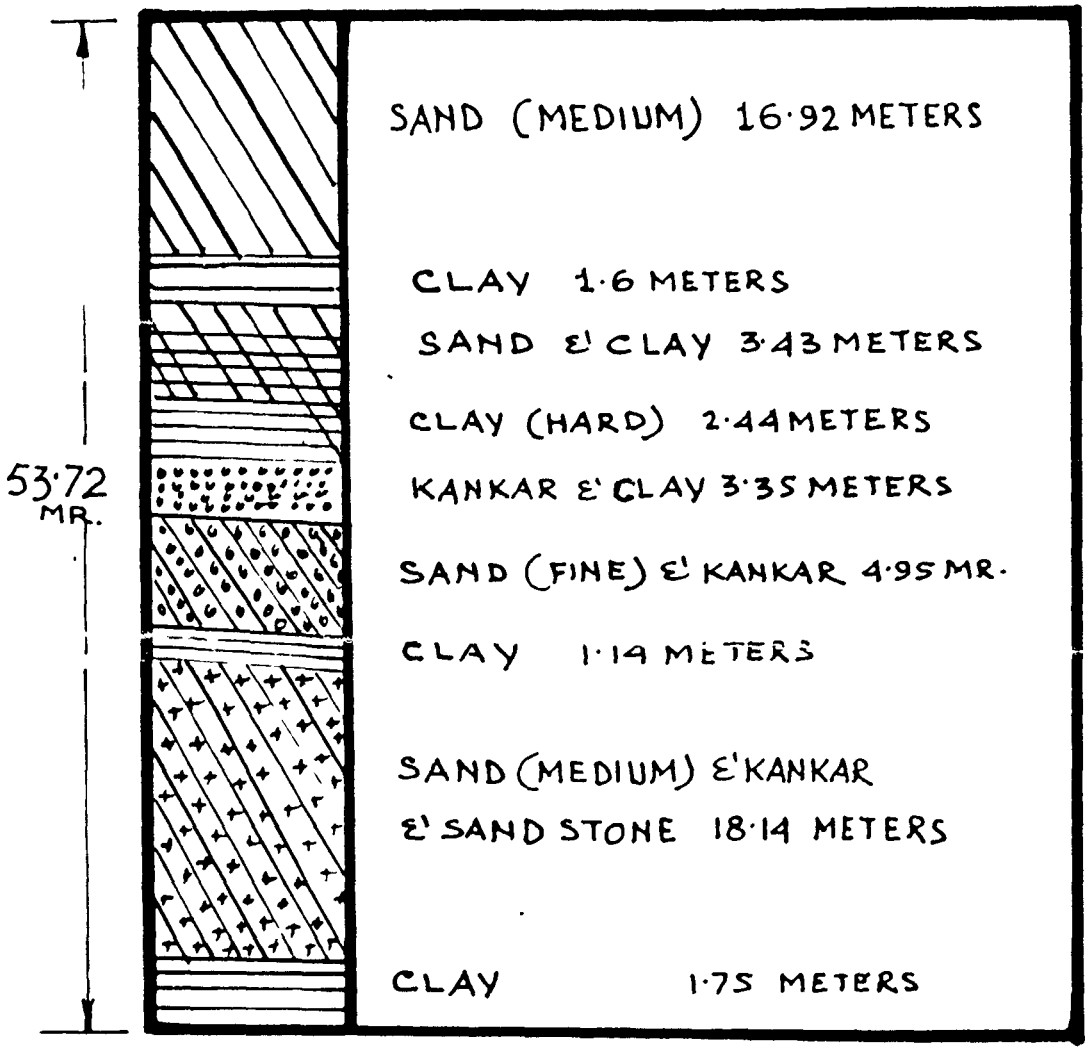

FIG. 8

5.	North Bellrain	1. Bhadi	1- 7	2688.72
		2. Landaria	1-12	3316.79
		3. Mahadeva	1- 5	1937.21

GEOLOGY

The tract is situated entirely on the alluvial formation of the Gangetic plains showing succession of beds of sand and loam varying in thickness according to the configuration of the ground. There are no prominent eminences and the only irregularities of the surface are formed by the river beds and the high banks which flank them on either sides.

SOILS

The park is a doab between the Mohana and the Suheli rivers. The high banks of the river are sandy. The underlying soil consists of alluvial formation of gangetic plain showing a succession of beds of sand and loam, varying in thickness according to the configuration of the ground. All of these, however, are subjected to great variation because there are large number of streams, nullahas and tals which are flooded every year and affect the surface soil. The different layers of the soil have been recorded by Kakar

and Shrivastava at Sonaripur forest rest house which is more or less in the centre of the park. The different layers were recorded upto the depth of 53.72 m. However ground soil of the park can be broadly divided into the following types.

1. Pure Sand

The river beds and open land situated along the banks of rivers consist of pure sand. This is also known as low alluvium.

2. Sand and Clay

In the sal forests, soil is rich in loamy sand with apparent variation in sand and day proportions. This is known as middle alluvium.

3. Moist Sandy Loam

The ditches and water courses covered with grasses consist of moist sandy loam mixed with fair proportion of decomposed vegetative matter.

4. Stiff Sandy Loam

This has a fair proportion of clay and slight admixture of humus.

5. Micaceous Sand

It has little or no clay and is marked by an almost complete absence of humus.

6. Stiffy Clay

In low lying areas, soil consists of stiff clay with large amount of decayed and partly decomposed vegetation matter.

7. Kankar

They are found in several parts of the park viz. streams and nullahs.

CLIMATE

There are three distinct seasons as under:

1. Winter (October 15th to March 15th)
2. Summer (March 15th to June 15th)
3. Rainy Season (June 15th to October 15th)

1. Winter Season

The winter season is characterized by cold and foggy night while the days are bright and cool. The coldest period is from mid-December to end of January. The maximum

temperature during winter has been recorded upto 30°C and mean humidity is 74.2 per cent.

2. Summer Season

In summer season days are hot, while the nights are moderately cool. Hot winds blow from end of May till the premonsoon showers. The maximum temperature has been recorded upto 47°C while minimum is 20°C during nights.

3. Rainy Season

Rains generally start from middle of June. Sometimes there are light showers in the end of May or in the first week of June. Heavy rains have been recorded in the month of July and August. The average rainfall is 160 cms. Rainfall between June to September accounts for about 90 per cent of the total rainfall. The relative humidity in these months is about 78 per cent. During rainy season the area gets more or less flooded. The roads usually dry up by the middle of October and become fit for vehiclur traffic. This however, get delayed sometimes and flooding continues upto November.

Water Supply

A large area of the park is covered by water as the rivers and streams frequently change their course, leaving

old channels in which the water remains and tals and swamps are formed. There are two river: Suheli, Mohana which frequently flood the area. The main nullahs of the park are: Jauraha, Bajahi, Chawa, Neura and Nagral. The important ponds are: Bhadi, Landaria, Churella, Ranwas, Nagra, Bakey Kakraha, Chapra, Mutna, Tedhia and Purana. Nearly 130 sq. km that is about 22 per cent[1] of the total area is covered by water bodies.

Park Vegetation

The forests are of moist deciduous type and are represented by trees, shrubs, perennial herbs and grasses. Most of the undergrowth is seasonal which appear during the rainy season. Flora of the park can be broadly divided into the following types.

(i) Northern Tropical Semi Evergreen Forests: This type occurs locally in wet hollows and on soils which are more or less permanently wet and which usually consist of fine clay, very rich in humus. It is usually met along the Junraha, Suheli, Neora, Chhawa and Bajohi nullahs and also near the 'tals', for example along the Jauraha nullah in Mesankhambh.

(ii) North Indian Moist Deciduous Forests: (Damar Sal Forests). It includes the best sal forests of the tract which occur on the well drained such as in Kiratpur, Amargarh,

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1 Singh, R.L., Frontline "Dudhwa Rare Attraction" 1987, January 10-23, p.63.

Belghat, Dingania, Chandpara, Bladraula, Chhota Palia, Sarota, Lauki, Bhadi, Laudaria, Mahadeva blocks where the soil is rich, slightly sandy loam of good quality. Sal is the main species but the top canopy also contains an admixture of asna (Terminalia tomentosa), bahera, (Terminalia baleria), asidh (Logerstroemia parviflora), kusum (Schleichera oleosa), heldu trees (Adina cardifolia). The underwood is mainly of rohini. Its other associates are Sandan, Jamun and dudhi.

(iii) Alluvium Plain Sal Forests: These forests are found generally where the ground tends to be slightly low lying than the surrounding high level alluvium. Sal and Asna are main species. Other common species are in the over wood are haldu, pula, padal, kusum and various species of figs.

Teak has been introduced at places in such forests either by gap planting or by clear felling. It has started regenerating on its own.

(iv) Western Light Alluvium Sal Forests: These forests are generally found along the banks of the Jauraha and Bajahi nullahs. An almost pure belt of jamun is found along the Jauraha nullah. The common climbers are maljhan, ganj rangoi and aila.

(v) Moist Sal Savannah Forests: The most striking features of the Dudhwa landscape is the tall grass that grows upto 6-7 metres in height. Around 22 per cent area is covered by grasses which are also called 'Phantas' in local lanugage. These occur throughout the sal forest and are represented by a number of grasses viz. nari arundo donase, narkul, retwa (found in swampyarea). Scattered and standed trees are also seen in this area. These are the areas where maximum concentration of wild life can be seen.

Most of the phantas are elongated in the direction of the general slope of the land suggesting that these are old river beds or prehistoric lakes and swamps which are now silting up and are devoid of any tree growth.

These Phantas have scattered tree growth consisting of semal pinsar, shisham, haldu and khair.

(vi) Alluvial Savannah Wood Land: Along various nalas and the Suheli river are found in many places along various nalas and the Suheli river. They occur mainly a small patche. The main tree species are semal, asidh gutel, padal, aonla (Emoloea officinalis), kari, jamun, haldu, rohini, oel and phalsa with a small admixture of kaim (Mitragvna parvifolia), jhingan (Lannea grandis) kakar (Garugapinnata) dhak, maholi, chila (Casearia tomentosa), amaltas, chamror etc.

(vii) Tropical Seasonal Swamp Forests: These forests occupy small areas on the banks of the Suheli, Jauraha, Neora and Chhawa nalas and also near some tals. The soil in these areas is rich in humus, consisting of fine clay. At certain places these forest get mixed with other forests. Sygygium species are mostly represented in swamp forest. The other species are jamun, gular (Fieus glomerata), sehora (Streblus asper) neora (Barringtoma acutangula) and patin (Patrainjiva roxburghii). Shrubs of bhakmal and bhant are also present.

(viii) Plantation: Various exotics have also been introduced at various stages in the tract, Almost all the 'Phantas' and grasslands which are not waterlogged have been planted up with useful miscellaneous species. Most notable species are teak, eucalyptus and mulbery. The plantation of eucalyptus in this area was unfortunate and attempts should be made to remove it to allow the natural rehabilitation of indiginous species.

Mostly the plantation are not successful due to annual floods. Therefore the planted trees are either scattered or in patches. Common species are Khair, (Acacia catechu), Sissoo (Dalbergia sissoo), semal (Salmalia malparica), haldu (Adina cordifolia), gutel (Trewia nudiflora) and

a few ficus species e.g. ficus rumphu, ficus glomerata and ficus religiosa.

Mixed Forest

The areas in which soil is not suitable for sal trees are covered generally with small proportion of poor sal along with numerous miscellaneous species. These forests are quite open and more suitable for wild life. Other species are Termineallia and various ficus species. The smaller trees consist of Sygyium cumini, Miliusa Valutina Bauhima Malabaricum and Butea nonosperma. The undergrowth consist of grasses.

Aquatic and Marsh Land Vegetation

Lakes and ponds of the park are mostly shallow. Different type of vegetation are seen in each lake. Depending upon the nature of waterbody, vegetation has been recognized in six types.

1. Free floating hydrophytes
2. Suspended hydrophytes
3. Submerged attached hydrophytes
4. Floating attached hydrophytes
5. Emergent amphibious hydrophytes
6. Wet land hydrophytes.

Fauna of the Park

These forests lie well outside the hills in the northern parts of the Ganga plain and is perhaps the last stronghold of fauna of the Indo Gangetic tract left with us. Mohana river constitute the natural boundary of the park with Nepal in the northeast. At various places the river is shallow thus allowing easy migration of different animals from the Nepal forest to the park areas. Some migrations are permanent due to better shelter and food, while other are annual or for short period e.g. migration of elephants.

Abundant lantana bushes provide a very good cover to animals. The abundance of varieties of animal life is the great attraction of the park. But the main attraction of the park is swamp deer commonly known as 'Barasingha' or 'gond' (cervus duvauceli duvanceli). Todays there are 2,690 of the species - the larget known concentration of Barasingha anywhere. The national park was established basically to provide a legally protected home for this rare Indian animal.

The forest is home for ecologically viable populations of four other species of deer also. Spotted deer (Axis axis),

hog deer (Axis poroinus) barking deer (Muntiacus muntijak) and sambar (Cervus unicolour).

This is the unique or India's first nature reserve where the reintroduction of threatened wildlife species was initiated. In 1984-85 more than a century after the disappearence of rhino from this forest, seven one horned rhinos (three from Assam and four from Nepal were reintroduced here. According to records, the last rhino was shot here in 1878 in the forest areas adjoining the park.

The other sensation of the park is the rediscovery of the Bengal florican and the occurrence of hispid hare (Caprolagus hispidus) which has created almost sensation among naturalists.

The other notable wildlife in the park includes tiger, leopard, jungle cat, leopard cat, fishing cat, the Indian civet, wolf, jackal, otter, sloth bear, elephant (migrating from the bordering Nepal forests) blue bull or the large Indian antelope, blackbuck, wild boar, crocodile, python and over 340 species of birds including many migratory ones.

The habitat including many ponds and tals of Dudhwa attract many migratory birds. There are many ponds

like the Kakraha tal, Banke tal, Nagra tal, Puraina tal, Mutna tal, Churaila tal and Laudaria tal are the shelter place for the migratory birds from the Arctic region and the high Himalayas.

Among the Arctic migrants are white stork, black stork, spoonbill, eastern greyleg goose, barheaded goose, pintail, mallard, gadwall, wigeon, shoveller, pochards, European ulryneck, the Siberian dusky leaf warbler and western yellow headed wagtam.

During winters the birds of high Himalaya also come down to Dudhwa. The notable ones among these are the gold fronted finch, grey wagtail, the Indian magpierobin, west Himalayan long tailed minivet, the Ladakh grey backed shricke, great horned owl and surkhab (nests in Tibet).

The resident birds which stay throughout the year and breed in Dudhwa are among the most attractive in India. These include the make bird or darter, painted stork, whistling teal, comb duck, fishing eagle, black partridge, red jungle fowl, Indian Moorhen, jacana, Bengal green pigeon, brain fever bird, night jar, horn bill (three species), Indian Pitta, the Bengal florican and the Indian Shama (the famous song bird).

Among reptiles two species of lizards march crocodile (crocodilus palustries) and monitor lizard (Vananus monitor) are found. Snake both poisonous and non poisonous are present in large number. A variety of game fishes viz. hopeo rohita, Nolopterus, Wallagoattu and Mystus Seenghala are found in rivers and ponds.

List of important wildlife of the park

S.No.	English name	Scientific name
	Mammals	
1.	Tiger	Panther Tigris
2.	Panther or Leopard	Panthera pardus
3.	Sloth bear	Melursus ursinus
4.	Indian elephant	Elephas maximums
5.	Large Indian Antelope	Boselaphus tragocamelus
6.	Swamp deer	Cervus duvauceli duvauceli
7.	Sambhar	Cervus unicolor
8.	Black buck	Antelope cervicapra
9.	Spotted deer	Axis axix
10.	Hog deer	Axis porcinus
11.	Barking deer	Muntiacus Muntjac
12.	Hyaena	Hyaena Hyaena
13.	Jackal	Canis aureans
14.	Wild boar	Sus Scrofa

contd.....

15.	Porcupine	Hysterise indica
16.	Langur	Presbytis entallus
17.	Rhesus monkey	Macaca mulatta
18.	Otter	Lutra lutra
19.	Indian Patel	Mellivora indica
20.	Mongoose	Herpestes mungo
21.	Hare	Lepus ruficaudatus

Reptiles

1.	Marsh crocodile	Crocodilus palustris
2.	Python	Python molurus
3.	Hamdryad	Naja hannah
4.	Monitor lizard	Varamis monitor
5.	Pangolin	Maris cressicudata

Birds

1.	Grey Partridge	Francolinus pendecerianus, Gamelin
2.	The black Partridge	Francolinus Francolinus Linnaeus
3.	The common quail	Coturnix doturnia Linnaeus
4.	The common pea Forol	Pavo cristatus Linnaeus
5.	The Red Jungle Howl	Gallus Gallus
6.	The Red Turtle Drove	Streptopalia tranguebarsica Hermann

contd.....

7.	The common Green Pigeon	Taeron phoenicop, tera, Latham
8.	Indian sand grouse	Pterooles exustus
9.	The comb duck	Sackidiornis melanotes Pennant
10.	Brahminy duck	Tadorua Ferruginea
11.	Spotbill duck	Anas poocilorhvncha Forester
12.	Cooton teal	Nettapus coromondclianus
13.	Grey Hornbill	Tockus birostris scopoli
14.	Pied king fisher	Ceryle lugurbris Temminck
15.	Common king fisher	Alcedo atthis, Linnaeus
16.	Stork billed King fisher	Pelargopsis Capensis
17.	Chestnut headed bee eater	Merops leschanaultivieillot

Other Features

The cultural heritage of the park is unique and the Tharu tribe living in buffer zone offer a great opportunity to study tribal culture. Their traditional life style and folk dances, customs, beliefs, social organization and land use pattern provide a great source of attraction for the park visitors. They are called 'Tharu' as they are believed to have come from the 'Thar' area of Rajputana. It is said that after the defeat of Maharana Pratap in the battle of Haldighati, brave Rajputs finding

themselves encircled by enemies, sent their women and children accompanied by servants into the wood. It so happened that these brave warriors were slain in the battle and thus their wives were left widowed with the servants. In the absence of men of nobler blood, the Rajput women folk married their servants. This explains why Tharust is a matriarchal society. They are settled cultivators and keep large herds of cattle and some sheeps and goats. Their dependance on forests is for food, fodder, medicine, hygiene, fuel, housing agricultural implements, narcatics, crafts, social and religions ceremonies etc. The ethnobotanical studies of the Tharust have been carried out and need to conserve the cultivated and wild species of plant they use has been greatly felt.

The main crop plants of the Tharus are rice, maize, wheat, barley, gram, lentil, pea, potato and mustard. Jute (corchorus, capsularish), sunnhemp (Crotalaria Juncea L) and kenaf (Hibiscus cannobinus) are cultivated in some villages for the extraction of fibre.

The most popular traditional drink of Tharus is 'Jaund' a locally prepared rice bear made by the Dangoria Tharus from fermented rice and dried lubers of Asparagus adscendens roxb, and roots of Nelsonia Canescens spreng.

This liquor is supposed to be responsible for giving them their partial immunity from malaria.

The forest land under their possession has now been transferred to the Revenue Department in 1976 and are now full fledged revenue villages.

Land Use

The major land use outside the park boundary is agriculture though in the north and partly in the south there are reserved forests within the northern side forest's buffer zone situated the 37 Tharu villages. The main occupation of this Tharu tribe is agriculture. So there are agricultural fields around these Tharu villages.

The forest of the south constitute a part of the North Kheri forest Division which again are acting as a buffer to the park.

The northwest side is bounded with Nepal and originally there were forests in this side as well, but recently a strip along the border has been clear felled and converted into agricultural fields. This has given rise to many problems in the way of park management. But remaining portion of south and almost entire boundary along

west side touches the agricultural fields of the local villagers. The wild life of the Park cause considerable damage to the crop in these fields. Also before the constitution of the park these villagers used to graze their cattle in these forests, which has been completely stopped since then. It must therefore be appreciated that the local villagers have contributed a lot in the successful implementation of the park rules. However to avoid further hardship to these villagers the park boundaries on these sides need to be fenced.

APPENDIX 1

List of Rare and Endangered Species

Mamalls

1. Andaman wild pig
2. Bharal
3. Binturang
4. Black buck
5. Blue whale
6. Brow-antlered Deer
7. Capped langur
8. Caracal
9. Cetecean species
10. Cheetah
11. Chinese Pangolin
12. Chinkara or Indian Gazelle
13. Clouded Leopard
14. Crab eating macaque
15. Desert Cat
16. Dugong
17. Fishing Cat
18. Fourhorned antelope
19. Dolphin (Gangetic)
20. Flying squirrels
21. Golden Cat
22. Golden langur
23. Himalayan Ibex
24. Himalayan Tahr
25. Hispid Hare
26. Hog Badger
27. Hoolock Gibbon
28. Hump backed whale
29. Indian Elephant
30. Indian Lion
31. Indian Wild Ass
32. Indian Wolf
33. Kashmir Stag
34. Leaf Monkey
35. Leopard or Panther
36. Leopard Cat
37. Lesser or red Panda
38. Lion tailed Macaque
39. Loris
40. Hynx

APPENDIX 1 (Contd.....)

41. Malabar Civet
42. Malay or Sun Bear
43. Marbled Cat
44. Markhor
45. Mouse Dur
46. Musk deer
47. Nilgiri Tahr
48. Ovis Ammon or Nyan
49. Pallas's Cat
50. Pangolin
51. Pygmy Hog
52. Ratel
53. Rhinoceros
54. Rusty Spotted Cat
55. Serow
56. Sloth Bear
57. Slow Loris
58. Small Travancore Flying Squirrel
59. Spotted Linsang
60. Swamp Deer
61. Snow Leopard
62. Takin or Mishmi Takin
63. Tibetan Antelope or Chiru
64. Tibetan Gazelle
65. Tibetan Wild Ass.
66. Tiger
67. Urial or Shapu
68. Wild Buffalo
69. Wild Yak

Amphibians and Reptiles

1. Agra Mointor Lizard
2. Atlantic Ridley Turtle
3. Barred, Oval or Yelloe Mointor Lizard
4. Crocodiles
5. Gharial
6. Ganges Soft Shelled Turtle
7. Green Sea Turtle
8. Hawpsbill Turtle
9. Himalayan Newt or Salamander
10. Indian Egg-eating Snake
11. Indian Soft Shelled Turtle
12. Indian Tent Turtle
13. Large Bengal Monitor Lizard
14. Leathery Turtle
15. Logger-head Turtle

contd.....

APPENDIX 1 (Contd.....)

16. Olive-back Logger Head Turtle
17. Peacock-marked Soft Shelled Turtle
18. Pythons
19. Three-Keeled Turtle
20. Toroise
21. Viviparous Toad
22. Water Lizard

Birds

1. Andaman Teal
2. Assam Bamboo Partridge
3. Bazas
4. Bengal Florican
5. Black-necked Crane
6. Blood Pheasants
7. Brown Headed Gull
8. Cheer Pheasant
9. Eastern White Stork
10. Forest Spotted Owlet
11. Great Indian Bustard
12. Great Indian Hornbill
13. Hawks
14. Hooded Crane
15. Horbills
16. Houbara Bustard
17. Humes bar-backed Pheasant
18. Indian Pied Horbill
19. Jerdon's Courser
20. Hammergeier
21. Large Falcons
22. Large Whistling Teal
23. Monal Pheasants
24. Mountain Quail
25. Narcondom Hornbill
26. Nicobar Megapode
27. Nicobar Pigeon
28. Osprey or Fish Eating Eagle
29. Peacock Pheasant
30. Peafowl
31. Pinkheaded Duck
32. Scalatea's Monal
33. Siberian White Crane
34. Spur Fowl
35. Tibetan Snow Cock
36. Tragopan Pheasants
37. White Bellied Sea Eagle
38. White Earned Pheasant
39. White Spoonbill
40. White Winged Wood Duck

Source: From State of India's Environment, 1982, p.168.

APPENDIX II

Major National Parks/Wild Life Sanctuaries in Different Biogeographical Provinces

Biogeographical Province	Area hectare
A. Tropical Dry Forests/Woodland	
1. Indus Ganges Monsoon Forest	35,67,182
Kanha N.P., M.P.	
Corbett N.P., U.P.	
Dudhwa N.P., U.P.	
Great Indian Bustard WS/Maharashtra	
Chambar WS, U.P.	
2. Burma Monsoon Forest	2,98,009
Kazirang N.P., Assam	
Pakkui WS, Arunachal Pradesh	
3. Mahanadian	10,87,681
Nagarjun Sagar-Srisailam WS, A.P.	
Chilka WS, Orissa	
4. Coromandel	53,451
Pulicat WS, A.P.	
5. Deccan Thorn Forest	4,20,451
Bandipur WS, Karnataka	
Bannarghatta NP, Karnataka	
Daudeli WS, Karnataka	
Someshwara WS, Karnataka	

APPENDIX II (Contd.....)

B. **Warm Desert/Semi Desert**	
1. **Thar Desert**	10,05,982
Gir Lion N.P., Gujarat	
Velavadar N.P., Gujarat	
Wild Ass WS, Gujarat	
Desert WS, Rajasthan	
C. **Mixed Mountain System**	
1. **Himalayan Highlands**	5,24,460
Sanjay Gandhi N.P.	
Kedarnath WS, U.P.	
Govind Pashu Vihar WS, U.P.	
Khangchendzena N.P., Sikkim	
2. **Szechwan Highlands**	1,80,782
Namdnapa WS, Arunachal Pradesh	
D. **Andaman and Nicobar Islands**	2,000
Barren Islands WS	
Narchondam Islands WS	
North Reef Islands WS	
South Sentinel Islands WS	

APPENDIX II (Contd.....)

E.	Tropical Humid Forests	
1.	Malabar Rainforest	15,27,009
	Evavikulam Rajmallay N.P., Kerala	
	Borivli N.P., Maharashtra	
	Vansda N.P., Gujarat	
	Anaimalai WS, Tamil Nadu	
	Wynad WS, Kerala	
	Periyar WS, Kerala	
2.	Bengalian Rainforest	3,34,703
	Sundarbans Tiger Reserve West Bengal	
	Sajnakhali WS, West Bengal	

Note: N.P. National Park, WS-Wild Life Sanctuary

Source: IUCN, 1982, List of National Parks and Protected Areas, 1982.

Male Barasingha with its fully developed antelores

Tiger find a cosy home and tall grass, the most striking feature of the Dudhwa landscape

Barasinga, the largest known concentration of the species anywhere

Another Tiger in the Park whose stripes merging with the surrounding

A blackbuck with its striking dark coat and long spiral horns

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